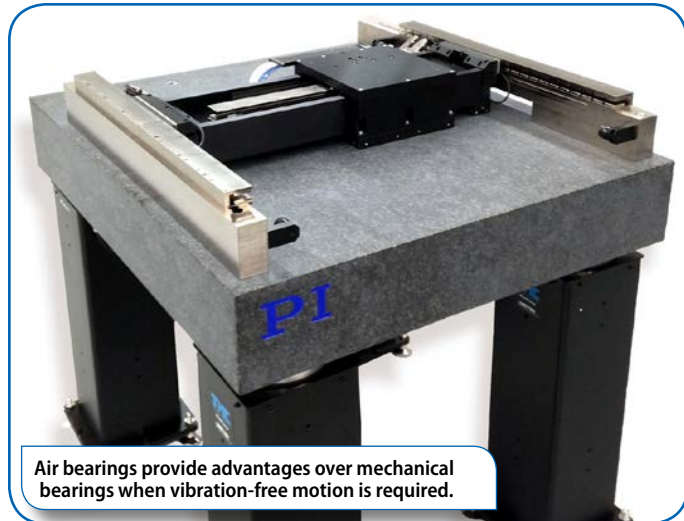


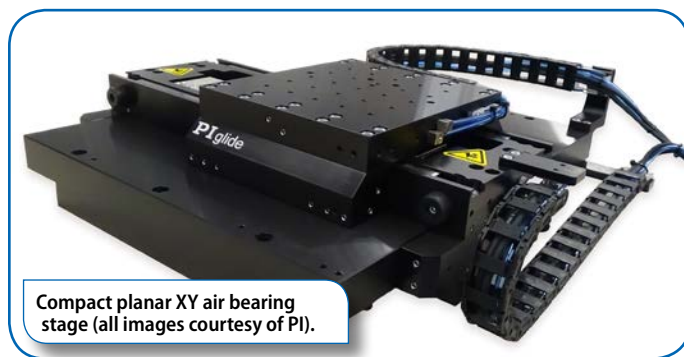
# Eight Reasons to Use Air Bearings Over Mechanical Bearings

PI (Physik Instrumente) L.P.



Air bearings provide advantages over mechanical bearings when vibration-free motion is required.

Mechanical guiding systems, such as crossed-roller bearings, work well for most motion control applications; however, when precision, angular repeatability, and geometric performance (runout, straightness...) are critical or where submicron bearing rumble is problematic, air bearings are recommended. An air-bearing stage is a rotary or linear positioner that floats on a cushion of air, using one of several preload mechanisms, nearly eliminating mechanical contact and thus wear, friction, and hysteresis effects. Here are eight reasons why an air-bearing stage might be the right choice for your application:



Compact planar XY air bearing stage (all images courtesy of PI).

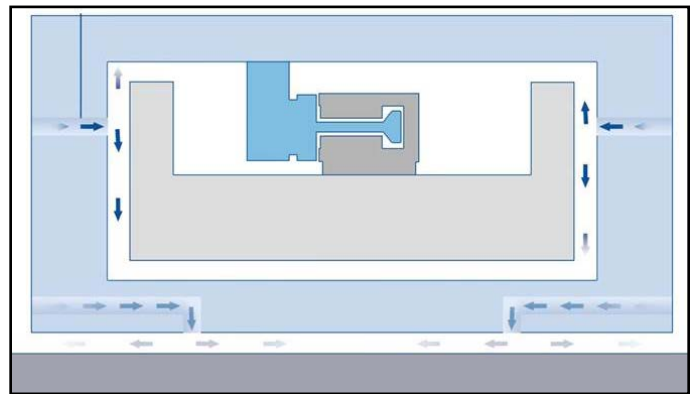
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## 1. Frictionless, High Precision Motion

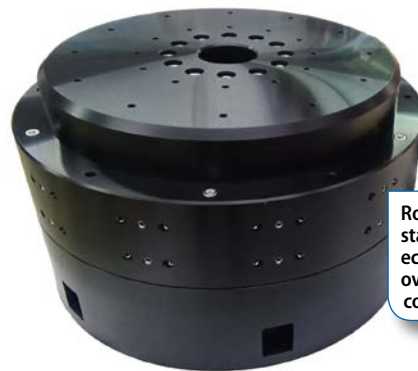
A direct-drive motor and high-resolution encoder can position a moving carriage supported by an air bearing to within nanometers in a linear application or within tenths of arc-seconds in rotational applications. The lack of friction and mechanical contact means there is minimal hysteresis or reversal error, making it highly repeatable and ideal for many inspection and manufacturing operations. Stiction is virtually eliminated, improving resolution capabilities and reducing in-position "hunting" (limit cycling), and position repeatability can be obtained within a few fundamental encoder counts. Similar precision can be obtained by piezo flexure guided stages, however over much smaller travel ranges. Magnetic levitation is another option.



