Azipod® VI and ICE Product Introduction

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Preface

This Product Introduction provides Azipod propulsion system data and information for initial project planning of an icebreaking or ice-going ship with an Azipod propulsion solution. Our design and sales persons are available to give more detailed guidance on our products, the Azipod system design and the installation of system components. Please contact ABB in the early phase of the ship design process for expert advice and help in selecting and dimensioning system components.

Our products are constantly upgraded and developed for the needs of our customers and the market. Our goal is to have the most reliable and top-performing products in the market, and to ensure the best possible total life cycle cost for the ship owner during the ship's lifetime. Therefore, we reserve the right to make changes to any data and information herein as required, without notice.

All information in this publication is offered for the purposes of guidance only. Project-specific designs shall be agreed separately and therefore any information given in this publication is not intended for use as part of agreement or contract.

Important information regarding the products and services of ABB Marine & Ports are also available on our web site. Please visit the relevant web pages for guidance on Azipod model size selection and drawings showing main dimensions.

Helsinki, 2019

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General

The first Azipod® installation made onboard a ship was commissioned in 1990. By May 2018, the milestone of 15 million cumulative operating machinery hours was reached, with a remarkable 99.8% availability achieved.

In the case of ice-going vessels, by the end of 2018 the following milestones had been reached:

- 60+ vessels with heavy ice class equipped with Azipod propulsion
- 25+ years icebreaking experience with Azipod propulsion
- 140+ Heavy ice class Azipod propulsion units sold
- 0 incidents for Azipod propulsion caused by ice

1.1 Azipod propulsion and steering
The Azipod system is a podded electric main propulsion and steering device that uses a fixed-pitch propeller fed through a variable-frequency drive to control the speed and direction of the propulsion motors. The Azipod VI and ICE series main propulsion and steering systems are Azipod products that are designed for ice-going and icebreaking ships.

Azipod propulsion is designed for the preferential use of the (directly driven) pulling propeller when driving in the Ahead direction. The Azipod VI and ICE family of products are azimuthing (steering around its vertical axis) freely by 360°. Azipod VI is available generally for power ratings from 6 MW to 17 MW, depending on the ship size and ship characteristics. Azipod ICE propulsion is designed for smaller power range from 2 MW to 6 MW.

The full ship system consists of the Azipod Propulsion Units themselves and an "ACS" series marine propulsion power drive for each Azipod unit. A remote control system and power plant (generators, switchboards) are also usually included in the scope of the ABB delivery, plus propulsion supply transformers (if needed).

The Azipod Propulsion Module and the associated Steering Module structures are made of fabricated steel. The submerged Propulsion Module incorporates a three-phase electric propulsion motor in a dry environment, directly driving a fixed-pitch propeller.

Steering Module

Propulsion Module

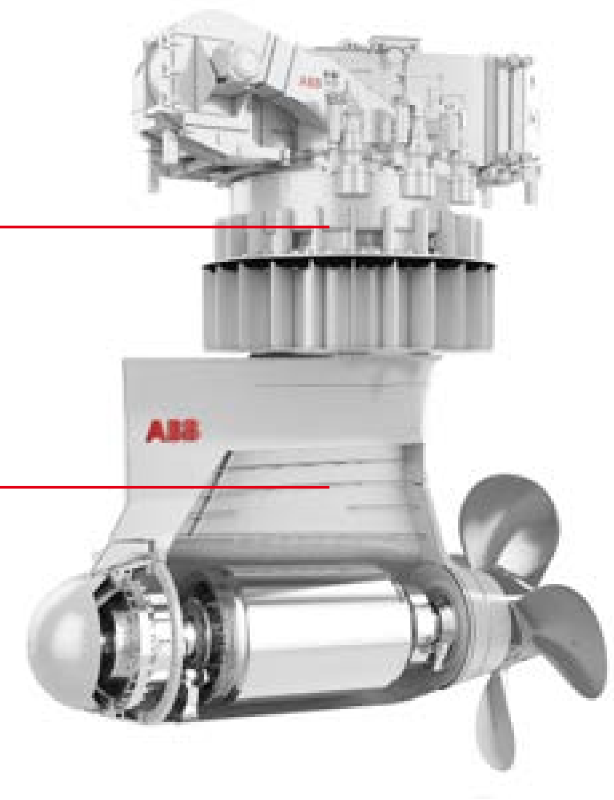

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Figure 1-2
Basic arrangement of the Azipod VI

Azipod VI uses synchronous electric motor technology. Azipod ICE, meanwhile, uses permanent magnet electric motor technology for lower power ranges, which makes a simpler system layout possible and requires fewer auxiliary units.

For each project, the propeller is tailor made by ABB to fulfill the needs of the ship yard and ship designer.

1.2. 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 electric switchboards installed 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 largely standard, although this is dependent on the delivery of engines or, for example, gas turbines from contractors.

During the whole project, the basic tool used for power plant design is the so-called single-line diagram. This clear visual representation allows the actual onboard configuration to be discussed efficiently, even at the early stages of work.

