

WÄRTSILÄ

Propellers

**WÄRTSILÄ FIXED PITCH
PROPELLER SOLUTIONS**



ENERGY
ENVIRONMENT
ECONOMY



PROPULSION SOLUTIONS WITH FIXED PITCH PROPELLERS

Each ship's hull has its own characteristics. For the vessel to achieve the highest possible overall efficiency, the propeller must be perfectly matched with the engine and hull. The Wartsilä fixed pitch propeller is the choice when optimum efficiency, reliability and robustness are required.

Wartsilä is able to solve all your needs with regard to fixed pitch propeller installations:

- Total system solutions supplied
- Easy assembly and maintenance
- Durable construction
- Optimum efficiency through tailor-made design
- Worldwide service and maintenance.



WÄRTSILÄ FIXED PITCH PROPELLERS

All WÄRTSILÄ® propellers are custom designed and made for each specific application.

The propellers vary in diameter from 1 to 12 metres, and can weigh from hundreds of kilos to 140 tonnes.

Given the complex geometry of modern propellers, the casting process is monitored from start to finish to ensure the highest quality.

Wartsilä has produced some 9000 FP propellers to date, for ocean-going vessels within our segments; Merchant, Special

Vessels, Cruise & Ferry, Offshore and Navy.

The tailor-made design and use of the latest available technology that are features of Wartsilä FP propellers for all ship types, guarantee maximum efficiency with minimum noise and vibration levels. They are also easy to repair.

Wartsilä's patented Cunial® material provides excellent casting, machining, and fatigue strength properties.

Wartsilä FP propellers can be produced with any required blade number and size,



The production process of fixed pitch propellers.



The mechanical properties of Cunial:

Mass density	7650 kg/m ³
E-modulus (at 20° C)	121000 N/mm ²
Poisson's ratio	0,33
Yield stress	min. 250 N/mm ² *
Tensile strength	min. 650 N/mm ²
Elongation (longitudinal)	min. 18%
Coefficient of thermal expansion (from 20 to 100°C)	16 · 10 ⁻⁶ K ⁻¹

*At request the yield stress of the material can be increased up to 270 N/mm²

21. 03. 2013

from 1 m upwards. For ships sailing the inland waterways, our Wärtsilä Inland Water Ways product group is available to serve this market.

THE PRODUCTION PROCESS

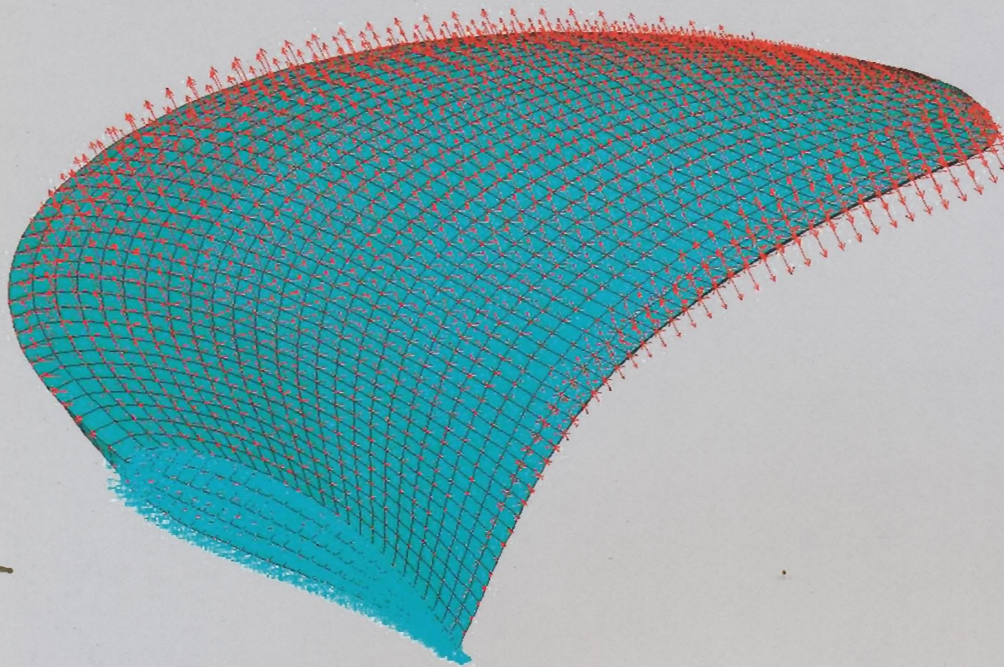
Of the more than 25 different bronze alloys developed by Wärtsilä for marine propellers, Cunial bronze is the most-used and therefore the best-known material. Cunial bronze, which stands for an alloy composed of copper, nickel

and aluminium, has unparalleled durability and reliability. The high quality of this alloy is the result of years of research. Monitoring is carried out throughout the melting process to check that the various elements are present in the correct composition.

Having complete control over the production process provides us with valuable information, such as the fatigue strength in seawater. This information in turn allows our hydrodynamic design team to design the propellers according to efficiency limits, thus minimizing propeller weight.

Casting the form of a marine propeller is an extremely complex procedure. To predict the casting process, we use solidification simulation software for difficult propeller geometries. Accurate control of the process allows us to use a minimum casting allowance.

Today, Wärtsilä F.P. propellers are increasingly being worked mechanically with the aid of grinding robots. However, the expertise and eye for detail of the finisher is still critical to give the propeller that essential finishing touch.



