THORDON

THORDON BEARINGS INC.

Oil and Grease Free Bearing Applications for Dredgers

DB2014.1

THORDON

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The information contained in this document has been prepared from the company's many years of experience in the manufacturing and installing of Thordon Bearings worldwide.

This information is offered as part of our service to customers. It is intended for use by persons having technical training and skill, at their discretion and risk.

The company reserves the right to change or amend any specification without notice.

THORDON

Corporate Profile

Thordon Bearings Inc. is a leading designer and manufacturer of pollution free propeller shaft, rudder and deck equipment bearings and bushings. Thordon products are found on tankers, bulkers, dry cargo, dredge, container, cruise, yacht, offshore, ferry, naval and coast guard vessels. With 30 years of experience, Thordon offers worldwide technical support through an extensive sales, distribution and service network.

Our engineered bearing system solutions are being designed into marine applications where reliability, long life, low friction and non-polluting operations are of key importance.

Fitted to over 2000 ships, Thordon seawater lubricated propeller shaft bearing systems eliminate oil leakage from stern tubes (no pollution risk), provide excellent operational and bearing wear performance as well as offer lower in-service seal costs. With over 35 years experience and over 4000 Thordon pollution free rudder bearings installed, Thordon's rudder bearings offer a low coefficient of friction and total freedom from grease above and below the water line. To eliminate grease in your deck equipment applications, ThorPlas bearings can easily be back-fit into virtually any applications where greased bronze is currently installed. Thordon Composite dredge cutterhead shaft bearings are fitted to the largest dredgers in the world offering long wear life and reduced maintenance dockings.

We offer in-house design, CAD and the proprietary Thordon Bearing Sizing Calculation Program to help correctly size our bearings. Our decades of experience mean that we offer the right technical support during the design, machining, installation and operation stages of the project. Thordon is supported through an extensive distribution and service network in over 100 countries.

Thordon bearings, and bearing systems, are the proven, cost-effective, environmentally friendly, solution for rigorous and demanding journal bearing applications

Product Grades and Configurations

Thordon Bearings, a pioneer in the development of grease and oil free elastomeric polymer bearing systems, offers a choice of environmentally friendly journal bearing solutions for dredge cutterhead shaft, propeller shaft, rudder, pump and deck equipment solutions.

Thordon is a proprietary, elastomeric synthetic polymer alloy originally developed by Thordon Bearings over 30 years ago as a journal bearing for vertical pump applications. Thordon's unique flexible polymer structure can extend at least twice of its original dimensions and can recover its dimension after deformation offering the best combination of flexibility and strength. Thordon is tough, self-lubricating, has a much lower coefficient of friction and is able to accommodate much higher specific pressures than rubber.

Continuous research over the years has resulted in the development of five different bearing grade elastomer products - XL, SXL, COMPAC, HPSXL and Composite. This allows selection of an optimum solution based on matching product characteristics to the specific application requirements.

ThorPlas is a new, proprietary engineered thermoplastic bearing product recently introduced by Thordon Bearings. While the Thordon range of high performance elastomer products clearly offer superior performance in the applications which they can be specified, there are technical limits, such as maximum pressures which they cannot be used.

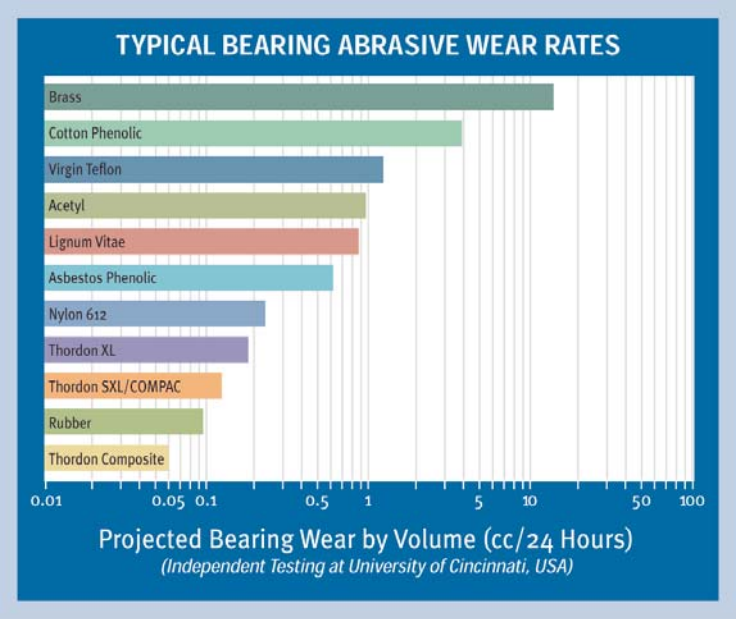
To address this issue, Thordon Bearings has introduced ThorPlas®, which significantly expands the range of applications where Thordon Bearings can be specified, while still maintaining many of the recognized Thordon performance advantages.

Product Grades and Configurations ...cont'd.

Thordon Composite

Thordon Composite is a two component bearing formulated specifically for use in very abrasive environments such as water lubricated cutterhead shafts or open water propeller shaft bearings. The actual bearing surface is a black material and is referred to as GM2401. This softer material is fused to a yellow, stiff, high strength polymer sleeve. GM2401 is homogeneous - there are no layers of differing materials and properties are consistent through the wall thickness.

Composite bearings are available in a full range of sizes in both tube and stave configurations.



Thordon SXL

Thordon SXL offers a low coefficient of friction for reduced break away torque and smoother operation at lower shaft RPM in water lubricated applications. SXL offers:

- Higher resistance to abrasion than XL in wet applications; good abrasion resistance operating dry
- Lower coefficient of friction (typically 0.08-0.15) than XL
- Dry start-up capability as a vertical pump bearing
- High resistance to shock loading and vibration

Product Grades and Configurations ...cont'd.

Thordon COMPAC

Thordon COMPAC is a high performance grade of Thordon that is used in open water lubricated propeller shaft bearing systems. Specially formulated with a low coefficient of friction to reduce startup friction and eliminate stick- slip, COMPAC's unique configuration is designed to promote early formation of a hydrodynamic film at lower shaft rpm. The COMPAC bearing system is Class-approved for 2:1 L/D ratios. COMPAC's design properties are effectively similar to SXL.