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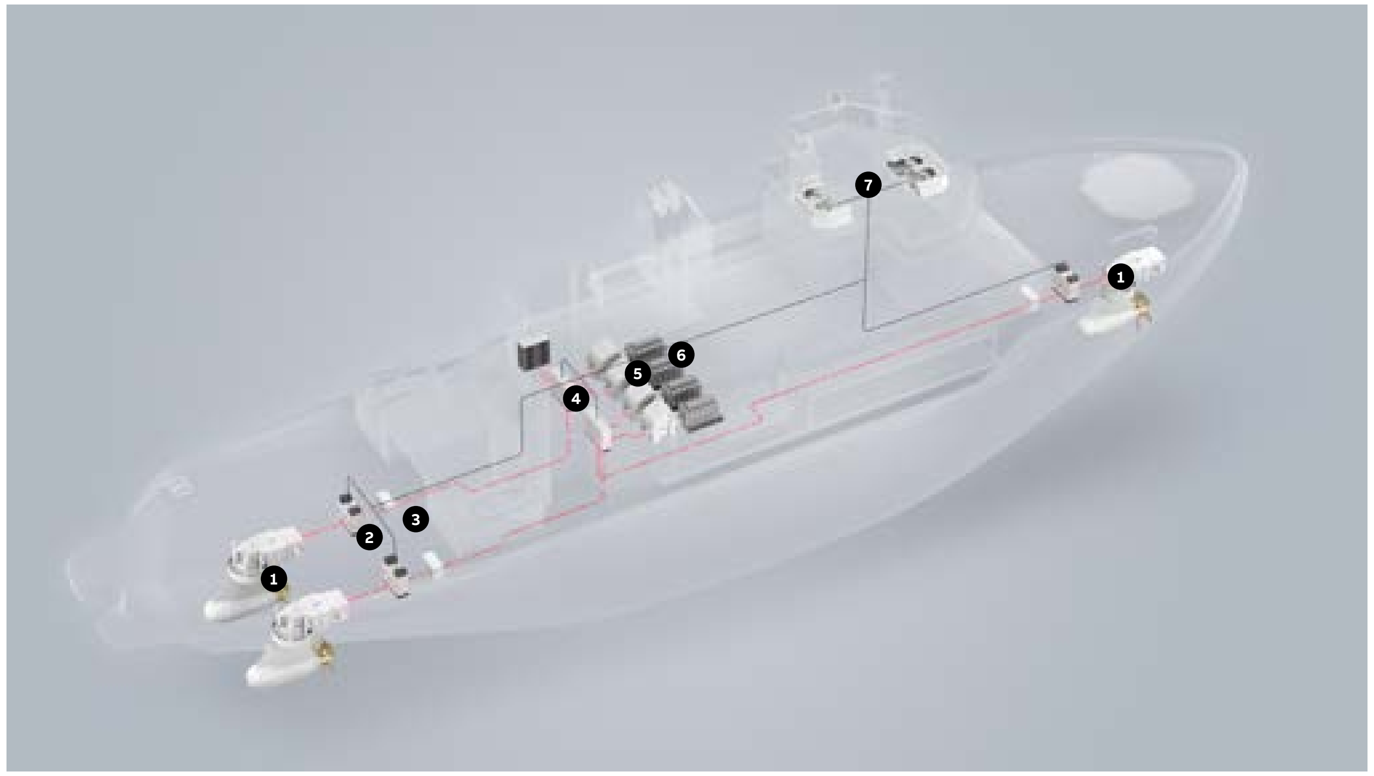
Figure 1-4
Typical ABB Azipod system delivery



1 Azipod VI propulsion units
2 LV switchboards
3 Propulsion transformers
4 MV switchboards
5 Generators sets
6 Variable speed drives
7 Propulsion control

Azipod system design principles for icebreaking vessel

The 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. Clearly, the absence of a mechanical connection between the power plant and the electric motor driving the propeller prevents mechanical losses in the icebreaker propulsion system.

The propulsion motors used in the Azipod VI and ICE series are capable of delivering 100% propeller power in the bollard pull condition. Usually in an icebreaking ship the Azipod unit motor is also dimensioned for the cyclic over-torque capacity. The figure below presents a typical Azipod unit motor torque - RPM characteristic curve.

The ultimate performance for the Azipod system is usually expressed as a relationship between the propeller power and the available thrust in the bollard pull condition (full Azipod system power, 0 kn ship speed). Azipod unit bollard pull capacity in relation to Azipod unit power is presented in the figure 2-2.

Propeller thrust values are evaluated for a specific project by using model test data and selected propeller design data. Therefore, the curve in the figure 2-2 shows the estimated Azipod Unit bollard pull thrust achievable in relation to power where a non-ducted propeller is used.

The benefits of electric propulsion are known to include:
- Appropriate torque characteristics
- Dynamic response
- Redundancy
- Ship dynamic positioning capability

In addition, the Azipod VI and ICE 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 module 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 units provide great design flexibility and space-saving possibilities in the aft ship
- Better operational efficiency in icebreaking and open water – better ship total life cycle cost

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Figure 2-3
Azipod VI
Propulsion Unit

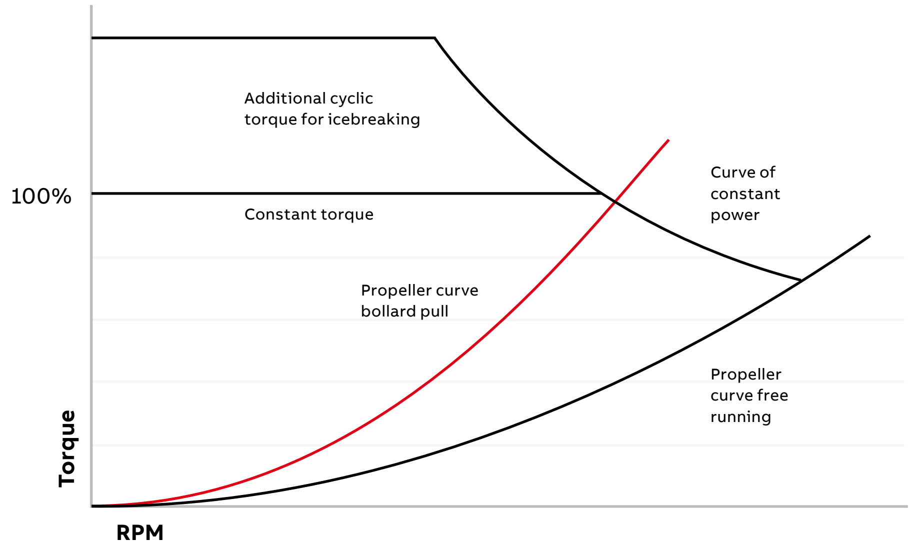

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Figure 2-1
Drive and propeller motor torque – RPM capacity

