APPLICATION NOTES

For TEAM

HYDROSTATIC PAD BEARINGS

Summary

The pad bearing is used to constrain test articles being subject to vibration and earthquake simulation. The pad bearing provides the test The pad bearing provides 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.

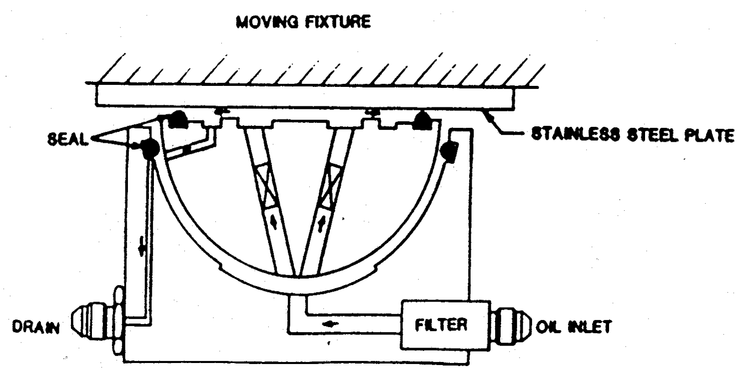

Fig. 1

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.

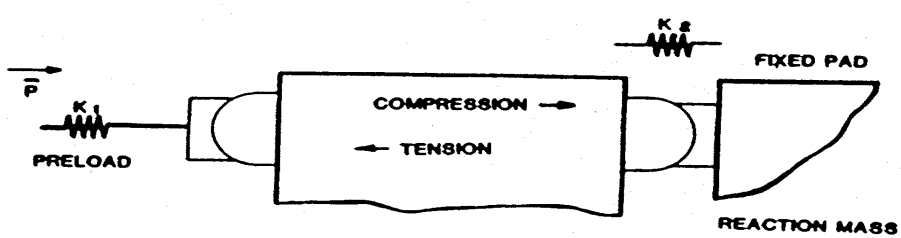

Fig. 2

The idea behind the preload is to apply a constant load against the fixed pad through the spring K1. K1 should be compliant 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 on the table. Additional dimensional changes result from the out of parallel, machining tolerance, on each pad face. By allowing small dimensional changes, without changing the preload significantly, the tension/compression load can be held relatively constant. The idea behind the preload pad is to apply a constant load against the fixed pad through the spring K1.

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. The accumulator is necessary to assure a uniform loading of the pad.

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.

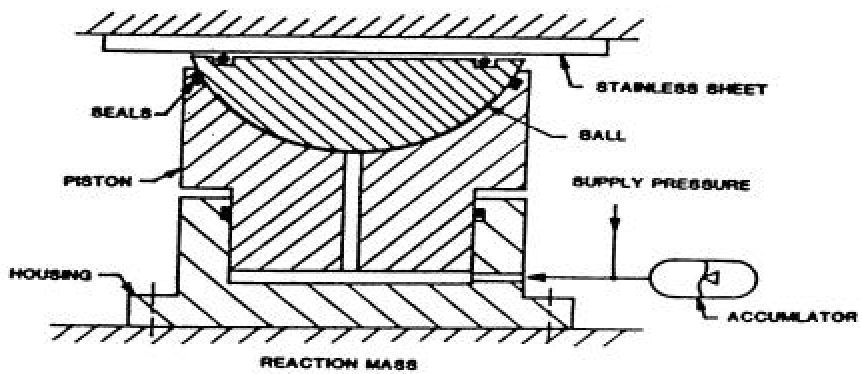

Fig. 3

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..

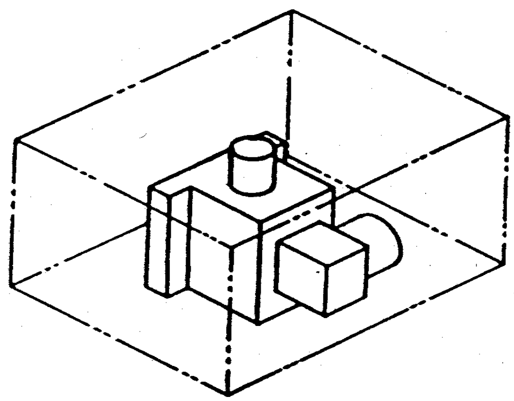

Fig. 4

Put the shaker inside….

