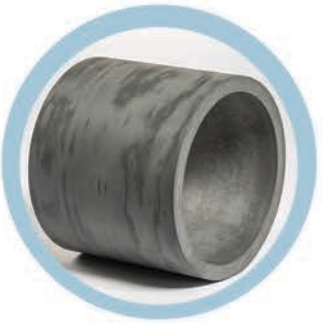
BLUE OCEAN INDUSTRIES

TUFCOT

TUFCOT® T100 MARINE ENGINEERING MANUAL



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INDEX

3. Introduction / Rudder Design Information
4. T100 Marine Interference Chart
5. T100 Marine Running Clearances
6. Running Clearance & Minimum Wall Thickness
7. Rudder Bearing Calculation Requirements
8. Machining Guidelines
9. Turning Speeds & Turning Feeds
10. Grooving, Drilling, Sawing & Sanding
11. Installation Data & Procedure
12. Press Fitting Information
13. Additional Fitting Information / Handling & Safety
14. Material Specification for T100 Marine
15. Product Photos

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TUFCOT® T100 MARINE - ENGINEERING MANUAL

Tufcot is a Lloyds and DNV type approved supplier of Rudder and Rudder Pintle bearings for the Tufcot® T100 Marine grade.

Blue Ocean Industries hold "Key Customer" status with Tufcot Engineering Ltd meaning we have exclusive rights for the sale of Tufcot® throughout Australia.

TYPE APPROVED PRODUCT DNV DNV.COM/AF

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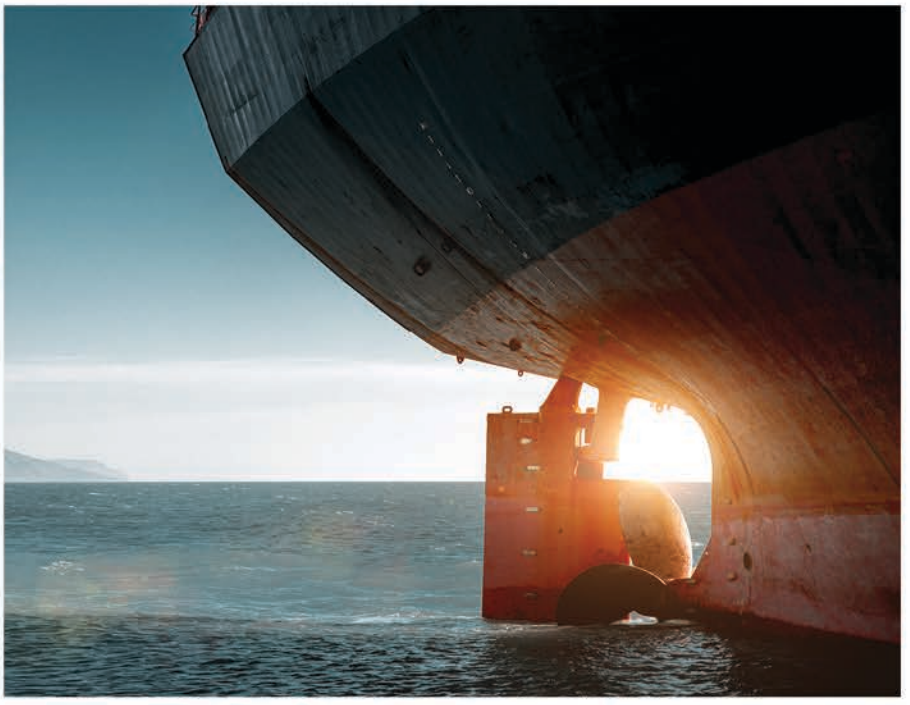

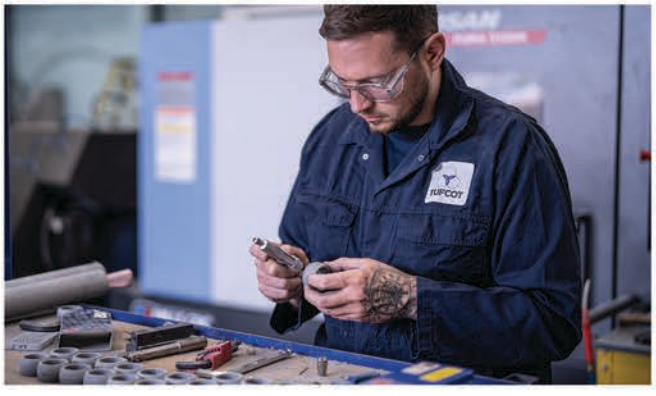

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INTRODUCTION

With Tufcot's extensive experience in the manufacture of resin bonded composite materials, the T100 Marine material has been specifically formulated for many applications within the marine environment.

