SECTION 3

TEST EQUIPMENT AND INSTALLATION METHODS

3.1 Test Equipment

A wide variety of IBM mainframe computer systems and peripheral equipment were tested in the three test series. A description of the test equipment tested in each series is given below.

3.1.1 June 1991 Test

The test equipment for this series consisted of two IBM mainframe computer systems: An IBM 9370 system, with DASD and tape drive units, and a fully configured IBM 9371 system. Both systems were configured with devices commonly found in data processing facilities and were fully operational.

The overall sizes and weights of these two mainframe computer systems, shown in Fig. 3-1, are given in Table 3-1. In addition to the size differences, the two systems also differ in base style. The IBM 9370 system base consists of four casters, two in the front and two in the back. The two in the back are free to swivel, but the two in the front are not. Moreover, there is a stabilizing foot in the front as shown in Fig. 3-2, the purpose of which is to stabilize the body from tipping forward.

The IBM 9371 system base consists of four glides, these are round in shape like a cylinder and about 1.0m in height.

3.1.2 August 1991 Test

The equipment tested in this series consisted of two mainframe computer systems, a printer and some miscellaneous stand alone computer periphery. One of the mainframe systems was a fully functional IBM 9221 system with a 9348 tape drive, 9336 DASD, a CEC processor and a 5020 Beach "B" box; the other was a nonfunctional IBM 9221 system consisting of two 9335 *A* units and four 9335 *B* units. The printer tested was a 6252 printer unit. Only test results from the mainframe computer systems are considered here. The overall sizes and weights of these two mainframe computer systems can also be found in Table 3-1.

Both units are similar in base style to the IBM 9370 system, and both are designed to accommodate a stabilizer foot. However, the foot was not used during the test.

3.1.3 June 1992 Test

The equipment used for this test consisted of three mainframe computer systems: A half-frame Frame-8 computer system, a full-frame Frame-1 computer system, and a non-operational Endicott frame computer system (Fig. 3-3). The overall sizes and weights of these three mainframe computer systems are included in Table 3-1.

3.2 Installation Methods

A large variety of installation methods as described below were used in the three test series, representing a cross-section of typical installations as well as innovative passive energy dissipation devices.

3.2.1 IBM 9370, June 1991

Locked Casters. The casters were locked into position with thumb screws. The system was otherwise free to swivel and slide on the surface of the raised floor.

This is a more typical installation, although it may not be entirely suitable if large sliding motion is expected. Less sliding motion is expected in the case of locked casters than that of free casters due to the additional frictional restraining force at the caster-floor interface.

Free Casters. The casters were not locked into position and the system was free to roll on the surface of the raised floor without any external restraint.

For this case, unrestrained motion of the system relative to the floor would be possible except where limited by attachment power or signal cables which now acts as an (unintended) tether. This free-rolling installation approach is not typical. In practice, however, it may occur following service, installation, or when machines are moved from one location to another and the casters are mistakenly left in the unlocked position.

Testing this free-rolling configuration required more care than most of the other methods because larger sliding motion was expected and the behavior of the system was unpredictable. For this reason, the input test levels were initially selected at a much reduced level and then gradually increased while observing the response of the system.

The final test level attained was one-third of the level used for the other installation methods.

Bungee Cords (with tethers). Bungee cords, attached to eye bolts on each side of the rear casters, were secured through two-inch diameter cut-out holes in the raised floor to eye bolts attached to steel plates which, in turn, were bolted to the shaking table. The bungee cords were 14 inches in length and had metal hooks at each end as shown in Fig. 3-4.

One of the purposes of evaluating the performance of bungee cords, as well as the spring restraints, was to examine the general feasibility of using tethers as a viable installation approach. The advantages of tethers are low cost, and the simplicity and adaptability it affords to a variety of field installations.

Spring Restraints. Two springs, stretched to an estimated preload of 128 lbs in each spring, were secured from eye bolts in the floor to eye bolts on either side of the casters via steel cables through the two-inch cut-out holes in the floor. This arrangement is shown in Fig. 3-5(a). Following tests on the two-spring installation, it was augmented with two more springs for a single test. This arrangement is shown in Fig. 3-5(b).

