CABLE RESTRAINT SCHEMATICS FOR PIPING

I3.1 – Introduction:

This section will present several basic schematics for the seismic cable restraints for single clevis supported pipe. The figures and descriptions in this section will be based on the Kinetics Noise Control drawing SS-20070950 titled Cable Restraint Schematics for Piping – Sheet A. There are several drawings in this specific series. They have been designed to aid the installing contractor with the installation of seismic cable restraints for pipe and duct. Each drawing has a number designation ranging from SS-20070950 through SS-20070959. Also each drawing is also identified by a particular letter designation ranging from Sheet A though Sheet H. Each of the drawings in this series has several views on each sheet designated by a specific letter. Where the figures in this section correspond with those views on the Kinetics Noise Control drawings SS-20070950 through SS-20070959 they will be cross referenced by sheet letter and figure letter, for instance Sheet A – View D.

The schematics in this section are intended to be a quick guide for planning and inspection purposes. The details on making structural connections and pipe attachments for the seismic restraint cables and components are covered in Sections I5.0 and I6.0 respectively. Hanger rod stiffeners may be required at some seismic restraint locations to prevent buckling of the hanger rod when the combination of seismic uplift loads and the reaction forces to the horizontal seismic loads generated at the restraint locations exceed the weight load. They are not addressed in this section, but are covered in Section I8.0. Also, piping supported on isolation hangers is not shown in this document. The seismic restraint schematics and attachments for isolated and non-isolated pipe are identical. However, the isolation hangers must receive special treatments that are described in Section I1.7 of this manual.

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I3.2 – Transverse (T) Cable Restraint Schematics for Clevis Supported Pipe:

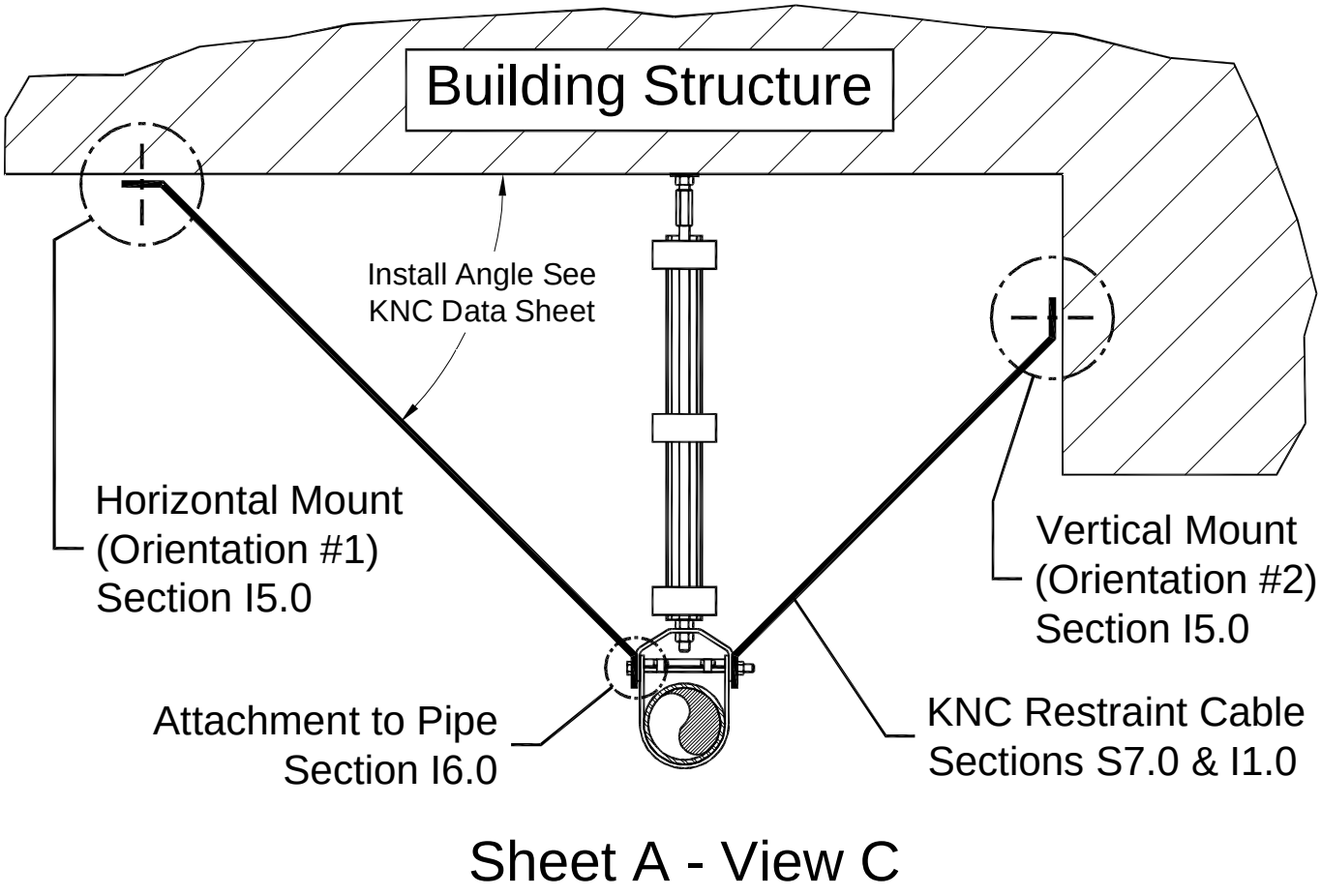

Figure I3-1; Transverse (T) Cable Restraint Schematic Arrangement for Single Clevis Supported Pipe – Cable Restraints Attached to Clevis Hanger

