CP Propeller Equipment

Contents:

MAN B&W Diesel A/S, Alpha, Denmark

CP Propeller Equipment

Introduction

The purpose of this Product Information brochure is to act as a guide in the project planning of the MAN B&W Alpha propeller equipment.

The brochure gives a description of the basic design principles of the MAN B&W Alpha controllable pitch (CP) propeller equipment. It contains dimensional sketches, thereby making it possible to work out shaft line and engine room arrangement drawings. Furthermore, a guideline to some of the basic layout criteria is given.

Our design department is available with assistance concerning speed and bollard pull prognoses, determining power requirements from the propeller, as well as advice on more specific questions like installation aspects and different modes of operation.

All our product range is constantly under review, being developed and improved as needs and conditions dictate.

We therefore reserve the right to make changes to the technical specification and data without prior notice.

In connection with the propeller equipment the Alphatronic Control System is applied. Special literature covering this field can be forwarded on request.

General Description

MAN B&W Alpha have manufactured more than 6,500 controllable pitch propellers of which the first was produced in 1902.

In 1903 a patent was taken out covering the principle of the CP propeller. Thus more than a century of experience is reflected in the design of the present MAN B&W Alpha propeller equipment.

The basic design principles are well-proven, having been operated in all types of vessels including ferries, tankers, container, cruise, supply vessels and navy ships many of which comply with high classification requirements.
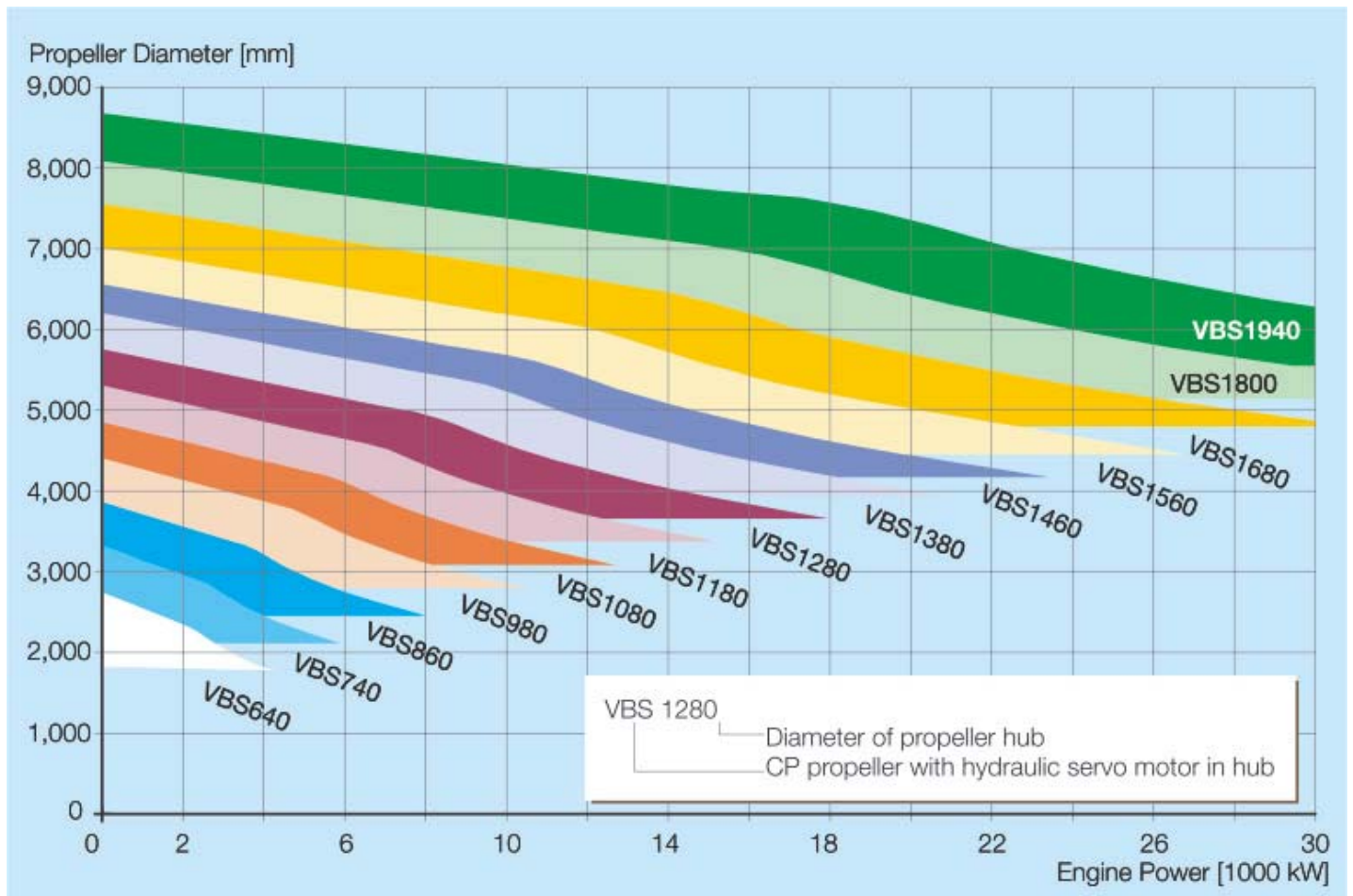

Fig. 1: VBS propeller programme

Today the MAN B&W Alpha controllable pitch propeller equipment portfolio handle engine output up to 30,000 kW, fig 1.

Controllable pitch propellers can utilize full engine power by adjusting blade pitch irrespective of revolutions or conditions.

They offer not only maximum speed when free sailing, but also maximum power when towing, good manoeuvrability with quick response via the Alphatronic control system and high astern power.

These are just a few of many advantages achieved by controllable pitch propellers.

Propeller equipment

The standard propeller equipment comprises a four bladed CP propeller complete with shafting, stern tube, outer and inboard seals, oil distributor (OD) box and coupling flange.

The location of the OD-box depends on the propeller and propulsion configuration.

Propeller type VBS

The present version of the MAN B&W Alpha propeller equipment is designated VBS and was introduced in 1996. It features an integrated servo motor located in the aft part of the hub and sturdy designed internal components.

A well-distributed range of different hub sizes makes it possible to select an optimum hub for any given combination of power, revolutions and ice class. The different hub sizes are in principle geometrical similar and incorporate large servo piston diameter with low pressure and reaction forces and few components, while still maintaining short overall installation length.

- Oil Distributor box
The VBS propeller equipment can be supplied with three different oil distribution systems for controlling the pitch de pending on the type of propulsion system i.e. direct driven two-stroke or geared four-stroke. All three types incorporate the possibility for emergency
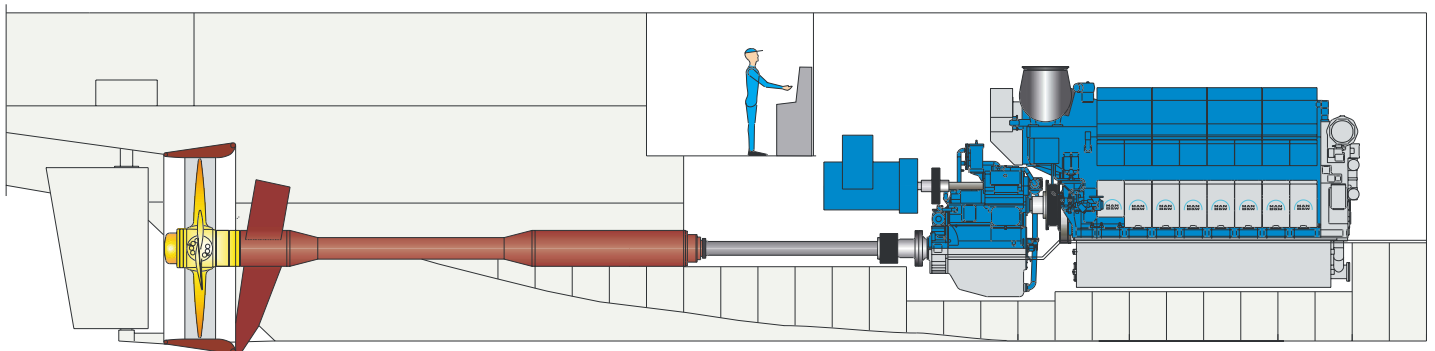

Fig. 2: Propeller equipment type VBS-ODG (8L27/38 engine, AMG28EV reduction gear, VBS860 propeller)
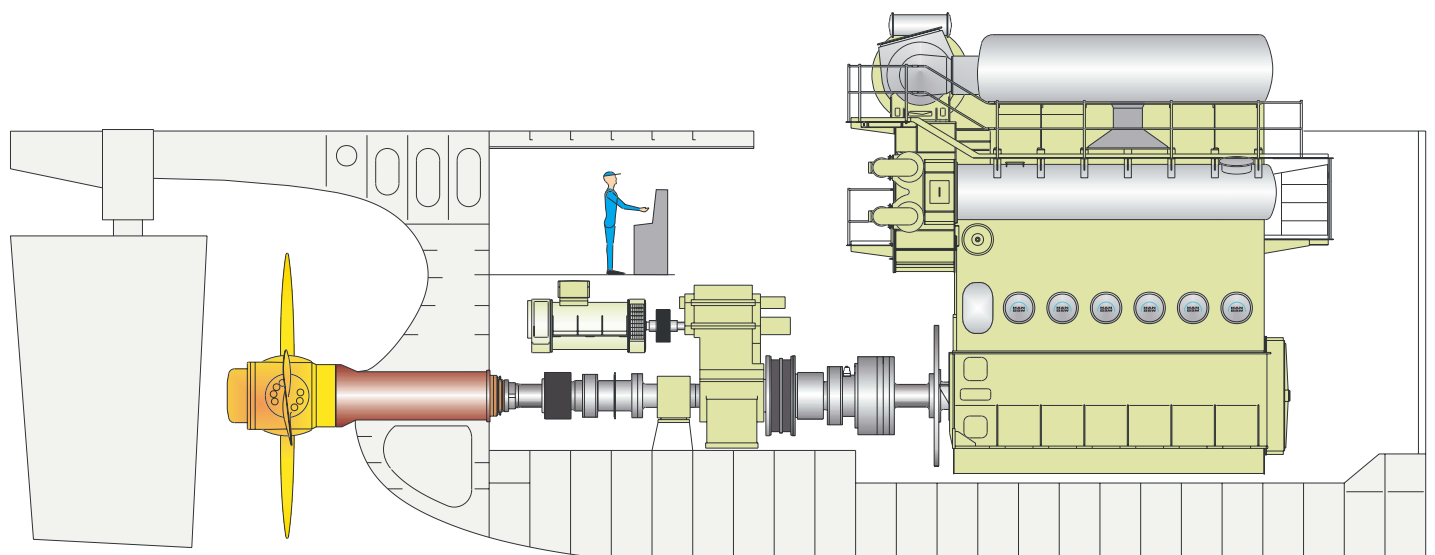

Fig. 3: Propeller equipment type VBS - ODS (6S42MC engine, Tunnel gear, Alpha Clutcher, VBS1380 propeller)

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operation and a valve box that will keep the propeller pitch fixed in case the hydraulic oil supply is interrupted. The latter is required by classification societies and will prevent the propeller blades from changing the pitch setting.