Thordon XL

Thordon XL is a general purpose bearing offering superior performance compared to other bearings commonly used in water lubricated propeller shaft and other marine applications. XL offers:

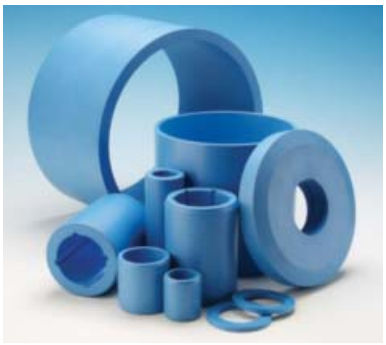
- Low co-efficient of friction (typically 0.13-0.20)
- High resistance to abrasion in dry applications
- High resistance to shock loading and vibration

Thordon HPSXL TRAXL

Thordon HPSXL is designed for higher pressure water lubricated applications where the HPSXL bearing is bonded into a bronze shell. HPSXL TRAXL offers:

- A maximum dynamic working pressure to 55.0 MPa (8000 psi) in limited motion
- Lowest coefficient of friction (typically 0.06-0.12)
- Moderately abrasion resistant (lower abrasion resistance than XL or SXL)
- High resistance to shock loading and vibration

ThorPlas-Blue®



ThorPlas-Blue is a non elastomeric material developed by Thordon specifically as a homogeneous high pressure bearing. ThorPlasBlue offers:

- A maximum dynamic working pressure to 31.0 MPa (4500 psi)
- Low coefficient of friction (typically 0.10-0.17)
- Very low wear in non-abrasive environments
- Reasonable abrasion resistance - less than Thordon elastomer grades, but better than bronze, epoxy phenolics and many other non-metallic bearing materials

Dredge Bearing Applications

Composite Water Lubricated Cutterhead Shaft Bearings

Thordon Composite bearings were introduced in 1974 after laboratory tests on a highly abrasion resistant compound known as GM2401 (black wear surface) showed wear resistance to be better than rubber in dirty water conditions. Thordon's first large cutter head shaft bearings were installed in August 1978 on the Zanen Verstoop Dredge, Gouda, operating in the Middle East. The Thordon Composite bearing outperformed the previous cutless rubber bearing by a factor of approximately 2 times.

Due to their tough, elastomeric properties, Thordon Composite bearings resist wear by tending to deflect, and then reject, abrasive particles allowing them to be flushed through the bearing without tearing away bearing material. Less wear translates into less downtime and fewer bearing replacements over the operating life of the vessel.

The design pressure for cutterhead shaft bearings is between 0.4 MPa (58 psi) and 0.6 MPa (87 psi). The maximum design pressure for full rotation is 1.4MPa (203 psi). Typically, the L/D ratio is 3:1.

The mating surface (shaft liner) should be corrosion resistant and as hard as possible: mimimum 40 HRC; typically 60 HRC or greater such as Ni-Cr-B.

The required water flow for flushing and cooling the bearings is 0.15 L/min/mm (1 U.S.Gal./min./inch) of shaft diameter. Thordon Composite in combination with a hard shaft liner offers the best combination for long bearing wear life in abrasive environments. However, a good quality water flush also prevents the bearing from being clogged from the sand and rock particles from the cutterhead operation. Reducing the level of abrasive particles in the water flush to the bearings will translate into a longer wear life of the bearing.

Composite cutterhead shaft bearing removed from dry ice and ready to be installed in housing

Composite cutterhead shaft bearing being installed on *CSD J.F.J. de Nul*

Dredge Bearing Applications ...cont'd.

Composite Water Lubricated Cutterhead Shaft Bearings

Composite cutterhead staves being installed for *CSD Abu Al Abyadh*

Composite cutterhead staves installed on *CSD Abu Al Abyadh*

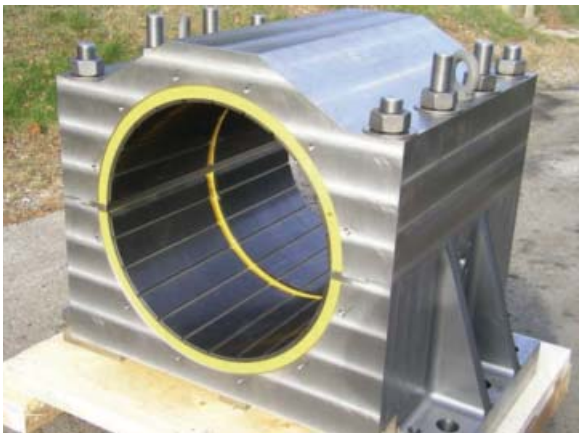
Composite Water Lubricated Cutterhead Intermediate Lineshaft Bearings

Thordon Compsite has consistently outperformed rubber in dredge cutter head shaft bearing applications for many years. Now, Thordon has built on this success and developed a water lubricated intermediate lineshaft bearing utilizing Thordon Composite. The risks for pollution from grease leaking out, or damage to the bearing from water leaking in, that conventional bearings face are totally eliminated with this new Thordon design.

Thordon cutterhead intermediate lineshaft bearings offer the following benefits to the owner:

- Uses seawater for lubrication
    - Eliminates grease and greasing system
    - No pollution
    - No clean-up after dredging
    - Improved safety for crew (no slippery ladder)
- Lower maintenance costs
    - Able to change bearing with shaft in place
    - Ship's crew can change bearing
    - no grease purchases
- High abrasion resistance
- Less friction; no noise or vibration
- Accomodates edge loading caused by shaft misalignment
- Greater impact resistance/resiliance

Dredge Bearing Applications ...cont'd.



New Composite cutterhead intermediate lineshaft bearing

Cutterhead shaft line showing 2 of 3 Composite intermediate bearings

New Composite cutterhead intermediate lineshaft bearing installed

Cutter ladder installation in *CSD D'Artagnan*

Other Applications for Thordon on a Cutterhead Dredge

Propeller shaft bearings: Composite, SXL, XL, COMPAC
Rudder bearings: SXL
Ladder drive bearings: SXL
Ladder trunion bearings: HPSXL TRAXL, ThorPlas-Blue
Ladder wire rope sheave bearings: SXL
Pipe support swivels: HPSXL TRAXL, ThorPlas-Blue
Spud housing bushes: SXL
Pump Bearings: Composite, SXL, XL, HPSXL TRAXL, ThorPlas-Blue

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Shaftline Conversion from Oil to Water Saves Dredge Owner Money

Installed with RiverTough Propeller Shaft Bearings for Abrasive Waters

Installation of Thordon RiverTough propeller shaft bearings on the triple screw dredger, Fraser Titan

Triple screw dredger, Fraser Titan converted from oil to water lubricated propeller shaft bearings in 2011

In April 2011, the *Fraser Titan*, a triple screw 2300m^3 (8,124 ft.^{3}) dredger, was converted to Thordon RiverTough water lubricated propeller shaft bearings from an oil lubricated system. The previous oil lubricated system had many issues - frequent maintenance of aft seals, water ingress contaminating the lubricating oil, and unplanned drydockings. The vessel had its first drydocking with water lubricated shaftlines in March 2012 at Esquimalt Drydock (Canada), reporting no sealing issues (as there is no aft seal) and very little wear. At current bearing wear rates after 6,100 hours of operation, RiverTough bearings are expected to last over 10 years (+60,000 hours).

"We chose Thordon RiverTough for this vessel because these bearings are known for long wear life in abrasive waters, they eliminated the aft sealing issues we had and come with no risk of pollution," says Dmitry Kravtsov, Technical Superintendent for FRPD (Fraser River Pile and Dredge GP Inc. of Vancouver, Canada) "The Thordon solution onboard the vessel has reduced our downtime and maintenance costs."

