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I1.1 – Seismic Restraint Categories and Types:

Seismic restraints for pipe and duct are generally separated into to two categories.

1. Transverse Seismic Restraints: These act to keep the pipe or duct from swinging side-to-side. They are normally placed so that they act perpendicular, at right angles, to the pipe or duct, as shown in Figure I1-1. These seismic restraints are located at, or very near, the pipe or duct hangers. If the restraints are not attached directly to the hanger, they may be attached to the pipe or duct with in four (4) inches of the hanger location. This is so that any vertical reaction loads from the restraints go to the structure directly through the hanger and not the pipe or duct.

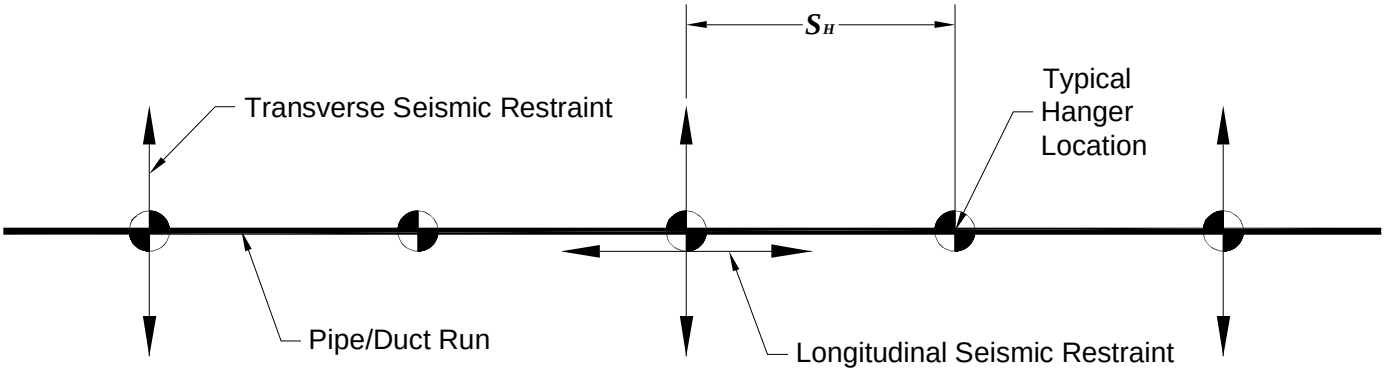

Figure I1-1; Definition of Transverse and Longitudinal Seismic Restraints

2. Longitudinal Seismic Restraints: These act to keep the pipe or duct from swinging back-and –forth along the length of the pipe or duct. Typically, they are placed parallel to, or along, the length of the pipe or duct, as shown in Figure I1-1. The seismic restraints are also located at, or very near, the hanger locations of the pipe or duct for the same reason stated above.

Seismic restraints may be further broken down into two basic types based on the way they work.

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1. Strut Restraints (Rigid Braces) – these restraints carry both tension (pull) and compression (push) loads along the axis of the strut. Only one strut is required to restrain a pipe or duct in one direction, either transverse or longitudinal. These restraints are normally constructed of a structural member with attachment brackets on either end for the structure and the pipe or duct. The common structural members that are used are, AISI rolled angles, pipe, conduit, and UNISTRUT™ channels. ***Caution*** must be used when applying this type of restraint. The seismic forces will produce both tensile and compressive reactions in the hanger rod that may equal or exceed the dead load of the pipe or duct. In other words, the seismic forces acting on the strut restraints may be capable of ***breaking the hanger rod***, or ***pulling the rod anchor out of the structure***. If strut restraints are to be used, the engineer of record needs to be informed. The hanger rods and rod anchors may need to be increased in size and capacity to carry the additional tensile reaction loads in the hanger rod generated by the seismic forces.
2. Cable Restraints (Tension Only Braces) – these restraints can carry only tension (pull) loads along the length of the able. They must be used in pairs where the cables are oriented ~180° apart to keep the pipe or duct from moving back-and-forth. Remember, ***you can't push a rope***, so there must be two cables for each restraint location and direction, transverse and longitudinal. The seismic forces in the restraint cables will produce only compressive reaction loads in the hanger rods.

I1.2 – Drawing Symbols:

On the drawings provided by Kinetics Noise Control the symbols shown in Figure I1-2 are used to indicate the approximate locations of the seismic restraints required for a run of pipe or duct. For duct or single clevis hung pipe the seismic restraint location is shown as a single large dot. For trapeze supported pipe, the symbol used is an "**I**" shaped bar centered on a large dot. The "**I**" shaped bar will extend on either side of the central dot to cover all of the pipes that are assumed to be supported on the trapeze bar.

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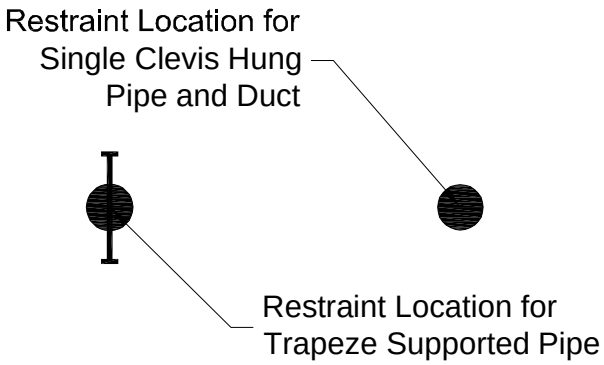

Figure I1-2; Kinetics Noise Control Restraint Location Symbols

The category of the restraint indicated for each location along with the restraint kit and the anchorage (structural attachment) hardware kit for the project's seismic conditions are shown by the symbol in Figure I1-3. The symbol at a location (**T**) indicates that the restraint is a transverse restraint, the symbol (**L**) indicates that the restraint is to be a longitudinal restraint, and symbol (**TL**) indicates that both transverse and longitudinal restraints are required for that location.

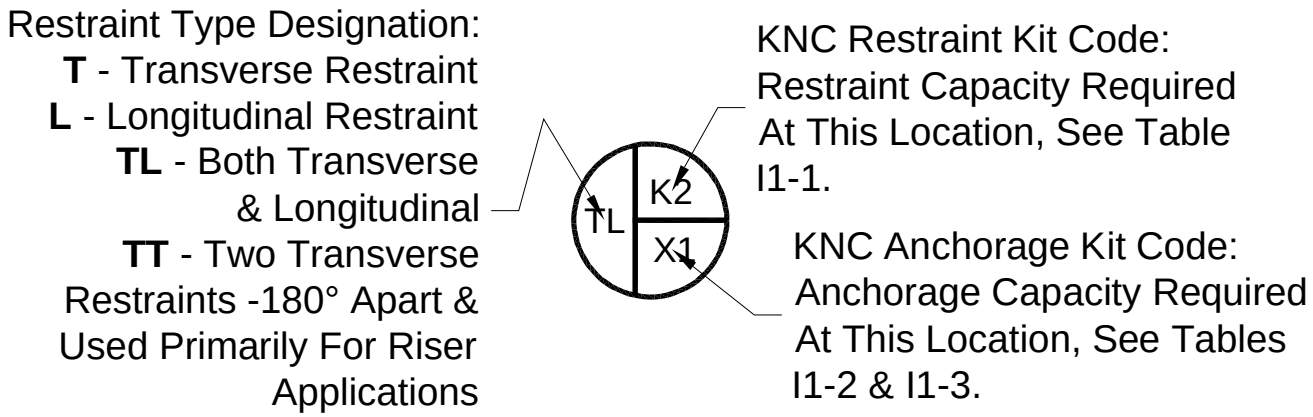

Figure I1-3; Kinetics Noise Control Restraint Kit and Anchorage Kit Symbol

The seismic restraint kits provided by Kinetics Noise Control along with the code designations used on the drawings provided by Kinetics Noise Control are shown in Table I1-1. Each kit contains enough components to make two complete seismic restraint cable assemblies. The brackets supplied with each kit may be used to make one seismic restraint strut assembly with the