Toggle Bars. The toggle bar installation (Foss and Nikolakopoulou, 1980) was essentially an adjustable threaded steel rod in tension. Four threaded rods, with turnbuckle adjustment, were attached from the base of the IBM 9370 near the casters through two-inch diameter clearance holes in the raised floor. The ends of the toggle bars were attached with steel hooks to eye bolts firmly attached to the floor. In use, the turnbuckles were adjusted to relieve all play in the rods.

This installation approximates a fixed base condition, although some limited motion between the equipment and the base is possible because of the clearance hole. Two of the toggle bars can be seen in the photograph shown in Fig. 3-6.

Viscoelastic Dampers. Four viscoelastic dampers, supplied by the 3M Company, were used to secure the system to the surface of the raised floor. The design of these dampers allowed direct attachment to the machine. During these tests, the casters were locked with the locking thumb screws.

Two different designs were tested: One denoted as a 2-Hz, "type F" damper, and the other denoted as a 5-Hz, "type D" damper. These dampers were secured by brackets bolted to the machine and to the floor, as shown in Fig. 3-7.

Wire Ropes. Four coiled wire rope dampers were bolted directly to the IBM 9370 base and the raised floor. The casters were also locked into place during the tests.

A photograph of this restraint system installed on the IBM 9370 machine is shown in Fig. 3-8, where the foot-plate brace attached to the front of the machine had been removed to permit viewing.

Fixed Base: The base of the IBM 9370 system was bolted directly to the raised floor by means of brackets mounted adjacent to the base of the casters.

3.2.2 IBM 9371, June 1991

While the majority of the tests were conducted on the IBM 9370 system, four different installation approaches were tested on the IBM 9371 machine. These are described below.

Glides. The IBM 9371 system was placed on the raised floor and was not restrained in any manner. The system was supported at the base on glides and can slide freely on the raised floor, as shown in Fig. 3-1(b).

Viscoelastic Dampers in Rear. Two viscoelastic dampers, similar to those used for the IBM 9370 tests, but designated as 0.5 Hz, "type E" damper, were used to secure the rear of the system to a bracket on the raised floor. The front end of the machine was not secured.

Fixed in Rear. The two type E viscoelastic dampers as mentioned above were removed and replaced with threaded rods which were used to bolt the rear of the machine to the bracket on the raised floor. The front of the machine was unrestrained.

Fixed Base. The system was bolted directly to the slab through the cut-out holes in the raised floor using two threaded rods. The threaded rods were positioned at two diagonal corners of the system as shown in Fig. 3-9.

3.2.3 IBM 9221, August 1991

The installation methods used on the IBM 9221 mainframe computer system consisted of the following:

Locked Casters. Same as described in Sec. 3.2.1.

Free Casters. Same as described in Sec. 3.2.1.

Toggle Bars. Same as described in Sec. 3.2.1, but with 40 and 80 durometer grommets used at the floor interface.

Fixed Base. Same as described in Sec. 3.2.1, except that the front and back were fixed. In some tests, the sides were fixed as well.

Viscoelastic Dampers - Case 1. Four viscoelastic dampers were mounted vertically from the eye bolts on the bottom of the mainframe to the shaking table This is a very soft mounting system due to flexibility of the viscoelastic dampers.

Viscoelastic Dampers - Case 2. Viscoelastic dampers in this case were mounted in a criss-cross configuration, between the eye bolts of the computer system and the shaking table, at the front and back sides of the computer system.

Viscoelastic Dampers - Case 3. Two viscoelastic dampers in this case were mounted vertically between the middle eye bolts of the front and back side of the computer system and the shaking table.

3.2.4 Frame 1, Frame 8 and Endicott Frame, June 1992

Toggle Bars. Same as described in Sec. 3.2.1. In this installation, the lateral displacement was controlled using bushings fitted into the raised floor surface. The bushings used during these tests consisted of two sets: An 80-durometer neoprene set and an aluminum set.

Wire Cables. Either 3/16-in or 5/32-in wire cables were connected between the eyebolts in the floor and the computer system. A schematic of a typical installation is shown in Fig. 3-10 (Frey and Nikolsky, 1992). The bushings used here to control lateral displacements also consisted of two sets: An 80-durometer neoprene set and a Teflon set.