It is ideally suited to the operating conditions for both topside and subsea applications such as:

- Rudder & Pintle bearings
- Rudder carrier and thrust bearings
- Water lubricated stern tube bearings
- Stabiliser fin bearings
- Stern Rollers
- Deck Cranes
- Deck Winches
- Hatch cover pads

RUDDER DESIGN INFORMATION

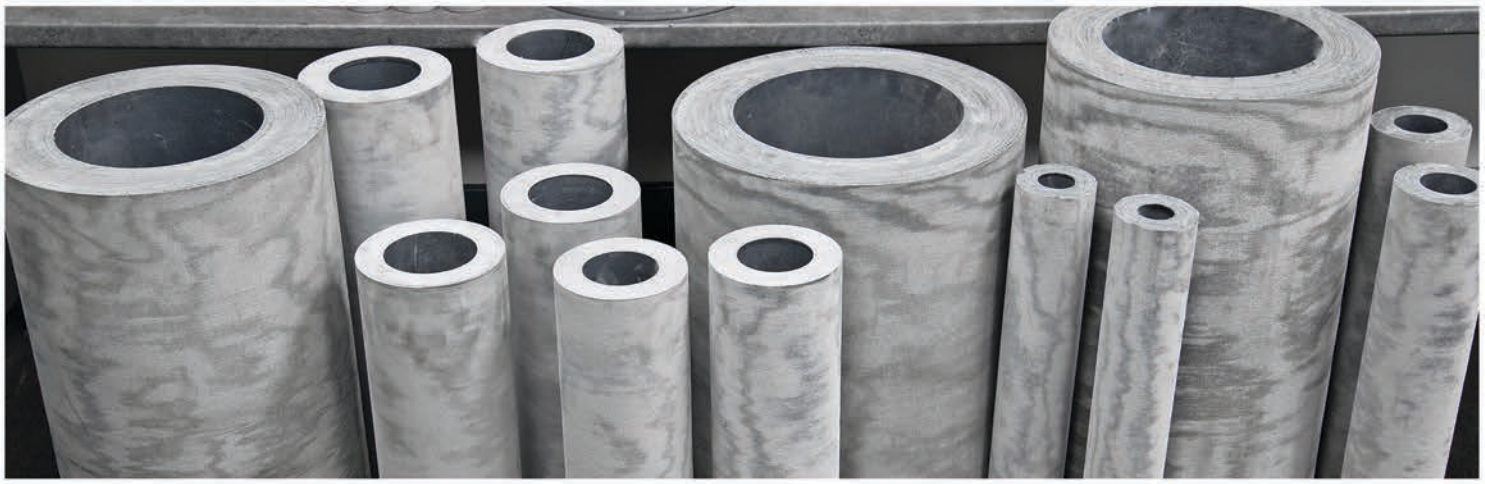
HOUSING - Tufcot® T100 Marine bearings require radial support from the bearing housing. Under normal operating conditions the interference fit quoted is adequate to retain the bearing in its housing. The use of a retaining ring or a shouldered housing bore is recommended and lead in chamfers are required on the bearing housing to prevent shaving of the bearing during fitting.

SHAFT - The external diameter of the shaft should be constant over the length of the bearing operating surface. The surface finish should be a maximum of 1.6 Ra.

