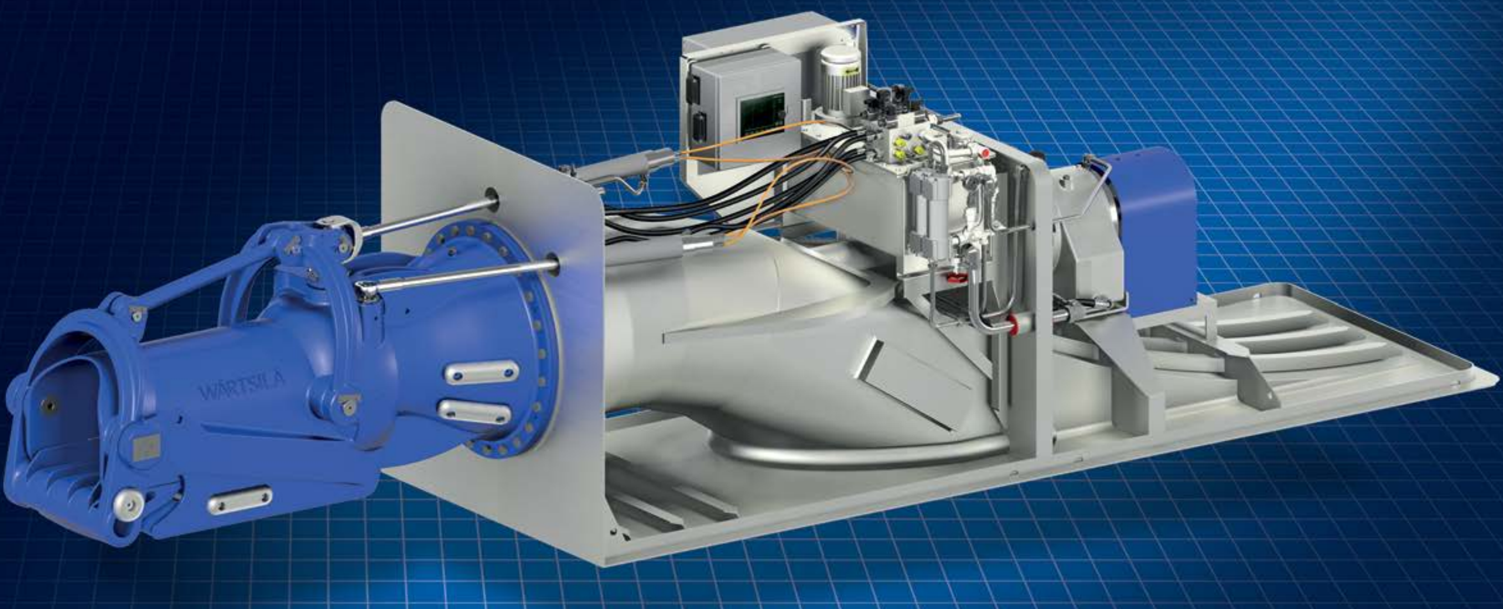
WÄRTSILÄ Propulsors

MIDSIZE WATERJETS PRODUCT GUIDE



Introduction

This Product Guide provides data and system proposals of midsize waterjet installations for the early design phase of a vessel. Apart from this midsize concept product guide also a guide exists for the modular concept. For contracted projects specific instructions for planning the installation are always delivered. Any data and information herein is subject to revision without notice.

Issue	Published	Updates
2/2015	12.11.2015	Changes in text and QR code updated
1/2015	16.09.2015	Changes in text
2/2014	31.20.2014	Chapter "Propulsion Control System" added, text and figures updated
1/2014	28.03.2014	First issue of PG Midsize Waterjets

November 2015

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Table of contents

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1. Midsize Waterjet

Wärtsilä has developed the Midsize waterjet range to provide an easy to install solution for waterjet propulsion up to 4500 kW. The inlet duct is added to the supply and delivered pre-assembled on a skid for direct 'weld-in' or 'bolt-in' connection into the hull. The shaft line of the waterjet is aligned and all waterjet components are mounted on the skid. All auxiliary systems are mounted on the skid including the piping and electrical wiring.

After integration of the unit with the ship, the yard needs to establish the following connections:

- Cooling water
- Electrical wiring to the waterjet control cabinet for e-motor and signals
- Connection to the prime mover

All midsize waterjet sizes are available in a steering/reversing (SR) or booster (B) execution. The range consists of 5 sizes starting with the LJX 510 up to the LJX 810.

To reduce weight of the waterjet system, aluminium is chosen for the construction of several components. Components that play a critical role in the performance of the waterjet, like the stator bowl and the impeller, are constructed out of a high grade stainless steel like in our modular waterjet series.

In contrast to the welded construction on the modular waterjets, most of the midsize waterjets main components are cast. This method allows the waterjet to have a unique shape for the optimized steering concept, to allow optimal hydrodynamic properties on the inside and an eye catching design on the outside.

Steering and reversing are done by actuating hydraulic cylinders. The midsize waterjet is designed with inboard hydraulics. The location inside the ship enables good maintainability and prevents environmental pollution as there is no oil containing component outboard, and has a water lubricated bearing in the stator bowl.

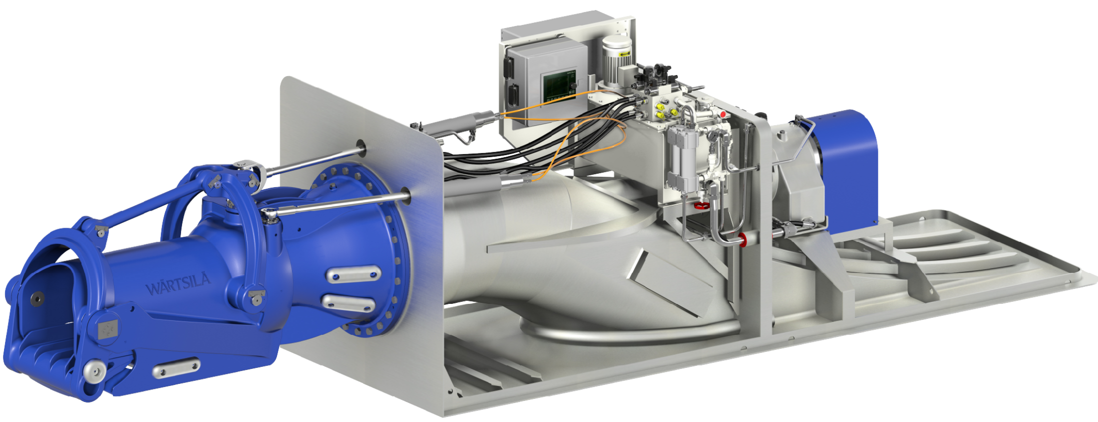

Fig 1-1 Midsize waterjet

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2. Waterjet Principle of Operation

The thrust produced by a waterjet is generated from a water flow that is accelerated in between the entrance at the inlet duct and exit at the nozzle. The figure illustrates this in its most basic form. Water from underneath the hull flows into the jet inlet duct. The dividing streamline indicates what part of the flow is entering the inlet duct and what part of the flow is passing by.

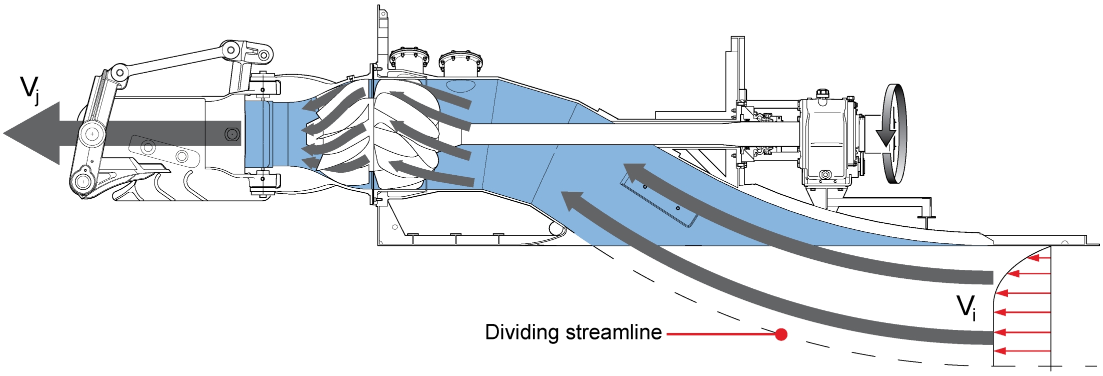

Fig 2-1 Waterjet flow

2.1 Waterjet thrust

We can calculate the waterjet thrust when entrance speed (v_i), exit speed (v_j) and volume flow are known.

Take for example an average entrance speed (v_i) into the jet at 20 m/s, an exit speed (v_j) at the nozzle of 40 m/s and a volume flow (v) of 3 m^3/s. From the volume flow and the specific density of sea water, the mass flow through the system is calculated. In this case 3 m^3/s x 1025 kg/m^3 = 3075 kg/s. The thrust generated by the system can be calculated with Isaac Newton's formula; Force equals mass x acceleration [F=ma]. For our example using the mass flow and the speed difference over the system in the derived formula this results in F= 3075 (40-20) = 61000 N or 61 kN.

2.2 Influence of ship parameters on waterjet thrust, jet selection and size

It is impossible to give generic performance data for a waterjet without considering the ship parameters. The most important effects will be explained in the next paragraphs.

2.2.1 Influences on the average inlet speed (v_i)

There are three main parameters influencing the speed of the water flow (v_i) entering the jet system: ship speed (1), the wetted length of the hull in front of the jet intake duct (2) and the location of the dividing streamline (3).

1. **The relation of the inlet speed 'v_i' with the ship speed is obvious. The faster a ship moves through the water, the faster water will flow along the hull and v_i will vary in a relative direct relation with the ship speed.**
2. **The relation of v_i with the wetted hull length in front of the intake duct (= ship waterline length minus the length of the jet inlet duct) is relatively simple as well. A longer**

wetted length results in a longer frictional path of the water flowing along the hull resulting in a relatively lower v_i for a longer hull and a higher v_i for a shorter hull.

3 **The relation of v_i to the location of the dividing streamline is mainly determined by the size and power density of the jet pump. A large pump with a high power density demands a high flow resulting in a relative higher suction depth and thus a deeper located dividing streamline. Due to the variation in speed over the ship's boundary layer resulting from the friction with the hull, the average v_i will decrease or increase with a deeper or more shallow location of the dividing streamline.**

2.2.2 Effects of variations in the average inlet speed (v_i)

The first main effect of a variation in v_i downstream is seen with the pressure build up in front of the impeller. Depending on the ship speed, v_i is usually more than the pump requires. This means the water enters the inlet faster than the pump can pump out. The kinetic energy of the flow entering the system is transformed by the inlet duct into potential energy or pressure build up in front of the impeller. This pressure build up is referred to as the Net Positive Suction Head Available; NPSH(A).

The NPSH(A) in front of the impeller will partly determine the cavitation margins of a certain ship/jet application. The ships wetted length is thus a parameter of importance for predicting the cavitation behavior of a jet in a certain vessel and must be known during the jet selection process. The second main effect of a variation in v_i downstream is the variation of the average jet speed (v_j) at the exit nozzle of the system. The relation between the intake and jet nozzle speed is however not linear. A lower v_i will result in a lower v_j, but the decrease of v_j will be relatively much smaller than the decrease of v_i.

A lower v_i thus increases the acceleration of the mass flow over the system and by that increases the thrust generated by the system.

2.3 Computational Fluid Dynamics

Analyses of the flow through the waterjet inlet are made with a Computational Fluid Dynamics (CFD) inlet analysis tool. The tool is based on a commercial CFD software program and a fully automated in-house made 3D mesh generator. The commercial CFD code can solve the Reynolds Averaged Navier-Stokes equations for any three dimensional geometry.

Wärtsilä has extensive knowledge in the interaction of ship hulls and waterjet inlets. For over 20 years CFD is used to analyse hull/inlet interaction to determine the best performing inlet geometry.

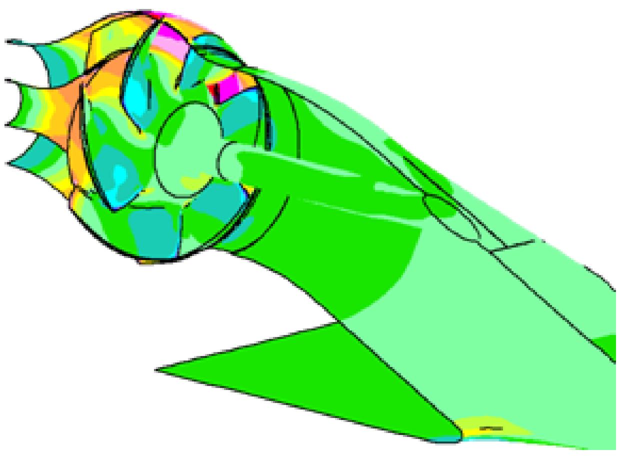

Fig 2-2 CFD calculation

3. Wärtsilä Design Method and Philosophy

3.1 Design method

State of the art engineering tools are used within Wärtsilä to make designs and manage the product data. A global Product Data Management (PDM) system with integration of 3D design software is the backbone of the engineering tools. The PDM system manages the engineering data like 3D CAD models, (production) drawings and technical documents, but also the Bill of Materials (BoM) for each order. This ensures the right data is connected to the right order. The benefits are an accurate and efficient production process, the availability of product data throughout the life cycle of the product (e.g. for spare parts), and the ability to keep orders attached to product management and developments.

The fact the system is global means that each user can make use of the vast Wärtsilä knowledge and data.

The 3D setup in the system, where the PDM Bill of Materials dictates the assembly, means that the complete assembly is already checked in the system during design. The 3D data is also used in the production process for the complex 3D machining of components. The same 3D models are used in downstream engineering tools like the Finite Element Method (FEM) program, or the Computation Fluid Dynamics (CFD) program.

3D models of the waterjet can be exported in various formats (e.g. STEP), to allow the customer to import our design into their cad design of the vessel. This will clarify the location of the waterjet unit and may prevent interface issues with the vessel's structure or other positioned components.

