Application Notes For *Team* Hydrostatic Pad Bearings

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Summary

The pad bearing is used to contrain test articles being subject to vibration and earthquake simulation. The pad bearing proves the test engineer with a versatile, inexpensive support bearing. This paper will explain its principle of operation and give some applications.

Description

The pad bearing consists of two hydrostatic bearing surfaces. One is a spherical segment and the other a flat surface. It is illustrated in Figure 1.

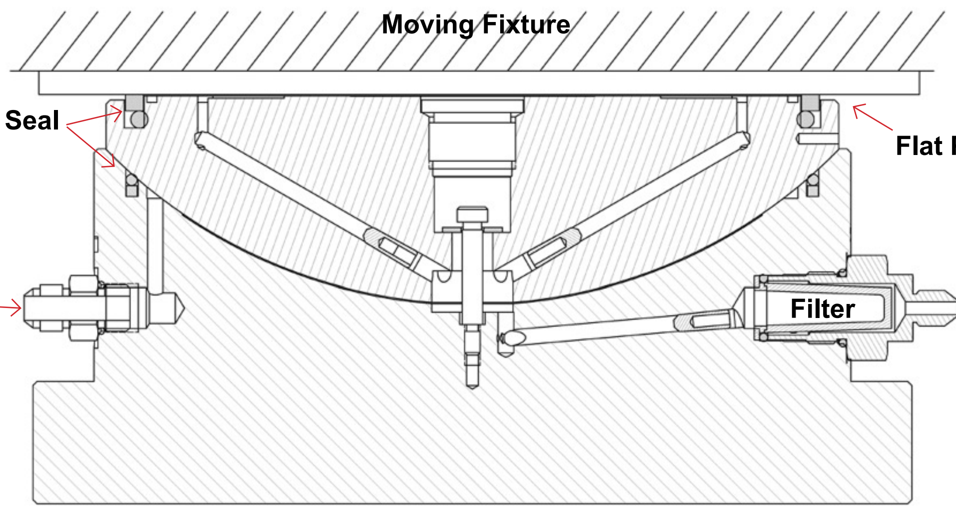

Fig. 1

Oil enters through the inlet filter at a pressure of 1,000 to 3,000 psi. It flows through a series of calibrated restrictors and then spills across the lands into the drain groove.

The bearing clearances in the illustration are exaggerated. In fact, the gaps involved are on the order of .001 inches. The compressibility of the oil film is quite high. Hence, the stiffness of the bearing is almost as great as the material in the bearing. In general, the stiffness is limited by the back up structure.

The oil used is generally a medium viscosity hydraulic fluid. At a viscosity of 300 ssu (65 cp) the flow is approximately ¼ gpm.

(In applications requiring no striction, the seal can be moved and the drain attached to a suction pump. Consult factory for additional help).

Preloading

Pad bearings carry compression loads only. Therefore, it must be used in conjunction with an opposing bearing to restrain tension and compression on loads.