Looking from the top…

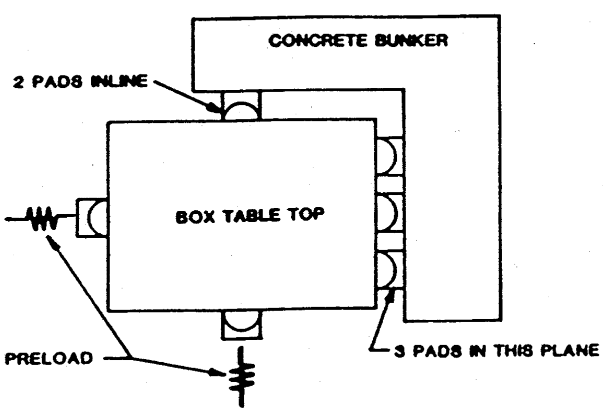

Fig. 5

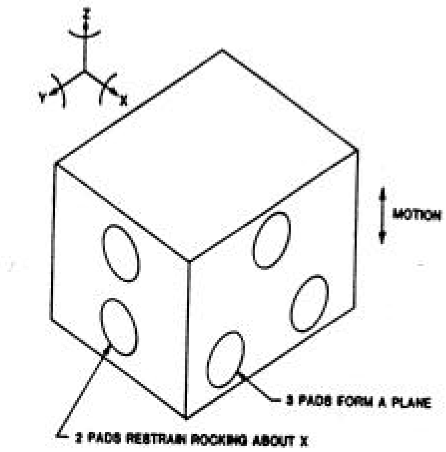

Fig. 6

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

Side View….

Side view......