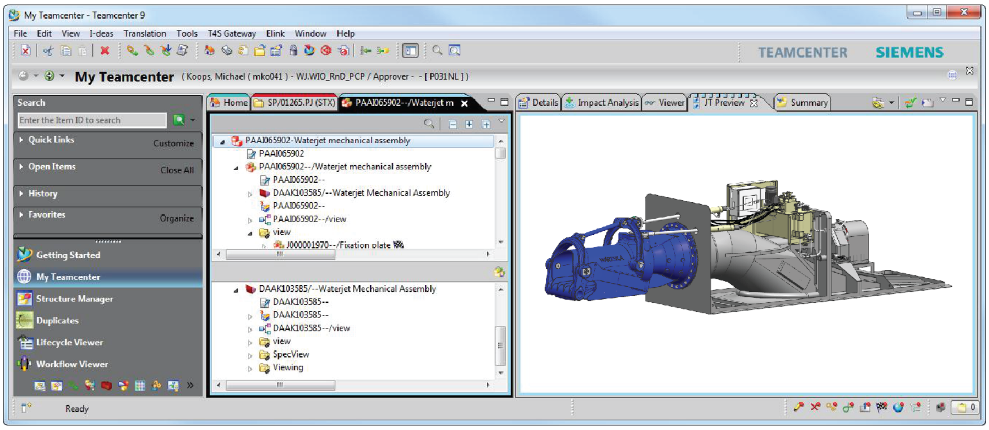

Fig 3-1 **PDM utility**

Designs are evaluated with the FEM tool. All real life load cases can be simulated to determine the behavior of the components and assess their suitability for use. This is the normal way of working for Wärtsilä development engineering. The tool has been an integral part of the design process of the Midsize waterjet as well. This allowed us to use materials and their properties optimally in the final designs of the components.

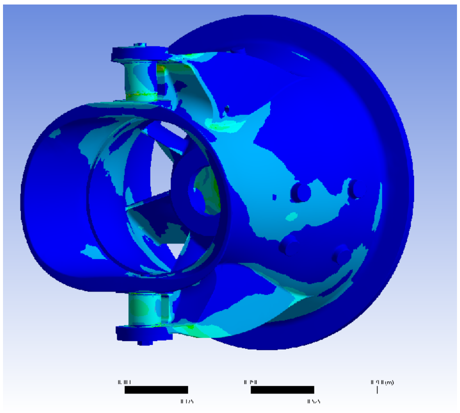

Fig 3-2 FEM simulation

3.2 Philosophy

The key for a good propulsor is of course to generate as much thrust as possible from the input power. Equally important is the mechanical integrity of the product. The requirement is an excellent performing propulsor that keeps performance over its life time. The philosophy can be viewed from three angles

3.2.1 Efficiency

For efficiency optimal hydrodynamic performance is required. In general, so also for the Midsize waterjet, this is assured using CFD analysis and model scale testing. The actual structure is moulded around this hydrodynamic shape, using FEM and other analysis to assure strength and endurance. The hydrodynamic performance and technology of the Midsize waterjets is the same as for the modular waterjets, which has proven itself in applications with powers ranging from 1200 kW to 26000 kW.

3.2.2 Economy

Wärtsilä looks in two ways to economy; it is delivering a cost effective product, but equally important, it is also about the total cost a customer has to make, both in installation and in the life time, where often a lot of cost can be saved. For the yard this means work is to be minimized. This is why the Midsize is a pre-installed unit, so no assembly of major parts or aligning procedures during the installation are required. Also the electrical connections are pre-wired on the unit, and the controls are commissioned in the factory to save valuable commissioning time on that part during vessel commissioning.

We can give many examples of life time cost considerations. A few examples are; The use of stainless steel for the most demanding parts that determine the (enduring) performance. The inboard bearing layout is designed for endurance. Wear parts are designed to be easily replaceable without docking (saving operators time and money), and scheduled maintenance is centered around normal ship docking intervals.

Details on the components and how they contribute to this philosophy can be found in the next chapter.

3.2.3 Environment

In consideration of the environment we have been able to avoid using oil in the stator bowl or outboard for the Midsize waterjet.

Details on the components and how they contribute to this philosophy can be found in the next chapter.

4. Description Main Components

This chapter describes in brief the main components and features of the waterjet. The waterjet installation consists of a impeller, a stator bowl, an inboard thrust bearing block, a shaft seal, and a seat ring. Waterjets are equipped with a steering device, called jetavator (brief for jet deviator). Mounted behind the stator bowl this jetavator can deflect the jet stream sideways to create a steering action. The jetavator also contains the reversing plate to create astern thrust.

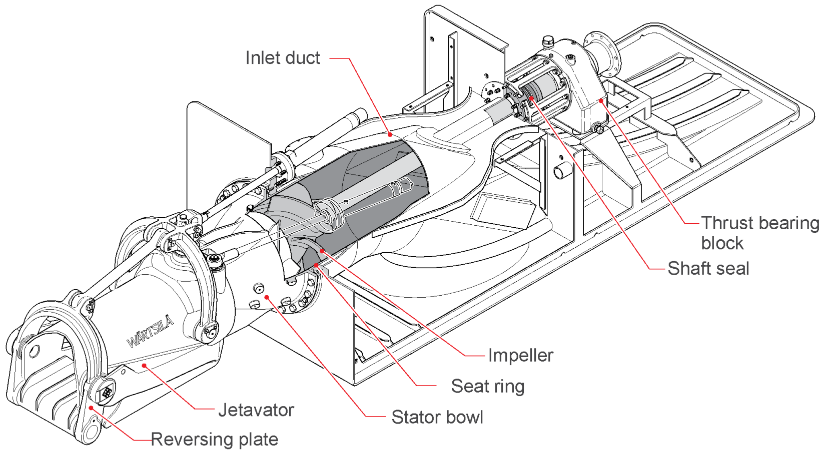

Fig 4-1 **Waterjet with steering and reversing capability**

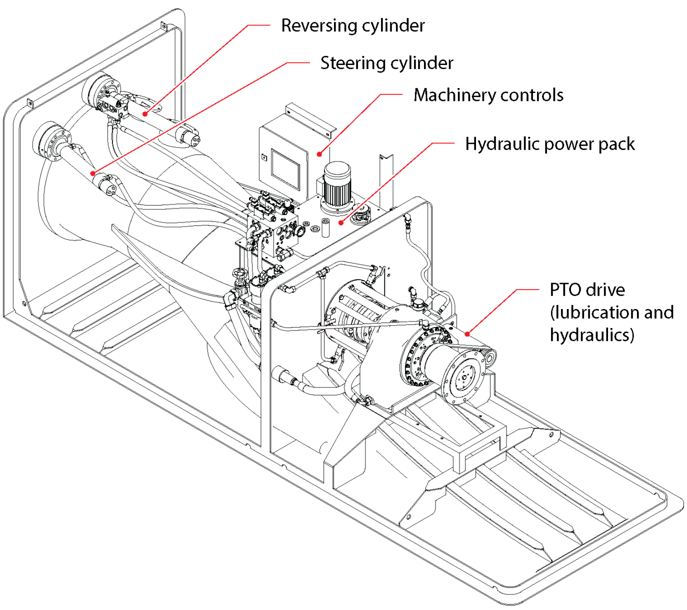

Fig 4-2 **Waterjet auxilliaries**

During operation, water enters the waterjet installation through the inlet duct. After passing the impeller, rotation in the flow is removed and the water is accelerated in the stator bowl. This creates the thrust necessary to propel the ship.

Each waterjet is driven by a main engine through a gearbox with a clutch. The clutch makes it possible to start the prime mover without driving the impeller shaft.

The impeller shaft is supported inside the ship by a thrust bearing block and outside the ship in the stator bowl by a water lubricated bearing. A shaft seal prevents water from entering the ship.

4.1 Inlet duct

The inlet is designed to give minimal losses and to ensure a high overall efficiency of the waterjet installation. The inlet duct is built according the designed waterjet hydraulic profile. The inlet includes part of the transom and bottom to form a part of the aft and the bottom of the ship.

The completed inlet duct enables simple installation. When the rectangular shaped frame has been welded (or bolted) in the hull, the ship is equipped with a high efficiency inlet duct.

The inlet is equipped with an inspection hatch through which debris, clogging the impeller, can be removed. For maintenance work the impeller shaft can be supported through the inspection hatch. The second hatch is used to have excess to the anode chain that is positioned in the space between the inlet duct and the seat ring.

For customized design options for the inlet duct, see chapter *4.11*.

4.2 Impeller and shaft line

The impeller has been designed to have excellent efficiency, cavitation and noise characteristics.

The impeller rotates inside the stainless steel seat ring. The impeller is hydraulically fitted on the shaft. A shaft sleeve is mounted on the rear end of the shaft, preventing the shaft from wear caused by running in the water lubricated bearing.

4.3 Stator bowl assembly

The stator bowl is located behind the seat ring. The stainless steel stator bowl eliminates the rotational component from the water flow leaving the impeller and is equipped with an integrated nozzle to accelerate the flow. This increases overall performance of the waterjet. The stator bowl also acts as the support for the water-lubricated bearing.

4.3.1 Water-lubricated bearing

The use of a water-lubricated bearing in the stator is beneficial for the environment and enhances the reliability and maintainability of the waterjet.

The standard bearing used in Wärtsilä waterjet systems consist of a stainless steel bush with a composite lining. Replacement of the water lubricated bearing can be done with the vessel afloat.

4.4 Steering and reversing equipment

For steerable waterjets, the jet stream is deflected by a jetavator which is mounted behind the stator bowl. The jetavator is actuated by an inboard mounted hydraulic cylinder. The jetavator can be turned 30° to port and 30° to starboard.

The jetavator contains a hydraulically activated reversing plate through which part or all of the jet stream can be deflected forward. The reversing plate can be gradually moved, which makes it possible to vary the thrust from full ahead via the zero thrust position to full astern and vice versa.

The reversing plate must be in the zero thrust position before the impeller shaft is clutched in. The zero thrust position prevents the ship from moving when the impeller shaft is rotating. The reversing cylinder is equipped with an counter balance valve (load holding valve). This safety device keeps the reversing plate movement controllable and prevents that, in the event of a hose failure, the reverseing plate moves to full astern without control.

Steering and reversing are activated by the control system. The position of the jetavator and the position of the reversing plate are fed back to the control system, via position sensors inside the hydraulic cylinders.

4.5 Shaft seal

The sterntube seal is an elastomer based radial face type seal with split components and an inflatable emergency seal to close the stern tube in case of a seal failure and to facilitate servicing of the seal while the vessel is afloat.

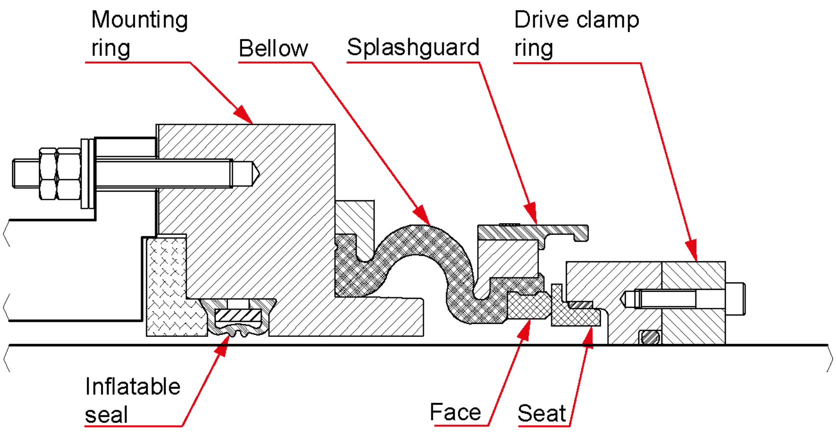

Fig 4-3 **Shaft seal**

The seal is specifically designed for high speed operation and offers a robust and reliable solution, even when operating in shallow or dirty waters. The seal is lubricated and cooled with a forced water flow from the ships cooling system.

4.6 Thrust bearing block

The thrust bearing block (TBB) is located inside the ship. The location inside the ship enables good maintainability, and allows the use of large size bearings for increased operating life time.

The TBB supports the shaft and transmits the axial thrust coming from the impeller to the ship. The TBB contains a double row spherical roller bearing and a spherical roller thrust bearing, which are positioned to have a common pivot point. The block is sealed by means of two lip seals running on the bearing bush.

The TBB has a forced lubrication, which is also used for cooling. The bearing housing has an integrated sump, which ensures there always is an oil bath in the housing, independent of the functioning of the lubrication pump.

A dip-stick with integrated breather is mounted to prevent pressure buildup and to check the oil level in the TBB.

In case of malfunctioning of the lubrication pump, the oil level in the thrust bearing block and the cooling capacity of the TBB are sufficient for operation at reduced rpm.

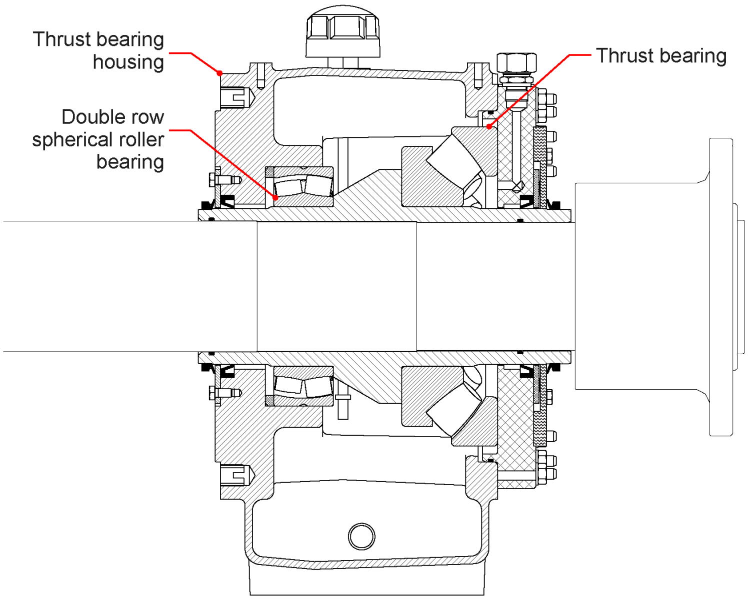

Fig 4-4 **Sectional view of thrust bearing block**

4.7 Lubrication system

The lubrication system is a closed loop system. The hydraulic system diagram is shown in figure *4-5*. A belt driven pump circulates the lubrication oil from the thrust bearing block, through the oil-cooler mounted on the Hydraulic Powerpack and than back into the thrust bearing block.

The lubrication system is equipped with a PT-100 temperature sensor placed in the thrust bearing block to monitor the bearing temperature. The signal is used in the control system to give alarm signals when the bearing temperature exceeds a preset value.

4.8 Hydraulic system

The hydraulic system consists of a main pump, a power pack with a secondary pump and the hydraulic cylinders. The main pump is powered by a belt driven PTO connected to the waterjet shaft. The oil is purified by a return filter. Proportional directional valves on the power pack direct the required pressurized oil flow to the steering and the reversing cylinder. The proportional valves get their input signals from the control system. The sensor signals are transfered to the control system and / or the central alarm system.

For back up (if the belt driven pump is out of order), start-up and test situations an electrically driven hydraulic pump is available on the hydraulic power pack.

