

SEISMIC PROTECTION OF NON-STRUCTURAL MEP, HVAC AND FIRE PROTECTION SYSTEM COMPONENTS

1. DESCRIPTION

This section defines the methods, standards and elements to be used for the seismic protection of non structural elements of HVAC, MEP, Fire Protection System components according to the below standards.

1.1. STANDARDS

- 2010 National Fire Protection Association Pamphlet 13 (NFPA-13 2019)
- 2006 International Building Code (IBC 2006)
- FM Global Property Loss Prevention Data Sheets 2.8 (May 2017)
- Seismic Restraint Manual Guidelines for Mechanical Systems (SMACNA)
- ASCE 7 (American Society of Civil Engineers)
- FEMA (Federal Emergency Management Agency (412-413)
- ASHRAE

2. SEISMIC PROTECTION OF NON-STRUCTURAL COMPONENTS

2.1 BASIC TERMS

a. Transverse seismic restraints (T): These act to prevent the pipe or duct from swinging side-to-side. They are normally placed perpendicular to the pipe or duct. The word lateral is often used for transverse when describing these restraints.

b. Longitudinal seismic restraints (L): These act to prevent the pipe or duct from swinging back-and-forth along the length of the pipe or duct. They are usually placed parallel to the pipe or duct. The word axial is also used when describing this type of restraints

Rigid braces – these restraints carry both tension and compression loads along the axis of the strut. Only one pipe is required to restrain a pipe in one direction, either transverse or longitudinal. These types of restraints provide a rigid load path between the building and the pipe so that the pipe will move with the building, and there will be no relative displacement between the pipe or duct and the building at the restraint locations.

Cable Restraints (tension only braces) – these restraints carry only tension loads along the axis of the cable. They are used in pairs 180° apart to restrain the pipe or duct in one direction, either transverse or longitudinal. Here too, these types of restraints provide a rigid load path between the building and the pipe or duct so that the pipe or duct will move with the building, and there will

be no relative displacement between the pipe or duct and the building at the restraint locations.

2.2 HORIZONTAL SEISMIC DESIGN FORCE

While calculating Horizontal Seismic Design Force acting on the non-structural components below formula should be used based on the provisions found in ASCE/SEI 7-05

$$F_p = \left[\frac{0,4 \cdot a_p \cdot S_{DS} \cdot Wt.}{\frac{R_p}{I_p}} \right] \cdot \left[1 + \left(2 \cdot \frac{z}{h} \right) \right]$$

The maximum and minimum values for the design horizontal seismic force will be respectively;

$$0,3 \cdot S_{DS} \cdot I_p \cdot Wt. \leq F_p \leq 1,6 \cdot S_{DS} \cdot I_p \cdot Wt.$$

Where:

F_p = the design horizontal seismic force acting on a pipe or duct acting at its center of gravity.

S_{DS} = the short period design spectral acceleration.

a_p = the component amplification factor. This factor is a measure of how close to the natural period of the building the natural period of the component is expected to be. Typically this will vary from 1.0 to 2.5, and is specified by component type in ASCE/SEI 7-05

I_p = the component importance factor which be either 1.0 or 1.5.

W_p = the operating weight of the pipe or duct that is being restrained.

R_p = the response modification factor which usually will vary from 1.0 to 12.0. This factor is a measure of the ability of the component and its attachments to the structure to absorb energy. It is really a measure of how ductile or brittle the component and its attachments are. The values are specified by component type in ASCE/SEI 7-05

z = the structural attachment mounting height of the pipe or duct hanger in the building relative to the grade line of the building.

h = the average height of the building roof as measured from the grade line of the building.

3. REQUIREMENTS and EXCEPTIONS

3.1 PIPING

3.1.1 Seismic restraints are required for the following piping installations

- a) Medical gas, vacuum pipe, compressed air and other hazardous pipe 1" diameter and larger
- b) Fuel piping 1" diameter and larger
- c) All piping 1 1/4" diameter and larger in boiler rooms, mechanical equipment rooms and refrigeration mechanical rooms
- d) All piping 2 1/2" diameter and larger (*For Fire Protection piping refer to section 3.3.*)
- e) Trapeze supported pipe weighing 10 lbs/ft (14.86 kg) or more
- f) Trapeze supported piping that would require seismic bracing if supported individually.

(Note: All trapeze assemblies supporting pipes shall be braced considering the total weight of the pipes on the trapeze.)

