

ADVANCED MATERIALS

Engineered Fluid Film Bearings for Demanding Applications



WB **WAUKESHA**
BEARINGS
A DOVER COMPANY



Waukesha Bearings

For over fifty years, innovation has driven the value we provide our customers. From the application of fluid film bearing technology to new product development and testing, Waukesha Bearings is committed to engineering leadership and understanding customers' real needs.

Our goal is to exceed the demanding expectations of turbomachinery builders. Machine performance shouldn't be limited by a catalog bearing with pre-designed performance and size envelopes. Waukesha Bearings engineers design between the lines by applying a collection of patented and optimized design features and materials to an already extensive range of fixed profile and tilting pad products. The end result is a machine with the best possible performance.

With more than 25 years of advanced materials experience, Waukesha Bearings has led the design and development of polymer and ceramic technologies for demanding fluid film bearing applications.

Polymer technology was initially utilized as a high-performing substitute for metallic linings while ceramics were used as a specific solution for process fluids and abrasive environments. Continued innovation with the latest polymer and ceramic materials, extension of the range of design features and adoption of new manufacturing processes has expanded their application to a wide variety of rotating machinery.

Our team in North America, Europe and Asia provides responsive and personalized service to customers all over the world. If you're looking for the leader in fluid film and active magnetic bearing technology choose the benchmark.

[Choose Waukesha Bearings.](#)





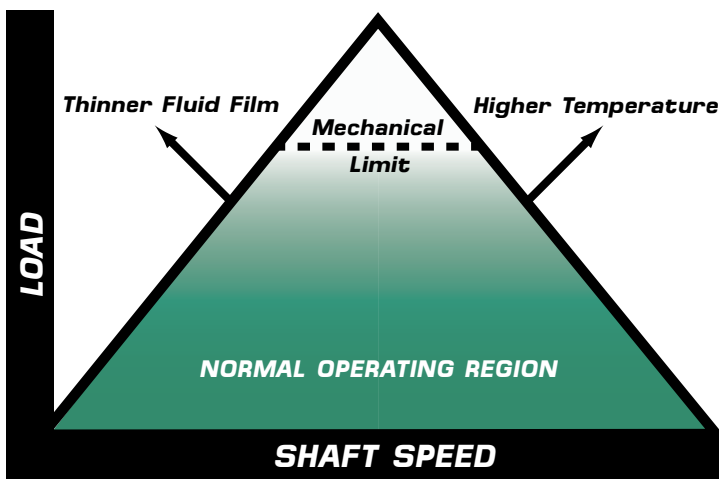
High-Performance Materials

Waukesha Bearings offers high-performance engineered polymer and ceramic materials that extend the operating limits of both fixed profile and tilting pad bearing operating limits. Load carrying capacity, lubrication configuration and temperature all play a vital role in the selection of bearing material.

Application and design experience combined with advanced materials expertise provides the foundation for Waukesha Bearings' highest performing products.

Advanced materials are compatible with even the most challenging lubricants and process fluids:

- Mineral/Synthetic Oils – VG5 to VG220 •
- Water/Seawater • Freon • Toluene • Amine •
- Crude Oil • Hydrocarbon Condensates •
- Methane • Liquid O₂ • Liquid CO₂ •
- Propane • Butane • Hexane •



Expanding the Performance Envelope

The application of advanced materials expands the limits of pad temperature and operating film thickness.

Thinner Hydrodynamic Films

Surface properties and mechanical strength allow polymer and ceramic bearings to operate with thinner films.

- Higher Load Capacity - Up to 10 MPa (1,500 psi)
- Operation with Low Viscosity Lubricants
- Reduced Power Loss - Up to 30% Savings

Higher Temperature Capability

Both polymer and ceramic materials have higher melting points and retain their mechanical properties at elevated temperatures.

- Polymers up to 250° C (480° F)
- Ceramics up to 400° C (750° F)

The proper design and configuration of the lubrication system is necessary to ensure sufficient cooling of bearing surfaces and formation of the optimum hydrodynamic film. This is especially critical with low viscosity fluids or with fluids having a low boiling point.

Corrosion Resistant

Engineered polymers and ceramics are resistant to most chemicals including hydrogen sulphide and ammonia.

