inter•noise 96
25th Anniversary Congress – Liverpool

INCE: 46

VIBRATION ISOLATION TREATMENTS FOR COORDINATE MEASURING MACHINES

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Coordinate measuring machines (CMM) have become popular as an accurate means of dimensionally measuring a manufactured part. Improvements in CMM accuracy have resulted in external floor vibration becoming a potential problem area. Compromises in CMM accuracy occur when it is placed in a location which exhibits excessive vibration.

The Need For Vibration Isolation If all components of a CMM, including the item to be measured, were to vibrate in unison, little degradation in performance would result. Accuracy problems occur when the measuring probe of a CMM vibrates out of phase with the part to be measured. Poor repeatability will occur since the relative distance between the probe and the part will fluctuate.

Sources Of External Disturbing Vibration Vibration transmission components can be categorized into one of three (3) broad categories (Figure 1):

A) **Source** - The equipment or activity which generates the disturbing vibratory energy
B) **Path** - The structure into which the vibration is transmitted and is carried to the:
C) **Receiver** - The equipment or individual which is affected by the vibration.

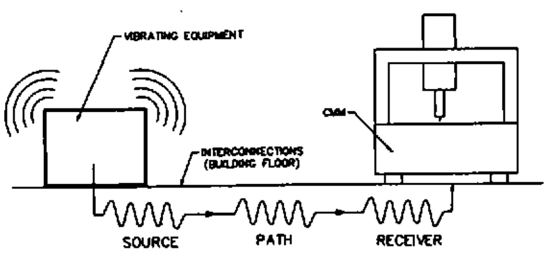


FIGURE 1: SOURCE – PATH – RECEIVER

Isolation of the vibratory energy is most effective the earlier in this sequence it can be accomplished.

Source - Vibration can be created by a variety of sources. In a typical manufacturing facility, some common vibration sources may include:

1) Production equipment, such as presses, air compressors, feeders, and conveyors.
2) Heating and ventilation equipment, such as out-of-balance fans, blowers, and pumps.
3) Low aircraft flyover or external rail and highway traffic
4) Lift truck or similar product moving vehicles within the plant.
5) Shipping and receiving areas (dropped pallets, truck impacts into the dock, etc.)

The most effective method of minimizing vibration is to control the source. This concept is limited, however, when some potential sources are considered, such as low flying aircraft.

Path - The path for vibrational energy is the structure common to both the source and the receiver. Some examples of paths include building structures, soil, piping, and ductwork.

A common method of controlling vibration through path modification is to move a CMM away from potential vibration sources. Unfortunately, for many installations, exactly the opposite is required. The CMM may need to be located adjacent to a piece of vibrating production equipment which is producing the item which the CMM must measure.

Receiver - Vibration isolators can provide a stable support for the CMM. However, the vibratory energy is still being produced by the source and is still present in the adjacent ground. The concept of receiver isolation is popular since the cost of suitable isolators can be included in the initial CMM installation budget.

Manufacturer's Vibration Criteria Levels CMM manufacturers must qualify the maximum amount of vibration which their machines can tolerate. This vibration criteria specification becomes an important part of a customer's pre-installation site review.

Some manufacturers have subjected their CMM's to a series of tests and have thus developed a detailed vibration specification. Others have reviewed past installations and have generated a criteria based upon what appears to be working well at existing sites. However the method, it is important that all involved have a clear understanding of the site vibration requirements prior to the installation of a new machine.

Accurate Determination of Environmental Vibration Levels A critical part of any pre-installation site qualification involves the accurate determination of the ground borne vibration levels. This analysis may also be used to qualify several potential CMM location sites within a given facility.

This determination of vibration levels is easily accomplished through the performance of a vibration survey at the proposed CMM location. A set of three axes vibration transducers is placed on the floor of the test site. The electrical signals produced by the transducers are typically recorded for future analysis, which also permits a permanent record of the vibration levels to be maintained for reference. The data is then analyzed and compared to the manufacturer's vibration criteria specification.

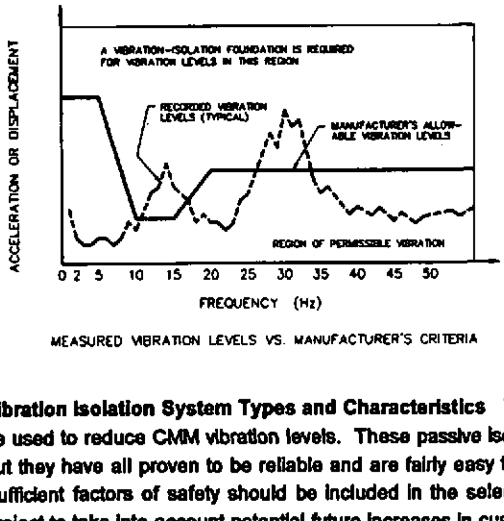
The performance of the vibration survey requires specialized equipment, knowledge, and experience. A frequent difficulty involves the use of an inappropriate vibration transducer.