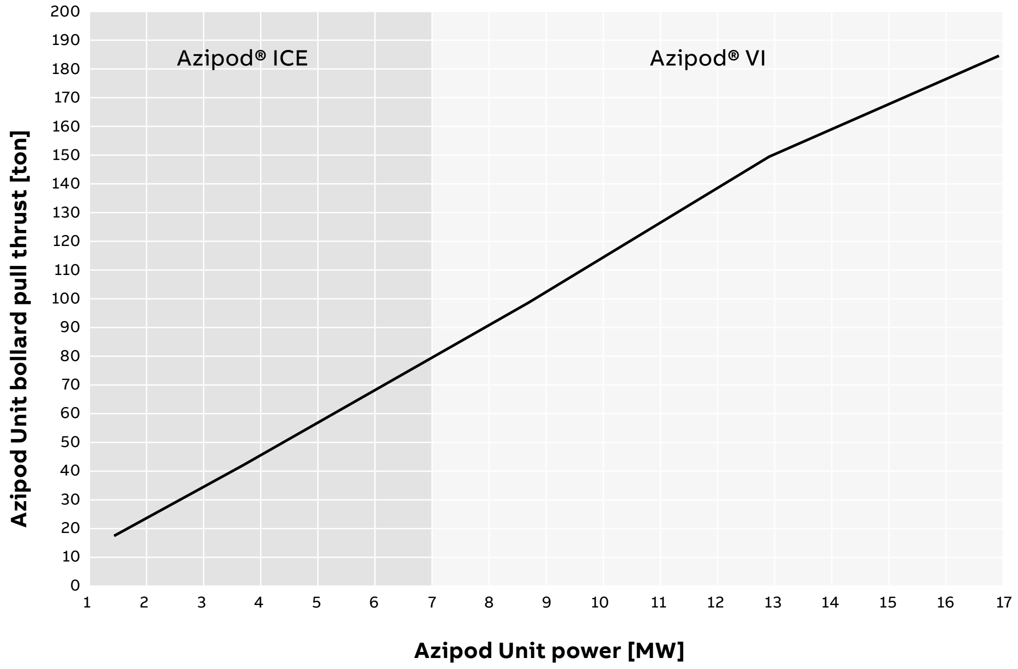

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Figure 2-2
Azipod VI / ICE power – bollard pull thrust curve

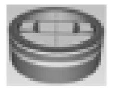
Azipod VI

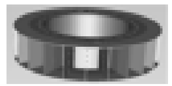
3.1. Steering Module
The Azipod I4000 Steering Module is bolt-connected to the Mounting Flange. The mounting flange delivered by the shipyard is welded to the machined part of the ship's hull as a structural member. The Propulsion Module is bolted to the Connection Block of the Steering Module.

The Azipod V2900 Steering Module is welded to the ship's hull as a structural member. The Propulsion Module is bolted to the azimuthing part of the Steering Module.

3.2. Azipod VI propulsion system scope of supply
Each Azipod VI delivery usually consists of the following fourteen items: two (2) modules and twelve (12) auxiliaries. They are built internally at ABB ready for separate deliveries, for shipyard installation. The steering module I4000 and its nominated ship interface structures and scope of supply are presented on the figure 3-1. An example of a layout for Azipod VI modules and auxiliaries is presented on the figure 3-2.


1 Machinery block (ABB scope)


2 Connection block (ABB scope)


3 Mounting flange (shipyard scope)


4 Mounting structure (shipyard scope)

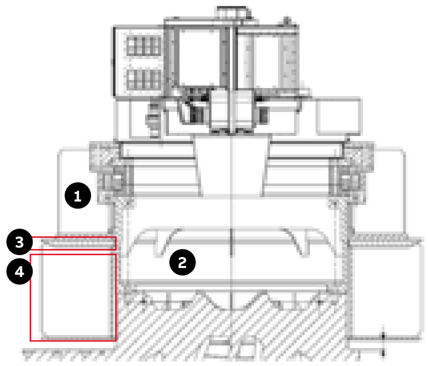


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Figure 3-1
Steering module I4000 and ship interface structures naming and scope of supply

1 Propulsion Module
2 Steering Module
3 Oil Treatment Unit (OTU1)
4 Oil Treatment Unit (OTU2)
5 Hydraulic Power Unit (HPU)
6 Cooling Air Unit 1 (CAU1)
7 Slip Ring Unit (SRU)
8 Cooling Air Unit 2 (CAU2)
9 Gravity Tank (GTU)
10 Air Control Unit (ACU)
11 Local Backup Unit (LBU)
12 Oil Dewatering Unit (ODU) (optional)
13 Azipod Interface Unit (AIU)

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Figure 3-2
Layout example of Azipod modules and auxiliaries

3.3. Cooling arrangement for the propulsion 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.

There are two fans and two or four heat exchangers. The cooling air unit can be designed to be semi- or fully-redundant. Air cooling ducts are provided with inserted air filter elements. Fan motors can be run with control drives to adjust the cooling power according to Azipod unit motor power and heat losses.