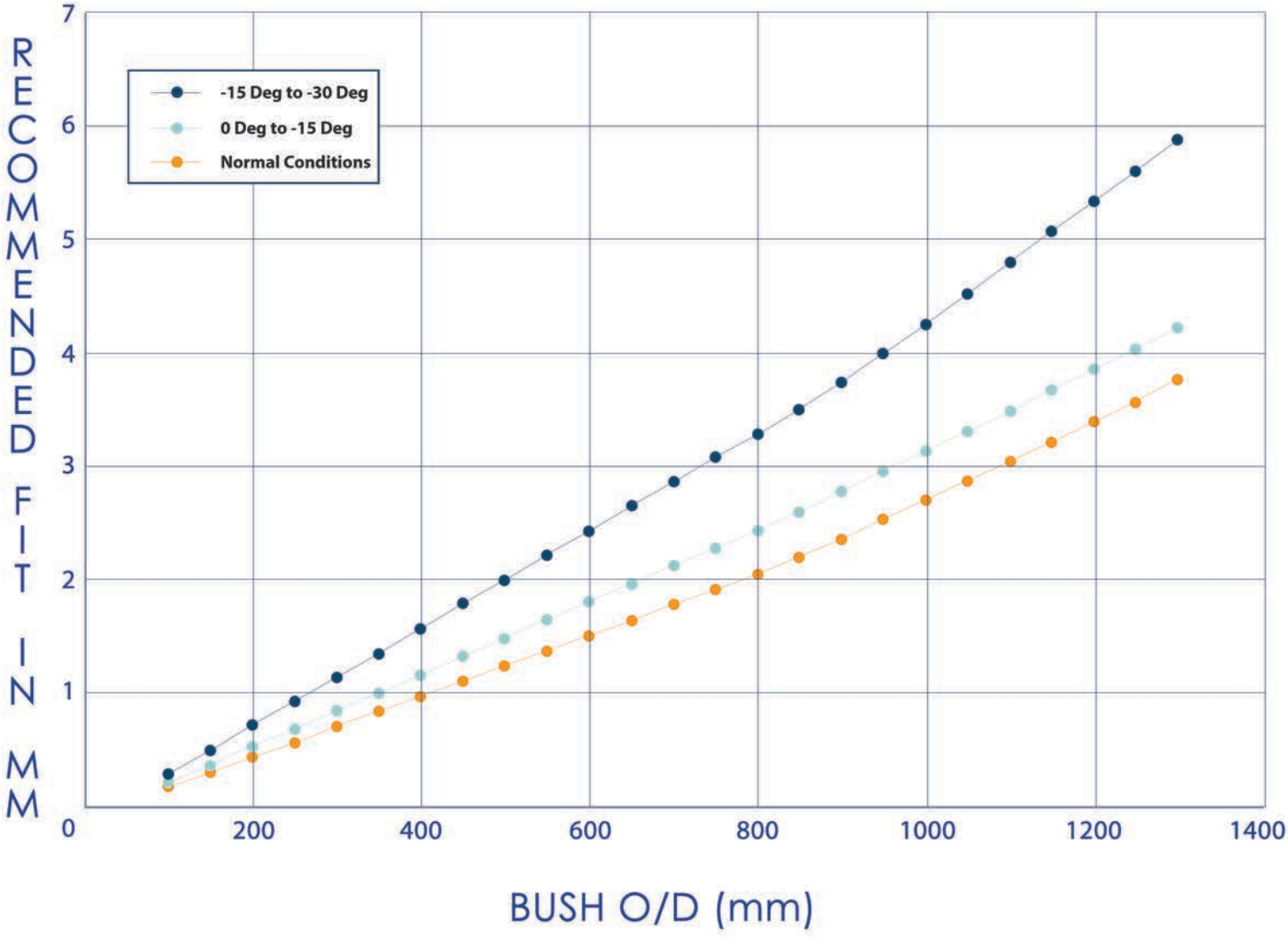
As Tufcot material typically replaces phosphor bronze, lignum vitae and other synthetic bearing materials, supply sizes can be adjusted/recalculated to ensure the correct performance of T100 Marine in your existing application.

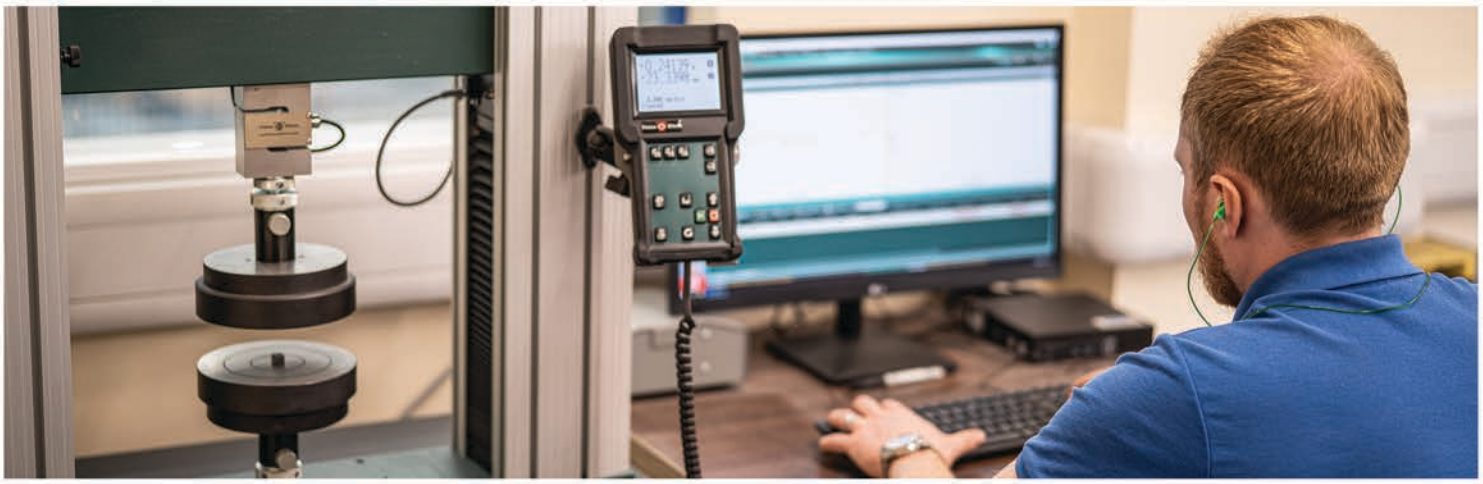
BEARING DESIGN INFORMATION

The following information is given in good faith and is intended to give design data for Rudder Bearings only.