Most conventional accelerometers are ill-suited for the monitoring of low level ground vibrations, and low frequency seismometers or geophones capable of providing reliable results at frequencies below 40 Hz are recommended.

A vibration site survey should occur over a minimum time span of 30 minutes, during which all relevant disturbing sources should be individually cycled. The large amount of data gathered for longer duration tests is typically redundant. One exception concerns transient sources that cannot be scheduled, such as a passing train.

The results obtained from the survey analysis should be overlaid onto the manufacturer's criteria curve, thus permitting easy comparison (Figure 2).

FIGURE 2: PERMISSIBLE VIBRATION FOR TYPICAL INSPECTION EQUIPMENT



MEASURED VIBRATION LEVELS VS. MANUFACTURER'S CRITERIA

More sophisticated data analysis, such as power spectral density, may be useful for the vibration practitioner, but most users are not familiar with these units. The type of averaging (peak, RMS, peak-to-peak) must also be expressed and compatibility with the manufacturer's criteria should be maintained.

Vibration Isolation System Types and Characteristics Vibration isolation systems can be used to reduce CMM vibration levels. These passive isolators can take several forms, but they have all proven to be reliable and are fairly easy to design, install, and maintain. Sufficient factors of safety should be included in the selection of isolators for a specific project to take into account potential future increases in customer required CMM accuracy or possible increases in site vibration levels.

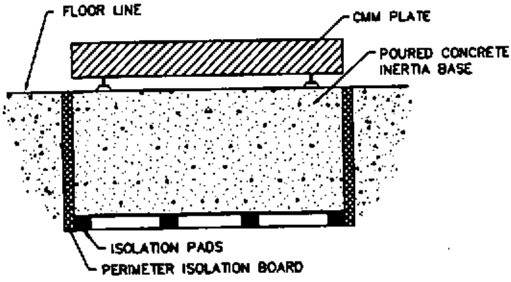


FIGURE 3: INERTIA BASE WITH PAD ISOLATORS

Passive isolators can be grouped into three (3) broad categories:

A) **Pads** - Vibration isolation pads are made in a variety of shapes and sizes using neoprene, fiberglass, polyurethane, felt, cork, or similar material (Figure 3).

Pad natural frequencies typically fall within a range from 5 Hz to 30 Hz. Pads are generally inexpensive, and they exhibit a high resonance damping rate.

An important concern with pads involves their stability over time. Many pads will creep when statically loaded, resulting in a continuous elevation change for the equipment. Further, some pad material (primarily neoprene) exhibits age stiffening, which increases the pad's natural frequency and vibration transmissibility with time. These issues should be reviewed with potential pad suppliers.

B) **Springs** - Helical steel coil springs are available in many sizes and load carrying capabilities. Their natural frequency range generally varies from 6 Hz to 1 1/2 Hz, corresponding to static deflections (i.e., compression under load) from 1/4" to 4". Springs exhibit a low damping rate so amplification at resonance may be a concern. Springs are typically more expensive than pads. but properly manufactured springs do not exhibit creep or settling. They are usually provided with adjustment bolts to permit equipment leveling.

C) **Air Springs** - Air spring isolators, with natural frequencies typically falling in the 3/4 Hz to 4 Hz range, are the softest, most efficient, and most expensive isolator style available. The air pressure within the spring can be easily varied so the user can adjust the isolator height, load carrying capacity, and stiffness. Air springs can be equipped with automatic height sensing valves which adjust the air pressure to compensate for equipment load changes. Air springs can also offer a variable damping rate which allows user adjustment.

An important part of any isolation system is an inertia base. An inertia base is an equipment platform supported by the vibration isolators (Figure 4). Inertia bases are typically manufactured from concrete or steel. They should be designed to match the support requirements of the isolated equipment and to accept different isolator styles for the possibility of future isolator changes.

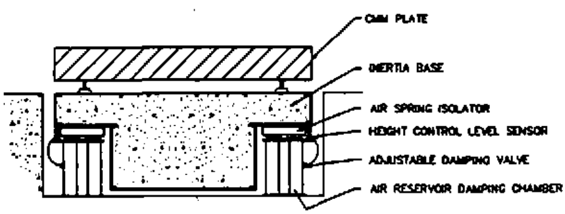


FIGURE 4: INERTIA BASE WITH AIR SPRING ISOLATORS

Inertia bases lower the isolated center of gravity which reduces any tendency for the equipment to "rock". This is critical since many CMM's have been recently found to be sensitive to rotational vibration modes.

Inertia bases made using prefabricated steel pouring frames offer advantages over solid concrete bases. The steel frame can be manufactured complete with all required internal concrete reinforcing bars, mounting bolts, and stiffening members. On site labor costs and coordination are minimized since the only required site work is to place the inertia base frame into position and to fill it with concrete. Single source isolation system responsibility is obtained when the vibration isolator supplier is also responsible for the inertia base.