- ODS - Shaft mounted OD-box

For direct driven propellers without reduction gearboxes the oil distribution box must be located in the shaft line.

The ODS type is intended for this type of installations and features beside the oil inlet ring a hydraulic coupling flange, pitch feed-back and the valve box. The unit design ensures short installation length and all radial holes and slots are located on the large diameter coupling flange and are carefully designed to avoid stress raisers.

- ODF - Gearbox mounted OD-box

For geared four-stroke propulsion plants the oil distribution box is usually located on the forward end of the reduction gearbox.

The ODF contains the same elements as the ODS type and comes in different sizes according to the selected type of VBS propeller equipment.

For long shaft lines with one or more intermediate shafts it is recommended to use the ODS type of oil distribution that will ensure a short feed-back system leading to a more precise control of the pitch setting.

- ODG - Gearbox integrated OD-box

For MAN B&W designed gearboxes (AMG, Alpha Module Gears) the oil distribution and pitch control system is an integral part of the gearbox. Apart from the stand-by pump no external hydraulic power unit is needed thus facilitating a simple and space saving installation.
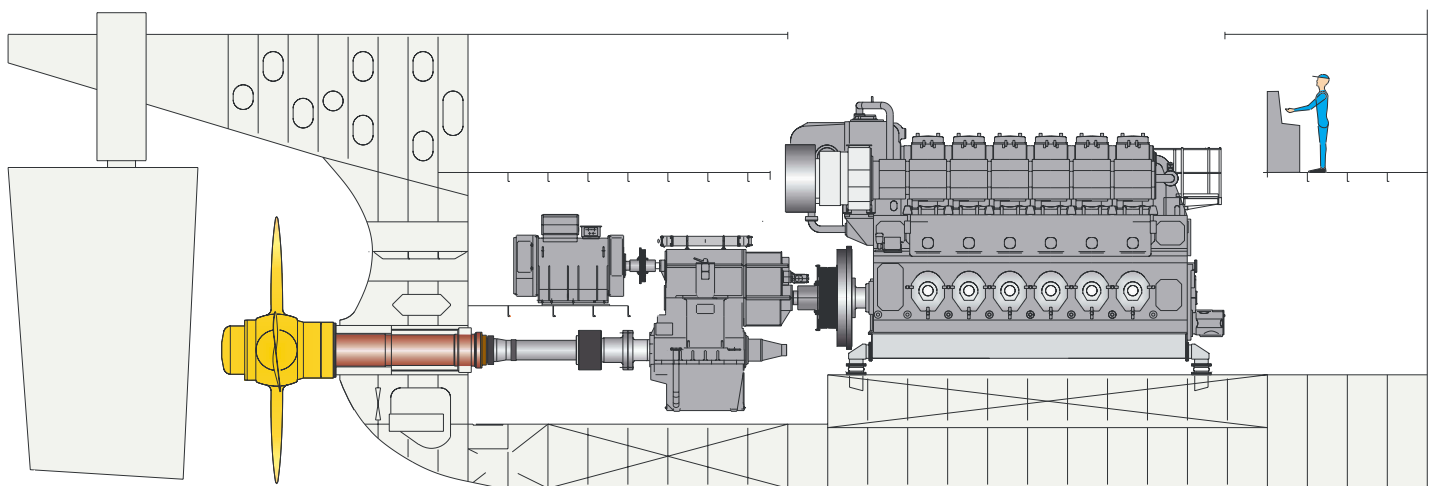

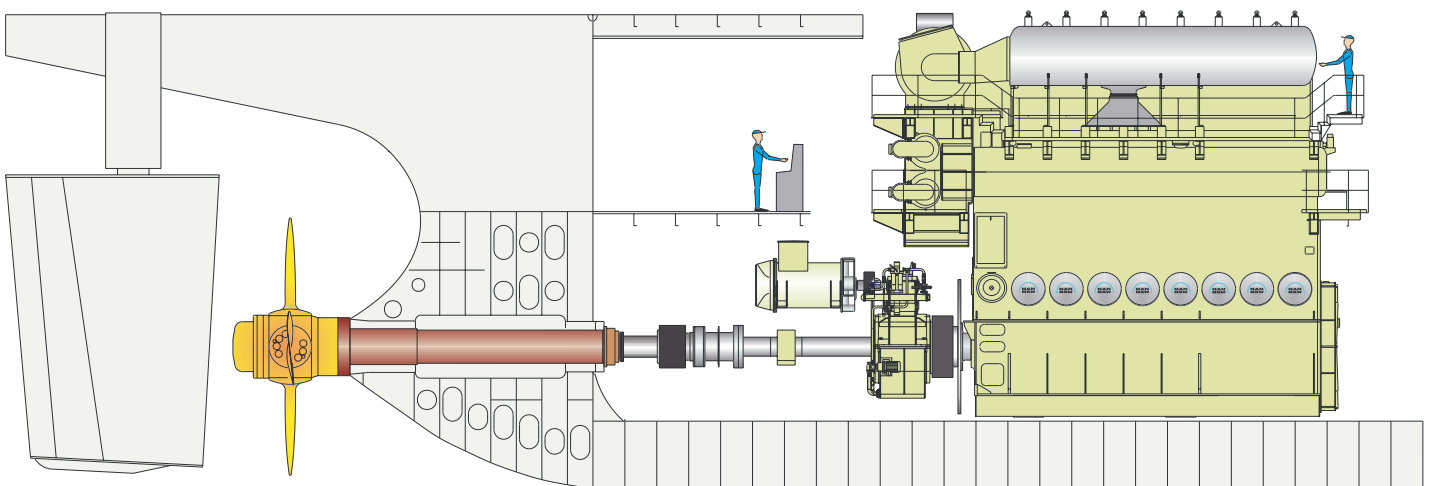Fig. 4: Propeller equipment type VBS - ODF (6L48/60B engine, reduction gear, VBS1380 propeller)

Fig. 5: Propeller equipment type VBS - ODS (8S50MC-C engine, Renk tunnel gear, VBS1680 propeller)
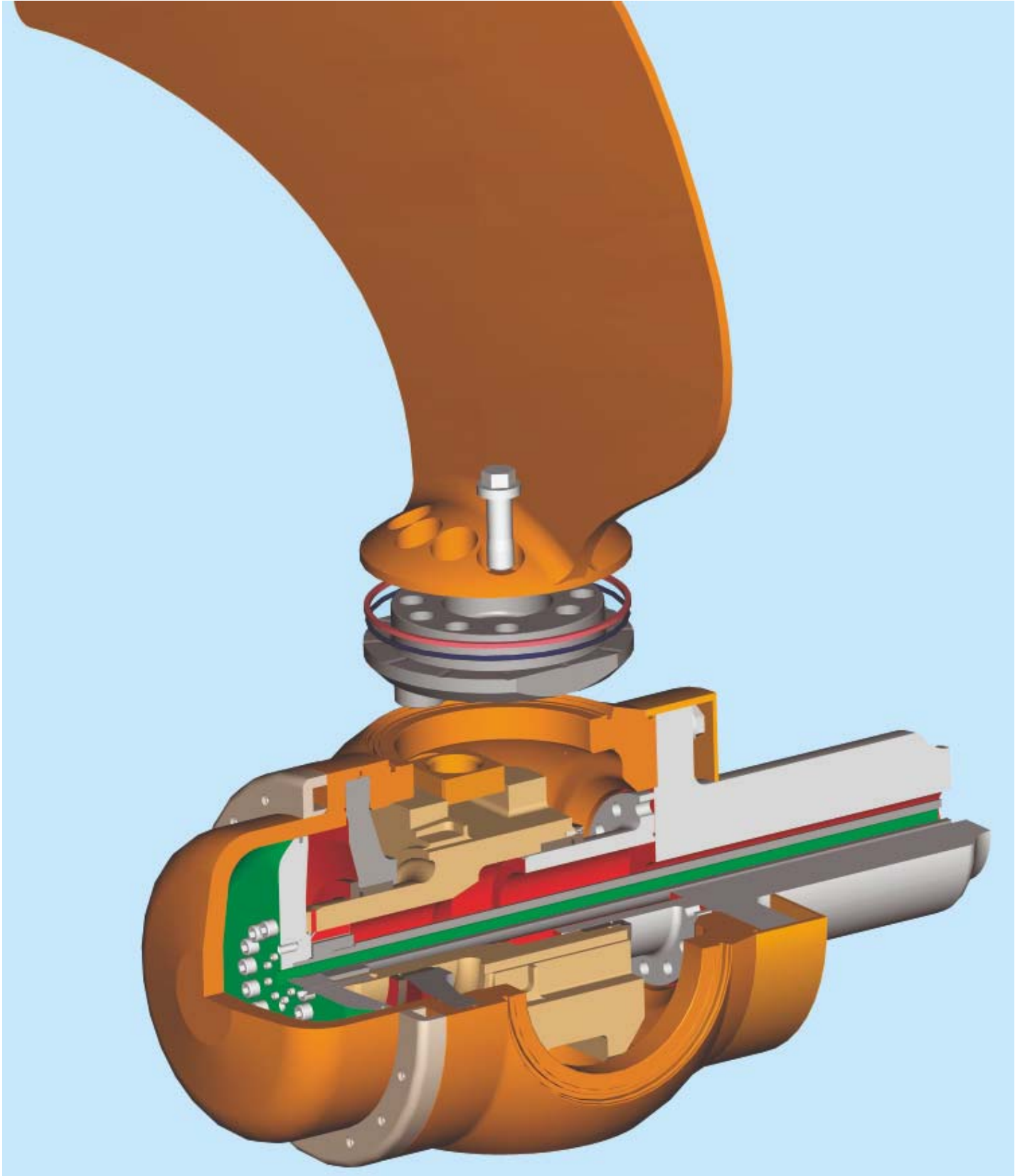
Fig. 6: Propeller hub type VBS

Mechanical Design

Hub design

The hydraulic servo motor for pitch setting is an integral part of the propeller hub. The design is shown in fig 6. The propeller hub is bolted to the flanged end of the tailshaft, which is hollow bored to accommodate the servo oil and pitch feed-back tube. The servo piston which is bolted to the pitch control head, forms the hydraulic servo motor together with the propeller cap.

The high pressure servo oil system at the aft end of the hub is completely isolated from the pitch regulating mechanism and thus also from the blade flanges, which means that the blade sealings only are subjected to gravitation oil pressure.

By using a large servo piston diameter and balanced blade shapes, the oil pressure and reacting forces are minimized.

Blade sealing rings are placed between blade foot and hub, fig 7. A compressed O-ring presses a PTFE (teflon) slide ring against the blade foot.

This design ensures maximum reliability and sealing without leakages, also under extreme abrasive wear conditions.

Optionally an intermediate flange can be inserted, by which underwater replacement of propeller blades is possible.

For servicing and inspection of the internal parts, the hub remains attached to the shaft flange during disassembly thereby reducing time and need for heavy lifting equipment. Access to all internal parts is even possible without dismantling the propeller blades thus reducing the time for inspection and maintenance during docking.