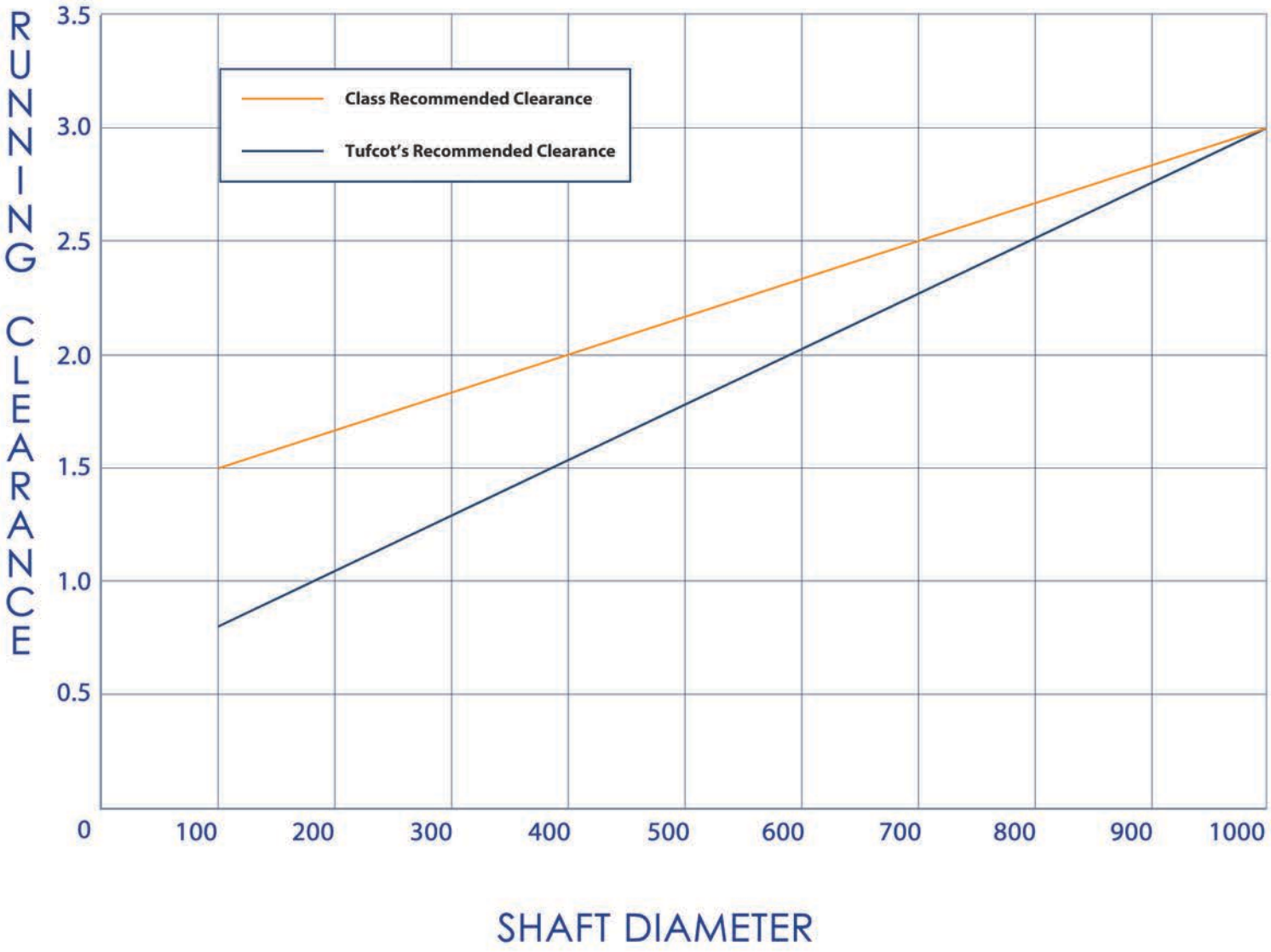


T100 MARINE INTERFERENCE CHART





TYPICAL T100 MARINE RUNNING CLEARANCES



RUNNING CLEARANCE

Recommended minimum running clearances (R-CL) should comply with the relevant classification society to which the vessel is registered.

However, when such information is not given or available the following formula can be applied.

R-CL = 0.0015 x Rudder Shaft dia +1 mm although the minimum clearance should not fall below 1.3mm.

Maximum water swell of T100 Marine is 0.1%, typically no allowance is required when calculating final running clearance.

MINIMUM BEARING WALL THICKNESS

Minimum wall thickness for T100 Marine rudder bearings; -

Minimum Wall = 0.035 x Rudder Shaft dia +2 mm.

The above formula is suitable for both Rudder Stock and pintle bearings in applications where press fitting, freeze fitting or Bonding are to be employed.

RUDDER BEARING CALCULATION REQUIREMENTS

Information required for correctly determining machining dimension.