The *Fraser Titan* has three shaftlines with diameters of 165 mm (6.6"). The Thordon RiverTough propeller shaft bearings operate in combination with hard coated Nickel-Chrome-Boron shaft sleeves which provide superior wear life in highly abrasive wear conditions experienced on the Fraser River in British Columbia. Water is used as a lubricant (instead of oil) and is taken from the river, pumped through the bearings using a Thordon Water Quality Package and returned back to the river. Since no aft seal is required, there is no risk of damage by abrasives or rope. This results in lower in-service maintenance costs and the elimination of storage, sampling and disposal of oil from the stern tube. Mill Log Marine, Thordon's authorized distributor in British Columbia, Canada, has worked with FRPD on this project and continues to advise on problem areas where Thordon solutions may further help them reduce operating costs. NW

At current wear rates, Thordon RiverTough bearings are expected to last over 10 years

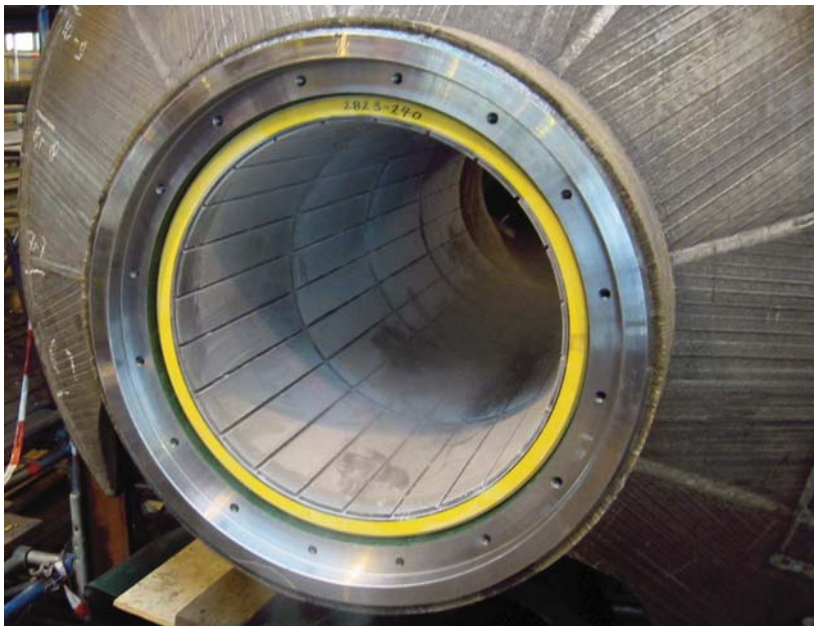
COMPOSITE BECOMING THE BEARING OF CHOICE FOR CUTTERHEAD DREDGES

Recently Built Jumbo Dredger, D'Artagnan, Owned By Société De Dragage International Of France Equipped With Thordon Composite Cutterhead Shaft Bearings And Intermediate Lineshaft Bearings

Thordon Composite cutterhead shaft bearings have been recently installed or ordered on six cutter suction dredgers in Europe, China and the Middle East.

Thordon Composite is a tough two-component elastomeric polymer alloy bearing specifically formulated to provide superior wear life in very abrasive water conditions. Thordon Composite bearings operating in combination with a hard stainless steel shaft or hard coated shaft liner such as Ni-Cr-B, routinely outwear rubber bearings by a factor of two or more, significantly reducing maintenance downtime and costs over the operating life of the dredge.

"Archirodon Dredging Construction (Overseas) Co. S.A, of United Arab Emirates has been using Thordon Composite dredge bearings since 1999 and they have performed better than we expected", says Panos Zoglopitis, Mechanical Engineer for Archirodon Dredging Division. "These bearings last longer than rubber bearings. We have installed Thordon Composite on *CSD Pontos* and *CSD Aetos* and plan to continue using Thordon Composite bearings and staves."



Thordon Composite Cutterhead Shaft Bearing

Other Cutter Suction Dredgers to be equipped or having had Thordon

Thordon Composite Intermediate Lineshaft Bearing For CSD D'Artagnan

installed recently, include *Zeeland II* owned by Van Oord Ship Management B.V., Netherlands, *Huta Sete 07* owned by Huta-Sete Marine Works Ltd., Saudi Arabia, *Jin Hang Jun 215* owned by Tianjin Waterway Bureau, China and CSD 8060 owned by Jan de Nul of Belgium. National Marine Dredging Company of U.A.E has also been using Thordon Composite dredge bearings since 1996 with installations on five of their dredgers.

The recently built jumbo dredger, *D'Artagnan*, owned by S.D.I. S.A. (Société De Dragage International), France, also has water lubricated Thordon Composite intermediate lineshaft bearings installed in addition to the Composite cuttherhead shaft bearings.

COMPOSITE A KEY COMPONENT OF THE MOST ADVANCED DREDGER IN WORLD

When Caesar conquered Egypt in 48 B.C., he used dredgers to clear the way for his ships into the Alexandra Harbour. No one knows for sure what these dredgers looked like or how they worked. We can speculate, however, that if the Roman engineers who built them could see into the future, they would be astonished by the size and power of the *J.F.J. de Nul*.

Constructed at IHC shipyard in the Netherlands for Jan de Nul of Belgium, the *J.F.J. de Nul* is the most advanced self-propelled cutter suction dredger ever built. Her 6,000kW cutter drive, 30% more powerful than cutters currently in use, is capable of dredging from a depth of 6.5 m to 35 m (21 ft. to 115 ft.). According to IHC, the vessel incorporates the latest advances into dredging systems, engineering, and materials technology.

These advances included specifying Thordon Composite as the bearing material for the 950 mm (37.4") diameter cutterhead drive shaft.

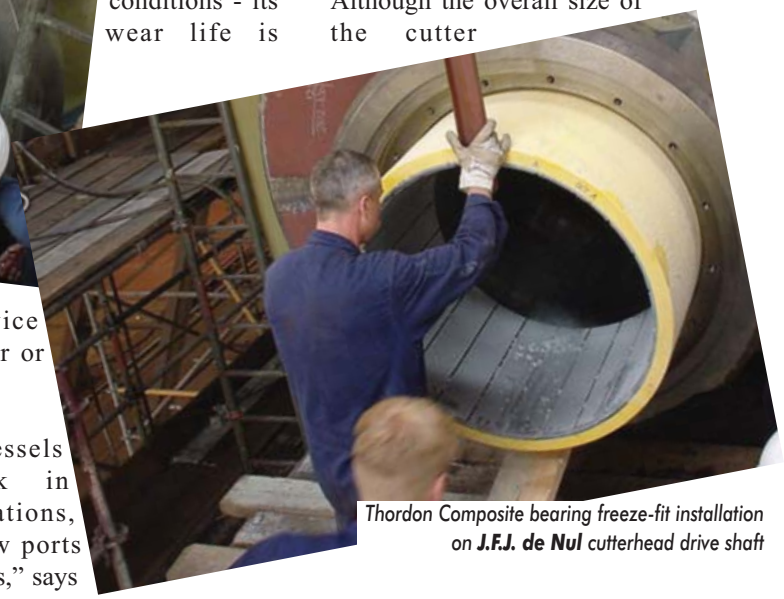
"Thordon was selected for a number of reasons," says Marc Butzelaar, Sales Manager for Sandfirden Technics BV, a Netherlands-based company that, in addition to being a Thordon Distributor, specializes in engineered products for industrial and marine applications. "Dredging systems are exposed to extreme underwater forces and unpredictable torque peaks. The *J.F.J. de Nul* needed a cutterhead bearing that not only performs well, but also has a long wear life in dirty, sandy water."