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structural member being provided by others. Tables I1-2 and I1-3 list the code designations for the various anchorage kits provided by Kinetics Noise Control for anchorage to concrete/steel and wood/steel respectively. Each anchorage kit will contain enough hardware of the correct size and grade to attach the restraint kit to concrete, steel, or wood. For restraint cable kits the hardware is divided equally between the two cable assemblies. These same hardware kits may also be used with strut restraints that have the same capacity as the cable restraints for which the anchorage kit was recommended.

Table I1-1; Seismic Restraint Cable Kit vs. Code Cross-Reference

KNC Restraint Kit Code	Restraint Kit Description Note: Each kit contains enough components for (2) complete seismic restraint cable assemblies or (1) complete seismic restraint strut assembly with the structural member by others.
K2	KSCU-2 Cable Kit – 2 mm or 1/8″ Cable & Appropriate Connectors
K3	KSCU-3 Cable Kit – 3 mm or 1/8″ Cable & Appropriate Connectors
K4	KSCU-4 Cable Kit – 5 mm Cable 3/16″ & Appropriate Connectors
K5	KSCU-5 Cable Kit – 6 mm or 1/4″ Cable & Appropriate Connectors
C1	KSCC-250 Cable Kit – 1/4″ Cable & Saddle + U-bolt Connectors
C2	KSCC-375 Cable Kit – 3/8″ Cable & Saddle + U-bolt Connectors
C3	KSCC-500 Cable Kit – 1/2″ Cable & Saddle + U-bolt Connectors
F	Direct Mounted to Floor or Roof Using Anchor Bolts
W	Direct Mounted to Wall Using Anchor Bolts

I1.3 – Seismic Restraint Spacings:

This part will discuss the seismic restraint spacings typically used by Kinetics Noise Control. First, the following definitions will be helpful.

S_H = the pipe or duct hanger spacing.

S_L = the calculated spacing for the longitudinal seismic restraints marked as (**L**).

S_T = the calculated spacing transverse seismic restraints marked as (**T**).

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Table I1-2; Structural Concrete/Steel Anchorage Kit vs. Code Cross-Reference

KNC Attachment Kit Code	Anchorage Kit Description per Restraint Cable Kit Note: Through bolts & nuts of the same size may be used for each kit and code shown below.
X1	(2) 1/4″ Concrete Anchor (with Grommet)
X2	(2) 3/8″ Concrete Anchor (with Grommet)
X3	(2) 1/2″ Concrete Anchor
Y1	(2) 5/8″ Concrete Anchor
Y2	(2) 3/4″ Concrete Anchor
Y3	(2) 7/8″ Concrete Anchor
Z1	(4) 3/8″ Concrete Anchors with Oversized Base Plate
Z2	(8) 3/8″ Concrete Anchors with Oversized Base Plate
Z3	(4) 1/2″ Concrete Anchors with Oversized Base Plate
Z4	(8) 1/2″ Concrete Anchors with Oversized Base Plate

Table I1-3; Structural Wood/Steel Anchorage Kit vs. Code Cross-Reference

KNC Attachment Kit Code	Anchorage Kit Description per Restraint Cable Kit Note: Through bolts & nuts of the same size may be used for each kit and code shown below.
W1	(2) 1/4″ Lag Screw (with Grommet)
W2	(2) 3/8″ Lag Screw (with Grommet)
W3	(2) 1/2″ Lag Screw
W4	(2) 5/8″ Lag Screw
W5	(2) 3/4″ Lag Screw
W6	(2) 7/8″ Lag Screw
W7	(4) 3/8″ Lag Screws with Oversized Base Plate
W8	(8) 3/8″ Lag Screws with Oversized Base Plate
W9	(4) 1/2″ Lag Screws with Oversized Base Plate
W10	(8) 1/2″ Lag Screws with Oversized Base Plate

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As mentioned above, the seismic restraint locations must be at, or very near, the pipe or duct hangers. So, the actual seismic restraint spacing will be some multiple of the actual hanger spacing. The longitudinal seismic restraint spacing may be equal to the transverse seismic restraint spacing, or it may be twice the transverse seismic restraint spacing depending on the seismic conditions and the weight per foot of the pipe or duct that is being restrained. The seismic restraint industry has historically relied on the recommendations of SMACNA for specifying the proper seismic restraint spacings. Table I1-4 shows the typical seismic restraint spacings used by Kinetics Noise Control when creating the drawings showing the seismic restraints and their approximate locations for a run of pipe or duct.

Table I1-4; Typical Seismic Restraint Spacings Used by Kinetics Noise Control

Transverse Seismic Restraint Spacing S_T (ft.)	Longitudinal Seismic Restraint Spacing S_L (ft.)	Comments on Maximum Allowable Restraint Spacings
10	10	Maximum Allowable Spacings for Low Deformability (Brittle) Piping.
10	20	Other Optional Spacings Used to Extend the Useful Range of Application for Specific Restraints.
15	30	
20	40	Maximum Allowable Restraint Spacings for Hazardous Gas Piping.
30	60	Maximum Allowable Restraint Spacings for Ductwork.
40	80	Maximum Allowable Restraint Spacings for HVAC & Plumbing Piping.

Kinetics Noise Control makes every possible effort to ensure that their drawings are to the scale indicated, so the approximate restraint locations make be determined on the job site by scaling the drawing. The locations are approximate because the engineers at Kinetics Noise Control have no way of knowing the exact location of the hangers, other components, and structure not shown on the drawings provided to them. As long as the illustrated restraint spacings are not exceeded, the exact location of the restraints along the run of pipe or duct is not critical as long as the restraints coincide with a hanger. This means that in some instances (when restraint spacing is not an even

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multiple of the support spacing), one or two extra restraint kits may be required for a run of pipe or duct.

Many project specifications call for standard hanger spacings of 5 ft. or 10 ft. for all pipe and duct. These hanger spacings work very well with those recommended by SMACNA and Kinetics Noise Control. There are some instances where a different hanger spacing may be required or specified. If for instance the specified hanger spacing was 8 ft. and the transverse and longitudinal restraint spacing specified by Kinetics Noise Control was 20 ft. and 40 ft. respectively, the transverse restraint spacing for the project would be 16 ft. and the project longitudinal spacing would be 32 ft. For this case, extra restraint kits would be required for any pipe or duct runs where the hangers were spaced at 8 ft.

