Bulletin No. SR/Spec.

Specifications for Mechanical System Vibration Isolation & Seismic Restraint

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General Information Vibration Isolation Products and Theory

Mechanical vibration and vibration-induced noise are often major sources of occupancy complaints in modern buildings. Lighter construction has made buildings more susceptible to vibration and vibration related problems. Increased interest in energy conservation has resulted in many new buildings being designed with variable air volume systems. This often results in the location of mechanical equipment in penthouses on the roof, in the use of roof-mounted HVAC units, and in the location of mechanical equipment rooms on intermediate level floors. These trends have resulted in an increase in the number of pieces of mechanical equipment located in a building, and they have often resulted in the location of mechanical equipment adjacent to or above occupied areas.

Occupant complaints associated with building vibration typically take one of three forms:

1. The level of vibration perceived by building occupants is of sufficient magnitude to cause concern or alarm.

2. Vibration energy from mechanical equipment, which is transmitted to the building structure, is transmitted to various parts of the building and is then radiated as structure-bourne noise.

3. The vibration present in a building interferes with proper operation of sensitive equipment or instrumentation.

Vibration can be isolated or reduced to a fraction of the original force with resilient mounts between the equipment and the supporting structure. To determine the excessive forces that must be isolated or that adversely affect the performance or life of the equipment, criteria should be established for equipment vibration. It is recommended that an isolation efficiency of 80% and greater be achieved for most HVAC equipment installations. To determine isolation efficiency, the following information is required about the equipment and proposed isolation system.

1. Equipment weight (W)

2. Operating speed of the equipment (Fd)

3. Number or isolators (N)

4. Isolator constant (Ky)

From this information, we can determine the static deflection of the isolation system by the formula:

$$\text{STATIC} = \frac{W}{(N \times Ky)} = \_\_\_\_\_ \text{ inches}$$

Using the result of this formula, we can now determine the natural frequency of the isolation system with the equation:

$$\text{NATURAL FREQUENCY (Fn)} = \frac{188}{\sqrt{\text{static}}} =$$

_____ CPM

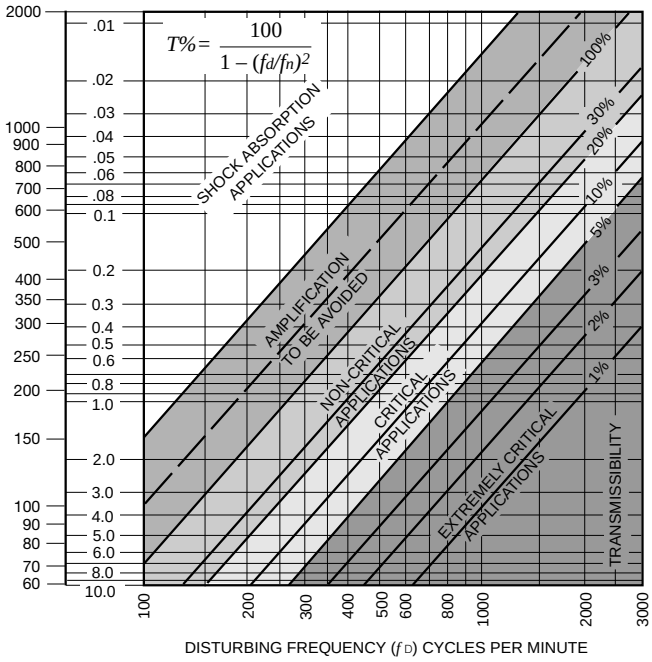
Transmissibility (T) can now be determined with the formula:

$$T = \frac{1}{(Fd/fn)^2 - 1} = \_\_\_\_\_ \%$$

Efficiency (the opposite of transmissibility) can now be determined:

$$\%E = 100 - 100 \times T = \_\_\_\_\_ \%$$

Fortunately, it is not necessary to use these calculations each time you wish to determine isolation efficiency. The chart below can be accurately used to show the relationship between equipment operating speed (RPM), static deflection and efficiency.



Once an acceptable level of isolation efficiency has been determined, a choice of isolation products from VIBRATION MOUNTINGS AND CONTROLS, INC. are available.

Our spring mountings provide the highest efficiency, adjustability and long life, and come complete with ribbed neoprene pads or cups to prevent high frequency noise transmission. All spring mountings manufactured by VMC incorporate bolts to facilitate installation and to compensate for variations in deflection due to uneven weight distribution.
Spring isolators are available either housed or free standing. Free standing springs are unrestrained devices which must be stable. In other words, the ratio of the lateral to the axial spring constants is approximately equal, or where the outside spring diameter is at least 0.8 of the spring operating height. Free standing springs (VMC Series A/C) are often preferred in order to avoid possible contact between housings or guides which may result either from lateral forces or poor vertical alignment. When large lateral forces are present resilient bumpers, or an inertia base will provide resistance to these forces for applications utilizing free

ding springs. Housed or guided spring isolators (VMC Series B/C/D) incorporate built in restraints which often counteract the effects of lateral forces by preventing horizontal displacement of the supported system. It is sometimes economically desirable to employ the housed isolator in preference to mounts requiring independent horizontal restraints. For equipment whose weight varies with the addition or removal of large amounts of water, such as cooling towers, chillers and boilers, and for equipment installed on rooftops subject to wind loads, the vibration isolators should incorporate vertical limit stops (VMC Series AWR).

Rubber in shear isolators (VMC Series R/RD) are suitable to meet transmissibility requirements for high disturbing frequencies. Where equipment does not require bolting to the floor, ribbed neoprene pads may be used singly or in multiple layers. Elastomeric isolators can be molded into any shape, vulcanized to metal, are available in different hardnesses, possesses inherent damping, meets the basic requirements as to resiliency and possesses excellent sound deadening characteristics.

Concrete inertia blocks (VMC Series MPF) of 6 inch minimum thickness should be used with pumps, fans having a 40 inch wheel diameter and larger. centrifugal fans driven by motors of 75 HP or larger, and certain types of compressors. This type of equipment usually possesses low rotational speed, high static pressure, or a large unbalanced force which can not be attenuated by the use of springs alone. The benefits of using an inertia block include the addition of mass to the isolated system which reduces movement. For example, if a 1000 lb. machine develops I00 lb. of unbalanced force, the machine would displace “x” inches. However, if you mount the machine to an inertia base weighing I000 lb., the same I00 lb. unbalanced force must now move 2000 lb. The displacement has been reduced by 50%. VMC inertia bases also lower the center of gravity of the isolated system offering greater stability and they provide a rigid base for the equipment to help maintain alignment.

Integral steel bases (VMC Series WFB) should be specified for all belt driven centrifugal fans not requiring concrete inertia blocks. The integral bases should be sufficiently rigid to maintain adequate drive alignment and to resist starting torque without the use of restraining snubbers.

Flexible connectors (VMC Series VMS/VMT/VMU) are available to reduce the vibration transmission along piping systems. They also compensate for movement due to starting torque.

All suspended piping and equipment should be isolated by use of our vibration hangers (VMC Series SH/RSH). They are available in spring, rubber, or combination spring/rubber depending on the application. VMC Spring-Flex hangers, when used throughout the mechanical equipment room, will prevent transmission of vibration to the building structure carried through piping systems.
Each product category and type is discussed in greater detail throughout our catalog.

Seismic Discussion

Vibration Mountings & Controls manufactures a wide variety of seismic mountings and restraints which will restrain the motion of equipment, piping, and ductwork during a seismic event. However, in order to properly select a mounting or restraint, it is important to understand what happens during an earthquake and how to properly restrain equipment, piping and ductwork against its forces

What Happens During An Earthquake?

A fault is a fracture in the earth’s crust, and an earthquake results from slippage along the fault plane. Any structure straddling the fault line will probably suffer damage, no matter how well it has been designed. However, most effects of earthquakes are not directly on the fault line. This is because the movement caused by the slippage creates waves in the earth that travel away from the fault plane. These waves change throughout the duration of the earthquake, add to one another, and result in extremely complex wave motions and vibrations. The direction or forces on structures can be horizontal, vertical, or rotational. In terms of the way they may affect a given building, they are not only unpredictable in direction, but also in strength and duration.

The general principle in resisting seismic loads is that we want equipment, ducts, and piping to resist seismic forces by the strength of their attachment to the building's structure. Naturally, we must assume that the building has been designed to perform safely in response to earthquake motions. So that they remain intact and functioning, we want equipment, ducts and piping to move with the building during an earthquake and not break away from their supports. Therefore, VMC Seismic Mounts and Restraints are sized to insure the chances of keeping these systems attached to the building's structure.

Resisting Seismic Loads

Because we cannot predict the directionality of seismic forces, it is important to restrain equipment, and brace piping and ductwork in several directions. Vibration isolated, floor mounted equipment is typically restrained by use of our Series AEQM or AWMR seismic spring isolators which keep the equipment captive. If the equipment does not require vibration isolators, properly sized anchor bolts or VMC Series SR seismic restraints can be used to seismically restrain the unit. In order to restrain piping and ducts from seismic forces, VMC Series SCR seismic cable restraints used in the longitudinal (in the direction of the run) and transverse (perpendicular to the run) directions together with their vertical support will resist lateral loads in any direction. Any suspended in-line equipment can also be restrained by use of Series SCR cable restraints and must be braced independently of ductwork.

It is important to correctly design restraint methods in seismic areas because earthquake damage to inadequately restrained HVAC equipment can be expensive. High costs are incurred to replace or repair the damaged equipment, and the building can not be occupied due to inadequate ventilation. The cost to restrain the equipment properly is relatively small compared to the possible damage that may occur.

When dealing with the design and construction of a new building, local building officials must be contacted to obtain specific requirements for the design of seismic restraints. Nearly all codes in the United States are based on model building codes developed by three organizations: International Conference of Building Officials (ICBO), Building Officials and Code Administrators (BOCA), and the Southern Building Code Conference (SBCC). Most seismic requirements adopted by local jurisdictions are based on the Uniform Building Code (UBC), which was developed by the ICBO. Restraint of piping and ductwork is fully detailed in the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) seismic restraint manual which is fully accepted by the ICBO. When reading our engineering specification, you will see that we have used all of these codes as our basis of design.