Introduced in 1977, Thordon Composite was first installed as a cutterhead bearing on the dredger, *Gouda*. Since that time the product has been installed in dozens of dredger applications worldwide. Thordon Composite performs reliably in highly loaded and abrasive laden water conditions - its wear life is typically twice that of rubber or more.

"Dredge vessels often work in remote locations, dredging new ports and waterways," says Butzelaar. "They can often be hundreds of miles away from an airport or commercial port where a bearing can be replaced. That's why reliability and long wear life is so crucial."

Portability is also an issue. Because dredgers can work in isolated areas around the globe, they must stow most of the materials they need for maintenance and repair onboard. At 958 mm (38") ID x 1084 mm (42.7") OD x 3475 mm (136.8") long, the required size of the cutter bearing for the *J.F.J. de Nul* was huge. So, to accommodate the need for both ease-of-maintenance and portability, the Thordon Composite bearing was engineered into five, 695 mm (27") long bearing tube segments. Each was shipped to the construction location, placed in dry ice, then inserted one by one into the 1080 mm (42.4")-cutterhead housing. "At installation, there was a 3 mm to 4 mm (0.1181" to 0.1574") gap left between the frozen bearing segments so that as the bearings reached ambient temperature, they would have room to expand and fit in place," says Butzelaar.

Although the overall size of the cutter bearing is the largest ever for a dredger, each individual segment weighs a manageable 258 kg (570 lbs.). The smaller bearing tubes are easier to transport and, if necessary, easy to stow aboard the *J.F.J. de Nul*.



*Thordon Composite bearing freeze-fit installation on **J.F.J. de Nul** cutterhead drive shaft*

Advanced materials like Thordon Composite are enabling dredge vessels to operate more productively with less down time. Sea trails for *J.F.J. de Nul* are planned to be completed by the end of November and handed over to Jan de Nul in the spring of 2004.

THORDON COMPOSITE INSTALLED IN CUTTERHEAD DREDGES

The specialized cutter suction dredger, *Al Sadr* was equipped with Thordon Composite staves in the 890mm (31 in.) diameter shaft cutterhead.

National Marine Dredging Company (NMDC) of Abu Dhabi specified Thordon Composite in their specialized 20,200kW cutter suction dredger built at IHC of Sliedrecht, Holland. Composite staves were installed in May 1999 with the assistance of Dutch Thordon Distributor, B&B Engineering. The staves for the *Al Sadr* were for a 890mm (31 in.) diameter shaft. *Al Sadr* has the capabiltiy to dredge to a depth of 27m (88 ft.), and will keep the important shipping lanes of the Abu Dhabi port open as well as create new ones as the port continues to grow.

Manson Construction Company of Seattle, USA, launched their cutterhead dredger, *H.R. Morris* in the fall of 1998 to dredge the Snohomish River in Washington. Constructed by Gunderson Marine and outfitted by Manson, *H.R. Morris* is equipped with Thordon Composite bearings in the 559mm (20 in.) diameter shaft cutter head.

Thordon's Washington distributor, Pacific Marine Equipment, also supplied Thordon SXL TRAXL trunnion bearings for *H.R. Morris* for their self-lubricating and shock absorbing characteristics.

Al Sadr installation of 48 Thordon Composite staves during construction at IHC Holland in Sliedrecht.

M/v Vesalius

Date of Installation:	August 2001
Vessel Name:	*M/v Vesalius*
Vessel Type:	Cutterhead Dredger
Owner:	M/S Jan De Nul Group of Belgium
Cutterhead Shaft Diameter:	635mm
Material Replaced:	Thordon Composite
Date of First Composite Installation:	February 1996

M/v Vesalius based in Mahe Island, Seychelles - August 2001

Cutterhead Housing of Dredger M/v Vesalius, housing diameter 730.25mm

Thordon Composite staves originally installed in February 1996 were removed after over five years of operation

Thordon Composite staves installed in test housing (except the 18th long and short stave) on a spare shaft prior to installation

Thordon staves installed on spare shaft of dredger M/v Vesalius

Dry ice box filled with Thordon Composite staves being shifted to the cutter head site for

Thordon staves being installed into the cutterhead shaft of dredger M/v: Vesalius

Thordon Composite staves installed into the cutterhead dredger

The cutter of dredger M/v Vesalius

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Cutterhead Shaft Bearing References
Dredge Vessels

Vessel Name	Tonnes (DWT)	Ship Owner	Shipyard	Application	Thordon Grade	Classification Society	Shaft Diameter (mm)	Initial Install Date
Artemis	2,320	Van Oord NV Netherlands	IHC Merwede Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	959	Apr -2013
Athena	2,320	Van Oord Netherlands	IHC Merwede Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	950	Nov -2011
J.F.J. De Nul	3,230	Jan de Nul BV Belgium	IHC Merwede Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	950	Jun -2003
Niccolo Machiavelli	2,680	Jan De Nul BV Belgium	Uljanik Brodogradiliste Croatia	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	950	Sep -2011
Taurus II	1,500	Boskalis Netherlands	 Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	912	Jun -2011
Ambiorix	2,600	DEME Group Belgium	IHC Merwede Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	900	May -2012
D'Artagnan	2,600	DEME Group Belgium	IHC Merwede Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	900	Oct -2005
Phoenix I	4,000	Boskalis Netherlands	 Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	822	Dec -2006
Al Sadr		National Marine Dredging Co. U.A.E.	Dubai Drydocks U.A.E.	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	800	Feb -1999
Huta 9		Huta Marine Works Saudi Arabia	Dubai Shipyard Saudi Arabia	Dredge-Cutterhead Shaft Bearing	Composite		800	Jan -2013
Huta 9 (Al Sakab)		Huta Marine Works U.A.E.	 U.A.E.	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	800	Jan -2013

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Cutterhead Shaft Bearing References
Dredge Vessels