HARDWARE DIMENSIONS

Housing Diameter Max
Housing Diameter Min

Shaft Diameter Max
Shaft Diameter Min

Machining Tolerance

Minimum Operating temperature for vessel (Will determine interference fit)

BEARING DIMENSIONS FOR MACHINING

Bearing Outside Dia Min = Housing Max + Interference fit

Bearing Outside Dia Max = Minimum Bush OD + Machining tolerance

Bearing Inside Dia Min = Maximum Shaft Dia + Running Clearance + Interference Fit

Bearing Inside Dia Max = Bearing ID Min + Machining Tolerance

After fitting the bearing will have at least the minimum operating clearance as specified in the classification rules.

MACHINING GUIDELINES

T100 Marine is readily machined using conventional modern machine tooling.

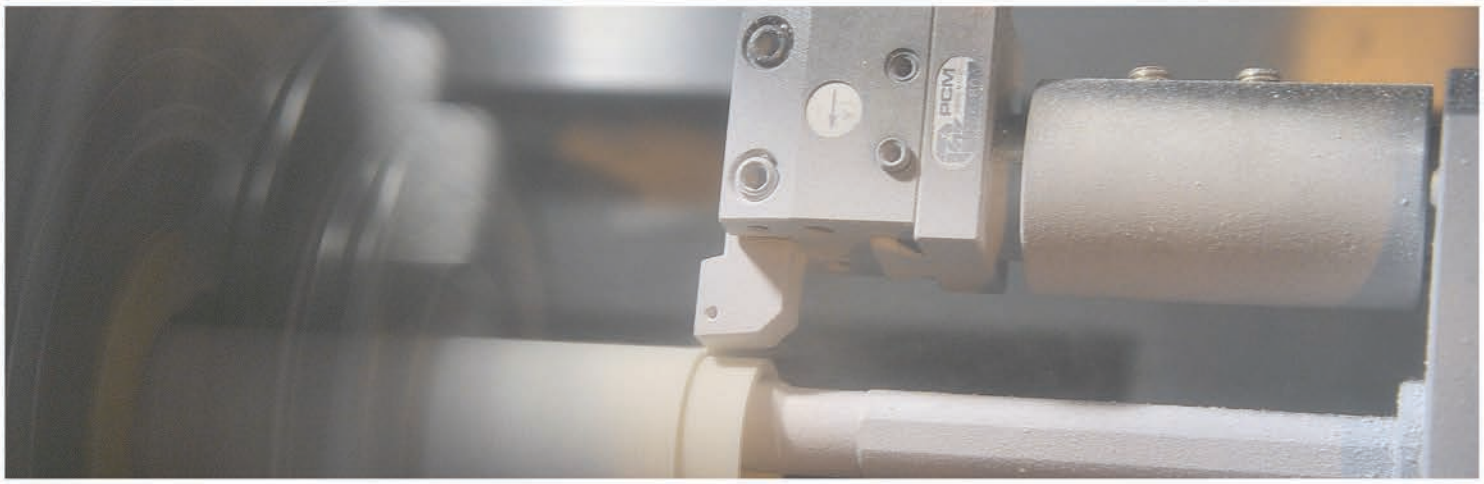
It is advisable that the material is machined in a dry condition using the suggested feeds and speeds and considerations noted below - typically a surface cutting speed of 300 - 350 m/min should be used to achieve the best cutting conditions and results.

TURNING TOOLING & GEOMETRY

Poly Crystalline Diamond (PCD) tipped tools are recommended to give the best results and extended tool life - Tungsten Carbide tipped tools will provide a good finish but tool life would be reduced.

The following tool geometries are recommended….

Tip Radius	**0.8 - 2.0mm**
Top Rake	**0 - 5° (Flat – Positive)**
Lead Angle	**0 - 5° (Flat – Positive)**
Heel Angle	**5 - 3° (Positive)**



TURNING SPEEDS

DIA in mm	RPM
0 - 50	2100
50 - 100	1000
100 - 150	700
150 - 200	550
200 - 300	450
300 - 400	350
400 - 500	250
500 - 600	200
600 - 700	175
700 - 800	150
800 - 900	125
900 - 1000	100