Abrasion Resistant

Ceramics are resistant to abrasives and will grind down debris such as sand in the lubricant. Polymers will embed dirt that enters the fluid film.

Electrical Insulating

The high electrical resistance of polymers has been utilized in motor and generator applications to prevent the passage of damaging current through the bearing and housing.

Reduction of Start-up Torque

Polymer bearing materials have lower coefficients of friction than whitmetal and can be used to reduce torque at start-up and avoid hydrostatic lift systems.



Oil Lubricated Applications

Subsea Pumping Equipment

The ongoing search for new oil and gas fields requires even higher levels of technology for extraction, production and processing. Subsea processing has evolved into a major participant in the exploration and production of oil and natural gas, including applications for separation, boosting, raw water injection and gas compression.

Machinery builders in this growing market are faced with significant challenges in lubrication and power supply. For bearing manufacturers, the demand for minimal power losses and high loads are both critical design parameters requiring bearings to operate on very thin hydrodynamic films. Polymer bearings have been widely used in multi-phase booster pumps as well as in water injection pumps.

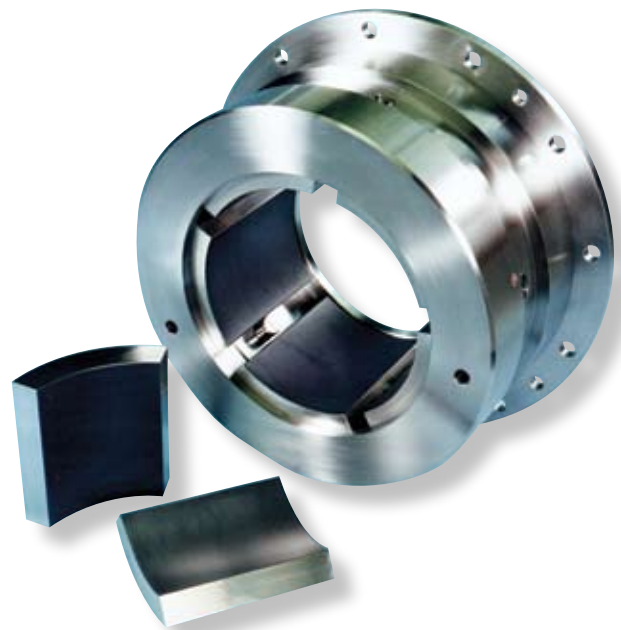


A subsea module containing two water-injection pumps with polymer thrust and journal tilt-pad bearings. (Photo courtesy of Framo Engineering AS.)

Gas Turbines

On shutdown of a gas turbine heat soaks along the shaft and the bearings can see temperatures up to 250° C (480° F) if no cooling oil is supplied. As a result, gas turbines are equipped with DC-operated safety systems to ensure a continuous flow of cooling oil to the bearings during normal and emergency shutdowns. During a shutdown sequence, oil will continue to flow through the turbine until the shaft temperature is reduced to a level that avoids damaging the whitemetal bearing lining. The system requires both an AC and DC power source should there be a loss of normal power.

Polymer-lined tilt-pad thrust and journal bearings can replace traditional whitemetal bearings in the hot section of the gas turbine as they can withstand the higher temperatures resulting from heat soak. This eliminates the need for the back-up system saving both weight and cost. Alternatively, polymer-lined bearings are used as an additional safety feature in the event the back-up system fails.



A polymer-lined tilt-pad journal bearing suitable for a 160 mm (6.3 inches) shaft diameter gas turbine.



Electric Submersible Pumps

Electric Submersible Pumps, or ESP's, are comprised of a motor, seal and pump section and are used in small diameter bore holes to lift oil to the surface. ESP's are often selected to operate at significant depths and at high ambient temperatures (placing unusually high demands on bearings and materials). Traditionally, bronze thrust washers were utilized to withstand elevated temperatures. However, this type of bearing has a limited load capacity, small tolerance for misalignment and a tendency to seize when contaminated with dirt.

