Experience Performance
EXPERT ANALYSIS, REPAIRS AND UPGRDES

GE Frame 7FA
419 mm (16.5") bore

Before

After

EXPERT ENGINEERING. PROVEN RESULTS™.
Bearings Plus™, a Waukesha Bearings® business, is a global leader in the complete design, manufacture and servicing of fluid film bearings and seals for turbomachinery applications.

Our team of highly trained designers and craftsmen applies proven technologies to improve the efficiency and service life of rotating equipment in the oil & gas, power generation, marine and general industrial markets.

With the most sophisticated testing facilities and advanced engineering expertise in the industry, we offer design upgrades as firsthand solutions and can provide second opinions when users work directly with OEMs. In addition, our precision manufacturing capabilities achieve the tight tolerances required for peak performance.

**SETTING THE STANDARD WITH RESPONSIVENESS**

Established in 1994, Bearings Plus (BPI®) has been providing responsive service, engineering excellence and custom-designed hardware for more than 20 years.

Our experts know the importance of paying attention to detail, whether performing routine maintenance or a full rotordynamic optimization and retrofit. By providing the industry with high-quality solutions and products, BPI has improved reliability and performance in countless machines for end users and OEMs.

We are proud of our long list of satisfied customers that rely on our steadfast ability to respond. Day or night, around the globe, we’ll be there to get you back up and running efficiently.

*Bearings Plus operates in a 150,000 sq. ft. shared Dover facility in Pearland, Texas, USA – and serves customers globally.*

*BPI restores bearings and seals to peak performance to maximize your plant’s effectiveness. Pictured above: Before and after photos of a 178 mm (7”) fan bearing refurbished by BPI. Work included rust removal, resurfacing and threading repair.*
Analytical Services

PROVIDING SCIENTIFIC KNOWLEDGE AND TECHNICAL LEADERSHIP

BPI offers unparalleled technical support capabilities. As part of our state-of-the-art analytical services, we offer a full rotordynamic analysis, evaluating the bearing and seal characteristics simultaneously to better understand the independent effect of each component. Our staff of experts uses this knowledge to create innovative solutions and optimize bearings and seals for individual operating conditions.

Contact us today about any of our analytical services:
• Lateral rotordynamic analysis
• Transient and steady state analysis
• Damper seal stability analysis and optimization
• Bearing analysis and optimization
• Failure analysis
• Finite element analysis
• Vibration analysis and diagnostics

Case Study

A DUAL SOLUTION FOR HIGH VIBRATIONS AND INCREASES IN BEARING CLEARANCE DUE TO PIVOT WEAR

A centrifugal compressor for natural gas exploration and production was experiencing increasing bearing clearance due to pivot wear, as well as high fluctuating vibrations. The compressor was designed to run non-stop, year-round, but the bearing clearance and stability issues required a rebalancing of the rotor and replacement of the bearings every six to nine months, taking the compressor offline for several days each time. After analyzing the system, Bearings Plus provided a two-part solution: Flexure Pivot® journal bearings with ISFD® technology.

The one-piece Flexure Pivot design, which operates through flexure and rotation of a center post rather than a rocking or sliding motion, eliminated pivot wear and high-contact stress to prevent bearing clearance changes.

Meanwhile, the ISFD integral squeeze film damper technology increased the system’s stability margin. The original equipment manufacturer had already applied an O-ring squeeze film damper in an attempt to correct the vibrations. However, the O-ring damper was being overloaded, which allowed the bearings to bounce against the bearing casing and made the O-ring damper ineffective. The ISFD technology provided optimized damping to reduce the vibrations to a low, steady state, and the end user was able to successfully run the compressor without the rotordynamic instability that had persisted for more than 13 years.