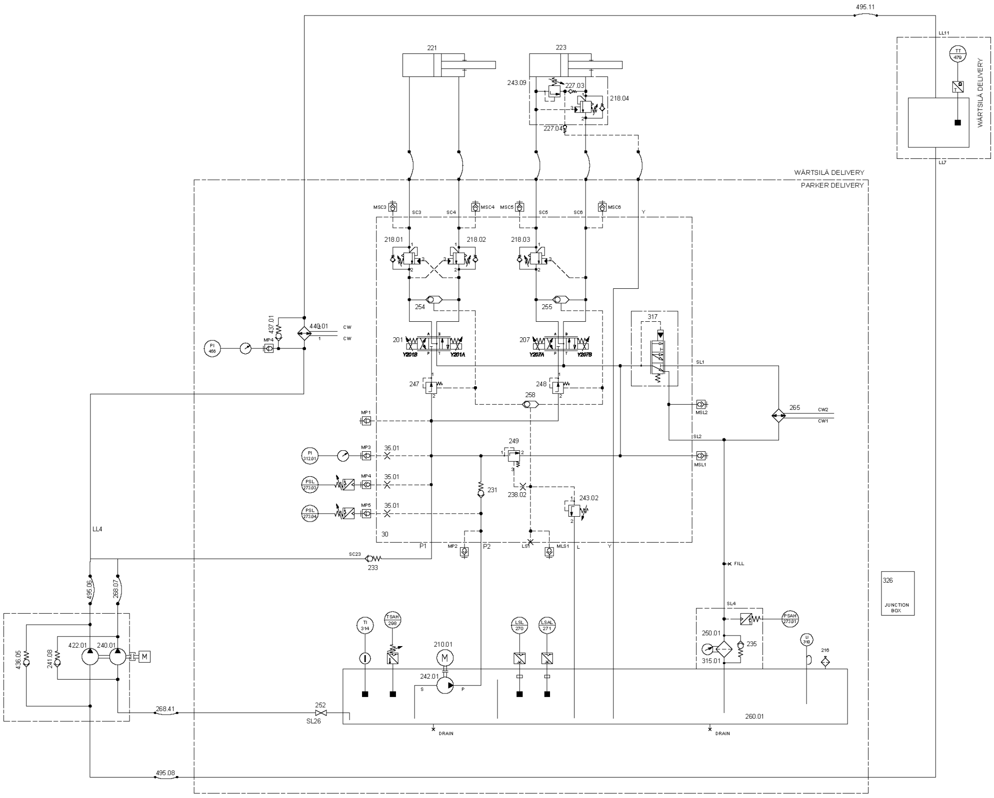

Fig 4-5 **Hydraulic system diagram**

4.9 Cathodic protection

Cathodic protection is added to protect the unit from galvanic corrosion. Sacrificial anodes are mounted on the waterjet assembly. The inlet duct is constructed with anode pockets on the sides and an anode chain in the cavity between the inlet and seat ring.

A proper cathodic protection system for the hull with due consideration of the presence of the stainless steel waterjet has to be provided by the yard. It is highly recommended to add additional anodes on the hull near the waterjet assembly.

4.10 Machinery controls

A Machinery Controls System is integrated on the waterjet. This system receives the commands from the Bridge Control System, and provides feedback signals to the Bridge Control System. It safeguards the health of the waterjet. It is connected to the Bridge Control System by a 2-Wire CAN connection. For the Integrated Alarm, Monitoring and Control System (IAMCS) the machinery controls provide alarms through the CAN bus or hardwired as an alternative. The main engine and the clutch must be controlled by the waterjet controls.

4.11 Customized design

The Midsize waterjet is a plug and play solution to allow easy integration of a high performance waterjet in vessels with powers up to 4,500 kW per waterjet. The Wärtsilä modular waterjet, which is available for powers up to 30,000 kW, allows for even more custom-tailored solutions.

On customer request for specific applications, project specific modifications can be made. Inlet design can be modified to better accommodate the vessels shape. The common inlet duct is made from aluminium. For vessels made of shipbuilding steel, the inlet duct material can be altered to accommodate this vessel. A bolt-in connection can be designed to accommodate the integration to a Fiber Reinforced Plastic (FRP) hulls.

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5. Waterjet Size Selection

5.1 Introduction

The thrust generated by a waterjet is the reaction on the acceleration of the flow from the average intake speed v_i at the inlet to the exit speed v_j at the nozzle. This is illustrated in figure *5-1*.

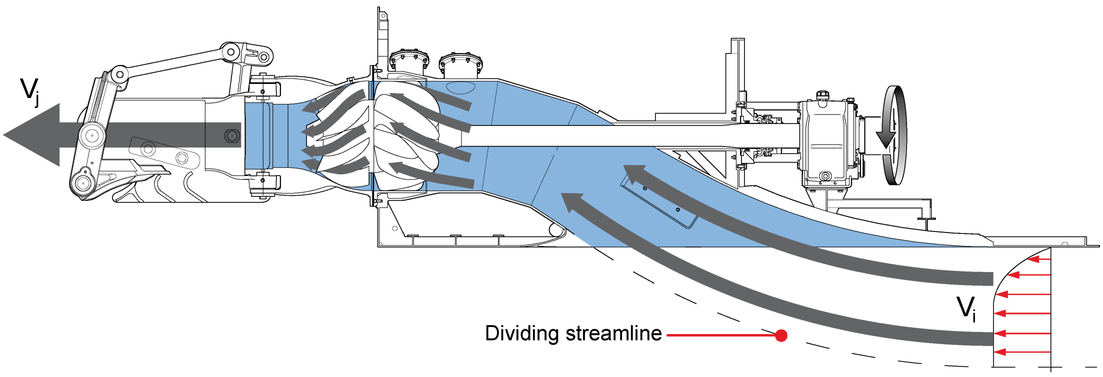

Fig 5-1 Waterjet flow

The relative speed at the inlet v_i is less than the ship speed. The water near to the hull gets accelerated by the passing of the ship. The relative speed is a function of the length of the ship and the flow through the unit. This affects both the efficiency of the jet and the maximum power which can be applied to the unit for the application.

This chapter presents two methods to select the jet size for your application.

NOTE

Please note that the jet selection and performance parameters can only be accurately determined based on ship design, engine and gearbox details. All graphs are for reference only.

Do not hesitate to contact us for optimized selections based on your unique ship design. To provide us with the necessary information, the waterjet selection questionnaire can be found in chapter *9. Drawings*.

5.2 Size selection for a given engine power

Figure *5-2* is used to select the proper waterjet size when the installed power per jet is known. First a correction factor is determined with aid of figure *5-2*. The minimum waterjet size is then determined with aid of figure *5-3*. The figures are based on transmission losses of 3%.

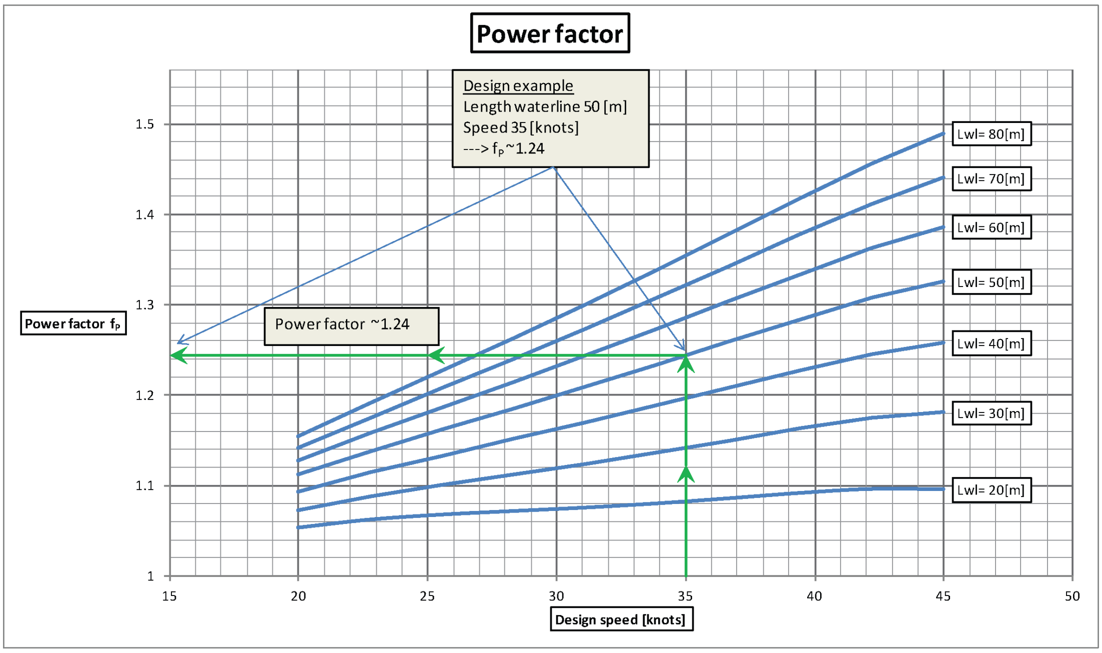

Fig 5-2 Power factor

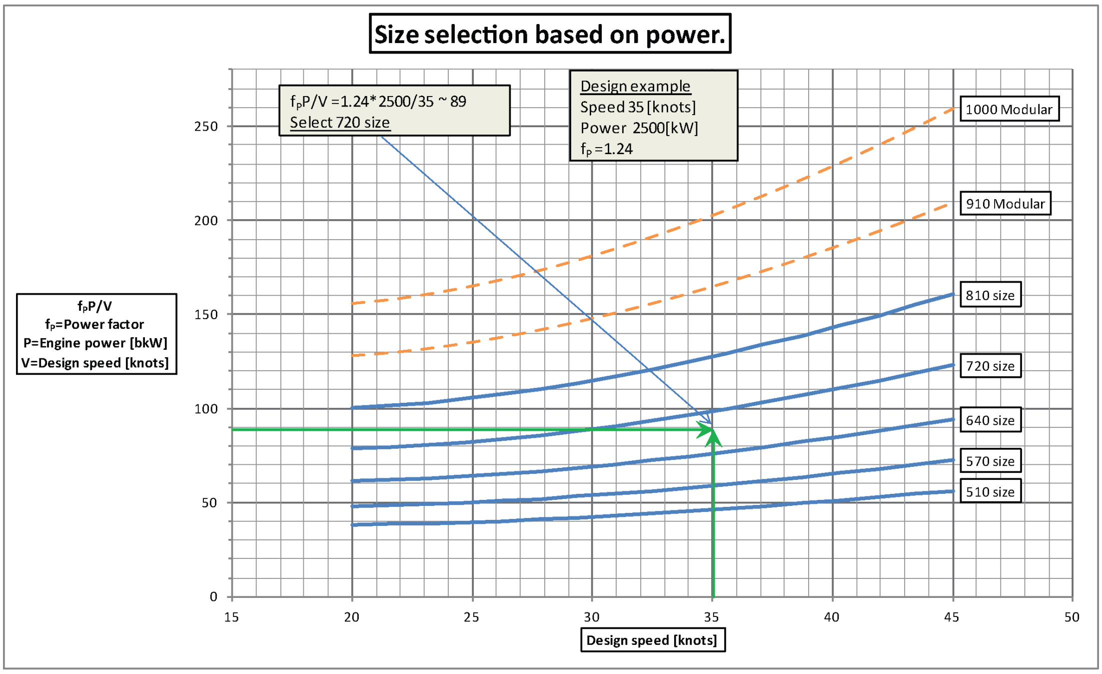

Fig 5-3 Size selection based on power

5.3 Size selection for a given resistance

Figure *5-4* is used to select the proper waterjet size when the resistance of the ship is known. First a correction factor is determined with aid of figure *5-4*. Finally, the minimum waterjet size is determined with aid of figure *5-5*.

NOTE

Please note the total resistance needs to be divided by the number of jets (of same size).

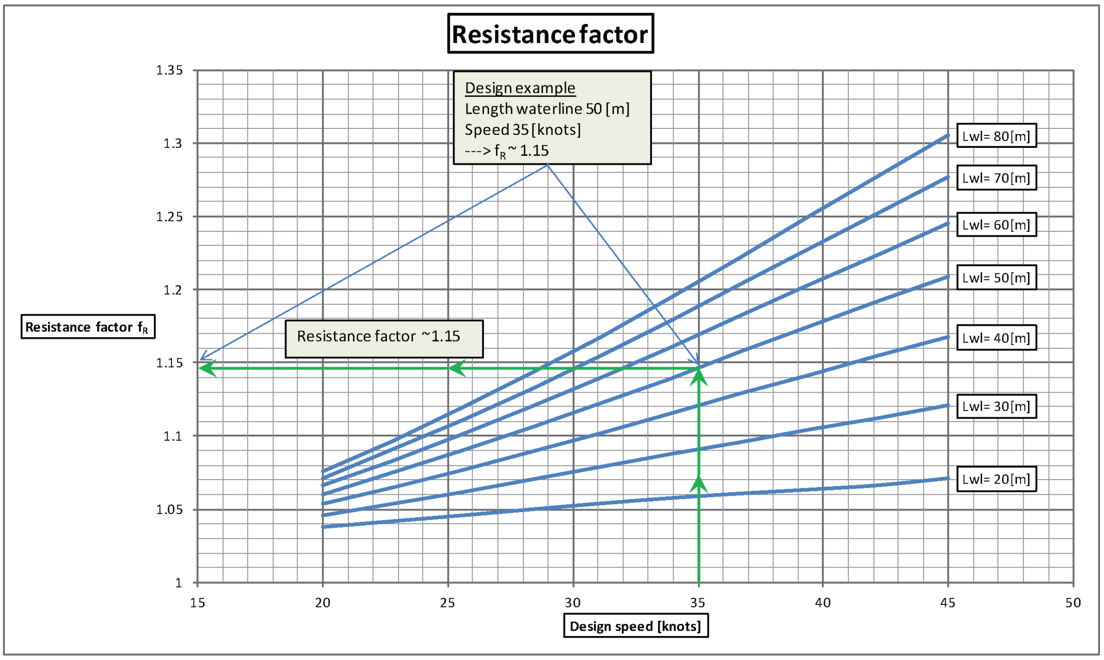

Fig 5-4 **Resistance factor**

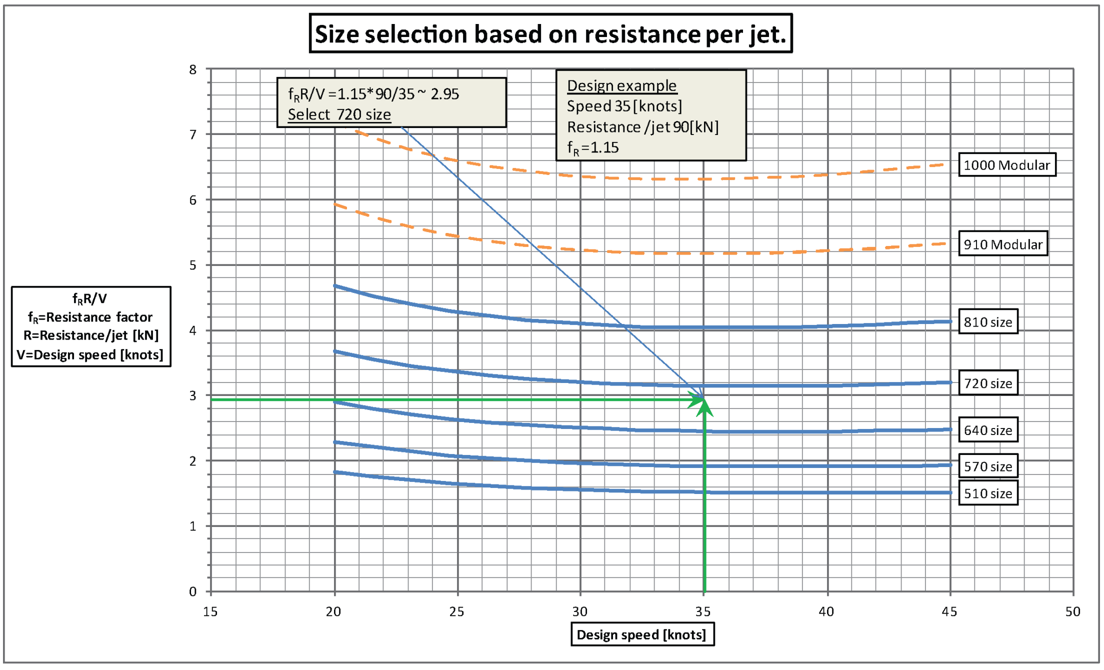

Fig 5-5 **Selection based on resistance**

For information on modular waterjets, refer to the separate "Waterjets Product Guide".