3.1.2. REQUIREMENTS

- a) Transverse bracing shall be provided at 40 ft. maximum spacing for welded steel pipe, brazed copper pipe or grooved piping with UL 213 listed connections. Threaded steel or copper pipe or NON-LISTED UL grooved connections shall not exceed 20 ft. maximum.
- b) Longitudinal bracing shall be provided at 80 ft. maximum spacing for welded steel pipe, brazed copper pipe or grooved piping with UL 213 listed connections. Threaded steel or copper pipe or NON-LISTED UL grooved connections shall not exceed 40 ft. maximum.
- c) Cast iron, No-Hub, Plastic, FRP and other pipe or constructed of non-ductile material, shall have the maximum brace spacing reduced to one-half of the maximum brace spacing for welded steel or brazed copper pipe. Due to differences in pipe manufacturing and pipe connection types, maximum spacing may vary depending on pipe manufacturers' requirements.
- d) When determining horizontal load requirements, consider all pipes full of water unless calculated for other substances.
- e) Seismic bracing shall not limit the expansion and contraction of the piping system. When thermal expansion or contraction is involved, longitudinal bracing shall be designed at the anchor point of the piping system. The

longitudinal bracing and the connections must be capable of resisting the additional force induced by expansion and contraction.

- f) When bracing trapeze supports, the bracing shall be attached directly to the trapeze with piping secured to the trapeze with pipe straps or 2-pc clamps. A minimum of one transverse brace and /or two longitudinal braces is required.
- g) Bracing installed on smaller piping shall not be used to brace larger piping.
- h) At pipe risers, provide lateral restraint at the top and bottom of the riser, and intermediate points not to exceed 30 ft. spacing. For multiple floors, provide lateral restraint at each floor, not to exceed 30 ft. spacing. No-Hub Cast Iron pipe shall have riser joint brace assembly installed at each unsupported joint between floors. Individual vertical and lateral supports shall be designed for pipe risers in buildings with 6 or more floors.
- i) In case of using cable restraints for bracing piping UL[®] listed cables with color codes must be used. UL[®] listing must exist for seismic restraint applications.

3.1.3. EXCEPTIONS

All piping suspended by individual hanger rods 12 inches or less in length from the top of pipe to the bottom of the support structure where hanger is connected.

Trapeze supported systems suspended 12 inches or less from the top of the trapeze to the bottom of the support structure where trapeze is connected, provided that any changes in direction allow for flexibility in the system. Examples would be flexible connections to equipment or long offsets.

In both exceptions above, all of the hangers of a run must comply with the 12 inch rule or bracing is required.

The 12 inch rod rule exception has additional requirements;

- a) Lateral motion of the piping will not cause damaging impact with other systems (e.g. other pipe, duct, or electrical systems, equipment, structural members etc., or fragile appurtenances such as sprinkler heads or lighting fixtures) or loss of system vertical support.
- b) Piping must be made of ductile material with ductile connections (e.g. welded steel pipe, brazed copper pipe etc.)
- c) Vertical rod hanger top connections to the building structure cannot develop moments.

3.2 DUCTS

3.2.1 Seismic restraints are required for the following ducting installations

- a) All ducts containing hazardous gases or exhaust unless exempt by specification or engineer of record.
- b) All round ducts 28" (71 cm) in diameter and larger
- c) All square and rectangular ducts having a cross-sectional area of 6 sq. ft. (0.56 sq mt) or larger
- d) Equipment installed within a run of duct weighing 50 lbs (22.5 kg) or more and rigidly attached to duct or weighing 20 lbs (9 kg) or more and flexibly attached to duct.

3.2.2 REQUIREMENTS

- a) Transverse bracing shall be provided at 30 ft. maximum spacing for ducts conforming to SMACNA standards.
- b) Longitudinal bracing shall be provided at 60 ft. maximum spacing for ducts conforming to SMACNA standards.
- c) Fiberglass, Plastic or other duct constructed of non-ductile material, shall have the brace spacing reduced to one-half of the maximum spacing for transverse and longitudinal braces listed above.
- d) Duct bracing for square, rectangle or oval duct consists of a trapeze support with two support rods to carry the gravity dead load. The trapeze must have a support member connected to the top of the duct and to the bottom of duct. Both trapeze members are connected to the duct with #10 sheet metal screws spaced at maximum 12" O.C. Support rods may need to be stiffened. Transverse and/or longitudinal bracing is then attached to the top of the upper trapeze member.
- e) Floor penetrations may be considered transverse and longitudinal bracing when duct is framed tight and secure and change in direction does not exceed the maximum allowable offset length of two times the duct width as measured from the floor penetration to the inside of a 90 degree turn.
- f) In case of using cable restraints for ducting piping UL[®] listed cables with color codes must be used. UL[®] listing must exist for seismic restraint applications.