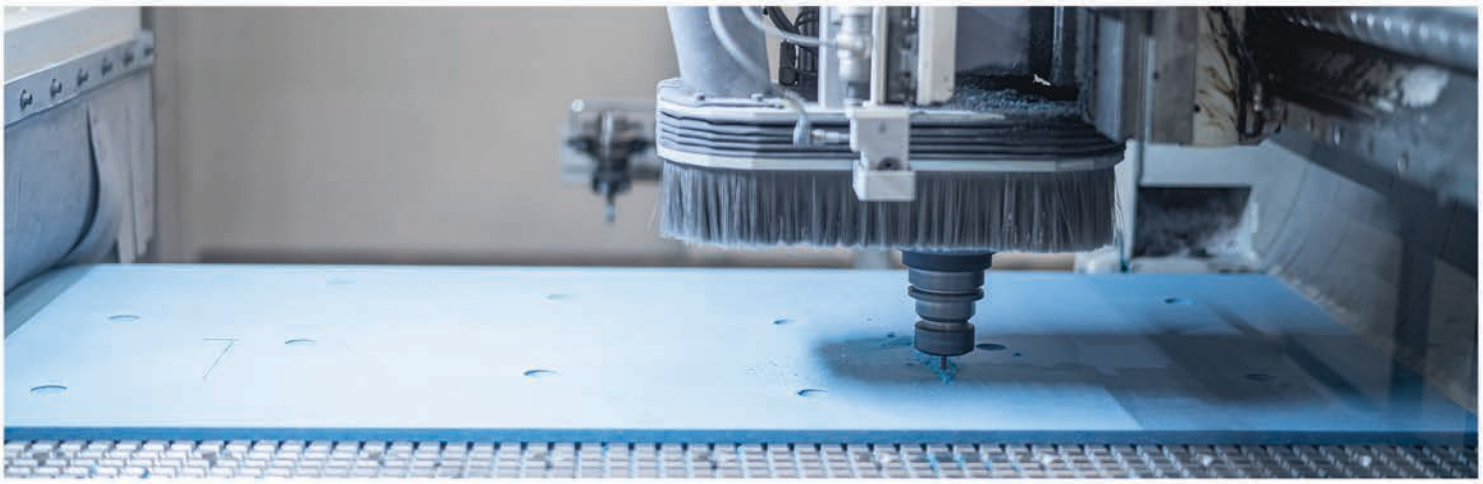
TURNING FEEDS

OPERATION	ROUGHING	FINISHING
TURNING & BORING	0.3 – 0.25 mm/rev	0.1 – 0.15 mm/rev
PARTING	0.2 – 0.3 mm/rev	0.2 – 0.3 mm/rev

* For turning on CNC Lathes – Constant Surface Speed should be turned off. Use of this may result in excessive spindle speed, excessive heat generation and risk the workpiece becoming loose.

DRILLING

DRILL DIAMETER	DRILL SPEED (rpm)	FEED RATE (mm/rev)
5	1000	400
10	800	400
15	600	300
20	400	300
25	350	250
30	300	200
35	250	200
40	200	100



GROOVING

T100 Marine bearings can be readily grooved on a lathe or milling machine.

Radial grooves should be added using standard turning methods as part of the normal turning process.

Axial grooves should be milled or broached if this is not possible.

When milling the same surface cutting speed should be used as noted for turning with typical feed rate of 0.20 – 0.40 mm per tooth.

When broaching – a highspeed tool should be mounted in a boring bar, the tool must have at least 3° of clearance on all side and be very sharp, depth of cut should not exceed 0.5mm per pass, feed should not exceed 20m/min, this of course is dependent on the length and wall thickness of the bearing and must take into account the length and stiffness of the bar.

DRILLING

T100 Marine is easily drilled using HSS or Carbide drills – Carbide is recommended to ensure prolonged tool life, for deeper holes peck drilling is preferred with a full retraction after each peck to ensure flute clearance and to minimise heat build-up drag and clogging.

See page 9 for the suggested feeds and speeds.

SAWING

T100 Marine can be cut using tradition Bandsaws and Tablesaws using conventional blades.

SANDING

T100 Marine should be sanded using Silicone Carbide Open Face sanding belts for best results and avoid belt clogging – Aluminium Oxide belts should be avoided as material contamination may result in damage to running surface and contamination.

No asbestos is used in the manufacture of Tufcot® T100 Marine, the material is non-toxic.

Dust extraction is recommended or as a minimum the correct PPE to avoid inhalation.

Refer to the MSDS available on request.

INSTALLATION

The bearings can either be pressed into the housing or freeze-fitted.

For recommendations on freeze fitting see attached data sheet.

Care must be taken at all times not to damage the bush during the fitting process.

Bore sizes must be checked along all axes at ambient temperature to ensure the minimum shaft clearance has been achieved.

Bearings can also be installed using many of the 2-part epoxy chocking compounds available.