Springs. Simple extension springs with spring constants of 570 lb/in and 290 lb/in were used. They were attached to respective eyebolts using wire cables. A schematic of a typical installation is shown in Fig. 3-11 (Frey and Nikolsky, 1992). Teflon bushings were used to limit the lateral displacements of the computer systems.

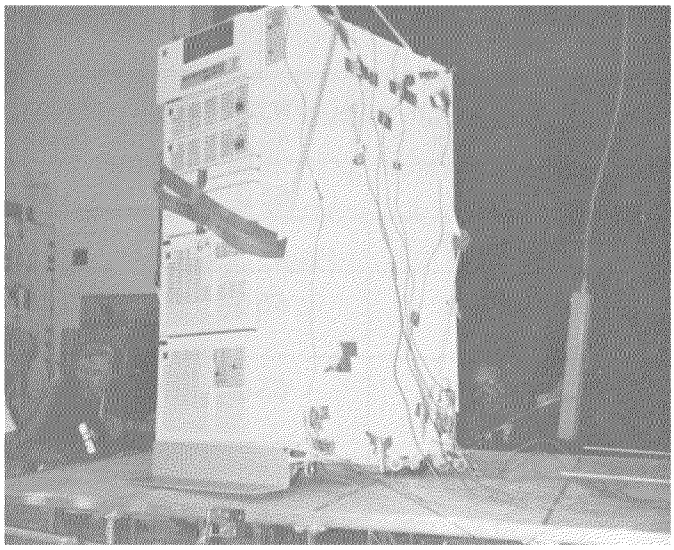
Fixed Base. The computer system was bolted directly to the concrete floor without the raised floor surface in between. These tests were for cases where there was no raised floor surfaces.

Levelers. The types of levelers used during these tests consisted of two types. One type, referred to as the normal leveler, was obtainable off the shelf. It consisted of a round foot with a plastic coating on it. This leveler could be adjusted to raise the casters off the floor.

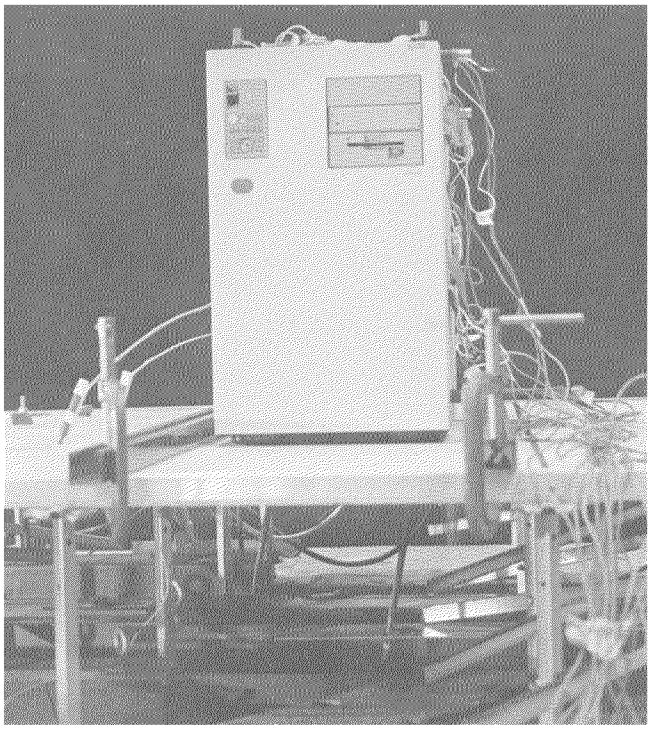
The other type, referred to as the NTT leveler, had an M20 tapped hole on the bottom of its foot. This hole was used for attaching either a toggle bar or a wire cable type anchoring device to the concrete floor surface. A schematic of a typical installation is shown in Fig. 3-12 (Frey and Nikolsky, 1992).

Table 3-1 Sizes and Dimensions of Test Equipment.

Unit	Length (mm)	Width (mm)	Height (mm)	Weight (kg)
9370	884	650	1503	375.8
9371	787	381	546	87.7
9221 (Functional)	884	650	1600	395.3
9221 (Non-Functional)	884	650	1575	426.5
Frame-8	870	830	1775	420
Frame-1	1640	835	1775	900
Endicott	1067	749	1765	408



(a) IBM 9370 System



(b) IBM 9371 System

Fig. 3-1 IBM 9370 and 9371 Systems