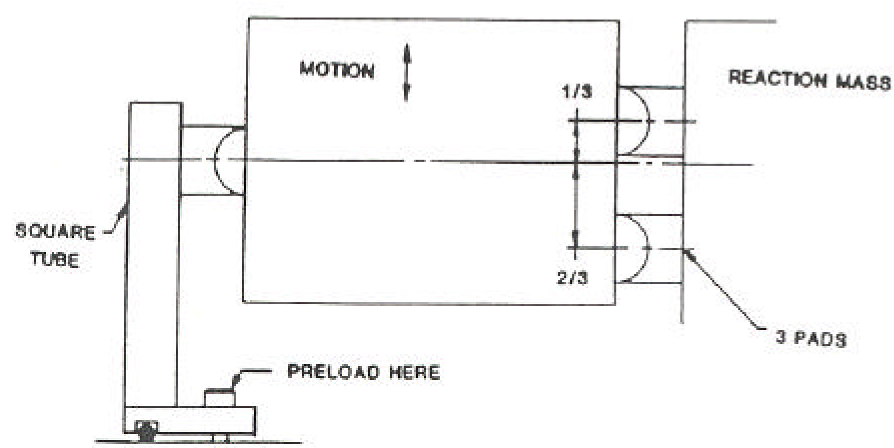

Fig. 7

Example of Biaxial Earthquake

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

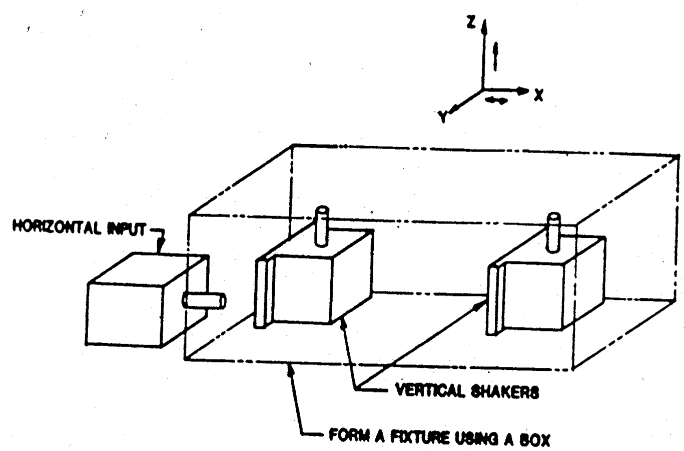

Fig. 8

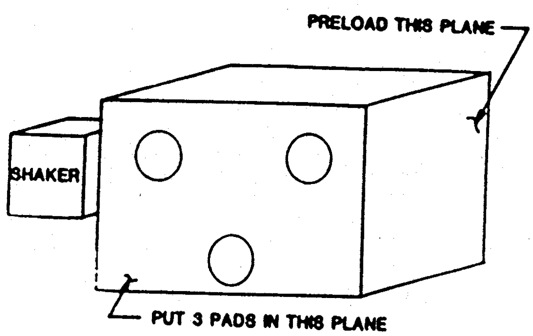

Fig. 9

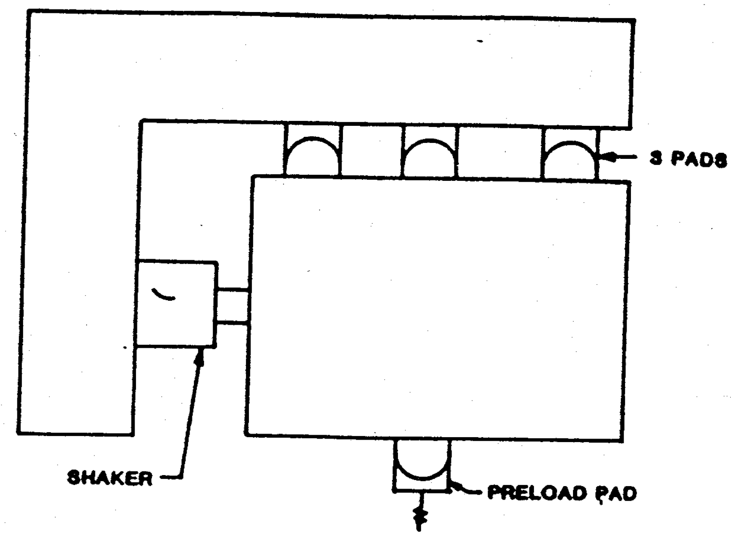

Fig. 10

Example of a Horizontal Vibration

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

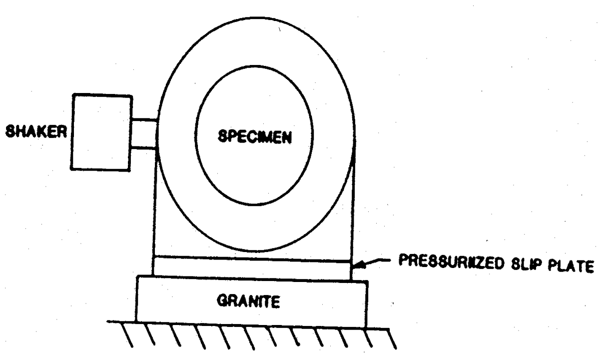

Fig. 11

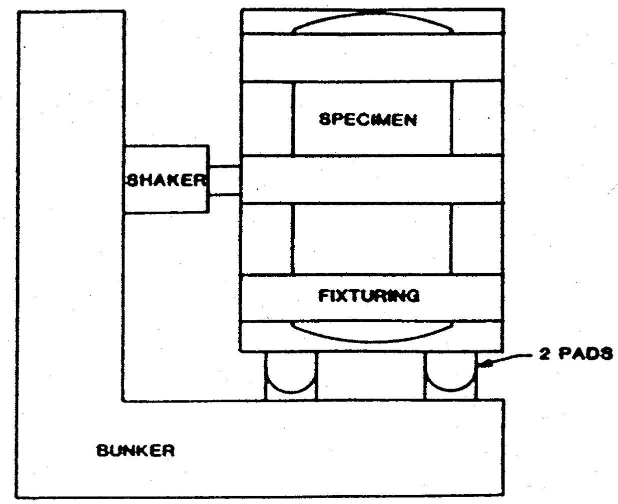
SPECIMEN
SHAKER
FIXTURING
2 PADS
BUNKER

Fig. 12

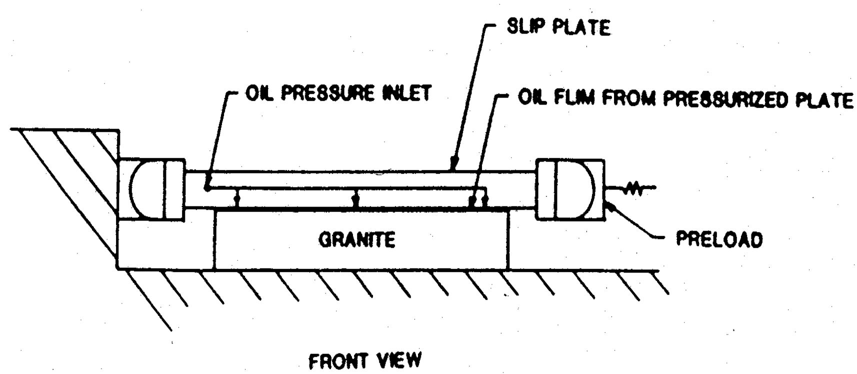
SLIP PLATE
OIL PRESSURE INLET
OIL FLIM FROM PRESSURIZED PLATE
GRANITE
PRELOAD
FRONT VIEW

Fig. 13

Prepping The Fixture

The area where the pads ride on the fixture should be milled flat or fly cut after the fixture is welded. We have found that this provides a flat enough surface for flat bearings to operate properly.

In addition to the mill cut, we recommend laminating a 1/16" sheet of stainless over the working area. This provides a smooth surface for the seals to work against and prevents premature seal failure. This sheet should be bonded on, using an epoxy.

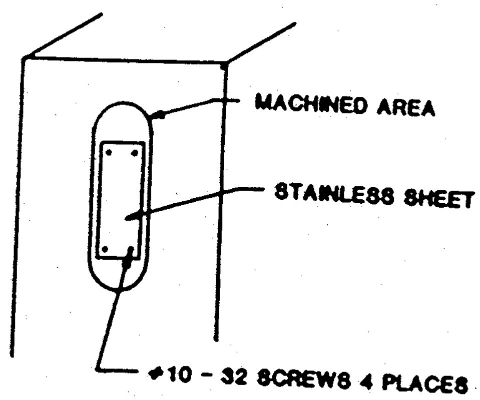

Fig. 14

We recommend using good machining practice. It should be possible to machine all parallel surfaces parallel to a common reference to within .006 in. per foot. In other words, the maximum out of parallel that might be generated is about .006 in /12. , or .0005 radians, using ordinary mills.

VIBRATION TESTING EQUIPMENT

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 in 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 by dynamic resonances of the fixture, reaction mass and specimen.

Kinematics

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

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

dof = 6 – No. degrees of constraint
dof = 6 – No. of pads

or No. of pads = 6 – dof (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 dof table, two linear and one rotation. Two pads in a common plane yields 4 dof or 2 doc.

In general, you don't want too many doc or too many pads. 4 pads in a single plane, for instance, means a redundant doc. 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 com – pliant. 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.