

### Notes for [Table 47](#): Selection Guide for Vibration Isolation

These notes are keyed to the column titled *Reference Notes* in [Table 47](#) and to other reference numbers throughout the table. Although the guide is conservative, cases may arise where vibration transmission to the building is still excessive. If the problem persists after all short circuits have been eliminated, it can almost always be corrected by altering the support path (e.g., from ceiling to floor), increasing isolator deflection, using low-frequency air springs, changing operating speed, improving rotating component balancing, or, as a last resort, changing floor frequency by stiffening or adding more mass. Assistance from a qualified vibration consultant can be very useful in resolving these problems.

**Note 1.** Isolator deflections shown are based on a reasonably expected floor stiffness according to floor span and class of equipment. Certain spaces may dictate higher levels of isolation. For example, bar joist roofs may require a static deflection of 1.5 in. over factories, but 2.5 in. over commercial office buildings.

**Note 2.** For large equipment capable of generating substantial vibratory forces and structureborne noise, increase isolator deflection, if necessary, so isolator stiffness is less than one-tenth the stiffness of the supporting structure, as defined by the deflection due to load at the equipment support.

**Note 3.** For noisy equipment adjoining or near noise-sensitive areas, see the section on Mechanical Equipment Room Sound Isolation.

**Note 4.** Certain designs cannot be installed directly on individual isolators (type A), and the equipment manufacturer or a vibration specialist should be consulted on the need for supplemental support (base type).

**Note 5.** Wind load conditions must be considered. Restraint can be achieved with restrained spring isolators (type 4), supplemental bracing, snubbers, or limit stops. Also see [Chapter 55](#).

**Note 6.** Certain types of equipment require a curb-mounted base (type D). Airborne noise must be considered.

**Note 7.** See section on Resilient Pipe Hangers and Supports for hanger locations adjoining equipment and in equipment rooms.

**Note 8.** To avoid isolator resonance problems, select isolator deflection so that resonance frequency is 40% or less of the lowest normal operating speed of equipment (see [Chapter 8 in the 2009 ASHRAE Handbook—Fundamentals](#)). Some equipment, such as variable-frequency drives, and high-speed equipment, such as screw chillers and vaneaxial fans, contain very-high-frequency vibration. This equipment creates new technical challenges in the isolation of high-frequency noise and vibration from a building's structure. Structural resonances both internal and external to the isolators can significantly degrade their performance at high frequencies. Unfortunately, at present no test standard exists for measuring the high-frequency dynamic properties of isolators, and commercially available products are not tested to determine their effectiveness for high frequencies. To reduce the chance of high-frequency vibration transmission, add a 1 in. thick pad (type 1, Note 20) to the base plate of spring isolators (type 3, Note 22, 23, 24). For some sensitive locations, air springs (Note 25) may be required. If equipment is located near extremely noise-sensitive areas, follow the recommendations of an acoustical consultant.

**Note 9.** To limit undesirable movement, thrust restraints (type 5) are required for all ceiling-suspended and floor-mounted units operating at 2 in. of water or more total static pressure.

**Note 10.** Pumps over 75 hp may need extra mass and restraints.

**Note 11.** See text for full discussion.

### Isolation for Specific Equipment

**Note 12. Refrigeration Machines:** Large centrifugal, screw, and reciprocating refrigeration machines may generate very high noise levels; special attention is required when such equipment is installed in upper-story locations or near noise-sensitive areas. If equipment is located near extremely noise-sensitive areas, follow the recommendations of an acoustical consultant.

**Note 13. Compressors:** The two basic reciprocating compressors are (1) single- and double-cylinder vertical, horizontal or L-head, which are usually air compressors; and (2) Y, W, and multihead or multicylinder air and refrigeration compressors. Single- and double-cylinder compressors generate high vibratory forces requiring large inertia bases (type C) and are generally not suitable for upper-story locations. If this equipment must be installed in an upper-story location or at-grade location near noise-sensitive areas, the expected maximum unbalanced force data must be obtained from the equipment manufacturer and a vibration specialist consulted for design of the isolation system.

**Note 14. Compressors:** When using Y, W, and multihead and multicylinder compressors, obtain the magnitude of unbalanced forces from the equipment manufacturer so the need for an inertia base can be evaluated.

**Note 15. Compressors:** Base-mounted compressors through 5 hp and horizontal tank-type air compressors through 10 hp can be installed directly on spring isolators (type 3) with structural bases (type B) if required, and compressors 15 to 100 hp on spring isolators (type 3) with inertia bases (type C) weighing 1 to 2 times the compressor weight.