A hydraulic tube, located inside the shafting, is connected to the piston. With hydraulic oil flowing through the tube, oil
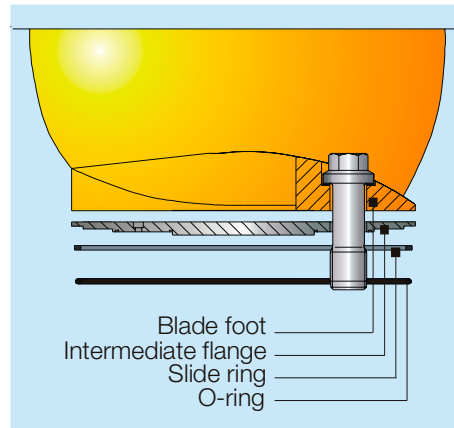

Fig. 7: Blade sealing rings

is given access into the after section of the propeller hub cylinder, displacing the servo piston forward, into an ahead pitch position. The displaced hydraulic oil from forward of the piston is returned via the annular space between the tube and shaft bore to the oil tank. Reverting the flow directions will move the propeller in astern position.

OD-Box Design

ODS type

The shaft mounted unit, fig. 8, consists of coupling flange with OD-ring, valve box and pitch feed-back ring. Via the oil distribution ring, high pressure oil is supplied to one side of the servo piston and the other side to the drain.The piston is hereby moved, setting the desired propeller pitch. A feed-back ring is connected to the hydraulic pipe by slots in the coupling flange. The feed–back ring actuates one of two displacement transmitters in the electrical pitch feed-back box which measures the actual pitch.

The inner surface of the oil distribution ring is lined with white-metal. The ring itself is split for easy exchange without withdrawal of the shaft or dismounting of the hydraulic coupling flange.

The sealing consists of mechanical throw-off rings which ensures that no wear takes place and that sealing rings of V-lip-ring type or similar are unnecessary.

The oil distributor ring is prevented from rotating by a securing device comprising a steel ball located in the ring.

Acceptable installation tolerances are ensured and movement of the propeller shaft remains possible.

In the event of failing oil pressure or fault in the remote control system, special studs can be screwed into the oil distribution ring hereby making manual oil flow control possible. A valve box located at the end of the shaft ensures that the propeller pitch is maintained in case the servo oil supply is interrupted.

ODF type

The gearbox mounted unit, fig 9, consists in principle of the very same mechanical parts as the ODS type. However, the pitch feed-back transmitter is of the inductive type that operates contactless and thus without wear.

The drain oil from the oil distribution is led back to the hydraulic power unit tank.

ODG type

The gearbox-integrated unit, fig 10, consists in principle also of the very same parts as the ODF type. The main difference is the use of the gearbox sump as oil reservoir for both the propeller and gearbox.
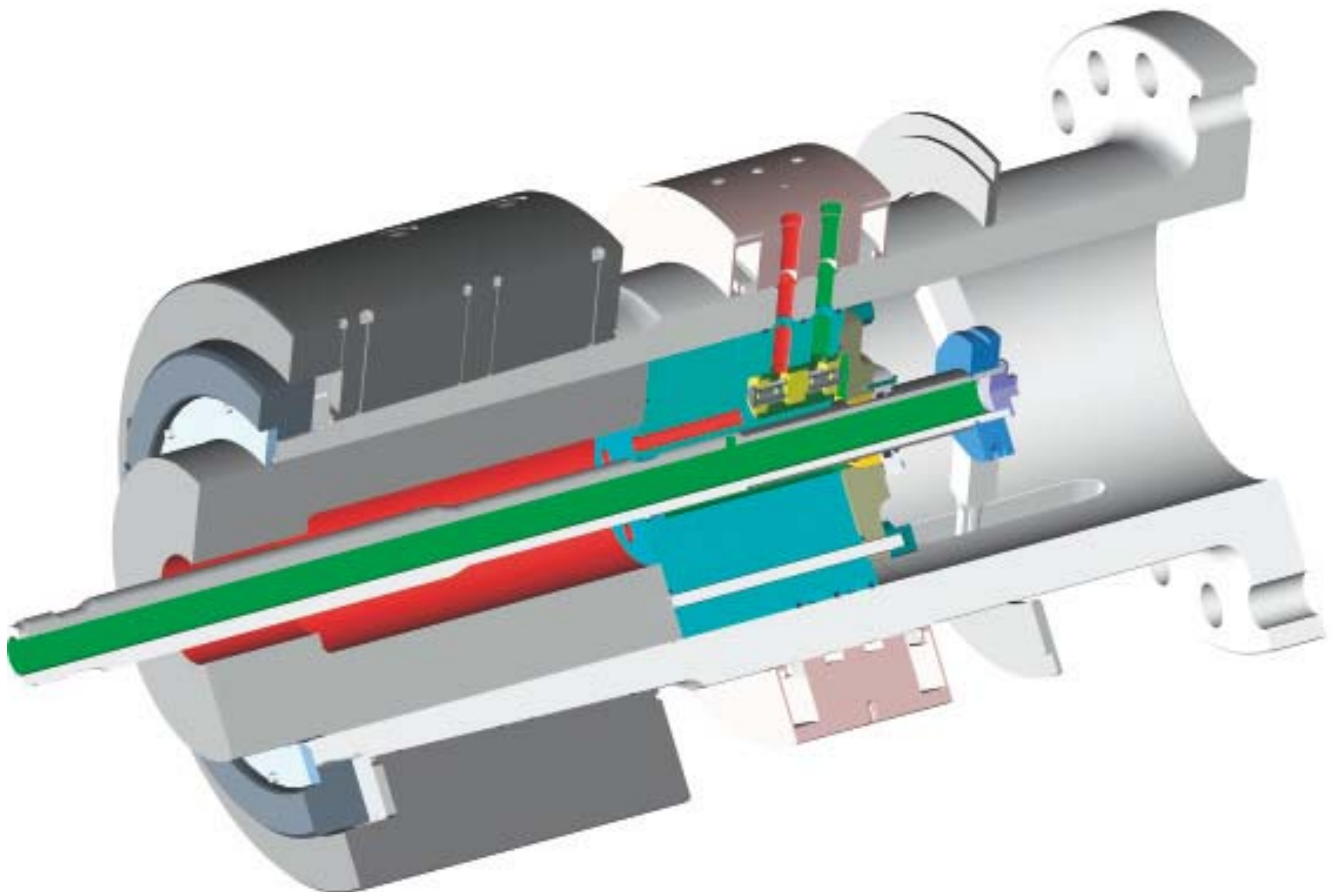

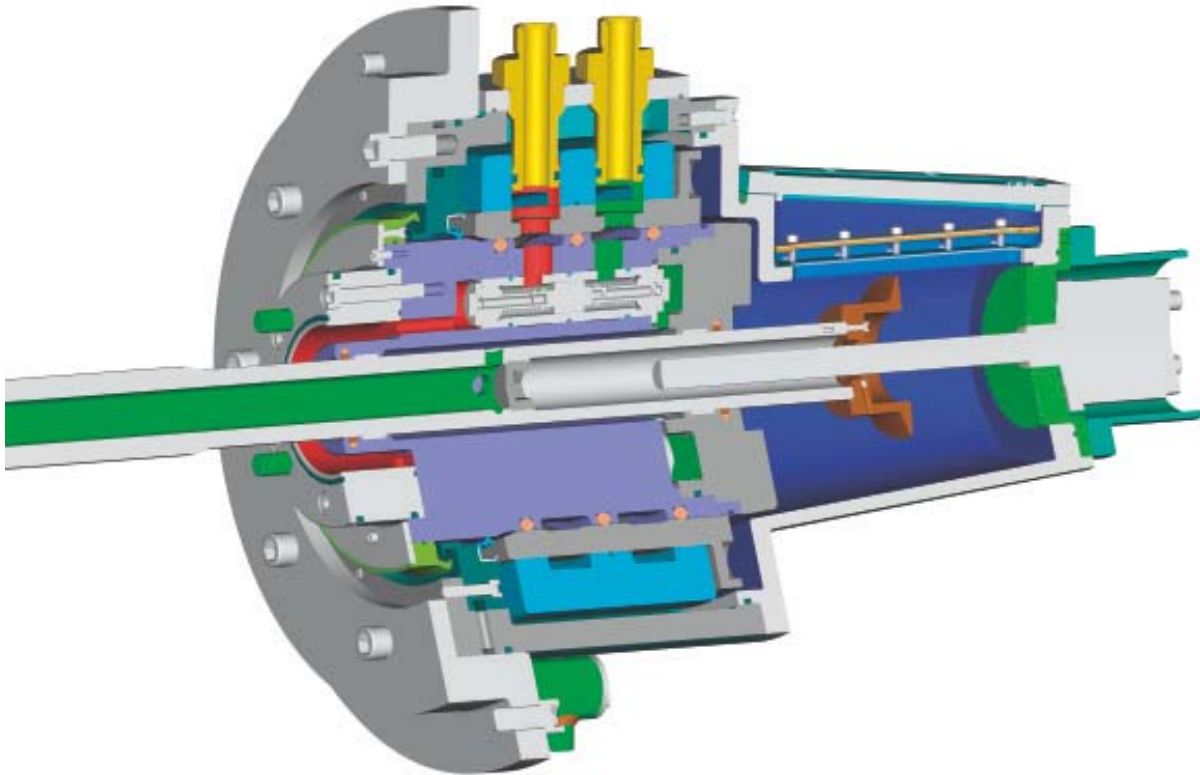*Fig. 8: ODS type - OD box with coupling flange and pitch feed-back ring*

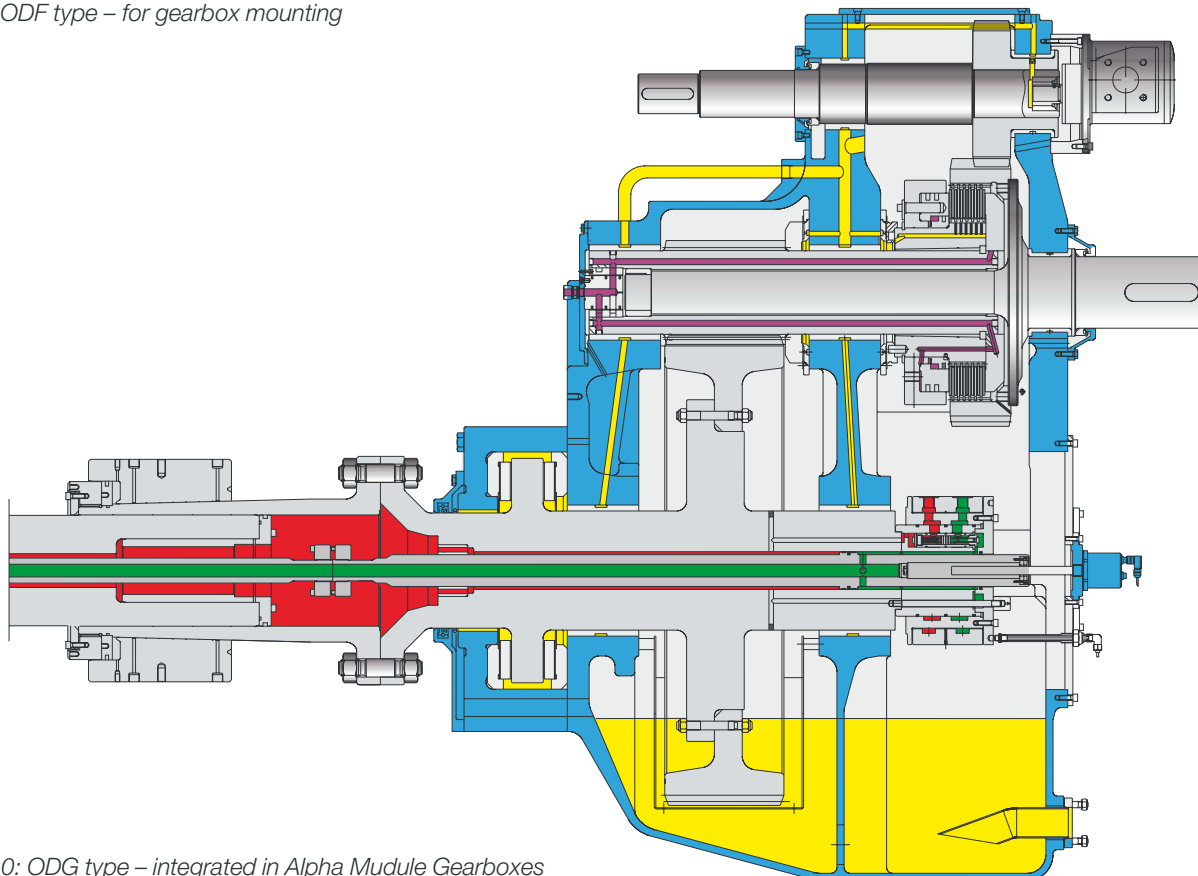Fig. 9: ODF type – for gearbox mounting

Fig. 10: ODG type – integrated in Alpha Mudule Gearboxes

Servo Oil System
ODS-ODF-ODG

A servo oil pump delivers high pressure oil to a valve unit consisting of non return valves, safety valve, pressure adjusting valve and an electrical operated proportional valve. This proportional valve, which is used to control the propeller pitch can also be manually operated.