The dual solution not only made continuous natural gas production available but provided significant cost-savings. The nature of the Flexure Pivot design with ISFD technology allowed for a drop-in retrofit, reduced maintenance needs and extended bearing life.
**Case Study**

**ELIMINATING SUBSYNCHRONOUS VIBRATIONS ON A STEAM TURBINE**

Flexible rotors in high-speed and high-pressure applications are especially susceptible to rotordynamic instabilities and high amplification factors through critical speed transitions. A 46 MW steam turbine, part of a combined cycle system for generation of electricity as well as heat recovery, experienced strong subsynchronous vibrations during the initial commissioning process that prevented the drive train from operating at full load (Figure 1).

When multiple changes to the bearing clearances failed to mitigate the vibrations, the manufacturer contacted Bearings Plus. BPI proposed a system-level rotordynamic assessment of the turbine, which revealed the cause of the vibrations to be a flexible rotor combined with steam whirl forces in secondary sealing locations.

For a solution, BPI proposed tilt pad bearings with ISFD technology. The patented ISFD design provides low stiffness and high damping to maximize the damping ratio and eliminate subsynchronous vibrations.

The ISFD configuration has integral “S” springs connecting an outer and inner ring, and a squeeze film damper land extending between each set of springs. Bearing pads are housed in the inner ring. (Figure 2) The unique design produces superior damping effectiveness by separating stiffness from damping, and unlike fluid film bearings, allows the stiffness and damping to be engineered independently to required values for each application.

For the steam turbine, a damped eigenvalue analysis of the solution showed a better stability margin by a factor of 12 with the ISFD design compared to the original bearings. After installation, field vibration data showed that the subsynchronous vibration spikes experienced at the initial commissioning were eliminated (Figure 3).

With this drop-in retrofit solution, the turbine was able to run at full load to generate maximum power.

*The complete paper can be found in the proceedings of the ASME Turbo Expo 2014, GT2014_27066.*
Bearing Repairs, Replacements and Upgrades

With 24/7 operations and a global presence, Bearings Plus is a service-oriented shop for bearing repairs and custom technology upgrades on your most critical applications.

**FIXED PROFILE (PLAIN) JOURNAL BEARINGS**
- Sizes from 9.5 mm (0.375") to over 910 mm (36")
- Surface speeds up to 60 m/sec (200 ft/sec)
- Unit loads up to 2.8 MPa (400 psi)
- CNC manufacturing of spherical OD bearings
- Complete replacements and rebabbitting

**FIXED PROFILE (PLAIN) THRUST BEARINGS**
- Sizes to over 910 mm (36")
- Surface speeds up to 60 m/sec (200 ft/sec)
- Unit loads up to 2.4 MPa (350 psi)
- Flat land and taper land
- Complete replacements and rebabbitting

**TILT PAD JOURNAL BEARINGS**
- Sizes from 9.5 mm (0.375") to over 910 mm (36")
- Surface speeds up to 120 m/sec (400 ft/sec)
- Unit loads up to 3.1 MPa (450 psi)
- Rocker back or ball and socket pivot
- Complete replacements and rebabbitting

**TILT PAD THRUST BEARINGS**
- Sizes to over 910 mm (36")
- Surface speeds up to 240 m/sec (800 ft/sec) at OD
- Unit loads up to 5.5 MPa (800 psi)
- Self-equalizing and directed lubrication
- Ball and socket pivot option
- Complete replacements and rebabbitting
- Polymer lined

**FLEXURE PIVOT® JOURNAL & THRUST BEARINGS**
- Typical sizes from 7 mm (0.3") to 150 mm (6")
- Surface speeds up to 125 m/sec (410 ft/sec)
- Unit loads up to 3.5 MPa (500 psi)
- Integral radial pads for elimination of pivot wear
- Tight tolerance EDM manufacturing process
- Compact design for retrofit

**ISFD® INTEGRAL SQUEEZE FILM DAMPER**
- Sizes up to 400 mm (16")
- Shaft centering availability
- Application-specific stiffness and damping
- Available with rolling element, fixed profile or tilt pad bearings
FOR HEAVY FRAME GAS TURBINES

BPI has developed a line of brush seals to increase the performance of heavy frame gas turbines. Flexible brush seals, made from backward-angled alloy bristles, are immune to rubbing and maintain original clearance longer than labyrinth seals alone, ensuring minimum compressor stage leakage and improved turbine efficiency. BPI brush seals use identical materials and technology to the seals originally developed for aircraft engines and proven in the harshest environments.