Vessel Name	Tonnes (DWT)	Ship Owner	Shipyard	Application	Thordon Grade	Classification Society	Shaft Diameter (mm)	Initial Install Date
Artemis	2,320	Van Oord NV Netherlands	IHC Merwede Netherlands	Dredge-Int Ladder Shaft Bearing	Composite	Bureau Veritas	773	Apr -2013
Athena	2,320	Van Oord Netherlands	IHC Merwede Netherlands	Dredge-Int Ladder Shaft Bearing	Composite	Bureau Veritas	765	Nov -2011
Al Jarraf	1,240	DEME Group Belgium	ASL Shipyard Singapore	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	750	Oct -2010
Amazone	1,240	DEME Group Belgium	ASL Shipyard Singapore	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	750	Dec -2011
Ambiorix	2,600	DEME Group Belgium	IHC Merwede Netherlands	Dredge-Int Ladder Shaft Bearing	Composite	Bureau Veritas	720	May -2012
Inai Dahlia		Inai Kiara Sdn Bhd Malaysia	Selat Melaka Shipyard Malaysia	Dredge-Cutterhead Shaft Bearing	Composite		717	Aug -2011
Pontos C-108		Archirodon Construction (Overseas) Co. SA U.A.E.	Dubai Drydocks U.A.E.	Dredge-Cutterhead Shaft Bearing	Composite		717	Oct -1997
Huta 1		Huta Marine Works Saudi Arabia	Dubai Shipyard Saudi Arabia	Dredge-Cutterhead Shaft Bearing	Composite		709	Jun -2013
Huta 2		Huta Marine Works Saudi Arabia	Dubai Shipyard Saudi Arabia	Dredge-Cutterhead Shaft Bearing	Composite		709	Jan -2013
Umm Al Zemoul		National Marine Dredging Co. U.A.E.	Dubai Drydocks U.A.E.	Dredge-Cutterhead Shaft Bearing	Composite		680	Jul -2002
Noordzee		Van Oord Netherlands	Tianjin Xinhe Shipbuilding China	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	658	Oct -2008

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Cutterhead Shaft Bearing References
Dredge Vessels

Vessel Name	Tonnes (DWT)	Ship Owner	Shipyard	Application	Thordon Grade	Classification Society	Shaft Diameter (mm)	Initial Install Date
Al Mirfa		National Marine Dredging Co. U.A.E.	Dubai Drydocks U.A.E.	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	654	Feb -2000
Huta 7		Huta Marine Works Saudi Arabia	Saudi Drydock, Jeddah Saudi Arabia	Dredge-Cutterhead Shaft Bearing	Composite		654	Sep -2005
Kattouf		National Marine Dredging Co. U.A.E.	IHC Merwede Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	654	Nov -2000
UMM Al Anber	2,670	Emirates Telecommunications Corp. U.A.E.	U.A.E.	Dredge-Cutterhead Shaft Bearing	Composite	DNV (Det Norske Veritas)	654	Jul -2013
Huta 10		Huta Marine Works Saudi Arabia	Saudi Drydock Saudi Arabia	Dredge-Cutterhead Shaft Bearing	Composite		650	Jun -2012
Jin Hang Jun 215		CCCC / CHEC Tianjin Dredging Company China	Dalian Shipbuilding Industry Co., Ltd. China	Dredge-Cutterhead Shaft Bearing	Composite	CCS (China Classification Society)	648	Oct -2004
Abu al Abyadh		National Marine Dredging Co. U.A.E.	IHC Merwede Netherlands	Dredge-Cutterhead Shaft Bearing	Composite		635	Jun -1996
Condreco		Jan De Nul BV Belgium	IHC Merwede Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	635	Jul -1993
Hondius		Jan De Nul N.V. Belgium	Tianjin Xinhe Shipbuilding China	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	635	Sep -2006
Kaerius		Jan De Nul N.V. Belgium	Tianjin Xinhe Shipbuilding China	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	635	Jun -2006
Vesalius		Vlaamse Belgium	IHC Merwede Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	635	Feb -1996

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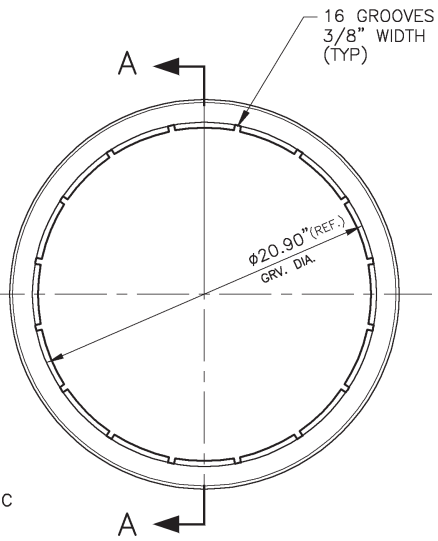
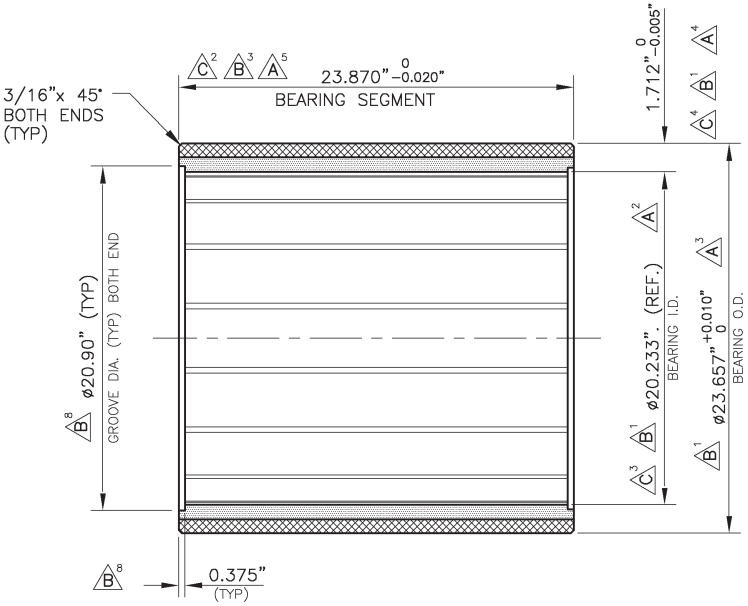
Cutterhead Shaft Bearing References
Dredge Vessels