I1.4 – Examples of How Kinetics Noise Control Drawing Symbols are used:

For single clevis hung pipe, a typical run of pipe will be marked for seismic restraint and anchorage kits as shown in Figure I1-4. Notice that every location with a longitudinal seismic restraint will also have a transverse seismic restraint. This is true for virtually all cases of seismic restraint for pipe and duct. The two restraint callouts at the corner are for transverse seismic restraints. If these transverse seismic restraints can be located within 24 in. (2 ft.) of the corner, the transverse restraint in on one leg will serve as the longitudinal restraint on the other leg. Kinetics Noise Control will always assume that a hanger can be placed within 24 in. of the corner and mark the drawings accordingly. If these restraints can not be located close enough to the corner, additional kits may be required to provide restraint in the longitudinal direction for each leg. Note that in all cases the seismic restraint kits will all be K3, KCSU-3. These kits have 1/8″ or 3mm cables with connectors provided by Kinetics Noise Control. The anchorage kits will all be X2, 3/8 in. concrete anchors and 3/8-16 UNC bolts.

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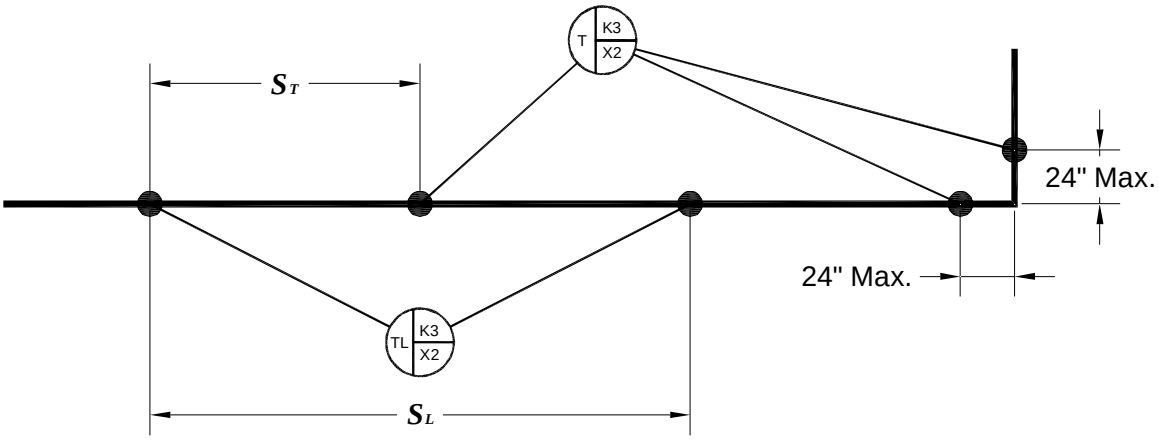

Figure I1-4; Typical Kinetics Noise Control Seismic Restraint Kit and Anchorage Kit, and Location Callouts for Single Clevis Hung Pipe

A typical run of trapeze supported pipe is shown with the approximate locations and callouts for the seismic restraint is shown below in Figure I1-5.

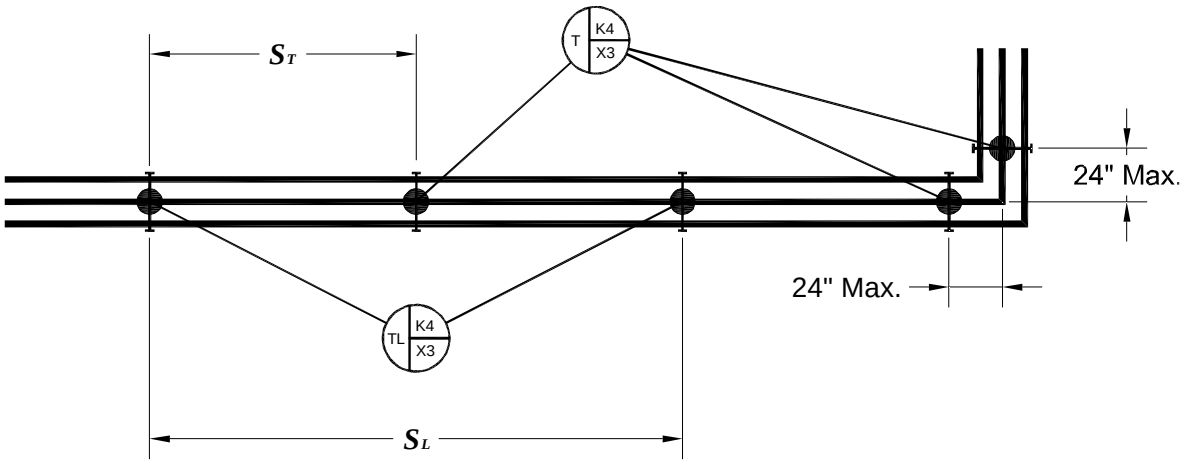

Figure I1-5; Typical Kinetics Noise Control Seismic Restraint Kit and Anchorage Kit, and Location Callouts for Trapeze Supported Pipe

The "**I**" bars indicate that these three pipes are assumed to be supported on the same set of trapeze bars. Unless otherwise instructed, Kinetics Noise Control assumes that runs of pipes that lie parallel and very close together are supported on the same set of trapeze bars. If the actual pipe runs are single clevis hung, more restraints will be required. Note that the restraint kits are

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K4, KSCU-4. These kits contain 5 mm or 3/16″cables and appropriate connectors. The anchorage kits are X3, 1/2 in. concrete anchors and 1/2-13 UNC bolts. The seismic restraint kits and anchorage kits have much higher capacities than the ones called out for the previous example in Figure I1-4. Assuming the two figures are of similar scale and that the pipe sizes are similar, this makes sense. The seismic restraint and anchorage requirements are based on the weight of the pipe or duct that is being restrained, and all other things being equal, three pipes will weight much more than one pipe of a similar size, and will require larger cable and anchors to keep them from swinging side-to-side, or back-and-forth.

For pipe runs supported by trapeze bars, the longitudinal restraints must be arranged to prevent the pipes from being twisted by the seismic forces. In some instances, an extra restraint kit may be required per longitudinal restraint location. This will be discussed further in the next section.

Figure I1-7 shows the seismic restraint callouts and approximate locations for a typical run of duct.