**Note 16. Pumps:** Concrete inertia bases (type C) are preferred for all flexible-coupled pumps and are desirable for most

close-coupled pumps, although steel bases (type B) can be used. Close-coupled pumps should not be installed directly on individual isolators (type A) because the impeller usually overhangs the motor support base, causing the rear mounting to be in tension. The primary requirements for type C bases are strength and shape to accommodate base elbow supports. Mass is not usually a factor, except for pumps over 75 hp, where extra mass helps limit excess movement due to starting torque and forces. Concrete bases (type C) should be designed for a thickness of one-tenth the longest dimension with minimum thickness as follows: (1) for up to 30 hp, 6 in.; (2) for 40 to 75 hp, 8 in.; and (3) for 100 hp and up, 12 in.

Pumps over 75 hp and multistage pumps may exhibit excessive motion at start-up (“heaving”); supplemental restraining devices can be installed if necessary. Pumps over 125 hp may generate high starting forces; a vibration specialist should be consulted.

**Note 17. Packaged Rooftop Air-Conditioning Equipment:** This equipment is usually installed on lightweight structures that are susceptible to sound and vibration transmission problems. The noise problems are compounded further by curb-mounted equipment, which requires large roof openings for supply and return air.

The table shows type D vibration isolator selections for all spans up to 20 ft, but extreme care must be taken for equipment located on spans of over 20 ft, especially if construction is open web joists or thin, lightweight slabs. The recommended procedure is to determine the additional deflection caused by equipment in the roof. If additional roof deflection is 0.25 in. or less, the isolator should be selected for 10 times the additional roof deflection. If additional roof deflection is over 0.25 in., supplemental roof stiffening should be installed to bring the roof deflection down below 0.25 in., or the unit should be relocated to a stiffer roof position.

For mechanical units capable of generating high noise levels, mount the unit on a platform above the roof deck to provide an air gap (buffer zone) and locate the unit away from the associated roof penetration to allow acoustical treatment of ducts before they enter the building.

Some rooftop equipment has compressors, fans, and other equipment isolated internally. This isolation is not always reliable because of internal short-circuiting, inadequate static deflection, or panel resonances. It is recommended that rooftop equipment over 300 lb be isolated externally, as if internal isolation was not used.

**Note 18. Cooling Towers:** These are normally isolated with restrained spring isolators (type 4) directly under the tower or tower dunnage. High-deflection isolators proposed for use directly under the motor-fan assembly must be used with extreme caution to ensure stability and safety under all weather conditions. See Note 5.

**Note 19. Fans and Air-Handling Equipment:** Consider the following in selecting isolation systems for fans and air-handling equipment:

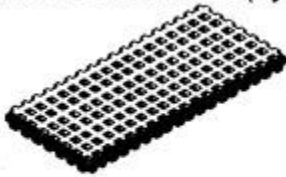
1. Fans with wheel diameters of 22 in. and less and all fans operating at speeds up to 300 rpm do not generate large vibratory forces. For fans operating under 300 rpm, select isolator deflection so the isolator natural frequency is 40% or less than the fan speed. For example, for a fan operating at 275 rpm,  $0.4 \times 275 = 110$  rpm. Therefore, an isolator natural frequency of 110 rpm or lower is required. This can be accomplished with a 3 in. deflection isolator (type 3).
2. Flexible duct connectors should be installed at the intake and discharge of all fans and air-handling equipment to reduce vibration transmission to air duct structures.
3. Inertia bases (type C) are recommended for all class 2 and 3 fans and air-handling equipment because extra mass allows the use of stiffer springs, which limit heaving movements.
4. Thrust restraints (type 5) that incorporate the same deflection as isolators should be used for all fan heads, all suspended fans, and all base-mounted and suspended air-handling equipment operating at 2 in. or more total static pressure. Restraint movement adjustment must be made under normal operational static pressures.

### **Vibration Isolators: Materials, Types, and Configurations**

Notes 20 through 32 include figures to assist in evaluating commercially available isolators for HVAC equipment. The isolator selected for a particular application depends on the required deflection, life, cost, and compatibility with associated structures.