Vessel Name	Tonnes (DWT)	Ship Owner	Shipyard	Application	Thordon Grade	Classification Society	Shaft Diameter (mm)	Initial Install Date
Ohio		Great Lakes Dredge & Dock U.S.A.	 U.A.E.	Dredge-Cutterhead Shaft Bearing	Composite		610	Nov -2013
Huta 2		Huta Marine Works Saudi Arabia	 U.A.E.	Dredge-Cutterhead Shaft Bearing	Composite		600	Jan -2013
Zeeland II		Van Oord Netherlands	 Netherlands	Dredge-Cutterhead Shaft Bearing	Composite		600	Dec -2005
Maxville		E.I. Dupont U.S.A.	Starke, Florida U.S.A.	Dredge-Cutterhead Shaft Bearing	Composite		570	Aug -1998
Al Mahaar	1,086	Middle East Dredging Qatar	 U.A.E.	Dredge-Int Ladder Shaft Bearing	Composite	Bureau Veritas	560	Feb -2013
Gouda		Zanen ver Stoep Netherlands	 Bahrain	Dredge-Cutterhead Shaft Bearing	Composite		559	Oct -1978
		E.I. Dupont U.S.A.	Florida U.S.A.	Dredge-Cutterhead Shaft Bearing	Composite		559	Sep -2002
Al Jarraf	1,240	DEME Group Belgium	ASL Shipyard Singapore	Dredge-Int Ladder Shaft Bearing	Composite	Bureau Veritas	540	Oct -2010
D'Artagnan	2,600	DEME Group Belgium	IHC Merwede Netherlands	Dredge-Int Ladder Shaft Bearing	Composite	Bureau Veritas	540	Oct -2005
HR Morris		Manson Construction & Eng. U.S.A.	Manson Construction, California U.S.A.	Dredge-Cutterhead Shaft Bearing	Composite		533	Aug -1998
Haarlem		Van Oord NV Netherlands	 Netherlands	Dredge-Cutterhead Shaft Bearing	Composite	Bureau Veritas	532	Apr -2011





SECTION A–A

A1 TABLE
B2

A8 B4 C1
SHAFT DIA. = 20.000"±0.002"
B5 A6 HOUSING DIA. = 23.525"
C6 B6 A7
TEMPERATURE RANGE = –2°C TO 30°C
RUNNING CLEARANCE = 0.051"

GENERAL NOTES:

01. MAT'L – THORDON COMPOSITE
02. ALL DIMENSIONS ARE EXPRESSED IN INCHES UNLESS NOTED OTHERWISE.
03. DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED.
04. TOLERANCES FOR ALL DIMENSIONS SHALL BE NONCUMULATIVE.
05. BREAK ALL CORNERS AND DEBURR ALL SHARP EDGES.
06. ALL FILLET AND RADII DIMENSIONS ARE NOMINAL UNLESS NOTED OTHERWISE.
B7 07. THREE (3) BEARING SEGMENTS REQUIRED FOR A TOTAL BEARING LENGTH
C5 OF 71.610"

REFERENCE: MANSON CONSTRUCTION,
DREDGE H.R. MORRIS.

ZONE	LTR LET	REVISION	DATE	DWN DES	CKD VER	APPVL APP
B4	C6	HOUSING LG. DIM. REMOVED	FEB 22/99	G.C.	G.C.	D.P.
A4	C5	NOTE 7 MODIFIED (LG. WAS 72.600")	FEB 22/99	G.C.	G.C.	D.P.
B1	C4	DIM WAS 1.711"	FEB 22/99	G.C.	G.C.	D.P.
B1	C3	DIM WAS ø20.235"	FEB 22/99	G.C.	G.C.	D.P.
B2	C2	DIM WAS 24.200"	FEB 22/99	G.C.	G.C.	D.P.
B4	C1	SHAFT TOL. WAS +.002"/–.002"	FEB 22/99	G.C.	G.C.	D.P.
B2	B8	RADIAL GROOVE ADDED	JULY 15/98	R.G.	R.G.	D.P.
A4	B7	NOTE 07 ADDED	JULY 15/98	R.G.	R.G.	D.P.
B4	B6	HOUSING LENGTH WAS 24.50"	JULY 15/98	R.G.	R.G.	D.P.
B4	B5	HOUSING DIA. ADDED	JULY 15/98	R.G.	R.G.	D.P.
B4	B4	SHAFT TOLERANCE ADDED	JULY 15/98	R.G.	R.G.	D.P.
B2	B3	BEARING LENGTH WAS 24.00"	JULY 15/98	R.G.	R.G.	D.P.
B4	B2	TABLE REMOVED	JULY 15/98	R.G.	R.G.	D.P.
B1	B1	BEARING I.D., O.D. & WALL THK. ADDED	JULY 15/98	R.G.	R.G.	D.P.
B4	A8	INTERFERENCE, BORE CLOSURE, THERMAL EXPANSION AND ABSORPTION ALLOWANCE REMOVED	JUNE 19/98	R.G.	R.G.	D.P.
B4	A7	HOUSING LG. WAS 24.00"	JUNE 19/98	R.G.	R.G.	D.P.
B4	A6	HOUSING DIA. WAS 24.00"	JUNE 19/98	R.G.	R.G.	D.P.
B2	A5	DIM. WAS 23.847"	JUNE 19/98	R.G.	R.G.	D.P.
B1	A4	DIM. WAS 1.947"+0/–0.005	JUNE 19/98	R.G.	R.G.	D.P.
B1	A3	DIM. WAS 24.118"+0.010/–0	JUNE 19/98	R.G.	R.G.	D.P.
B1	A2	DIM. WAS 20.233" (REF.)	JUNE 19/98	R.G.	R.G.	D.P.
B4	A1	TABLE ADDED	JUNE 19/98	R.G.	R.G.	D.P.

CONDITIONS – UNLESS OTHERWISE SPECIFIED:/CONDITIONS – SAUF INDICATION CONTRAIRE:

DIMENSIONS ARE IN/DIMENSIONS SONT EN
ORIGINAL SCALE/ECHELLE ORIGINALE IN N.T.S.

TOLERANCES	IMP. (in)	MET. (mm)
SURFACE FINISH/FINIS DE SUEFACES	125	3.2
DECIMAL/DECIMALE – 1 PLACE (X.X)	± 0.1	TABLE A
DECIMAL/DECIMALE – 2 PLACE (X.XX)	± 0.01	
DECIMAL/DECIMALE – 3 PLACE (X.XXX)	± 0.005	
FRACTIONAL	± 1/64	
ANGULAR DECIMAL/ANGULAR DECIMALE		
HOLE SIZES/DIM DE TROUS	± 1/64	± 0.4
FLAME CUTTING, SHEARING, NIBBLING, FORMING AND WELDING FLAMME DECOUPAGE, CISAILLER, POINTE, FORGEAGE ET SOUDURE AUTOGENE	± 1/16	± 1.6

TABLE A

DIMENSIONS ABOVE AU–DELA DE	DIMENSIONS THROUGH JUSQU'A	TOLERANCE (mm)
	6	± 0.1
6	30	± 0.2
30	100	± 0.3
100	300	± 0.5
300	1000	± 0.8
1000	2000	± 1.2
2000	4000	± 2
4000	8000	± 3
8000	12000	± 4
12000	16000	± 5