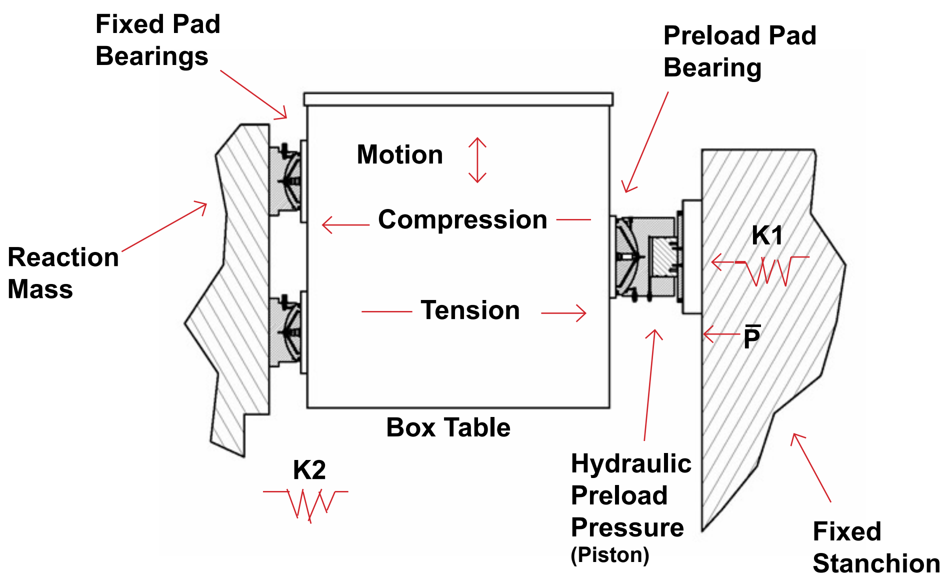

Fig. 2

The idea behind the preload is to apply a constant load against the fixed pad through the spring K1. K1 should be compliant (low spring rate) yet able to handle the preload. Compliance assures that small dimensional changes across the table will not appreciably effect the preload.

Dimensional changes will occur because of temperature differences on the table. Additional dimensional changes result from the out of parallel, machining tolerance on each pad face. The idea behind the preload pad is to apply a constant load against the fixed pad through the spring K1 that is greater than the max external tension load.

The fact that K1 is a low spring rate will not degrade overall stiffness. The real constraint to ground is governed by the relatively stiff spring K2.

Self Preloading Pad

A self preloading pad is illustrated in Figure 3. This pad has an appropriately sized piston to bring the pad to full output load.

This pad can be used in installations where making a compliant spring is difficult, there are space limitations, and where a totally loose set up can be tolerated when the pressure is off.

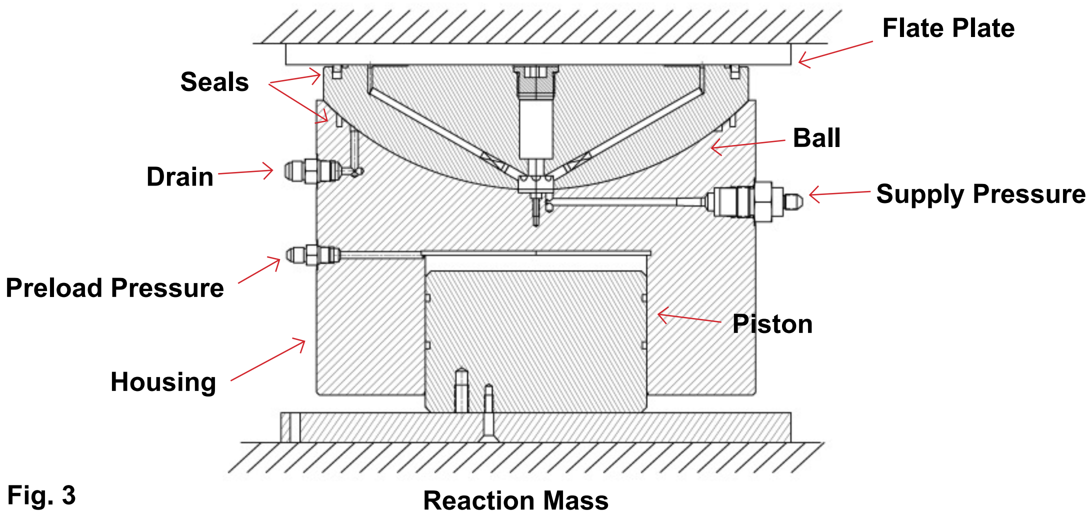

Fig. 3

Examples of Vertical Tables

A vertical vibration table is one of the most difficult things to support. The following is an example of a vertical table used with either ED or EH shakers.

Start with a box.

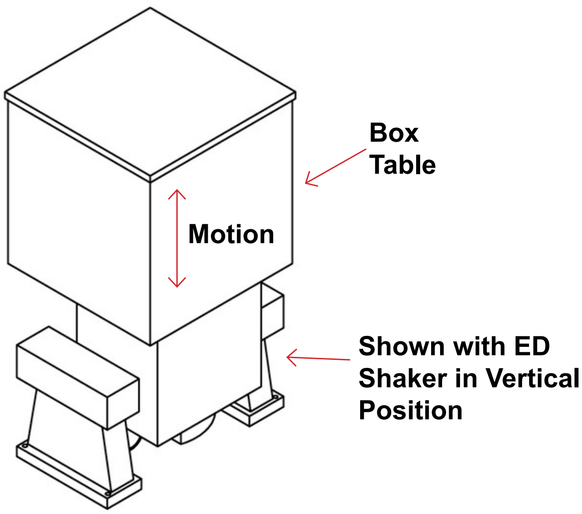

Fig. 4

Shaker Located Under Box

Looking from the top...