NOTE
Waterjet selection and performance parameters can only be accurately determined based on ship design, prime mover and gearbox details. All graphs are for reference only. Do not hesitate to contact us for optimized selections based on your unique ship design.

6. Design Details and Considerations

6.1 Power train considerations

For a suitable combination of prime mover and gearbox, use figure *6-1 Power vs rpm* to define the impeller shaft speed needed. With the known shaft rpm, the gearbox ratio can be determined.

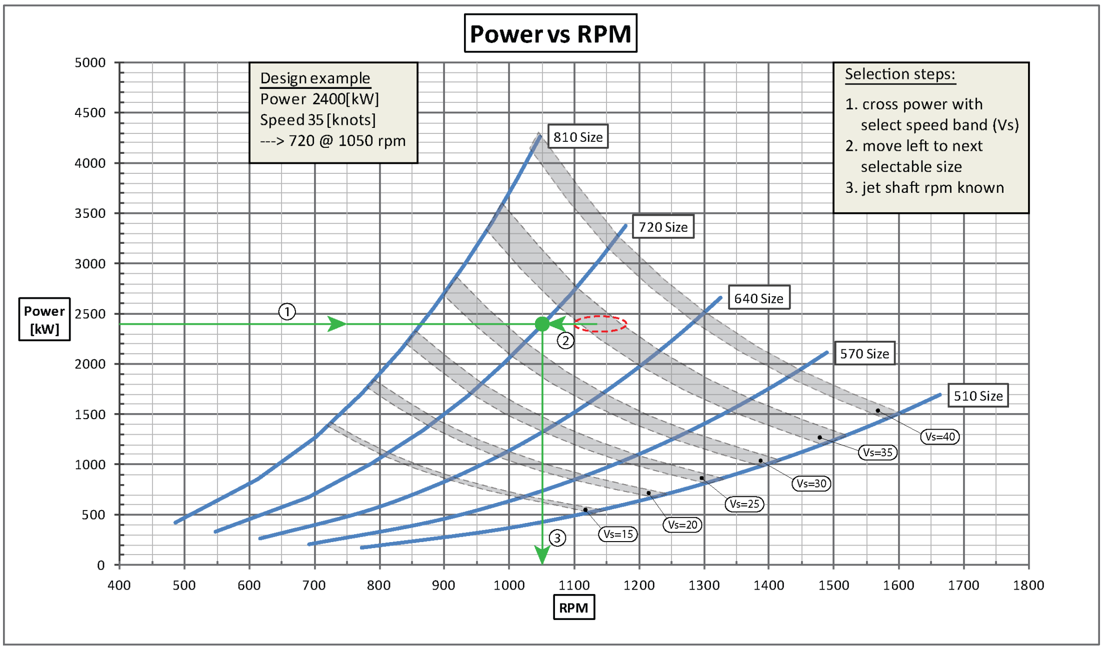

Fig 6-1 Power vs rpm

6.2 Waterjet assembly (outboard parts)

The waterjet assembly is the part of the waterjet that is located outboard. The waterjet assembly is mounted to the transom. Forces generated in this assembly are loading the inlet.

6.2.1 Ship design considerations

Over the top of the waterjet assembly there should be enough clearance for maintenance and for the hydraulic cylinders and reverse linkages to move freely. Minimal top clearance dimensions are given in table *8-1*. It is advisable to create a proper hoisting provision above the waterjet for mounting and maintenance purposes. When the jet is reversing the water is thrusted forward at an angle below the ship. For this to work properly, the reverse jet should not be obstructed by the ships structure or trim tabs. For information on the reverse water flow path, see the drawing "*Interface drawing reverse jet*", attached in chapter *9.*.

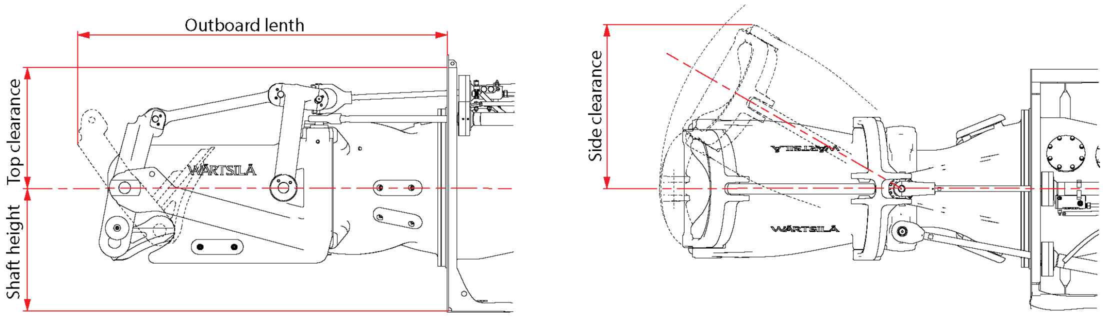

Fig 6-2 Waterjet assembly

6.3 Waterjet unit integration in vessel

The waterjet installation is welded in the hull. The ship’s structure needs to be designed to accommodate the forces generated by the waterjet.

6.3.1 Ship design considerations

The inlet structure has been designed to take up the internal axial forces of the waterjet. This means the resulting nett thrust and steering and reversing forces and moments are transferred to the ship through the transom part and bottom part of the inlet. For the structural design of the vessel it can be assumed that the thrust is mainly taken up by the bottom plating, while the steering and reversing forces and moments are taken up by the transom.

It should be noted that the dynamic forces resulting from the vessel dynamics need to be taken into account in the vessel design. Support structure has been added to the inlet, that can be used by the structural designer to connect ship structure to. If required, additional support may be added around the inlet, but it is advised to consult Wärtsilä in this case.

A bulkhead plate is foreseen on the inlet, which may be incorporated in a watertight bulkhead. All waterjet piping that passes this bulkhead is already sealed.

In the design of the vessel it should be taken into consideration that the athwartships angle of the waterjet unit, when fitted into the vessel, should not exceed 15°. The hydraulic unit, fitted on top of the waterjet unit, will function according specification at this angle. Temporary transverse inclination (roll) of 22.5° has been taken in account for the design.

The centre of the shaft line must be at water level or below for proper operation of the waterjet. The height of the shaft centre line to bottom of the inlet structure is presented in table *8-1 Waterjet dimensions and weights*. For the use of multiple waterjets, the sum of the side clearances can be taken to determine the minimum distance between two adjacent shaft centre lines. The side clearance per waterjet size is given in table *8-1*. A smaller distance between shaft centre lines is possible, but in that case additional “Anti collision” provisions are needed in the controls, or steering angle can be limited per side individually in the machinery controls.

The entrained water given in table *8-1* is the estimated volume of water in the inlet duct (with a shape corresponding to the shaft height mentioned in the same table), causing extra weight in the ship. This should be taken into consideration during the design of the ship.

6.4 Maintenance space requirements

In the design phase of the vessel, space for maintenance and emergency operation has to be taken into account. The maintenance space is needed for removing and mounting of the components of the waterjet unit. For emergency operation, the valves on the hydraulic powerpack need to be accessible for manual operation. The HMI panel on the junction box provides visual indication on steering angle and reversing plate positions. The space requirements for the midsize waterjets are stated in table *6-1 Space requirements*.

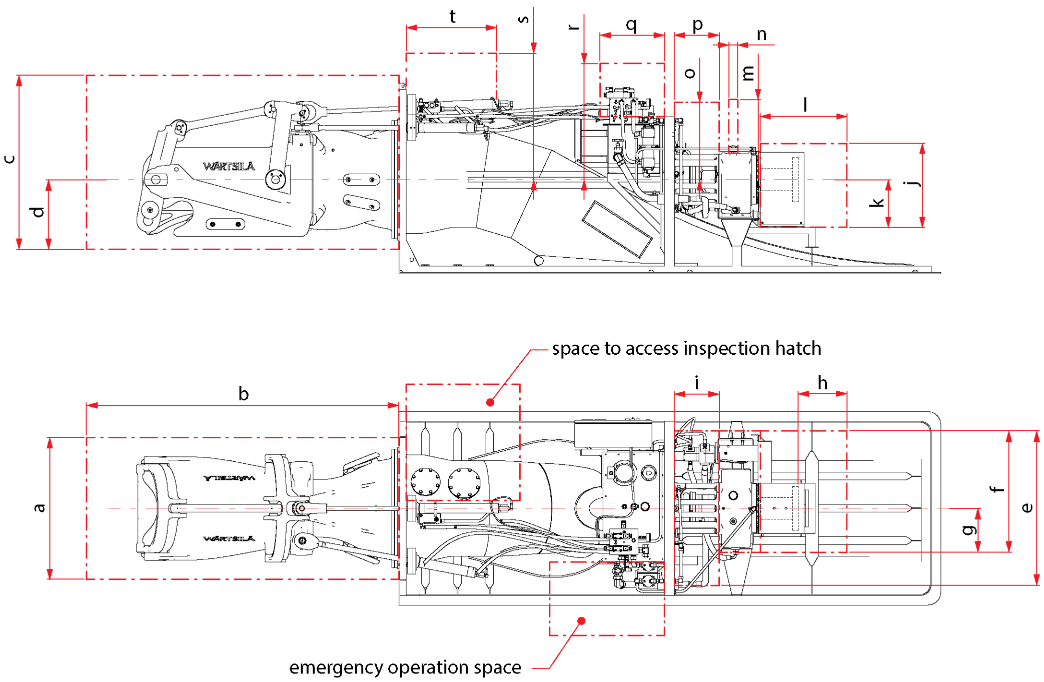

Fig 6-3 **Space requirements**

Table 6-1 **Space requirements**

Dimension	510	570	640	720	810
a	850	900	1000	1100	1200
b	1750	1850	2050	2400	2650
c	1000	1100	1200	1350	1500
d	410	450	490	540	600
e	1050	1050	1200	1200	1270
f	810	810	950	950	1020
g	310	310	370	370	370
h	350	350	380	380	400
i	350	350	350	350	350
j	530	530	650	650	740
k	290	290	370	370	430
l	530	530	580	580	650
m	580	580	600	600	650
n	70	70	70	70	70
o	580	580	600	600	650
p	350	350	350	350	350
q	500	500	500	500	500
r	760	790	860	900	990
s	850	900	950	980	1000
t	700	700	700	700	700

6.5 Auxiliary connections

With the waterjet unit integrated into the vessel, auxiliary connections to the unit must be made. An overview of these connections is displayed in figure *6-4 Interfacing connections*.

In the following chapters these connections will be described.

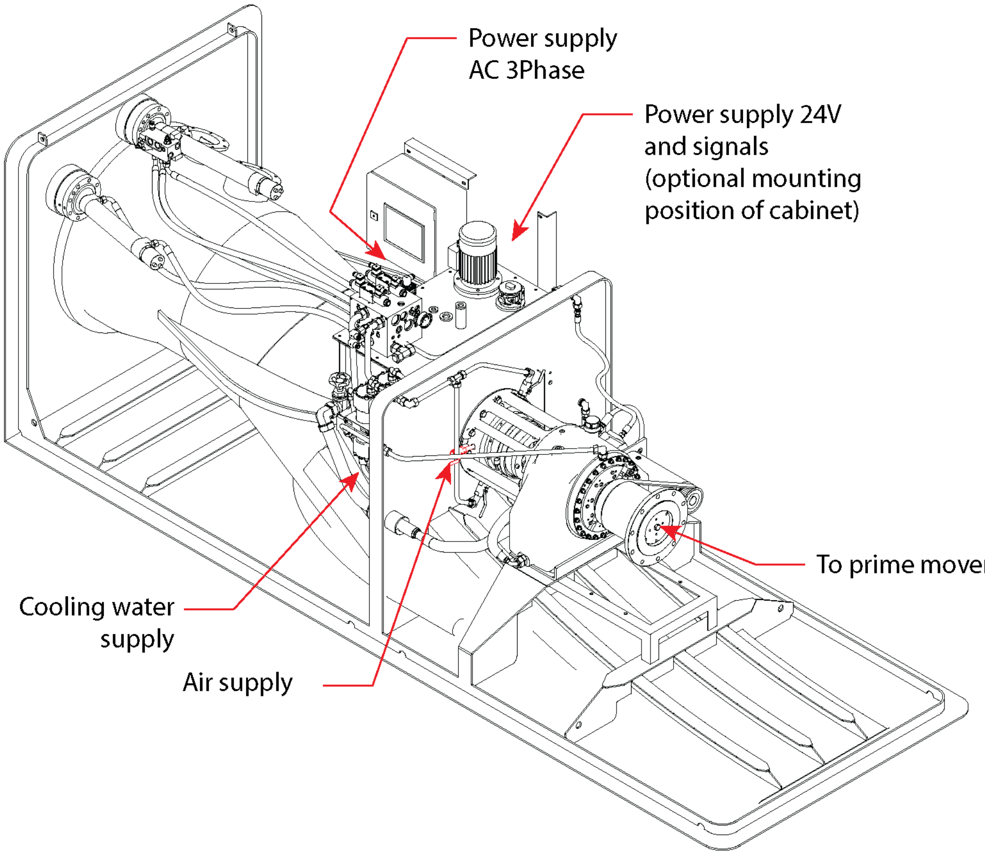

Fig 6-4 Interfacing connections

6.6 Coupling

At the forward end of the impeller shaft a coupling flange is mounted. The interface between shaft and coupling flange is made with an splined connection.