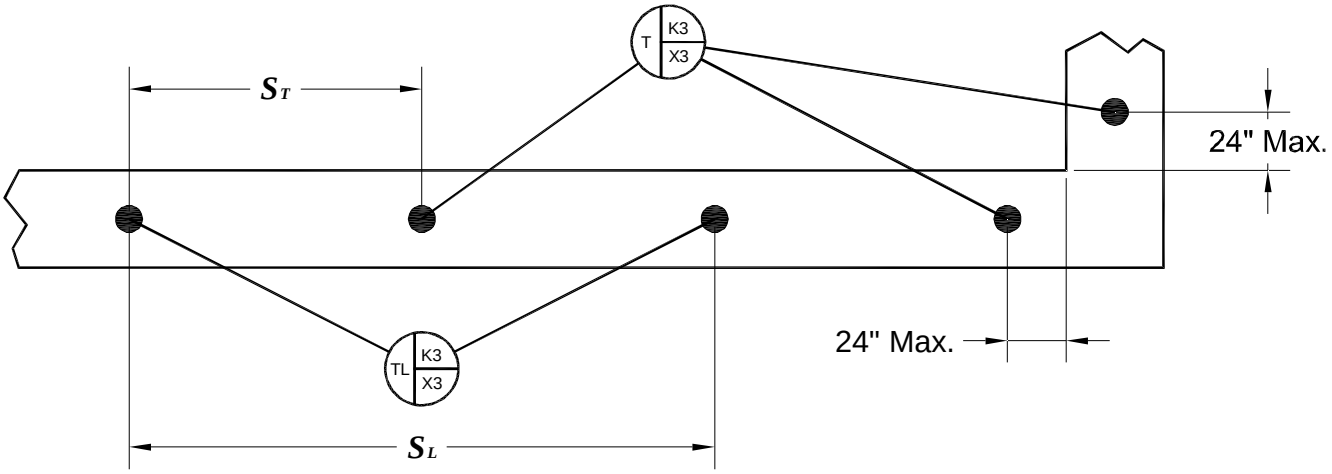

Figure I1-6; Typical Kinetics Noise Control Seismic Restraint Kit and Anchorage Kit, and Location Callouts for Duct

Rectangular duct is normally supported on some type of trapeze bar arrangement. As with the trapeze supported pipe runs, this may require some special arrangements and potentially extra

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cable kits per longitudinal restraint location to keep the duct from being twisted by the seismic forces. See the next part for a more complete discussion of this issue.

I1.5 – Typical Seismic Restraint Arrangements for Single Clevis Hung Pipe:

In this section the basic installation arrangements for pipe and duct will be discussed. This is by no means a complete treatment of the subject. There are many different arrangement for supporting and restraining pipe and duct, and whenever it appears that all of them have been covered a new situation develops that requires new and innovative ways for supporting and restraining the runs of pipe and duct. This section will show just the basic arrangements. More arrangements are shown in a set of drawings, SS-20070950 Sheets A through G, that are sent out with each order shipment of seismic restraint and anchorage kits. If the drawings are not part of the order shipment, or available from the authorized representative of Kinetics Noise Control, they are available directly from Kinetics Noise Control.

Figures I1-7 through I1-9 show single clevis hung pipes with transverse cable restraints. The installation shown in Figure I1-7 is typical for cable restraints. The recommended installation angle for the cable restraints is 45° when measured against the horizontal. Note that a clear distance on either side of the hanger rod approximately equal to the hanger rod length will be required to make the attachment to the roof or floor structure above. Also, between the pipe run attachment and the structural attachment, the cable restraint ***can not*** touch any other component or structure. In normal practice, the installation angle is allowed to vary down to 30° and up to a maximum of 60°. Figure I1-8 is a typical single clevis hung pipe with transverse seismic cable restraints that are installed at 30°. Note that twice as much space on either side of the hanger rod is required for seismic restraints with a 30° installation angle as those seismic restraints which have a 45° installation angle. Installation angles greater than 30° will require increasingly more clear room for installation; which is not normally available in most buildings.

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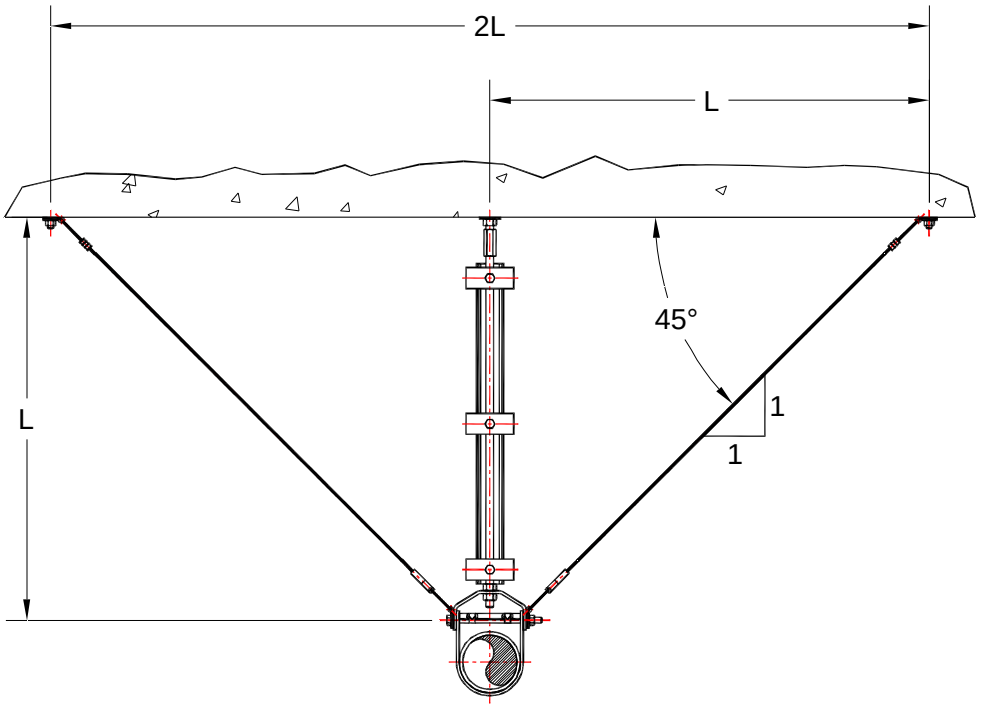

Figure I1-7; Single Clevis Hung Pipe with Typical Transverse Seismic Cable Restraints @ 45°