In the past, equipment such as pumps,chillers, cooling towers, etc., were simply mounted on bases or spring mounts with little or no consideration taken for earthquake forces. Because of the vast research done with seismic forces in modern building design, all of the codes have been updated requiring that all equipment be restrained in order to survive an earthquake. It has been found that the increased cost to properly restrain equipment is far less than the cost to rehabilitate a building that has been devastated by an earthquake. While the building may survive, it typically could not be occupied due to damage to an inadequately restrained HVAC system. Proper sizing of seismic restraints and accurate calculation of anchor bolt forces is imperative in order to adequately restrain equipment against seismic effects.

In order to properly select the correct seismic restraints and anchor bolts, VMC engineers reduce the force generated by an earthquake to an equivalent static force, which acts in a horizontal direction at the equipment's center of gravity (Cg). The resulting overturning moment is resisted by shear and tension (pullout) forces on the anchor bolts. By calculating what the forces at the anchor bolts will be, we are able to resist those forces and adequately restrain the equipment

When restraint for piping and ductwork is required, we typically refer to the SMACNA seismic restraint manual as the accepted basis of design. However, it is important to follow some basic guidelines when restraining suspended piping and ductwork.

First, when piping or ductwork is hung using spring or rubber isolators, VMC Series SCR seismic cable restraints are required so as not to short circuit or bypass the isolators. Angle bracing can be used when piping and ductwork is hard mounted to the structure.

Angle Bracing vs. Cable Restraints

When suspended equipment, piping or duct is hung using spring or rubber vibration isolators, cables are required for seismic restraint so as not to short circuit or bypass the isolators. Angle bracing can be used when piping and duct is hard mounted to the structure.

General Requirements For Seismically Restraining Ducts

Rectangular ducts with cross-sectional areas of 6 square feet and larger, and round ducts with diameters of 28 inches or larger generally require seismic restraint. No bracing is required if the duct is suspended by hangers 12 inches or less in length, as measured from the top of the duct to the bottm of the support where the hanger is attached. Bracing of ductwork shall be at 30 foot intervals, at each turn and at each end of a duct run.

General Requirements For Seismically Restraining Pipe

All piping of 2½ inches nominal diameter and larger requires seismic restraint. All piping located in boiler rooms, mechanical equipment rooms, and refrigeration mechanical rooms that have a nominal diameter of 1¼ inches and larger require restraints. Fuel oil piping and gas piping (fuel gas, medical gas, compressed air) of 1 inch nominal diameter and larger require seismic restraint. No bracing or restraint is required for piping suspended by individual hangers 12 inches or less in length as measured from the top of the pipe to the bottom of the support where the hanger is attached.

All seismic bracing installed using VMC seismic cables shall require a minimum of two cables per bracing attitude. Any threaded hanger rods that have seismic bracing attached to them or to the single hanger or trapeze support they are attached to may require the installation of VMC Series SRBC seismic rod bracing clamp as a rod stiffener. When rod stiffeners are required, a minimum of 2 SRBC clamps should be installed.

For complete guidelines on restraint of piping and ductwork, please do not hesitate to contact VMC's engineering and sales departments for assistance.

Vibration Mountings & Controls vibration isolation and seismic restraint specification for HVAC, Fire Protection, Electrical and Plumbing

PART 1 – GENERAL

1.01 SCOPE

Unless otherwise noted on equipment schedules or specification, all equipment shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted structure-borne noise to the building structure. The scope of this specification encompasses the necessary design and product specifications for the vibration isolation of mechanical equipment, piping, and ductwork, and is part of the general conditions for the HVAC, plumbing, fire protection and electrical contracts. Requirements for seismic restraint are included.

1.02 REQUIREMENTS

All vibration mountings shall be manufactured entirely in the United States.

1.03 INTENT

It is the intent of the seismic restraint portion of this specification to provide restraint of non-structural building components. Restraint systems are intended to withstand the stipulated seismic accelerations applied through the component center of gravity. The work in this section includes the following:

- Vibration isolation elements for equipment
- Equipment isolation bases
- Piping flexible connectors
- Seismic restraints for isolated equipment
- Seismic restraints for non-isolated equipment
- Certification of seismic restraint designs and installation supervision
- Certification of seismic attachment of housekeeping pads

1.04 DEFINITIONS

The term EQUIPMENT will be used throughout this specification. It includes all non-structural components within the facility and/or serving this facility, such as equipment located in outbuildings or outside of the main structure on grade within five feet of the foundation wall.
Equipment buried underground is excluded but entry of services through the foundation wall are included. The term “equipment” shall refer (but not be limited to) the following:

AC units
Air Handling Units
Air separators
Battery Chargers
Battery Racks
Boilers
Bus Ducts
Cabinet Heaters
Cable Trays
Chillers
Compressors
Comp. Rm. Units
Condensers
Condensing Units
Conduit
Cooling Towers
Ductwork
Fans (all types)
Generators
Heat Exchangers
Light Fixtures
Mtr. Cntrl. Ctrs.
Piping
Pumps (all types)
Rooftop Units
Switching Gear
Tanks (all types)
Transformers
Unit Heaters
Unit Substations
Unit Ventilators
Var. Freq. Drives
Water Heaters

Life Safety systems shall be defined as:

- All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, and smoke exhaust systems
- All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers and all circuits to fire protection, and smoke evacuation.
- All medical and life support systems.
- Fresh air relief systems on emergency control sequence including air handlers, conduit, duct, etc.

Positive attachment shall be defined as a support location with a cast-in or wedge type expansion anchor, a double sided beam clamp, a welded or through bolted connection to the structure.

Transverse Bracing - Restraint(s) applied to limit motion perpendicular or angular to the centerline of the pipe, duct, or conduit.

Longitudinal Bracing - Restraint(s) applied to limit motion along the centerline of the pipe, duct, or conduit.

1.05 RESPONSIBILITIES

The manufacturer of vibration isolation and seismic restraint shall determine the sizes and locations of isolators and seismic restraints, provide equipment isolation and seismic restraints as specified, guarantee specified isolation system deflections, provide installation instructions, proper drawings, and shall certify correctness of installation upon completion.

The Contractor shall cause all vibration isolation systems, including the isolators, seismic restraints/snubbers and flexible connectors between the isolated equipment and associated piping, ducting and/or electrical work, to be designed by a Manufacturer experienced in this type of work. This provision, however, shall not be construed as relieving the Contractor of his over-

all responsibility for the work. The Contractor shall provide to the manufacturer of vibration isolation products a listing of all mechanical equipment to be isolated including RPM, total weight, center of gravity, and mounting attachment points. The structural integrity of the supported equipment shall be the responsibility of the equipment manufacturer.

1.06 DESIGN - VIBRATION ISOLATION SYSTEMS

Vibration isolators shall be selected based on known or estimated operating weight distributions of the isolated equipment, with the quantity and location as shown on the component drawing.
Isolator type shall be tabulated for each isolated piece of equipment. Isolators shall have either known non-deflected heights of spring element or calibration markings so that, after adjustment, when carrying their load, the deflection under load can be verified to determine if the load is within the proper range of the isolator and if the correct degree of vibration isolation is being provided. Isolators shall function in the linear portion of the load versus deflection curve.
Theoretical vertical natural frequency shall not differ from the design objectives by more than 10%.

Substitution of internally or externally isolated and restrained equipment supplied by the equipment vendor, in lieu of the isolation and restraints specified in this section, is acceptable provided all conditions of this section are met. The Equipment manufacturer shall provide a letter of guarantee from their Engineering Department stamped and certified per the section on Seismic Restraint Design (paragraph 1.07) stating that the seismic restraints are in full compliance with these specifications. Letters from field offices or representatives are unacceptable. All costs for converting to the specified vibration isolation and/or restraints shall be borne by the equipment vendor in the event of non-compliance with the preceding. Internal isolation is not acceptable for:

- Rooftop equipment over or adjacent to:
  - Patient or operating areas
  - Theater space
  - Critical office location such as executive and conference areas.
  - Assembly areas

Unless the equipment incorporates unit construction using an integral unit frame or is specified otherwise, each item of mechanical equipment, along with its drive unit, shall be mounted on a rigid steel or steel and concrete base. The equipment, including the base, shall be mounted on, or suspended from, vibration isolators to prevent the transmission of vibration and mechanically transmitted structureborne sound to the supporting structure.

Isolation hangers shall be used for all piping in equipment rooms or for 50 ft. from vibrating equipment, whichever is greater. To avoid reducing the effectiveness of equipment isolators, at least three of the first hangers from the equipment should provide the same deflection as the equipment isolators, with a maximum limitation of 2 inch deflection. The remaining hangers shall be spring or combination spring and rubber with a minimum of 0.75 inch deflection. To prevent load transfer to the equipment flanges when the piping system is filled, the first three hangers adjacent to the equipment shall be the positioning type (specification type 5). Floor supports for piping in equipment rooms and adjacent to isolated equipment shall use restrained vibration isolators. They should be selected according to the guidelines for hangers.

1.07 DESIGN - SEISMIC RESTRAINTS/SNUBBERS

Internally isolated equipment in lieu of specified isolation and restraint systems must include certification by the equipment manufacturer that the internal isolation system meets the specified isolation and system restraint criteria. In the event that the equipment is internally isolated and restrained, the entire unit assembly must be seismically attached to the structure. This attachment and certification thereof shall be by this section. Unless otherwise specified, all isolated equipment and all piping and duct work shall be seismically restrained in accordance with requirements contained herein. All non-isolated mechanical equipment shall be adequately secured to the structure.

Each piece of isolated equipment shall receive a minimum of four all-directional restraint/snubbers, located as close to the equipment corners as practical. These shall consist of either restrained isolators or free standing isolators with separate snubbers. All snubbers must have an impact surface consisting of a high quality elastomer. The elastomer shall be easy to inspect for damage and shall be replaceable. All seismic restraint devices shall maintain the equipment in a captive position and not short circuit isolation devices during normal operating conditions.