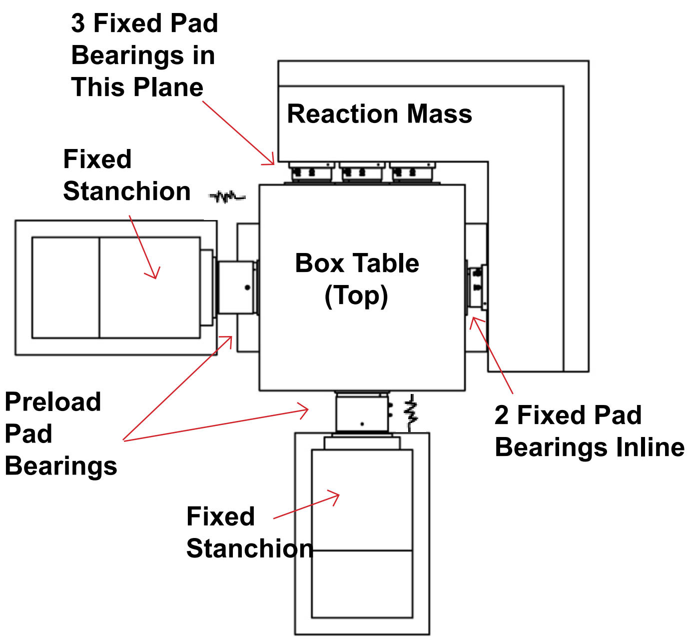

Fig. 5

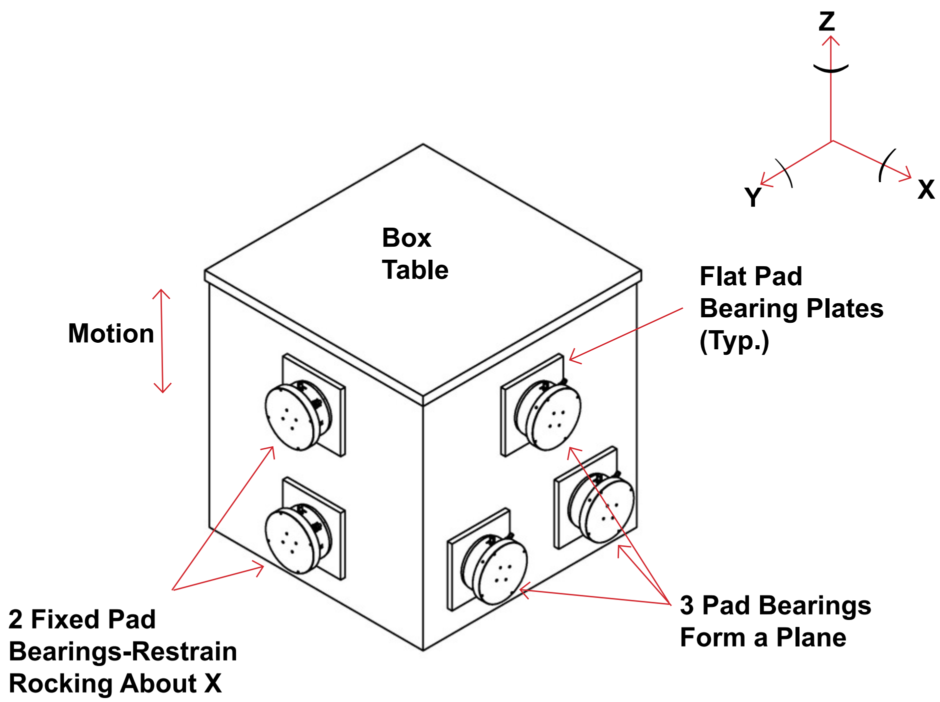

Fig. 6

The three pads in the Y-Z plane restrain rocking about Y and Z axes.
The two pads in X-Z plane constrain the table to simple vertical motion only.
The opposite faces have a single preloading pad.