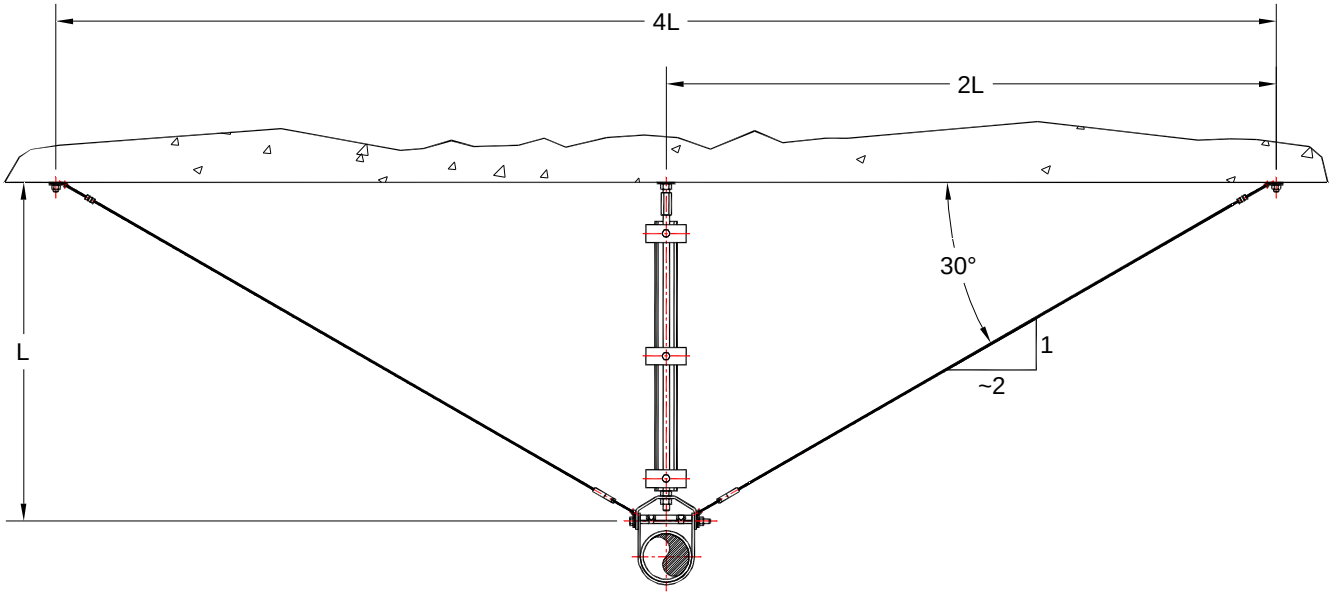

Figure I1-8; Single Clevis Hung Pipe with Typical Transverse Seismic Cable Restraints @ 30°

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Figure I1-9 is a typical single clevis hung pipe with transverse seismic cable restraints that are installed at 60°. Here, half as much space on either side of the hanger rod is required for seismic restraints with a 60° installation angle as those seismic restraints which have a 45° installation angle. No installation angles greater than 60° are permitted as there will be almost no restraint benefit from the cables; the pipe will simply swing side-to-side on the cables and hanger rod with little or no resistance.

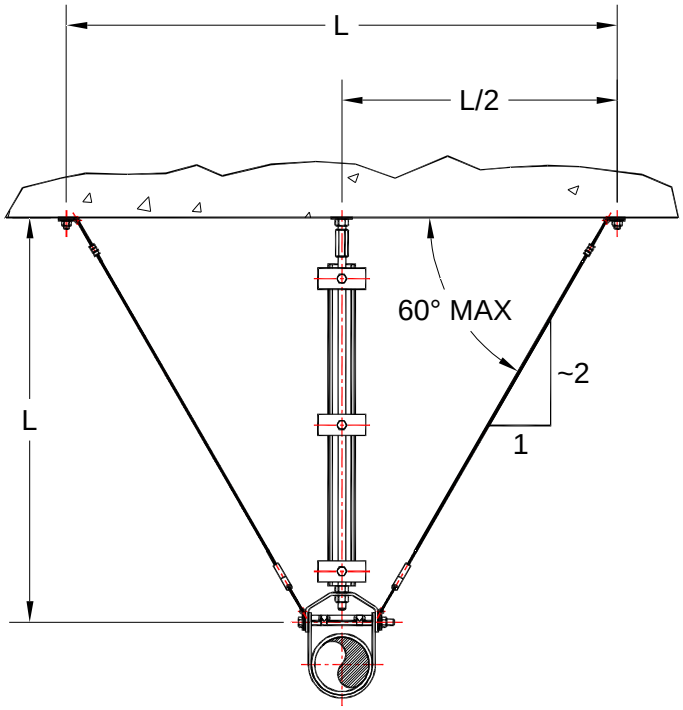

Figure I1-9; Single Clevis Hung Pipe with Typical Transverse Seismic Cable Restraints @ 60°

All three of the cases shown in Figures I1-7 through I1-9 assume that the structural anchorage will be made to the roof or floor structure above. The structural attachment may also be made to walls, beams, and or columns. These attachments will need to be approved by the structural engineer since the roof, floor, walls, columns, and beams were designed without knowledge of the exact placement of the seismic restraints. The use of strut restraints can cut the space required along side the pipe or duct for installing these restraints basically in half, which is probably their one big benefit.

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For single clevis hung pipe, the longitudinal restraints may be installed similar to that shown in Figure I1-10. A more detailed set of views for this arrangement is shown in Figure I1-11.

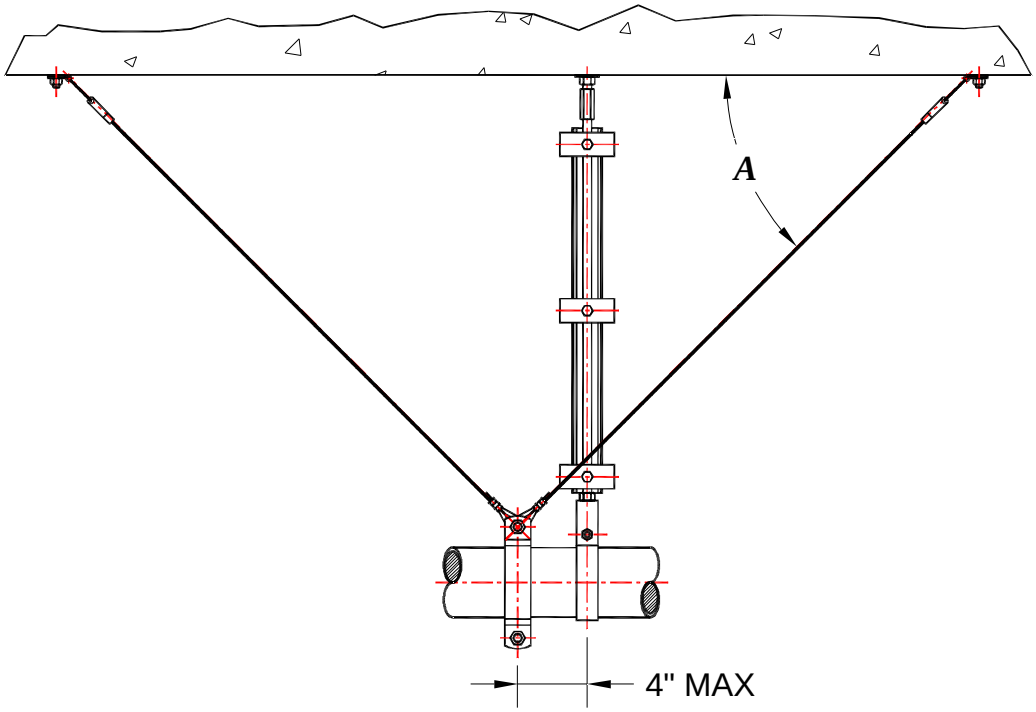

Figure I1-10; Single Clevis Hung Pipe with Typical Longitudinal Seismic Cable Restraints

These two figures show the longitudinal seismic restraints attached directly to the pipe with in 4 inches of the hanger location. The longitudinal restraints may also be attached to the clevis hanger, but some physical means to keep the pipe from sliding back-and-forth in the hanger must be used. Figure I1-11 shows that the pipe clamp is to be rotated slightly to allow the restraints to miss the hanger rod and any rod stiffener that may be in its path. Strut type longitudinal restraints may also be attached to the pipe with a pipe clamp. As with the transverse restraints, the installation angle may vary from 30° up to a maximum of 60°.

If the pipe is insulated it is good practice to clamp directly to the pipe and insulate over the clamp. Clamping seismic restraints to the pipe over the insulation could damage the insulation during installation, and will typically not remain secure during an earthquake.