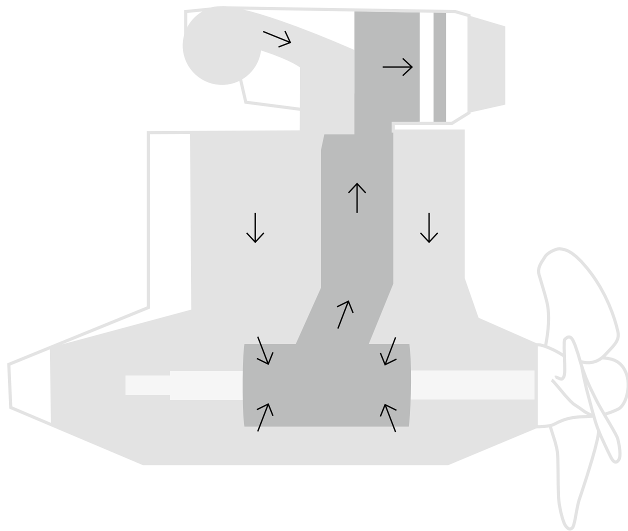

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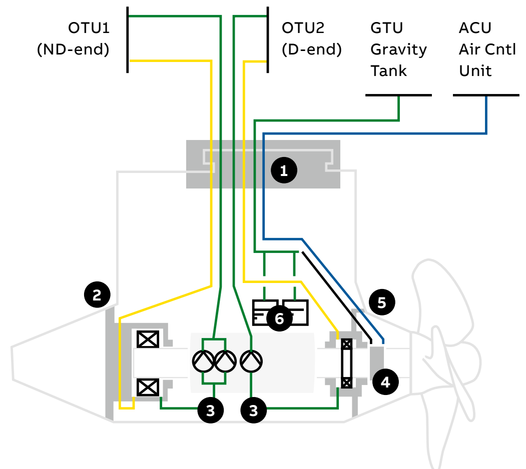
Figure 3-3
The air cooling arrangement of the Azipod propulsion motor

3.4. Shaft line arrangement
The shaft line 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 two Oil Treatment Units (OTU), where oil treatment consists of filtering and temperature stabilization. Both Oil Treatment Units also monitor the relative water contents in the lube oil using a detection device.

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



1 Fluid Swivel (in the SRU)
2 Thrust bearing (ND end)
3 Oil sump lubrication
4 Prop. shaft seals
5 Propeller bearing (D end)
6 Seal tanks

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Figure 3-4
Overview of the shaft line arrangement of the Azipod system

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

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 (generally) be used in ice operation.

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Figure 3-5
Hybrid thrust bearing, changing the thrust pads inside the Azipod VI2300

The propeller bearing is of the roller type, but the Azipod unit's shaft thrust bearing is available with both roller and hybrid types depending on the size of the Azipod unit. Hybrid type bearings enable enhanced life cycle cost performance and reliability in icebreaking. Hybrid type thrust bearing pads (to stop wear) can be changed from inside the Azipod unit without dry-docking the ship or pulling out the Azipod module's shaft.

3.5. Drainage functionalities
The Azipod Propulsion Module has a built-in drainage subsystem for the drainage of shaft lube oils or potential oil/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 fed 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 switchboard. Status information from level switches inside the pod is fed via AIU into the ship's machinery automation system (MAS).

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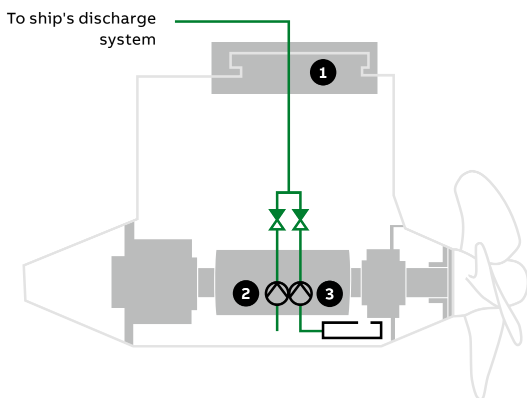
Figure 3-6
Drainage arrangement of Azipod VI

1. Fluid Swivel (in the SRU)
2. Space draining pump
3. Tank draining pump



Azipod ICE

4.1. General
The mounting flange delivered by the shipyard is welded to the machined part of the ship's hull as a structural member. The Azipod Steering Module is bolt connected to the Mounting Flange. The Propulsion Module is bolted to the Steering Module.

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Figure 4-1
Layout example of Azipod ICE modules and auxiliaries VII

1. Hydraulic Power Unit (HPU)
2. Steering Module
3. Slip Ring Unit (SRU)
4. Local Backup Unit (LBU)
5. Propulsion Module

4.2. Azipod ICE propulsion system scope of supply
Each Azipod ICE delivery usually consists of the following five items: two (2) modules and three (3) auxiliaries. They are built internally ready for separate deliveries, for shipyard installation, as follows:
- Propulsion Module
- Steering Module
- Slip Ring Unit (SRU)
- Hydraulic Power Unit (HPU)
- Local Backup Unit (LBU)

4.3. Cooling arrangement for the propulsion motor
The Azipod ICE motor is directly cooled to seawater through the Azipod unit's hull. No separate cooling air unit is needed. The Azipod ICE hull is designed for seawater cooling all around the motor tube, given that the motor stator is 'shrink-fitted' directly to the motor tube.

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Figure 4-2
direct seawater cooling arrangement of the Azipod ICE propulsion motor

4.4. Shaft line arrangement
The Azipod ICE propulsion module contains a permanent magnet electric motor, which directly drives the propeller.

The propeller shaft seal prevents seawater from entering the propulsion module.

The propeller shaft seal system includes the housing, a combination of a face- and lip-type seal and a liner. The entire Propulsion Module is pressurized, while there are also drainage lines between the face- and lip-type seals.

Lubrication for the lip seals is carried out by a programmable lubrication devise - the same device that is used for the propeller bearing. The device is located in the steering module and includes alarms covering low lubricant levels and pump malfunction. The device is accessible from the Azipod room.

The shaft brake is located in the motor module. It uses compressed air supplied by the ship's pneumatic air system or the Azipod ICE unit's standby compressor.

Propeller and thrust bearings are of the roller type. Propeller and thrust bearing are directly cooled by the surrounding water through the steel structure. The propeller bearing is automatically grease-lubricated.

The thrust bearing is lubricated by a self-lubricating oil reservoir. The thrust bearing has a local oil tank that is mounted on the bearing shield.