The flange is designed to accommodate intermediate shafts from various manufacturers. The main interface dimensions of the coupling are given in table *6-2 Coupling interface dimensions.* Other interfaces are available as an option.

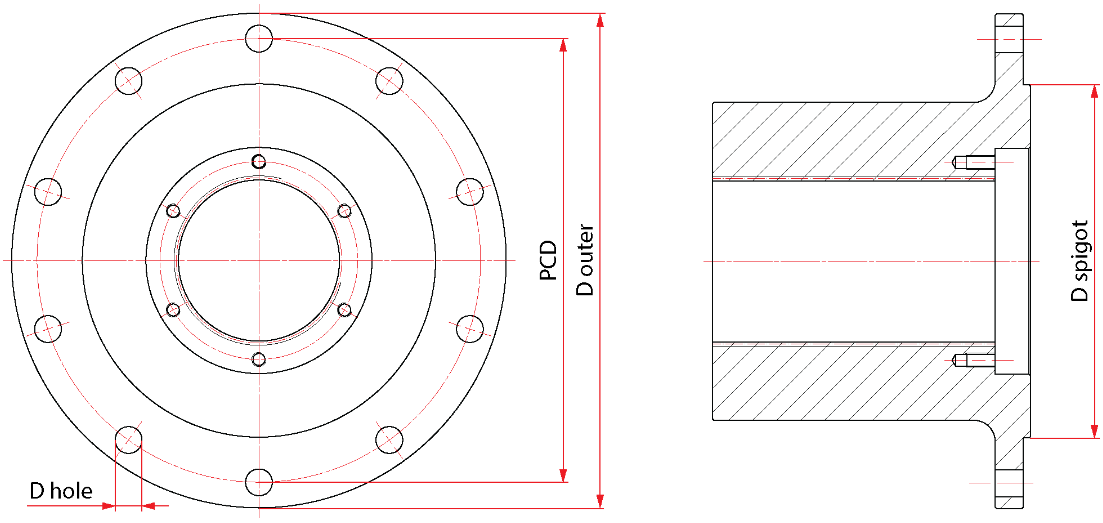

Fig 6-5 Coupling interface dimensions

Table 6-2 Coupling interface dimensions

Waterjet Size	Outer diameter	Spigot diameter (h6)	Pitch Circle Diameter	Holes on PCD	Hole diameter
	[mm]	[mm]	[mm]		[mm]
510	Ø285	Ø175	Ø245	8	Ø20.1
570	Ø285	Ø175	Ø245	8	Ø20.1
640	Ø315	Ø175	Ø280	8	Ø22.1
720	Ø350	Ø220	Ø314	10	Ø22.1
810	Ø390	Ø250	Ø345	10	Ø24.1

6.7 Intermediate shaft

Between waterjet coupling and gearbox an intermediate shaft is required. For these power transmitting components we recommend using cardan shafts or intermediate shafts with flex couplings.

The intermediate shaft is not in the standard Wärtsilä scope of supply. Upon request it is possible to supply a suitable solution for this intermediate shaft.

6.8 Shaft seal

The shaft seal is connected to the inlet. It is equipped with a backup inflatable seal. When the inflatable seal is pressurized, it is not allowed to rotate the shaft.

6.8.1 Air supply (emergency seal)

To activate the backup inflatable seal a clean air supply is needed. This can be provided through the ship’s compressed air system, or through a manual pump or compressed air cylinder. See the table for the pressure requirements.

Table 6-3 Air requirements

Waterjet size	Min. pressure (MPa)	Max. pressure (MPa)	Size of connection
510	0.2	0.25	3/8" BSP
570	0.2	0.25	3/8" BSP
640	0.2	0.3	3/8" BSP
720	0.2	0.3	3/8" BSP
810	0.2	0.3	3/8" BSP

6.8.2 Cooling water requirements

The cooling water supply needed for the shaft seal is inter connected with the cooling water for the hydraulics. For specification and requirements refer to paragraph *6.9.2 Cooling water requirements*.

6.9 Hydraulics

The hydraulic power pack is mounted on top of the inlet duct. The directional valves for steering and reversing are mounted on top of the HPP tank. The main pump is PTO driven via the impeller shaft. An electric motor driven stand-by pump is mounted on the HPP tank. All hydraulic piping is ready mounted. The hydraulic system is operated via the machinery controls system.

6.9.1 Ship Design considerations

For manual operation of the steering and reversing valves on the valve block (local backup controls), the best standing location is on the starboard side of the unit, next to the hydraulic tank. The feedback signals indicating the steering and reversing position are shown on the Machinery Controls Cabinet, which is located next to the hydraulics on the skid.

6.9.2 Cooling water requirements

The Hydraulics, thrust bearing block and the shaft seal need (open loop) cooling water. The systems are inter connected, so there is only one cooling water connection per waterjet.

Sea water can be used with a maximum intake temperature of 32°C. No filtration is required. Filtration can be used to increase the seal lifetime. Recommended filtration level is 200μm or better.

Table 6-4 Water requirements

Waterjet size	Min flow (l/min.)	Max flow (l/min.)	Max. water pressure (MPa)	Connection size
510	20	30	0,4	G 3/4" BSP
570	20	30	0,4	G 3/4" BSP
640	30	40	0,4	G 3/4" BSP
720	30	40	0,4	G 3/4" BSP
810	40	50	0,4	G 3/4" BSP

6.10 Machinery Controls

Physically the Machinery Controls are located on the Waterjet. As our machine is a propulsor, these controls are called Propulsion Control Unit (PCU). The PCU consists of two cabinets per waterjet. The smaller of the two has a screen that provides basic information.

The propulsion control unit contains two controllers with I/O points:

- A main controller which handles all normal functionality like thrust control, steering, engine start/stop, clutch control and mode selection.
- A backup controller which is used for backup control of thrust control and steering in case of malfunctioning of the main controller.

6.10.1 Ship design considerations

The large cabinet is mounted on the waterjet during delivery. It needs to be electrically disconnected during the welding proces. For this reason it is equipped with connectors. If convenient for the vessel arrangement this cabinet can be located anywhere in the vicinity of the waterjet, provided the door can be opened after installation (see fig. *6-6* for dimensions), and obeying the length of the connector cable, which is 5m.

The requirements for ambient conditions of the mounting area are:

- Maximum ambient temperature: 55°C
- Minimum ambient temperature: 0°C
- Maximum relative humidity: 95%

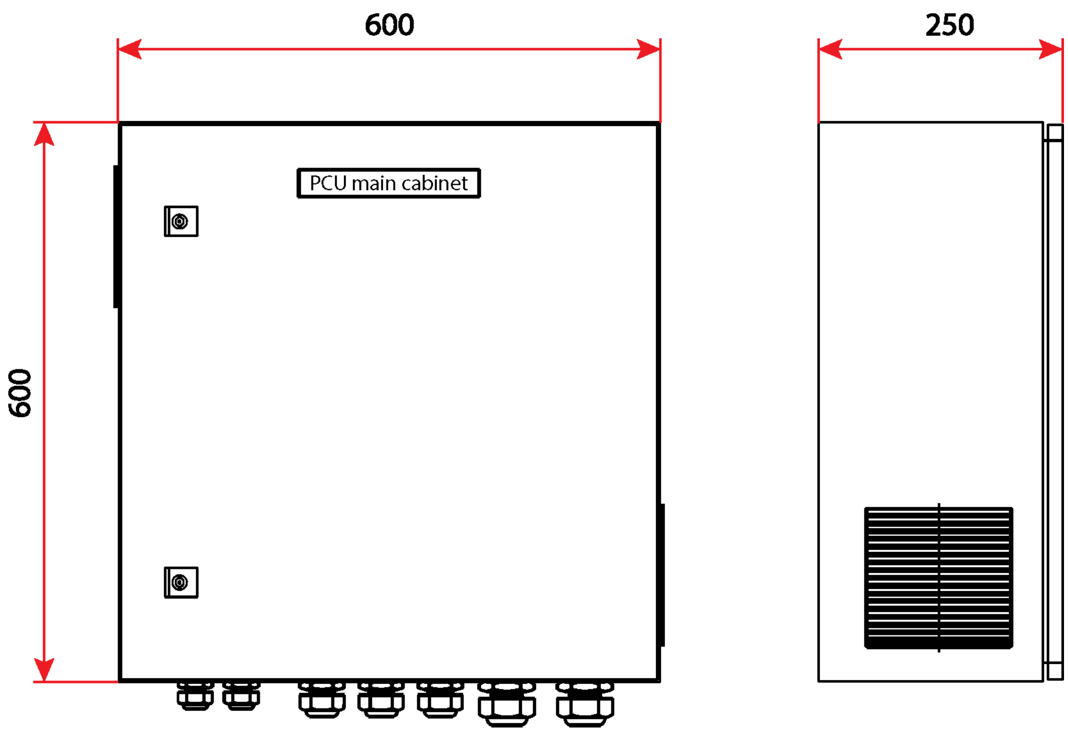

Fig 6-6 PCU Cabinet

The small cabinet is mounted on the waterjet. All electrical interfaces with the sensors and valves on the waterjet unit are connected to this cabinet. This cabinet comes with an Human Machine Interface (HMI) panel, allowing users to view the indications of the waterjet unit.

6.10.2 Electrical supply

All electrical connections are integrated in the machinery controls, including the starter of the Hydraulics backup pump. 3 Phase AC power needs to be brought to the small cabinet. Two separate 24V DC (normal and backup) power supplies are needed and all signal wiring (including CAN wiring) has to be connected to the large control cabinet.

Table 6-5 Power requirements

	Voltage [V]	Frequency [Hz]	Max Power [W]	Nominal Power [W]
Power Supply Hydraulics	400/480 AC	50/60	1100	40
Power Supply MCS	24 DC	-	240	240

7. Propulsion Control System

The machinery controls of the Midsize waterjet is designed to work with Wärtsilä as well as third party Propulsion Control System (PCS). The Midsize waterjet is delivered without PCS, but this can be optionally added to the scope of delivery.

The Wärtsilä Propulsion Control System is a comprehensive system of levers and touch-screen interfaces, designed to suit all the possible propulsion configurations of a modern ship.

Wärtsilä Protouch, the human-machine interface of the Wärtsilä Propulsion Control System, represents the state of the art answer to market demands for modern and compact design control devices. With its safe and intuitive arrangement it gives the power to the user.

7.1 Wärtsilä Protouch key benefits

Compact design: The components to be installed at the operator stations of the bridge and engine control room are interconnected by field bus technology (CAN OPEN) and thus require a minimum of cables. The whole system footprint is reduced significantly allowing the designers more flexibility to place the propulsion control system components according to their ergonomic needs and meeting the functional requirements of the complete operator station.

Modularity/flexibility: The extended modularity of hardware and graphic user interfaces offers a flexible solution for any vessel layout. The system fits all the propulsion products and, as a result, all types of vessels. The system configuration is designed to meet the requirements of redundancy and independency for main class societies.

Safety: By removing the visual challenge of finding critical information in large panels with buttons and gauges, and by giving the user relevant information when needed, the system improves safety, both at sea and in port. In case of a control transfer the levers are automatically lined-up enabling operators to keep focused on their navigational tasks. The main propulsion levers are provided with back-up facilities integrated in the same lever allowing the operator to respond adequately and control smoothly in case the back-up system needs to be activated.

User friendly, Intuitive operations: By the means of the displays, with touch-screen technology, the operator can easily get all the functions and information handy, fully and easily under user's control. The system will guide the user when a more complex sequence or action is required. Immediate feedback is given also by the led colour on the lever, showing the current status of the selected propulsor.

Simpler installation and maintenance: this PCS is fully pre-configurable and thus minimizes installation time and costs, simplifies commissioning and reduces maintenance needs. Integration with other systems: The system enables easy integration via serial interfaces towards other systems at bridge level. Protocols like MODBUS RTU RS485 and NMEA 0183 are supported for VDR, IAMCS and centralized dimming.

7.2 Protouch system layout

The scope of supply for a midsize waterjet Protouch control system varies with the layout of the waterjets and the number of control positions.

Common waterjet layouts are:

- Mono-hulls with two steerable waterjets and optionaly one or two booster jets
- Catamarans or mono-hulls with two or four steerable waterjets

Other configurations also combined with other propulsors (e.g. Controllable Pitch Propeller) are possible upon request.