From the proportional valve the servo oil is led to an oil distributor ring. Servo oil is also used for lubricating and cooling of this ring. This excess servo oil is led back in the servo oil system.

From the oil distributor ring high pressure oil is led through pilot operated double check valves to one or the other side of the servo piston, until the desired propeller pitch has been reached.

The pilot operated double check valves keep the propeller pitch fixed in case the servo oil supply is interrupted.

The propeller is equipped with an electrical pitch feed-back transducer. This feed-back signal is compared to the order signal to maintain the desired pitch.

The pitch setting is normally remotely controlled, but local emergency control is possible.

Hydraulic Power Unit (ODS - ODF)

Hydraulic Power Unit, fig 11, consists of an oil tank with all components top mounted, to facilitate installation at yard.

Two electrically driven pumps draw oil from the oil tank through a suction filter and deliver high pressure oil to the proportional valve through a duplex full flow pressure filter. One of the 2 pumps is in service during normal operation. A sudden change of manoeuvre will start up the second pump; this second
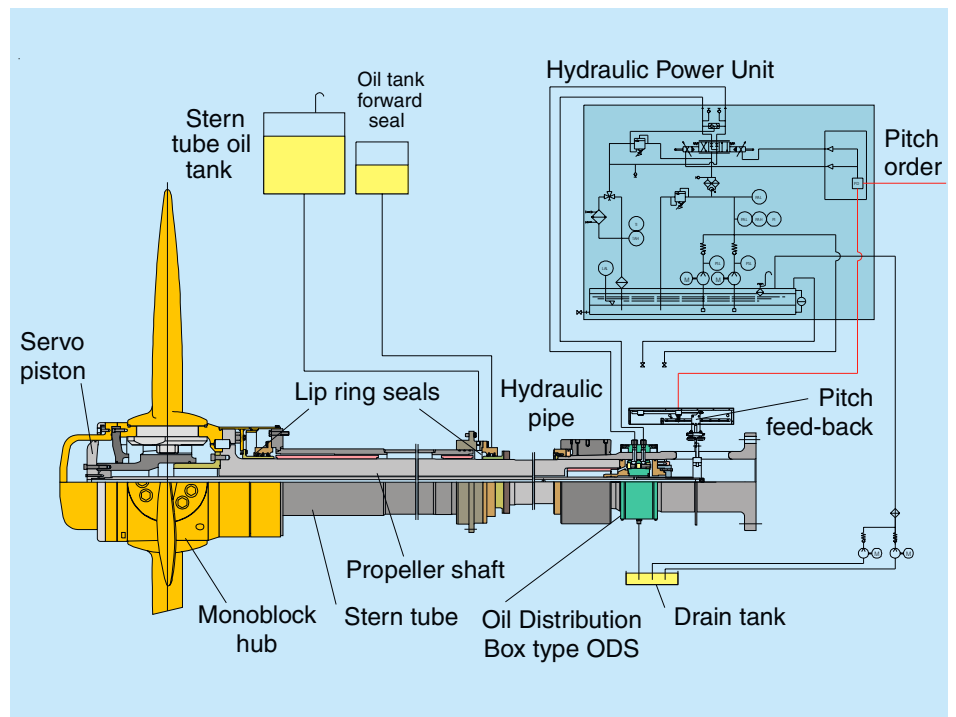

Fig. 11: Hydraulic Power Unit

Fig. 12a: Propeller equipment type VBS - ODS

pump also serves as a stand-by pump. A servo oil pressure adjusting valve ensures minimum servo oil pressure constantly, except during pitch changes, hereby minimizing the electrical power consumption. Maximum system pressure is set on the safety valve.

The return oil is led back to the tank through a cooler and a filter. The servo oil unit is equipped with alarms according to the Classification Society as well as necessary pressure and temperature indication.

Hydraulic system, ODG

The hydraulic components of the ODG type are built on the gearbox and the propeller control valves form together with the gearbox hydraulics an integrated system. The same functions as described by the ODS-ODF type are available with the ODG integrated solution - the major difference being the common oil sump for both the propeller and the gearbox.

In addition to the gearbox driven oil pump, an electric stand-by pump will automatically start-up in the event of missing servo oil pressure.

Lubricating oil system, VBS

The stern tube and hub lubrication is a common system. The stern tube is kept under static oil pressure by a stern tube oil tank placed above sea level, see fig. 12 a, b and c.

As an option the propeller can be supplied with two separate systems for lubrication of hub and stern tube.

All MAN B&W Alpha propeller equipment with seals of the lip ring type operates on lub oil type SAE 30/40 - usually the same type of lubricating oil as used in the main engine and/or reduction gear.
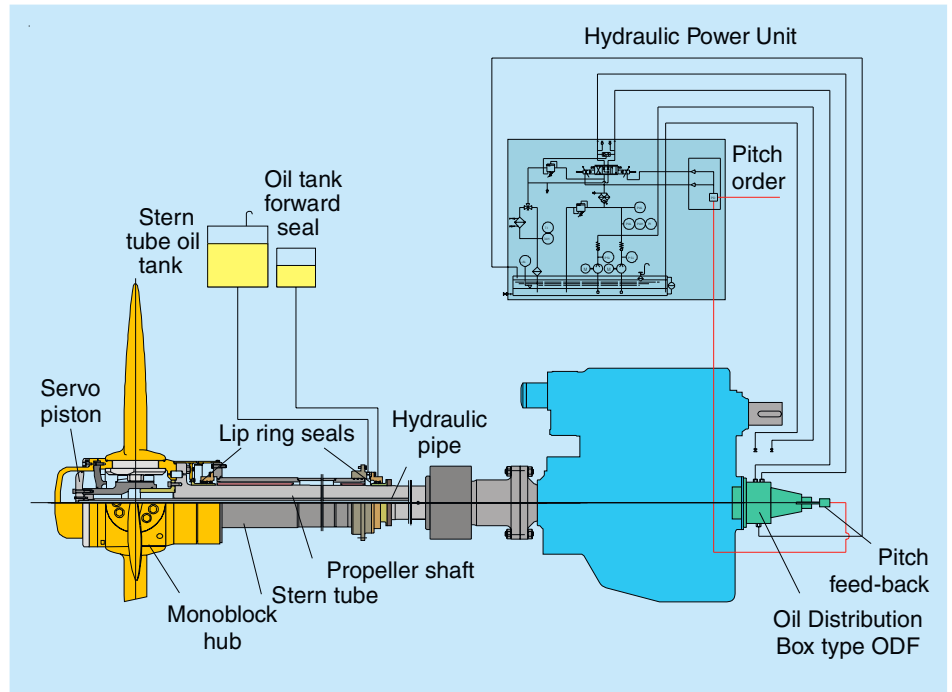

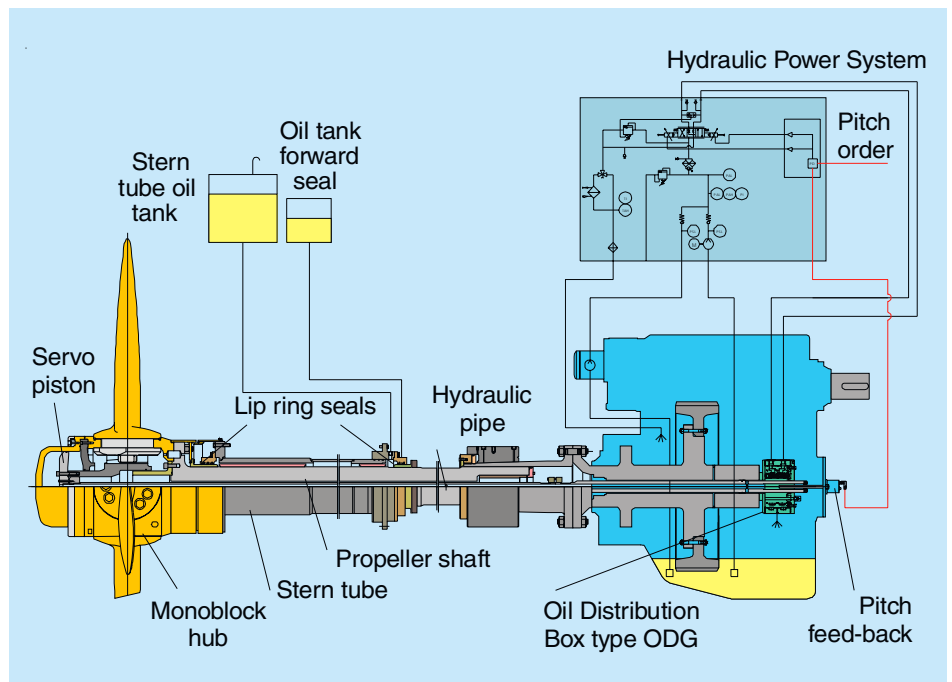
Fig. 12b: Propeller equipment type VBS - ODF

Fig. 12c: Propeller equipment type VBS - ODG

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Propeller Shaft and Coupling Flange

The tailshaft is made of normalized and stress relieved forged steel, table 1.

Material		Forged steel type S45P
Yield strength	N/mm²	minimum 350
Tensile strength	N/mm²	minimum 600
Elongation	%	minimum 18
Impact strength Charpy V-notch	J	minimum 18

Table 1

The tailshaft is hollow bored, housing the servo oil pipe.

The distance between the aft and forward stern tube bearings should generally not exceed 20 times the diameter of the propeller shaft. If the aft ship design requires longer distances, special counter-measures may be necessary to avoid whirling vibration problems.

Coupling flange

For connecting the tail shaft a hydraulic coupling flange is used, fig 13. To fit the flange high pressure oil of more than 2,000 bar is injected between the muff and the coupling flange by means of the injectors in order to expand the muff.