FP propeller FEM mesh.



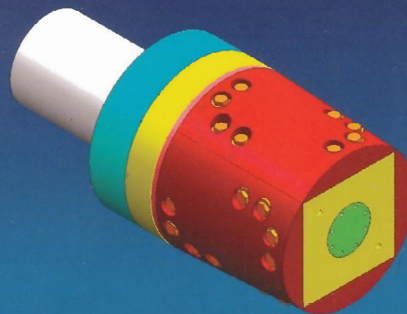
DESIGN PHILOSOPHY

The main targets when designing an FP propeller are:

- Efficiency (related to speed)
- Cavitation behaviour (related to noise)
- Pressure pulses on the hull (related to vibrations)
- Meeting the strength requirements.

Wärtsilä FP propellers meet these demands, and provide a wide variation in speed and power densities for any type of ship. Our design experience covers a range of vessel applications, including high-powered fast containerships, tankers, bulk carriers and cruise liners.

We have extensive hydrodynamic knowledge and have developed design tools based upon years of experience with calculations, model test results, and full-scale measurements. Our research and development efforts are dedicated towards continuous improvement in the hydrodynamic design of our propellers. To achieve this goal, we co-operate with research institutes and universities in joint research projects. Our aim is to improve our knowledge and full scale experience, and to improve our design and analysis methods, including Computational Fluid Dynamics (CFD).



Built-up propeller hub.

PRODUCT PORTFOLIO

Wärtsilä is able to supply fixed pitch propellers with a maximum finished weight of over 140 tonnes. We also supply a wide array of propulsion equipment, such as shaftlines, shaftline accessories, and rudders.

We produce our monobloc fixed pitch propellers as standard with a keyless bore. This allows the propeller to be hydraulically press-fitted onto the propeller shaft, a method that offers two advantages. First, it avoids the stress concentrations that develop when installing the propeller with keys and keyways. Furthermore, hydraulic mounting and dismounting is a relatively simple installation procedure. Keyed propellers can also be supplied on request.

FIXED PITCH PROPELLER (MONOBLOC)

Wärtsilä can supply fixed pitch propellers with any number of blades. The most common are 4-, 5- and 6-bladed propellers, but we have also supplied propellers with up to 9 blades. The maximum propeller diameter supplied so far has been 11.64 m, and the heaviest propeller has a finished weight of over 100 tonnes.

BUILT-UP PROPELLERS

Our standard built-up propellers are mounted to the flange of the tail shaft and the blades are de-mountable. The hub is designed for strength and robustness with the minimum number of parts.



FP propeller in hold of vessel during transport.

The main reasons for applying Wärtsilä built-up propellers are:

- Regular occurrence of blade damage by collision with ice or other objects
- Easy transport in case of damage
- Only spare blade needed instead of complete spare propeller

We supply built-up propellers with a minimum of 3 and a maximum of 6 blades.

SHAFTLINE:

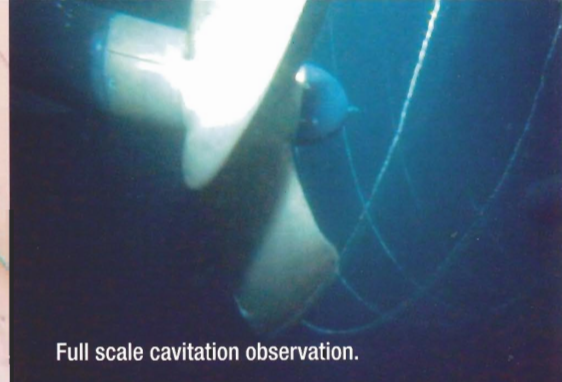
Each ship's shaftline has its own design and requirements. The propeller shaft installation has a proven basic design, which enables easy installation in the ship:

- Hydraulic toolsets
- Hydraulic nut

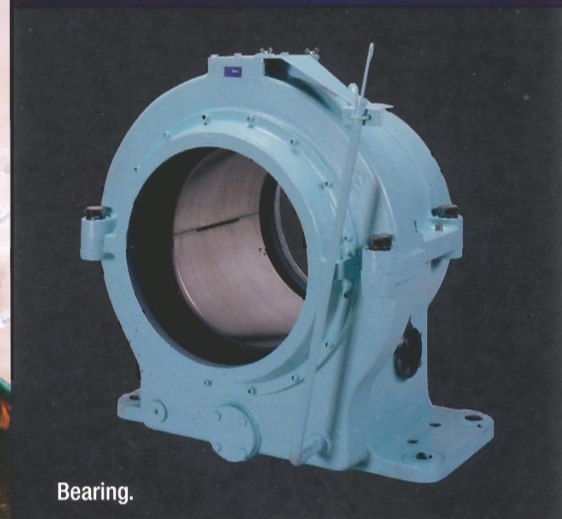
- Hydraulic ring
- Propeller and intermediate shafts
- Hydraulic coupling flange
- Hydraulic sleeve coupling.

SHAFTLINE ACCESSORIES

- Sterntubes with or without bearings (oil/water)
- Seals and bearings (oil/water)
- Thrust bearings
- Torque measurement device
- Turning device
- Shaft grounding device
- Shaft locking device
- Shaft brake.



Full scale cavitation observation.



Bearing.



Seal.

NOZZLES

The advantage of using a nozzle is in the additional amount of thrust it develops. Various types of nozzles, such as the 19A, 37 and the LIPS HR high-efficiency nozzle, can be supplied.