7.2.1 Basic four steering/reversing waterjet system

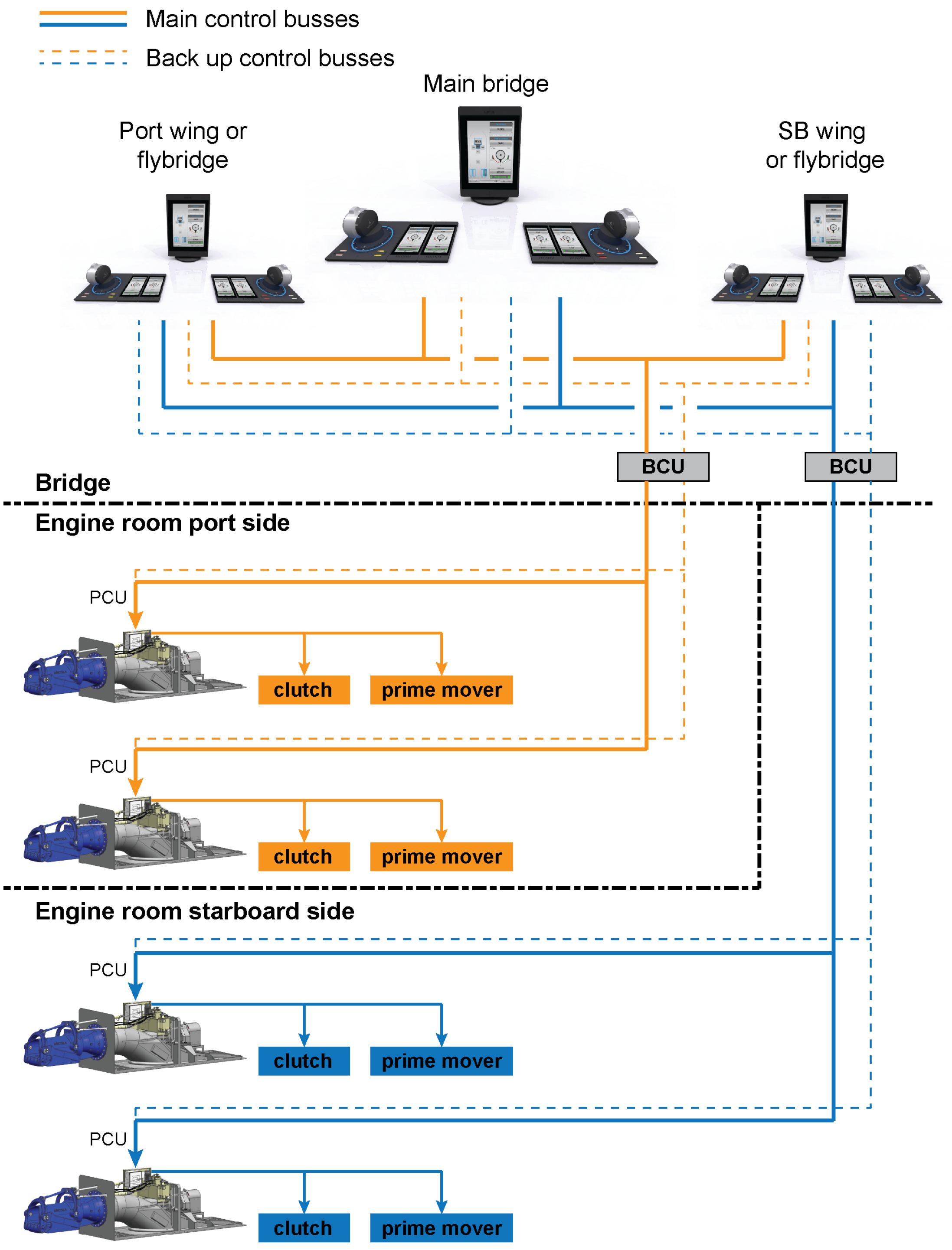

Fig 7-1 Four steerable waterjet system

The above schematic layout is a control system with four steerable waterjets and 3 control positions at the bridge. The systems on PS and SB are fully independent.

7.2.2 Basic two steering/reversing waterjet system

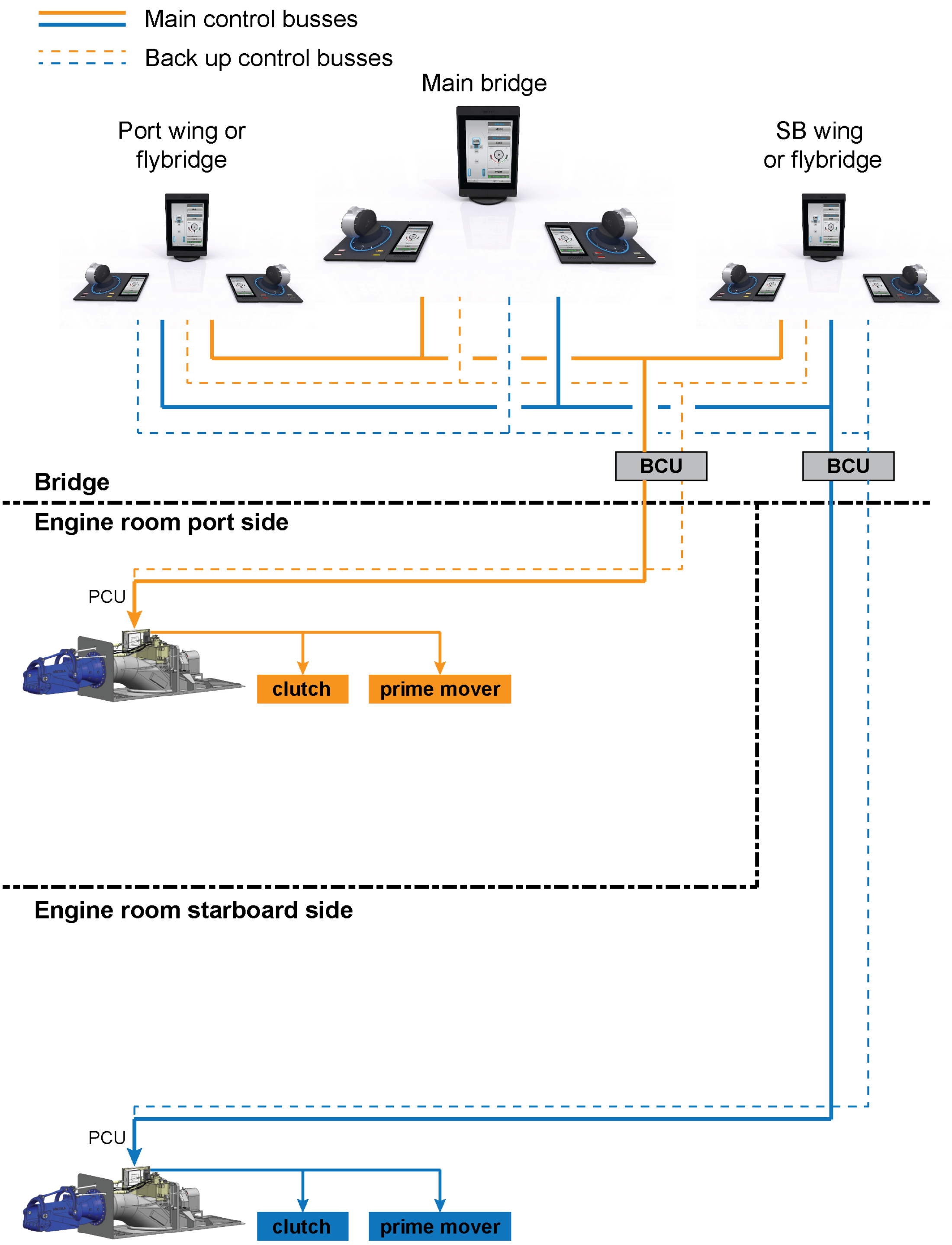

Fig 7-2 Two steerable waterjet system

The above schematic layout is a control system with two steering waterjets and 3 control positions at the bridge. The systems on PS and SB are fully independent.

7.2.3 Basic two steering/reversing and booster waterjet system

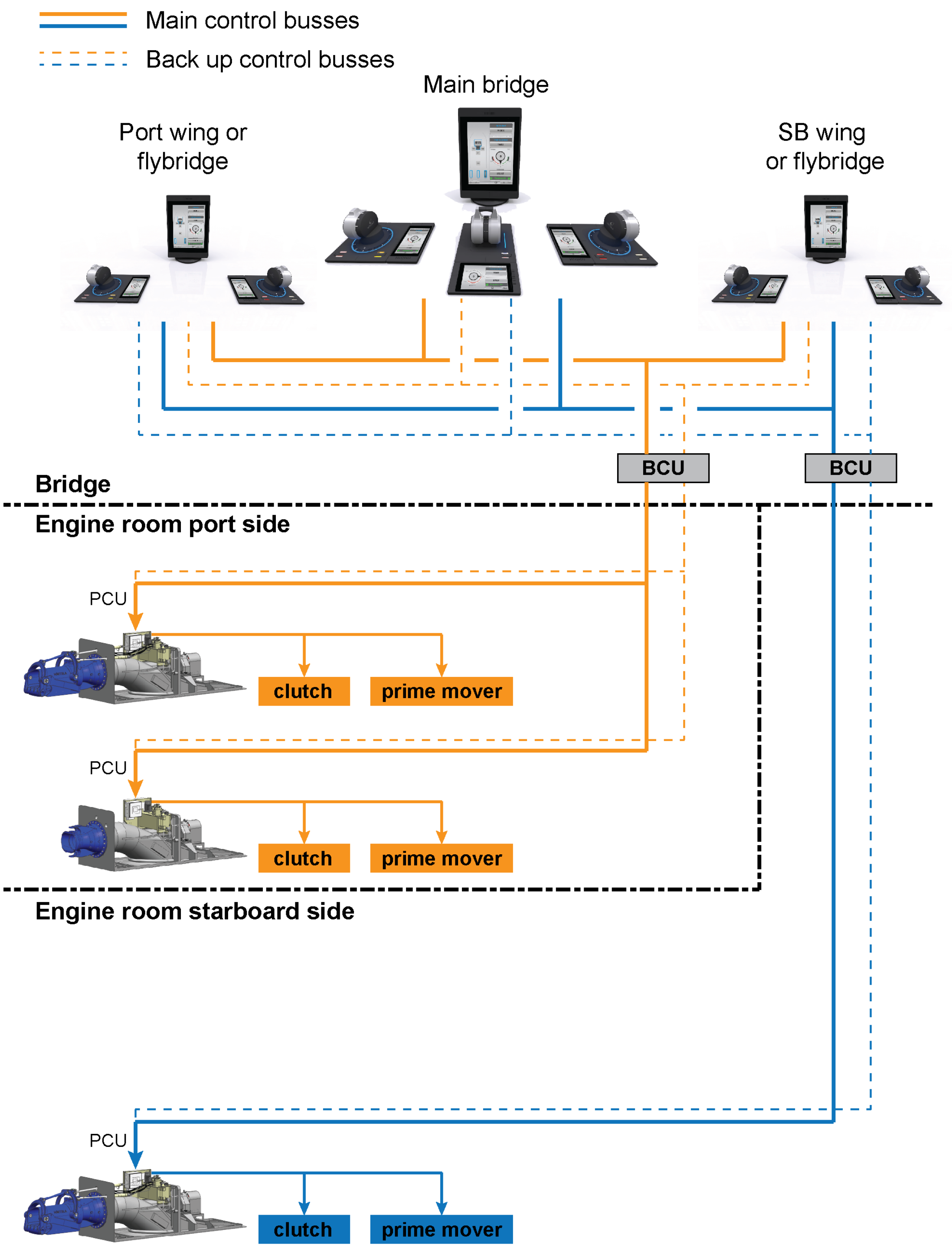

Fig 7-3 **Two steerable and one booster waterjet system**

The above schematic layout is a control system with two steerable waterjets, one booster jet and 3 control positions at the bridge. The systems on PS and SB are fully independent. The booster jet does not generate steering or reversing signals and is added to the PS system. In case of two booster jets, one is added to each independent side.

7.3 Components

Wärtsilä Protouch is build up with the following components:

- Lever unit
- Side display
- Main display (optional)
- Overhead Indicator
- Power module
- Bridge Control Unit

These components are described in the next paragraphs. Details about signals and connections will be supplied in the order specific Installation and Planning Instructions (IPI).

Fig 7-4 Example of a bridge panel (4 waterjets configuration)

7.3.1 Lever units

The propulsion controls has different lever units for each type of Midsize Waterjet:

- Steerable waterjet lever unit (see fig. *7-4*).
- Booster jet lever unit.

The lever unit has motorized axis, emergency stop button, backup select button, indication ring or bar, lever normal electronics and lever backup electronics (so for normal and backup control the same lever is used.)

NOTE

The booster jet lever unit does not include backup selection and backup electronics

The motorized axis is used for following functions:

- Synchronised movement of levers not in control (bump less control transfer).
- Higher friction at certain lever positions (detents, maximum 15 detent positions can be configured)

The lever motor will be switched off in case of a failure in the normal lever control board or normal bus failure, to avoid counter actions of the lever motor during backup control.

All lights on the lever unit are illuminated via led's.

7.3.2 Displays

The propulsion controls has three different displays:

- Side display, present for each propulsor on all applicable stations (see fig. *7-4*).
- Main display, hinged version or flat version, for common functionality, optional present at a station (see fig. *7-4*).

The side display is best located beside the corresponding lever unit and can provide following functionality:

- Control transfer with in control status indication
- Gauges (steering, bucket position, impeller RPM, thrust bearing temp)
- Indication of thrust status and steering status
- Mode selections (Individual mode / Parallel mode)
- Propulsor start/stop control (motor / engine, hydraulics, lubrication, clutch)
- Dimming slider (side display, lever and overhead indicator)
- Button for indication test
- Slowdown indication, with optional override
- Shutdown indication, with optional override

The main display is optionally present at a remote station and can provide following functionality:

- Common control transfer and in control status indications (all available propulsors)
- Mode selections (with individual override of DP / JS modes)
- Side display functionality for all applicable propulsors
- Event list
- Common dimming (all devices at a control station)
- Button for indication test
- Button for day / night mode selection

7.3.3 Overhead indicators

The overhead indicators are microprocessor based indicators with a graphical display. The indicator is available in two sizes: 148 x 102 mm and 196 x 148 mm.

Multiple indications can graphically be shown at the display, like steering, reversing plate position and impeller RPM.

Fig 7-5 **Overhead indicator**

7.3.4 Power module

The power distribution module (PMOD) provides the power supply to the bridge components. Depending on the configuration, each station has two power distribution modules, one for the portside and one for the starboard side, each equipped with a backup and a normal power supply. One PMOD per side (port/starboard) also provides the power supply to the BCU.

The power distribution module houses the following main components:

- Main power switches
- Power supplies
- Redundancy module
- Fuses
- Insulation monitoring device

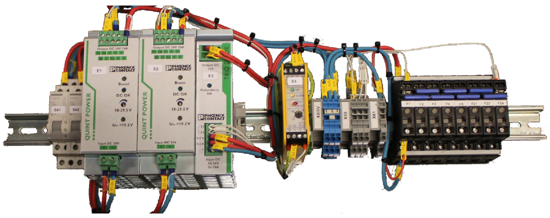

Fig 7-6 Power module

7.3.5 Bridge Control Unit

The Bridge Control Unit (BCU) is a control cabinet with two embedded controllers (normal and backup) for data communication between all the Wärtsilä Protouch components, propulsion control units and external interfaces (steering wheel, steering stick).

Connection to the Wärtsilä Protouch components and the propulsion control units is via normal and backup field bus connections. Emergency stop connections are hardwired. External system connections are hardwired, via serial interface or via a separate delivered interface box.

Separate bridge control units are present for the port and starboard installations; these units are electrically separated from each other.

The cabinet is placed at or near the bridge and is equipped with connectors for yard cabling and cable connectors delivered with the BCU cabinet. The BCU cabinet receives a main and a backup power supply from a power distribution module.

