Precision Engineering Applied to High Speed Machinery

Drew Devitt, Chairman & CTO

New Way Air Bearings

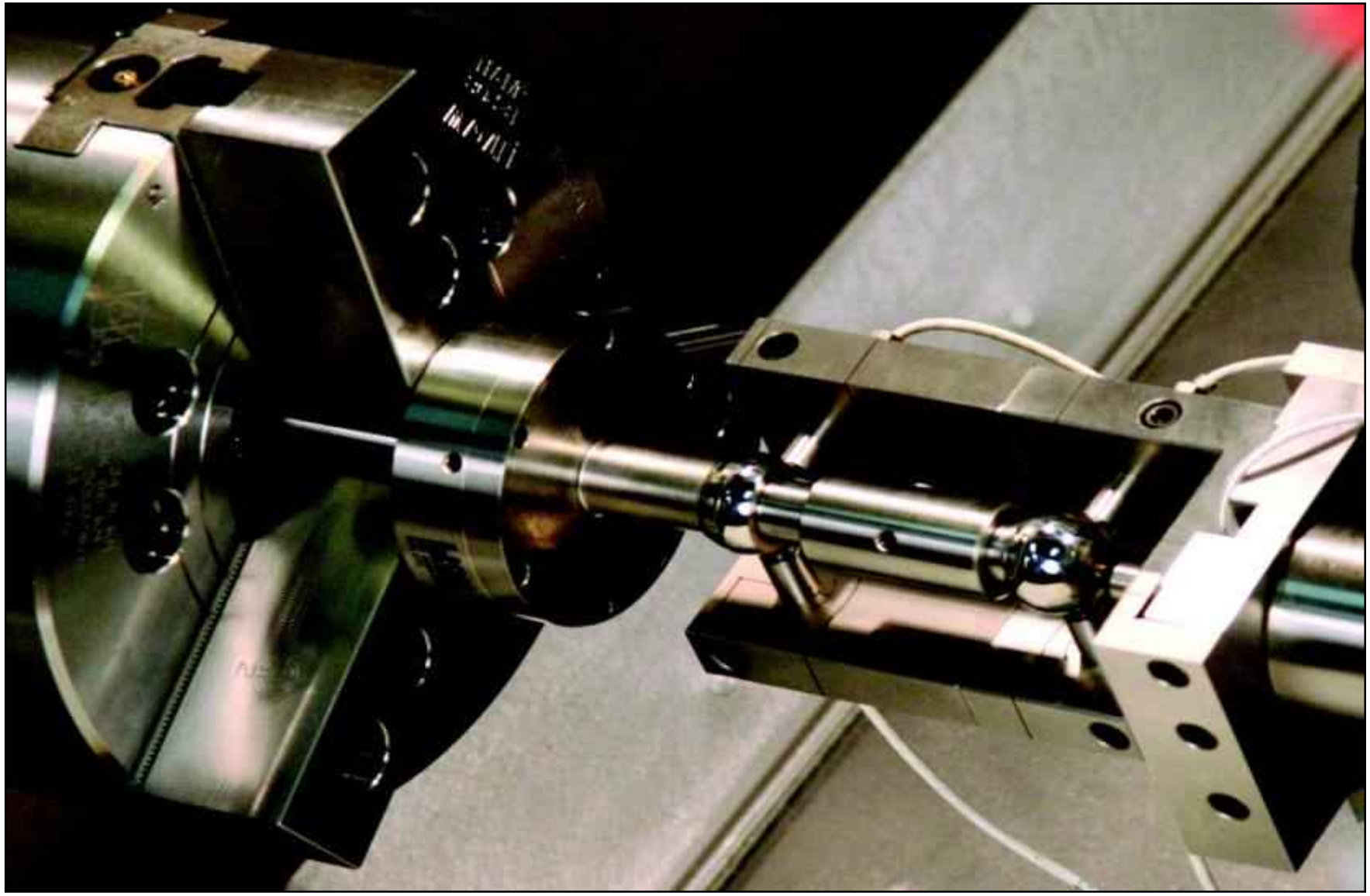
Aston, PA, USA

Axis of Rotation Metrology

The Standards:

- ISO 230-7 Geometric Accuracy of Axes of Rotation

- ASME B89.3.4-1985 Axes of Rotation, Methods for Specifying and Testing



Bearing NEWS

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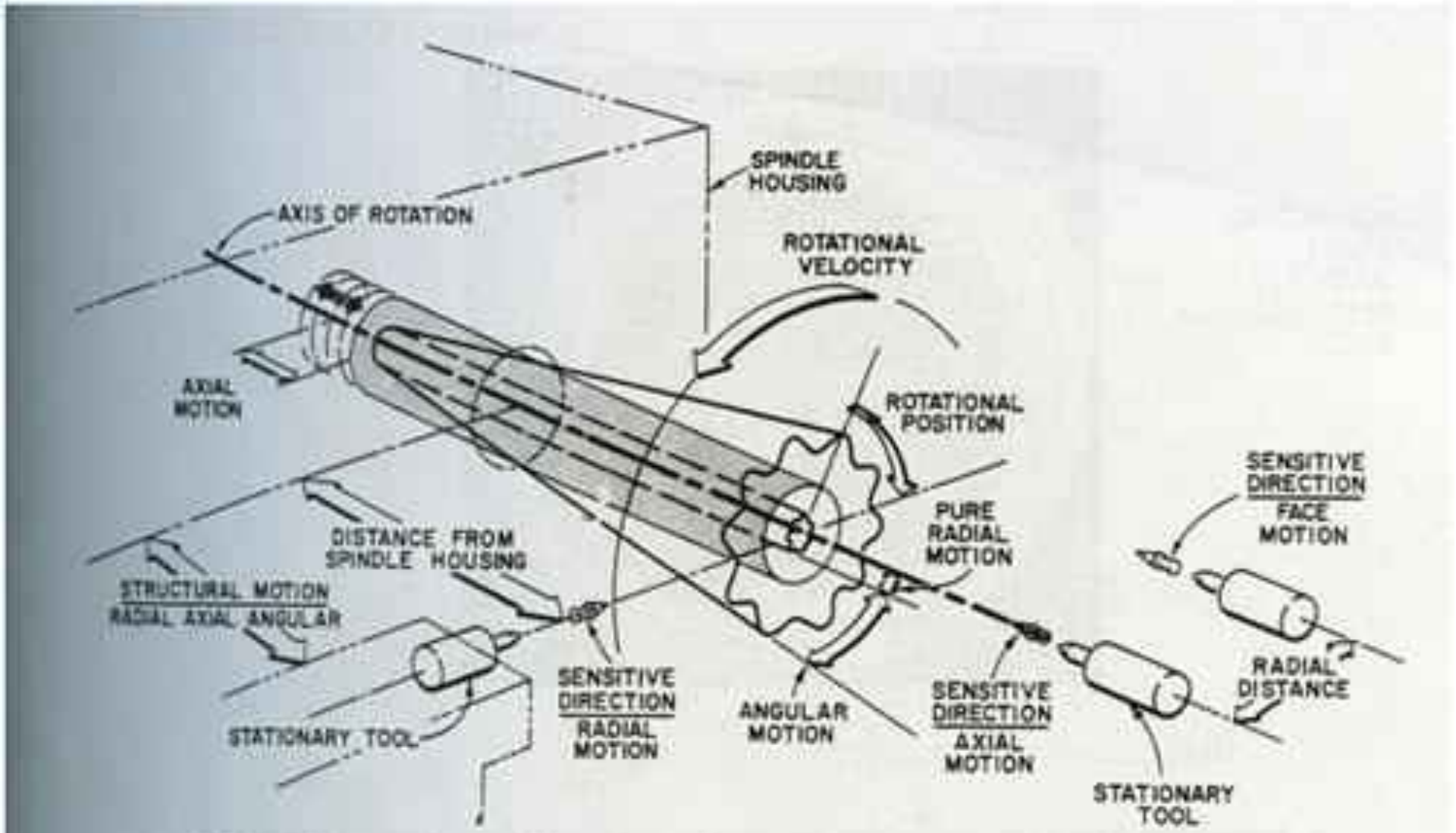
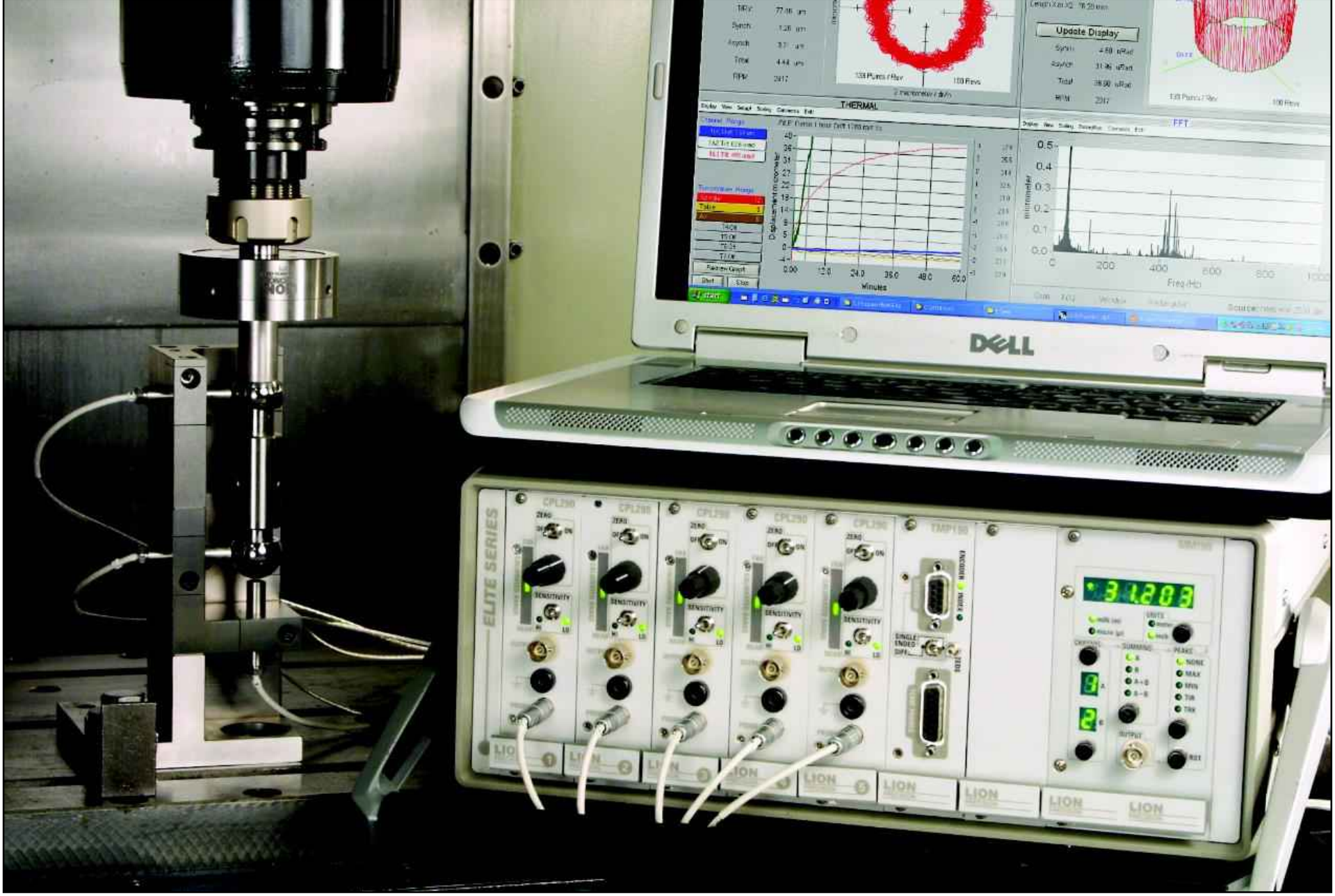
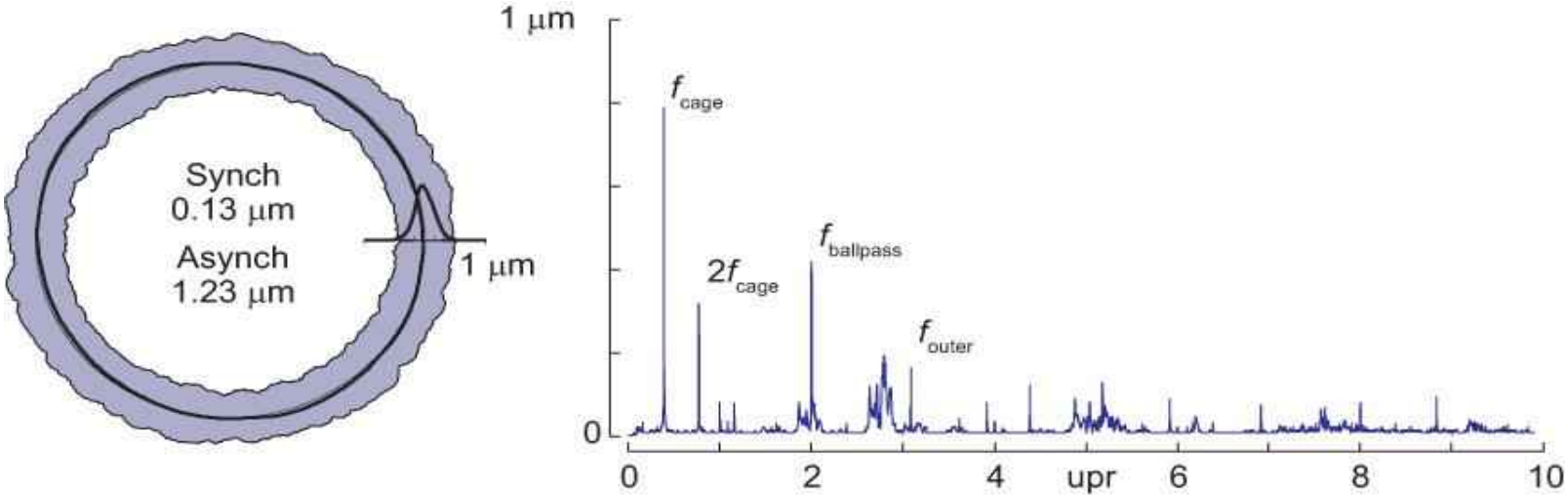
Types of Error Motions



2. Three primary—and unwanted—motions of a spindle are angular motion, axial motion, and pure radial motion. There are also two secondary motions: face motion, which combines axial and angular motion; and radial motion combining pure radial and angular



FFT for Rolling Element



Ball diameter b
Pitch diameter p
Ball count n
Contact angle α

Cage rotation $f_{cage} = \frac{f_s}{2}\left(1 - \frac{b}{p}\cos\alpha\right)$

Cage-to-inner race $f_{ci} = \frac{f_s}{2}\left(1 + \frac{b}{p}\cos\alpha\right)$

Outer ballpass $f_{bpo} = n\, f_{cage}$

Inner ballpass $f_{bpi} = n\, f_{ci}$

Ball rotation $f_r = \frac{f_s}{2}\frac{p}{b}\left(1 - \left(\frac{b}{p}\cos\alpha\right)^2\right)$