BEARING FREEZE FITTING PROCEDURE

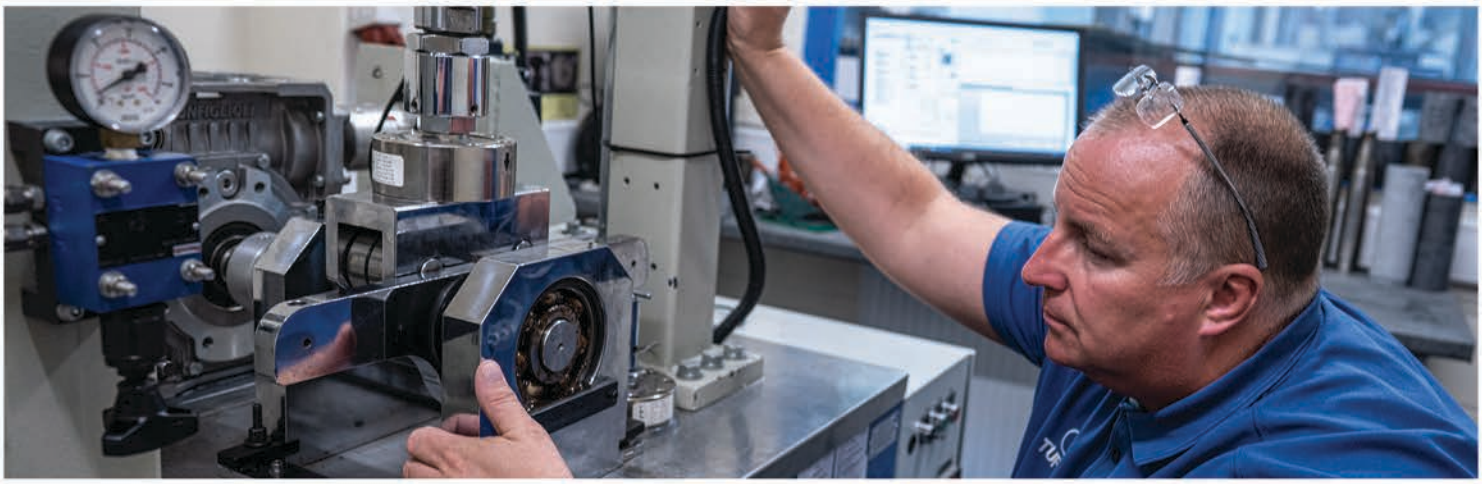
Tufcot® T100 Marine composite bearing material is capable of being freeze fitted using Liquid Nitrogen, the procedure for this process is as follows.

1 - Select or Manufacture a Thin Wall Steel Container
Select or manufacture a thin wall steel container which can be clad with insulating material around its outside diameter. The container should be just large enough to hold the bearing and allow it to be completely immersed in the liquid nitrogen.

2 - Place the Bearing into the Container
Place the bearing into the container then start to pour in the nitrogen. For the first few moments the nitrogen will boil off as soon as it contacts the steel surface. Once the steel surface has cooled sufficiently the nitrogen will start to fill the container.

3 - Make Sure the Bearing is Completely Covered
Due to the extreme temperature differential the liquid nitrogen will continue to boil off for some time. During this period it will be necessary to keep topping up the container ensuring the bearing is completely covered by the nitrogen.

4 - Leave the Bearing to Stand in the Nitrogen
When the boiling has subsided, the bearing should be left to stand in the nitrogen for a further period of time. This will be dependant upon the bearing size and can vary from a minimum of 10 minutes for small bearings, up to 45 minutes for large bearings.



PRESS FITTING INFORMATION

Fitting Considerations

Lubrication to assist fitting should not be used and the fitting procedure should be done dry. Any lubricant residue left on the interference surfaces could adversely affect bearing retention.

A "Push Plate" should be used to ensure even and square fitting pressure is applied around the bearing diameter. Ideally this plate should be 10mm smaller the OD of the bearing to be fitted and have thickness greater than 35mm to ensure stiffness. This should be placed between the bearing and the fitting equipment.

When press fitting a bearing into the rudder assembly you must ensure the bearing is correctly in line and square with the housing and ensure a lead in chamfer is present on the front end of the bearing.

The bearing should be free from any contamination, sharp edges and have a broken corner on the insertion side.

Prepare the fitting conditions an area thoroughly before starting the process to avoid interruptions whilst fitting as the bearing should (where possible) be done in one movement.

Once fitted the bearing should be allowed to stand for a period to settle for a minimum period of 3-5 hours to normalise in the bearing housing – preferable this should be left overnight where possible.

Equipment to be Used

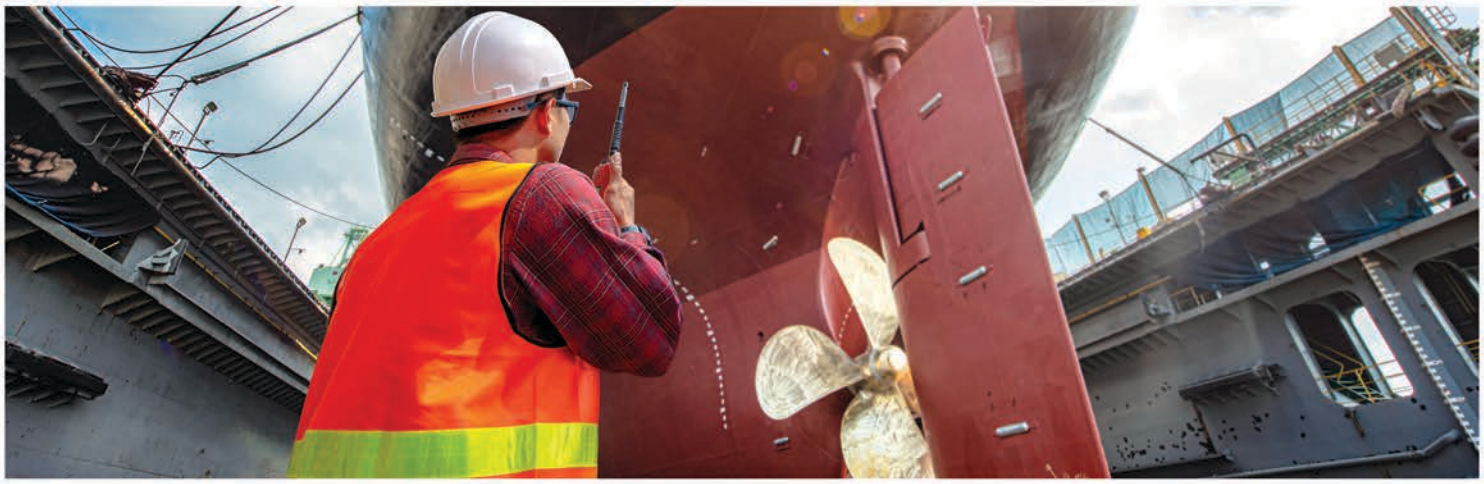
Suitable and correct equipment should be used for press fitting the bearing into the housing and as such it is beneficial to understand the force that will be required to successfully install the bearing into the housing.