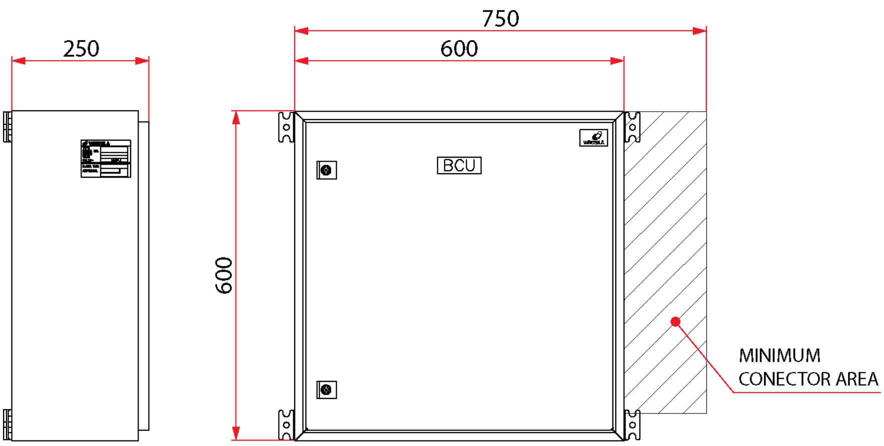

Fig 7-7 BCU cabinet

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8. Main Data

8.1 Waterjet dimensions and weights

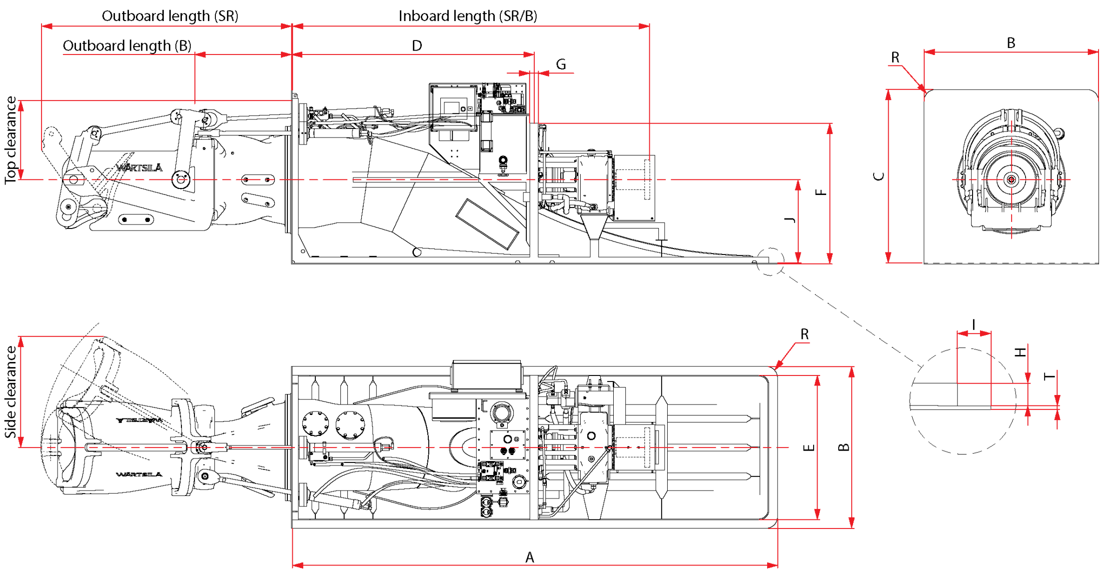


Fig 8-1 Waterjet dimensions

Table 8-1 Waterjet dimensions and weights

	510	570	640	720	810
Inboard length	2350	2520	2720	3000	3220
Outboard lenght (SR)	1540	1730	1930	2170	2440
Outboard lenght (B)	625	695	780	875	985
Side clearance	690	760	860	970	1090
Top Clearance	620	660	700	750	810
Entrained water [ltr]	450	600	850	1250	1750
Mass (SR) [kg]	1400	1750	2400	2850	3600
Mass (B) [kg]	1050	1300	1800	2250	3000
A	2975	3325	3735	4200	4725
B	1100	1200	1400	1400	1400
C	1065	1190	1335	1500	1690
D	1490	1660	1870	2100	2360
E	1050	1100	1300	1300	1300
F	996	1058	1128	1208	1300
G	50	50	75	75	75
H	35	40	45	50	55
I	25	50	50	50	50

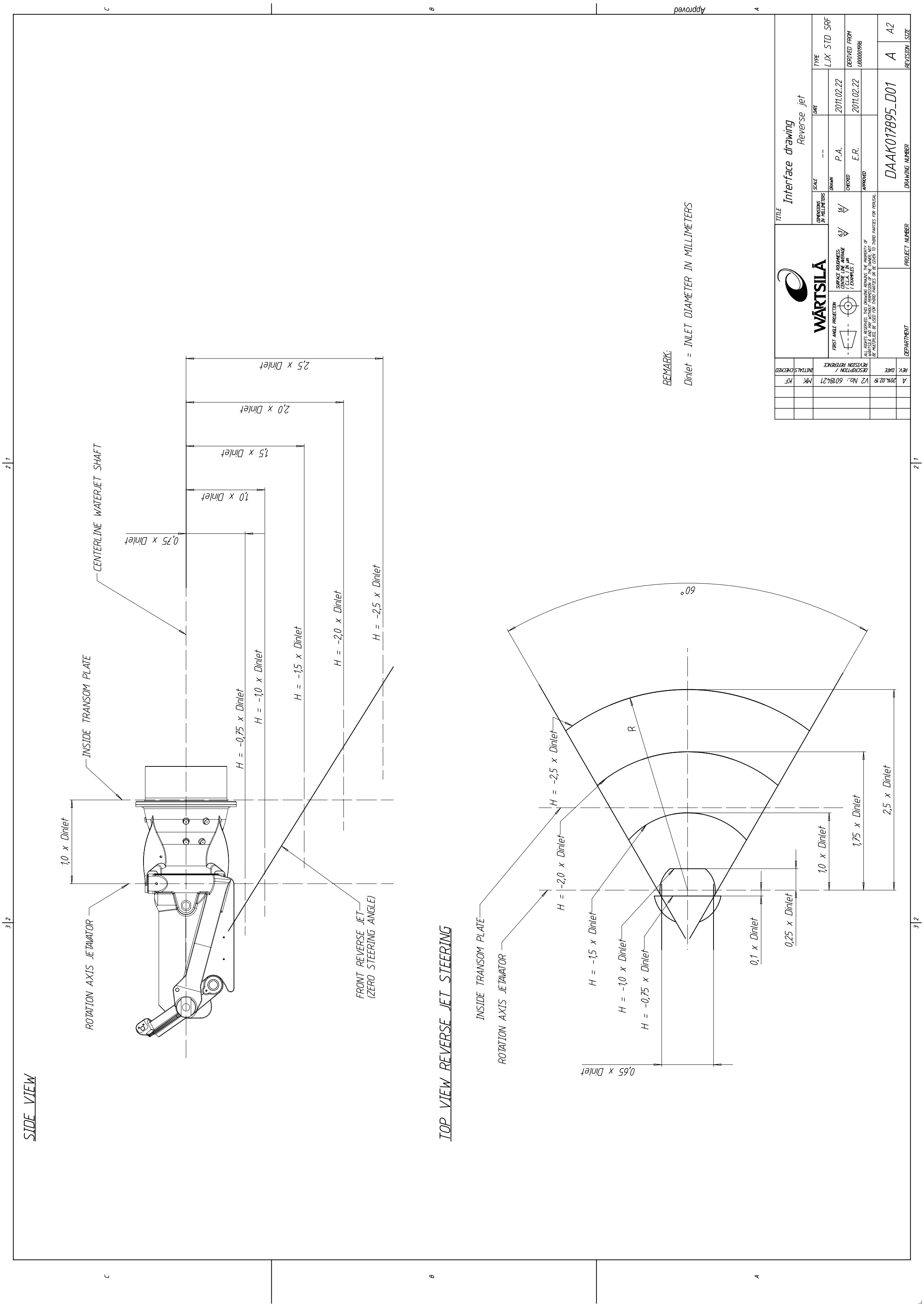
	510	570	640	720	810
J	510	570	640	720	810
R	81	83	83	83	85
T	6	8	8	8	10

Table 8-2 Waterjet performance data

Waterjet Size	Max. Power	Min. shaft speed (trailing)	Max. shaft speed	settling time steering/reversing
	[kW]	[rpm]	[rpm]	[s/s]
510	1700	170	1665	5/5
570	2100	142	1490	6/6
640	2700	135	1330	6/6
720	3400	122	1180	6/6
810	4300	107	1050	8/8

9. Drawings

9.1 List of Drawings


SIDE VIEW
CENTERLINE WATERJET SHAFT
INSIDE TRANSOM PLATE
ROTATION AXIS JETAVATOR
FRONT REVERSE JET
(ZERO STEERING ANGLE)
1,0 x Dinlet
0,75 x Dinlet
1,0 x Dinlet
1,5 x Dinlet
2,0 x Dinlet
2,5 x Dinlet
H = -0,75 x Dinlet
H = -1,0 x Dinlet
H = -1,5 x Dinlet
H = -2,0 x Dinlet
H = -2,5 x Dinlet
TOP VIEW REVERSE JET STEERING
INSIDE TRANSOM PLATE
ROTATION AXIS JETAVATOR
60°
R
H = -2,5 x Dinlet
H = -2,0 x Dinlet
H = -1,5 x Dinlet
H = -1,0 x Dinlet
H = -0,75 x Dinlet
0,65 x Dinlet
0,1 x Dinlet
0,25 x Dinlet
1,0 x Dinlet
1,75 x Dinlet
2,5 x Dinlet
REMARK:
Dinlet = INLET DIAMETER IN MILLIMETERS
WÄRTSILÄ
TITLE
Interface drawing
Reverse jet
TYPE
LJX STD SRF
DRAWN P.A. 2011.02.22
CHECKED E.R. 2011.02.22
DAAK017895_D01
A
A2
DRAWING NUMBER
PROJECT NUMBER
DEPARTMENT
REVISION
SIZE
Approved

	Document title: WATERJET selection questionnaire							
Doc. no.		Rev.		Date		Template no.	DBAC993354/-	Page 1 of 2

Company Details

Company ______________________
Address ______________________
Telephone ______________________
Fax ______________________
E-mail ______________________
Contact person ______________________

General Data

Order number ______________________
Yard ______________________
New building number(s) ______________________
Owner ______________________
QMS-Number ______________________
Project Reference ______________________
Number of Vessel(s) ______________________
Operating Profile ______________________

PROJECT REFERENCE				
TYPE OF CRAFT	☐ Monohull	☐ Catamaran	☐ SES	Other:..............................
APPLICATION	☐ Ferry	☐ Navy	☐ Yacht	Other:..............................
HULL MATERIAL	☐ Aluminium	☐ Steel	☐ GRP	Other:..............................

WÄRTSILÄ	Document title: **WATERJET selection questionnaire**						
Doc. no.		Rev.		Date		Template no.	DBAC993354/-	Page 2 of 2

CRAFT DATA			
L.O.A.	(m)	TRIAL DISPL.	(t)
L.W.L.	(m)	FULL DISPL.	(t)
BEAM	(m)	DEADRISE	(°)
DRAFT	(m)	LCG from transom	(m)
PROPULSION CONFIGURATION			
ENGINE TYPE		ENGINE TYPE	
No. OF ENGINES		No. OF ENGINES	
MAX POWER	(kW)	MAX POWER	(kW)
MAX RPM*		MAX RPM*	
CONT POWER	(kW)	CONT POWER	(kW)
CONT RPM*		CONT RPM*	
No. OF WATERJETS		No. OF WATERJETS	
INLET DUCT TO BE SUPPLIED (YES**/NO)			
*please supply RPM when no reduction gearbox is to be applied			
**only applicable for Plug and Play Midsize Waterjet, types 510, 570, 640, 720, 810			
PERFORMANCE			
DESIGN SPEED	(kts)	CONT. SPEED	(kts)
MAX. SPEED	(kts)	OTHER	(kts)

THRUST PREDICTION (@ ...... load)**						
SPEED (kts)						
THRUST (kN)						
**if possible please supply datasheet (Excel) with thrust prediction						

WATERJET CONTROLS			
No. OF CONTROL STATIONS		SPECIAL REQUIREMENTS	
CLASSIFICATION			
CLASSIFICATION NOTATION		CLASS	
DELIVERY TIME			
REQUIRED DELIVERY TIME (MM/YYYY)			

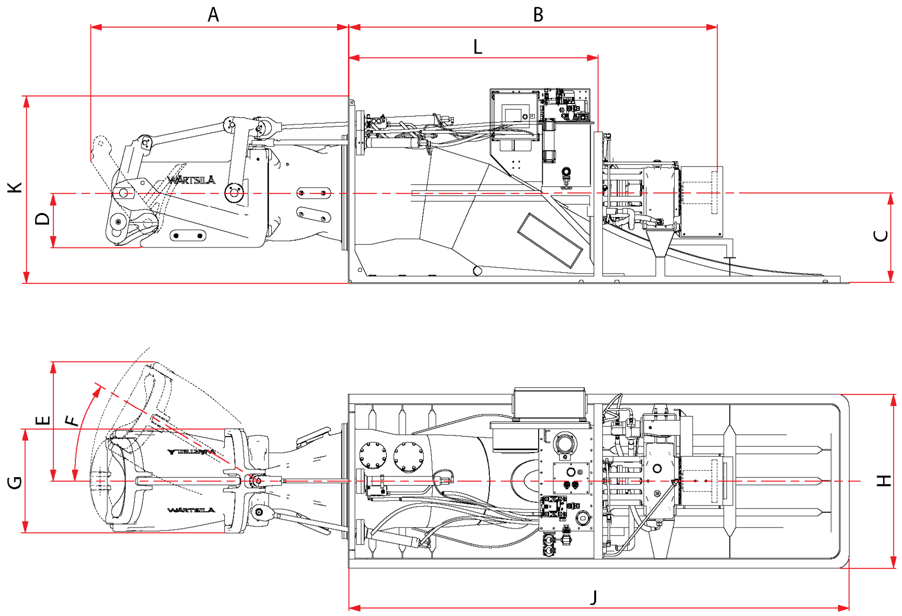
Cells are necessary for a proper Waterjet Selection

Basic Data of waterjet type:	LJX 510 SRF	14.9.2015
Waterjet construction material		
- Impeller and Shaft		Duplex 2205
- Bowl and Seatring		Duplex 2205
- Nozzle		Aluminium
- Inlet 1)		Aluminium
Outboard length	(A)	1540 [mm]
Inboard length	(B)	2350 [mm]
Shaft height	(C)	510 [mm]
Deflector depth	(D)	310 [mm]
Steering offset	(E)	690 [mm]
Steering angle	(F)	30 [degrees]
Width	(G)	630 [mm]
Width (Inlet duct)	(H)	1100 [mm]
Length (Inlet duct)	(J)	2975 [mm]
Height (Inlet duct)	(K)	1065 [mm]
Bulkhead distance	(L)	1490 [mm]
Inlet diameter		510 [mm]
Dry mass		1400 [kg]
Total Entrained water 2)		450 [ltr]

Important: ***The above values are for reference only and subject to change upon final optimization***

