

Table 27 . . . Effect of Loading Direction on Flexibility of Rubber Mounts

	Rubber-in-Compression must be allowed room to bulge out (as in ribbed or waffled pads) to obtain reasonable vertical flexibility. Compression mounts may have too much horizontal flexibility.
	Rubber-in-Tension is not safe because bond can fail.
	Rubber-in-Shear is widely used because it permits substantial deflections. As shown, mount does not have enough horizontal flexibility for most applications.
	Balance between horizontal and vertical flexibility is achieved in many commercial rubber isolators by suitable arrangement of material to get compression and shear in each direction.

A more practical approach is to isolate the pipe from the building structure for at least the distance shown under B in Fig. 33. Within the indicated distance, the pipe should be suspended only from flexible pipe hangers having a static deflection of at least 4 times the static deflection of the machine mounts. In basement installations, these hangers should not be supported from the ceiling, but rather from the floor. As an additional safeguard, for pumps, it is often advisable to provide a removable spool piece in the lines so that a flexible

rubber hose can be inserted later if a noise problem is found to exist.¹⁰

Flexible pipe connections are needed in the suction as well as the discharge lines, and should be arranged to allow for both horizontal and vertical motion. Expansion joints are designed to take up longitudinal motion, but metallic or rubber hose should not be subjected to longitudinal forces. The arrangement shown in diagram A of Fig. 33 is preferred.¹¹ Where this is not possible, a single hose can be used, but it should be installed parallel to the machine axis because axial vibrations usually are not severe.

Recommended minimum lengths of flexible metallic hose are listed in Table 26. The $\frac{1}{2}$ in. machine movement for which reciprocating compressors of over 75 hp, unless the compressor base consists of a heavy concrete block, which in turn is supported by the vibration isolators. Such an inertia block decreases the vibrational motion, as shown in Fig. 24. To be effective, the inertia block should weigh at least as much as the machine. The inertia block also provides rigid drive alignment and a low center of gravity desirable for stability.

Isolator Material and Configuration

The choice of resilient material for any given application largely depends on the required deflection. Practical deflection ranges of various materials are shown in Fig. 30.

Other points to be considered are life, chemical stability, cost, and damping.

Damping is a result of internal friction in the resilient material. In the normal operating range, damping reduces the isolating efficiency. A certain amount of damping is desirable, however, because it reduces the vibrational motion of the machine during startup and shutdown when the speed passes through resonance (see Fig. 24).¹²

Mounts made of rubber or neoprene of 40 to 50 durometer hardness (ASTM D-676-59T) should provide 20 percent

Sound Control

greater deflection than that read from Fig. 30, in order to compensate for damping. For 55 to 65 durometer material, the correction factor is 40 percent.

Several ways in which rubber elements can be arranged in vibration isolators are shown in Table 27. The useful life of rubber mounts at normal load and temperature is three or more years of continuous operation.¹³

Cork, which has a very high internal damping and a limited flexibility, will seldom isolate primary vibrations. Cork pads are useful, however, for noise isolation. Cork pads should be sized to provide a load bearing area of about 5 to 15 sq. in. for each 100 lb of supported weight. For very light loads, felt is often used instead of cork.

Steel springs, which have a very high flexibility and very low damping, are used to obtain a high degree of isolation at even low speeds. Steel springs have practically unlimited life, and are therefore preferred for applications where isolator replacement must be avoided.

Several typical designs of commercial spring mounts are shown in Fig. 34. Housings are needed for stability when the springs are slender. If the outside diameter of the spring is approximately equal to the height, no housing is needed, as such springs are inherently stable. Bare spring mounts retain their isolating efficiency under lateral thrust and vibration.

Special vibration isolators for concrete block bases can be embedded when the concrete is poured at the site into a form resting on the floor. After installation, the machine and the inertia block are raised off the floor by taking up on the leveling bolts of the isolators. (See Fig. 34B.)

It should be noted that all the spring mounts shown in Fig. 34 feature an acoustical pad between the spring and the foundation. These pads, which can be made of rubber, neoprene, or cork, prevent audible frequency transmission due to internal resonances within the spring elements.¹⁴ Such wave effects occur in rubber mounts, but to a much lesser degree.

Mounts made of knitted stainless steel wire or of plastic enclosed glass fiber are available for installations requiring high flexibility as well as high damping.

To maintain drive alignment, motors should be mounted on a common base with the equipment they drive. The isolators supporting the concrete base should be located and leveled in such a manner that all will carry the same load and have the same deflection. The isolators should be located high enough or spaced far enough apart so that the machine will not tend to rock excessively. The manufacturer's recommendations should be followed closely in the selection and installation of the isolators.

STEP 7—CHECKING COMPLETED INSTALLATION

In spite of all precautions taken, there will be occasional complaints about noise in a completed installation.

If the actual source of the noise can be identified, the remedy is often obvious. The following discussion includes: (1) ways of identifying actual noise sources, using only simple instruments, or without any instruments, and (2) possible corrections which may be made.