Side View...

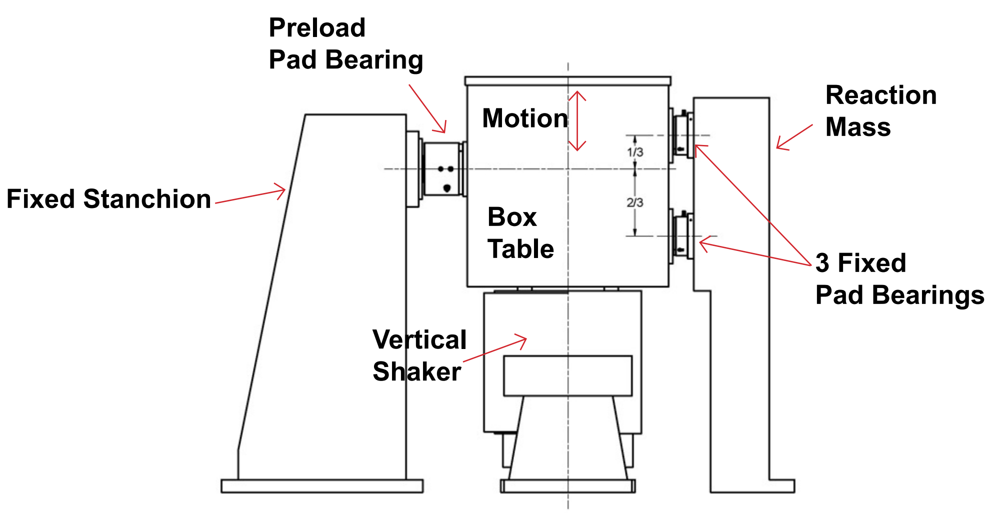

Fig. 7

Example of Biaxial Earthquake NEB System

In this case, the requirement is to have two D.o.F (degrees of freedom) remaining. The vertical is driven by two hydraulic shakers. The horizontal axis is driven by a single hydraulic shaker.