Calculations by the Manufacturer's qualified licensed Engineer substantiating the mounting system, seismic restraints and recommended anchor bolts shall be submitted for approval along with the shop drawings. Minimum spacing and embedment of anchor bolts, as well as location from edges of structure or concrete, shall be identified.

Unless otherwise specified, all equipment, piping and duct work shall be restrained to resist seismic forces. Restraints shall maintain mechanical equipment, piping or duct work in a captive position. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest issue of:

- Uniform Building Code, Section 2312; or
- BOCA, Section 1610; or
- Southern Building Code; or
- applicable state and local codes (engineer to specify)

Exclusions for seismic restraint of piping and duct shall be according to the applicable codes. This site is classified as Seismic Zone (engineer to specify zone 1 thru 4). However, the minimum horizontal restraint capability shall be 0.5g horizontal and .33 vertical. Life safety equipment such as fire pumps, emergency generators, sprinkler piping, etc. shall be designed to survive a minimum 1.0g. horizontal load and .67g vertical load.

1.08 SUBMITTALS

A seismic design Errors and Omissions insurance certificate must accompany submittals from the seismic engineer. Manufacturers product liability insurance certificates are not acceptable.

The manufacturer of vibration isolation products shall submit an itemized list of all isolated and non-isolated equipment with detailed schedules showing isolators and seismic restraints proposed for each piece of equipment, referencing material and seismic calculation drawing numbers. The schedule shall include the weight, center of gravity, and RPM of each piece of equipment. When equipment center of gravity is not available, assumed locations for center of gravity shall be identified in submittals.
Submittals for hangers and mountings shall indicate specific model numbers with complete dimensional and deflection data and color code. Base drawings for equipment shall include dimensions, structural member sizes, support point locations.

Seismic calculations, signed by a qualified licensed Professional Engineer, shall be submitted showing adequacy of bolt sizing and type. Calculations shall be furnished for anchors on restraint devices, cable, isolators and rigidly mounted equipment. Calculations shall specify anchor bolt type, embedment, concrete compressive strength, minimum spacing between anchors, and minimum distances of anchors from concrete edges. All performance of products (such as strut, cable, anchors, clips, etc.) associated with restraints must be supported with manufacturer's data sheets or certified calculations. Seismic analysis must indicate calculated dead loads, derived loads, and materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or weld length.

1.08.1 RELATED WORK

Housekeeping pad design shall be by the project structural engineer. Attachment shall be designed and certified according to this section by the seismic/isolation supplier. Material and labor required for attachment and construction shall be by the concrete section contractor.

Housekeeping pads shall be sized to accommodate a minimum of six (6) inches of clearance all around the equipment and its mounting package. Structural support and connections for all equipment, including roof mounted equipment, specified in other sections shall comply with the seismic requirements of this section.

Part 2 – PRODUCTS

2.01 DESCRIPTION

All vibration isolation and seismic devices described in this section shall be the product of a single manufacturer. **Vibration Mountings and Controls, Inc.** is the base manufacturer of these specifications. Products of other manufacturers are acceptable provided their systems strictly comply with intent, structural design, performance and deflections of the Base Manufacturer.

Design of hardware and devices such as beam clamps, anchor bolts, cable and cast-in-place plates must be by this section's supplier to ensure seismic compliance and certification. The contractor has the option to utilize alternate fastening devices (anchor bolts) so long as the sizing and dimensions on seismic submittals are followed.

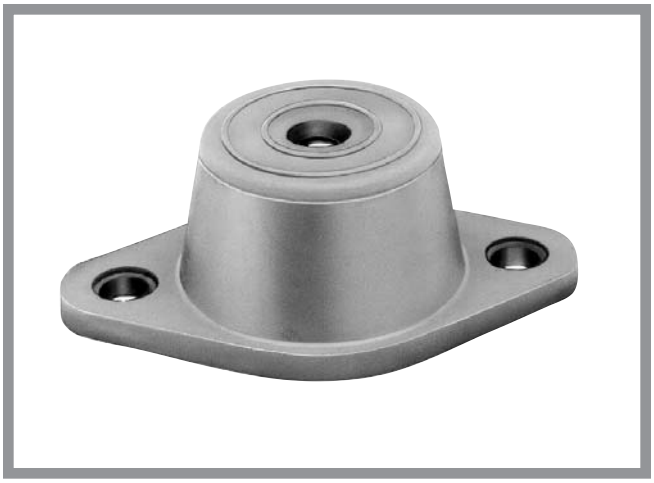
Unless otherwise specified, all isolator hardware shall be zinc plated. Springs with a deflection of up to 2 inches shall be coated with a polyester epoxy powder. Springs and rubber isolators shall be color coded for proper identification of rated load capacity. Zinc plating shall conform at ASTM B633, Class 2 SC2, minimum. All other metal parts used outdoors shall be hot spray or hot dipped galvanized.

2.02 VIBRATION ISOLATION &
SEISMIC RESTRAINT TYPES

TYPE I –
Double Deflection Neoprene

Double deflection neoprene mountings shall have a minimum rated static deflection of 0.40 inches. Steel top plate and base plate shall be completely bonded and embedded in oil-resistant elastomer. Mountings shall be molded in color for ease of identification of load capacity, and shall have ribbed neoprene surfaces on top and bottom to provide friction pads for those applications which do not need to be bolted to the floor or to equipment. Bolt holes shall be provided on the bottom plate, and a tapped hole on the top, for applications requiring positive tie down.

Neoprene mountings shall be Type RD as manufactured by Vibration Mountings & Controls, Inc.



Series "RD" Mountings
Neoprene mountings molded in four sizes to obtain maximum deflections within each load range.
Colored neoprene stocks identify capacities and simplify selections thereby avoiding installation errors.
Load range 10 to 4000 lbs. per mounting with static deflections up to 0.5".

TYPE 2 –
Floor Mounted Spring Isolators

Free standing spring-type isolators, shall be laterally stable without housing, snubbers, or guides, and shall include a steel reinforced, ribbed neoprene cup (1/4-inch minimum thickness) between the baseplate and the support.

Mountings shall have leveling bolts on the top, consisting of an adjusting bolt, cap screw and washer. Mountings shall include a bolt hole in the bottom cup or a two hole rectangular steel baseplate for bolting to the structure.

Springs shall not be welded to the baseplate or cup. Spring diameters shall be no less than 0.8 times the compressed height of the spring at rated load. Springs shall also have a minimum additional travel to solid equal to 50% of the rated deflection. Springs shall have a ratio of horizontal stiffness to vertical stiffness of .8 to 1.25.

Springs shall be color coded for proper identification of rated load capacity. Springs shall be coated with a polyester epoxy powder. Springs having rated deflection greater than 2 inches may be painted. Hardware shall be stainless steel, galvanized or zinc plated.

Free standing Spring-Flex Mountings shall be Series AC/ACB, as manufactured by Vibration Mountings & Controls, Inc..

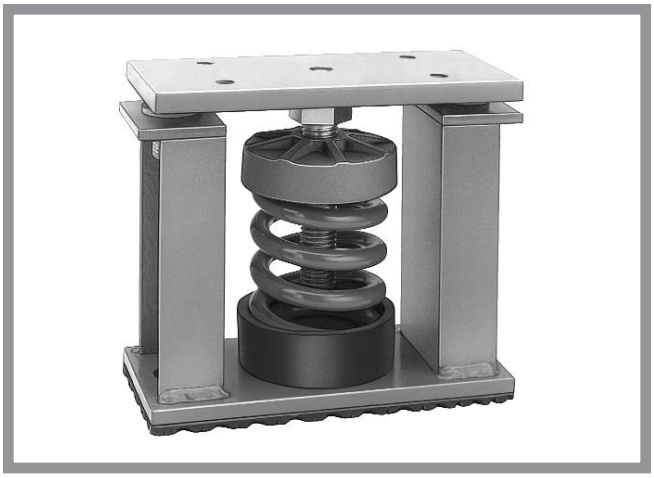
Series "AC" Spring-Flex Mountings
Open spring mounting with built-in leveling feature. Molded neoprene cup to and bottom. Static deflections to 2". Load range 60 to 2,500 lbs. For larger deflections up to 5" use Type AWHC Spring-Flex Mountings.

TYPE 3 –
Housed Springs with Limit Stops

Free standing, laterally stable spring-type isolators. Isolator is the same as described in Specification TYPE 2, except that it includes a housing to provide vertical limit stops to prevent spring extension during weight changes, or when equipment (such as cooling towers) are exposed to uplift loads such as wind loading.

The housing serves as blocking during erection, and shall be located between the equipment and supporting structure. Housing shall be painted or hot dip galvanized. There shall be a minimum clearance of 1/4-inch between the restraining bolts and the housing and spring to prevent interference with spring performance. Limit stops shall be out of contact during normal operation. Mountings shall have an adjusting bolt on the top of the spring compression plate. Neoprene acoustical non skid pads (1/4-inch minimum thickness) shall be attached to the bottom plate. When used in seismic applications, neoprene bushings shall be incorporated in the limit stop plate. Springs shall also have a minimum additional travel to solid equal to 50% of the rated deflection. Springs shall not be welded to cups or housings.

Spring-Flex Mountings shall be Series AWR or AWRS as manufactured by Vibration Mountings & Controls, Inc.



Type "AWR" Spring-Flex Mountings
Mounting incorporates a resilient vertical limit stop to prevent spring extension during weight changes (i.e. draining of water from cooling towers or chillers). Static deflections to 5". Load range 100 to 22,500 lbs.

TYPE 4 –
Combination Spring / Rubber Hangers

Spring-Flex hangers shall consist of a steel spring in series with a .2-inch (minimum) deflection neoprene element. Springs shall be color coded, and elastomer element molded in specific colors for proper identification of rated load capacity. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Pipe isolators shall have spring diameters and hanger box lower hole sizes of sufficient size to permit the hanger rod to swing approximately 30° before contacting the box. Hangers which are to be used with flat iron duct straps will be provided with eye bolts on both ends.