CONSULTANCY

On request we also assist in questions regarding propeller and shaftline design. In the case of damaged propellers, for instance, we are often contacted for a second opinion regarding propeller performance, propeller strength and material quality.

Our laboratory and metallurgical teams are perfectly equipped to answer all questions related to material quality, failure cause, and repair possibilities.



REPLACEMENT OF FIXED PITCH PROPELLERS

Over the years, shipowners and yards have often approached us for modernization and replacement solutions for fixed pitch propellers.

The main reasons for replacement are:

- The propeller has too much damage and cannot be repaired
- Upgrading of the propeller design to modern standards
- Improved efficiency
- Lower propeller induced pressure pulses
- Change in mission profile
- Poor initial design.

IMPROVING PROPELLER DESIGN

Wärtsilä has, in close co-operation with model test institutes and universities, conducted considerable research into improving propeller design. As a result, the new techniques we

have developed enable us to design propellers with higher efficiency without increasing the onboard levels of vibration and noise. This results immediately in lower fuel consumption.

In general, the following four options are available for increasing efficiency through a new propeller design, assuming that the geometry of the new propeller lies within the geometry of the old propeller:

- Reduce the blade area
- Change the blade contour
- Modify the radial pitch distribution
- Apply the Wärtsilä tip-rake concept.

REDUCING THE BLADE AREA

Reduction of the blade area may be possible in cases where the calculated power density of the propeller is relatively low compared to

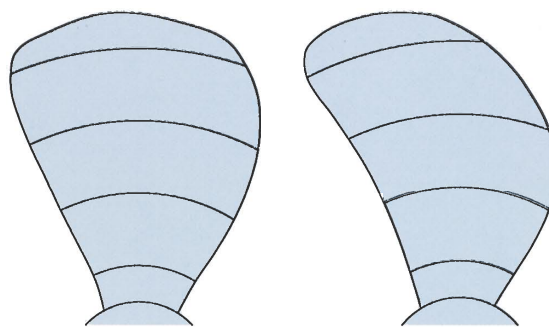
Wärtsilä standards. Reducing the blade area of an FP propeller, and optimizing the power density to an acceptable Wärtsilä value, can increase efficiency by more than 3%.

CHANGING THE BLADE CONTOUR

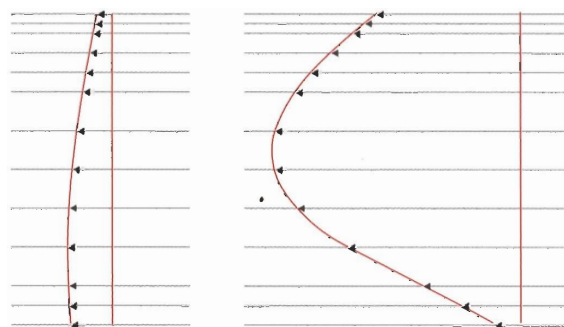
When it is not possible or desirable to reduce the blade area, changing the blade contour is an alternative means of increasing the efficiency of the FP propeller. Recent projects show that efficiency improvements of 3-4% can be achieved.

MODIFYING THE RADIAL PITCH DISTRIBUTION

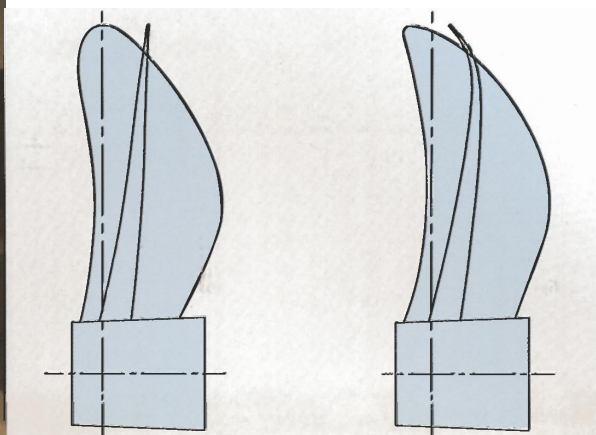
In past designs, it was usual to apply some kind of constant radial pitch distribution with a constant load at all radii. However, this



Blade contour.



Radial pitch distribution.



The tip-rake concept.

distribution can lead to intensive tip and hub vortex cavitation, which may damage the rudder and generate high-pressure pulses. For this reason, modern FP propeller design favours a variable pitch distribution with better cavitation behaviour and low pressure pulses. However, if the pressure pulses are kept at the same level as with the old design, reduction of the blade area is possible and efficiency will increase.

APPLYING THE TIP-RAKE CONCEPT

The tip-rake concept can be applied to achieve better efficiency, resulting in fuel savings and/or higher ship speed. Relative efficiency improvements of 2-4 % compared to normal propellers have thus far been measured. Tip-rake also leads to lower pressure pulse

levels and a quieter propeller, and therefore more comfort for the crew. When considering replacement or modernization of the existing propeller, it is worth investigating to what extent a new, state-of-the-art propeller design could reduce fuel consumption and/or pressure pulses.

WORLDWIDE SERVICE AND MAINTENANCE

We offer a worldwide service network that ensures reliable and efficient support, and the quickest possible solution to any propulsion problem, during the full operational lifetime of the vessel.