The type of clevis hanger that is represented in Figure I3-1 is a standard adjustable clevis hanger that is typified by the MSS Type-1 detail. This type of hanger is shown in a little more detail in Figure I3-9. This schematic arrangement may also be applied to an adjustable roller hanger MSS Type-43, which is pictured in more detail in Figure I3-10.

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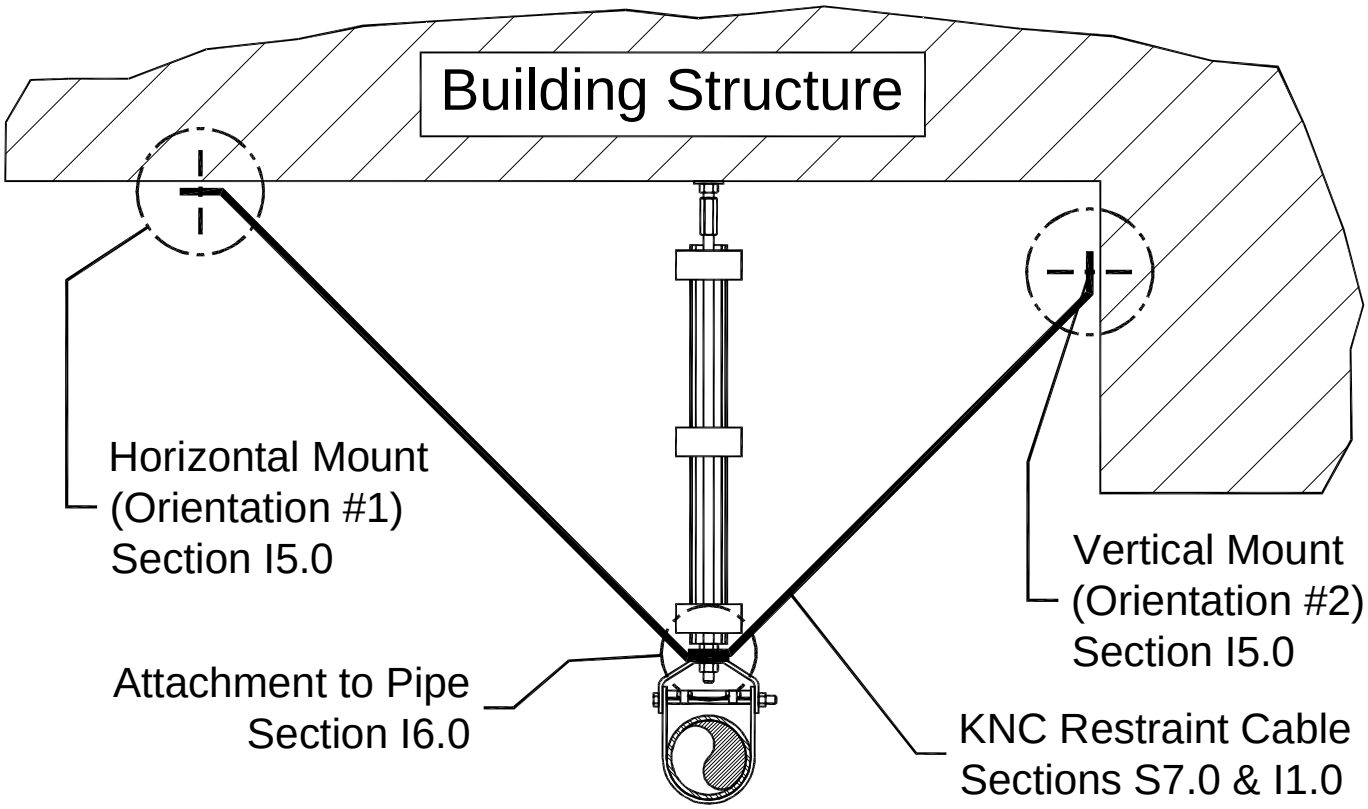

Figure I3-2; Transverse (T) Cable Restraint Schematic Arrangement for Single Clevis Supported Pipe – Cable Restraints Attached to Hanger Rod Immediately Above Clevis Hanger

Occasionally, it makes sense to have the transverse seismic restraints attached to the hanger rod immediately above the clevis hanger. Sometimes there can be access or clearance issues with the clevis hanger. Sometimes the seismic restraints are being retrofitted to piping that is already in place. The Kinetics Noise Control Model KSCA brackets will allow seismic restraints to be retrofit to the hanger rods of clevis supported and trapeze supported pipe. The KSCA brackets must be attached tightly to the rod and tight against the top nut on the clevis hanger or the trapeze support hanger as shown in Section I6.3 of this manual, to prevent bending of the hanger rod.