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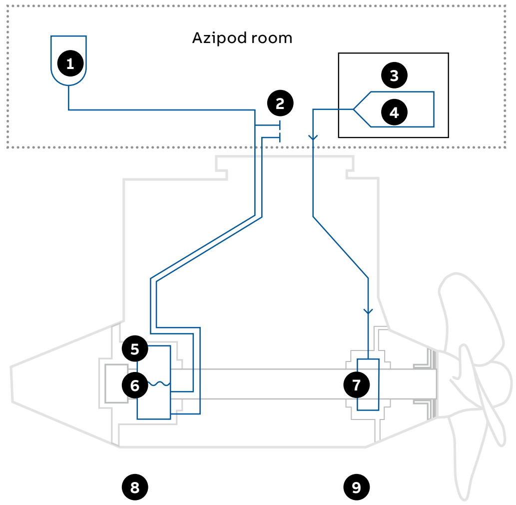
Figure 4-3
Overview of the shaft line arrangement of Azipod ICE

1. Oil level indicator
2. Oil filling / emptying plugs
3. Control and equipment box
4. Grease pump
5. Local oil tank
6. Oil level
7. Grease collection tank
8. Thrust bearing
9. Propeller side bearing



4.5. Drainage functionalities
The basic principle for leakage prevention in the Azipod ICE involves pressurizing the propulsion module. The Azipod ICE is also equipped with a drainage and leakage control system, which enables the follow-up of the sealing status of the propulsion module. This system consists of a compressed air connection, piping and sight glasses (level sensors).

Air is supplied from the ship's pneumatic air system. There is a standby compressor in the Azipod unit which starts if the air supply from the ship system is lost.

Two drainage lines connect from the air space in the shaft sealing, taking the small amount of water that penetrates through the water-lubricated face seal up to the Azipod room. Two drainage lines also connect into the bottom of the propulsion module, whose leakage detector is linked to the ship's automation system.

The amount of water leaking through the water-lubricated face seal can be observed visually from the sight glass in the Azipod system room.

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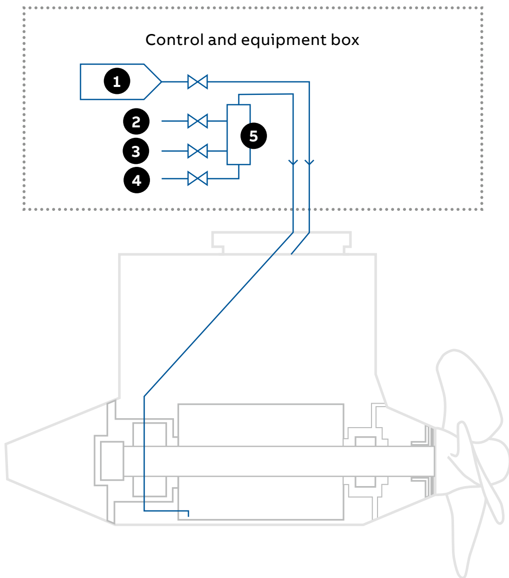
Figure 4-4
Drainage arrangement of Azipod ICE

1. External air supply
2. Normal operation small air flow
3. High level
4. Drain
5. Sight glass



Hydraulic steering gear for Azipod VI and ICE

The Azipod VI and ICE steer through 360 degrees with 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 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 a main pump (for steering) on the same shaft and a boost pump (a so-called "charge" pump) to secure the volumetric fill of the piping. The motor starters (2 pcs), servo boxes (2 pcs) and the steering alarm box (1 pc) are also built onto the HPU.

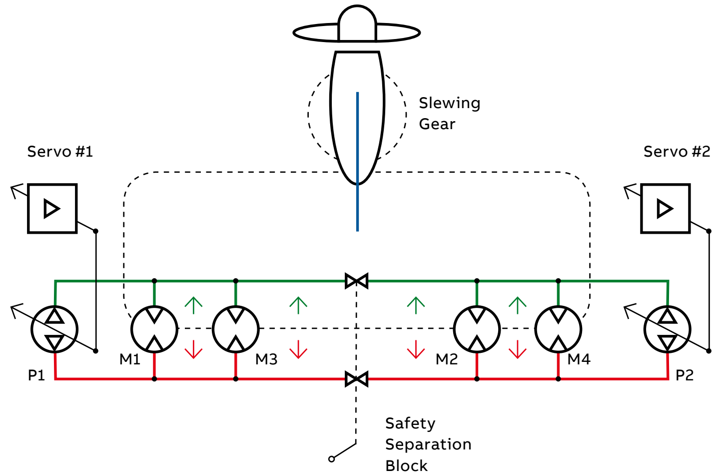


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Figure 5-1
Hydro-mechanical principle of the steering gear with four hydraulic motors

Slewing seal

Environmental seal design
No oil to water interface

Condition monitoring
Leakage detection and collection

Easy maintenance
Seal change can be done without dry docking from Azipod® room

Slewing seals can be changed in segments from Azipod room

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Figure 5-2
Changing the slewing seals from Azipod room without dry-docking (Steering Module I4000)

In the event of an external hydraulic leakage, the steering gear will be split automatically with a dedicated failure control subsystem. 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 personnelThe ship's personnel therefore manually perform single failure fault isolation, or automatically, depending on the particular failure control arrangement ordered with the Azipod system.

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

The Azipod unit steering module I4000 is designed for enhanced life cycle costs and reliability. It is possible to change slewing seals from inside the Azipod room without dry-docking.

Dimensions and weights

The following preliminary dimensions are to be used in the early stages of a ship project study. These dimensions must be checked during the technical drafting process with regard to the applied ship fit:
- The obtainable vertical measure (“C”) for the Propulsion Module is project specific, and subject to the hydrodynamic forces and ice loads calculated. ABB uses some standard heights “C” as the starting point of the project.
- The Azipod Steering Module height (“E”) can be altered under special consideration and/or in ABB given limit values in dimensioning drawings.
- The final Cooling Air Unit detail selection may slightly alter the related dimensions. (“J”, “K” and “L”). Azipod ICE has no air cooling unit.

NOTE: Please contact ABB Marine & Ports and submit an inquiry for equipment and Azipod propulsion unit selection and dimensioning. Available propulsion units correct frame size selection data and main dimensions drawings can be found on the ABB Marine & Ports web site. Please visit the web site for more detailed information.