Our service activities include:

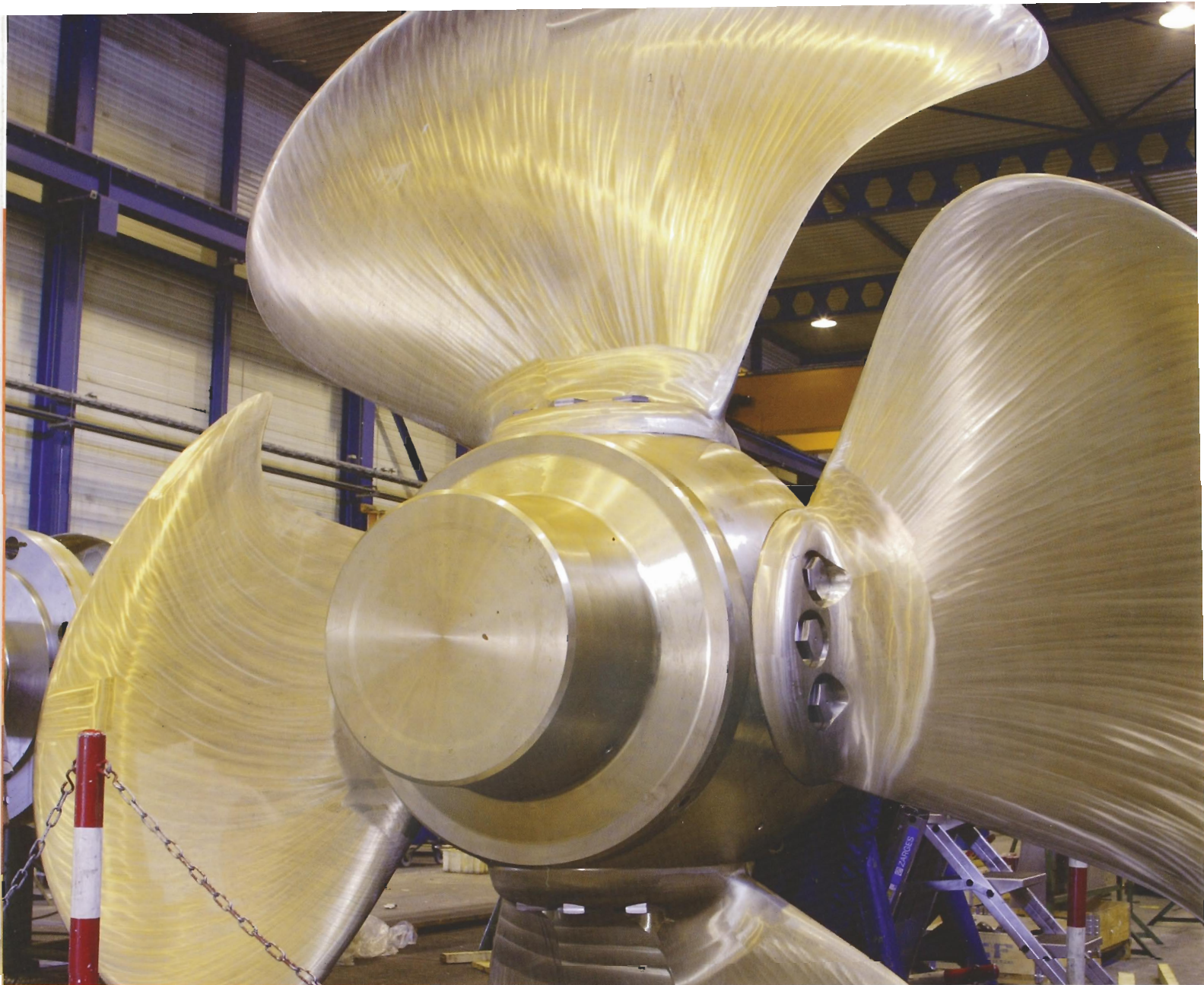
- Retrofits and upgrades
- Metallurgical repairs
- Modifications to heavy running propellers
- Underwater services and survey
- Original LIPS spare parts
- Personnel training programmes
- Helpdesk
- Worldwide field service
- In-house overhaul/repair.

WÄRTSILÄ

Propellers

WÄRTSILÄ CONTROLLABLE PITCH
PROPELLERS





PROPULSION SOLUTIONS WITH WÄRTSILÄ CONTROLLABLE PITCH PROPELLERS

Wärtsilä designs and produces controllable pitch propellers for the commercial, military and superyacht market. It is a unique product, the first design for which dates back to 1903. With this wealth of experience and more than 10,000 installations installed and sailing worldwide, we present in this brochure our latest innovative designs.

A WÄRTSILÄ® controllable pitch propeller installation consists of a hub, propeller blades, shafting, hydraulics and a Lipstronic remote control, as well as any further accessories needed to meet the customer's needs.

With 4- or 5-bladed propellers made of Cunial bronze or stainless steel, ducted or non-ducted, we always have the most appropriate solution.

The range of Wärtsilä controllable pitch propellers starts at an engine power of approximately 500 kW, and a propeller diameter of 1000 mm, and in principle has no upper limit. The highest powered controllable pitch propeller so far absorbs 44 MW, and the largest one has a diameter of 8400 mm.

The Wärtsilä controllable pitch propeller is manufactured completely "in-house". This

means that they are casted, machined and assembled in either Drunen, the Netherlands, in Rubbestadneset, Norway or in India.

We aim to be more than just a supplier; we actively co-operate with all parties involved. The result is a controllable pitch propeller with the highest possible efficiency, limited and controlled cavitation, and low pressure pulses.