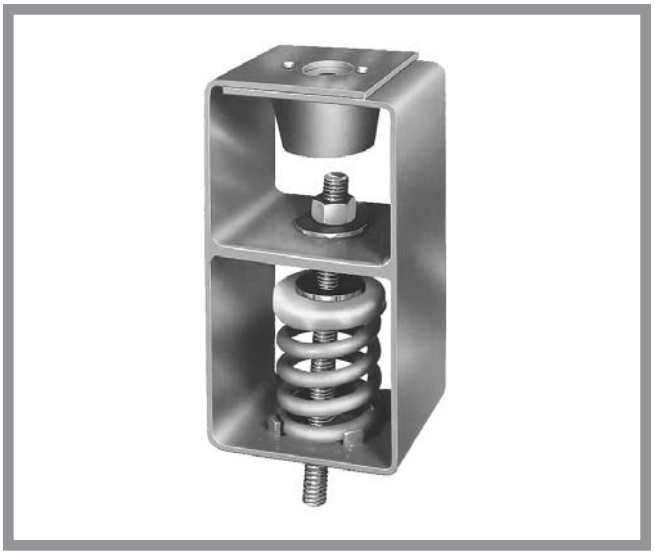
Spring-Flex hangers shall be series RSH/RSH-30A as manufactured by Vibration Mountings & Controls, Inc. Hangers with eyebolts to be type RSHSC/RSHSC-30A as manufactured by Vibration Mountings & Controls, Inc.

Series "RSH" Spring-Flex Hangers
Rectangular steel housing incorporates both neoprene noise absorbing elements and effective steel vibration isolating springs. This combination takes advantage of the best properties of both materials. Design permits installation in the hanger rods or at the ceiling. Deflections to 5" with a load range of 50 to 2,500 lbs. per hanger. Higher capacities, positioning type and 30° ARC capability avail-

TYPE 5 –
Spring / Rubber Pre-Positioning Hangers

Spring-Flex hangers shall consist of color-coded steel spring in series with a neoprene element molded in specific colors for proper identification of rated load capacity. Hanger design shall incorporate a means for supporting the suspended equipment or piping at a fixed elevation during installation regardless of load changes as well as a means for transferring the load to the spring.

Spring-Flex hangers shall be series RSHP or SHP (spring only) positioning hangers as manufactured by Vibration Mountings & Controls, Inc..



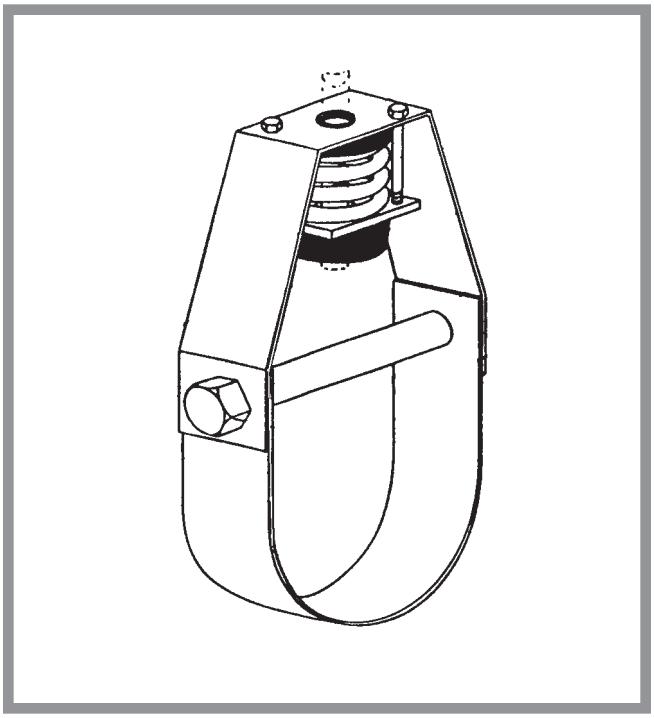
Series "RSHP" Spring-Flex Hangers
In addition to the features of the RSH Spring-Flex Hangers, the RSHP Series offer a load bearing plate that will keep suspended equipment and piping at a fixed elevation during installation. Once the system is completely installed and filled, the load can be transferred to the spring whilst minimizing piping stress.

TYPE 6 –
Isolated Pipe Hanger System

Spring-Flex pipe hanger system shall consist of a pre-compressed spring and elastomer isolation hanger combined with pipe support into one assembly. Replaces standard clevis, single or double roller, or double rod fixed support. The system shall have a spring element with a steel lower spring retainer and an upper elastomer retainer cup with an integral bushing to insulate the support rod from the isolation hanger. The neoprene element under the lower steel spring retainer shall have an integral bushing to insulate the support rod from the steel spring retainer.

The hanger shall be hinged to allow for a minimum of 30° misalignment between the rod attachment to structure and the connection to the isolation hanger. Hangers shall be designed and constructed to support loads over three times the rated load without failure. The system shall be pre-compressed to allow for rod insertion and standard levelling.

Spring-Flex Isolated Pipe Hanger System to be type CIH, CIR, TIH, TIR, and PIH as manufactured by Vibration Mountings & Controls, Inc.



TYPE 7 –
Pre-Compressed Hangers

Spring-Flex hangers shall consist of a color coded steel spring in series with a neoprene element molded in specific colors for proper identification of rated load capacity. Springs shall be pre-compressed to the rated deflection so as to support the suspended equipment or piping at a fixed elevation during installation regardless of load changes. For 30° misalignment capability, spring diameters and hanger box lower hole sizes shall be of sufficient size to permit the hanger rod to swing approximately 30° before contacting the box.

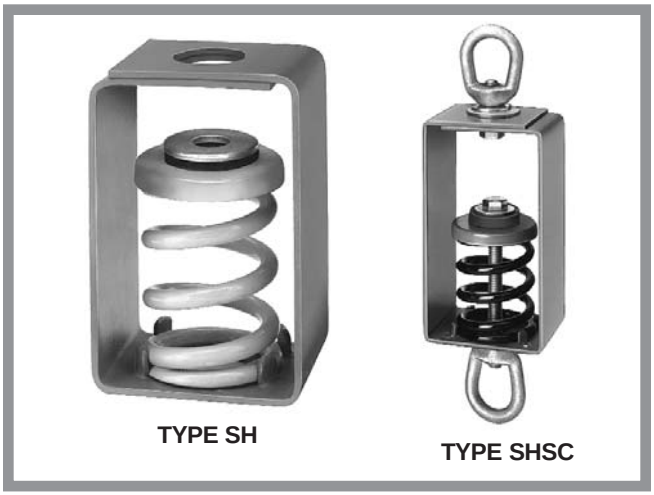
Spring-Flex hangers shall be Series RSHPR or RSHPR-30A as manufactured by Vibration Mountings and Controls, Inc.

Series "RSHPR" or "RSHPR-30A" Spring-Flex Hangers
The RSHPR line of hangers offers a pre-compressed spring designed to keep suspended equipment and piping at a fixed elevation during installation.

TYPE 8 –
Spring Hangers

Spring-Flex hangers shall consist of a color coded steel spring with a neoprene and steel washer which will properly distribute the load on the spring. For 30° misalignment capability, spring diameters and hanger box lower hole sizes shall be of sufficient size to permit the hanger rod to swing approximately 30° before contacting the box. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Hangers which are to be used with flat iron duct straps will be provided with eye bolts on both ends.

Spring-Flex hangers shall be Series SH, SH-30A, SHSC, SHSC-30A as manufactured by Vibration Mountings and Controls, Inc.

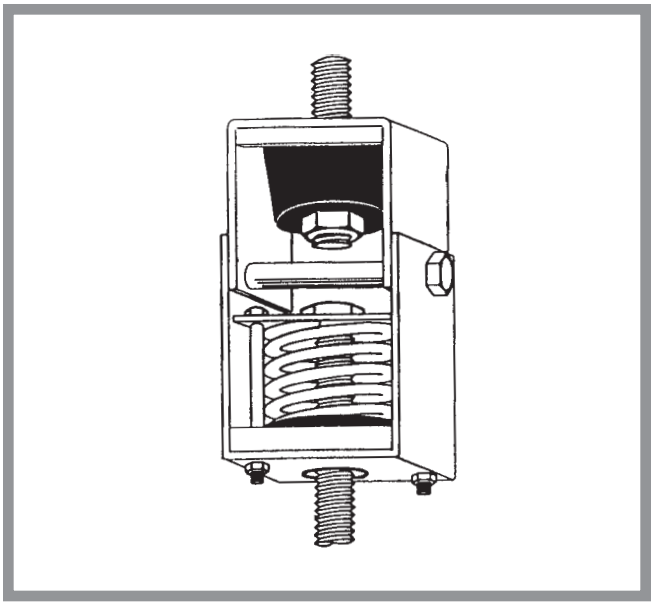


Series "SH" and "SHSC" Spring-Flex Hangers
VMC Spring-Flex Hangers offer static deflections up to 5", a 30° misalignment capability, and eyebolt hardware for duct strap connections.

TYPE 9 –
Self-Aligning Spring Hanger

Spring-Flex hangers shall consist of a color coded steel spring seated in a neoprene spring cup with integral bushing to insulate the lower support rod from the hanger box. The steel hanger box shall be hinged to allow for a minimum of 30° misalignment between the rod attachment to structure and the connection to the supported equipment. Hanger boxes shall withstand three times the rated load without failure.

Spring-Flex Self Aligning hangers shall be series SA as manufactured by Vibration Mountings and Controls, Inc.

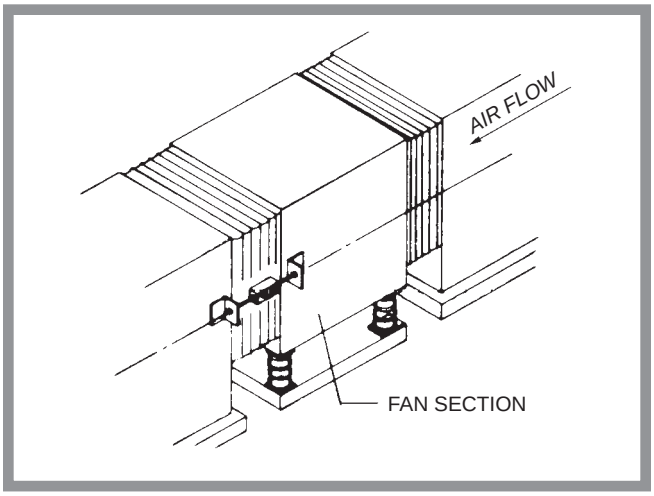


Series "SA" Spring-Flex Hangers

TYPE 10 –
Horizontal Thrust Restraints

Horizontal thrust restraints shall be provided to prevent excessive movement of air handling equipment having air thrust which exceeds 10% of the unit weight. The Horizontal thrust restraint shall consist of a steel housing containing a steel spring in series with a neoprene pad.
The restraint assembly shall be designed to be pre-adjusted by the manufacturer and permit further adjustment in the field to limit horizontal movement to a maximum of 1/4 inch. Assembly shall be furnished with back up plates and hardware for attachment to both the equipment and duct work or structure. Horizontal restraints shall be attached on the centerline of thrust on each side of the unit.