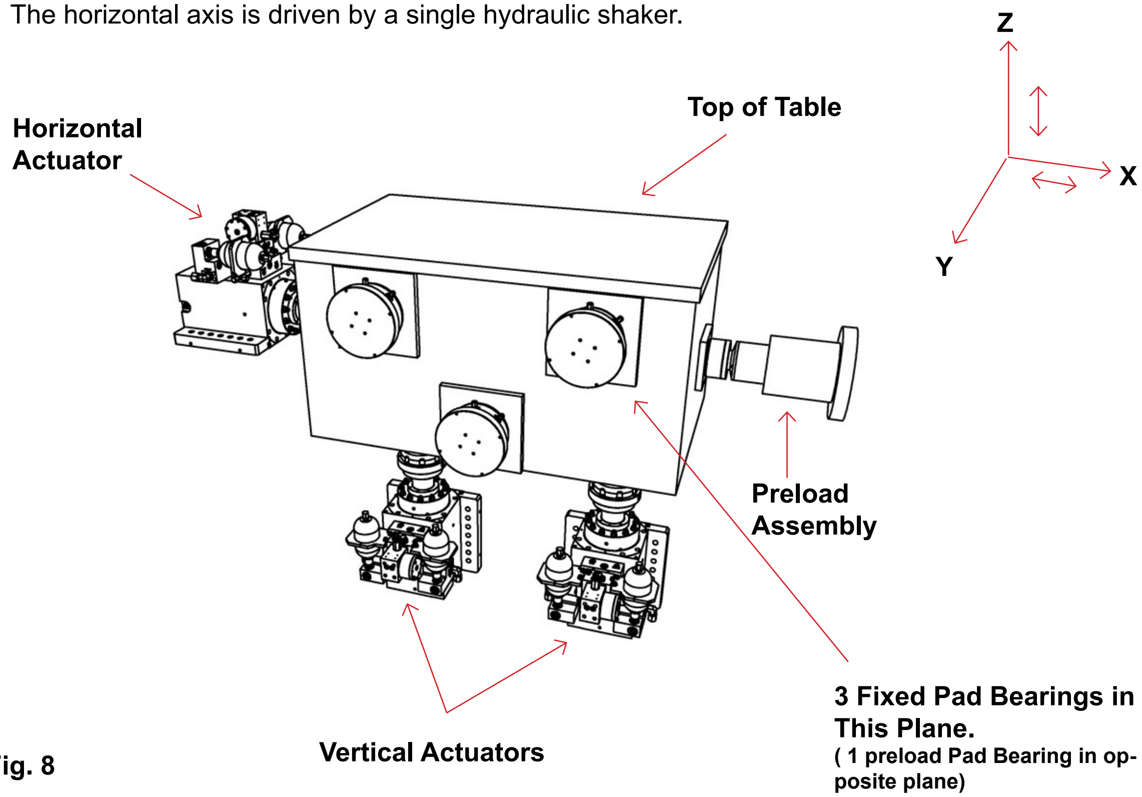

Fig. 8

Example of a Horizontal Vibration System

Assume a large heavy specimen must be vibrated in the horizontal. A rather inexpensive set up can be constructed using a combination of a pressurized slip plate and pads.

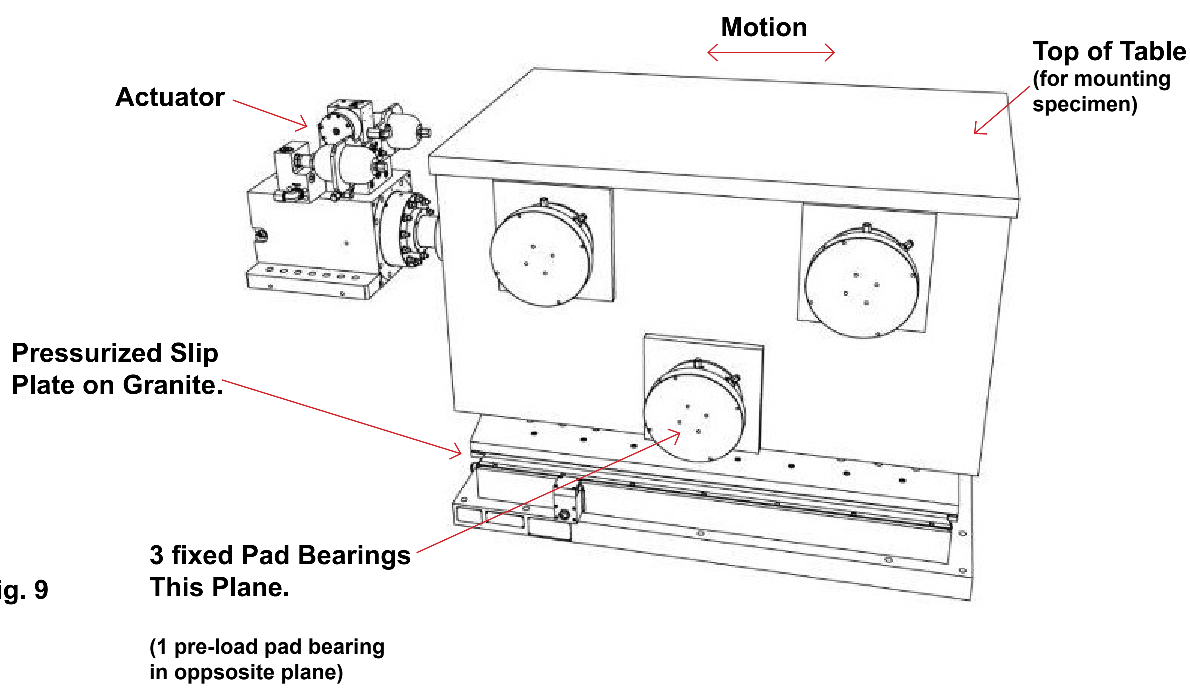

Fig. 9

Prepping The Fixture

The surface area where the pad plates mount on the fixture or table should be milled flat after welding or pre-machining process. This surface should be milled flat within .001”/12” x 12”. The structure behind the mounting surface should be well reinforced to prevent distortion under load.