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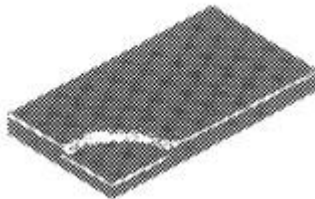
### RUBBER PADS (Type 1)



### RUBBER MOUNTS (Type 2)

**Note 20.** Rubber isolators are available in pad (type 1) and molded (type 2) configurations. Pads are used in single or multiple layers. Molded isolators come in a range of 30 to 70 durometer (a measure of stiffness). Material in excess of 70 durometer is usually ineffective as an isolator. Isolators are designed for up to 0.5 in. deflection, but are used where 0.3 in. or less deflection is required. Solid rubber and composite fabric and rubber pads are also available. They provide high load capacities with small deflection and are used as noise barriers under columns and for pipe supports. These pad types work well only when they are properly loaded and the weightload is evenly distributed over the entire pad surface. Metal loading plates can be used for this purpose.

### GLASS FIBER PADS (Type 1)



**Note 21.** Glass fiber with elastic coating (type 1). This type of isolation pad is precompressed molded fiberglass pads individually coated with a flexible, moisture-impervious elastomeric membrane. Natural frequency of fiberglass vibration isolators should be essentially constant for the operating load range of the supported equipment. Weight load is evenly distributed over the entire pad surface. Metal loading plates can be used for this purpose.

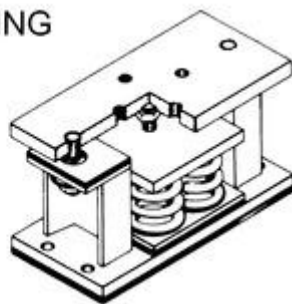
### SPRING ISOLATOR (Type 3)



**Note 22.** Steel springs are the most popular and versatile isolators for HVAC applications because they are available for almost any deflection and have a virtually unlimited life. Spring isolators may have a rubber acoustical barrier to reduce transmission of high-frequency vibration and noise that can migrate down the steel spring coil. They should be corrosion-protected if installed outdoors or in a corrosive environment. The basic types include the following:

**Note 23.** *Open spring isolators* (type 3) consist of top and bottom load plates with adjustment bolts for leveling equipment. Springs should be designed with a horizontal stiffness of at least 80% of the vertical stiffness ( $k_x/k_y$ ) to ensure stability. Similarly, the springs should have a minimum ratio of 0.8 for the diameter divided by the deflected spring height.

### RESTRAINED SPRING ISOLATOR (Type 4)



**Note 24.** *Restrained spring isolators* (type 4) have hold-down bolts to limit vertical as well as horizontal movement. They are used with (a) equipment with large variations in mass (e.g., boilers, chillers, cooling towers) to restrict movement and prevent strain on piping when water is removed, and (b) outdoor equipment, such as condensing units and cooling towers, to prevent excessive movement due to wind loads. Spring criteria should be the same as open spring isolators, and restraints should have adequate clearance so that they are activated only when a temporary restraint is needed.

Closed mounts or housed spring isolators consist of two telescoping housings separated by a resilient material. These provide lateral snubbing and some vertical damping of equipment movement, but do not limit the vertical movement. Care should be taken in selection and installation to minimize binding and short-circuiting.

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## AIR SPRINGS



**Note 25.** Air springs can be designed for any frequency, but are economical only in applications with natural frequencies of 1.33 Hz or less (6 in. or greater deflection). They do not transmit high-frequency noise and are often used to replace high-deflection springs on problem jobs (e.g., large transformers on upper-floor installations). A constant air supply (an air compressor with an air dryer) and leveling valves are typically required.



RUBBER HANGER  
(Type 2)

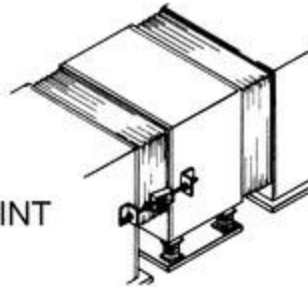
SPRING HANGER  
(Type 3)



**Note 26.** Isolation hangers (types 2 and 3) are used for suspended pipe and equipment and have rubber, springs, or a combination of spring and rubber elements. Criteria should be similar to open spring isolators, though lateral stability is less important. Where support rod angular misalignment is a concern, use hangers that have sufficient clearance and/or incorporate rubber bushings to prevent the rod from touching the housing. Swivel or traveler arrangements may be necessary for connections to piping systems subject to large thermal movements.

*Precompressed spring hangers* incorporate some means of precompression or preloading of the isolator spring to minimize movement of the isolated equipment or system. These are typically used on piping systems that can change weight substantially between installation and operation.