By increasing the pressure in the annular space C, with the hydraulic pump, the muff is gradually pushed up the cone.

Longitudinal placing of the coupling flange as well as final push-up of the muff are marked on the shaft and the muff.

Stern tube

The standard stern tube is designed to be installed from aft and is press-fitted and bolted to the stern frame boss, fig 14.
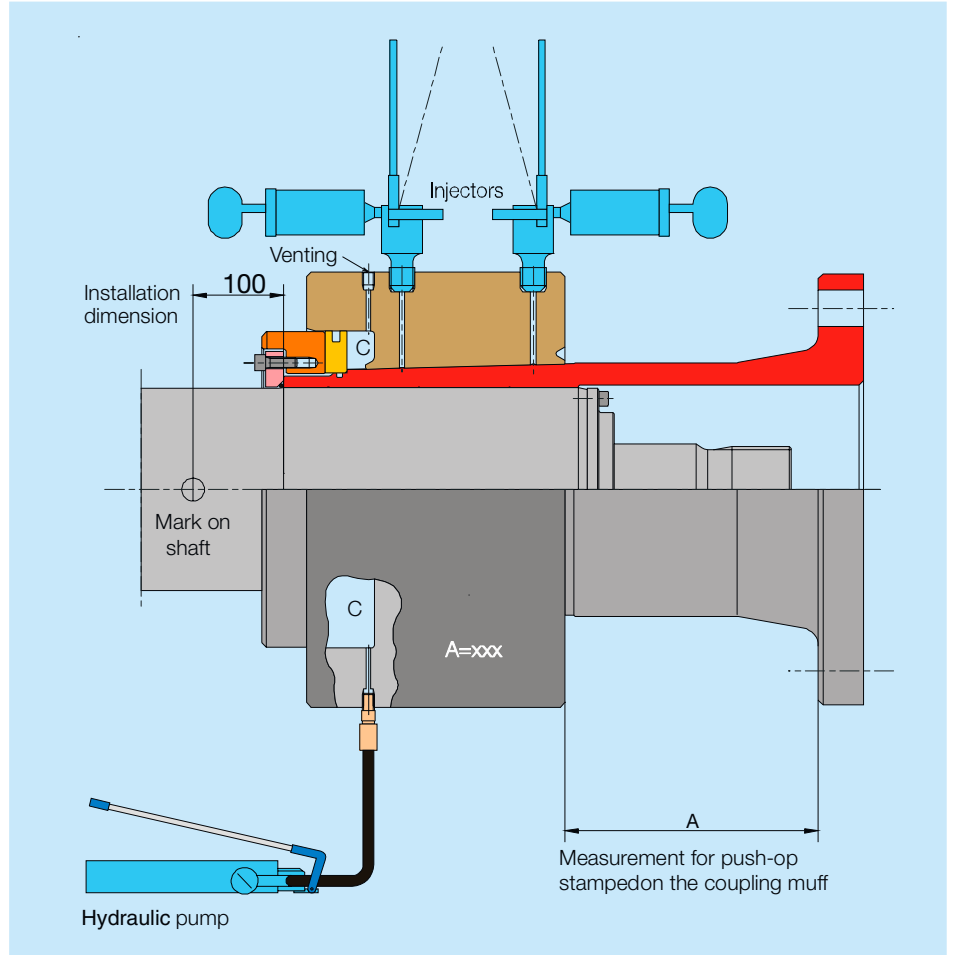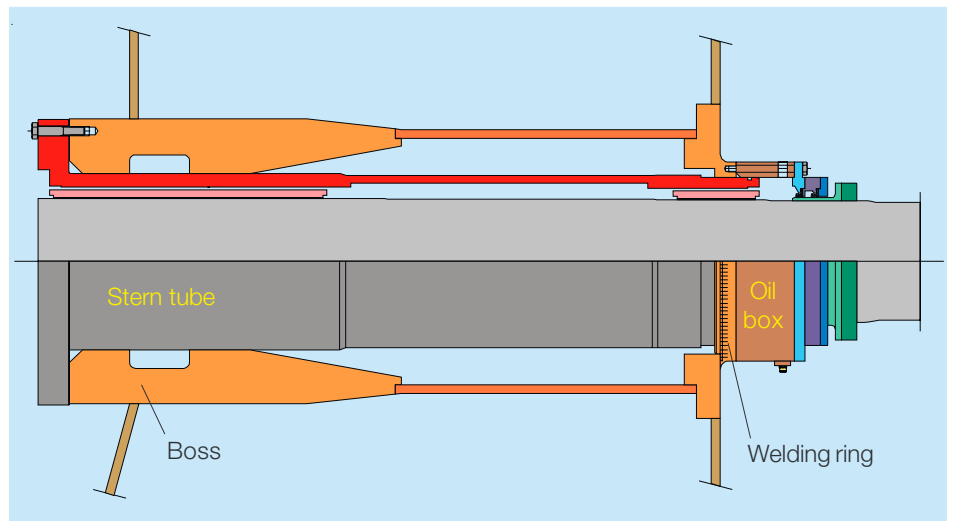

Fig. 13: Shrink fitted coupling flange

Fig. 14: Standard stern tube – VBS

Cast-Iron   Lead-based
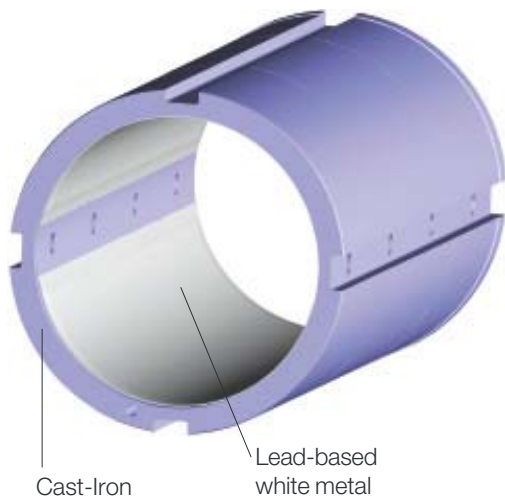   white metal

Fig. 15: Stern tube white metal liner

The forward end of the stern tube is supported by the welding ring.

The oilbox and the forward shaft seal are bolted onto the welding ring. This design allows thermal expansion/contraction of the stern tube and decreases the necessity for close tolerances of the stern tube installation length.

Normally the stern tube is supplied with 5 mm machining allowance for yard finishing.

The stern tube can be supplied machined and finished, if required.

As an option the stern tube can be installed with epoxy resin.
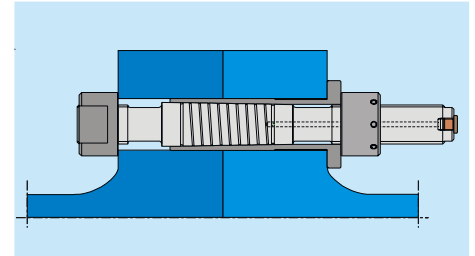
Fig. 17: Hydraulic fitted bolt

Liners

The stern tube is provided with forward and aft white metal liners, fig 15. Sensors for bearing temperature can be mounted, if required. A thermometer for the forward bearing is standard.

Seals

As standard, the stern tube is provided with forward and after stern tube seals of the lip ring type having three lip rings in the after seal and two lip rings in the forward seal, fig 16.

Hydraulic bolts

The propeller equipment can be supplied with hydraulic fitted bolts for easy assembly and disassembly, fig 17. Machining of holes is simple, reaming or honing is avoided.

Installation

Installation of propeller equipment into the ship hull can be done in many different ways as both yards and owners have different requirements of how to install and how to run the propeller equipment. Other designs of stern tube and/or shaft sealings may be preferred. MAN B&W Alpha are available with alternatives to meet specific wishes or design requirements.
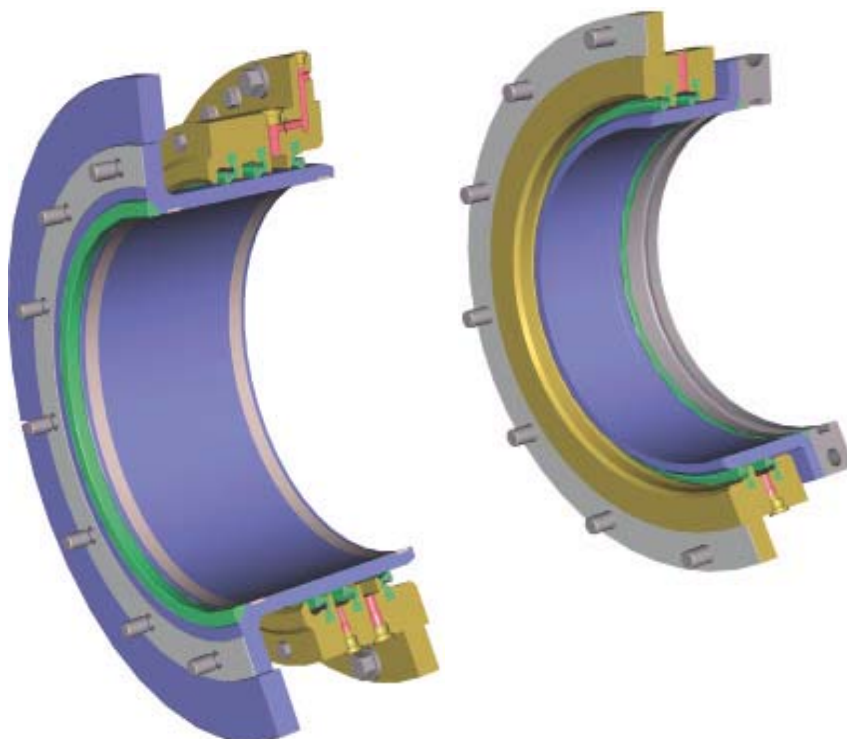
Fig. 16: Stern tube seals

Propeller Blade Manufacturing and Materials

The international standard organization has introduced a series of manufacturing standards in compliance with which propellers have to be manufactured (ISO 484). The accuracy class is normally selected by the customer and the table below describes the range of manufacturing categories.

Class	Manufacturing accuracy
S	Very high accuracy
I	High accuracy
II	Medium accuracy
III	Wide tolerances

If no Class is specified, the propeller blades will be manufactured according to Class I but with surface roughness according to Class S.

At MAN B&W Alpha the propeller blades are checked by computerized four-axis measuring equipment.

Blade materials

Propeller blades are made of either NiAl–bronze (NiAl) or stainless steel (CrNi). The mechanical properties of each material at room temperature are:

Material		NiAl	CrNi
Yield strength	N/mm²	min 250	min 380
Tensile strength	N/mm²	min 630	660-790
Elongation	%	min 16	min 19
Impact strength Kv at -10 °C	Joules	21	21
BrinellHardness	HB	min 140	240-300

Both materials have high resistance against cavitation erosion. The fatigue characteristics in a corrosive environment are better for NiAl than for CrNi.

Propeller blades are, to a large degree, exposed to cyclically varying stresses.

Consequently, the fatique material strength is of decisive importance.

The dimensioning of a propeller blade according to the Classification Societies will give a 10% higher thickness for the CrNi compared to NiAl in order to obtain the same fatigue strength.

As an example the difference in thickness and weight for a propeller blade for engine type MAN B&W 6S35MC (4,200 kW at 170 r/min) is stated in table 2.