Ball defect $f_{bp} = f_r$

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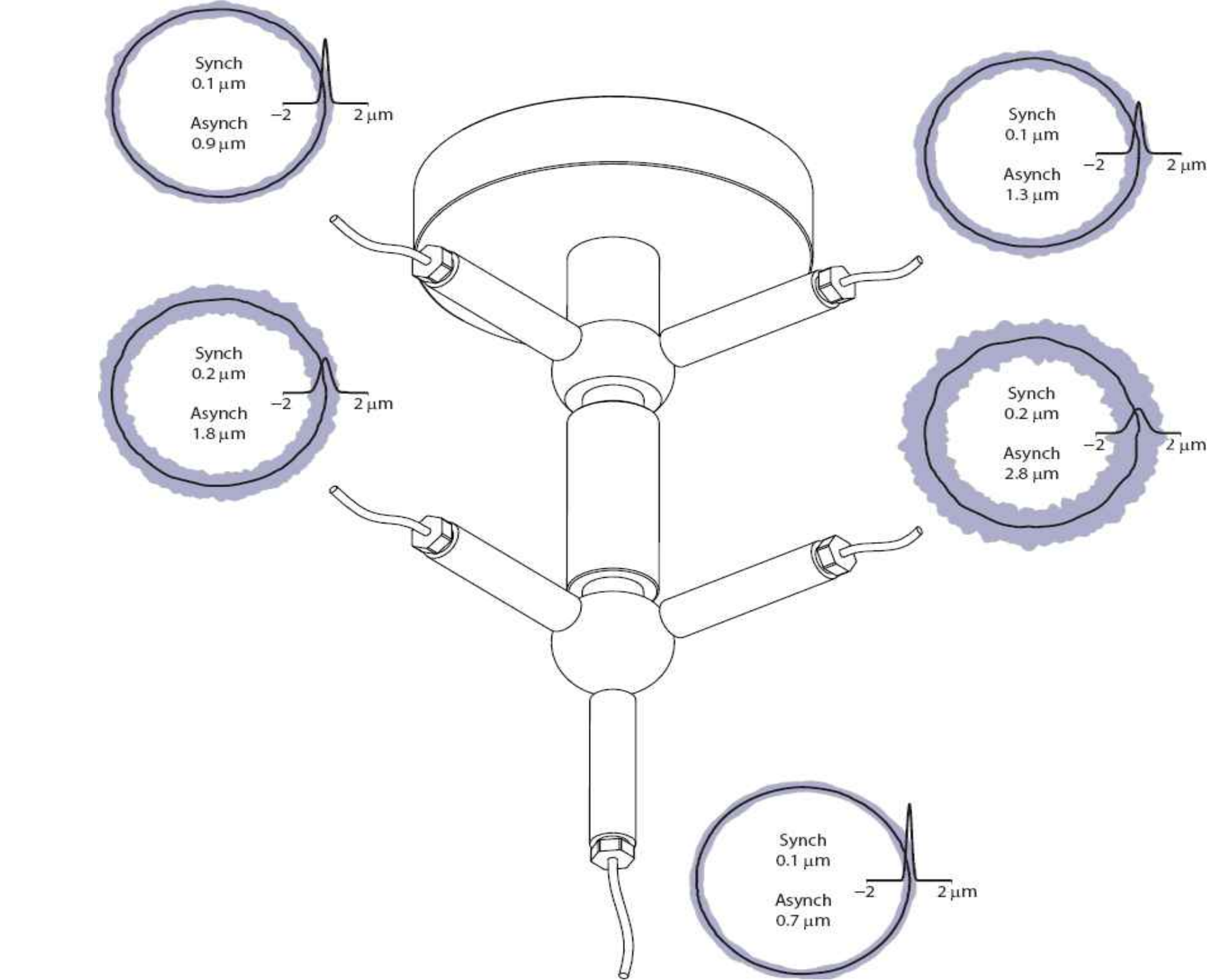
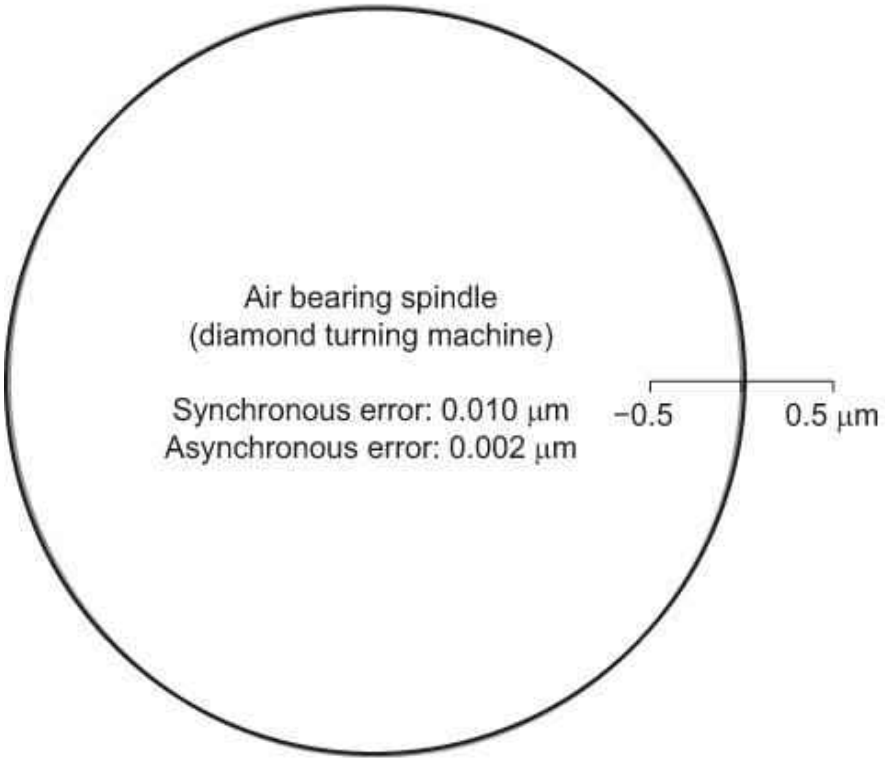
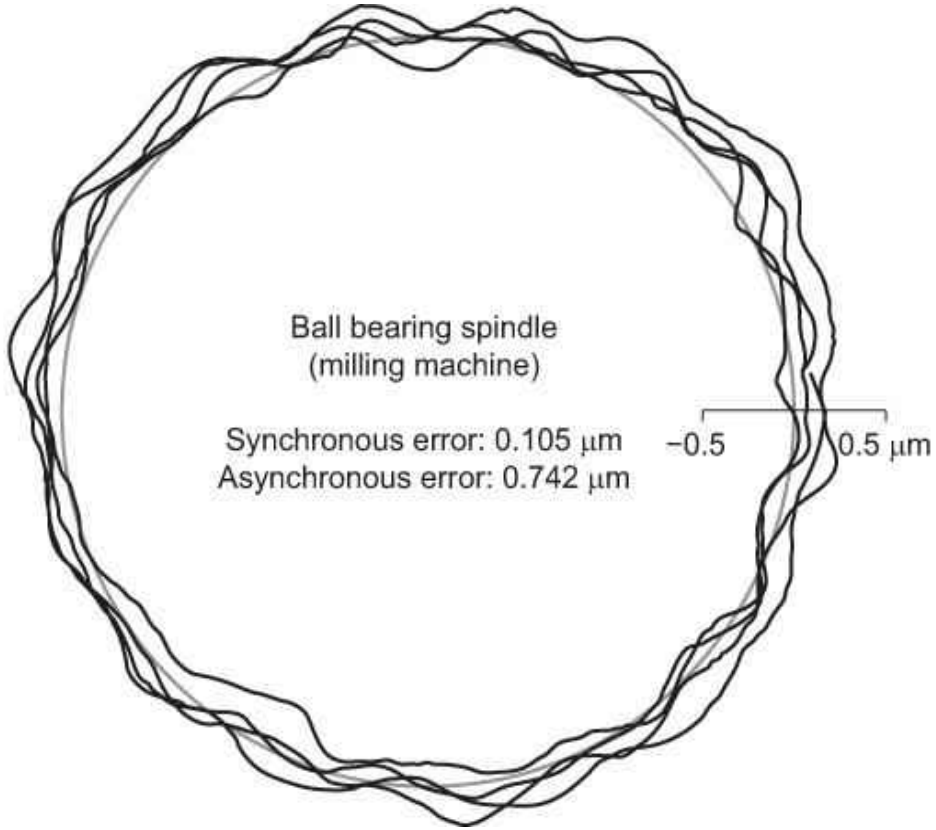

Synch
0.1 μm
Asynch
0.9 μm
−2
2 μm
Synch
0.1 μm
Asynch
1.3 μm
−2
2 μm
Synch
0.2 μm
Asynch
1.8 μm
−2
2 μm
Synch
0.2 μm
Asynch
2.8 μm
−2
2 μm
Synch
0.1 μm
Asynch
0.7 μm
−2
2 μm

Air Bearing vs Rolling Element Bearing





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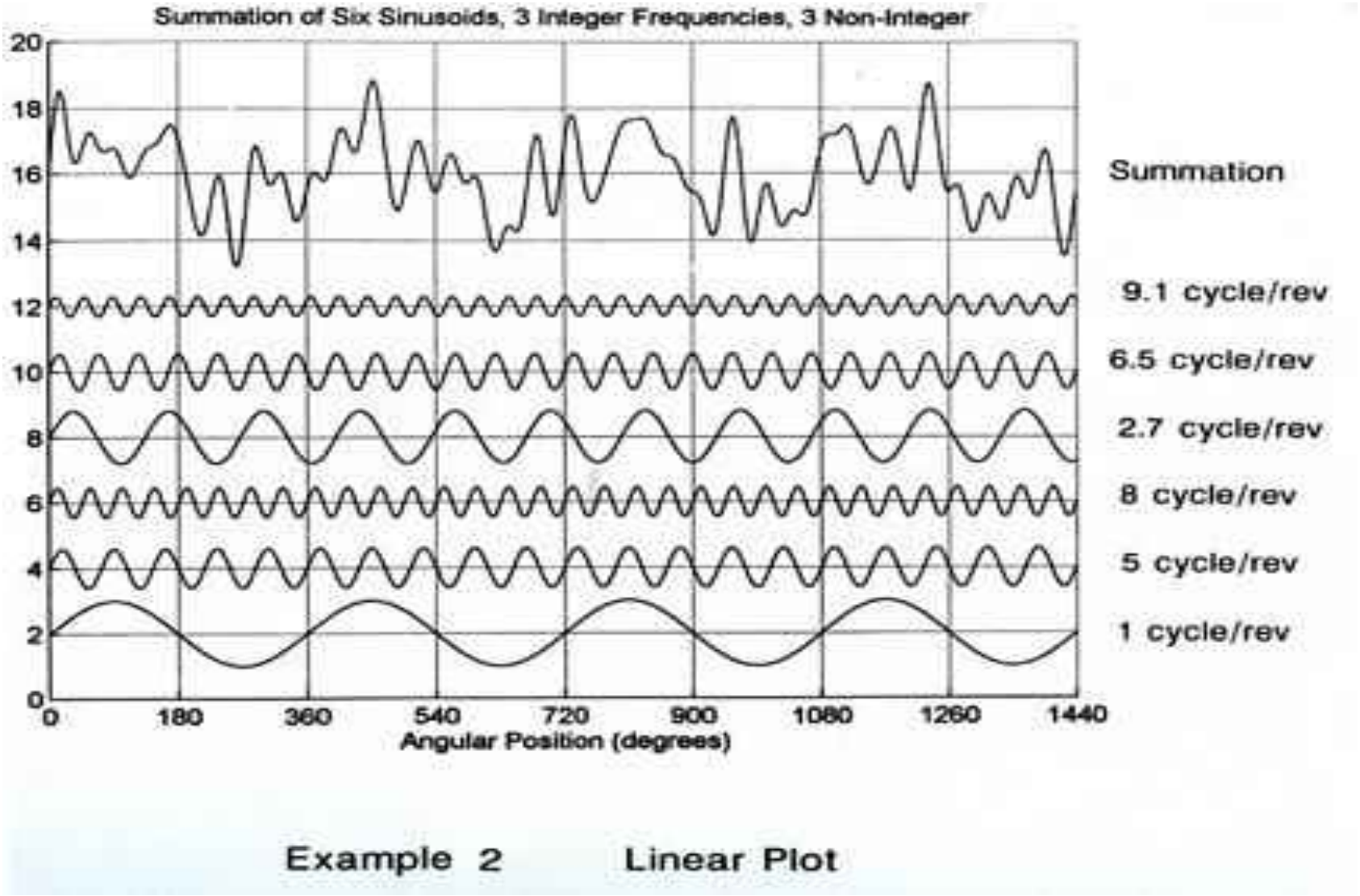
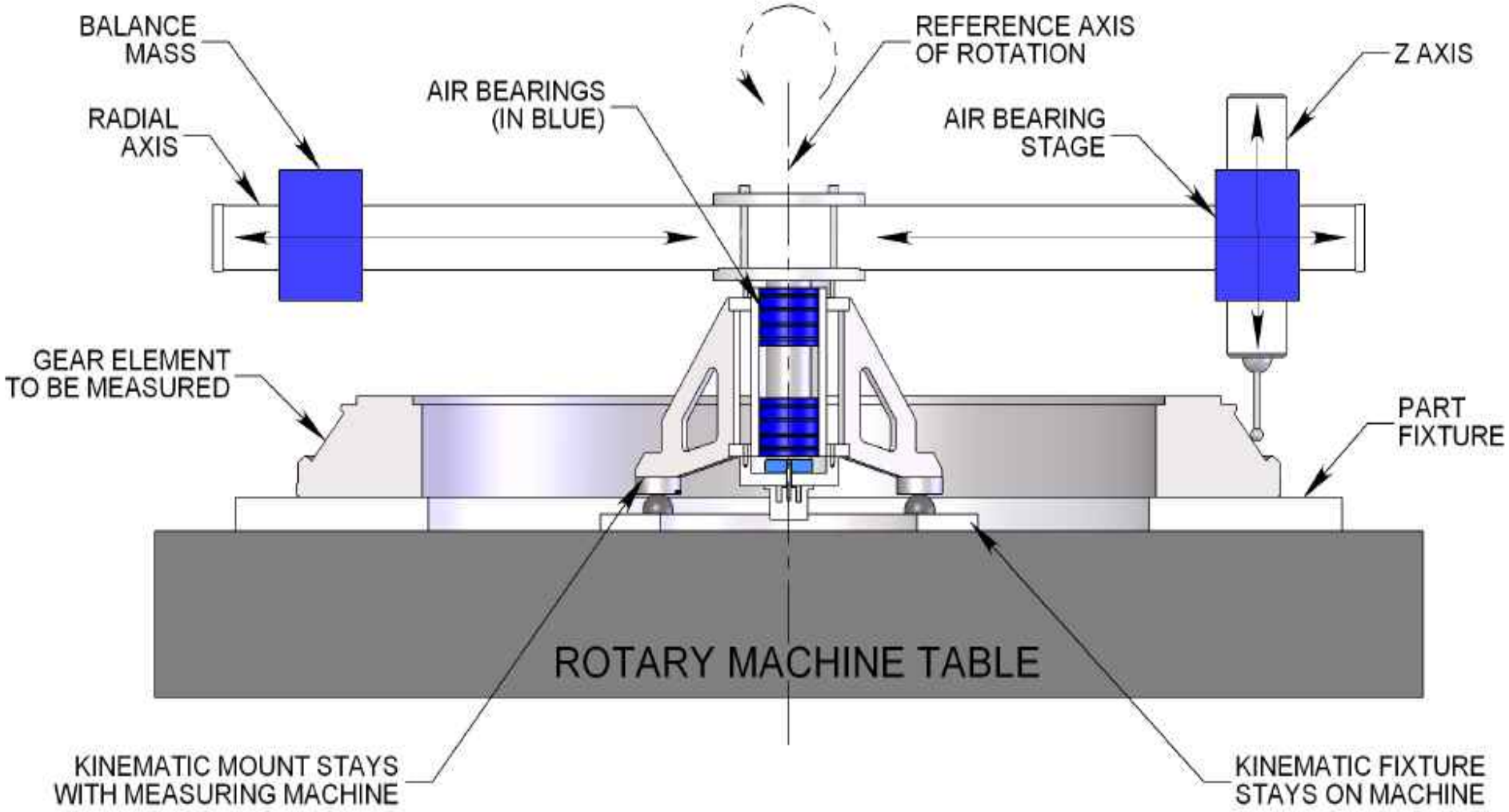
Asynchronous Error Motion



Example 2 Linear Plot

Portable Radial Measuring Machine



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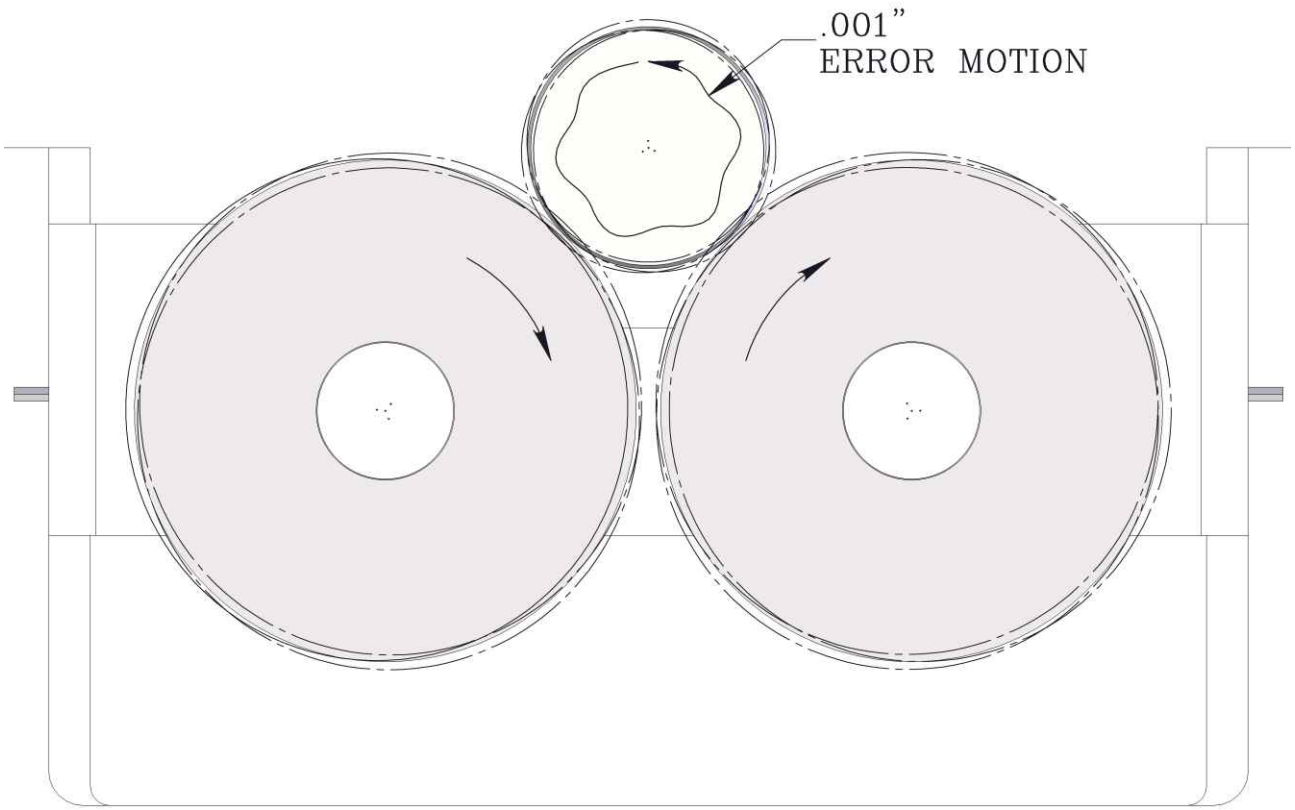
Low speed balancing on Rollers



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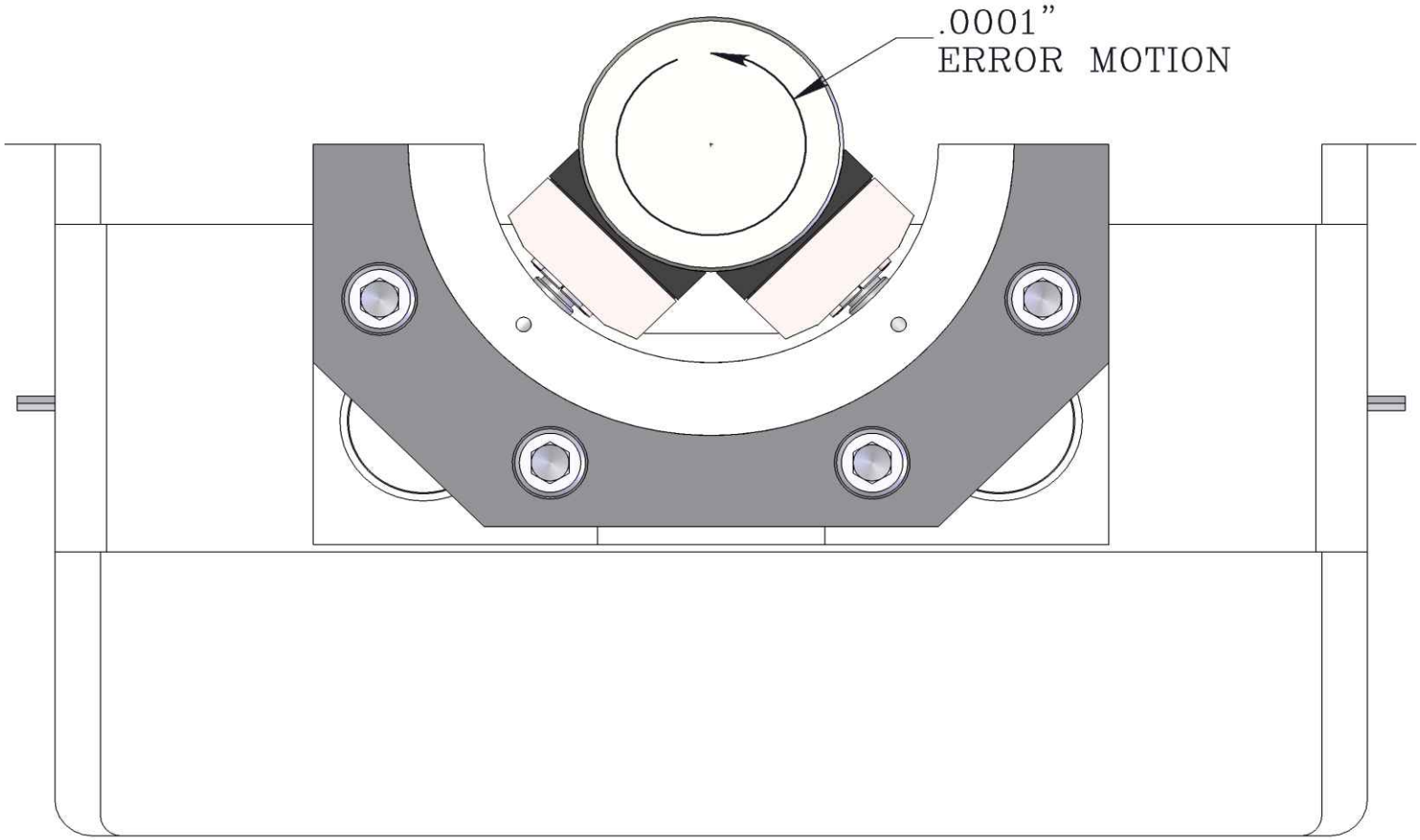
Low Speed Balancing on Air Bearings