THRUST RESTRAINT  
(Type 5)



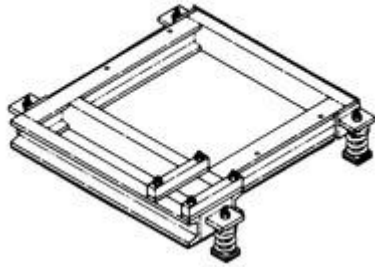
**Note 27.** Thrust restraints (type 5) are similar to spring hangers or isolators and are installed in pairs to resist the thrust caused by air pressure. These are typically sized to limit lateral movement to 0.25 in. or less.

DIRECT ISOLATION (Type A)

**Note 28.** Direct isolation (type A) is used when equipment is unitary and rigid and does not require additional support. Direct isolation can be used with large chillers, some fans, packaged air-handling units, and air-cooled condensers. If there is any doubt that the equipment can be supported directly on isolators, use structural bases (type B) or inertia bases (type C), or consult the equipment manufacturer.

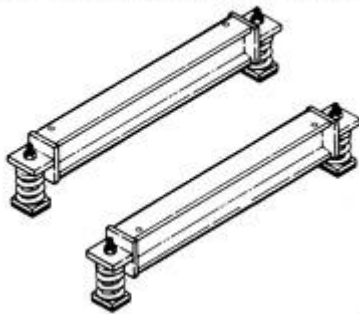
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## STRUCTURAL BASES (Type B)



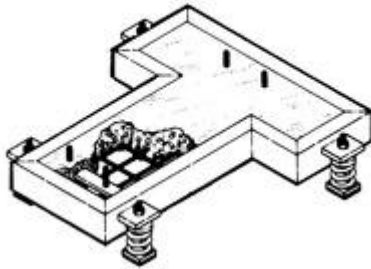
**Note 29.** Structural bases (type B) are used where equipment cannot be supported at individual locations and/or where some means is necessary to maintain alignment of component parts in equipment. These bases can be used with spring or rubber isolators (types 2 and 3) and should have enough rigidity to resist all starting and operating forces without supplemental hold-down devices. Bases are made in rectangular configurations using structural members with a depth equal to one-tenth the longest span between isolators. Typical base depth is between 4 and 12 in., except where structural or alignment considerations dictate otherwise.

## STRUCTURAL RAILS (Type B)



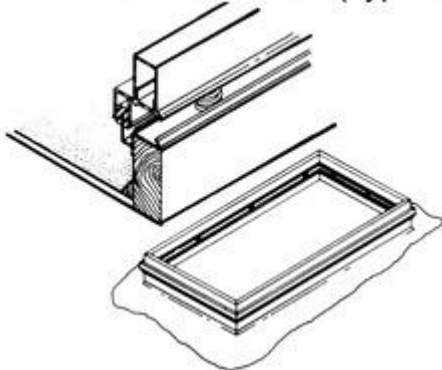
**Note 30.** Structural rails (type B) are used to support equipment that does not require a unitary base or where the isolators are outside the equipment and the rails act as a cradle. Structural rails can be used with spring or rubber isolators and should be rigid enough to support the equipment without flexing. Usual practice is to use structural members with a depth one-tenth of the longest span between isolators, typically between 4 and 12 in., except where structural considerations dictate otherwise.

## CONCRETE BASES (Type C)



**Note 31.** Concrete bases (type C) are used where the supported equipment requires a rigid support (e.g., flexible-coupled pumps) or excess heaving motion may occur with spring isolators. They consist of a steel pouring form usually with welded-in reinforcing bars, provision for equipment hold-down, and isolator brackets. Like structural bases, concrete bases should be sized to support piping elbow supports, rectangular or T-shaped, and for rigidity, have a depth equal to one-tenth the longest span between isolators. Base depth is typically between 6 and 12 in. unless additional depth is specifically required for mass, rigidity, or component alignment.

## CURB ISOLATION (Type D)



**Note 32.** Curb isolation systems (type D) are specifically designed for curb-supported rooftop equipment and have spring isolation with a watertight, and sometimes airtight, assembly. *Rooftop rails* consist of upper and lower frames separated by nonadjustable springs and rest on top of architectural roof curbs. *Isolation curbs* incorporate the roof curb into their design as well. Both kinds are designed with springs that have static deflections in the 1 to 3 in. range to meet the design criteria described in type 3. Flexible elastomeric seals are typically most effective for weatherproofing between the upper and lower frames. A continuous sponge gasket around the perimeter of the top frame is typically applied to further weatherproof the installation.