Therefore, having used the data previously calculated and outlined in this Marine Manual the force required to fit the bearing can be calculated using the following equation…

Force Required (N) = (0.4 x Max Interference value(mm) x Shaft Dia^2 (mm)) + 50,000

It is important to understand that the above formula gives an estimated value so a safety margin is advisable when selecting equipment to be used (10-20%).

The above is based on "ideal conditions" and as an accumulation of tolerance and fitting friction can increase force required the safety margin must be applied.



ADDITIONAL FITTING INFORMATION

To avoid the potential of Rudder Bushings moving in the housings the following guidelines have been included to comply with classification requirements.

The bushing shall be effectively secured to the bearing housing as recommended in the fitting guide which is normally sufficient for adequate retention of the bearing.

However, the following additional means of retention should be considered.

Guidance notes:

Bushing should be effectively secured in accordance with maker's recommendation.

Physical stopper or Keeper plate should be arranged to prevent the bushing from shifting in vertical direction also consideration should be made for this to include a means to also prevent the potential of rotation of the bearing.

HANDLING & SAFETY

When working with liquid nitrogen operators should ensure they are fully conversant with the necessary precautions for its handling and use, as prescribed by the liquid nitrogen supplier. The correct protective clothing and eye protection should be used at all times.

Liquid nitrogen is oxygen depleting and should not be used in confined spaces.

Thermal contraction coefficient of T100 Marine material is 3.5 x 10-5 / ˚C.

Bush OD x Pi = Circumference

Circumference x 0.000035 x Temperature Drop = Length Change

(Temperature, Liquid Nitrogen -197 or Dry Ice -68)

Circumference – Length Change x Pi = New OD after Freezing

It should be noted that Dry Ice typically will not give sufficient shrinkage of the bearing to facilitate freeze fitting and is not recommended unless additional mechanical force to press fit is also used.

Material Specification for T100 Marine

REQUIREMENT		TYPICAL VALUES	
		Imperial	Metric
Rockwell Hardness		80 - 90 Rockwell M.	80 - 90 Rockwell M.
Density		0.045 – 0.49 lbs/in^{-3}	1.25 – 1.40 (Gms/cc)
Tensile Strength			
Lengthwise		9427 PSI	65 N/mm²
Crosswise		8700 PSI	60 N/mm²
Flexural Strength			
Lengthwise		20.000 PSI	138 N/mm²
Crosswise		15.500 PSI	107 N/mm²
Shear Strength		19.500 PSI	134 N/mm²
Compressive Strength			
Flatwise		50.000 PSI	345 N/mm²
Edgewise		19600 PSI	135 N/mm²
Water Absorption, Volumetric		Less than 0.1%	Less than 0.1%
Coefficient of Thermal Expansion		Parallel to Laminations	6 - 7
20 - 100°C (Per °C x 10^{-5})		Right Angle to Laminations	12 - 13
Max Constant Operating Temp		212°F	100°C
Min Constant Operating Temp		-94 °F	-70°C
Tensile Modulus		0.47 (lbs/in² x 10^6)	0.32 (N/mm² x 10^4)
Lubricants		Molybdenum + PTFE	Molybdenum + PTFE
Colour		Light Grey	Light Grey
Coefficient of Friction, Tufcot® against Stainless Steel	Dry	0.10 – 0.12	0.10 – 0.12
Bearing Pressure 15.5 N/mm²	Water	0.01	0.01
Surface Speed 2.20 M/Sec	Oil	0.02	0.02

HEEL BEARING

MARINE BEARINGS

MARINE STAVE

DAVIT BEARINGS

STERN ROLLER BEARING

RUDDER BEARING

ROPE SPOOL

This page shows just a few examples of the products Tufcot manufacture for the marine sector.

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