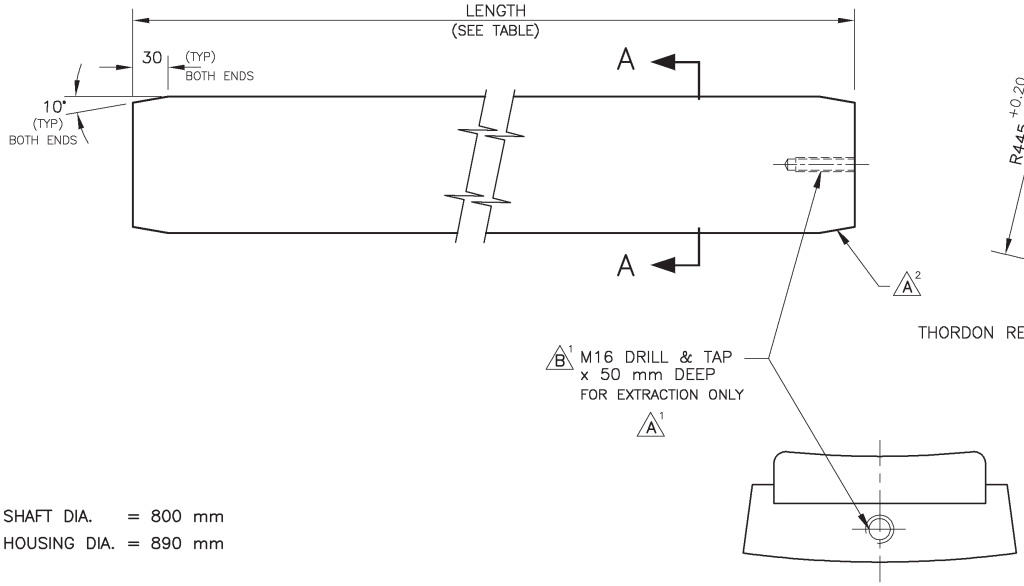
THIS IS NOT TO BE CONSIDERED AN APPROVED DRAWING UNLESS IT IS STAMPED BY THORDON BEARINGS INC. IN RED INK AND SIGNED.
CET DESSIN CE N'EST PAS CONSIDERE APPROUVE A MOINS QUE SOIT ESTAMPE' PAR THORDON BEARINGS INC. EN ENCRE ROUGE ET SIGNE'.

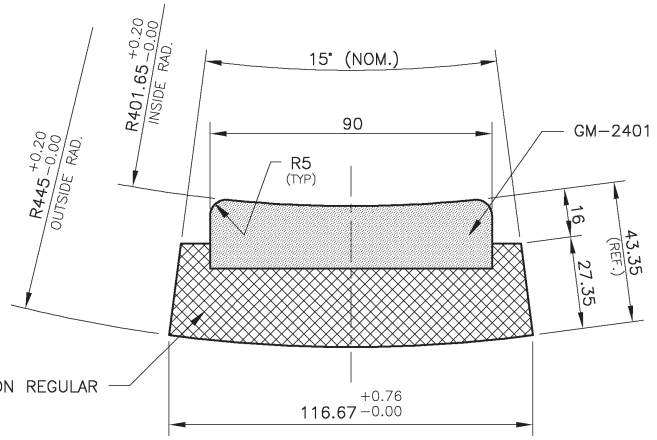
THORDON BEARINGS INC.
BURLINGTON, ONTARIO, CANADA

DWN/DESS	SIGN.	CKD/VER	SIGN.	APPVL/APP	SIGN.
R. GARCIA		V. POWER		D. PATTON	

CUSTOMER/CLIENT: PACIFIC MARINE
DRAWING DATE / DATE DU DESSIN: JUNE 16/98
MRP NO.:
SIZE: B
TITLE/TITRE: CUTTER HEAD COMPOSITE BEARING
DRAWING NO. DU DESSIN: TG–13902
REV.: C
SHEET / FEUILLE: 1 OF / DE 1

Millimetres/Millimetres 0 1 2 3 4 5 6 7 8 9 10
Centimetres/Centimetres





SECTION A–A

SHAFT DIA. = 800 mm
HOUSING DIA. = 890 mm

LENGTH	QTY.
$1587^{+0.00}_{-1.50}$	18
$1523^{+0.00}_{-1.50}$	6
$794^{+0.00}_{-1.50}$	24

GENERAL NOTES:

01. MAT'L – COMPOSITE
02. ALL DIMENSIONS ARE EXPRESSED IN MM UNLESS NOTED OTHERWISE.
03. DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED.
04. TOLERANCES FOR ALL DIMENSIONS SHALL BE NONCUMULATIVE.
05. BREAK ALL CORNERS AND DEBURR ALL SHARP EDGES.
06. ALL FILLET AND RADII DIMENSIONS ARE NOMINAL UNLESS NOTED OTHERWISE.

BORE CLOSURE = 0.32
RUNNING CLEARANCE = 2.01
THERMAL EXPANSION = 0.33
ABSORPTION ALLOWANCE = 0.64

CONDITIONS – UNLESS OTHERWISE SPECIFIED:/CONDITIONS – SAUF INDICATION CONTRAIRE:

DIMENSIONS ARE IN/DIMENSIONS SONT EN — MM
ORIGINAL SCALE/ECHELLE ORIGINALE — N.T.S.

TOLERANCES	IMP. (in)	MET. (mm)
SURFACE FINISH/FINIS DE SUEFACES	125	3.2
DECIMAL/DECIMALE – 1 PLACE (X.X)	± 0.1	
DECIMAL/DECIMALE – 2 PLACE (X.XX)	± 0.01	TABLE A
DECIMAL/DECIMALE – 3 PLACE (X.XXX)	± 0.005	
FRACTIONAL	± 1/64	
ANGULAR DECIMAL/ANGULAR DECIMALE		
HOLE SIZES/DIM DE TROUS	± 1/64	± 0.4
FLAME CUTTING, SHEARING, NIBBLING, FORMING AND WELDING	± 1/16	± 1.6
FLAMME DECOUPAGE, CISAILLER, POINTE, FORGEAGE ET SOUDURE AUTOGENE		

TABLE A

DIMENSIONS ABOVE AU–DELA DE	DIMENSIONS THROUGH JUSQU'A	TOLERANCE (mm)
	6	± 0.1
6	30	± 0.2
30	100	± 0.3
100	300	± 0.5
300	1000	± 0.8
1000	2000	± 1.2
2000	4000	± 2
4000	8000	± 3
8000	12000	± 4
12000	16000	± 5

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CET DESSIN CE N'EST PAS CONSIDERE APPROUVE A MOINS QUE SOIT ESTAMPE' PAR THORDON BEARINGS INC. EN ENCRE ROUGE ET SIGNE'.

ZONE	LTR LET	REVISION	DATE	DWN DES	CKD VER	APPVL APP
A3	B1	THREAD WAS M12	NOV 17/98	R.G.	V.P.	D.P.
B2	A2	CHAMFER ADDED	NOV 09/98	R.G.	V.P.	D.P.
A3	A1	EXTRACTION HOLE ADDED	NOV 09/98	R.G.	V.P.	D.P.