Over the past 25 years polymer-lined tilt-pad thrust bearings have become the standard for operating temperatures up to 200° C (400° F) and loads up to 8 MPa (1,200 psi). The high temperature and load capabilities of the polymer lining are complimented by the tilt-pad designs' higher tolerance for misalignment. The polymer-lined bearings are used in the motor to account for thermal expansion and in the seal section to withstand the pump load. As an additional benefit in the motor, the bearings provide electrically insulating properties.

Continuing innovation in bearing designs and materials meet ongoing demands for ESP's to operate at greater depths and higher temperatures. For example, Canadian tar sand applications require steam to liquefy the oil to allow the ESP to operate effectively. Elevated temperatures of 300° C (575° F) caused by the steam have necessitated the use of advanced ceramic materials to withstand the temperature and shock loads.



A 62 mm (2.5 inches) OD polymer-lined tilt-pad thrust bearing used in an ESP motor.



A 110 mm (4.3 inches) fiber-reinforced ceramic tilt-pad thrust bearing used in a high temperature ESP seal.



Polymer-lined pads are available for non-equalized and equalized tilt-pad thrust bearings as well as tilt-pad journal bearings. Designs can include either flooded or 'Directed Lubrication' configurations with provisions for RTD's or thermocouples for temperature measurement. The photo above shows a 215 mm (8.5 inches) thrust bearing with 'Directed Lubrication' and temperature sensors to resist heat soak in a high-speed gas turbine.

Water & Process Lubrication

A variety of applications use water or the process fluid to lubricate the bearings. In these applications the materials need to be both chemically resistant to the fluid and be able to support the associated thin films. With clean fluid, solid polymer bearings provide a high load capacity and inert solution. Where abrasives such as sand are present, ceramic bearings provide a water-resistant option.

Pumps

Pumps using the processed media as the lubricant for the bearings contain fewer seals. Without a separate oil lubrication system the pumps can be smaller and lower cost. The solid polymer bearing provides a solution for high load capacities up to 10 MPa in clean water and has been used with success in swash-plate pumps, power station heater-lift pumps and mine-dewatering pumps.

Water-Filled Motors

Water-filled motors are widely used for water extraction applications. The thrust bearings support the pump load and are lubricated by the water cooling the motor.

Water-Lubricated Compressors

Water-Lubricated compressors are desirable for use where oil contamination of the compressed product needs to be avoided. Lubricating the bearings with water eliminates such contamination and simplifies sealing components.

ORC Turbines

ORC Turbines, based on the Organic Rankin Cycle, are used to produce electricity from low grade heat sources such as diesel engine exhaust gases and landfill gas. These systems use solvents such as toluene and hexane as both the working fluid and the lubricant for the bearings. Polymer journal and thrust bearings can sustain the thin films associated with these fluids despite the high operating speeds of 10,000 to 30,000 rpm. The sealing and the flow path of the lubricant are key issues for successful operation.



A 170 mm (6.75 inches) OD high performance thrust bearing for a swash-plate pump.



"Wet wound" heater lift pumps used in large power stations are being upgraded with solid polymer thrust bearings to replace ferrobestos materials.
(Photo courtesy of Weir Engineering Services Ltd.)