CrNi-steel requires thicker blades than NiAl-bronze, which is unfortunate from the propeller theoretical point of view (thicker = less efficiency). Additionally, the CrNi is more difficult to machine than NiAl.

For operation in ice the CrNi material will be able to withstand a higher force before bending due to its higher yield strength and for prolonged operations in shallow water the higher hardness makes it more resistant to abrasive wear from sand.

The final selection of blade and hub material depends on owners requirements and the operating condition of the vessel. In general terms the NiAl material is preferable for ordinary purposes whereas CrNi could be an attractive alternative for non-ducted propellers operating in heavy ice or dredgers and vessels operating in shallow waters.

Ice class		C		1A*	
Material		NiAl	CrNi	NiAl	CrNi
Thickness at r/R = 0.35	mm	132	146	169	187
Thickness at r/R = 0.60	mm	71	78	90	100
Thickness at r/R = 1.00	mm	0	0	15	13
Blade weight	kg	729	877	952	1053

Table 2: Classification Society: Det Norske Veritas
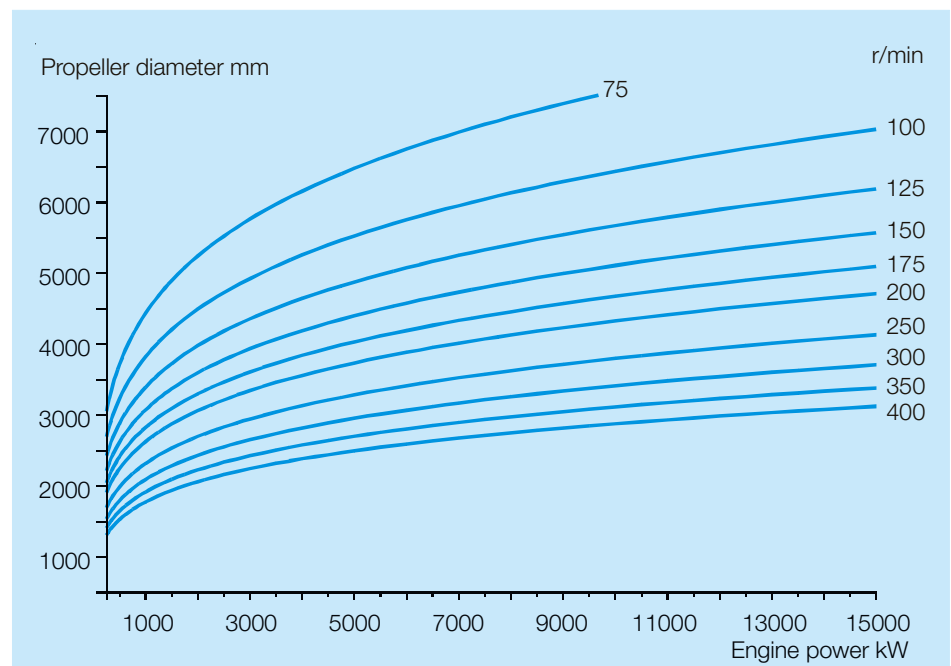

Fig. 18: Optimum propeller diameter

Optimizing Propeller Equipment

Propeller design

The design of a propeller for a vessel can be categorized in two parts:

- Optimizing the complete propulsion plant
- Hydrodynamic design of propeller blades

Optimizing the complete propulsion plant

The design of the propeller, giving regard to the main variables such as diameter, speed, area ratio etc, is determined by the requirements for maximum efficiency and minimum vibrations and noise levels.

The chosen diameter should be as large as the hull can accommodate, allowing the propeller speed to be selected according to optimum efficiency.

The optimum propeller speed corresponding to the chosen diameter can be found in fig 18 for a given reference condition (ship speed 12 knots and wake fraction 0.25).

For ships often sailing in ballast condition, demands of fully immersed propellers may cause limitations in propeller diameter. This aspect must be considered in each individual case.

To reduce emitted pressure impulses and vibrations from the propeller to the hull, MAN B&W Alpha recommend a minimum tip clearance as shown in fig 19.

The lower values can be used for ships with slender aft body and favourable inflow conditions whereas full after body ships with large variations in wake field require the upper values to be used.

In twin screw ships the blade tip may protrude below the base line.

The operating data for the vessel is essential for optimizing the propeller successfully, therefore it is of great importance that such information is available.

To ensure that all necessary data are known by the propeller designer, the data sheets on page 22 and 23, should be completed.

For propellers operating under varying conditions (service, max or emergency speeds, alternator engaged/disengaged) the operating time spent in each mode should be given.

This will provide the propeller designer with the information necessary to design a propeller capable of delivering the highest overall efficiency.
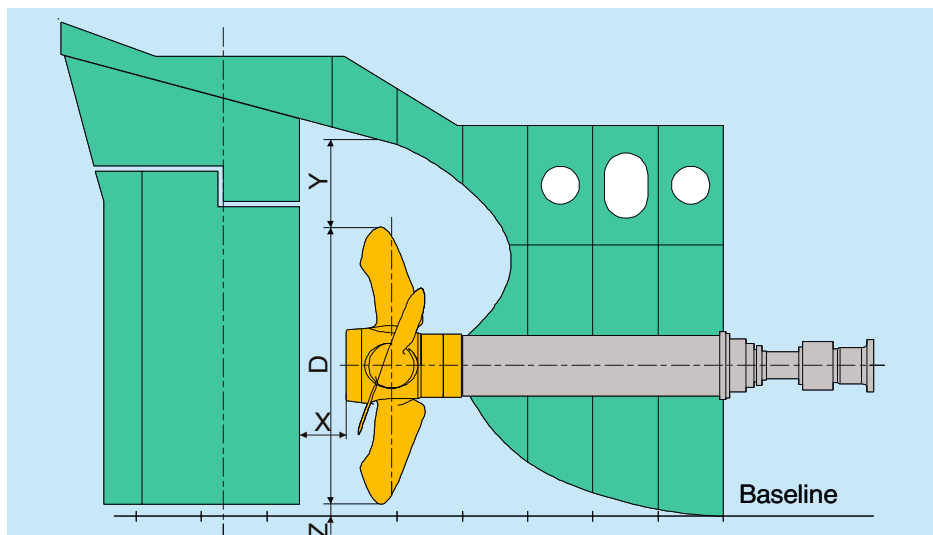
Hub	Dismantling of cap X mm	High skew propeller Y	Non–skew propeller Y	Baseline clearance Z mm
VBS 640	125			
VBS 740	225			
VBS 860	265			
VBS 980	300			
VBS 1080	330			
VBS 1180	365	15–20% of D	20–25% of D	Minimum 50–100
VBS 1280	395			
VBS 1380	420			
VBS 1460	450			
VBS 1560	480			
VBS 1680	515			
VBS 1800	555			
VBS 1940	590			

Fig. 19: Recommended tip clearance

Power (kW)

Fig. 20: Speed prognosis

Fig. 20: Speed prognosis

Consumption (kg/hour)

Fig. 21: Fuel oil consumption

Tow force (kN)

Fig. 22: Tow force

Pitch/diameter ratio
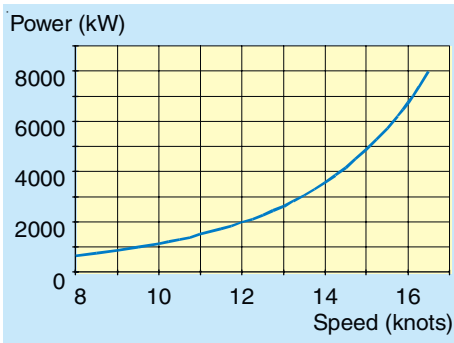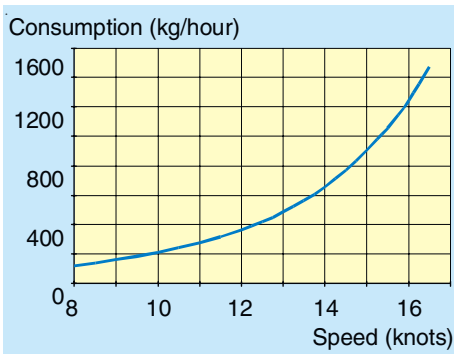
Fig. 23: Pitch distribution along radius

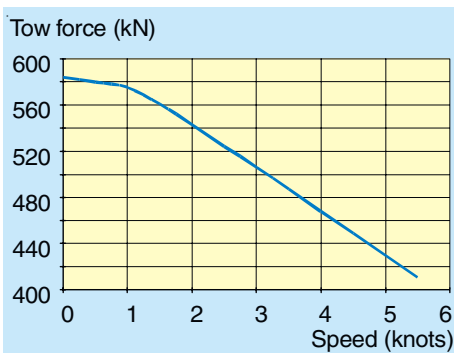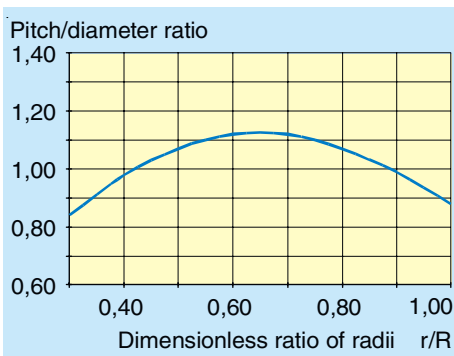To assist a customer in selecting the optimum propulsion system, MAN B&W Alpha are able of performing speed prognosis, fig 20, fuel oil consumption calculations, fig 21, and towing force calculations fig 22. Various additional alternatives may also be investigated (ie different gearboxes, propeller equipment, nozzles against free running propellers, varying draft and trim of vessel, etc).

Hydrodynamic design of propeller blades

The propeller blades are computer designed, based on advanced hydrodynamic theories, practical experience and frequent model tests at various hydrodynamic institutes.

The blades are designed specially for each hull and according to the operating conditions of the vessel.

High propulsion efficiency, suppressed noise levels and vibration behaviour are the prime design objectives.

Propeller efficiency is mainly determined by diameter and the corresponding optimum speed. To a lesser, but still important degree, the blade area, the pitch and thickness distribution also have an affect on the overall efficiency.

Blade area is selected according to requirements for minimum cavitation, noise and vibration levels.

To reduce the extent of cavitation on the blades even further, the pitch distribution is often reduced at the hub and tip, fig 23.

Care must be taken not to make excessive pitch reduction, which will effect the efficiency.

Thickness distribution is chosen according to the requirements of the Classification Societies for unskewed propellers.

Cavitation

Cavitation is associated with generation of bubbles caused by a decrease in the local pressure below the prevailing saturation pressure. The low pressure can be located at different positions on the blade as well as in the trailing wake.

When water passes the surface of the propeller it will experience areas where the pressure is below the saturation pressure eventually leading to generation of air bubbles. Further down stream the bubbles will enter a high pressure region where the bubbles will collapse and cause noise and vibrations to occur, in particular if the collapse of bubbles takes place on the hull surface.