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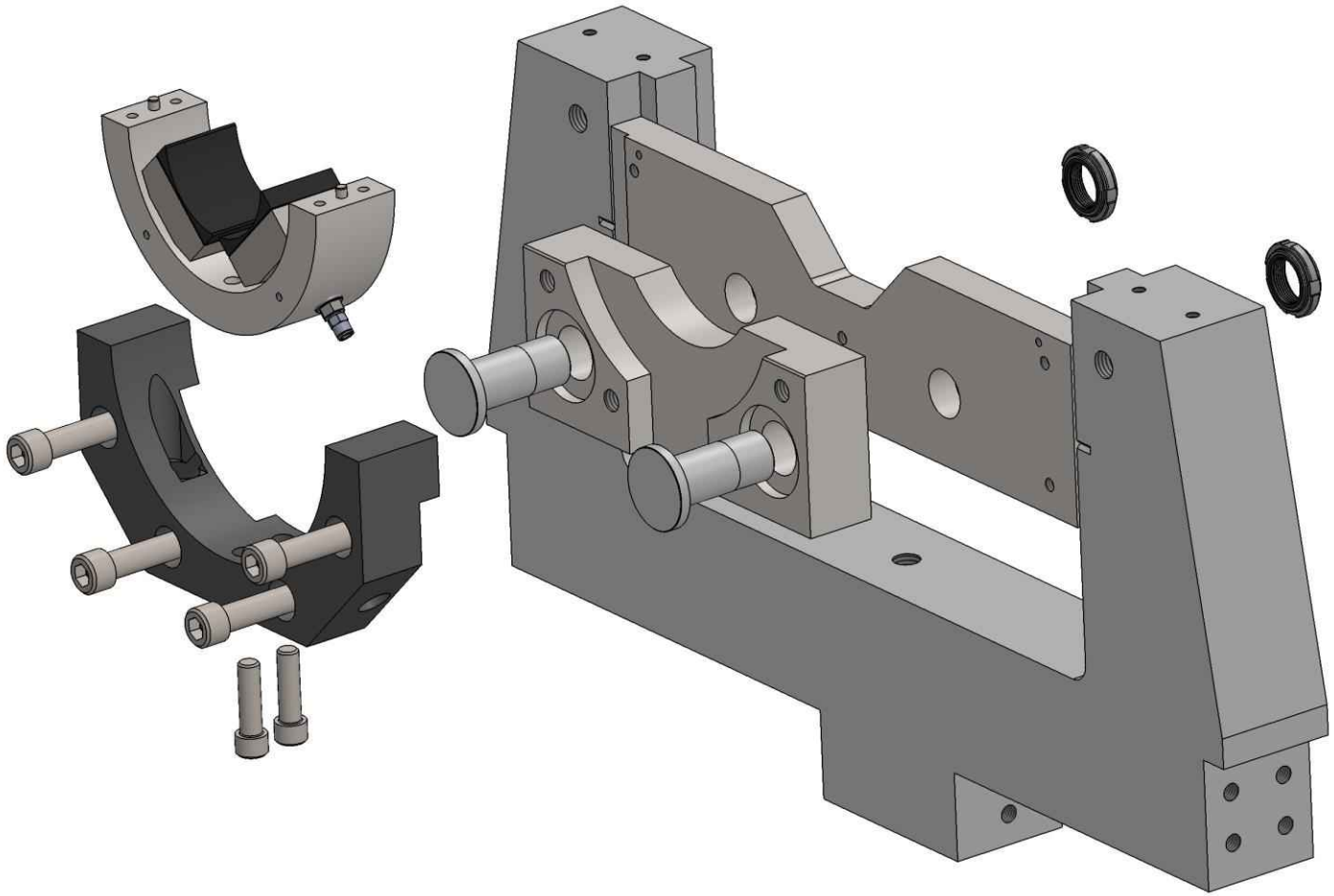
Roller to Air Bearing Retrofit



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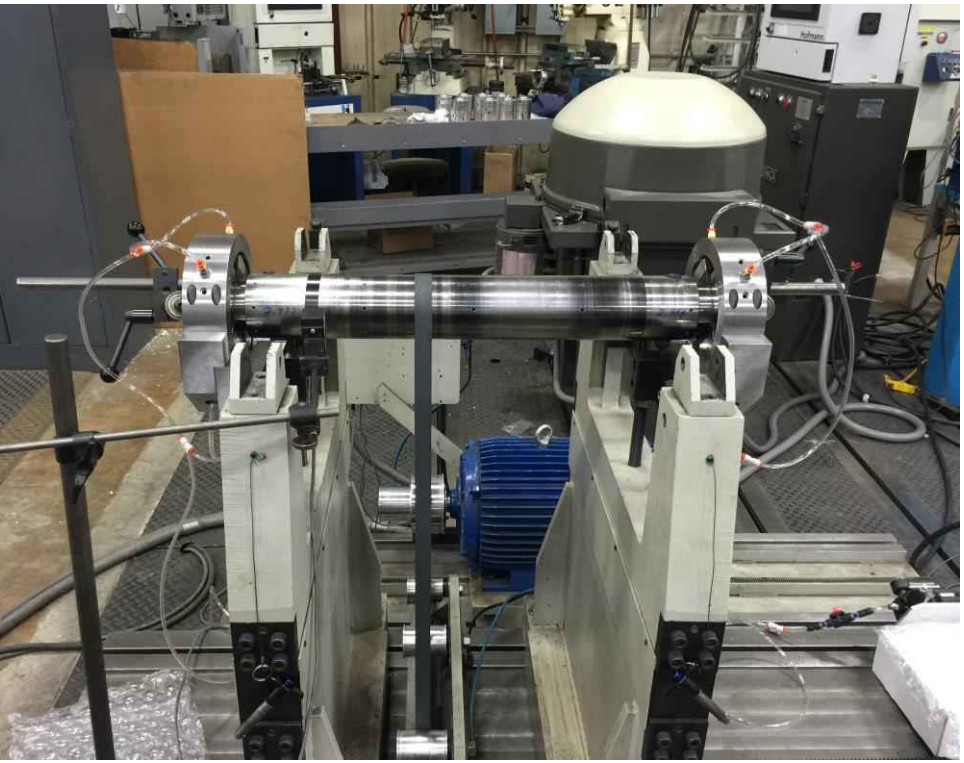
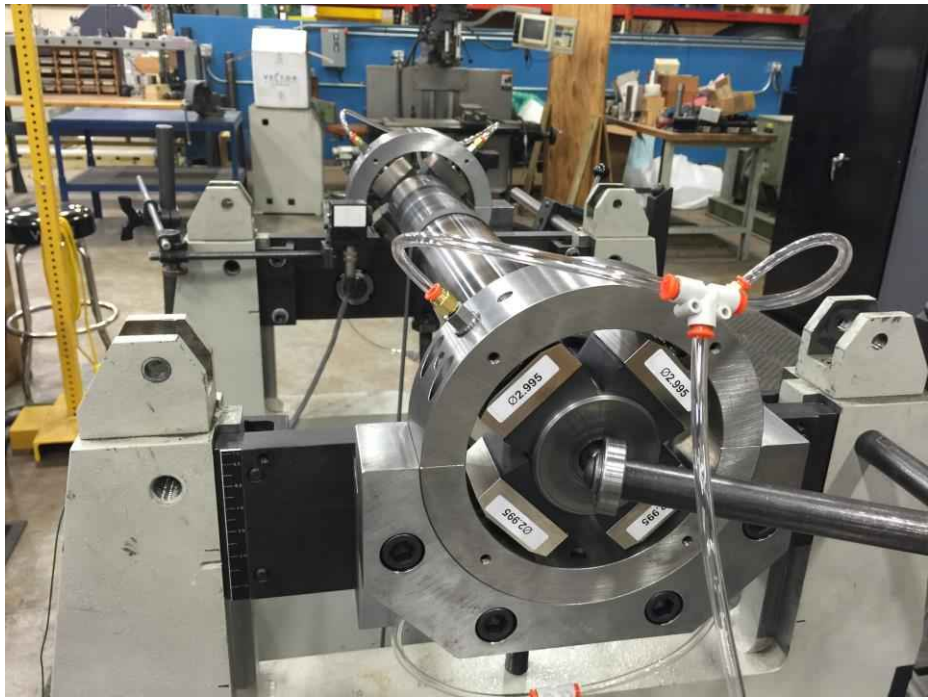
Air Bearing Retrofit in a Hofmann Balance Machine





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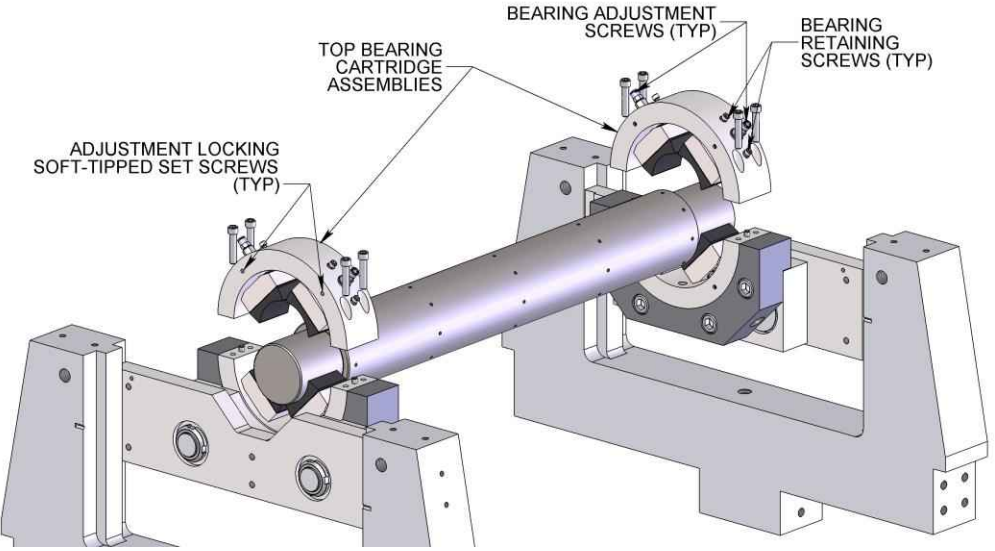
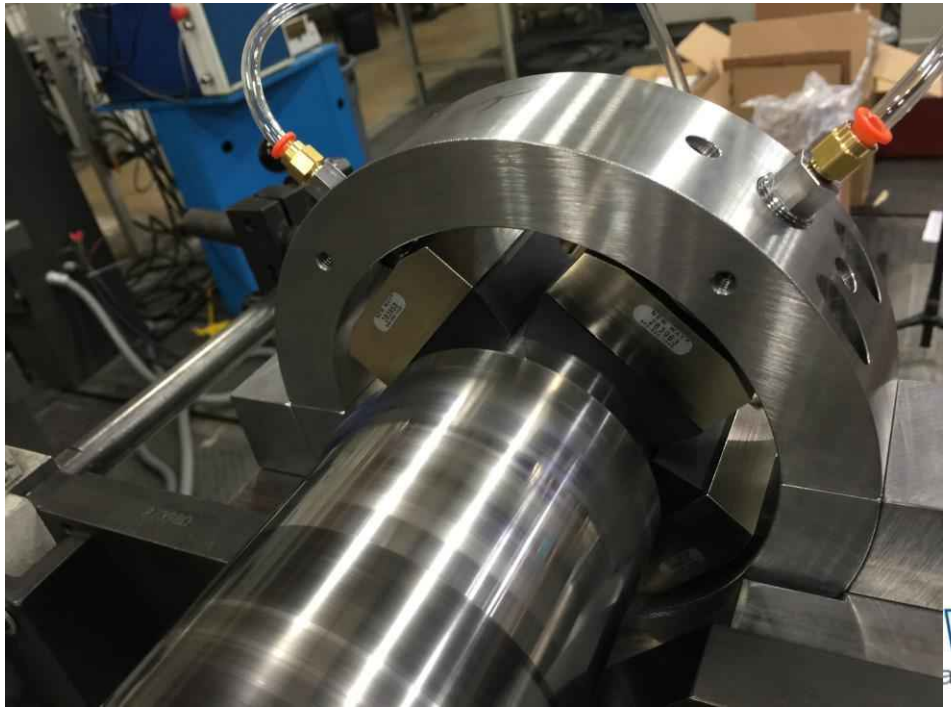
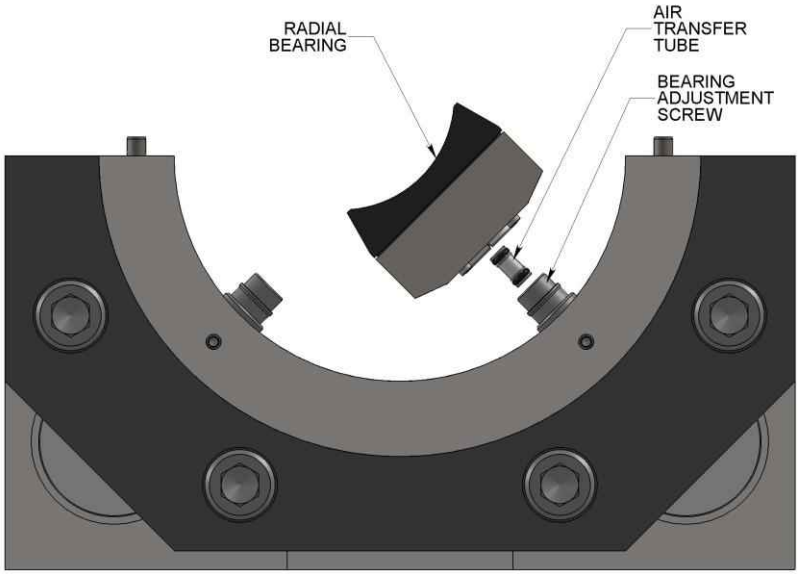

BEARING ADJUSTMENT SCREWS (TYP)
BEARING RETAINING SCREWS (TYP)
TOP BEARING CARTRIDGE ASSEMBLIES
ADJUSTMENT LOCKING SOFT-TIPPED SET SCREWS (TYP)