The equipment is designed for the ship's life. And when maintenance or service is required, we offer you our worldwide service network, which operates 24 hours a day, 7 days a week.

HYDRODYNAMIC DESIGN

Wärtsilä controllable pitch propellers are custom-designed for each ship. Each vessel



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has a different hull form and for that reason different wake fields. All Wärtsilä propellers are wake-adapted and, in co-operation with the customer, both yard and owner, the propeller is designed for optimal performance in all operating conditions.

The main features of the propeller design are:

- Highest propulsive efficiency in all operating conditions
- Excellent behaviour regarding cavitation, with no erosive types of cavitation
- Lowest pressure pulse fluctuations on the hull to minimize noise and vibration levels on board.

Wärtsilä controllable pitch propellers for all ship types guarantee maximum efficiency and

minimum noise and vibration levels thanks to their tailor-made design and use of the latest state-of-the-art technology:

- A special radial loading distribution is used to obtain high efficiency
- Unloading of the blade tip minimizes cavitation and pressure pulses
- Optimized blade profile sections are developed and used in the design and lead to better results regarding both cavitation behaviour and efficiency.

Wärtsilä's design experience covers many types of ships, varying from heavy-duty vessels like hopper dredgers to high-speed passenger ferries, and from small fishing boats to enormous oil platforms carriers. Our long history of designing propellers gives us extensive hydrodynamic knowledge and we

have developed design tools based on a large number of model test results and full-scale measurements. Our research and development efforts are dedicated to continuously improving the hydrodynamic design of our propellers by:

- Co-operation with well known research institutes and universities worldwide
- Full-scale measurements
- Simulation using Computational Fluid Dynamics (CFD).

In order to fulfil the strength requirements of the propellers we perform Finite Element (FEM) analyses to check the blade strength properties of each blade design. Both fatigue strength and stresses in peak load conditions are checked.



Twin-screw cruise RoPax Pride of Rotterdam.



Tanker Credo.



Twin-screw offshore supply ship Normand Ivan.



Seismic research vessel Ramford Sovereign.



Twin-screw hopper dredger Rotterdam.



WHY A WÄRTSILÄ CONTROLLABLE PITCH PROPELLER?

When a Wärtsilä controllable pitch propeller is installed the optimum pitch setting for all possible operating conditions can be selected.

Further optional pitch settings are required and possible in the following cases:

- Manoeuvring and free-sailing mode
- Summer and winter mode (one or two engines per shaft, typically for RoRo ferries)
- Shaft generator mode
- Fouling of the engine
- Increased resistance of the ship's hull, due to fouling
- Change of sea state and/or weather condition.

The shaft generator (PTO) with constant rpm can be installed either at the reduction gear

or directly at the shaftline through a tunnel gear. A shaft generator also allows the use of a redundant propulsion system, in which case the PTO can operate as an electric motor (PTI).

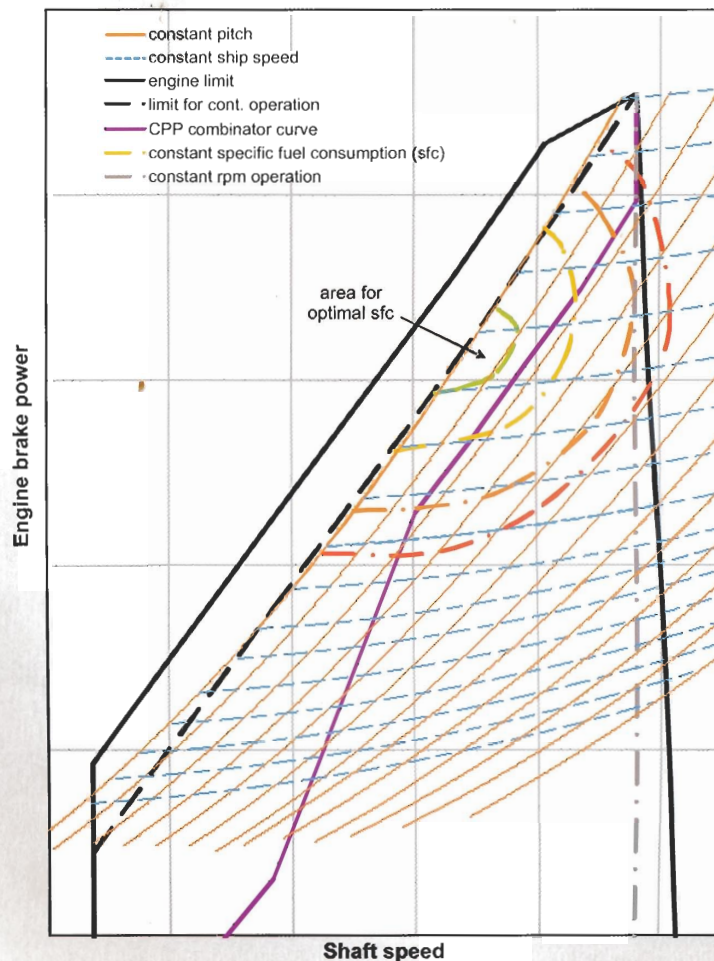
For certain types of "double-duty" vessels, like tugs, trawlers and dredgers, Wärtsilä controllable pitch propellers give both better pull and higher ship speed, because adjusting the pitch makes it possible to absorb full power both at low and high ship speeds.