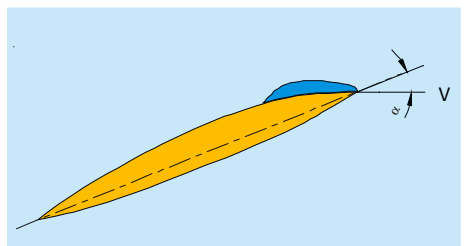Three main types of cavitation exist - their nature and position on the blades can be characterized as:

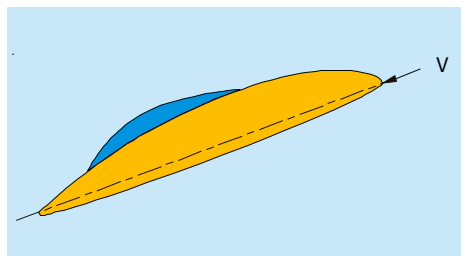*Fig. 24: Suction side (sheet cavitation)*
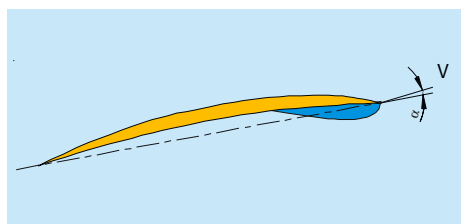
Fig. 25: Suction side (bubble cavitation)

Fig. 26: Pressure side (sheet cavitation)

- Sheet cavitation on suction side

The sheet cavitation is generated at the leading edge due to a low pressure peak in this region. If the extent of cavitation is limited and the clearance to the hull is sufficient, no severe noise/vibration will occur. In case the cavitation extends to more than half of the chord length, it might develop into cloud cavitation. Cloud cavitation often leads to cavitation erosion of the blade and should therefore be avoided. Sheet cavitation in the tip region can develop into a tip vortex which will travel down stream. If the tip vortex extends to the rudder, it may cause erosion, fig. 24.

- Bubble cavitation

In case the propeller is overloaded - ie the blade area is too small compared to the thrust required - the mid chord area will be covered by cavitation. This type of cavitation is generally followed by cloud cavitation which may lead to erosion. Due to this it must be avoided in the design, fig. 25.

- Sheet cavitation on pressure side

This type of cavitation is of the same type as the suction side sheet cavitation but the generated bubbles have a tendency to collapse on the blade surface before leaving the trailing edge. The danger of erosion is eminent and the blade should therefore be designed without any pressure side cavitation, fig. 26.

By using advanced computer programmes the propeller designs supplied by MAN B&W Alpha will be checked for the above cavitation types and designed to minimize the extent of cavitation as well as to avoid harmful cavitation erosion.

For each condition and all angular positions behind the actual hull, the flow around the blade is calculated. The extent of cavitation is evaluated with respect to noise and vibration, fig 27.
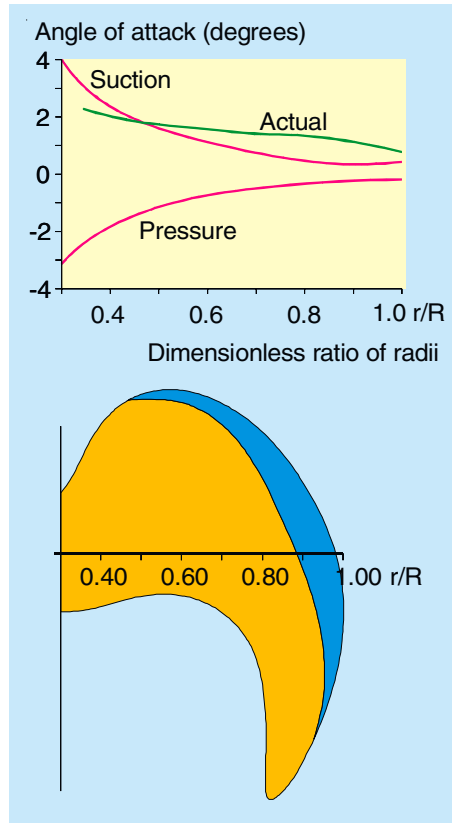
Fig. 27: Cavitation chart and extension of sheet cavitation – suction side
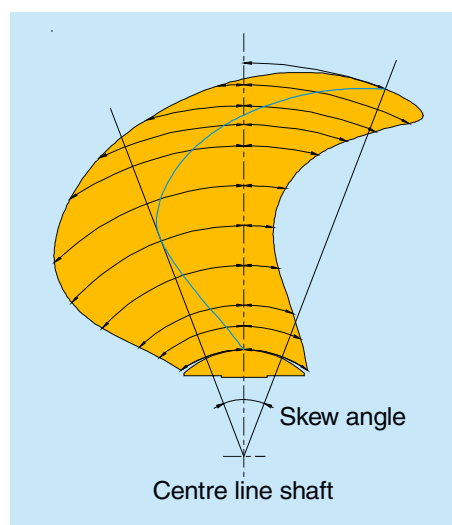
High skew

To suppress cavitation induced pressure impulses even further, a high skew blade design can be applied, fig 28. By skewing the blade it is possible to reduce the vibration level to less than 30% of an unskewed design. Because skew does not affect the propeller efficiency, it is almost standard design on vessels where low vibration levels are required.

Today, the skew distribution is of the "balanced" type, which means that the blade chords at the inner radii are skewed (moved) forward, while at the outer radii the cords are skewed aft. By designing blades with this kind of skew distribution,

it is possible to control the spindle torque and thereby minimize the force on the actuating mechanism inside the propeller hub, fig 29.

For high skew designs, the normal simple beam theory does not apply and a more detailed finite element analysis must be carried out, fig 30.

Fig. 28: High skew design
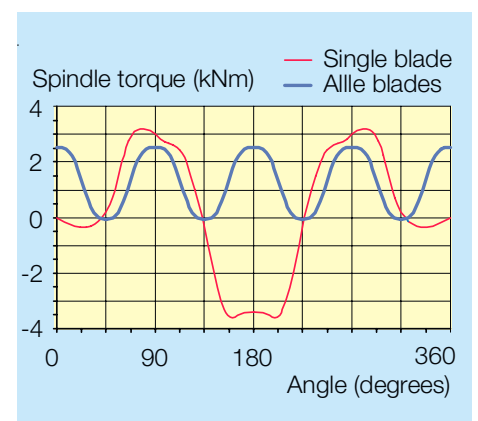
Fig. 29: Spindle torque
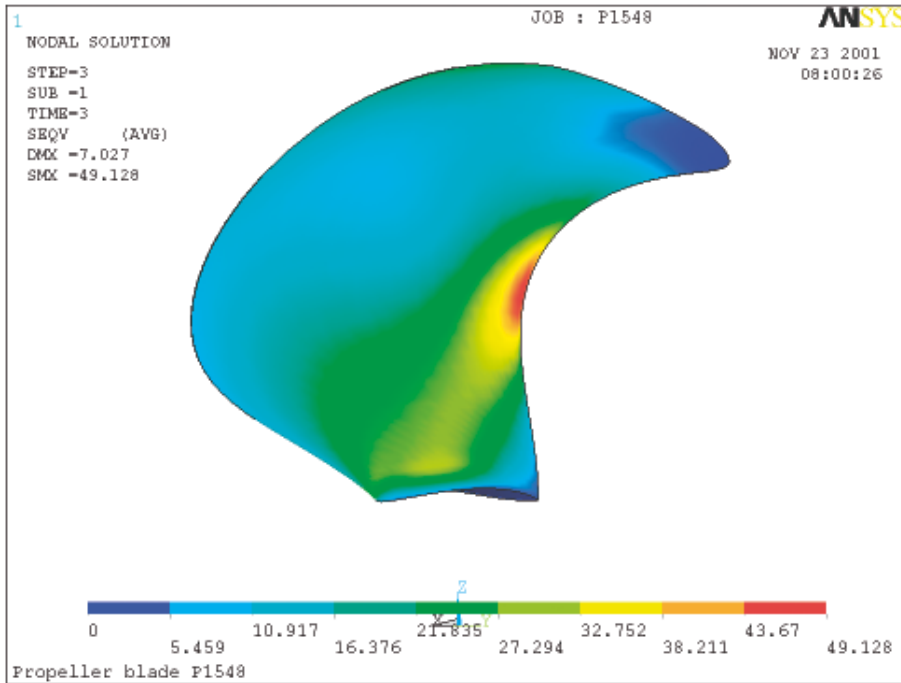
Fig. 30: Finite element calculation of propeller blade

Technical Calculation and Services

Arrangement drawings

Provided MAN B&W Alpha have adequate information on the ship hull, an arrangement drawing showing a suitable location of the propulsion plant in the ship can be carried out with due consideration to a rational layout of propeller shaft line and bearings.

In order to carry out the above arrangement drawing MAN B&W Alpha need the following drawings:

- Ship lines plan
- Engine room arrangement
- General arrangement

Moreover, to assist the consulting firm or shipyard in accomplishing their own arrangement drawings, drawings of our propeller programme can be transmitted by e-mail or a disk can be forwarded by regular post. The disks are compatible with various CAD programmes. Should you require further information, please contact MAN B&W Alpha.

Installation Manual

After the contract documentation has been completed an Installation Manual will be forwarded. This manual will comprise all necessary detailed drawings, specifications and installation instructions for our scope of supply.

CAE programmes are used for making alignment calculations, epoxy chock calculations, torsional vibration calculations etc. In the following a brief description is given of some of our CAE programmes and software service.

Fig. 31: Calculated reactions and deflections in bearings

Bearing	Bearing reaction [kN]	Vertical displacement [mm]	Angular deflection [mRad]
Aft sterntube bearing	51.55	0.00	-0.476
Fwd sterntube bearing	22.81	0.00	0.221
Aft main gear bearing	15.67	0.70	0.007
Fwd main gear bearing	15.16	0.70	-0.003

Fig. 32: Torsional vibration calculation

Alignment instructions

For easy alignment of the propeller shaft line, alignment calculations are made and a drawing with instructions is given in the Installation Manual, fig 31.

The alignment calculations ensure acceptable load distribution of the stern tube bearings and shaft bearings.

Torsional vibrations

A comprehensive analysis of the torsional vibration characteristics of the complete propulsion plant is essential to avoid damage to the shafting due to fatigue failures.

Based on vast experience with torsional vibration analysis of MAN B&W two and four-stroke propulsion plants, the VBS propeller equipment is designed with optimum safety against failure due to fatigue. Stress raisers in the shafting or servo unit are minimized using finite element calculation techniques.

When the propeller is delivered with a MAN B&W engine a complete torsional vibration analysis in accordance with the Classification Society rules is performed. This includes all modes of operation including simulation of engine misfiring.

When the total propulsion plant is designed and manufactured by MAN B&W, the optimum correlation between the individual items exists. The extensive know-how ensures that the optimum solution is found as regards minimizing stresses in connection with torsional vibration calculations. Fig 32 shows the result of a torsional vibration calculation.

When propellers are supplied to another engine make than MAN B&W, a complete set of data necessary for performing the analysis is forwarded to the engine builder in question, fig 33.

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Propeller data

Inertia in air	kgm²	32900
Inertia in water (full pitch)	kgm²	39300
Inertia in water (zero pitch)	kgm²	34500
Number of blades		4
Propeller diameter	mm	6100
Design pitch		0.755
Expanded area ratio		0.48
Propeller weight (hub + blades)	kg	22230

Shaft data

Shaft section	Material	Tensile strength N/mm²	Yield strength N/mm²	Torsional stiffness MNm/rad
Propeller shaft	Forged steel	min 600	min 350	K1 99.0
Servo unit	Forged steel	min 740	min 375	K2 1105.0
Intermediate shaft	Forged steel	min 600	min 350	K3 105.6

Fig. 33: Propeller data for torsional vibration analysis

Whirling and axial vibration calculations

Based on our experience the propeller equipment and shafting are designed considering a large safety margin against propeller induced whirl and axial vibrations. In case of plants with long intermediate shafting or stern posts carried by struts, a whirling analysis is made to ensure that the natural frequencies of the system are sufficiently outside the operating speed regime.