THORDON BEARINGS INC.
BURLINGTON, ONTARIO, CANADA

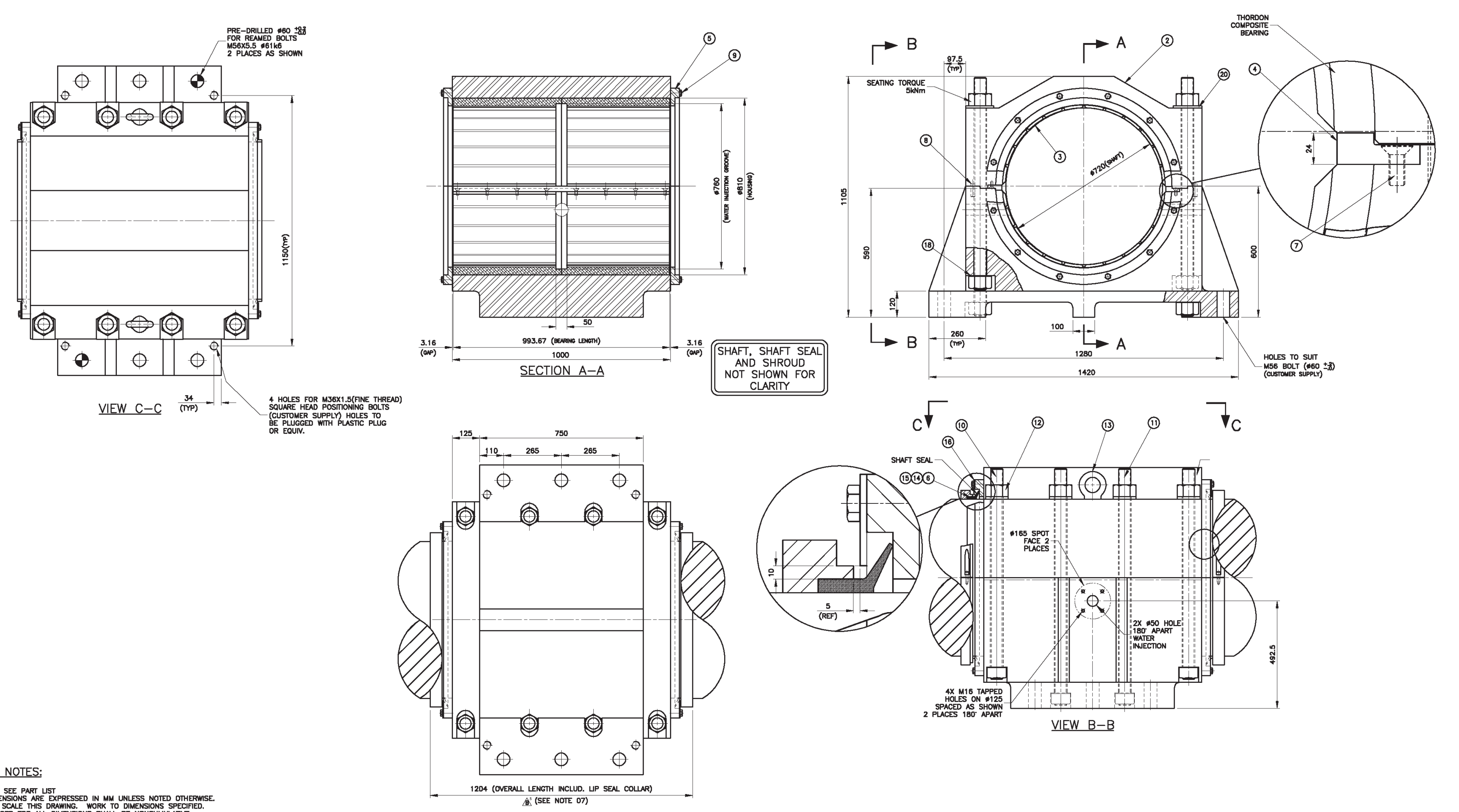
DWN/DESS	SIGN.	CKD/VER	SIGN.	APPVL/APP	SIGN.
R. GARCIA		V. POWER		D. PATTON	

CUSTOMER/CLIENT	DRAWING DATE DATE DU DESSIN	MRP NO.	SIZE
INTERTECH B.V.	SEP 03/98		B

TITLE/TITRE	DRAWING NO. DU DESSIN	REV.
CUTTER HEAD FOR NMDC COMPOSITE STAVE	TG–13964	B
	SHEET FEUILLE 1	OF DE 1

Eighths Huitiemes 0 1 2 3 4 5 6 7 8 9 10 Tenths Dixiemes
Millimetres/Millimetres 0 1 2 3 4 5 6 7 8 9 10
Centimetres/Centimetres

IF IN DOUBT, DO NOT ASSUME – ASK!



GENERAL NOTES:

01. MAT'L – SEE PART LIST
02. ALL DIMENSIONS ARE EXPRESSED IN MM UNLESS NOTED OTHERWISE.
03. DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED.
04. TOLERANCES FOR ALL DIMENSIONS SHALL BE NONCUMULATIVE.
05. BREAK ALL CORNERS AND DEBURR ALL SHARP EDGES.
06. ALL FILLET AND RADII DIMENSIONS ARE NOMINAL UNLESS NOTED OTHERWISE.
07. SHAFT LINER SHALL BE LONGER THAN OVERALL LENGTH SHOWN ON THIS DRAWING.
08. APPLY LOCTITE LOW STRENGTH SEALANT TYPE 509 OR (5203/5208) ON SPLIT HOUSING SURFACE AND DOWEL PINS AT FINAL ASSEMBLY
09. HOUSING BORE TO BE DRY-ABRASIVE BLAST CLEAN IN ACCORDANCE WITH SSPC STANDARD SP-6/NACE No.3 COMMERCIAL BLAST CLEAN.
9.1 APPLY ONE COAT OF DEVGUARD 4160 RUST INHIBITIVE ALKYD METAL PRIMER AT A RATE TO ACHIEVE A D.F.T. OF 1.5 TO 2 MIL TO PREVENT BORE CORROSION.
10. AT ASSEMBLY FILL ALL CAVITIES (BORED HOLES ETC.) WITH LOCTITE 5926 OR 587 BLUE RTV SILICONE.
11. AT ASSEMBLY SECURE ALL NUTS, HOISTING EYES ETC. WITH LOCTITE 243 OR 242 THREAD LOCKER
12. HOUSING EXTERIOR TO BE SAND BLASTED AND EPOXY COATED WITH RAL6005 MOSS GREEN

DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS SPECIFIED

[redacted]

ZONE	LTR LET	REVISION	DATE	DWN DES	CKD VER	APPVL APP

THORDON BEARINGS INC.
BURLINGTON, ONTARIO, CANADA

DWN/DESS	CKD/VER	APPVL/APP
G.Letourneau	V.POWER	K.OGLE

CUSTOMER/CLIENT	DRAWING DATE / DATE DU DESSIN	MRP NO.	SIZE
SANDFIRDEN TECNICS/ IHC DREDGER	05-MAY-04		D

TITLE/TITRE	DRAWING NO. DU DESSIN	REV.
THORDON COMPOSITE INTERMEDIATE CUTTER SHAFT BEARING GENERAL ARRANGEMENT	TG-16412	G

SHEET/FEUILLE 2 OF/DE 2

THORDON

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