Horizontal thrust restraints shall be Series HTR as manufactured by Vibration Mountings and Controls, Inc.

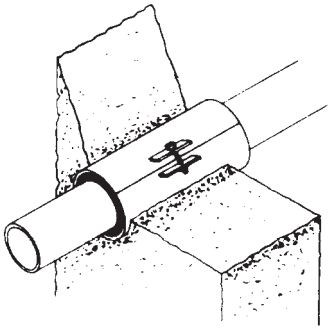


Series "HTR" Thrust Restraints
Excessive movement of air handling equipment can be controlled with our series HTR Horizontal Thrust Restraints. Motion resulting from high starting torque or air thrust will be limited to 1/4 inch.

TYPE 11 –
Floor, Wall,and Ceiling Sleeves

Where piping passes through walls, floors, or ceilings, a vibration control sleeve shall be provided to reduce the transmission of vibration. The sleeve shall consist of two pipe halves with neoprene sponge material bonded to the inside and a bolting arrangement for secure fit around piping. Where temperature exceeds 240°F, an appropriate density fiberglass shall be used in place of neoprene material.

Sleeve shall be type VCS as manufactured by Vibration Mountings and Controls, Inc.

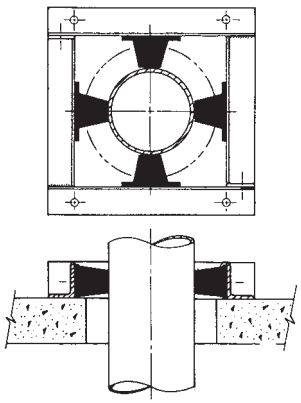


Series "VCS" Sleeves

TYPE 12 –
Resilient Pipe Guides

Where vertical piping runs between support points, a resilient pipe guide shall be provided. The guide shall consist of an angle frame and four double deflection neoprene mountings molded in specific colors for proper identification of rated load capacity.

Resilient pipe guide shall by type RPG as manufactured by Vibration Mountings and Controls, Inc.

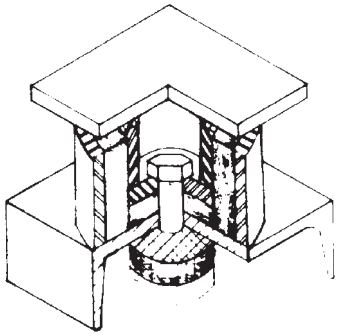


Series "RPG" Pipe Guides

TYPE 13 –
Pipe Anchors

Multi-directional pipe anchor shall consist of suitable steel sections in series with heavy duty duck and neoprene material assembled in a telescopic housing to provide the necessary restraint in both the vertical and horizontal directions. Pipe anchor shall be sized to limit load on neoprene and duck material to 500 psi.

Multi-directional pipe anchor shall by type MDPA as manufactured by Vibration Mountings and Controls, Inc.



Series "MDPA" Pipe Anchors

TYPE 14 –
Flexible Connectors

Quiet-Sphere flexible connectors shall be molded in spherical design of multiple layers of neoprene and synthetic fiber with integral corrosion resistant plate steel flanges. The connectors shall be suitable for pressures up to 214 psi and temperatures up to 240°F. Where piping is not anchored, control rods must be installed at each connector to limit movement within their specified limits.

Flexible connectors shall be Quiet-Sphere type VMS, VMT, or VMU as manufactured by Vibration Mountings and Controls, Inc.

Series "VMS" and "VMT"
Quiet-Sphere Flexible Connectors
Single-sphere (VMS) and twin-sphere (VMT) connectors are molded of neoprene and synthetic fiber and furnished with corrosion resistant floating steel flanges. Operating temperature to 240°F and operating pressure to 214 psi. Compensates for expansion, compression, transverse movement, and angular deflection. Reduces vibration and noise transmission. Size 1¼" to 20" I.D.

TYPE 15 –
Seismic Spring Mountings

Steel spring isolators incorporating elastomeric snubbing in all directions. The snubber shall be adjustable in the vertical direction and allow a maximum of 1/4" travel in all directions before contacting the elastomer cushion. Spring diameters shall be no less than 0.8 times the compressed height of the spring at rated load. Springs shall also have a minimum additional travel to solid equal to 50% of the rated deflection. Housings shall have provision to adjust the rebound plate and to inspect the spring. Housing shall be of cast ductile iron, malleable cast iron or of welded steel construction. Gray iron castings are not permitted. Springs shall be color coded for proper identification of rated load capacity. Springs shall be coated with a polyester epoxy powder. Hardware shall be stainless steel, or zinc plated.

Spring-Flex seismic mountings shall be Series AEQM, AWRS, ASCM or AWMR as manufactured by Vibration Mountings and Controls, Inc.

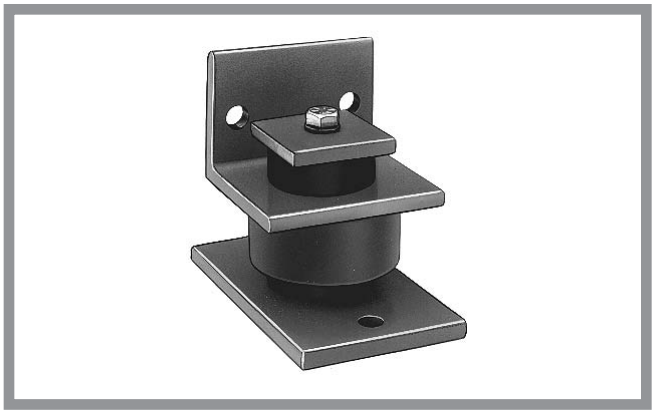
Series "AEQM" Spring-Flex Mountings
Designed for seismic and restrained applications, these mountings are capable of withstanding a minimum of 1.0g accelerated force in all directions and provide static deflections up to 1½" and loads to 2500 lbs. They also incorporate an all-directional neoprene grommet and an adjustable upward rebound plate. These mountings have been tested by an independent test laboratory and results are available on request.

Series "AWMR" Restrained Spring-Flex Mountings
The design incorporates a rugged welded steel housing with vertical and horizontal limit stops able to withstand a minimum of 1.0g accelerated force in all directions. Loads to 10,000 pounds and static deflections to 2". They are particularly recommended for equipment with differing installed and operating loads such as cooling towers and chillers or equipment subjected to severe wind loads.

TYPE 16 –
Seismic Snubbers / Restraints

All-directional seismic snubbers shall include all directional elastomer elements, having a minimum elastomer thickness of 1/4" in all directions. Elastomers shall be easy to inspect and shall consist of replaceable elastomer inserts. Elastomer shall be neoprene or a high quality rubber including anti-ozone and anti-oxidant materials and conform to ASTM 02000 Grade 2BC or Bridge Bearing Neoprene. Snubbers shall be manufactured with an air gap between steel and elastomer of 1/8 inch to 1/4 inch. Snubbers shall be installed with factory set clearances. Snubber must have at least two anchor bolt holes and shall have an ultimate load capacity of at least four times the rated static load capacity.

Seismic restraints shall be Series SR as manufactured by Vibration Mountings and Controls, Inc.



Series "SR" Seismic Restraints
Fabricated of welded steel components incorporating thick neoprene elastomer pads molded to Bridge Bearing quality specifications, the design of these restraints allows for the removal and replacement of the neoprene elements. These restraints are designed for a minimum of 1.0g accelerated force in all directions. Series "SR" for loads from 250 to 12,000 lbs.

TYPE 17 –
Cable Restraints

Steel aircraft cable restraints are designed and installed to limit motion on suspended isolated equipment, piping or ducting. Cables are installed with enough slack to engage only when 1/4 inch movement occurs. On suspended equipment, cables are installed in sets of four, located at 45° angles to all three axes. Where required at pipe hangers, cables are placed two at each location, alternating orientation at successive locations. Cable shall be 7x19 galvanized or stainless steel aircraft cable conforming to FED-STD-RR-W-410D.

Seismic cable restraint shall be Series SCR as manufactured by Vibration Mountings and Controls, Inc.

Series "SCR" Seismic Cable Restraints

TYPE 18 –
Captive Elastomer Mountings

Consist of a captive elastomeric mount molded from neoprene or EPDM compound conforming to the requirements of ASTM D2000. Load bearing elastomer element shall be housed in a cast ductile iron housing. Mount shall incorporate a fail-safe captive design, and shall provide a vertical natural frequency of approximately 8 Hz at rated static load. Mount shall be capable of providing dynamic deflections of up to .5 inches.

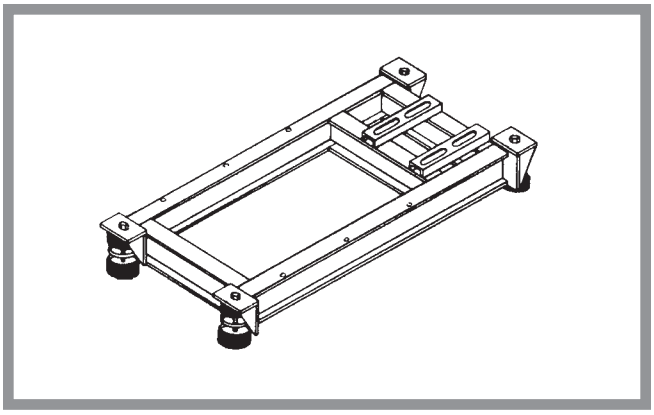
Captive elastomer mountings shall be type RSM as manufactured by Vibration Mountings and Controls, Inc.