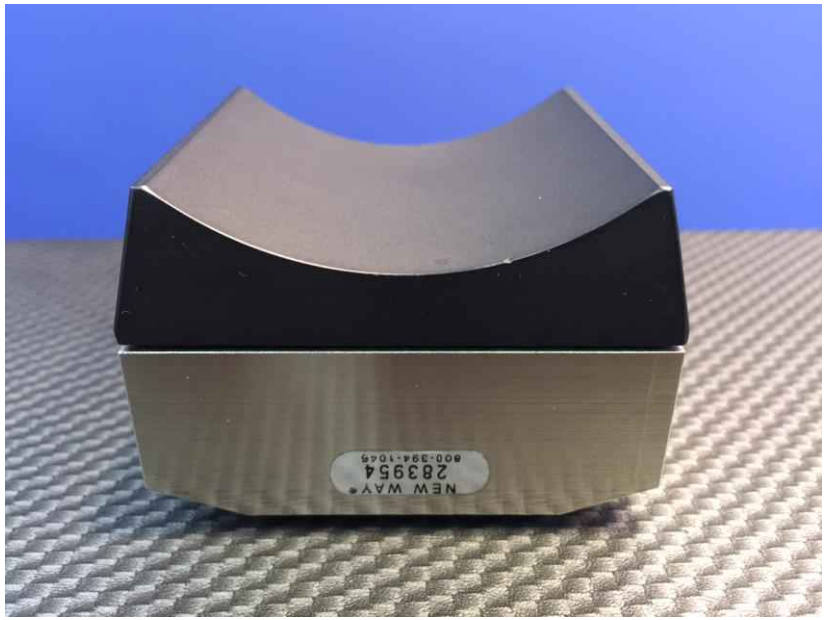

Ø2.995
Ø2.995
Ø2.995




Ø2.995
Ø2.995
Ø2.995

Easy to Change Air Bearings





Bearing NEWS

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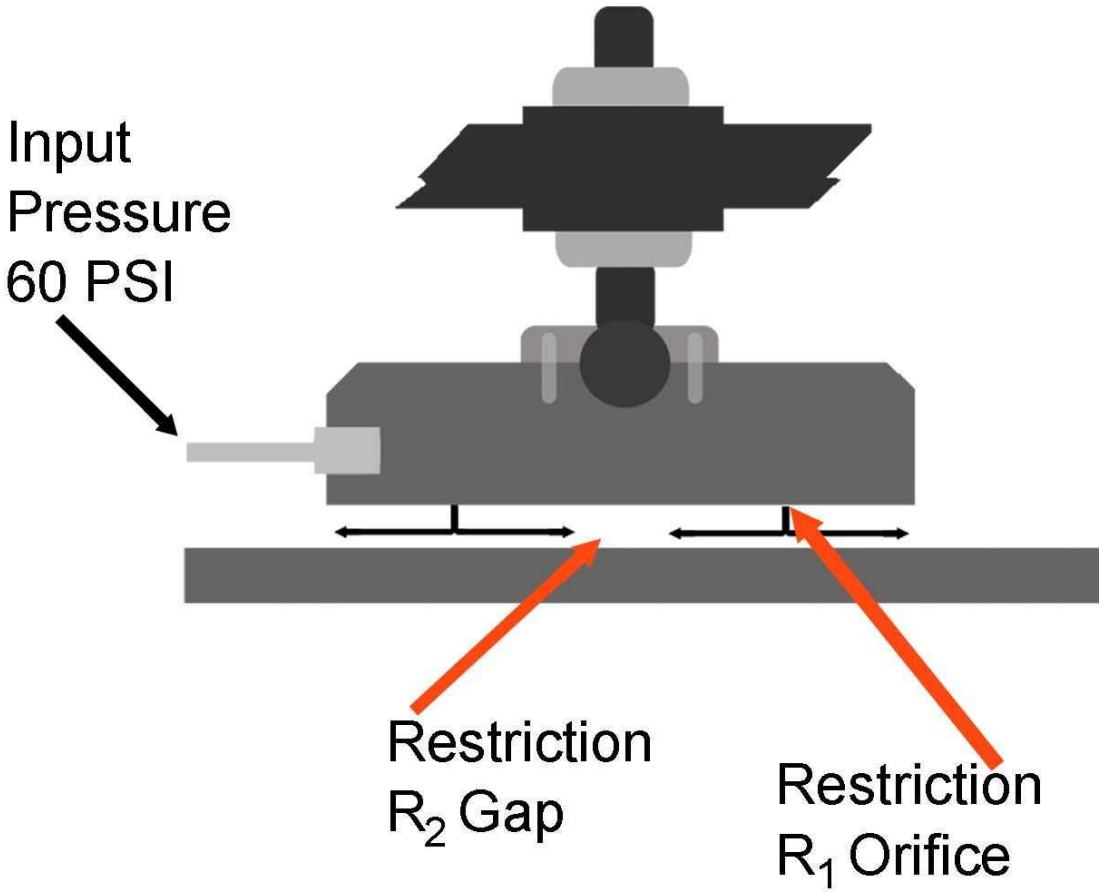
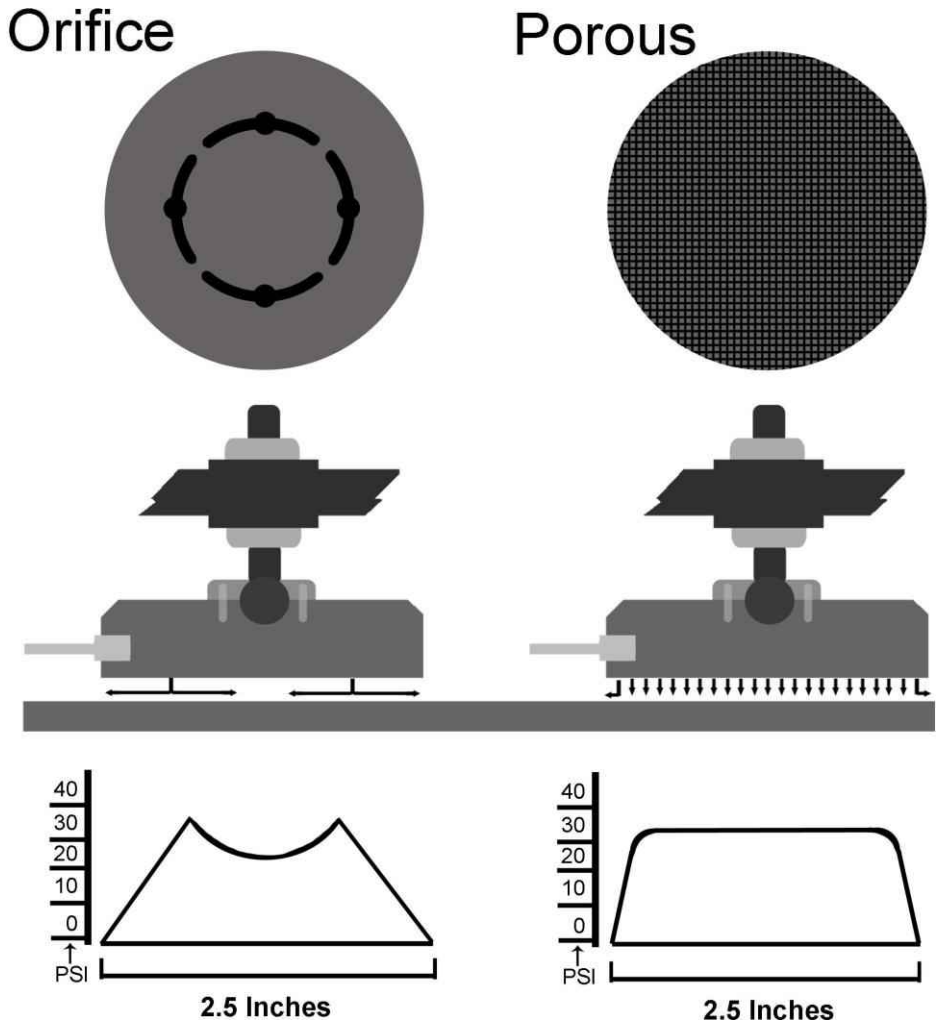
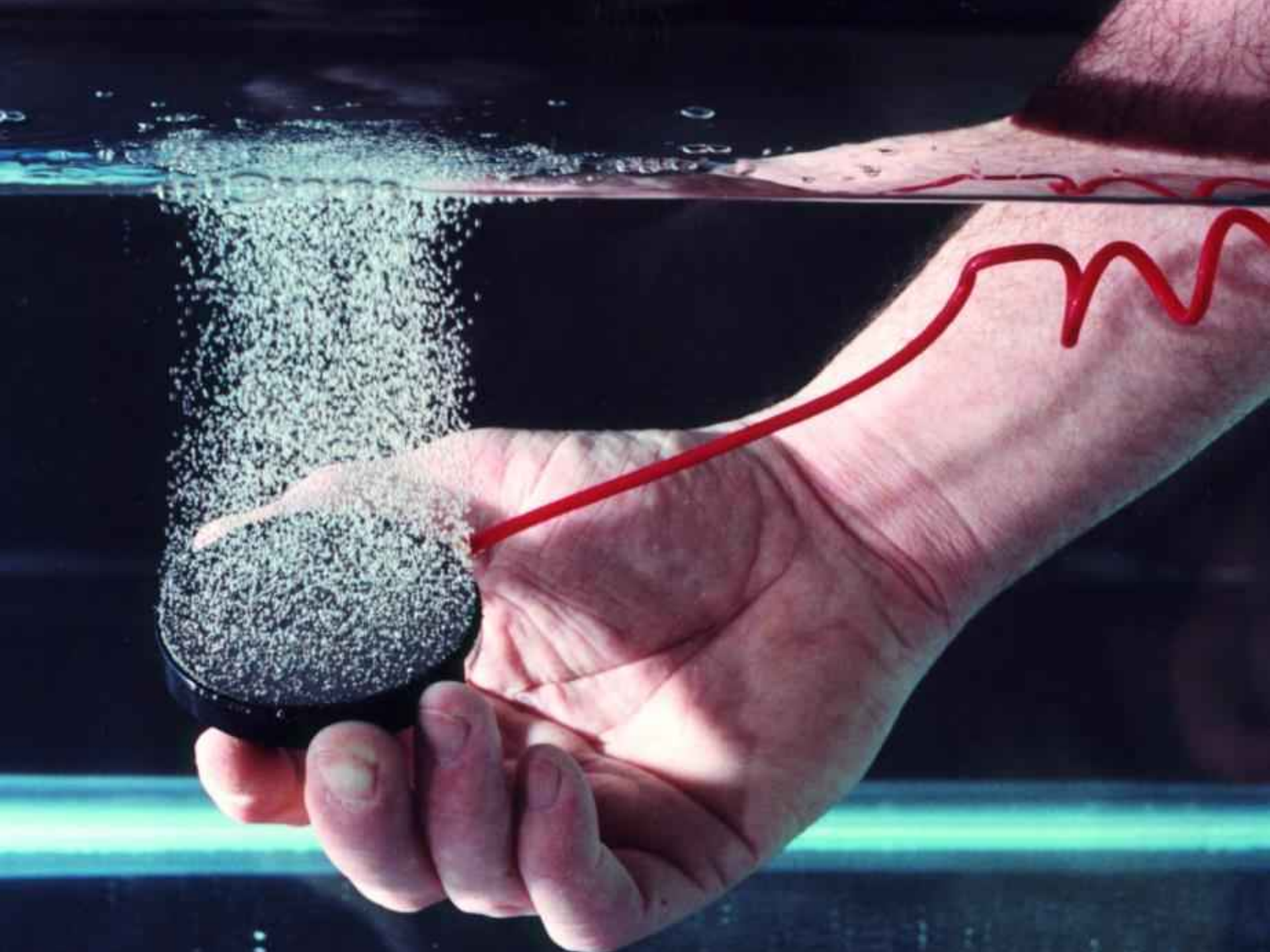
Externally Pressurized Air Bearings Orifice Compensation