Finally Wärtsilä controllable pitch propellers have high manoeuvring and dynamic positioning (DP) capabilities. At low ship speeds the controllable pitch propeller makes more power available than the fixed pitch propeller, and astern thrust is easily achieved using only the reverse pitch setting.

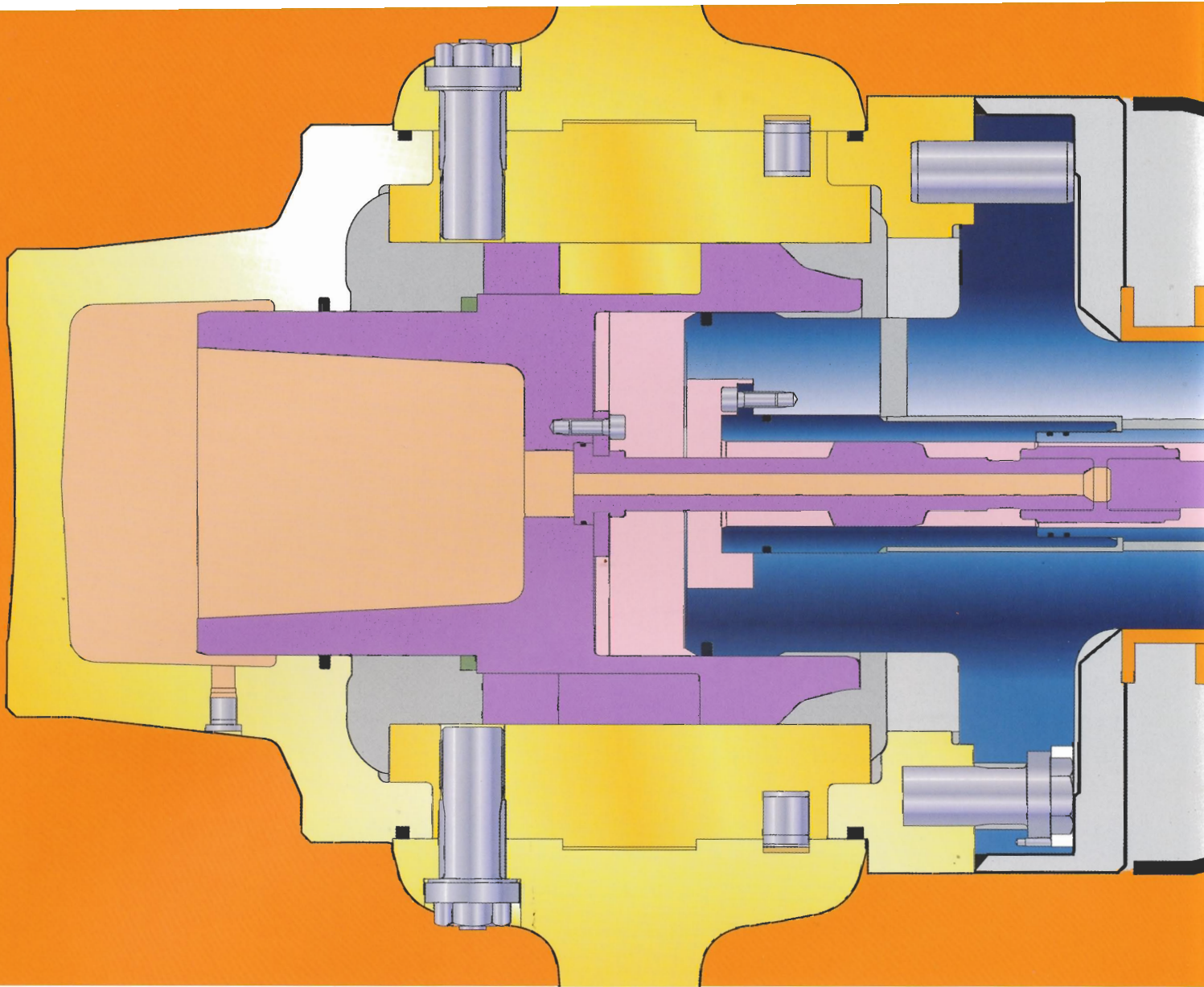
WÄRTSILÄ NOZZLES

Wärtsilä propellers can be applied for running in a nozzle. The advantage of using nozzles comes from the additional amount of thrust this develops. Various types of nozzles can be supplied, such as the standard types 19A and 37 and also the LIPS HR high-efficiency nozzle. The latter delivers higher thrust (6-8%) both in bollard and sailing conditions. Taking full advantage of a LIPS HR nozzle requires using a special blade design.

CPP OPTIMISED FOR COMBINATION WITH ENGINE



Characteristic curve of a controllable pitch propeller.



WÄRTSILÄ CONTROLLABLE PITCH PROPELLERS WITH LIPS D-HUB

FEATURES AND BENEFITS

- One-piece hub casting with integrated hub cover
 - Extra rigidity and robust construction
 - Low maintenance
- Double oil pipes
 - No water in hub in case of sterntube sealing leakage
 - Safe operation and no interference with sterntube lubrication system
- Double support of cylinder
 - Reliable and low maintenance
- Well-proven blade foot sealing system
 - No leakage of oil
 - Low maintenance

Two types of OD boxes available, for mounting at forward end of gearbox, or for mounting in the shaftline

- Reliable and low maintenance
- The gear mounted OD box has a short (de)mounting length
- The shaft mounted OD box is suitable for direct-driven systems and for extremely long shaftlines
- Manual emergency pitch setting in ahead condition
 - Safe operation
- Mechanical and electrical pitch feedback
 - Redundancy for safe operation
- Hydraulic flange coupling

- Easy (de)mounting of shafting and oil pipes
- Easy alignment of gearbox and engine
- Reliable and safe operation
- Integrated hydraulic power pack or integrated hydraulic system mounted on gearbox
 - Easy installation and maintenance
 - Safe operation
 - Bumpless pitch control through use of proportional valve.