Series "RSM" Elastomer Mount

TYPE A –
Structural Bases

Integral structural steel bases shall be rectangular in shape. All structural members shall be of wide flange, angle or channel steel with depth equal to a minimum of 1/10 of the longest span of equipment, but not less than 6 inches. Built-in adjustable motor slide rails and height saving brackets shall be supplied as in integral part of the base.

Structural bases shall be type WFB as manufactured by Vibration Mountings and Controls, Inc.

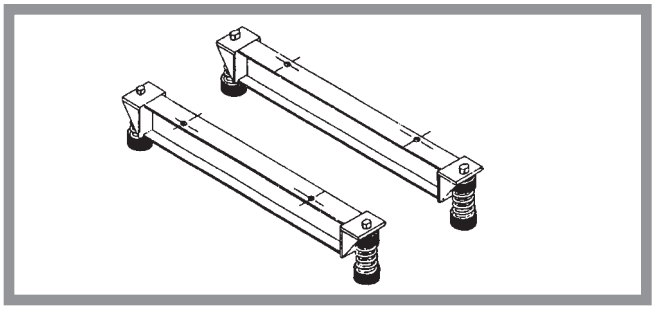


Type "WFB" Structural Steel Base

TYPE B –
Structural Rails

Structural steel rails shall be of wide flange, angle or channel steel with depth equal to a minimum of 1/10 of the longest span of equipment, but not less than 6 inches. Height saving brackets shall be supplied as an integral part of the rails. For seismic applications rails must be structurally attached to one another.

Structural steel rails shall by type WFR as manufactured by Vibration Mountings and Controls, Inc.

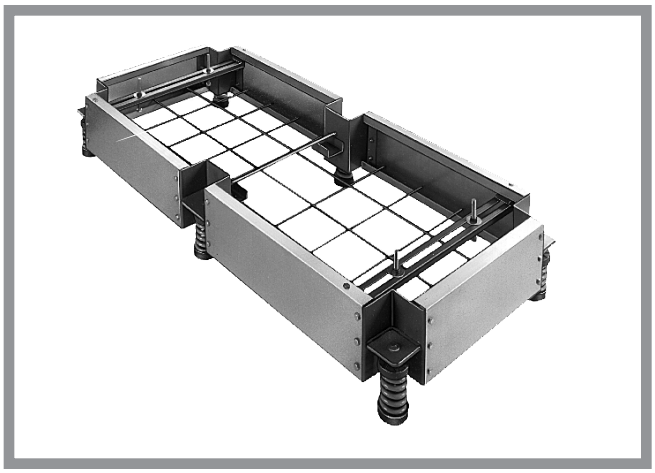


Type "WFR" Structural Steel Rails

TYPE C –
Concrete Inertia Base

Concrete inertia base forms shall be of formed steel members or removable concrete forms with a depth not less than 1/12 of the longest base dimension, but not less than 6 inches. Height saving isolator mounting brackets shall be bolted or welded to the members. Pouring forms shall include minimum 3/8 inch concrete reinforcing steel (rebar) on 8 inch centers running the length and width of the base. Pouring forms for split case pumps shall be wide enough to support suction and discharge elbows. Anchor bolt templates shall be provided to accept mounting hole location of the supported equipment.

Bases shall be type MPF or WPF as manufactured by Vibration Mountings and Controls, Inc.



Types "MPF" and "WPF" Concrete Inertia Bases

Mechanical equipment requiring a concrete inertia base can now be quickly and economically installed using VMC's modular pouring forms. These sturdy lightweight bases, when filled with concrete, are an effective means to isolate vibration and limit motion of any equipment.

Available in 6" and 10" thickness (10" is recommended for use when MPF base must exceed 8ft.) the added mass of MPF inertia bases lowers the center of gravity (Cg) of the equipment and allows a softer isolation system to be used. Greater isolation efficencies can now be obtained while limiting the motion of supported equipment.

TYPE D –
Spring Isolation Curb

Rooftop curb mounted equipment shall be isolated from the building structure by means of a factory assembled unitized vibration control base consisting of extruded aluminum upper and lower members incorporating zinc plated steel springs selected for 1 inch static deflection, sized and positioned to insure uniform deflection for the entire system. Unitized construction minimizes on site assembly. Field assembled curb kits not acceptable. A continuous flexible “Hydro-Gard” seal shall be provided between the upper and lower members of the vibration control base. A closed cell sponge rubber gasket to be bonded to the top and bottom members.

The unitized vibration control system shall be iso-curb type AXR as manufactured by Vibration Mountings and Controls, Inc.

Type "AXR" Spring Isolation Base

Type AXR Spring-Flex Bases are designed to isolate curb mounted rooftop equipment from the building structure. The 'Unitized' base is fabricated from extruded aluminum upper and lower members, with electro zinc plated springs designed for 1" static deflection.

The springs are mechanically fastened, sized and positioned within the frame to ensure uniform deflection for the entire system.

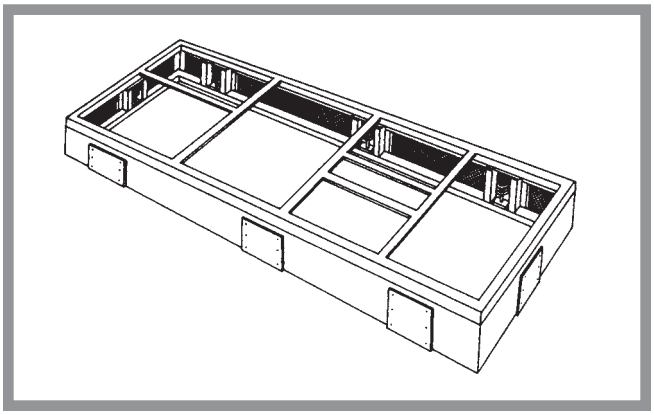
A continuous flexible '"Hydro-Gard"' seal is factory attached between the upper and lower members, and a continuous closed cell neoprene gasket bonded to the top and bottom surfaces provides an air and water seal.

TYPE E –
Roof Isolation Curb

The structural steel spring isolation curbs shall bear directly on the roof support structure and be flashed and waterproofed into the roof’s membrane waterproofing system. Equipment manufacturer’s or field fabricated curbs shall not be used. The curb shall consist of a rigid steel lower section containing properly spaced pockets with fully adjustable spring isolators. All springs shall be color coded for proper identification and spring pocket shall allow for easy removal or replacement of any spring without disturbance of the supported equipment. Pockets shall have removable waterproof covers to allow for spring adjustment. Spring pockets shall contain combination vertical and horizontal restraint in conjunction with a 1/4 inch thick neoprene rubber bushing which will resist wind and seismic forces. All springs shall be installed in series with a 1/4 inch thick neoprene acoustical cup or pad. The curb shall be the sound attenuating type utilizing
standard 2 inch roof insulation supplied and installed by the roofing contractor to act thermally outside and acoustically inside. Curbs supplied without this feature shall be factory acoustically lined with 2 inch duct liner. An air tight neoprene seal shall be incorporated into the curb design to prevent air leakage or infiltration. Air seal must not be exposed so that it could be damaged or that in the event of the air seal failure, water could leak into the curb’s interior.
Wood nailer and flashing shall be provided and curbs shall be manufactured to NRCA standards.

Curbs shall include a means of incorporating a sound barrier package, consisting of two layers of waterproof gypsum board furnished and installed by the General Contractor. Individual pier supported curbs are not acceptable.

Roof isolation curb to be type RIC or type P as manufactured by Vibration Mountings and Controls, Inc.



Type "RIC" Roof Isolation Curb

Specifically designed for rooftop unit vibration isolation, each custom built unit incorporates both the roof curb and spring isolation into one complete structure. With static deflections up to 5" available, the support equipment actually "floats" while protected from seismic forces through zone 4.

The optional acoustical package combines noise reduction

PART 3 - EXECUTION

3.01 EQUIPMENT ISOLATION

Isolation and seismic restraint systems must be installed in strict accordance with the manufacturer's written instructions and all submittal data. Locations of all vibration isolation products shall be selected for ease of inspection and adjustment, as well as for proper operation.

Electrical and plumbing connections to vibration isolated equipment shall be flexible. Equipment shall be isolated and restrained as indicated in the vibration isolation schedules.

The minimum operating clearance under bases shall be 1". All bases shall be placed in position and supported temporarily by blocks or shims prior to the installation of the equipment, isolators and restraints. Spring isolators shall be installed after all equipment is installed without changing equipment elevations. After the entire installation is complete and under full operational load, the spring isolators shall be adjusted so that the load is transferred from the blocks to the isolators. Remove all debris from beneath the equipment and verify that there are no short circuits of the isolators or the isolation system.

3.02 PIPING AND DUCTWORK ISOLATION

Vibration isolation hangers shall be positioned as close as possible to the structure without coming in contact with any object (including the structure). Hanger rods shall not contact any object which would short circuit the isolator. Parallel running pipes may be hung together on a trapeze which is isolated from the building. Do not mix vibration isolated and non-isolated pipes on the same trapeze. Attention must be paid to movements of piping caused in expansion and contraction. Type 6 hangers may be substituted for all other hangers listed below. Pre-compressed hangers shall only be used if installed along with piping.

Isolation hangers shall be installed for all piping in equipment rooms or for 50 ft. from vibrating equipment, whichever is greater. To avoid reducing the effectiveness of equipment isolators, at least three of the first hangers from the equipment should provide the same deflection as the equipment isolators, with a maximum limitation of 2 inch deflection. The remaining hangers shall be spring or combination spring and rubber with a minimum of 0.75 inch deflection. To prevent load transfer to the equipment flanges when the piping system is filled, the first three hangers adjacent to the equipment shall be the positioning type (specification type 5). Floor supports for piping in equipment rooms and adjacent to isolated equipment shall use restrained vibration isolators. They should be selected according to the guidelines for hangers. Vertical riser supports for pipe 4" diameter and larger shall be isolated from the structure using type 11 and type 12 anchors and guides.