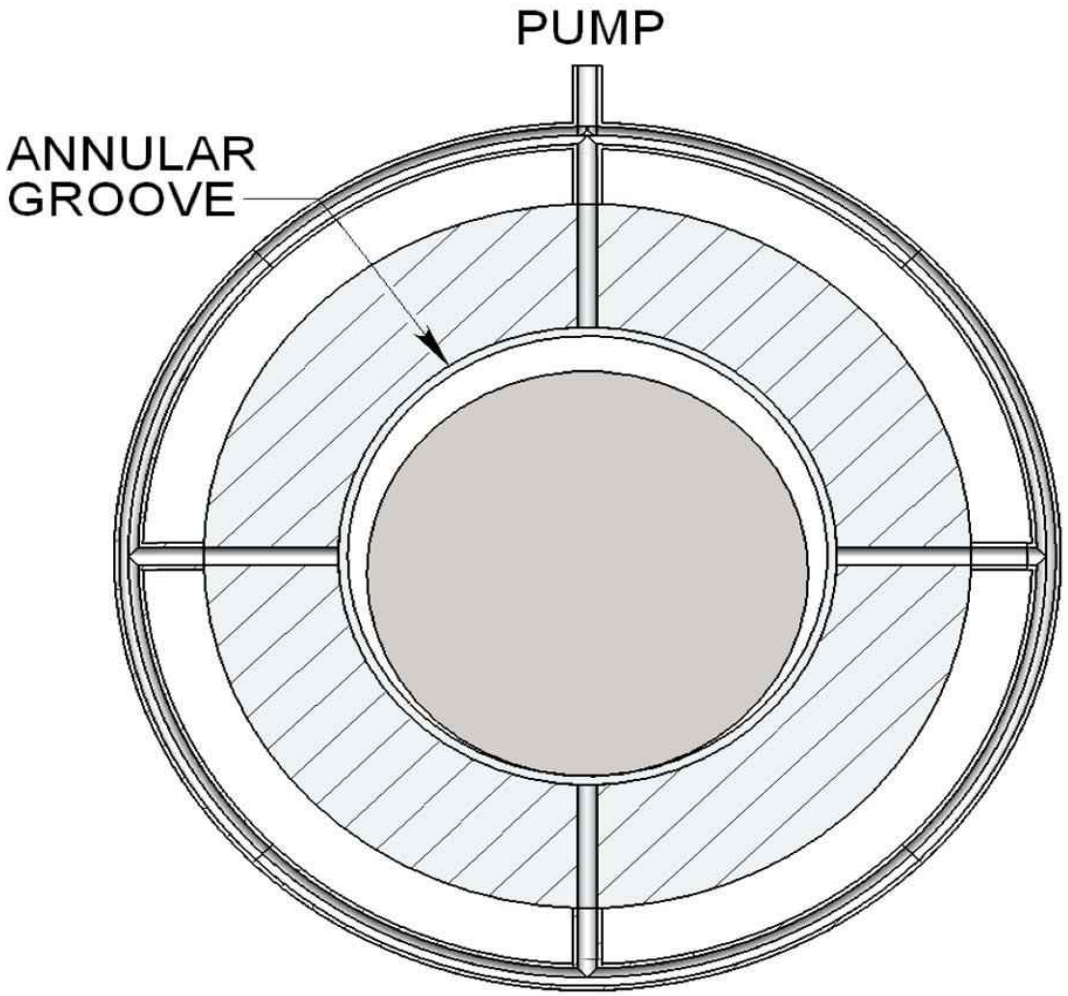


Orifice and Porous Compensation

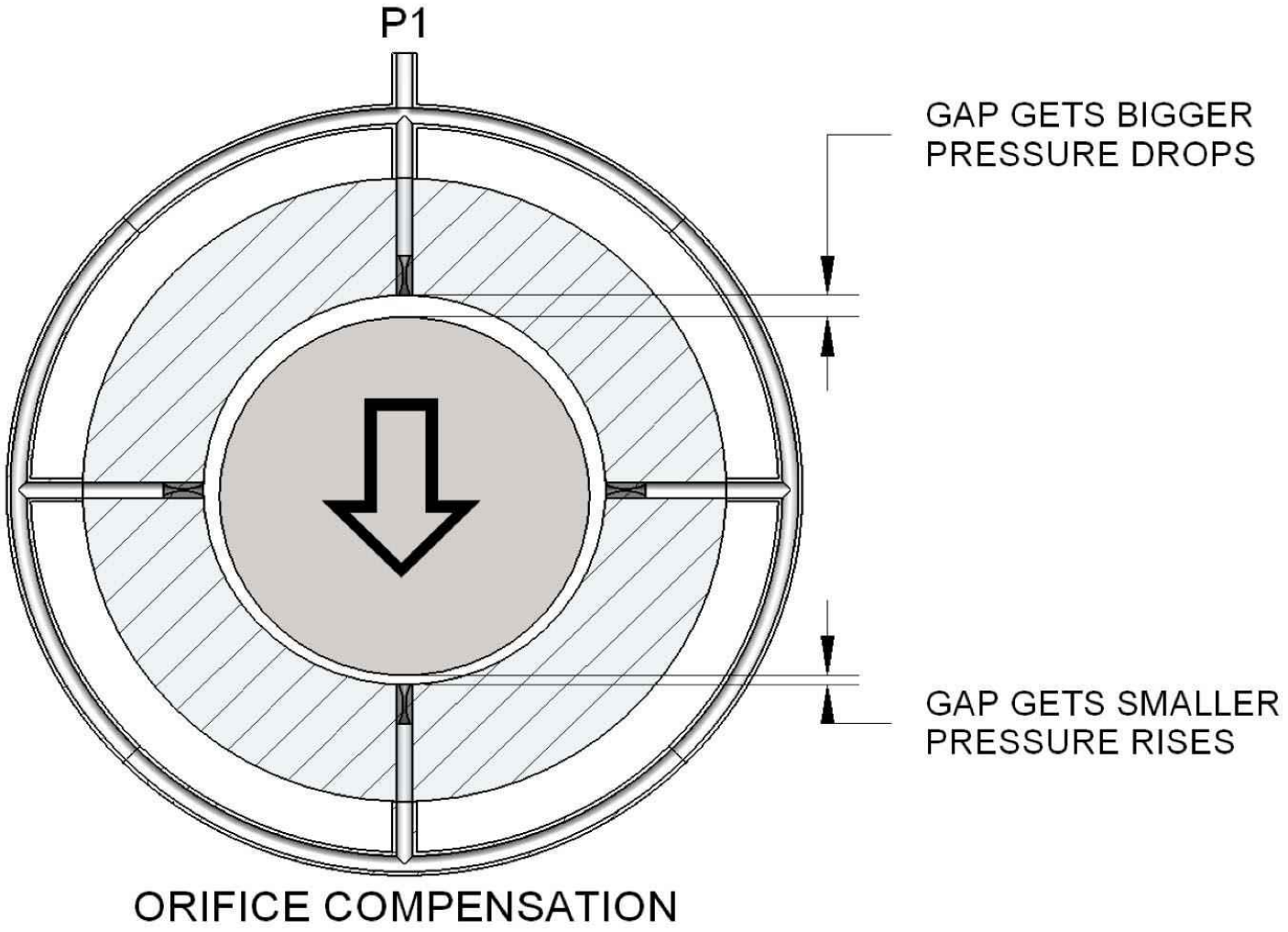




No Compensation

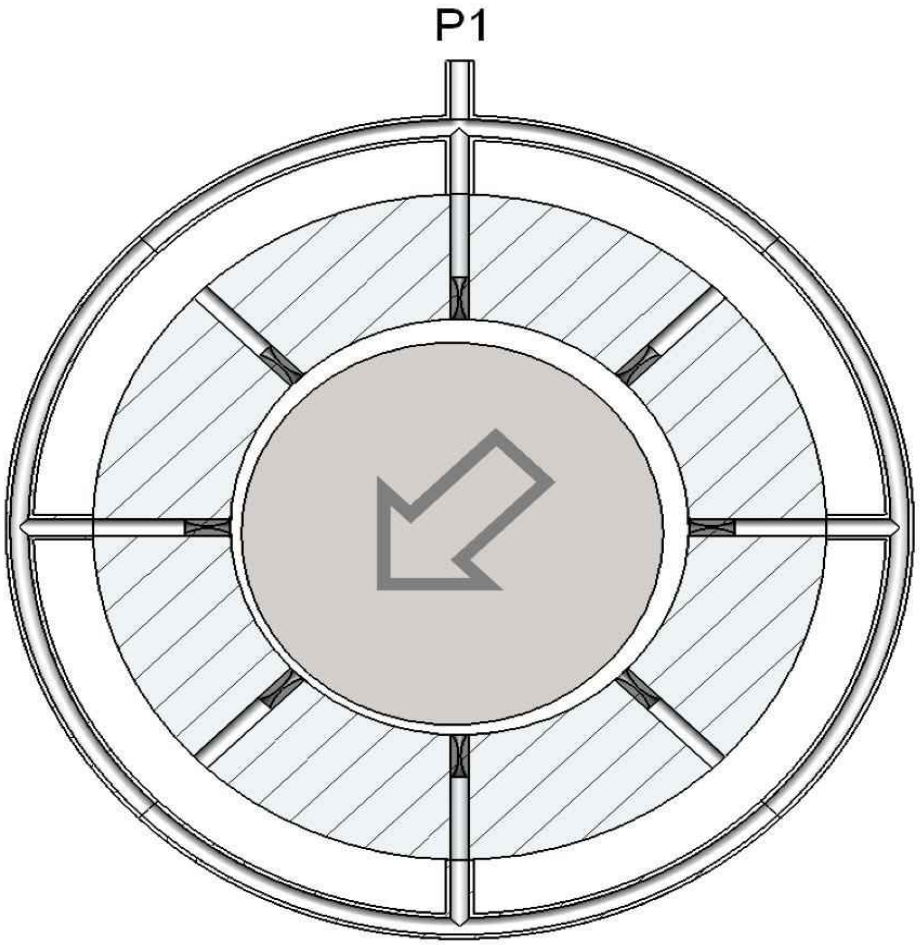


Orifice Compensation

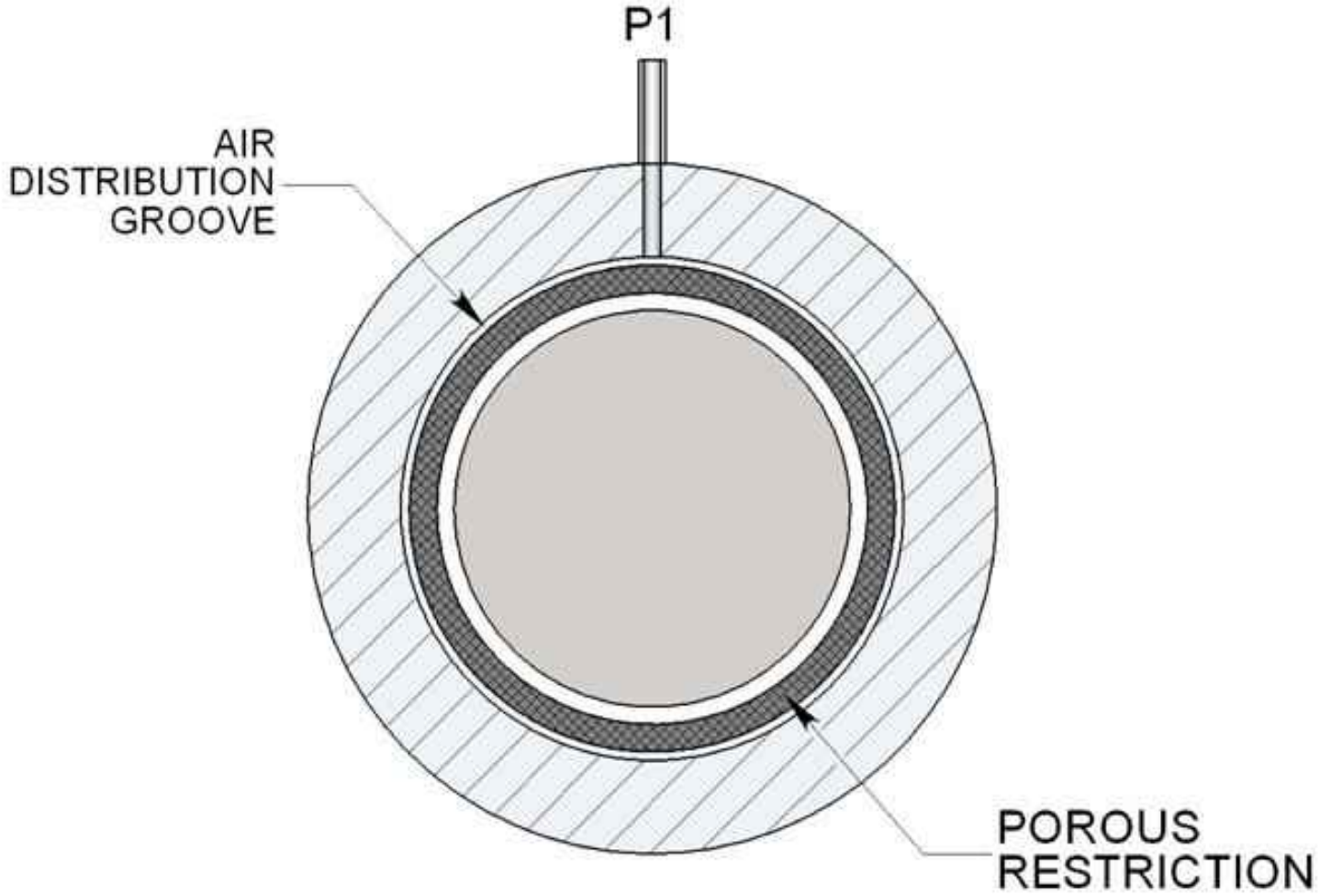


ORIFICE COMPENSATION

More Orifices



Porous Compensation



Bearing NEWS

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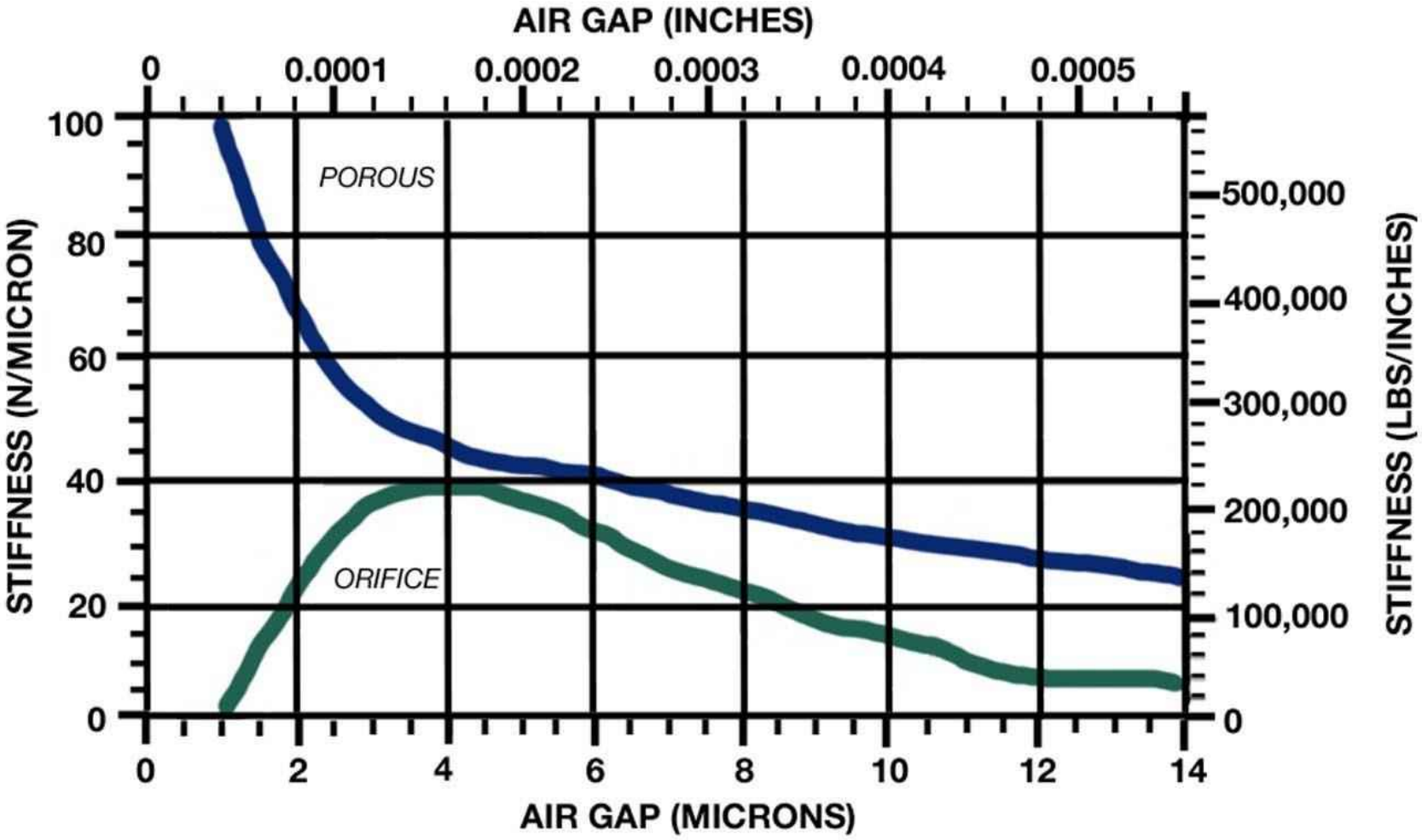
Porous Air Bearing Journals

Porous vs Orifice



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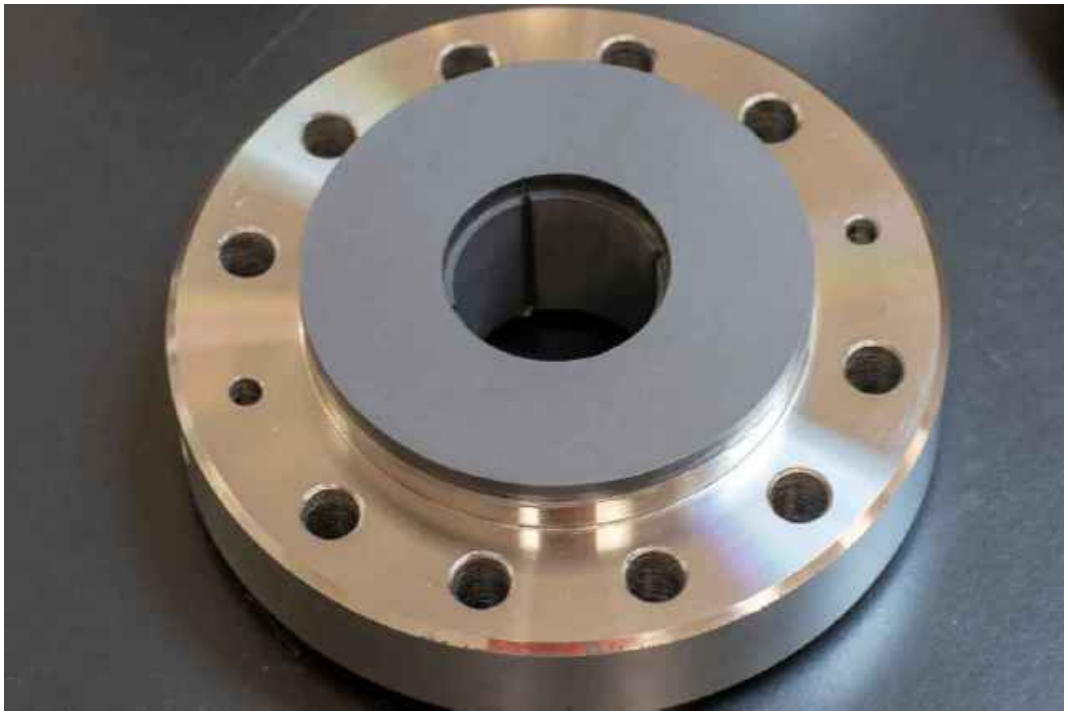
Orifice vs Porous Compensation Thrust Bearings also a Seal



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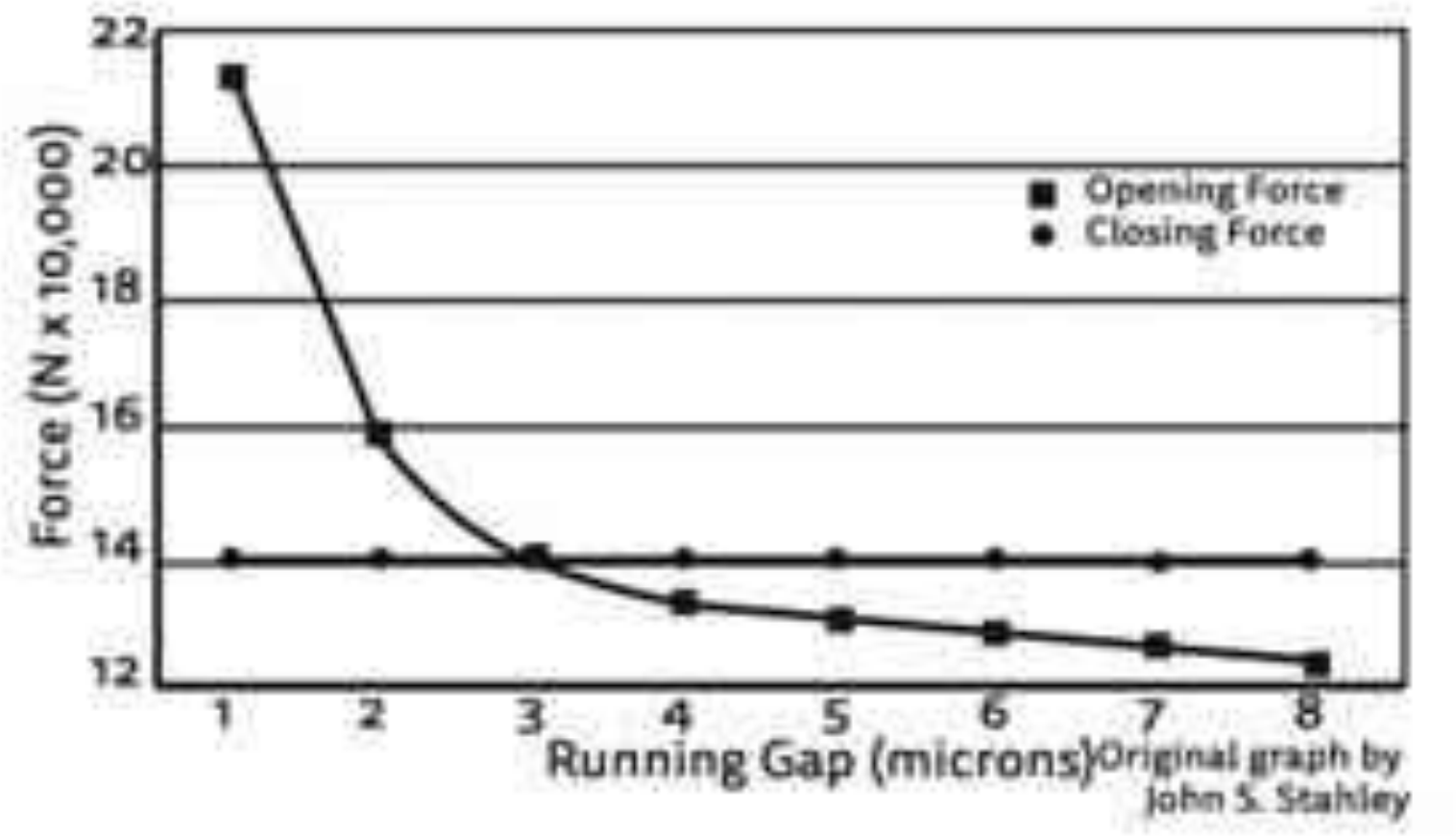
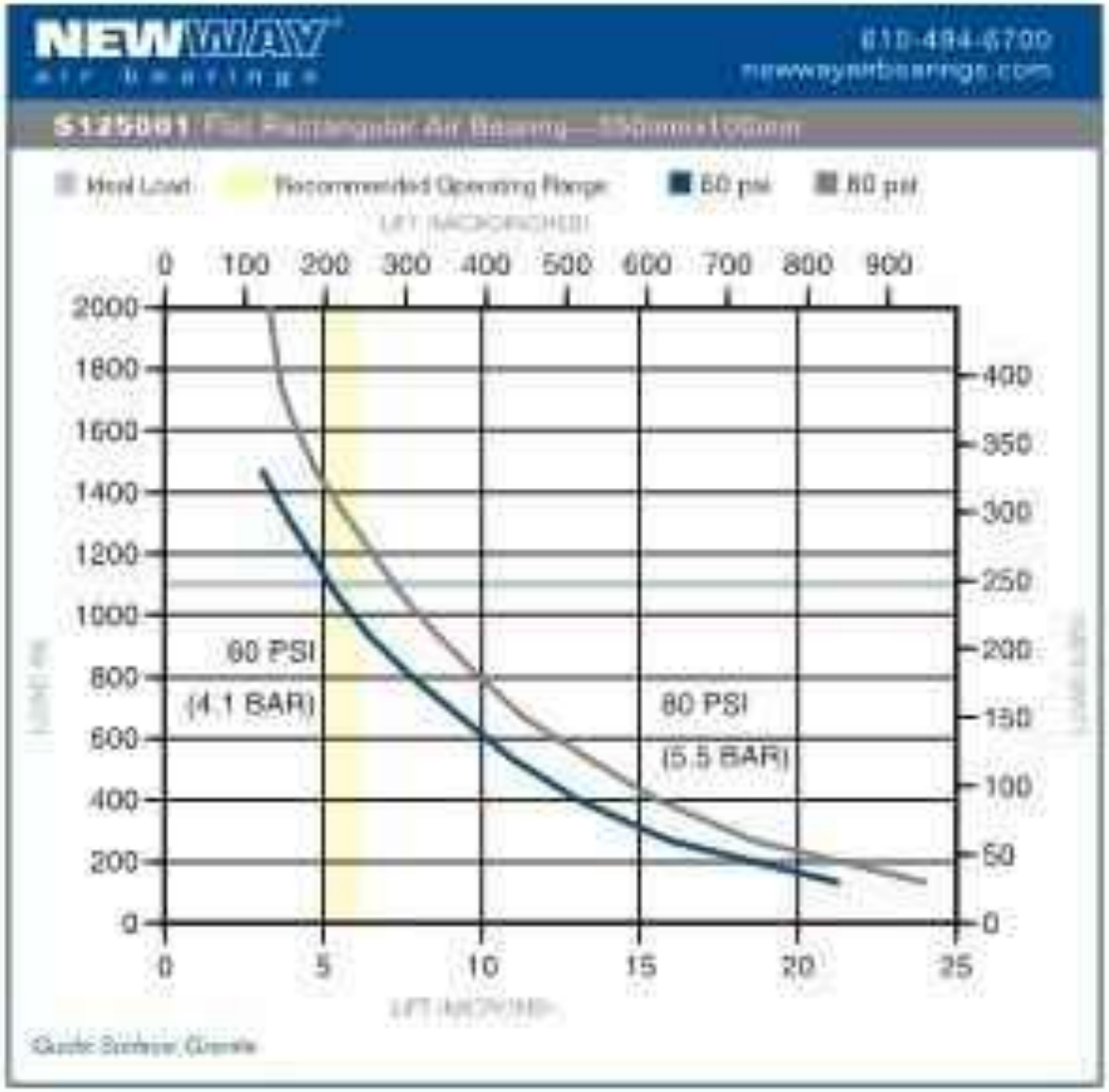
Gas Film vs Load in DGS