Propeller induced axial vibrations are generally of no concern but analysis of shafting systems can be carried out in accordance with Classification Society requirements.

Instruction Manual

As part of our technical documentation, an Instruction Manual will be forwarded.

The Instruction Manual is tailor-made for each individual propeller plant and includes:

- Descriptions and technical data
- Operation and maintenance guide lines
- Work Cards
- Spare parts plates

The manual can be supplied in two different versions – a printed copy as well as an electronic book in English on CD–ROM.

Main Dimensions

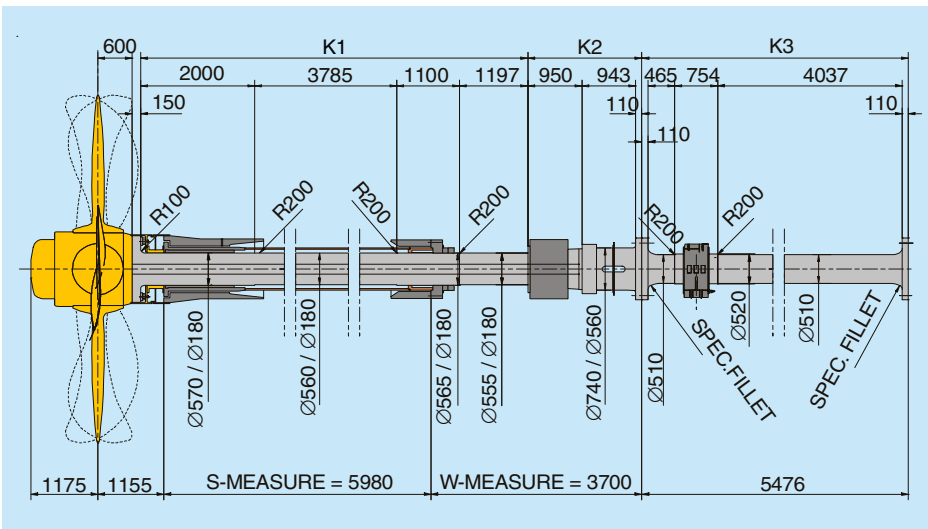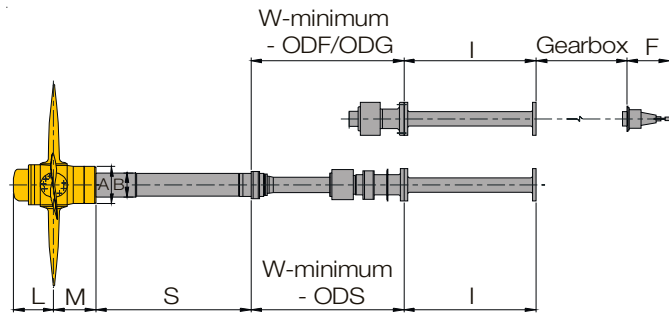| HUB VBS-Type	Max shaft Diameter [mm]	ODS/ ODG Type	A [mm]	* B [mm]	L [mm]	* M [mm]	* W-min ODS [mm]	* W-min ODG [mm]	F ODF [mm]
640	270	180	500	330	491	604		1316	780
640	270	200	500	355	491	604		1316	780
640	270	225	500	380	491	604	2096	1331	780
740	307	200	580	355	569	661		1316	780
740	307	225	580	385	569	661	2096	1331	780
740	307	250	580	415	569	661	2231	1401	780
740	307	280	580	420	569	681	2352	1522	780
860	364	225	670	385	653	722	2096	1331	780
860	364	250	670	415	653	722	2231	1401	780
860	364	280	670	455	653	742	2352	1522	780
860	364	310	670	475	653	747	2367	1557	780
860	364	330	670	475	653	747	2482	1629	780
980	416	250	760	435	746	794	2231	1401	780
980	416	280	760	475	746	814	2352	1522	780
980	416	310	760	510	746	819	2367	1557	780
980	416	330	760	535	746	844	2482	1629	780
980	416	350	760	550	746	844	2503	1650	780
980	416	375	760	550	746	844	2578	1698	780
1080	458	280	840	475	821	890	2352	1522	820
1080	458	310	840	510	821	895	2367	1557	820
1080	458	330	840	535	821	920	2482	1629	820
1080	458	350	840	560	821	920	2503	1650	820
1080	458	375	840	590	821	920	2578	1698	820
1080	458	400	840	590	821	920	2518	1738	820
1180	502	310	915	530	885	947	2367	1557	820
1180	502	330	915	555	885	972	2482	1629	820
1180	502	350	915	580	885	972	2503	1650	820
1180	502	375	915	610	885	972	2578	1698	820
1180	502	400	915	640	885	972	2518	1738	820
1180	502	425	915	655	885	972	2648	1778	820
1180	502	450	915	655	885	972	2691	1831	820
1280	560	350	1000	580	957	1025	2503	1650	910
1280	560	375	1000	610	957	1025	2578	1698	910
1280	560	400	1000	640	957	1025	2518	1738	910
1280	560	425	1000	670	957	1050	2648	1778	910
1280	560	450	1000	700	957	1050	2691	1831	910
1280	560	475	1000	710	957	1050	2701	1881	910
1380	578	375	1070	610	1030	1081	2578	1698	910
1380	578	400	1070	640	1030	1081	2518	1738	910
1380	578	425	1070	670	1030	1096	2648	1778	910
1380	578	450	1070	700	1030	1096	2691	1831	910
1380	578	475	1070	730	1030	1101	2701	1881	910
1380	578	510	1070	730	1030	1101	2923	1913	910
1460	612	400	1130	650	1100	1121	2518	1738	910
1460	612	425	1130	680	1100	1136	2648	1778	910
1460	612	450	1130	710	1100	1136	2691	1831	910
1460	612	475	1130	740	1100	1141	2701	1881	910
1460	612	510	1130	775	1100	1141	2923	1913	910
1460	612	560	1130	775	1100	1141	3001	1966	910
1560	650	425	1210	680	1175	1197	2648	1778	1000
1560	650	450	1210	710	1175	1197	2691	1831	1000
1560	650	475	1210	740	1175	1202	2701	1881	1000
1560	650	510	1210	785	1175	1202	2923	1913	1000
1560	650	560	1210	810	1175	1237	3001	1966	1000
1560	650	600	1210	810	1175	1237	3101	2051	1000
1680	727	450	1295	720	1278	1274	2691	1831	1000
1680	727	475	1295	750	1278	1279	2701	1881	1000
1680	727	510	1295	795	1278	1279	2923	1913	1000
1680	727	560	1295	855	1278	1314	3001	1966	1000
1680	727	600	1295	900	1278	1344	3101	2051	1000
1800	764	510	1390	795	1367	1332	2923	1913	1120
1800	764	560	1390	855	1367	1367	3001	1966	1120
1800	764	600	1390	905	1367	1397	3101	2051	1120
1940	826	510	1500	805	1458	1412	2923	1913	1120
1940	826	560	1500	865	1458	1447	3001	1966	1120
1940	826	600	1500	915	1458	1477	3101	2051	1120

* Guiding approx dimensions

Propeller Layout Data
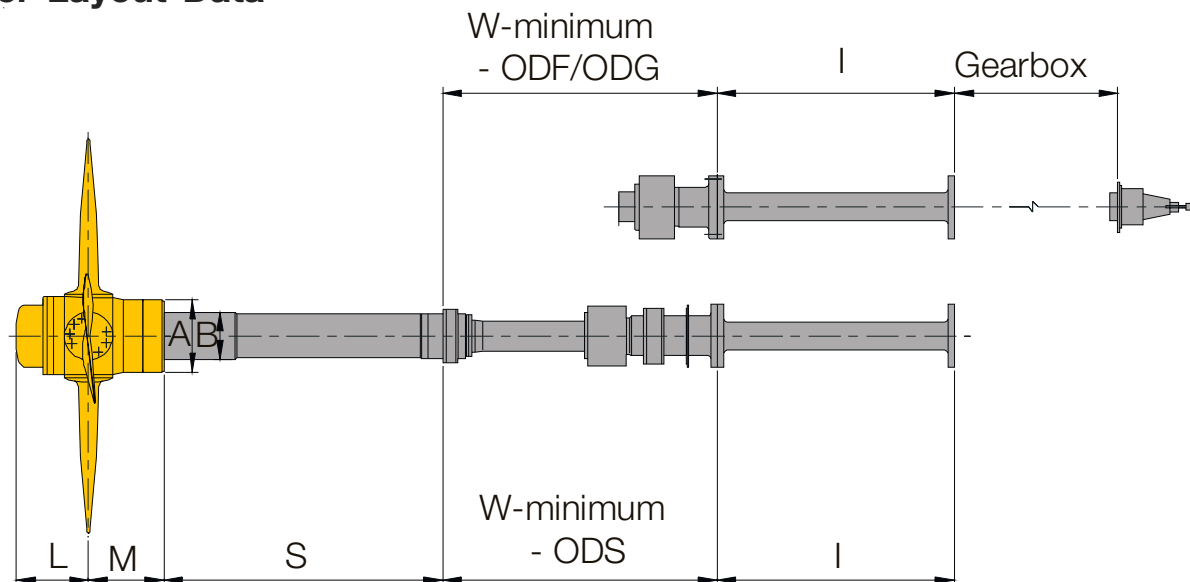
Project : _____   Type of vessel : _____

For propeller layout please provide the following information:

1.   S : _____ mm   W : _____ mm   I : _____ mm   (as shown above)

2.   Stern tube and shafting arrangement layout

3.   Stern tube mountings: Expoxy mounted   or interference fitted

4.   Propeller aperture drawing

5.   Copies of complete set of reports from model tank test (resistance test, self-propulsion test and wake measurement). In case model test is not available section 10 must be filled in.

6.   Drawing of lines plan

7.   Classification society : _____ Notation:_____Ice class notation :_____

8.   Maximum rated power of shaft generator : _____ kW

9.   To obtain the highest propeller efficiency please identify the most common service condition for the vessel:

Ship speed   : _____ kn   Engine service load   : _____ %

Service/sea margin   : _____ %   Shaft gen. service load   : _____ kW

Draft   : _____ m

10. Vessel Main Dimensions *(Please fill-in if model test is not available)*

	Nom	Dim	Ballast	Loaded
Length between perpendiculars	L_{PP}	m		
Length of load water line	L_{WL}	m		
Breadth	B	m		
Draft at forward perpendicular	T_F	m		
Draft at aft perpendicular	T_A	m		
Displacement	$\tilde{N}$	m^3		
Block coefficient (L_{PP})	C_B	-		
Midship coefficient	C_M	-		
Waterplane area coefficient	C_{WL}	-		
Wetted surface with appendages	S	m^2		
Centre of buoyancy forward of $L_{PP}/2$	LCB	m		
Propeller centre height above baseline	H	m		
Bulb section area at forward perpendicular	A_B	m^2		

11. Comments : _____

_____

_____

_____

Date:_____   Signature:_____