All ductwork over four square feet face area located in the mechanical equipment room(s) shall be isolated with type 8 hangers with a minimum of 0.75 inch deflection. Emergency generator exhaust shall be isolated with type 8 hangers with a minimum of 0.75 inch deflection.

Install type 14 flexible connectors at all connections of pipe to pumps and chillers, and to other isolated equipment only as shown on drawings. Where they are not installed on isolated equipment, insert spool pieces on the equipment side of shut-off valves.

3.03 SEISMIC RESTRAINT

All equipment shall be seismically restrained and isolated per the vibration isolation schedule.
All floor mounted equipment whether isolated or not shall be snubbed, anchored, bolted or welded to the structure to resist the specified acceleration. Calculations that determine that isolated equipment movement may be less than the operating clearance of snubbers do not preclude the need for snubbers. All equipment must be positively attached to the structure.

All suspended isolated equipment shall be restrained with type 17 seismic cable restraints. Non isolated equipment may be rigidly braced. VAV boxes attached directly to ductwork on the main supply side shall be considered as ductwork for seismic design purposes.

All isolated, horizontally suspended pipe, duct, cable trays, bus duct and conduit shall use restraint type 17. Non-isolated shall utilize rigid restraint methods. For seismic accelerations of .48g or less, spacing of seismic bracing shall be per the latest edition of the SMACNA seismic restraint manual for piping and ductwork.

In pipe risers which pass through cored holes, core diameters to be a maximum of 2" larger than pipe O.D., including insulation. Cored holes must be packed with resilient material or fire stop as specified in other sections of this specification and/or state and local codes. No additional horizontal seismic bracing is required at these locations. Non-isolated, constant temperature pipe risers through cored holes require a riser clamp at each floor level on top of the slab attached in a seismically approved manner for vertical restraint. Non-isolated, constant temperature pipe risers in pipe shafts require structural steel attached in a seismically approved manner at each floor level and a riser clamp at each floor level on top of, and fastened to the structural steel. The riser clamp and structural steel must be capable of withstanding all thermal, static and seismic loads.

Isolated and/or variable temperature risers through cored holes require type 12 and type 13 guides and anchors installed to meet both thermal expansion and seismic acceleration criteria.
Each floor level must have either a riser clamp that does not interfere with the thermal expansion/contraction of the pipe or a riser clamp/cable assembly capable of supporting the weight of the pipe between floors in the event of pipe joint failure. Chimneys, stacks and boiler breeching passing through floors are to be bolted at each floor level or secured above and below each floor with riser clamps.

3.04 INSPECTION

Upon completion of installation of all vibration isolation and seismic restraint devices, a certification report prepared by the manufacturer or the qualified representative shall be submitted in writing to the contractor indicating that all systems are installed properly and in compliance with the specifications. The report must identify those areas that require corrective measures or certify that none exists. Any field coordination type changes to the originally submitted seismic restraint designs must be clearly defined and detailed in the report.

TABLE II - Allowable Shear & Tension on Bolts Embedded in Concrete (pounds)

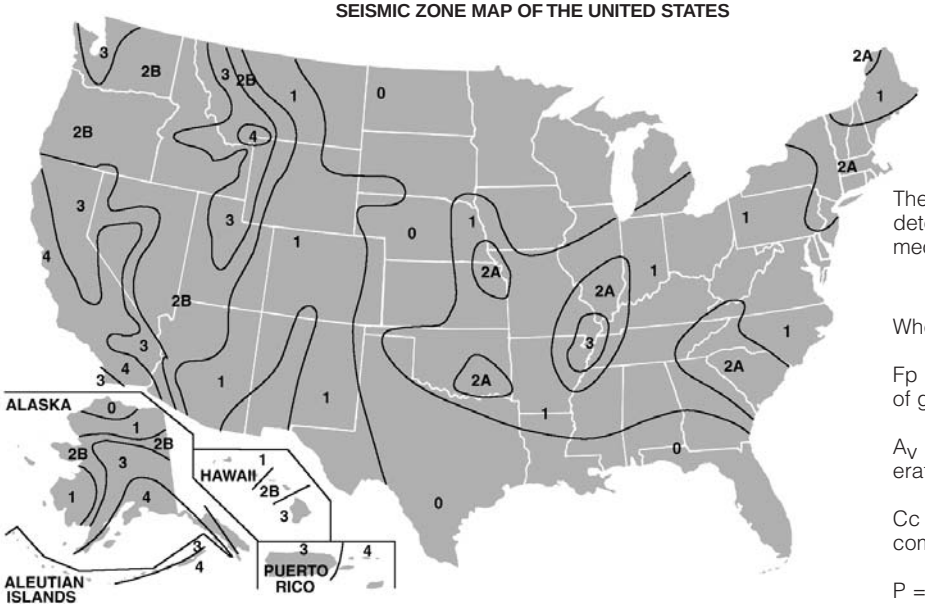
(Source - Uniform Building Code - 1991 - Table 26-E)

Diameter (inches)	Minimum Embedment (inches)	Shear (pounds)	Tension (pounds)	Minimum Bolt Spacing [3] (inches)	Minimum Edge Distance [3] (inches)
1/4	2 - 1/2	250	200	3	1 - 1/2
3/8	3	550	500	4 - 1/2	2 - 1/4
1/2	4	1000	950	6	3
5/8	4	1500	1500	7 - 1/2	3 - 3/4
3/4	5	1780	2250	9	4 - 1/2
7/8	6	2075	3200	10 - 1/2	5 - 1/4
1	7	2075	3200	12	6
1 - 1/8	8	2250	3200	13 - 1/2	6 - 3/4
1 - 1/4	9	2650	3200	15	7 - 1/2

Notes:

1. Double allowable tension loads only, where special inspection is performed.
2. Values are for minimum concrete compressive strength of 3,000 psi and bolts of at least A307 quality. Values may be increased for concrete of higher compressive strength.
3. Values are based upon a bolt spacing of 12 diameters with a minimum edge distance of 6 diameters. Such spacing and edge distance may be reduced 50% with an equal reduction in value. Use linear interpolation for intermediate spacing

SEISMIC ZONE MAP OF THE UNITED STATES



ZONE	1	2A	2B	3	4
A_V	.075	.15	.20	.30	.4

The "lateral force equation" is the key to determining seismic forces acting on mechanical equipment..

$$Fp = A_V \, Cc \, P \, a_c \, Wc$$

Where:

Fp = force acting at equipment center of gravity (Cg)

A_V = effective peak velocity related acceleration (see seismic map and related table)

Cc = coefficient of mechanical or electrical component

P = building performance criteria factor

a_c = attachment amplification factor

Wc = operating weight of mechanical or electrical component

All of these coefficients can be found in section 1610 of the latest BOCA codes.