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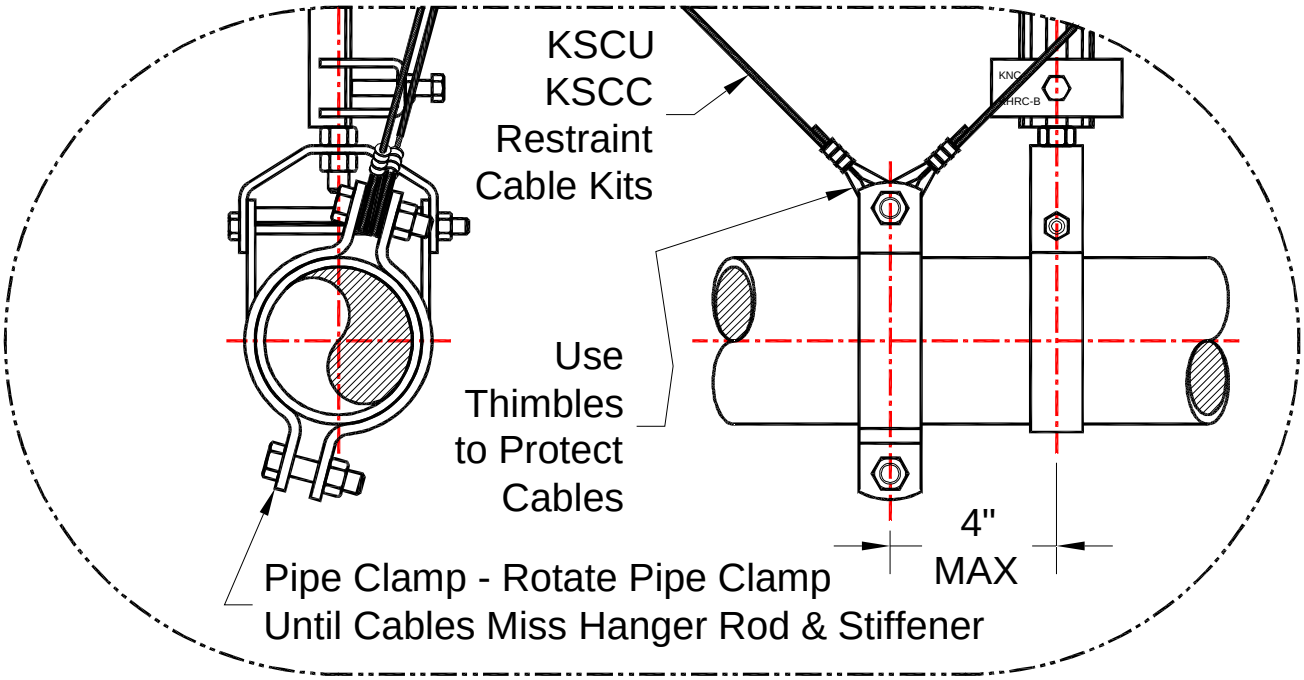

Figure I1-11; Typical Detail of Longitudinal Seismic Cable Restraints for Single Clevis Hung Pipe

I1.6 – Typical Seismic Restraint Arrangements for Trapeze Supported Pipe and Duct:

Typical transverse seismic restraint arrangements for trapeze supported pipe and duct are shown in Figures I1-12 and I1-13 respectively. Many more potential arrangements are shown in drawing SS-20070957 Sheets A1 and A2 provided by Kinetics Noise Control.

How the longitudinal restraints are applied to trapeze supported pipe and duct will determine whether additional restraints are required beyond those indicated in the Material Required List provided by Kinetics Noise Control. As much as practical Kinetics Noise Control design restraint installations that will require the fewest number of restraint kits. The longitudinal restraints for trapeze supported pipe and duct must be installed to balance the loads on the trapeze bar, and pipe or duct. This condition is best illustrated using plan views of the trapeze supported pipe and duct. Figures I1-14 and I1-15 show three plan views each for trapeze supported pipe and duct, respectively, with restraint locations requiring both transverse and longitudinal seismic restraints.

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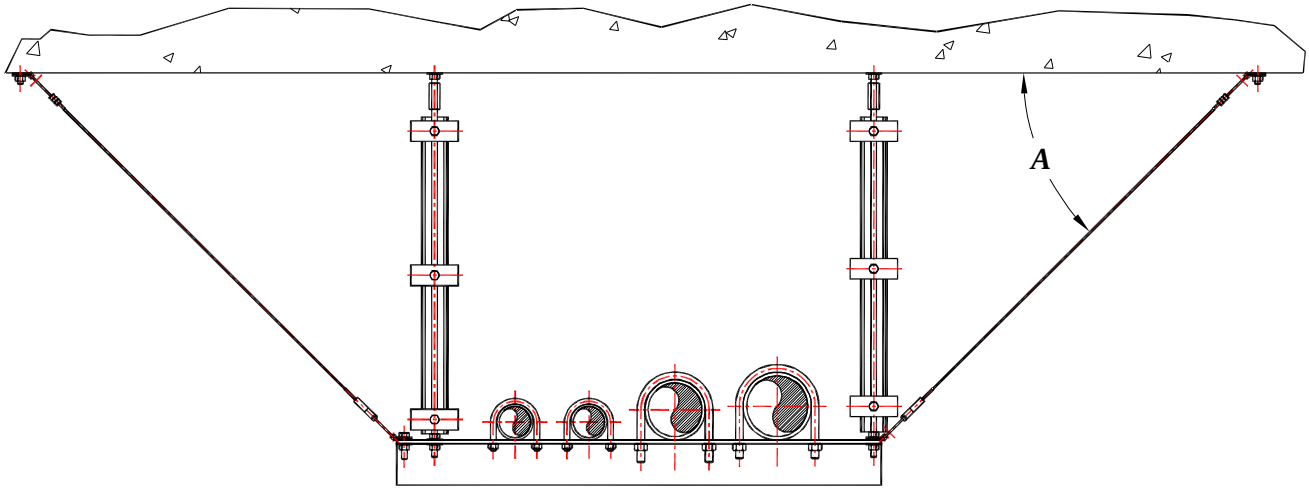

Figure I1-12; Typical Transverse Seismic Restraint Arrangement for Trapeze Supported Pipe