1) ***On special request the inlet can be designed from Shipbuiding Steel.***

2) ***Based on the above mentioned indicative shaftheight.***



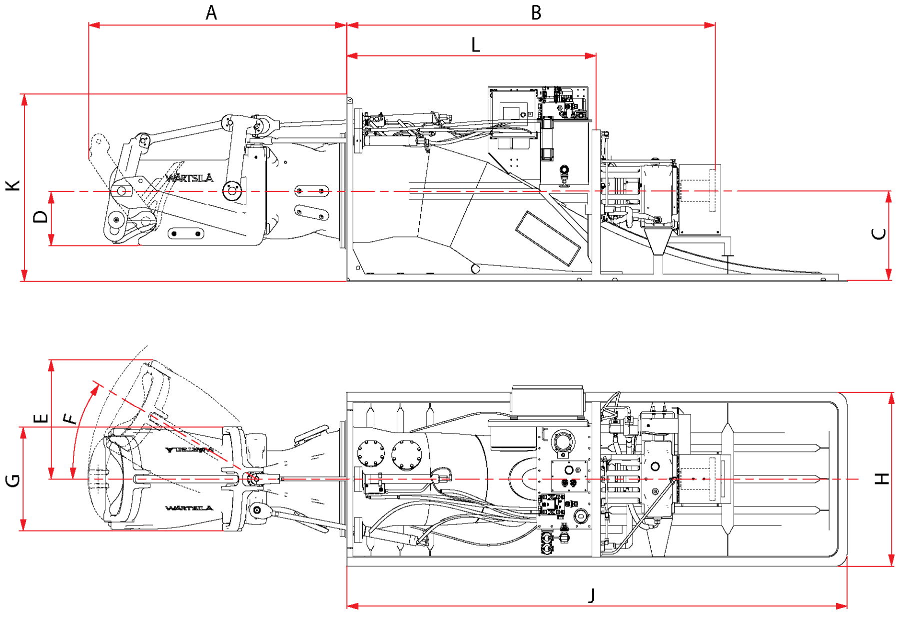
WÄRTSILÄ

Basic Data of waterjet type:	LJX 570 SRF	14.9.2015
Waterjet construction material		
- Impeller and Shaft		Duplex 2205
- Bowl and Seatring		Duplex 2205
- Nozzle		Aluminium
- Inlet 1)		Aluminium
Outboard length	(A)	1730 [mm]
Inboard length	(B)	2520 [mm]
Shaft height	(C)	570 [mm]
Deflector depth	(D)	350 [mm]
Steering offset	(E)	760 [mm]
Steering angle	(F)	30 [degrees]
Width	(G)	700 [mm]
Width (Inlet duct)	(H)	1200 [mm]
Length (Inlet duct)	(J)	3325 [mm]
Height (Inlet duct)	(K)	1190 [mm]
Bulkhead distance	(L)	1660 [mm]
Inlet diameter		570 [mm]
Dry mass		1750 [kg]
Total Entrained water 2)		600 [ltr]

Important: ***The above values are for reference only and subject to change upon final optimization***

1) ***On special request the inlet can be designed from Shipbuiding Steel.***

2) ***Based on the above mentioned indicative shaftheight.***

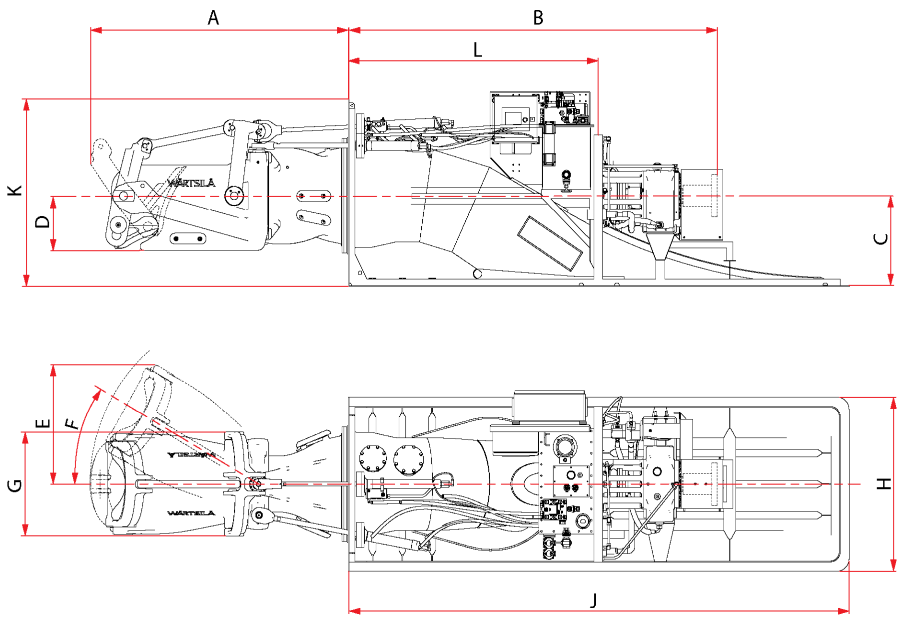


Basic Data of waterjet type:	LJX 640 SRF 14.9.2015	
Waterjet construction material		
- Impeller and Shaft		Duplex 2205
- Bowl and Seatring		Duplex 2205
- Nozzle		Aluminium
- Inlet 1)		Aluminium
Outboard length	(A)	1930 [mm]
Inboard length	(B)	2720 [mm]
Shaft height	(C)	640 [mm]
Deflector depth	(D)	390 [mm]
Steering offset	(E)	860 [mm]
Steering angle	(F)	30 [degrees]
Width	(G)	780 [mm]
Width (Inlet duct)	(H)	1400 [mm]
Length (Inlet duct)	(J)	3735 [mm]
Height (Inlet duct)	(K)	1335 [mm]
Bulkhead distance	(L)	1870 [mm]
Inlet diameter		640 [mm]
Dry mass		2400 [kg]
Total Entrained water 2)		850 [ltr]

Important: ***The above values are for reference only and subject to change upon final optimization***

1) ***On special request the inlet can be designed from Shipbuiding Steel.***

2) ***Based on the above mentioned indicative shaftheight.***

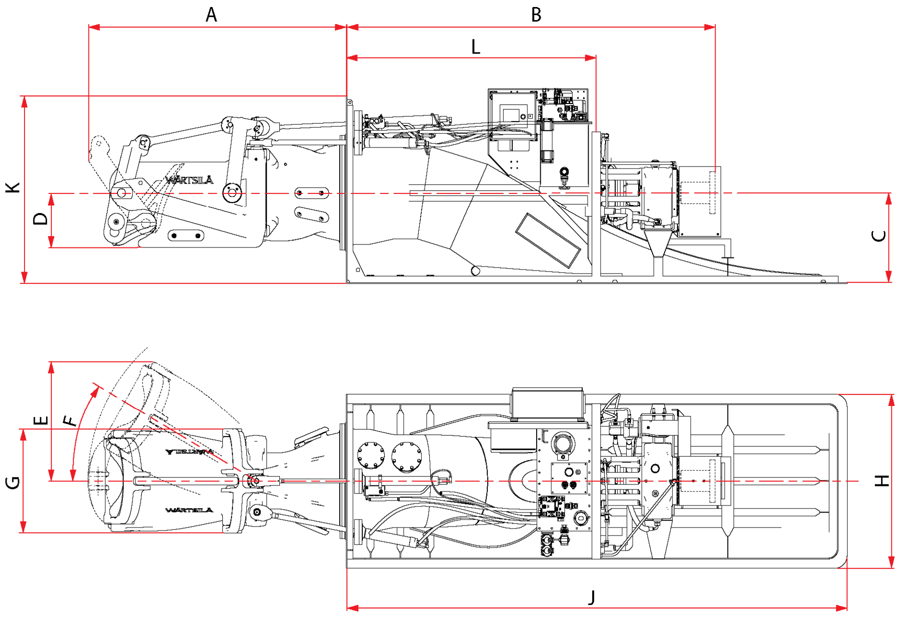


Basic Data of waterjet type:	LJX 720 SRF	14.9.2015
Waterjet construction material		
- Impeller and Shaft		Duplex 2205
- Bowl and Seatring		Duplex 2205
- Nozzle		Aluminium
- Inlet 1)		Aluminium
Outboard length	(A)	2170 [mm]
Inboard length	(B)	3000 [mm]
Shaft height	(C)	720 [mm]
Deflector depth	(D)	440 [mm]
Steering offset	(E)	970 [mm]
Steering angle	(F)	30 [degrees]
Width	(G)	870 [mm]
Width (Inlet duct)	(H)	1400 [mm]
Length (Inlet duct)	(J)	4200 [mm]
Height (Inlet duct)	(K)	1500 [mm]
Bulkhead distance	(L)	2100 [mm]
Inlet diameter		720 [mm]
Dry mass		2850 [kg]
Total Entrained water 2)		1200 [ltr]

Important: ***The above values are for reference only and subject to change upon final optimization***

1) ***On special request the inlet can be designed from Shipbuiding Steel.***

2) ***Based on the above mentioned indicative shaftheight.***



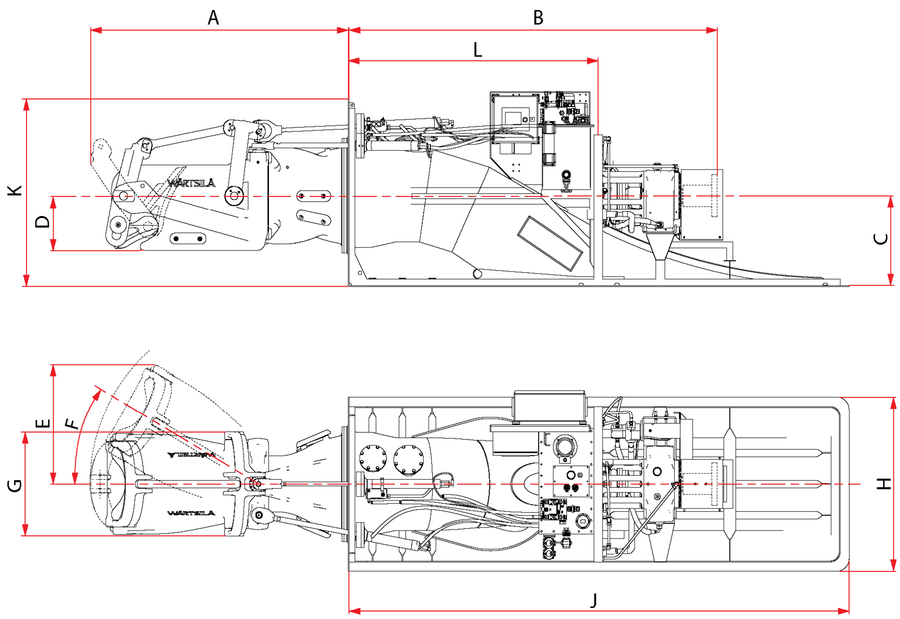
WÄRTSILÄ

Basic Data of waterjet type:	LJX 810 SRF	14.9.2015
Waterjet construction material		
- Impeller and Shaft		Duplex 2205
- Bowl and Seatring		Duplex 2205
- Nozzle		Aluminium
- Inlet 1)		Aluminium
Outboard length	(A)	2440 [mm]
Inboard length	(B)	3220 [mm]
Shaft height	(C)	810 [mm]
Deflector depth	(D)	495 [mm]
Steering offset	(E)	1090 [mm]
Steering angle	(F)	30 [degrees]
Width	(G)	970 [mm]
Width (Inlet duct)	(H)	1400 [mm]
Length (Inlet duct)	(J)	4725 [mm]
Height (Inlet duct)	(K)	1690 [mm]
Bulkhead distance	(L)	2360 [mm]
Inlet diameter		810 [mm]
Dry mass		3600 [kg]
Total Entrained water 2)		1750 [ltr]

Important: ***The above values are for reference only and subject to change upon final optimization***

1) ***On special request the inlet can be designed from Shipbuiding Steel.***

2) ***Based on the above mentioned indicative shaftheight.***



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10. Product Guide Attachments

This and other product guides can be accessed on the internet, from the Business Online Portal at www.wartsila.com. Product guides are available both in web and PDF format. Drawings are available in PDF and DXF format, and in near future also as 3D models. Consult your sales contact at Wärtsilä to get more information about the product guides on the Business Online Portal.

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Scan this QR-code using the QR-reader application of your smartphone to obtain more information.

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11. Annex

11.1 Unit conversion tables

The tables below will help you to convert units used in this product guide to other units. Where the conversion factor is not accurate a suitable number of decimals have been used.

Table 11-1 Length conversion factors

Convert from	To	Multiply by
mm	in	0.0394
mm	ft	0.00328

Table 11-2 Mass conversion factors

Convert from	To	Multiply by
kg	lb	2.205
kg	oz	35.274

Table 11-3 Pressure conversion factors

Convert from	To	Multiply by
kPa	psi (lbf/in^2)	0.145
kPa	lbf/ft^2	20.885
kPa	inch H_2O	4.015
kPa	foot H_2O	0.335
kPa	mm H_2O	101.972
kPa	bar	0.01

Table 11-4 Volume conversion factors

Convert from	To	Multiply by
m^3	in^3	61023.744
m^3	ft^3	35.315
m^3	Imperial gallon	219.969
m^3	US gallon	264.172
m^3	l (litre)	1000

Table 11-5 Power conversion factors

Convert from	To	Multiply by
kW	hp (metric)	1.360
kW	US hp	1.341

Table 11-6 Moment of inertia and torque conversion factors

Convert from	To	Multiply by
kgm^2	lbft^2	23.730
kNm	lbf ft	737.562

Table 11-7 Fuel consumption conversion factors

Convert from	To	Multiply by
g/kWh	g/hph	0.736
g/kWh	lb/hph	0.00162

Table 11-8 Flow conversion factors

Convert from	To	Multiply by
m^3/h (liquid)	US gallon/min	4.403
m^3/h (gas)	ft^3/min	0.586

Table 11-9 Temperature conversion factors

Convert from	To	Calculate
°C	F	F = 9/5 *C + 32
°C	K	K = C + 273.15

Table 11-10 Density conversion factors

Convert from	To	Multiply by
kg/m^3	lb/US gallon	0.00834
kg/m^3	lb/Imperial gallon	0.01002
kg/m^3	lb/ft^3	0.0624

11.1.1 Prefix

Table 11-11 The most common prefix multipliers

Name	Symbol	Factor
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

Wärtsilä is a global leader in complete lifecycle power solutions for the marine and energy markets. By emphasising technological innovation and total efficiency, Wärtsilä maximises the environmental and economic performance of the vessels and power plants of its customers. Wärtsilä is listed on the NASDAQ OMX Helsinki, Finland.

04.2014

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