Vibration Control Selection Guide – **Non-Seismic**

EQUIPMENT DESCRIPTION	EQUIPMENT LOCATION											
	Basement Below Grade		Grade and 20' Floor Span		25' Floor Span		30' Floor Span		40' Floor Span		50' Floor Span	
	Spec Type	Static Defl.	Spec Type	Static Defl.	Spec Type	Spec Defl.	Static Type	Spec Defl.	Static Type	Spec Defl.	Static Type	Spec Defl.
AIR COOLED CONDENSING UNITS	3-B	0.75	3-B	1.0	3-B	1.0	3-B	1.75	3-B	1.75	3-B	1.75
BOILER FEED PUMPS	1-B	0.25	1-B	0.25	1-B	0.25	1-B	0.25	1-B	0.25	1-B	0.25
BOILERS AND STEAM GENERATORS	1	0.5	1	0.5	1	0.5	1	0.5	1	0.5	1	0.5
CENTRIFUGAL FANS (Floor Mounted) 24" diameter and up Up to 40 HP. Up to 300 RPM.	2-A	2.0	2-A	2.0	2-A	2.0	2-A	2.0	2-A	2.0	2-A	3.0
CENTRIFUGAL FANS (Floor mounted) 24" diameter and up Up to 40 HP. Up to 500 RPM.	2-A	2.0	2-A	2.0	2-A	2.0	2-A	2.0	2-A	2.0	2-A	3.0
CENTRIFUGAL FANS (Floor Mounted) 24" diameter and up Up to 40 HP. 500 RPM and up	2-A	0.75	2-A	0.75	2-A	0.75	2-A	1.0	2-A	1.5	2-A	2.0
CENTRIFUGAL FANS (Suspended)	4	1.0	4	1.25	4	1.25	4	1.5	4	1.5	4	1.5
CHILLERS (Absorption Centrifugal)	3	0.75	3	1.0	3	1.75	3	1.75	3	1.75	3	2.0
CHILLERS (Reciprocating)	3	0.75	3	1.75	3	1.75	3	1.75	3	2.5	3	3.0
CHILLERS (Open Centrifugal)	3-C	0.75	3-C	0.75	3-C	0.75	3-C	1.75	3-C	1.75	3-C	1.75
CONDENSATE PUMPS	1-B	0.25	1-B	0.25	1-B	0.25	1-B	0.25	1-B	0.25	1-B	0.25
COOLING TOWERS Up to 300 RPM.	3	3.0	3	3.5	3	3.5	3	3.5	3	5.0	3	5.0
COOLING TOWERS 301 to 500 RPM.	3	2.0	3	2.0	3	2.0	3	2.5	3	2.5	3	3.0
COOLING TOWERS 500 RPM and up	3	1.0	3	1.0	3	1.0	3	1.0	3	1.5	3	1.75
ENGINE DRIVEN GENERATORS	2	0.75	2	0.75	2	0.75	2	1.0	2	1.5	2	1.5
FAN COIL UNITS	4	0.75	4	0.75	4	0.75	4	0.75	4	0.75	4	0.75
PACKAGED AIR HANDLING UNITS (Point mounted) Up to 5 HP.	2	0.75	2	0.75	2	0.75	2	0.75	2	0.75	2	0.75
PACKAGED AIR HANDLING UNITS (Point mounted) 7 1/2 HP and larger. Up to 575 RPM.	2	0.75	2	1.5	2	1.5	2	2.0	2	2.5	2	2.5
PACKAGED AIR HANDLING UNITS (Point mounted) 7 1/2 HP and larger. 576 RPM and up.	2	0.75	2	1.25	2	2.0	2	2.0	2	2.25	2	2.25
PACKAGED AIR HANDLING UNITS (Curb mounted rooftop) Up to 5 HP.	D	0.75	D	0.75	D	0.75	D	0.75	D	0.75	D	0.75
PACKAGED AIR HANDLING UNITS (Curb mounted rooftop) 7 1/2 HP and larger. Up to 575 RPM.	D	1.0	D	1.0	D	1.0	D	1.0	D	1.0	D	1.0
PACKAGED AIR HANDLING UNITS (Curb mounted rooftop) 7 1/2 HP and larger. 576 RPM and up.	D	1.0	D	1.0	D	1.0	D	1.0	D	1.0	D	1.0
PACKAGED AIR HANDLING UNITS (Suspended) Up to 5 HP.	4	0.75	4	0.75	4	0.75	4	0.75	4	0.75	4	0.75
PACKAGED AIR HANDLING UNITS (Suspended) 7 1/2 HP and larger. Up to 575 RPM.	4	0.75	4	1.5	4	1.5	4	2.0	4	2.5	4	2.5
PACKAGED AIR HANDLING UNITS (Suspended) 7 1/2 HP and larger. 576 RPM and up.	4	0.75	4	1.25	4	2.0	4	2.0	4	2.25	4	2.25
PUMPS (Close coupled) Up to 7.5 HP.	2-C	0.75	2-C	0.75	2-C	0.75	2-C	0.75	2-C	1.0	2-C	1.5
PUMPS (Close coupled) 10 HP and up.	2-C	0.75	2-C	0.75	2-C	1.0	2-C	1.0	2-C	1.5	2-C	1.75
PUMPS (End Suction and Split Case) Up to 40 HP.	2-C	0.75	2-C	0.75	2-C	1.0	2-C	1.5	2-C	2.0	2-C	2.0
PUMPS (End Suction and Split Case) 50 HP and larger.	2-C	0.75	2-C	1.0	2-C	1.5	2-C	2.0	2-C	2.5	2-C	2.5
PUMPS (Large Inline Floor Mounted) 5 HP to 25 HP.	2	0.75	2	0.75	2	1.75	2	1.75	2	1.75	2	1.75
PUMPS (Large Inline Floor Mounted) 30 HP and larger.	2	1.75	2	1.75	2	1.75	2	1.75	2	2.0	2	2.5
PUMPS (Large Inline Suspended) 5 HP to 25 HP.	4	0.75	4	0.75	4	1.75	4	1.75	4	1.75	4	1.75
PUMPS (Large Inline Suspended) 30 HP and larger.	4	1.75	4	1.75	4	1.75	4	1.75	4	2.0	4	2.5
RECIPROCATING COMPRESSORS	2-C	0.75	2-C	0.75	2-C	1.0	2-C	1.25	2-C	1.5	2-C	2.0
TRANSFORMERS	1	0.25	1	0.25	1	0.25	1	0.25	1	0.5	1	0.5
UNIT HEATERS	8	0.5	8	0.5	8	0.5	8	0.5	8	0.5	8	0.5
UNIT VENTILATORS	4	0.75	4	0.75	4	0.75	4	0.75	4	0.75	4	0.75
VAV BOXES (Fan powered)	4	0.75	4	0.75	4	0.75	4	0.75	4	0.75	4	0.75

Note: Static Deflection is measured in inches

Vibration Control Selection Guide – **Seismic**

EQUIPMENT DESCRIPTION	EQUIPMENT LOCATION											
	Basement Below Grade		Grade and 20' Floor Span		25' Floor Span		30' Floor Span		40' Floor Span		50' Floor Span	
	Spec Type	Static Defl.	Spec Type	Static Defl.	Spec Type	Spec Defl.	Static Type	Spec Defl.	Static Type	Spec Defl.	Static Type	Spec Defl.
AIR COOLED CONDENSING UNITS	15-B	0.75	15-B	1.0	15-B	1.0	15-B	1.75	15-B	1.75	15-B	1.75
BOILER FEED PUMPS	18-B	0.25	18-B	0.25	18-B	0.25	18-B	0.25	18-B	0.25	18-B	0.25
BOILERS AND STEAM GENERATORS	18	0.5	18	0.5	18	0.5	18	0.5	18	0.5	18	0.5
CENTRIFUGAL FANS (Floor Mounted) 24" diameter and up Up to 40 HP. Up to 300 RPM.	15-A	2.0	15-A	2.0	15-A	2.0	15-A	2.0	15-A	2.0	15-A	3.0
CENTRIFUGAL FANS (Floor mounted) 24" diameter and up Up to 40 HP. Up to 500 RPM.	15-A	2.0	15-A	2.0	15-A	2.0	15-A	2.0	15-A	2.0	15-A	3.0
CENTRIFUGAL FANS (Floor Mounted) 24" diameter and up Up to 40 HP. 500 RPM and up	15-A	0.75	15-A	0.75	15-A	0.75	15-A	1.0	15-A	1.5	15-A	2.0
CENTRIFUGAL FANS (Suspended)	4-17	1.0	4-17	1.25	4-17	1.25	4-17	1.5	4-17	1.5	4-17	1.5
CHILLERS (Absorption Centrifugal)	15	0.75	15	1.0	15	1.75	15	1.75	15	1.75	15	2.0
CHILLERS (Reciprocating)	15	0.75	15	1.75	15	1.75	15	1.75	15	2.5	15	3.0
CHILLERS (Open Centrifugal)	15-C	0.75	15-C	0.75	15-C	0.75	15-C	1.75	15-C	1.75	15-C	1.75
CONDENSATE PUMPS	18-B	0.25	18-B	0.25	18-B	0.25	18-B	0.25	18-B	0.25	18-B	0.25
COOLING TOWERS Up to 300 RPM.	15	3.0	15	3.5	15	3.5	15	3.5	15	5.0	15	5.0
COOLING TOWERS 301 to 500 RPM.	15	2.0	15	2.0	15	2.0	15	2.5	15	2.5	15	3.0
COOLING TOWERS 500 RPM and up	15	1.0	15	1.0	15	1.0	15	1.0	15	1.5	15	1.75
ENGINE DRIVEN GENERATORS	15	0.75	15	0.75	15	0.75	15	1.0	15	1.5	15	1.5
FAN COIL UNITS	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75
PACKAGED AIR HANDLING UNITS (Point mounted) Up to 5 HP.	15	0.75	15	0.75	15	0.75	15	0.75	15	0.75	15	0.75
PACKAGED AIR HANDLING UNITS (Point mounted) 7 1/2 HP and larger. Up to 575 RPM.	15	0.75	15	1.5	15	1.5	15	2.0	15	2.5	15	2.5
PACKAGED AIR HANDLING UNITS (Point mounted) 7 1/2 HP and larger. 576 RPM and up.	15	0.75	15	1.25	15	2.0	15	2.0	15	2.25	15	2.25
PACKAGED AIR HANDLING UNITS (Curb mounted rooftop) Up to 5 HP.	E	0.75	E	0.75	E	0.75	E	0.75	E	0.75	E	0.75
PACKAGED AIR HANDLING UNITS (Curb mounted rooftop) 7 1/2 HP and larger. Up to 575 RPM.	E	1.0	E	1.0	E	1.0	E	1.0	E	1.0	E	1.0
PACKAGED AIR HANDLING UNITS (Curb mounted rooftop) 7 1/2 HP and larger. 576 RPM and up.	E	1.0	E	1.0	E	1.0	E	1.0	E	1.0	E	1.0
PACKAGED AIR HANDLING UNITS (Suspended) Up to 5 HP.	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75
PACKAGED AIR HANDLING UNITS (Suspended) 7 1/2 HP and larger. Up to 575 RPM.	4-17	0.75	4-17	1.5	4-17	1.5	4-17	2.0	4-17	2.5	4-17	2.5
PACKAGED AIR HANDLING UNITS (Suspended) 7 1/2 HP and larger. 576 RPM and up.	4-17	0.75	4-17	1.25	4-17	2.0	4-17	2.0	4-17	2.25	4-17	2.25
PUMPS (Close coupled) Up to 7.5 HP.	15-C	0.75	15-C	0.75	15-C	0.75	15-C	0.75	15-C	1.0	15-C	1.5
PUMPS (Close coupled) 10 HP and up.	15-C	0.75	15-C	0.75	15-C	1.0	15-C	1.0	15-C	1.5	15-C	1.75
PUMPS (End Suction and Split Case) Up to 40 HP.	15-C	0.75	15-C	0.75	15-C	1.0	15-C	1.5	15-C	2.0	15-C	2.0
PUMPS (End Suction and Split Case) 50 HP and larger.	15-C	0.75	15-C	1.0	15-C	1.5	15-C	2.0	15-C	2.5	15-C	2.5
PUMPS (Large Inline Floor Mounted) 5 HP to 25 HP.	15	0.75	15	0.75	15	1.75	15	1.75	15	1.75	15	1.75
PUMPS (Large Inline Floor Mounted) 30 HP and larger.	15	1.75	15	1.75	15	1.75	15	1.75	15	2.0	15	2.5
PUMPS (Large Inline Suspended) 5 HP to 25 HP.	4-17	0.75	4-17	0.75	4-17	1.75	4-17	1.75	4-17	1.75	4-17	1.75
PUMPS (Large Inline Suspended) 30 HP and larger.	4-17	1.75	4-17	1.75	4-17	1.75	4-17	1.75	4-17	2.0	4-17	2.5
RECIPROCATING COMPRESSORS	15-C	0.75	15-C	0.75	15-C	1.0	15-C	1.25	15-C	1.5	15-C	2.0
TRANSFORMERS	18	0.25	18	0.25	18	0.25	18	0.25	18	0.5	18	0.5
UNIT HEATERS	4-17	0.5	4-17	0.5	4-17	0.5	4-17	0.5	4-17	0.5	4-17	0.5
UNIT VENTILATORS	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75
VAV BOXES (Fan powered)	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75	4-17	0.75

Note: Static Deflection is measured in inches

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