3.2.3 EXCEPTIONS

All ducts suspended by hanger straps 12 inches or less in length from the top of the duct to the bottom of the support structure where the hanger is connected. The strap hangers must be attached within 2 inches of the top of the duct with a minimum of two #10 sheet metal screws.

Trapeze supported systems suspended 12 inches or less from the top of the trapeze to the bottom of the support structure where trapeze is connected provided that any changes in direction allow for flexibility in the system. Examples would be flexible connections to equipment or long offsets.

In both exceptions above, all of the hangers in a run must comply with the 12 inch rule or bracing is required.

3.3 FIRE PROTECTION SYSTEM

The system piping shall be braced to resist both lateral and longitudinal horizontal seismic loads and to prevent vertical motion resulting from seismic loads.

The structural components to which bracing is attached shall be determined to be capable of resisting the added applied seismic loads. Horizontal loads on system piping shall be determined in accordance with section 2.2.

Seismic bracing to be used on fire protection system piping must include an UL/FM Approved pipe attached component (seismic pipe clamp) and an UL/FM Approved structure attached component having a proper anchor to the structure with a diagonal brace member capable of resisting tension and compression between, which can be used to brace horizontal piping in either the lateral or longitudinal direction or can be configured in pairs to act as a four-way brace on vertical piping,

3.3.1 REQUIREMENTS

- a) Provide lateral sway bracing on 2½ in. (65 mm) diameter and larger branch lines and portions of branch lines that are greater than 20 ft (6.1 m) in length in accordance with the following guidelines. All seismic bracing components including concrete or steel structure attachments and pipe attachments which are directly attached to the service pipe must be UL/FM approved.

1. Provide lateral sway bracing on straight runs of branch line spaced at a maximum of 40 ft (12.2 m).

2. For branch lines less than 4 in. (100 mm) in diameter, lateral sway bracing is not needed on pipes individually supported by rods that meet the following criteria:

All rods have a length less than 6 in. (150 mm) from the supporting member attachment to the top of the branch line, and

There is no more than 1/2 in. (13 mm) of space between the top of the branch line piping and the bottom of the support rod.

3. A four-way brace on a vertical pipe (e.g., at the bottom of a drop) may be counted as the initial lateral brace for the attached horizontal branch line of the same or smaller diameter when the brace is located within 2 ft (0.6 m) of the horizontal pipe.
 4. A longitudinal brace within 2 ft (0.6 m) of the end of a branch line connection to another branch line that is perpendicular and of the same or lesser diameter may be used to also act as a lateral brace for the perpendicular branch line.
 5. When more flexible couplings are installed on branch lines, provide additional lateral sway bracing: within 2 ft (0.6 m) of every other flexible coupling on straight pipe runs, and within 2 ft (0.6 m) of any horizontal change of pipe direction having flexible couplings.
 6. Locate the first lateral sway brace on a branch line no closer than 10 ft (3.1 m) nor greater than 40 ft (12.2 m), including all vertical and horizontal branch line section lengths, from the branch line connection to the cross main.
 7. For dead-end branch lines locate the last lateral brace not more than 6 ft (1.8 m) from the end. Consider seismic separation assemblies and flexible pipe loops as the end of the piping on both sides of the assembly or loop.
 8. Locate a lateral brace on branch lines not more than 6 ft (1.8 m) from horizontal changes in direction.
- b) Provide longitudinal sway bracing on 2 1/2 in. (65 mm) diameter and larger branch lines and portions of branch lines that are greater than 40 ft (12.2 m) in length in accordance with the following guidelines. All seismic bracing components including concrete or steel structure attachments and pipe attachments which are directly attached to the service pipe must be UL/FM approved.
1. Provide longitudinal sway bracing on straight runs of branch line spaced at a maximum of 80 ft (24.4 m).