Ceramic Bearings

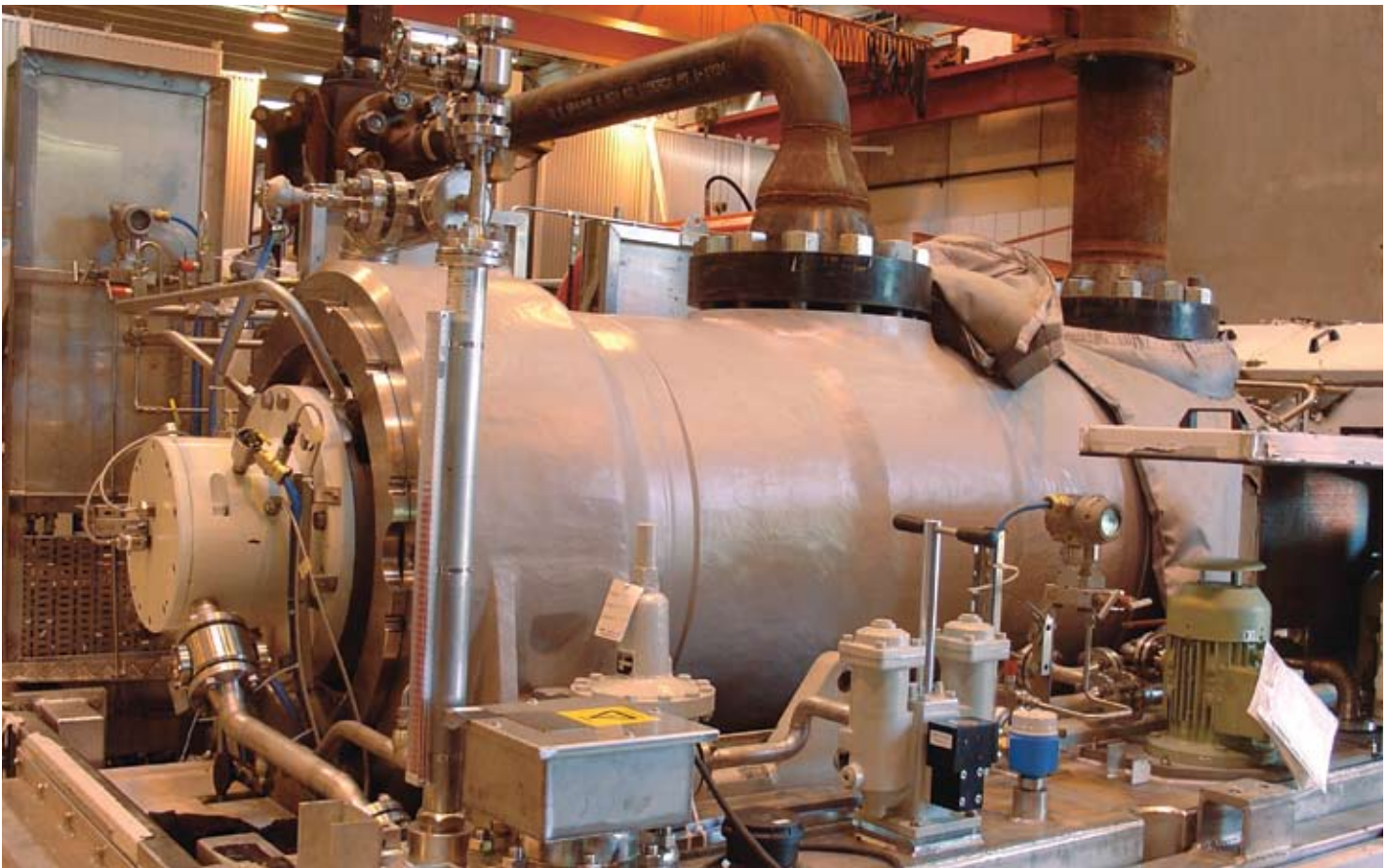
Ceramic bearings are used successfully in many process-lubricated pump applications. The ceramic components have high thermal conductivity and are harder than common abrasives such as sand. These characteristics allow excellent thin film performance and the ability to crush any abrasive debris in the system. Ceramic materials have been used for both tilt-pad thrust and journal bearings as well as for cylindrical bore bushes. Ceramic bearings can be used for mid-stage throttle bushes with a high pressure drop across them.

Ceramic bearings have been used extensively in water injection pumps in the North Sea as well as crude oil booster pumps, cryogenic pumps and various military applications.

A key new development for ceramic bearings is subsea pumping applications. OEMs are looking to simplify the system by eliminating the mechanical seals. These seals are seen as one of the components most likely to limit the life of the overall system where recovery costs are significant.



A 2,200 horsepower water-filled motor with a ceramic thrust bearing operating in a Nevada gold mine.



A large high-pressure water-injection pump designed for a North Sea oil platform. The pump utilizes two 165 mm ceramic journal bearings. (Photo courtesy of Aker Kvaerner Subsea.)



North America:
W231 N2811 Roundy Circle East
Suite 200
Pewaukee, WI 53072
262.506.3000

Europe:
53-55 The Broadway, Joel Street
Northwood, Middlesex
United Kingdom HA6 1NZ
44(0)1923.845.100

www.waukbearing.com