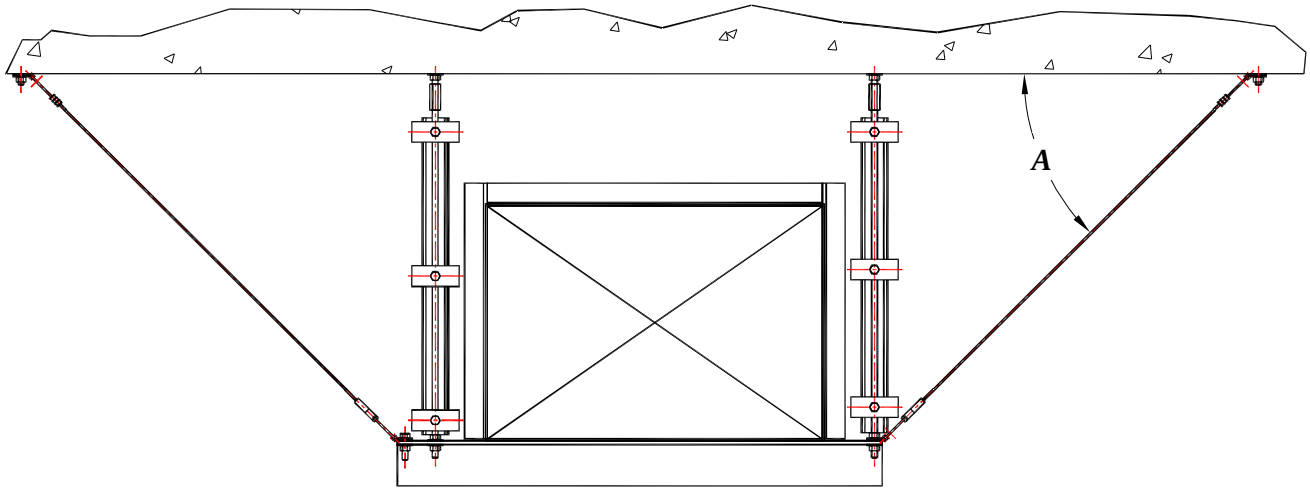

Figure I1-13; Typical Transverse Seismic Restraint Arrangement for Trapeze Supported Duct

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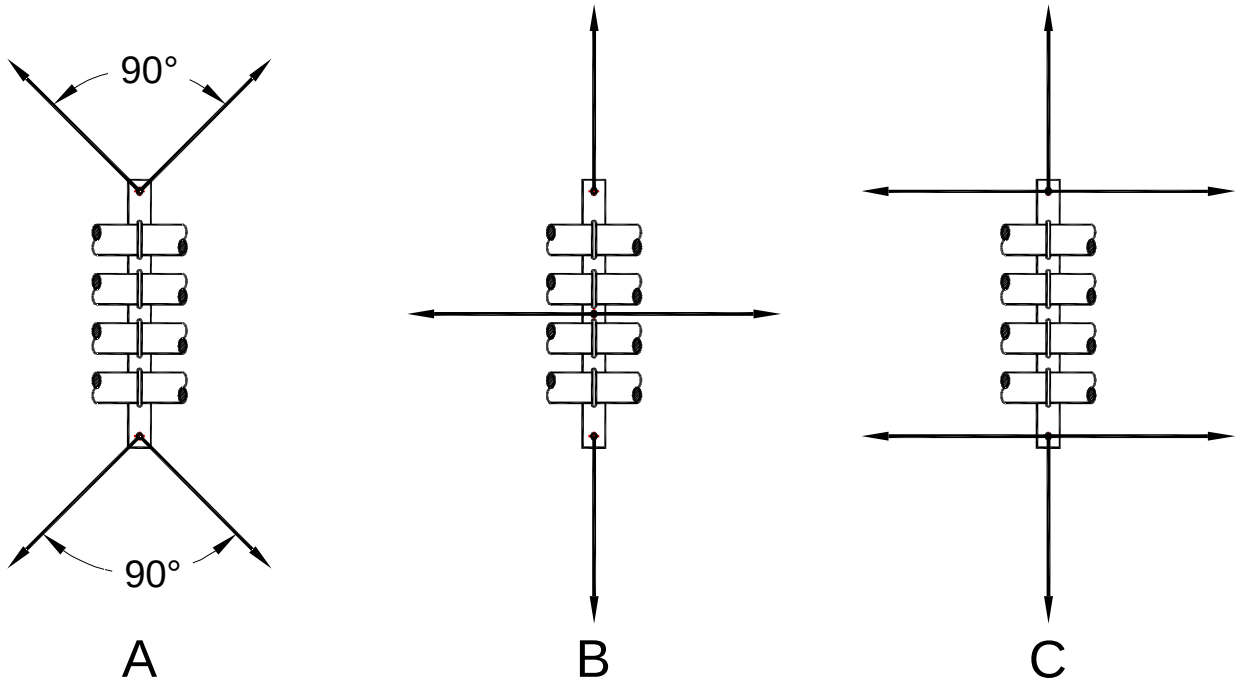

Figure I1-14; Balanced Longitudinal Seismic Restraints for Trapeze Supported Pipe

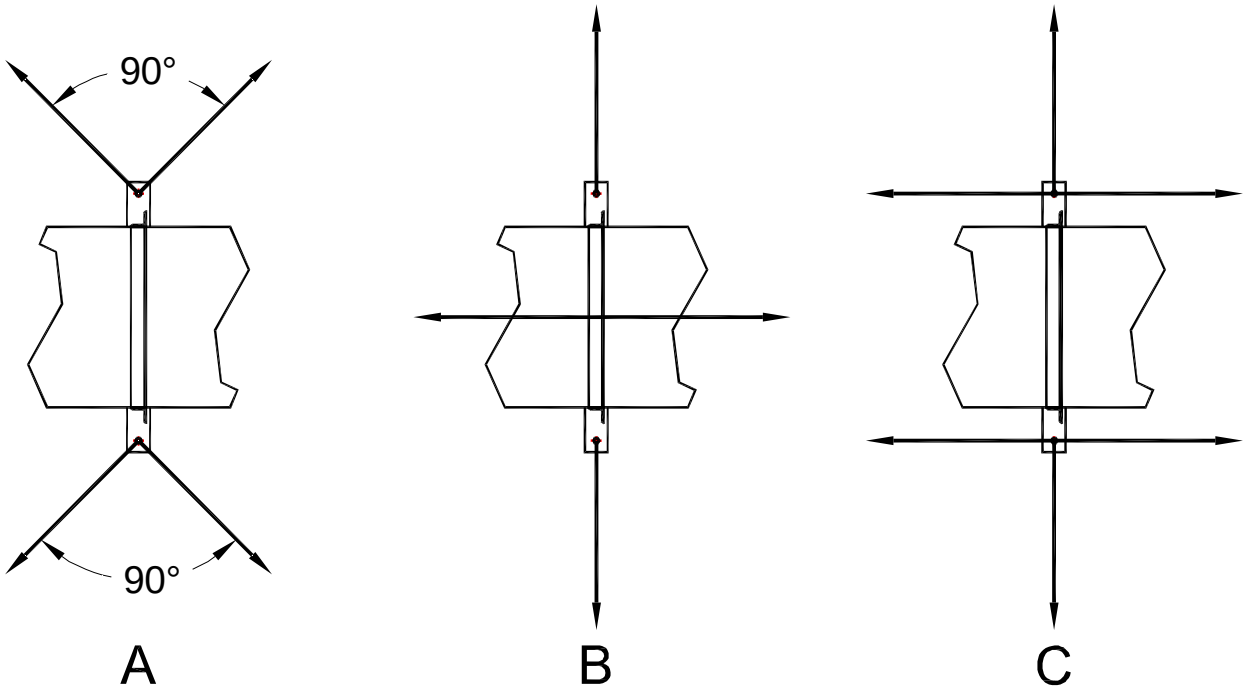

Figure I1-15; Balanced Longitudinal Seismic Restraints for Trapeze Supported Duct

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In Figures I1-14 A & B and Figures I1-15 A & B, the restraint of the trapeze supported pipe and duct may be made with the cable restraint kits which are normally called out and supplied by Kinetics Noise Control. If the installation issues require that arrangements such as the ones shown in Figures I1-14 C and I1-15 C be used, then an extra restraint and anchorage kit will be required for each such location.