2. A four-way brace on a vertical pipe (e.g., at the bottom of a drop) may be counted as the initial longitudinal brace for the attached horizontal branch line of the same or smaller diameter when the brace is located within 2 ft (0.6 m) of the horizontal pipe.
3. A lateral brace within 2 ft (0.6 m) of the end of a branch line connection to another branch line that is perpendicular and of the same or lesser diameter may be used to also act as a longitudinal brace for the perpendicular branch line.
4. Locate the first branch line longitudinal sway brace closest to the cross main between 20 ft and 80 ft (6.1 m and 24.4 m), including all vertical and horizontal branch line section lengths, from the branch line connection to the cross main.
5. For dead-end branch lines, locate the last longitudinal brace not more than 40 ft (12.2 m) from the end. Consider seismic separation assemblies and flexible pipe loops as the end of the piping on both sides of the assembly or loop.
6. E. Locate a longitudinal brace on branch lines not more than 40 ft (12.2 m) from horizontal changes in direction.

c) Provide adequately sized and configured bracing on sprinkler system risers, whether they are single or manifolded type and regardless of size, in accordance with the following guidelines. All seismic bracing components including concrete or steel structure attachments and pipe attachments which are directly attached to the service pipe must be UL/FM approved.

1. Provide a four-way sway brace within 2 ft (0.6 m) of the top of each riser. When possible, avoid the use of a single manifolded sway bracing assembly at the top of multiple adjacent risers. If used, limit the manifolded arrangement to two risers
2. In multistory buildings, provide a four-way brace on the riser within 2 ft (0.6 m) of each building floor level. A four-way brace can be considered to exist when the riser passes through a structural floor and clearances do not allow more than ½ in. (13 mm) movement in any horizontal direction.

3. Provide additional intermediate four-way sway bracing on risers at an interval not to exceed 40 ft (12.2 m). Where flexible couplings are used, arrange this intermediate four-way sway bracing so a brace is provided within 2 ft (0.6 m) of every other flexible coupling (adding four-way braces if necessary). For risers in multistory buildings or towers that have attached feed or cross mains not located at floor levels, add four-way braces if necessary such that a brace is provided within 2 ft (0.6 m) of these mains.
4. For risers fed from horizontal manifold piping, provide a two-way lateral sway brace within 2 ft (0.6 m) of the end of any horizontal manifold piping longer than 6 ft (1.8 m), or when any flexible couplings are used on either the horizontal manifold piping or on the riser stub between the floor and the connection to the horizontal manifold piping.

d) Branch Line Restraints

For sprinkler system branch lines that do not require lateral bracing (i.e., those with diameters less than 2½ in. [65 mm]), provide a short hanger or a lateral restraint not more than 6 ft (1.8 m) from the end of dead-end branch lines to control lateral deflections at that location. All restraints elements including concrete or steel structure attachments and pipe attachments which are directly attached to the service pipe must be UL/FM approved.

3.4 ELECTRICAL SYSTEM COMPONENTS

3.4.1 Seismic restraints are required for the following electrical installations:

- a) All conduits 2-1/2" diameter and larger.
- b) All conduits, cable trays and trapeze assemblies weighing 10 lbs./ft. or greater.
- c) All conduits 3" diameter and larger where I_p is equal to or greater than 1.0

3.4.2 REQUIREMENTS

- a) Transverse bracing shall be provided at 40 ft. maximum spacing.
- b) Longitudinal bracing shall be provided at 80 ft. maximum spacing.

- c) Conduits constructed of non-ductile materials shall have the brace spacing reduced to one half of the maximum spacing for transverse and longitudinal braces listed above.
- d) When bracing trapeze supports, the bracing shall be attached directly to the trapeze, with conduits or cable trays secured to the trapeze with straps, conduit clamps, or cable tray clips bolted to strut channel. A minimum of one transverse brace and /or two longitudinal braces is required
- e) In case of using cable restraints for bracing non structural electrical components, UL® listed cables with color codes must be used. UL® listing must exist for seismic restraint applications.

3.4.3 EXCEPTIONS

All conduit or cable trays suspended by individual hanger rods 12 inches or less in length from the top of the conduit to the bottom of the support structure where hanger is connected.

Trapeze supported systems suspended 12 inches or less from the top of the trapeze to the bottom of the support structure where trapeze is connected, provided that any changes in direction allow for flexibility in the system. Examples would be flexible connections to equipment or long offsets.

In both exceptions above, all of the hangers of a run must comply with the 12 inch rule or bracing is required.