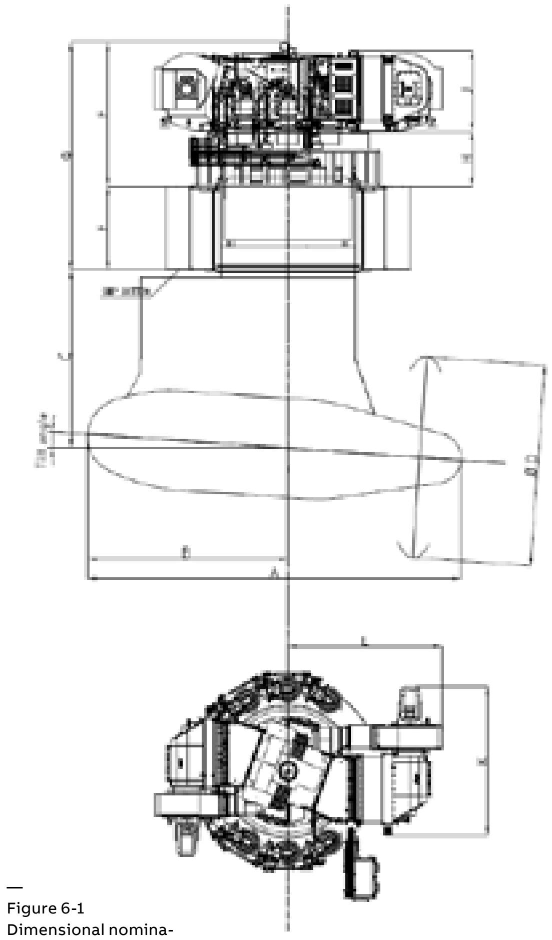

Figure 6-1
Dimensional nominations for the Azipod propulsion system

	Azipod ICE	Azipod VI1600	Azipod VI2300
	[ton]	[ton]	[ton]
Propulsion Module (excluding propeller)	35–56	118–123	220–245
Steering Module	19–24	97	140
SRU (Slip Ring Unit)	1.8	3	4
CAU (Cooling Air Unit)	N / A	8,5	10
HPU (Hydraulic Power Unit)	4.2	4.5	4.5
OTU (Oil Treatment Unit)	N / A	2x0.3	2x0.3
GTU+AIU+LBU+ACU	0.02 (LBU only)	0.5	0.5
Propeller	5–10	14–18	36–40

Figure 6-3
Example weights for the Azipod Modules and auxiliary units

	Azipod ICE	Azipod VI1600	Azipod VI2300
A [m]	5.2–6.2	8.5	10.6–11
B [m]	2.4–3.0	4.5	5.5–6
C [m]	2.8–2.9	3–3.2	4.2–5.3
ØD [m]	2.5–3.5	4–4.25	5.6–6
E [m]	0.7–1	1.3–1.9	1.5–3
F [m]	2	2.9	4
G [m]	2.7–3	4.7–5.3	5.5–7
H [m]	N / A	0.3–1.5	1.7
J [m]	N / A	2.25	2.5
K [m]	N / A	2.75	4.4
L [m]	N / A	6	4.5
Tilt [deg]	0	4	4

Figure 6-2
Example dimensions for the Azipod

Ambient reference conditions

7.1. Azipod system
- Rated sea water temperature -2…+ 32°C
- Azipod system is rated as a Permit Required Confined Space for personnel entry
- Installing firefighting media inside the Azipod unit, such as inert gas needs to be carefully planned to avoid release of media in case personnel are inside the Azipod Propulsion Module

7.2. Azipod room requirements
- Machinery area rating with sufficient air conditioning.
- Ambient temperature in Azipod room +2…+45°C.
- Ambient relative humidity 95 %: no condensation allowed on any parts

Ship system interface

8.1. Ship automation interface
The auxiliary functions of Azipod propulsion are controlled via 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 the related I/O specification together, as well as 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 level of detail/extent that needs to be defined during the project design stage.

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

8.2. Ship auxiliary power supply interface
The shipyard delivers the motor starter functionalities for the electric motors of the Azipod system 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.

8.3. Remote diagnostic system
ABB's remote diagnostic system is a dedicated monitoring and diagnostics platform for the collection, storage and analysis of data from individual components, sub-systems and integrated solutions. With the remote diagnostic system, ABB provides its customers with system monitoring and expert services through a single point of communication with ABB's 24/7 support centers.

The remote diagnostic system installed onboard the vessel records critical signals from controllers, drive units and sensors. It provides an easy access to engineers on duty at the ABB RDS centers. This connection transfers up-to-date measurement data to ABB technicians onshore. The technicians assess the situation and provide immediate guidance based on real-time data. This greatly enhances and accelerates fault-finding and troubleshooting processes.

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Figure 8-1
Typical interface with the ship's systems

1 Slip Ring Unit (SRU)
2 Pumps and sensors
3 Steering Gear Alarms
4 AIU Box
5 Cooling Air Unit (CAU)
6 Fans: x2
7 Group alarm
8 Propulsion Control Unit
9 Commands and info
10 MCC status info
11 Controlled power supplies
12 Ship's Automation System
13 Ship's Motor Control Center