Lift vs Load Chart 50 x 100mm Air Bearing

Bearing NEWS

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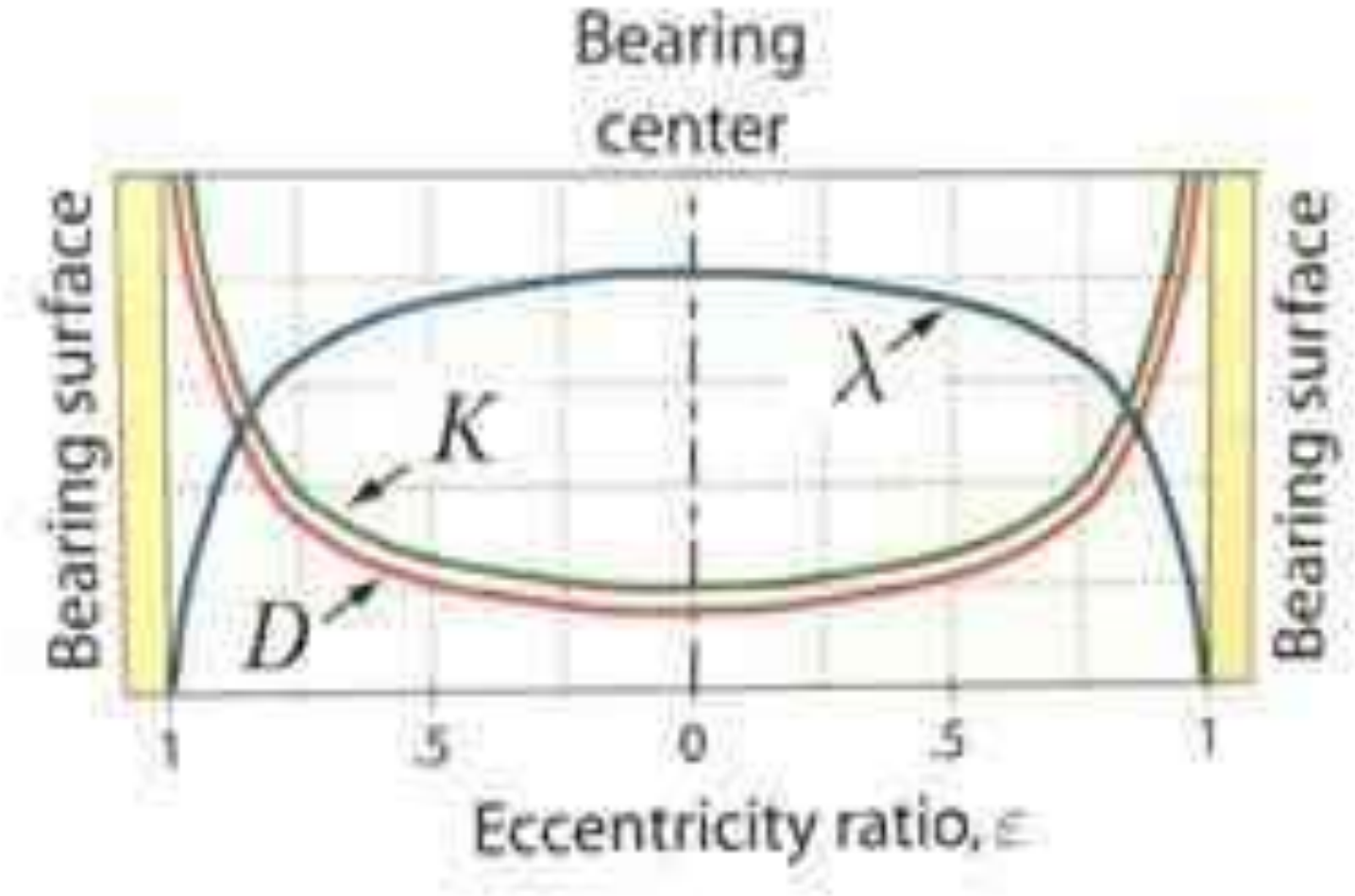
Eccentricity Plot (Don Bently)



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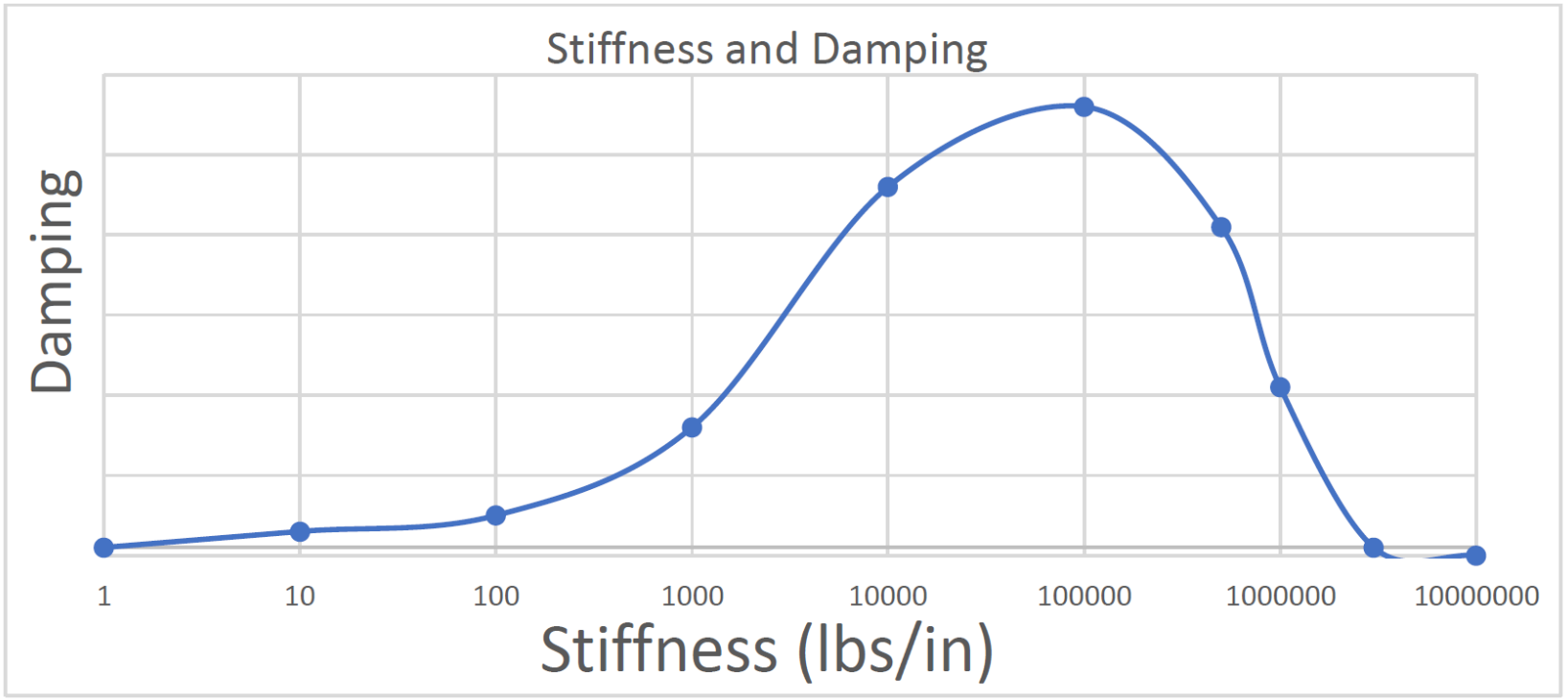
Zero Stiffness = Zero Damping
Infinite Stiffness = Zero Damping



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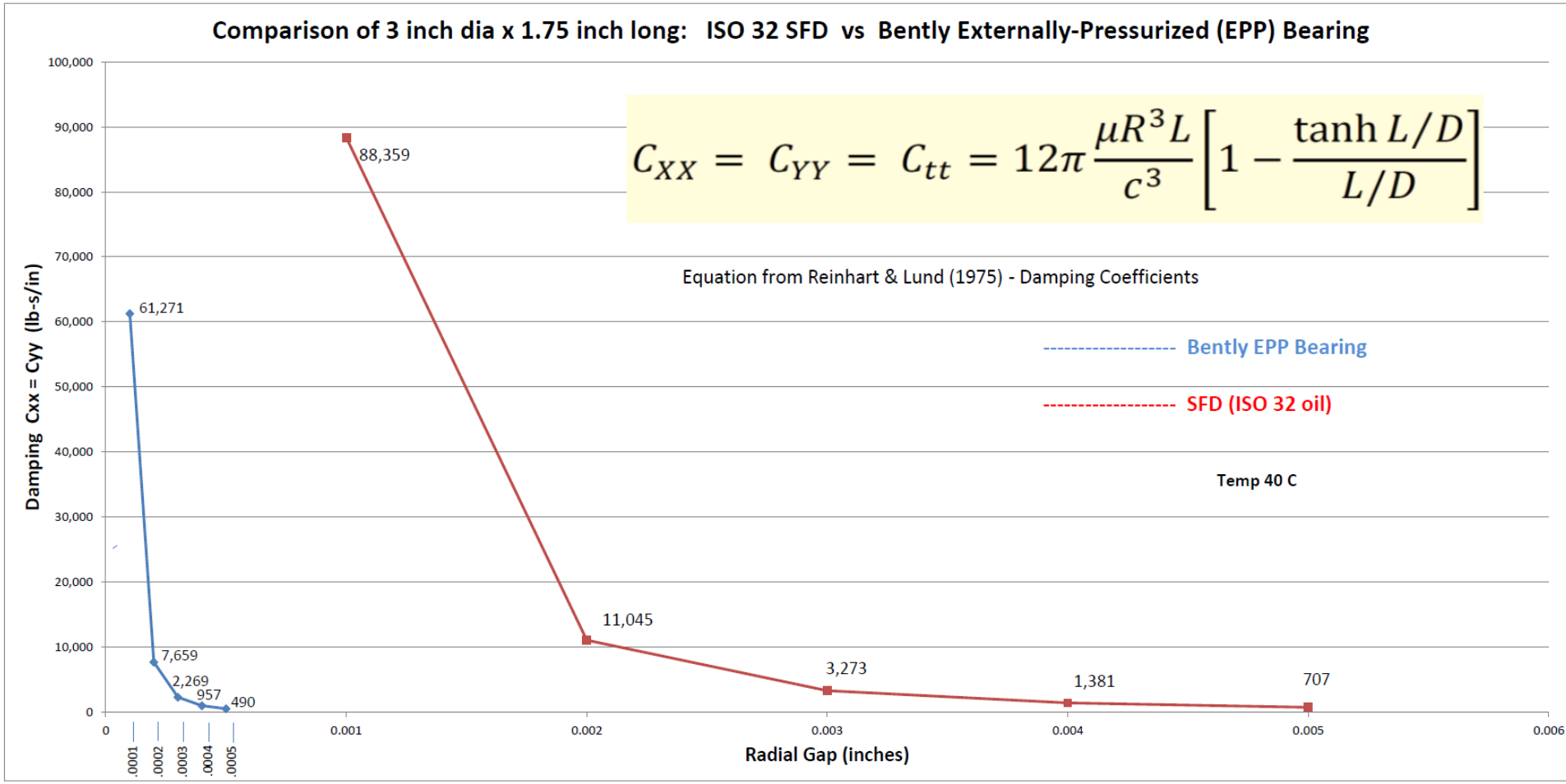
Damping; Oil vs Air
75mm Diameter 50mm long journal



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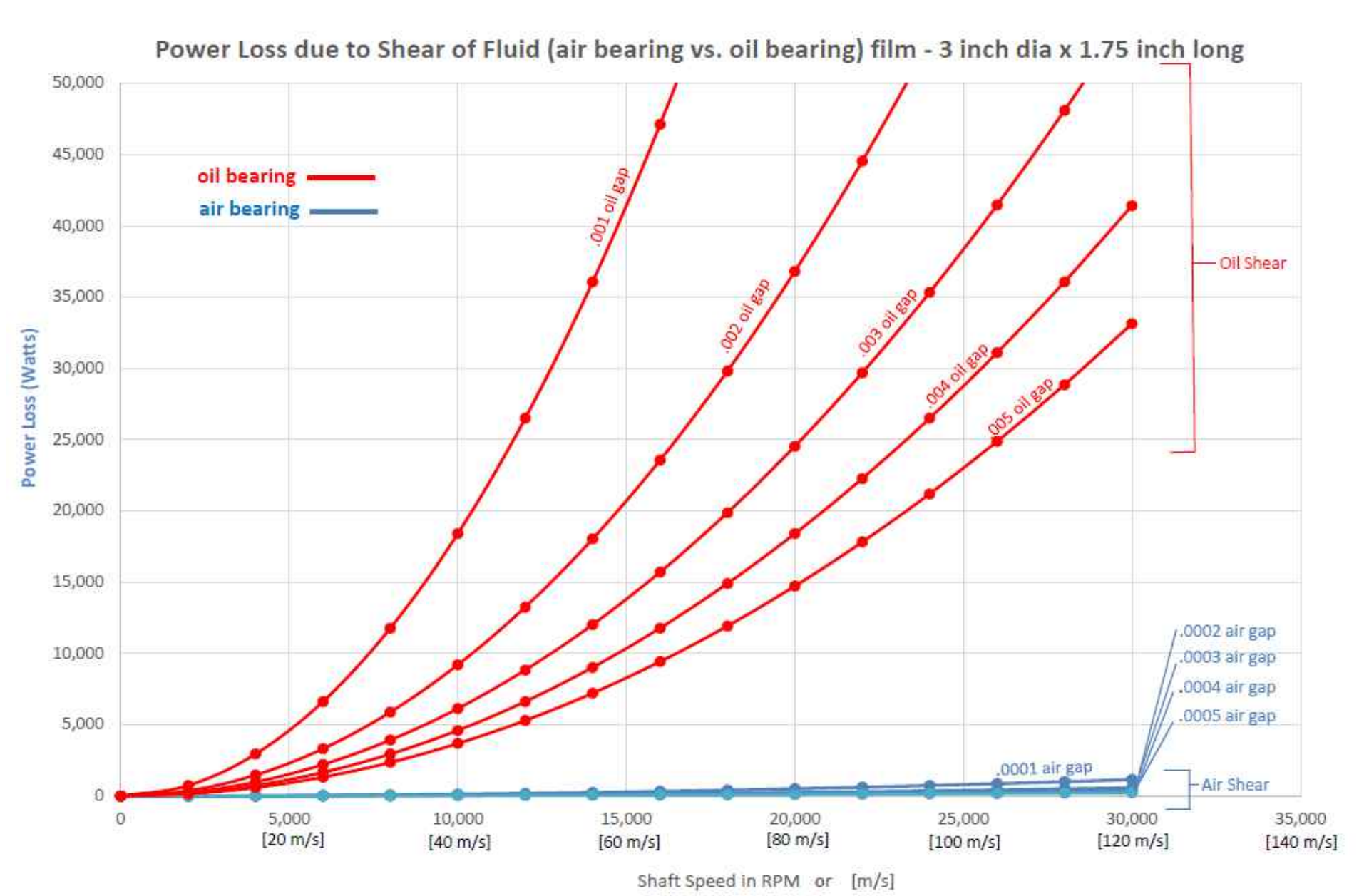
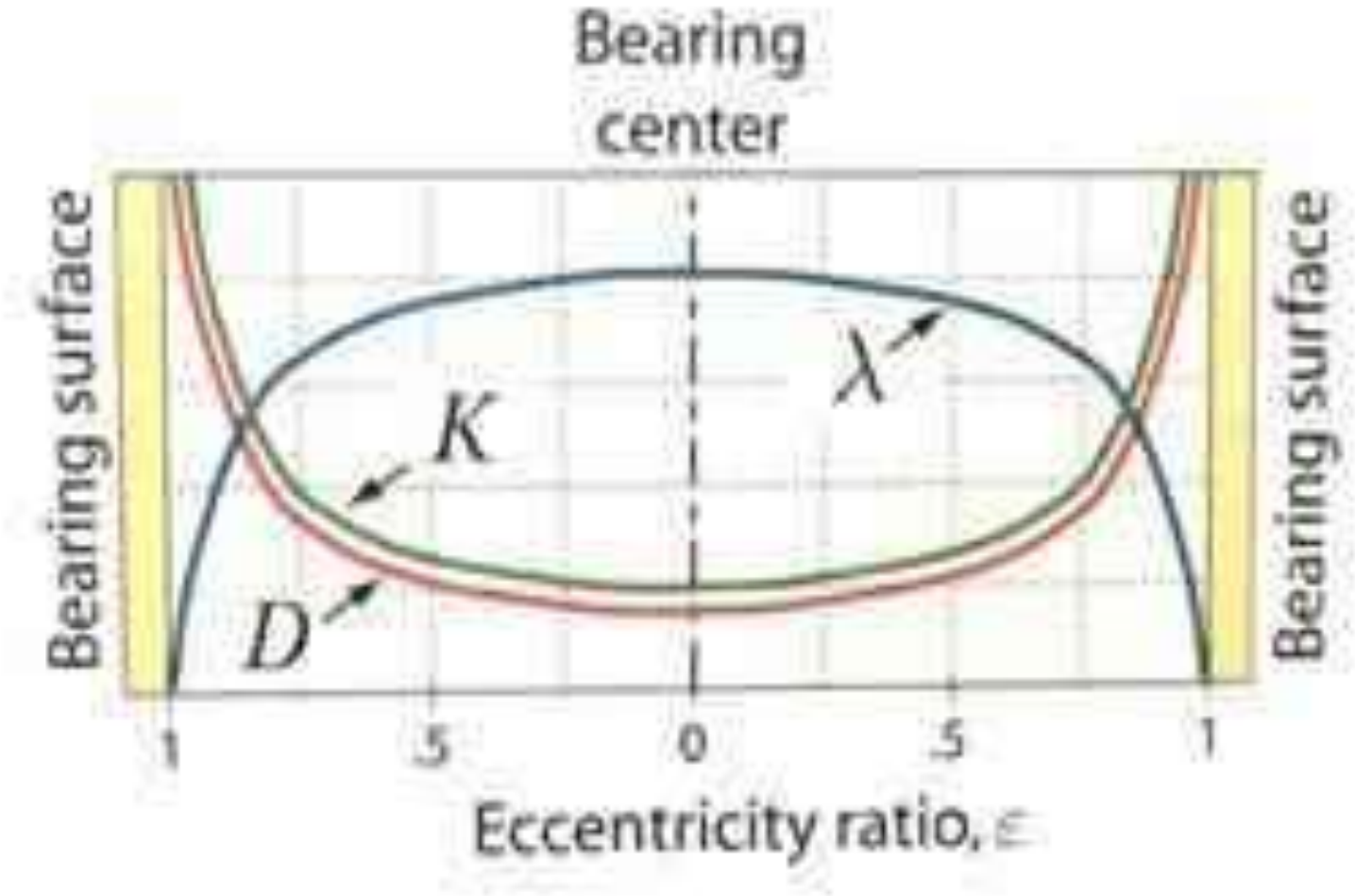