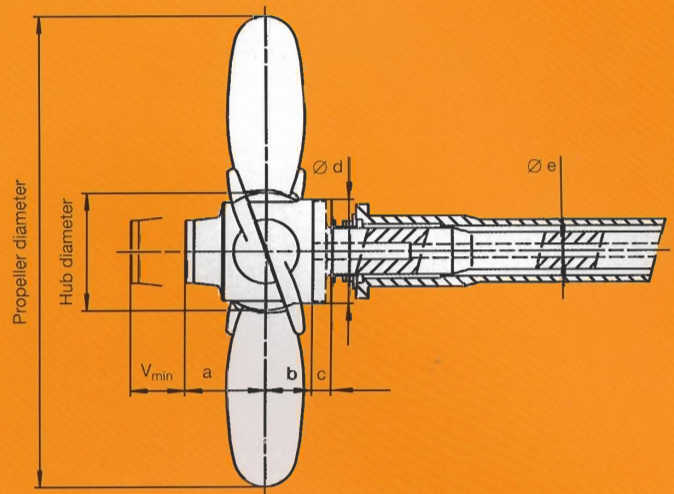
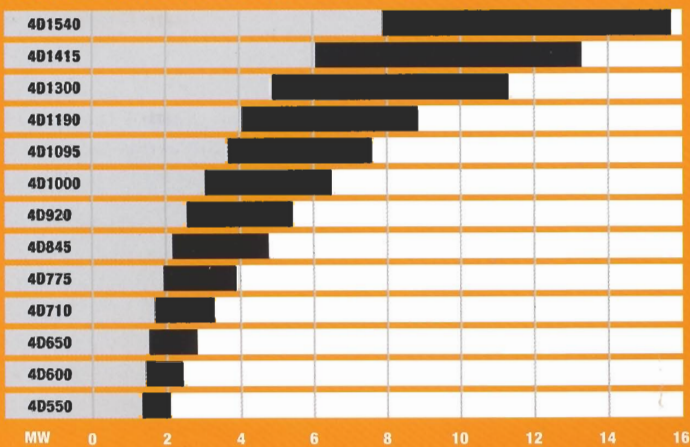


Single-screw RoRo vessel, cargo Spaarneborg.



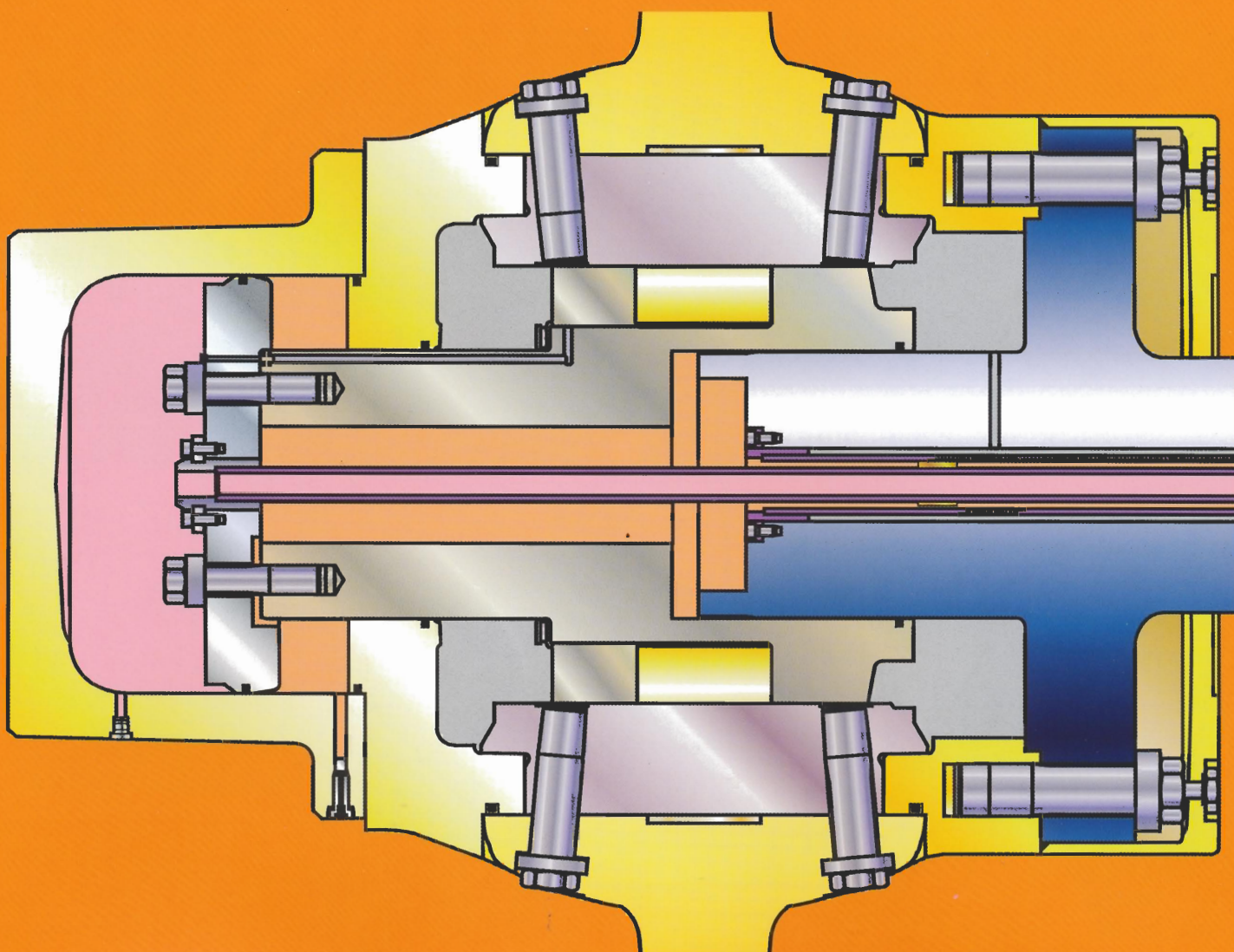
D-hub in machine shop.