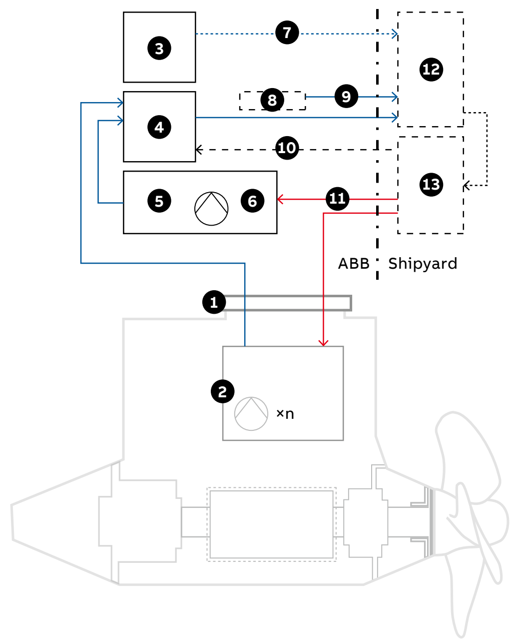

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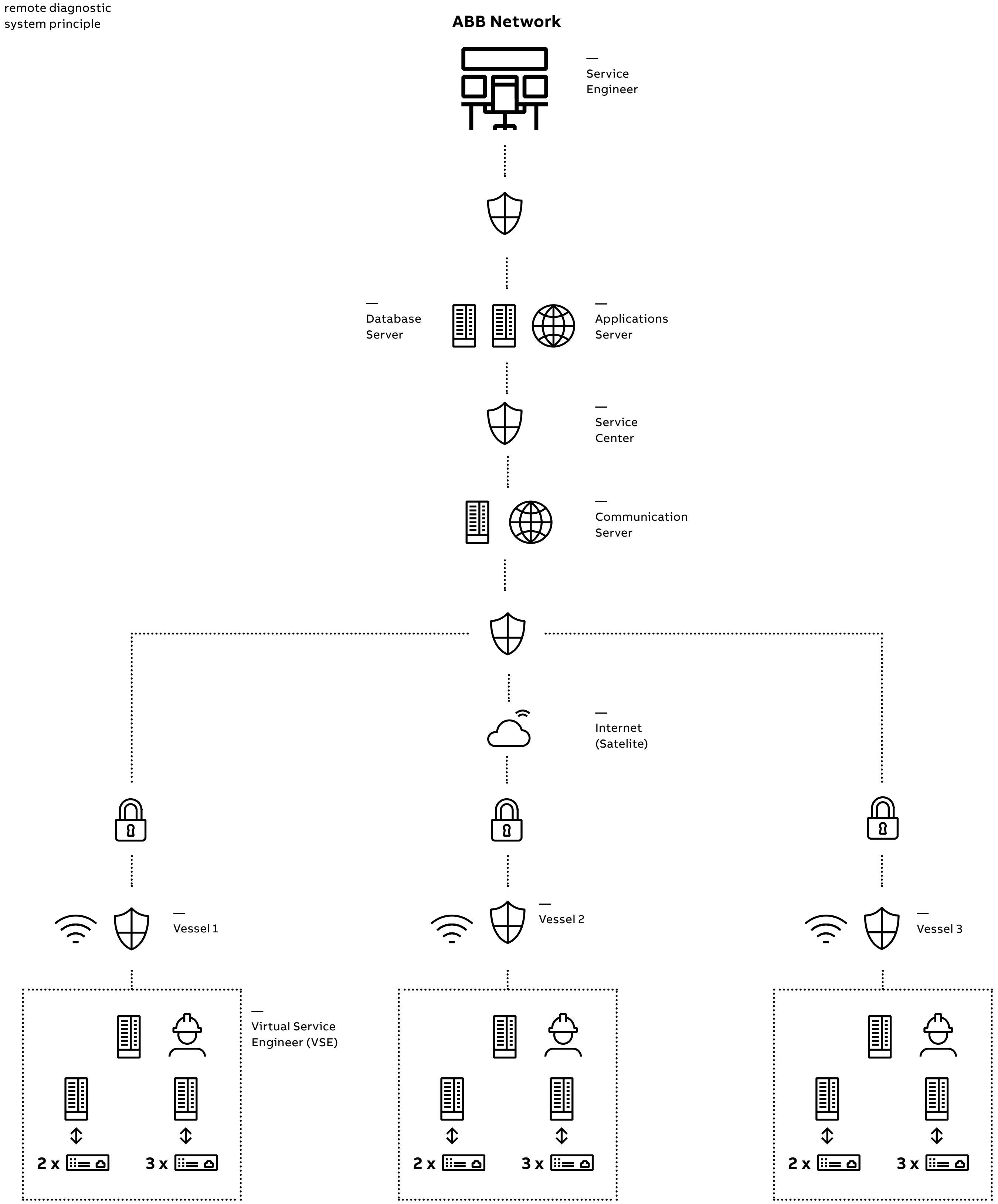
Figure 8-2
Typical fleet remote diagnostic system principle



Azipod remote control system

Figure 9-1
Typical remote control outfit

The ABB Onboard Remote Control System (RCS) operates Azipod® main propulsion and steering. The control system provides the operator's outfit to the Bridge and to the ECR. In addition, online operator guidance and feedback is included for optimal Azipod system use. The guiding principle of this functionality is achieving cost-efficient and smooth ship operation.

The ABB Onboard Remote Control System is consisting of following sub-systems:

- Remote Control Levers,
- Remote Control Panels,
- Indication System,
- Dimming System,
- Emergency Backup System.

Command reference feedback is provided for the thruster levers in the form of an electric shaft system. Hardwired backup controls are included in the basic scope of supply.

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

Figure 9-2
Example of ABB Remote Control System User Experience

Marine Pilot Control

The ABB Ability™ Marine Pilot Control simplifies ship maneuvering with an intuitive touch-screen-based user interface and enables safer, more efficient ship operations.

With its user-centric design, ABB Ability™ Marine Pilot Control reduces workload by automating navigational tasks, allowing bridge officers to take a more holistic approach to the overall control and positioning of the ship. The system integrates seamlessly with existing onboard equipment, and ensures ease of installation and maintenance, adding significant bridge-to-propeller value for shipowners.

One of the key benefits of the system is that it allows the operator to switch to joystick control for maneuvering the vessel at any speed all the way to docking and vice versa. ABB Ability™ Marine Pilot Control employs algorithms that calculate the optimal execution of command for controlling the vessel in any operational situation. Overall safety is increased as the crew is able to maintain full situational awareness, rather than having to focus on changing control modes.

Marine Pilot Control is a next generation DP system that replaces traditional solutions designed for disconnected operations. Embracing new technologies for the human-machine interface and offering tangible safety and efficiency benefits.