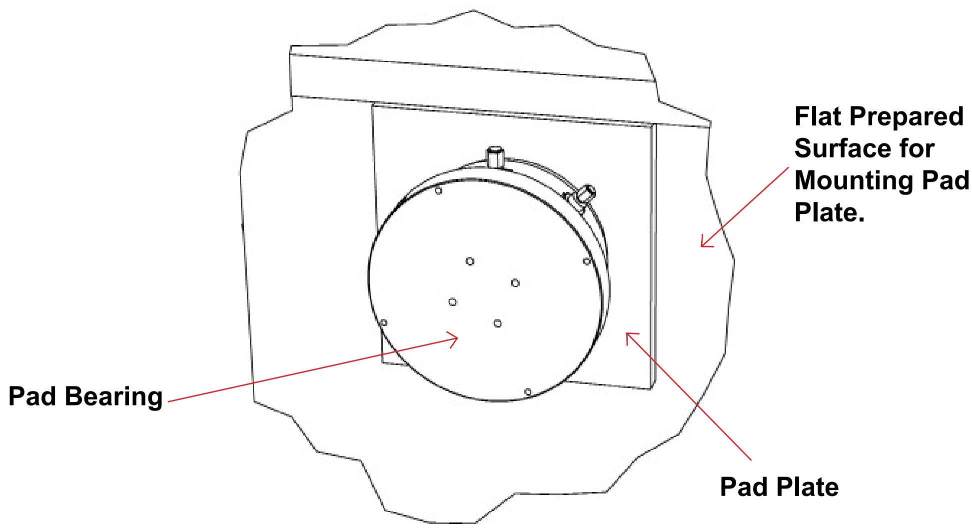

Fig. 10

The pad plate front and back surfaces should be machined parallel within .005”. The surface of the pad plate that mates with fixture should be machined flat within .0002”/ 3” x 3”. The surface of the pad plate that makes contact with the pad bearing should be machined flat .0002”/ 3” x 3” and have a surface finish of 16-32 Microinches Ra.

Crosstalk

Cross axis motion is that motion generated in an orthogonal direction as a result of an input in the primary axis. The cross axis run out due to machining tolerance will be on the order of .0005 inch. By the same token, the acceleration generated will be proportional. In other words, these relatively large machining tolerances will yield cross talk in the magnitude of .05%. This is not to imply the cross talk will be .05%. There is some cross talk caused the dynamic resonances of the fixture, reaction mass and specimen.

Kinematics

A single pad has five degrees of freedom (D.o.F.), three rotational and two translational in Cartesian coordinates. That is, a single pad has a single degree of constraint.

If a table having one D.o.F. is required, then how many fixed pads will be needed? To find out, use this simple rule of kinematics.

D.o.F. = 6 - No. of degrees of constraint
D.o.F. = 6 - No. of pads

or No. of pads = 6 - D.o.F. (desired)

The answer would be No. of pads = 6 - 1, or 5 pads required.
The placement of the pads is generally a function of the fixture shape. These in a single plane define a planar three D.o.F table, two linear and one rotation. Two pads in a common plane yields 4 D.o.F. or 2 D.o.F.

In general, you don't want too many D.o. F. or too many pads. 4 pads in a single plane, for instance, means a redundant D.o.F. Because of tolerance build up, one of the pads will not "load up" fully. Try to avoid redundant pads unless you are working with a compliant fixture.

Placement of the preload pads is easy. These pads are highly compliant. Hence, there is no problem with a redundant number. Place them where they load the fixed pads uniformly. That is, put them in the center of pressure of the fixed pads.

Alignment

The whole beauty of working pads is the freedom from tight tolerances on the machined surfaces. By the same token, alignment and set up is easy. Basically, there is no alignment. The only thing to watch for during set up is the amount of preload. The other potential problem is local misalignment or deformation of the fixture as the pad is loaded.