When the engineer is troubleshooting in the field, the most important thing is to listen to the offending sound. The best instruments are no substitute for careful listening. The human ear has a remarkable ability for identifying certain familiar sounds, for instance, the squeak of a bearing that needs oiling.

The ear is also a good direction finder and even range finder; a noise gets louder as one approaches the source. Not only the ear, but even the hands can help in identifying a noise source. When the general location of a hiss from a leaky high velocity duct has been found, the air jet from the leak can usually be felt and the sound may change as the hand

Table 28 . . . Background Correction

Decibel difference between A-sound level when air-conditioning equipment is operating (total level) and when it is not operating (background level)	0	1	2	3	4	7	10
Decibels to be subtracted from total A-sound level in order to get the A-sound level due to air-conditioning equipment alone	over 10	7	4	3	2	1	0.5

gets close. Panel or tubing rattle, etc., usually stops when the right spot is touched lightly.

Unless the source of the disturbing noise is quite obvious, the best way to identify it is by systematically eliminating all possible sources:

1. Make sure that the objectionable sound is really caused by the air-conditioning system. This must be done during the day when the building is in normal use, because at night, even the quietest air-conditioning system may seem noisy.

Unless the noise can be traced immediately to some part of the air-conditioning system, background noise should be checked in the room where the complaint arises.

If available, a sound level meter should be used to measure the A-sound level of the noise: (1) with the air-conditioning system in operation and (2) with the system shut off. The various system components (compressors, fans, pumps) should be turned off separately, and readings should be taken after each component is stopped.

If no sound level meter is available, the listener must stay in the room and have the system operated or shut off by a second person. Some signal must be given to the listener when any component of the system is turned off, because the ear detects changes in noise reliably, but not to absolute levels.

Any system component can be termed a significant noise source if, when that component is shut off, the A-sound level drops at least 3 db, or if the quality of the sound is audibly improved. The A-sound level which is measured when the entire air-conditioning system is not operating is called the background level.

The noise level due to the air-conditioning system may be calculated from the measured values of background level and total A-sound level (with the system in operation) by use of the correction factors given in Table 28.

2. When it has been established that some part of the air-conditioning system is the source of the objectionable noise, try to isolate the source further. By walking around in the room, determine whether the noise is coming from the air outlets or returns, or whether it seems to be coming through the walls.

3. If the noise is traced to an air outlet, measure the A-sound level close to it, but with no air blowing against the microphone. Then remove the inner assembly or core of the air outlet, and repeat the reading with the meter and the observer in exactly the same position as before. If the second reading is more than 3 db below the first, a significant amount of noise is caused by air flow over the vanes of the diffuser or grille. In this case, check whether the system is balanced properly. As little as 10 percent too much air will increase the sound generated by an air outlet by 2.5 db. As a last resort, a larger air outlet could be substituted to obtain lower air velocities, and hence less turbulence for the same air quantity. Before considering this, however, the air approach to the outlet should be checked.

Noise far exceeding the normal rating of a diffuser or grille will be generated when a damper installed close to it is throttled. Air jets from such a damper impinge upon the vanes or cores of the outlet and produce edge tones similar to the hiss that is heard when blowing against the edge of a ruler. The material of the vanes has no effect on this noise, although loose vanes may cause additional noise by vibration.

When balancing air outlets with integral volume dampers, consider the static pressure drop across the damper as well as the air quantity (see Table 6). Separate volume dampers should be installed sufficiently upstream from the outlet so that there is no jet impingement. Plenum inlets should be brought in from the side, so that the jets do not impinge on the outlet vanes.

4. If the air outlets are eliminated as sources of excessive noise, inspect the fan room. First check proper vibration isolation of all machines:

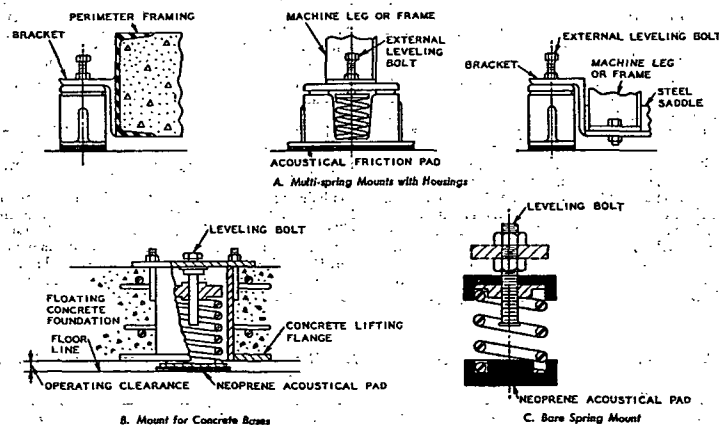


Fig. 34 . . . Typical Vibration Isolators Using Steel Springs