How planar air bearing stages work

## 2. Highly Constant Velocity and High Scanning Speeds

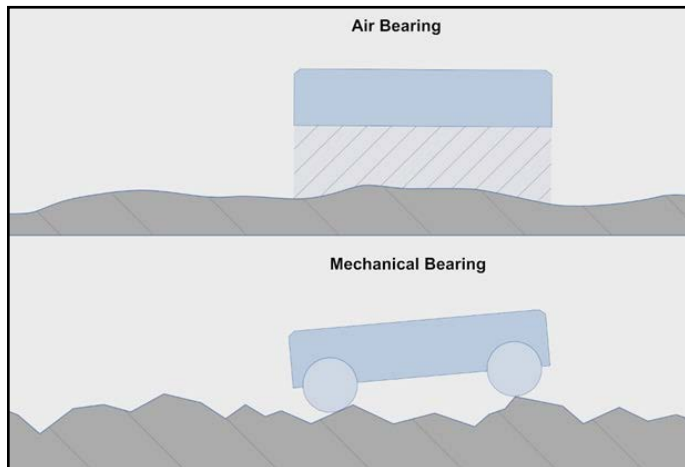
The lack of mechanical bearing elements means there is nothing to get in the way of smooth, controlled velocity (stability to better than 0.01 percent). Experiments and processes like inertial sensor testing, tomography, wafer scanning, and surface profiling require continuous motion at tightly controlled speeds are best served by air-bearing systems.



Rotary air bearing stages reduce wobble and eccentricity significantly over their mechanical counterparts.

### 3. Minimized Runout Errors

Linear air bearing stages have incredibly straight and flat travels, and pitch, roll and yaw errors can be measured in tenths of arc-seconds. Rotary stages can have tilt (wobble) errors less than 1 arc-second. Additionally, the angular performance of an air bearing is remarkably repeatable. This guarantees optimal part quality and measurement reliability for applications like mirror and optics inspection, semiconductor inspection, and medical device manufacturing.



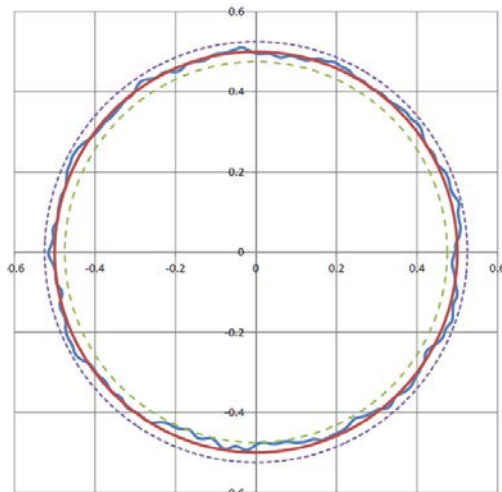
Surface averaging effect of an air bearing improves straightness / flatness of motion and reduces high-frequency bearing rumble.

### 4. Long-Range Motion Beyond Flexure Stage Capabilities

Piezo-driven flexure stages and actuators can satisfy many high-precision positioning applications. However, these designs are usually limited to a few millimeters of travel. Use an air bearing linear stage for travels of 25 mm or more. PI manufactures linear air bearings with travels up to a meter, and even greater with a custom design.

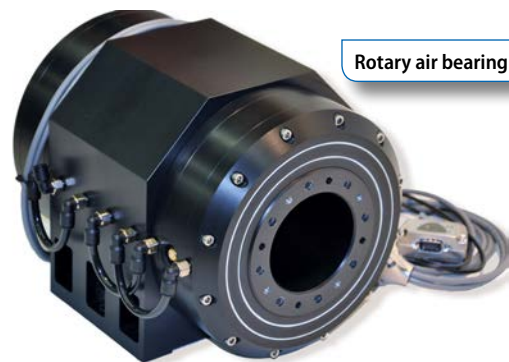
### 5. Wobble-Free or High Speed Rotary Motion is Needed

Rotary air bearings are exceptionally stiff and can deliver highly precise rotary motion. Radial, axial, and wobble error motions are much smaller than most mechanical bearing solutions can provide, and the rotary motion is very smooth,



Radial runout error motion of a 300mm rotary air bearing stage for use in a synchrotron beamline test facility is less than +/-35 nanometers. Wobble error motion is calculated to be +/-0.2 µrad (+/-0.04 arc-sec).

since there are no roller elements. Rotary positioning stages generally can achieve speeds up to 600 rpm, while air bearing spindles are used in higher speed applications. Rotary bearing designs can be mounted with the plane of the table in either the horizontal (i.e., turntable) or vertical orientations.



### 6. Minimal Maintenance

There are no contacting parts to undergo wear and tear, and no regular maintenance procedures to be performed, like lubrication. An air-bearing stage is essentially maintenance-free. Further, the system is highly stable; since there is no wear, the performance characteristics should not change over the life of the system. There is little need for re-calibration. Moving cables and hoses are often the only wear items in an air bearing system.

### 7. No Particulate Generation

Because air bearings are wear-free, they generate virtually no particulates that can become airborne. This makes them ideal for cleanroom applications like optics inspection, wafer inspection, bio-pharma research, and flat-panel display inspection. For extremely clean applications, it is recommended that the air bearing operate using 99.9 percent pure nitrogen.



Spherical air bearings can be used to simulate zero gravity.

### 8. Precise Force Control and Sensing

Air bearings are virtually frictionless, which means when they are coupled with a direct drive motor or voice coil, they are ideal for micro- and nano-Newton force control applications. Such applications can include pick-and-place of delicate items, materials testing, and coordinate measuring applications. **PTE**

**For more information:**

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