PROPELLER HUB RANGE FOR LIPS D-HUB



DIMENSIONS OF LIPS D-HUB (IN MM)

Type	Hub diameter	Dimensions					
		a	b	c	d	e	V _{min}
4D550	550	402	219	100	506	65	320
4D600	600	432	238	107	546	65	335
4D650	650	467	258	114	586	65	365
4D650	650	467	258	114	586	100	365
4D710	710	506	280	120	636	100	385
4D775	775	550	304	135	690	100	405
4D845	845	574	332	143	745	100	410
4D920	920	631	361	154	824	100	435
4D1000	1000	674	392	162	884	115	460
4D1095	1095	735	427	182	963	115	490
4D1190	1190	798	465	194	1052	115	525
4D1300	1300	859	508	207	1137	130	575
4D1415	1415	933	551	283	1229	130	610
4D1540	1540	1016	600	300	1332	130	655



WÄRTSILÄ CONTROLLABLE PITCH PROPELLERS WITH LIPS E-HUB

FEATURES AND BENEFITS

- Streamlined hub contour
 - Reduction of fuel consumption
 - No cavitation
 - Well suited for high ship speeds
- Non-split hub casting with loose hub cover
 - Extra rigidity and robust construction
 - Low and easy maintenance
- Steel blade carriers
 - Reduction of fuel consumption due to lower propeller / hub diameter ratio and higher propeller efficiency
- Double oil pipes
 - No water in hub in case of sterntube sealing leakage
 - Safe operation and no interference with sterntube lubrication system

- Double support of cylinder
 - Reliable and low maintenance
- Well-proven blade foot sealing system
 - No leakage of oil
 - Low maintenance

Two types of OD boxes available, for mounting at forward end of gearbox, or for mounting in the shaftline

- Reliable and low maintenance
- The gear mounted OD box has a short (de)mounting length
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- Manual emergency pitch setting in ahead condition
 - Safe operation

- Mechanical and electrical pitch feedback
 - Redundancy for safe operation
- Hydraulic flange coupling
 - Easy (de)mounting of shafting and oil pipes
 - Easy alignment of gearbox and engine
 - Reliable and safe operation
- Integrated hydraulic power pack or integrated hydraulic system mounted on gearbox
 - Easy installation and maintenance
 - Safe operation
 - Bumpless pitch control through use of proportional valve.

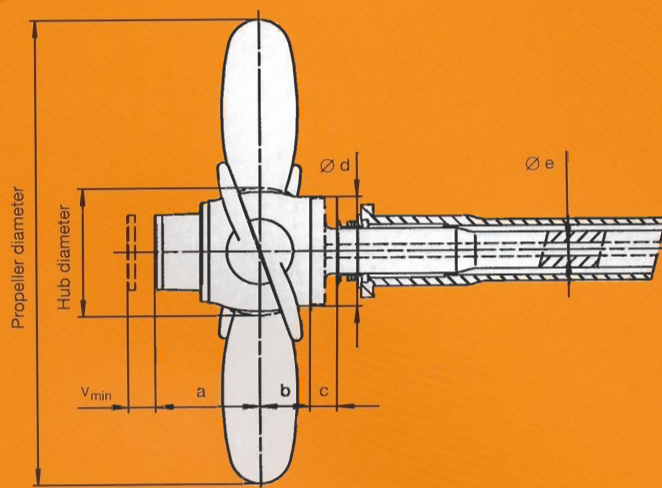


Twin-screw passenger ferry Pont Aven.



E-hub type 4E1415.

PROPELLER HUB RANGE FOR LIPS E-HUB



DIMENSIONS OF LIPS E-HUB (IN MM)

Type	Hub diameter	Dimensions					
		a	b	c	d	e	V _{min}
4E1000	1000	884	433	236	926	115	245
4E1095	1095	961	470	256	1014	115	260
4E1190	1190	1043	502	272	1096	115	275
4E1300	1300	1127	548	295	1201	130	295
4E1415	1415	1225	589	314	1298	130	320
4E1540	1540	1346	638	337	1415	160	345
4E1680	1680	1466	686	362	1544	160	375
4E1835	1835	1584	745	397	1679	160	400
4E1915	1915	1650	777	412	1752	160	415
4E2000	2000	1724	810	430	1825	190 (160)	435
4E2085	2085	1785	846	454	1907	190 (160)	450

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.

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