Eccentricity Plot (Don Bently)



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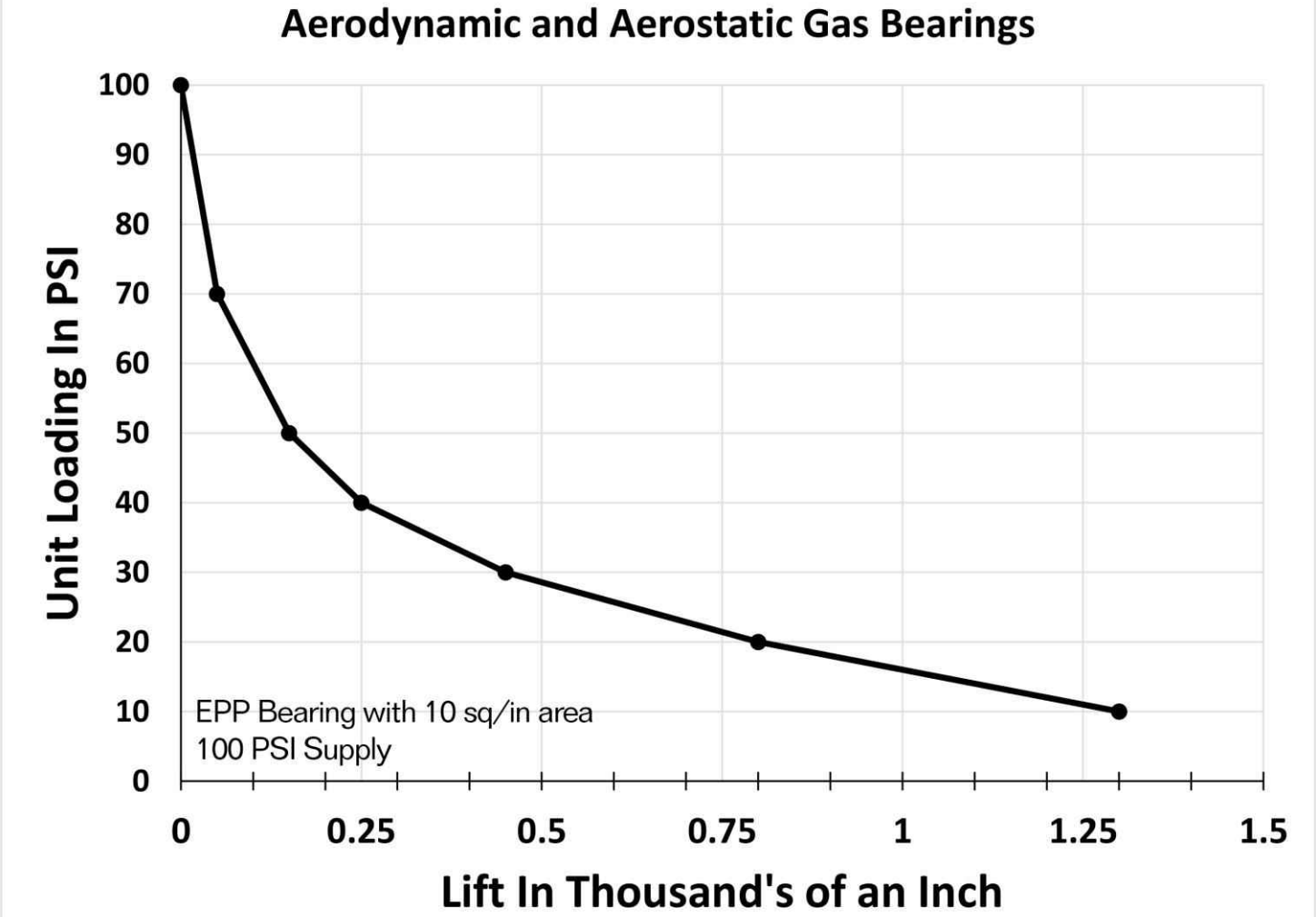
Lift vs Load Chart of an Externally Pressurized Porous (EPP) Air Bearing



Bearing NEWS

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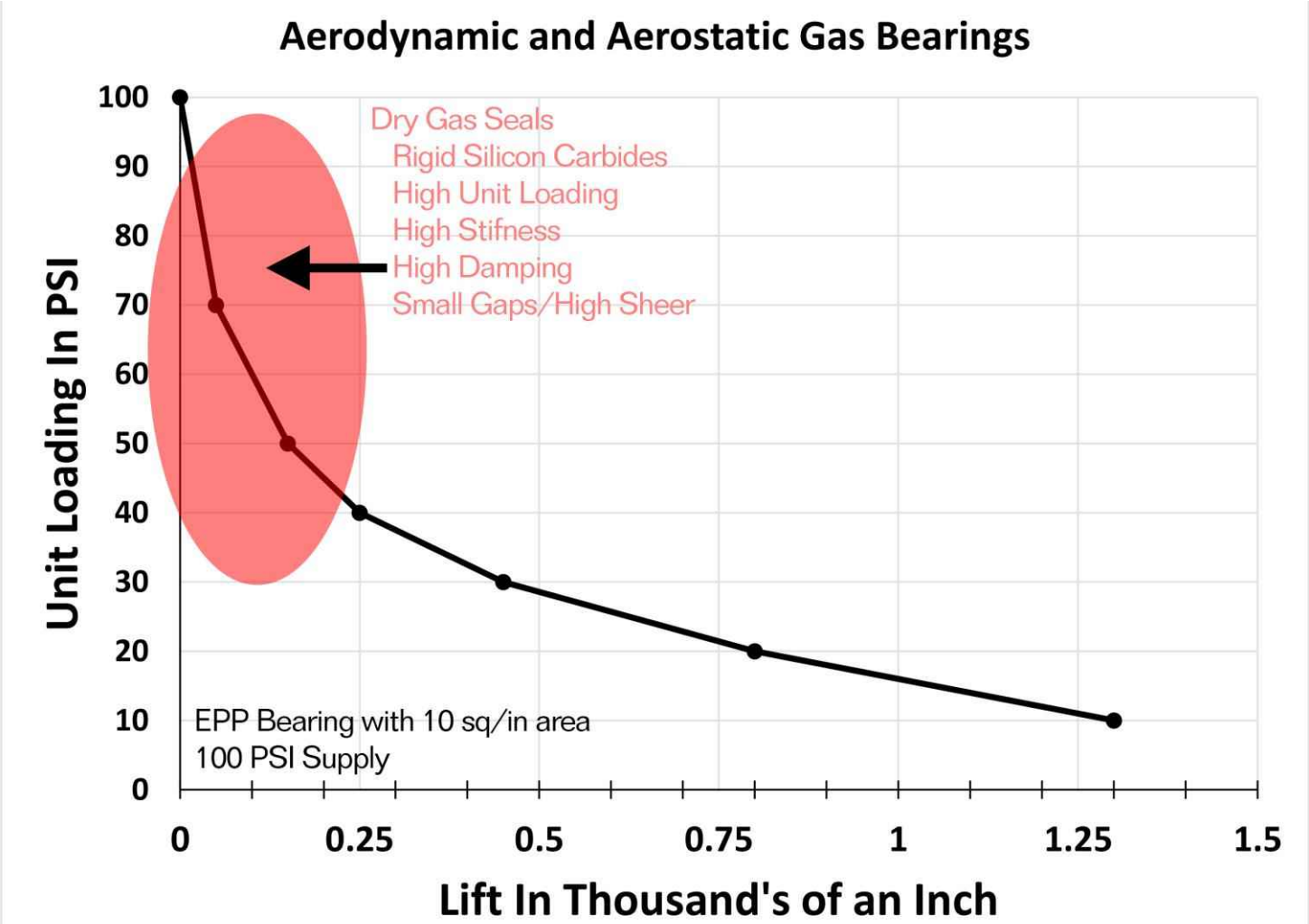
Dry Gas Seal Operating Range



Bearing NEWS

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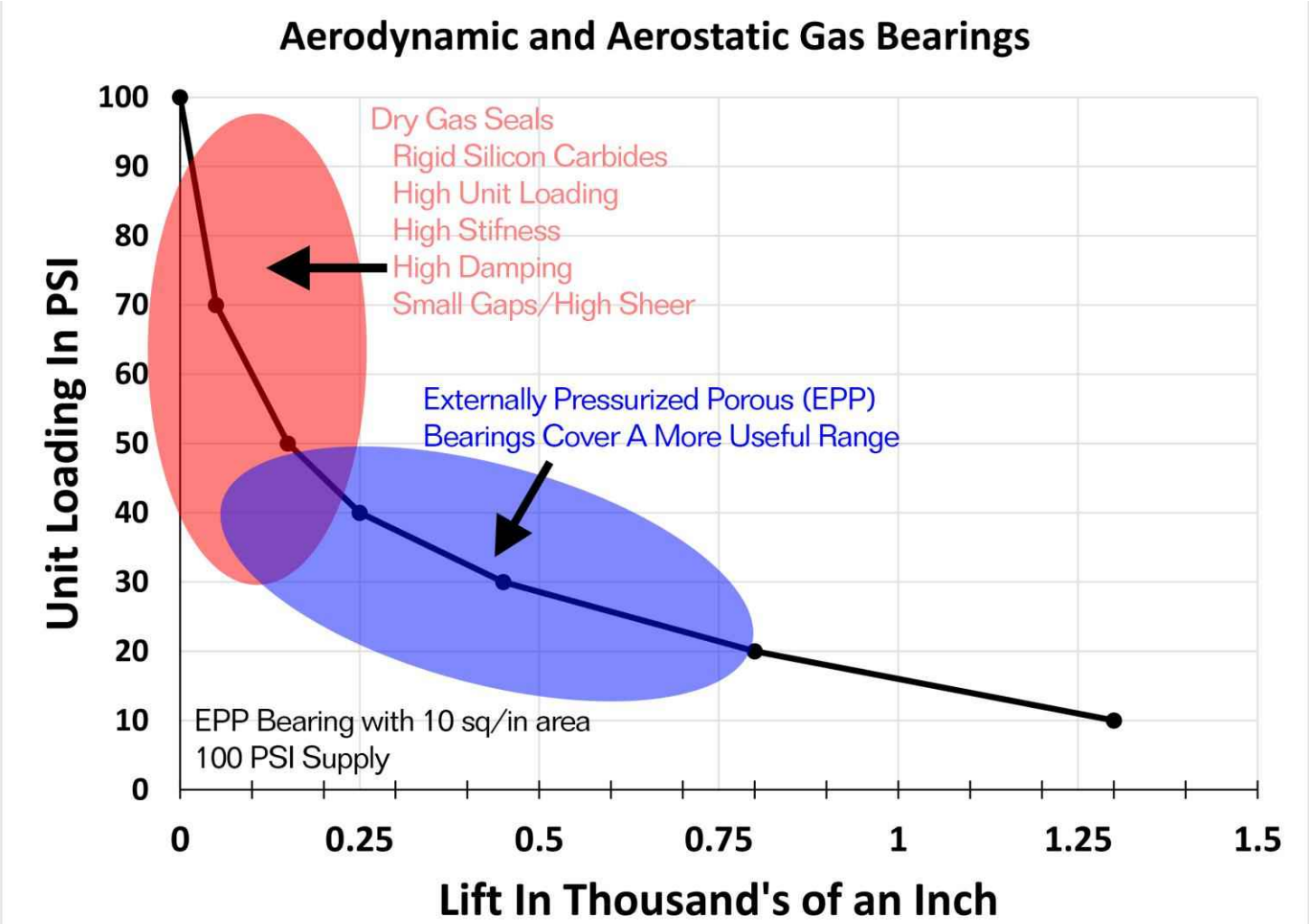
Operating Range for EPP Air Bearing



Bearing NEWS

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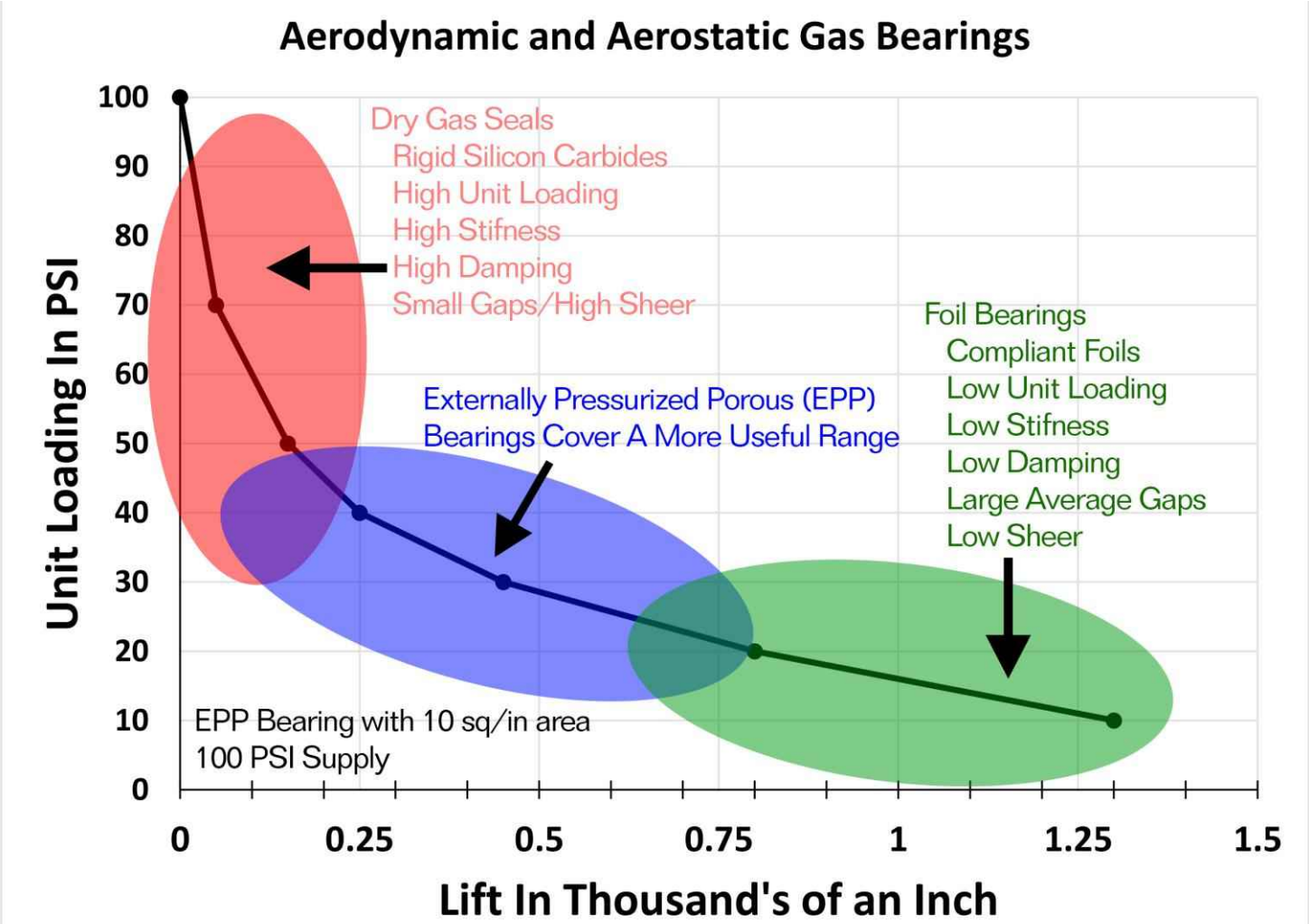
Operating Range of Foil Gas Bearings



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High Temperature EEP Bearings from Solid Carbon or Graphite

Bearing NEWS

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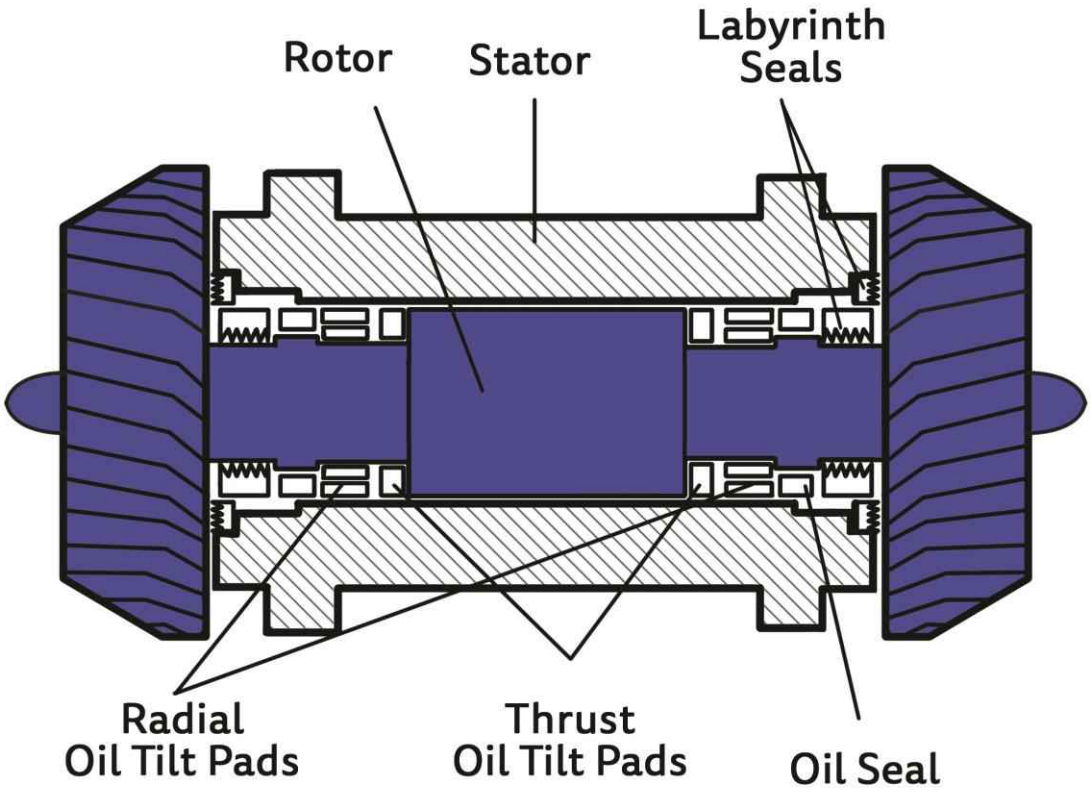
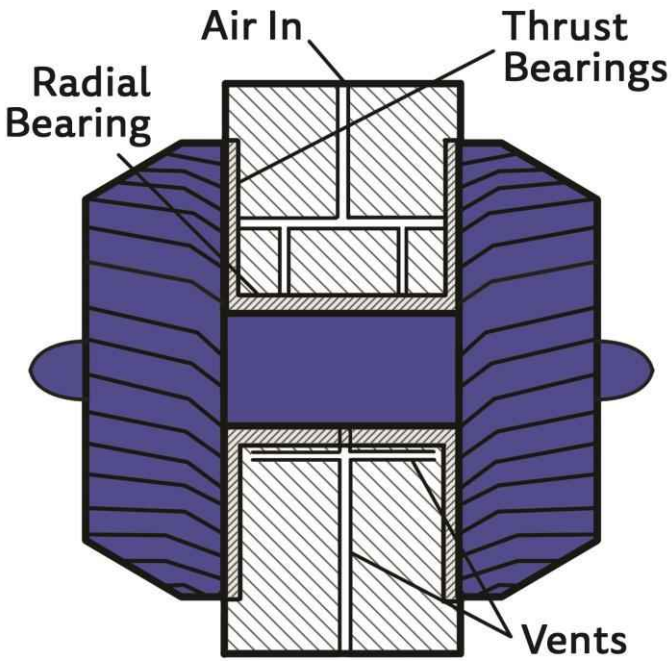
CMCs Fired at 900°C are Porous and Could be used as EPP Bearings and seals