The 12 inch rod rule exception has additional requirements , they are as follows:

- a) Lateral motion of the electrical system will not cause damaging impact with other systems (e.g. other electrical systems, piping, duct, equipment, structural members etc., or fragile appurtenances such as sprinkler heads or lighting fixtures) or loss of system vertical support.
- b) Electrical system must be made of ductile material with ductile connections.
- c) Vertical hanger top connection to the building structure cannot develop moments

3.5 SEISMIC PROTECTION OF EQUIPMENTS

Provide seismic protection for HVAC, MEP, Fire Protection and Electrical distribution equipments in accordance with the following guidelines.

- a) Calculate the design horizontal seismic load acting on the equipment.
- b) Equipment may be bolted or welded to the building floor or pad. To bolt to concrete, use post installed anchors, embedded headed studs or embedded J bolts.
- c) Use additional seismic snubbers if the desired anchors are insufficient for the calculated design horizontal load.
- d) For equipments desired to be vibration isolated, use seismic vibration isolators which are sufficient against the the calculated design horizontal load.
- e) For suspended components, brace the component with UL[®] listed cables with color codes regarding the the calculated design horizontal load.

4 SEISMIC PROTECTION ELEMENTS TO BE USED

4.1 Seismic Restraint Cables

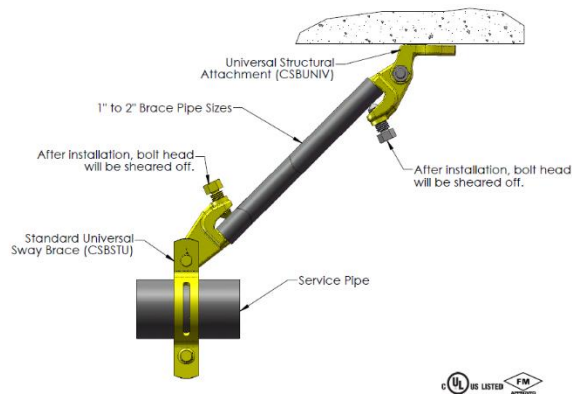
All cables to be used for seismic protection of non-structural MEP and HVAC Pipes, ducts, conduits and busbars must be with UL[®] listed cables with color codes. UL[®] listing must exist for seismic restraint applications. Necessary UL listings must be provided by the supplier. Wedge type fittings are not allowed to be used while installing the cables, the cables must be swagged for mounting. Fittings and sleeves must have a breaking strength equal to the breaking strength of the corresponding seismic cable. See below table

4.2 Standart Universal Sway Brace

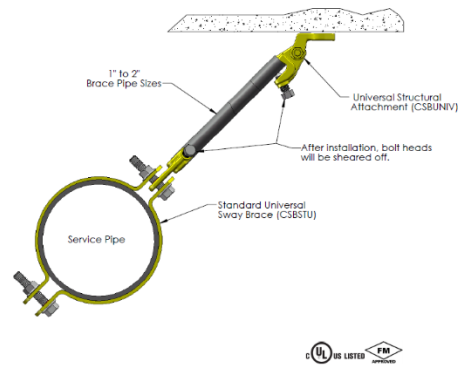
UL/FM approved rigid seismic bracing elements to be used for seismic protection of Fire Protection System piping. All elements including the clamps which are directly attached to the service pipe must UL/FM approved. Necessary UL listings and FM approvals must be provided by the supplier.

4.3 Universal Structural Attachments

UL/FM approved structural bracing element used for attachment of standard universal sway braces on concrete or steel structure. All elements must UL/FM approved. Necessary UL listings and FM approvals must be provided by the supplier.



Longitudinal Sway Bracing
Fire Protection Service Pipe



Lateral Sway Bracing for
Fire Protection Service Pipe

4.4 Branch Line Restraints

UL/FM approved branch line restraints elements including UL/FM approved structural attachments for concrete and steel structure and UL/FM approved direct pipe attachment. Necessary UL listings and FM approvals must be provided by the supplier.

4.5 Seismic Snubbers.

Seismic snubbers from structural steel or ready to use seismic snubbers sufficient to withstand against the calculated design horizontal load. Load capacities must be documented by the supplier showing that the snubbers are sufficient to withstand against the calculated design horizontal load.

4.6 Seismic Vibration Isolators

Seismic vibration isolators to be used for seismic protection of vibration generating equipment. Load capacities must be documented by the supplier showing that the isolators are sufficient to withstand against the calculated design horizontal load.