I1.7 – Isolated Pipe & Duct:

All of the restraint schematics shown in this manual depict non-isolated pipe and duct. For isolated pipe and duct, the restraints are installed in the same fashion as they are detailed for non-isolated pipe and duct. However, there are special treatments for the isolation hangers that must be followed during the installation to ensure the seismic performance of the system. These treatments are detailed in Figure I1-16.

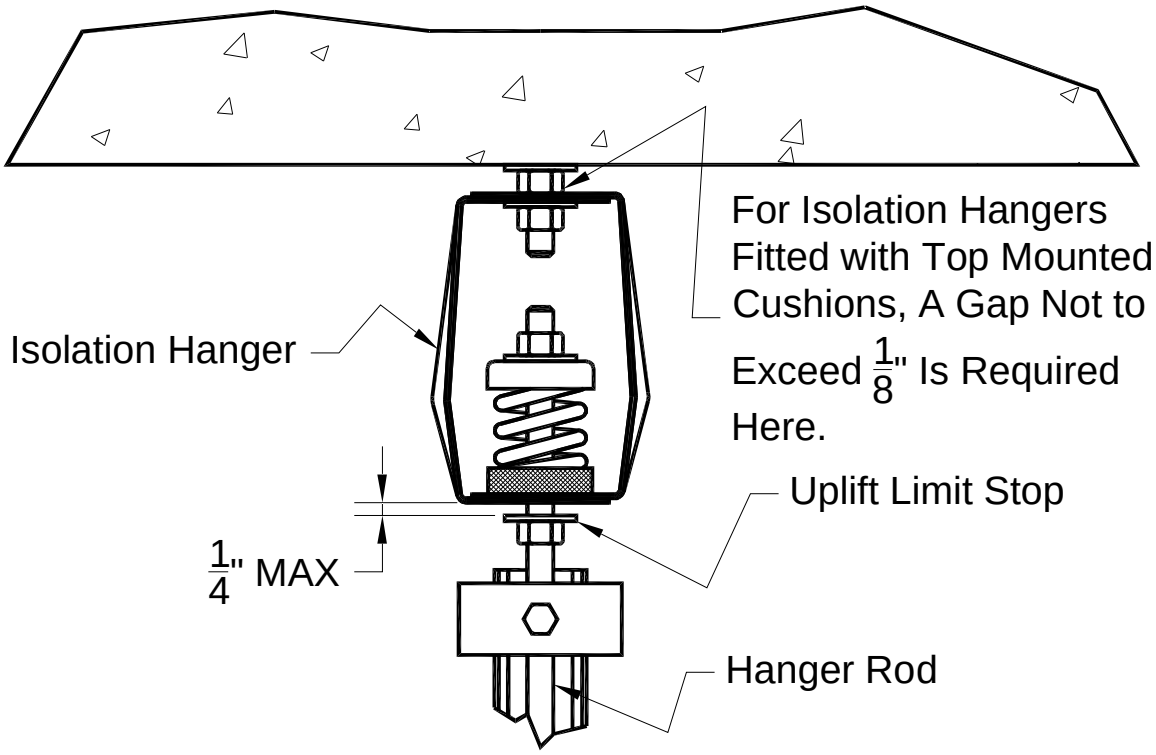

Figure I1-16; Treatments for Isolation Hangers at Seismic Restraint Locations

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The most important treatment from a seismic point of view, see Figure I1-16, is an uplift limit stop applied to the hanger rod just below the isolation hanger. Typically this consists of a nut and washer, as shown, which are adjusted to provide a gap not to exceed one quarter inch between the washer and the bottom of the isolation hanger. When top mounted cushions of neoprene or fiberglass are provided, a gap, not to exceed one eighth inch is required at the top of the isolation hanger. These treatments are valid for all isolated pipe and duct.

For isolated pipe and duct, it is good practice to use only cable type restraints. They provide flexibility and are not as likely to "short out" the isolation hangers. Strut type restraints provide a rigid load path in both tension and compression from the pipe or duct directly to the structure. This will for a continuous transmission path for sound and vibration to travel from the pipe or duct to the structure.

I1.8 – Important Things to Note and Remember:

1. There are two basic categories of seismic restraints.
    a. Transverse Seismic Restraints – perpendicular to the run of pipe or duct.
    b. Longitudinal Seismic Restraints – parallel to the run of pipe or duct.
2. There are two commonly used types of restraints.
    a. Strut Restraints (Rigid Braces) – carry both tension and compression loads along the length of the brace.
        i. ***One strut restraint*** is required at each transverse restraint and each longitudinal restraint.
        ii. Strut restraints ***will*** increase tensile loads in the hangers and anchors, and ***may exceed*** the allowable capacity of the hangers and anchors. Co-ordinate the use of strut restraints with the engineers of record.
        iii. Strut restraints will also create compressive loads in the hangers. Hangers at restraint locations must be capable of carrying compressive (buckling) loads, and may required hanger stiffeners.

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b. Cable Restraints (Tension Only Braces) – carry only tension loads along the length of the cable.
    i. ***Two cable restraints*** 180° apart are required for each transverse restraint and each longitudinal restraint.
    ii. Cable restraints load the hangers only in compression. The hangers at the restraint locations must be capable of carrying compressive load (buckling) loads and may require hanger stiffeners.

3. Seismic restraints must be located at or very near (within 4 inches) of the pipe and duct hanger locations to directly transfer the compressive reaction loads from the seismic forces to the structure of the building, rather than through the pipe and duct.
4. The recommended installation angle for seismic restraints is 45°, as measured from the horizontal.
    a. The maximum allowable installation angle is 60°. Seismic restraints with installation angles greater than 60° will have little or no horizontal restraint capacity.
    b. Normally the minimum allowable installation angle is 30°. This is primarily due to space considerations. Smaller installation angles may be used for special cases when required.
5. Anchorage of the seismic restraints to the building structure must be made at locations where the structure is strong enough to carry the seismic loads plus the normal working loads. Co-ordinate the locations and anchorage of all seismic restraints with the structural engineer of record and/or the architect.
6. The seismic restraints ***must not*** touch or interfere with any other component or structure between their attachment point on the pipe or duct run, and their anchorage point on the building structure.
7. Cable restraints and strut restraints ***can not*** be mixed on the same run of pipe or duct. They must all be cable restraints, or they must all be strut restraints.
8. ***For all*** restraint locations and directions, there ***must be*** a hard connection between the pipe or duct and the seismic restraint to prevent movement of the pipe or duct during an

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earthquake. Trapeze supported pipe and duct must be rigidly attached to the trapeze bar if the seismic restraints are attached to the hangers or trapeze bar.

9. For trapeze supported pipe and duct, the longitudinal seismic restraints ***must be*** balanced across the trapeze bar.
10. For isolated pipe and duct special treatments including uplift control are required. These treatments are detailed in Section I1.7.

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