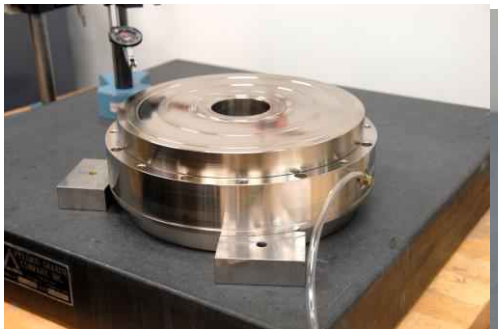
- High temperature capability
- Low Coefficient of thermal expansion
- Light weight
- High strength
- Tunable porosity
- Cast to near net shape

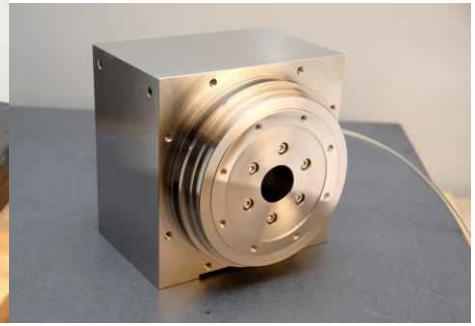
Expanders, Turbo Chargers and Gas Turbines

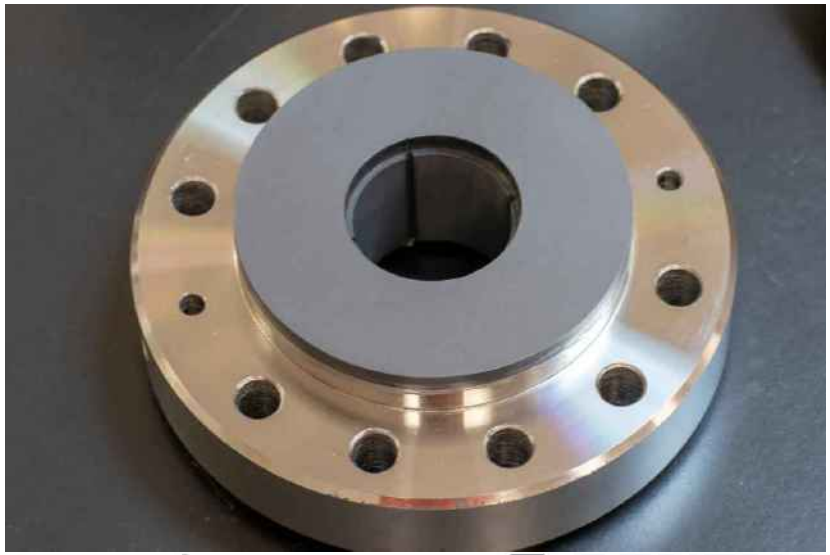


EPP Gas Bearings Acting on Impellers improve rotor dynamics, act as seal, shorten and simplify rotating equipment









Bearing NEWS

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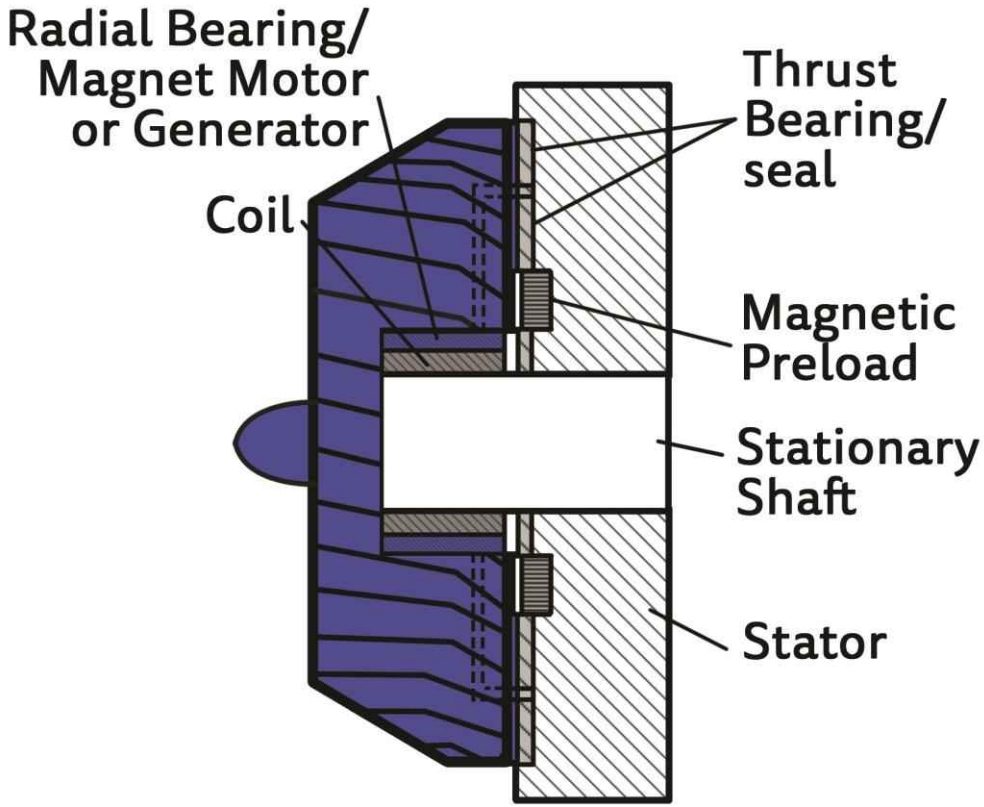
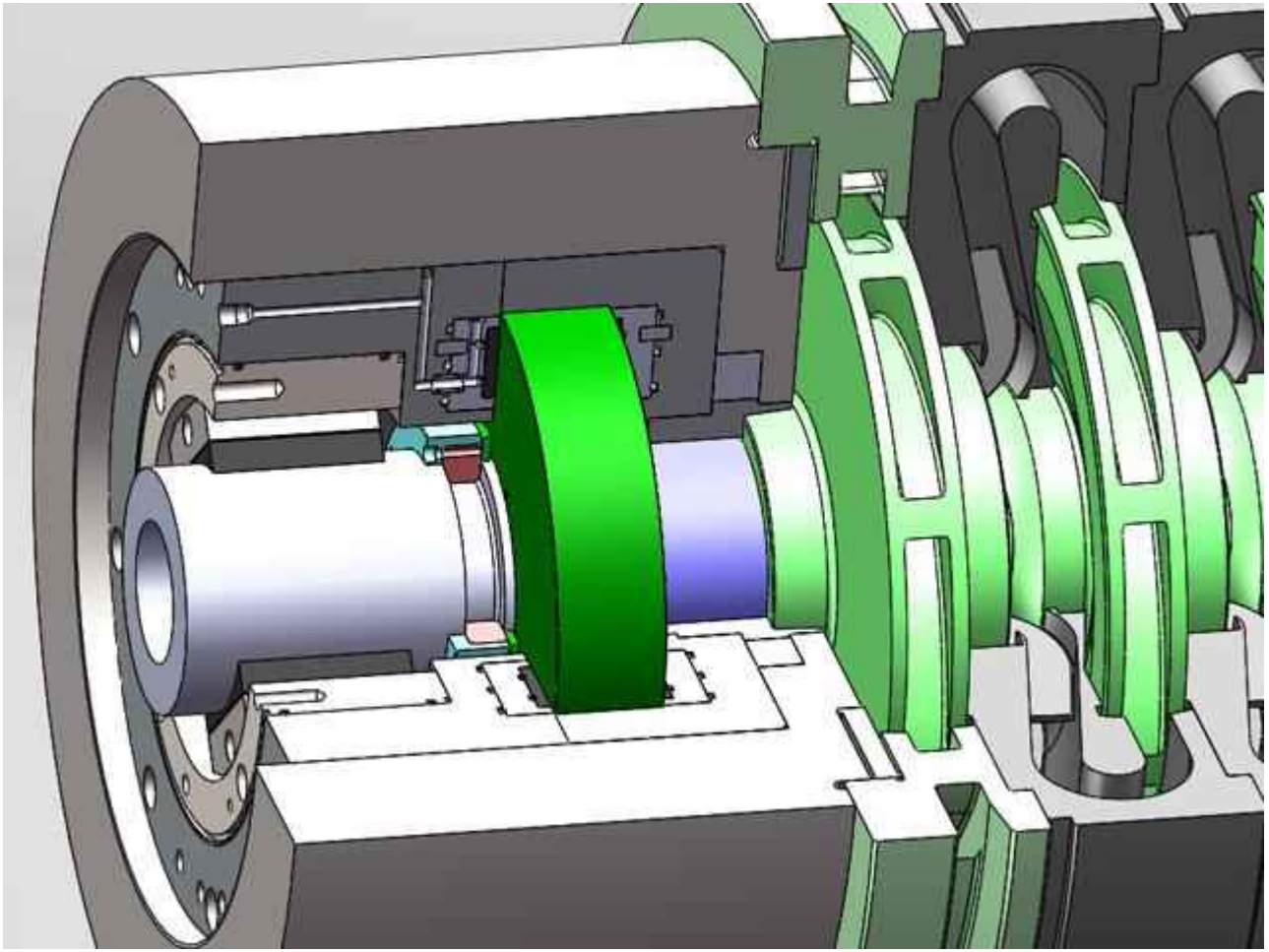
A generator could be integrated into the impeller eliminating a rotating shaft



EPP Gas Bearings as the Thrust bearing, Seal and Balance Piston



Bearing NEWS

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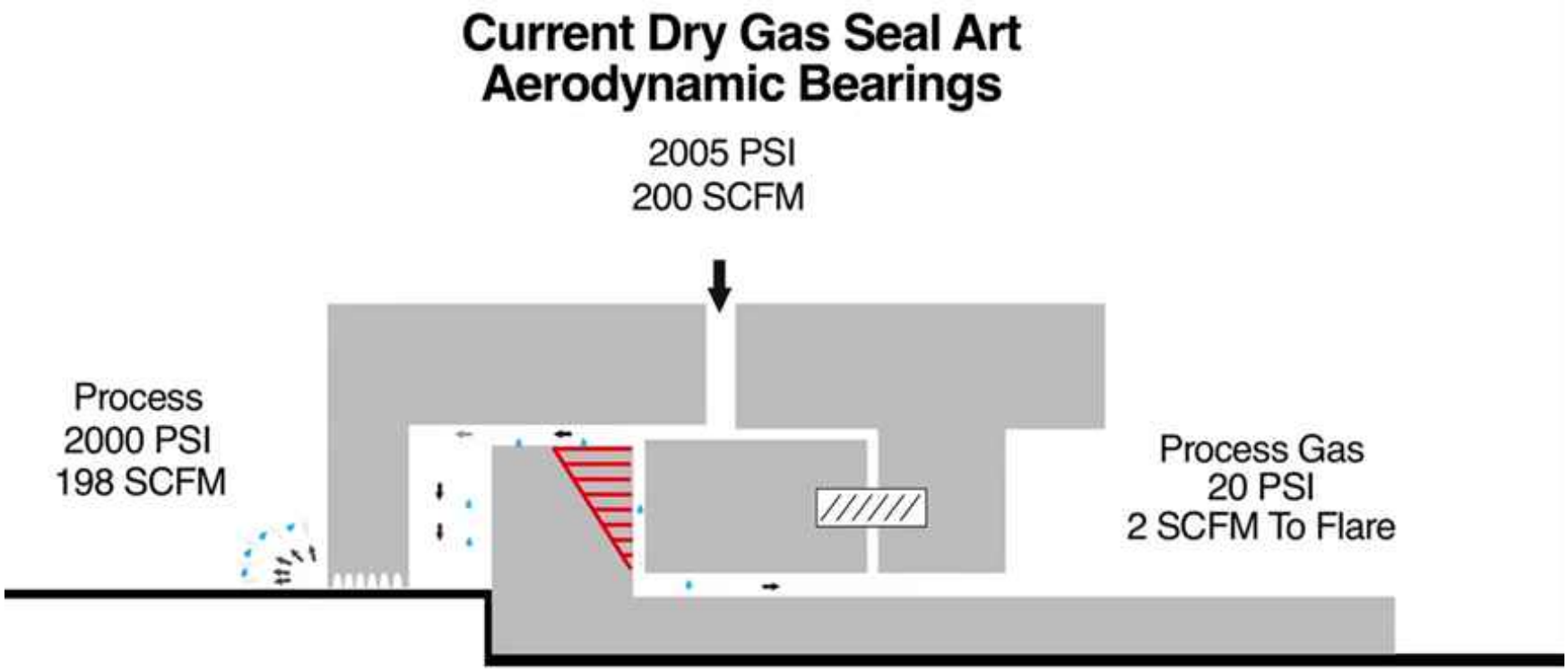
Conventional Dry Gas Seal (DGS) Flow Across the Face



Bearing NEWS

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EPP Gas Bearing as a DGS
No Flow Across the Face

Bearing NEWS

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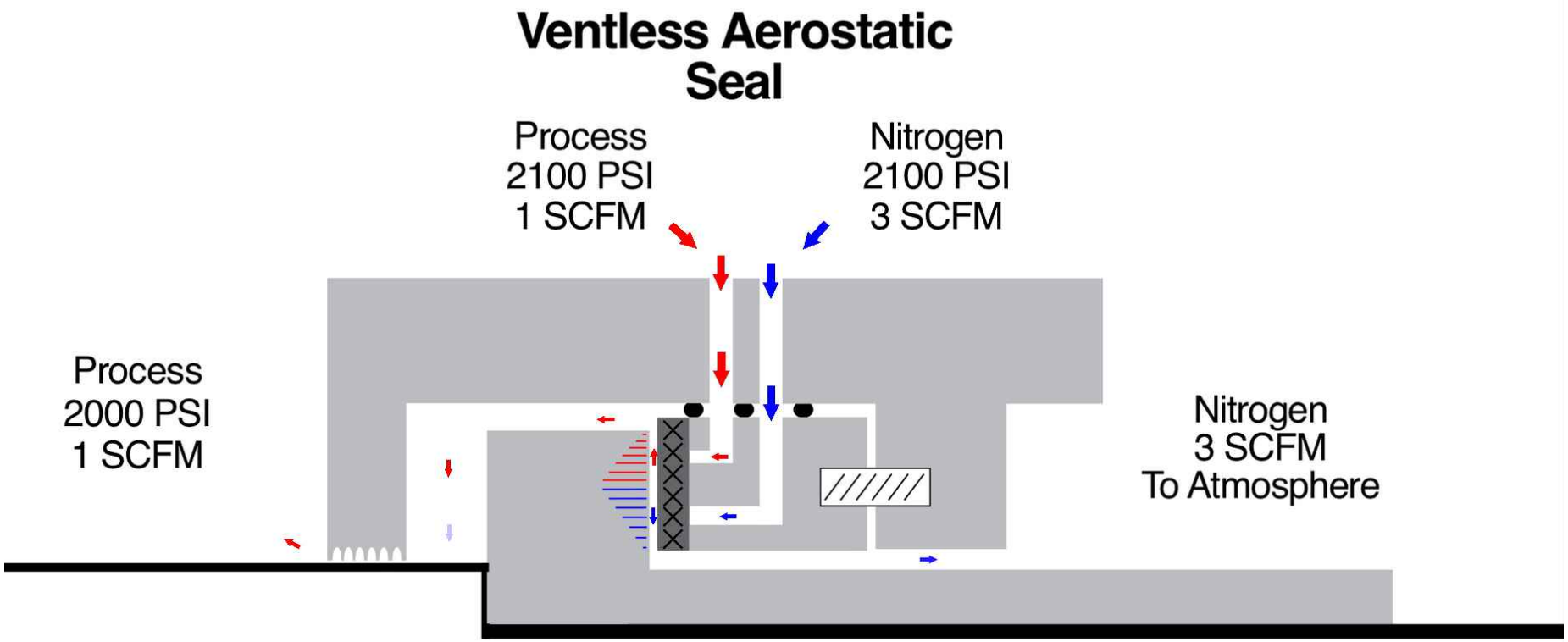
Segregation of Gases in a single Seal Face, No Process Gas Flows to Vent



Bearing NEWS

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Bearing Capabilities

	Hydrodynamic Oil	Active Magnetic	Aerostatic Gas	Aerodynamic Gas
Adjust Bearing Properties During Operation	●	●	●	●
Thrust Bearing is Also the Seal	●	●	●	●
Segregate Gasses in Single Face	●	●	●	●
Zero Friction at Startup and Stop	●	●	●	●
Operational at 800°C	●	●	●	o
Bear Directly on Impeller	●	●	●	o
Bearing is Magnetic Part of the Motor	●	o	●	●
Support 1000 PSI Unit Loading	o	●	●	o
Operate on or on Process Medium	●	o	●	●

● Yes ● No o Maybe

Bearing NEWS

NEWWAY® air bearings

BENTLY BEARINGS™

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New Way Air Bearings
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