BPI brush seals:
• Reduce labyrinth bypass air flow by up to 50%
• Increase turbine efficiency by up to 2%
• Minimize shaft bowing and heating caused by “rub-in” features
• Fit into existing labyrinths, eliminating the need for casing modifications
• Extend time between seal replacements
• Reduce future repair costs with their patented modular assembly

Bearing Housing Brush Seal

On turbines configured with three bearings, the #2 bearing housing seal is a potential leak path of high-pressure air. To minimize compressor air leakage and increase turbine performance, several retrofit options are available:
• Retrofit existing air seal with a modular brush seal
• Retrofit with a complete replacement bronze labyrinth and modular brush seal

High Pressure Packing (HPP) Brush Seal

The inner barrel between a compressor and turbine has HPP designed to control the bypass of compressor high-pressure air (the most expensive air) into the turbine wheel space. Brush seals can supplement labyrinth seals to offer half the leakage. Several retrofit options are available:
• Complete inner barrel retrofit includes grooving and modular brush seals
• OEM brush seal replacement includes roll-in single or double hook to match OEM designs

Interstage Brush Seal

On some heavy frame gas turbines, the second stage nozzle/diaphragm assembly contains a radial high-low labyrinth seal designed to reduce leakage between the diaphragm and turbine rotor into the stage 2 forward wheel space area. A brush seal solution is available to reduce setup time and increase efficiency:
• Replace the complex high-low labyrinth seal with a simple labyrinth seal augmented with a brush seal
FOR STEAM TURBINES, COMPRESSORS AND EXPANDERS

Augmenting labyrinth seals with brush seals, or installing complete replacement labyrinths with brush seals, is a simple and effective approach to eliminating problems from shaft contact wear, significantly improving and maintaining turbomachinery performance.

BPI brush seals:
• Reduce initial leakage by 50% compared to straight labyrinth seals, or by 30% compared to interlocking labyrinth seals
• Eliminate steam leaks and the safety hazards associated with high temperatures and toxic gases
• Reduce condenser capacity and space requirements in new steam turbines
• Require less axial space than labyrinths
• Are easily installed and field serviceable in a variety of sealing environments
• Allow a “wear-in” to minimal clearance through their flexible sealing mechanism
• Have standard components for cost-effectiveness and timely shipment
• Can be field fitted to undersized shafts, eliminating the need to weld or coat worn rotors

TAMSEAL™ POCKETED DAMPER SEALS

For rotating machinery operating in compressible fluids, including compressors, gas turbines and steam turbines, the TAMSEAL design is a superior alternative to conventional labyrinth seals.

TAMSEAL pocketed damper seals:
• Reduce or eliminate machinery vibrations
• Provide 50 to 100 times more damping than conventional labyrinth seals
• Withstand high pressure
• Are tolerant to fouling and particulate build-up
• Have a short axial length to provide excellent damping at impeller eye and shaft interstage seals
• Require no modifications to the rotor or housing
• Are accepted and field-proven by industry leaders
• Are available in conventional metals and high-performance thermoplastics

BEARINGS PLUS REPLACES AND UPGRADES:
• Labyrinth seals
• Brush seals
• Segmented steam seals
• Babbitted oil film floating seals
• Abradable seals
• Honeycomb seals
• Hole pattern seals
• TAMSEAL pocketed damper seals
Our Promise:
Only Waukesha Bearings® has the culture, commitment and entrepreneurial spirit to drive technological breakthroughs and operational excellence that exceed our customers’ expectations globally.

232B01-ENUS SE14