The fact that ABB Ability™ Marine Pilot Control can be used to control a vessel at any speed means that it can also take into account rudder forces from the Azipod units, and not simply the propelling force. Knowing the rudder forces mean that steering capability can be achieved using less acute angles, reducing wear and tear on the steering gear.

Figure 10-1
Example of ABB AbilityTM Marine Pilot Control User Experience

Azipod unit location on the ship's hull

It is important to place the Azipod unit at the correct location on the ship's hull. Typically, no part should not project beyond the side or by the transom. According to experience in the twin Azipod unit 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 need to be located far enough from each other to maintain sufficient clearance at all steering angles. Generally, propeller tips should not go under the ship's baseline at any steering angle. Again, propeller tip clearance of the ship's hull should be kept more than 25% of the propeller diameter to avoid propeller tip hull vortex. For more accurate design, the hull shape of the ship and ship wake field form needs to be evaluated in co-operation with ABB hydrodynamical engineers. This will ensure the best location for the Azipod units for open water and ice breaking operations.

For the maximum resultant mounting angle (longitudinal and lateral), please check product specific values from Azipod propulsion system technical specifications and main dimensions drawings.

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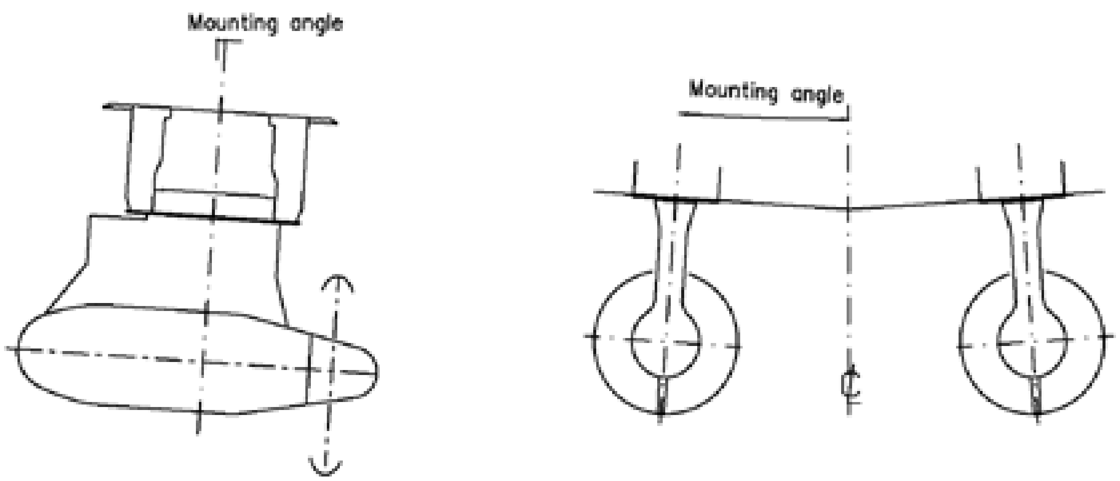
Figure 11-1
Mounting angles (longitudinal and lateral)



Propeller

Azipod system propellers are always fixed-pitch propellers (FPP) because of the control of the propeller speed and torque by a frequency converter. The typical Azipod unit has a pulling-type propeller as a Monoblock or with built-on blades. The propeller is optimized and tailor made for each project. ABB is usually in charge of the propeller design, which is accomplished in close co-operation with the shipbuilder's designers.

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.

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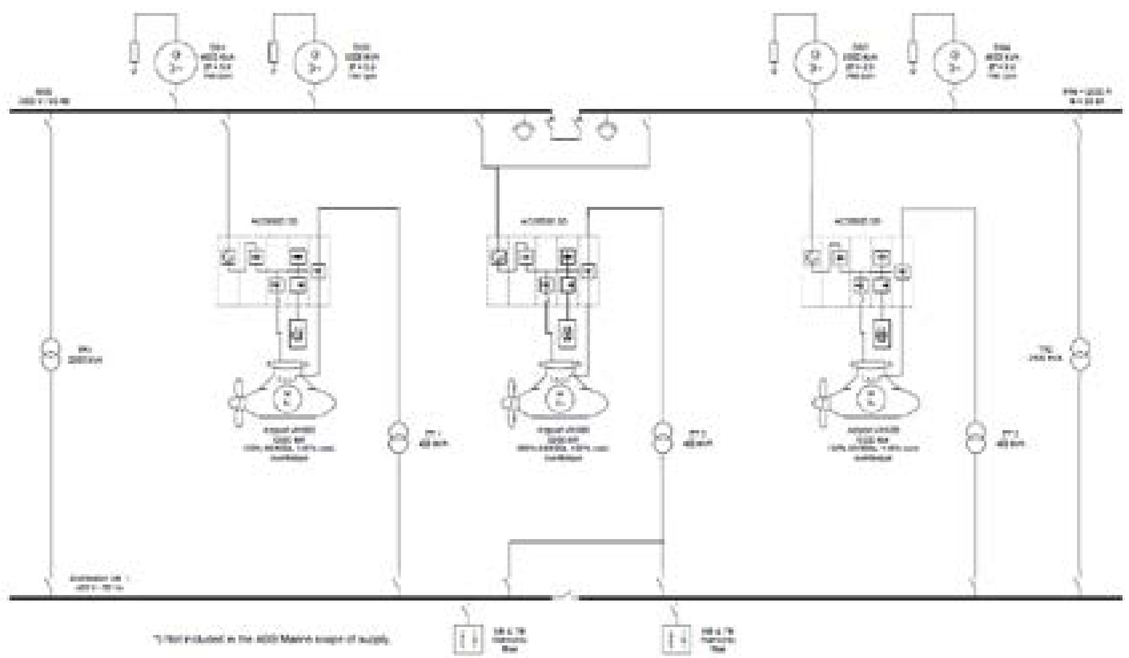
Figure 9-1
Typical single line diagram of the on-board power plant



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