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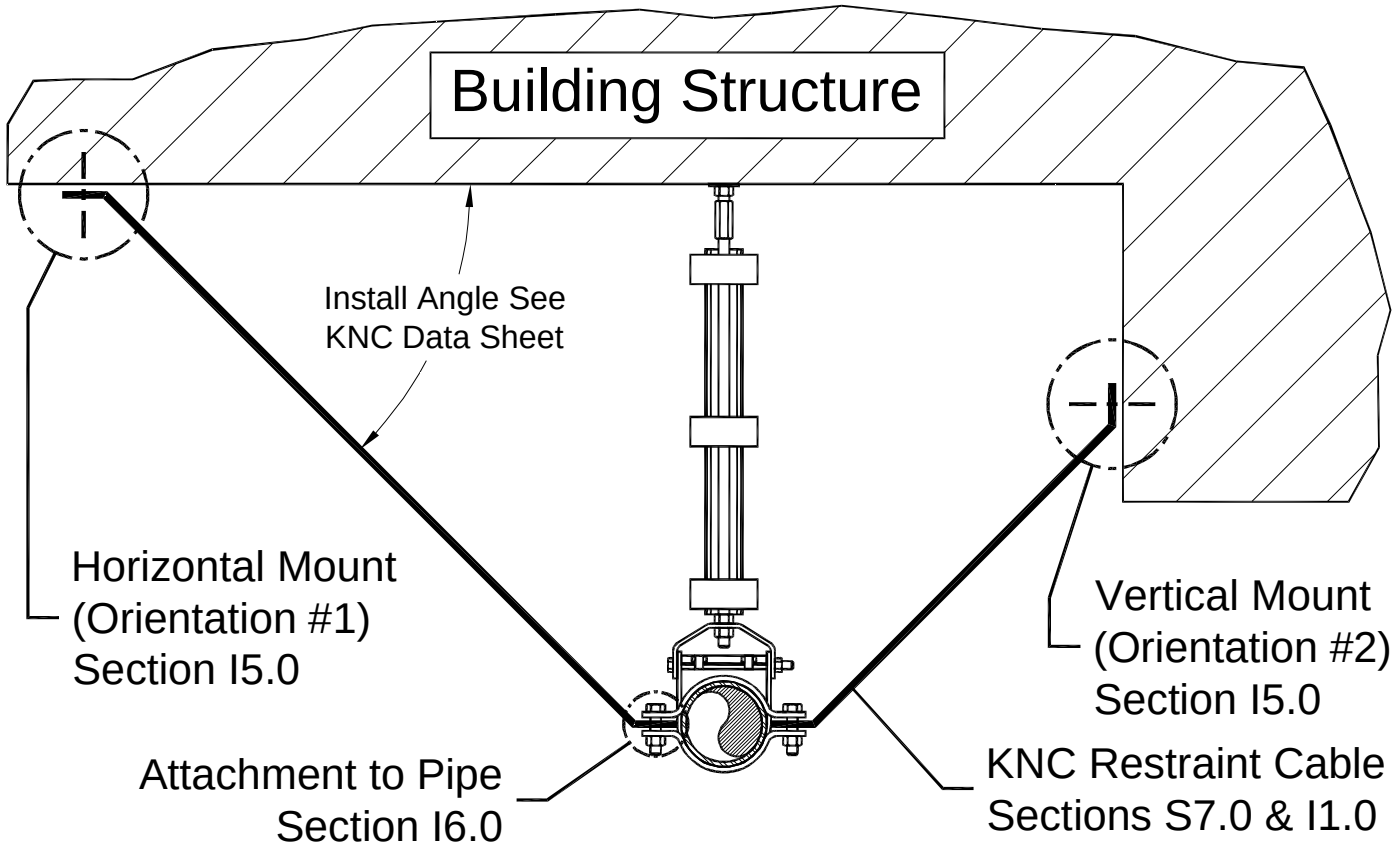

Figure I3-3; Transverse (T) Cable Restraint Schematic Arrangement for Single Clevis Supported Pipe – Cable Restraints Attached to a Pipe Riser Clamp Immediately Adjacent to the Clevis Hanger

For non-insulated pipe, this makes a convenient way to retrofit seismic restraints to piping that is already in place. The clevis hanger and hanger rod are not disturbed by the installation of the seismic restraints. Except in cases where the hanger rods may need to be reinforced with rod stiffeners to resist the seismic uplift forces.

The NFPA requires that the seismic restraints for fire protection piping systems be attached directly to the pipe itself. The pipe riser clamp provides an excellent means of making that attachment to steel pipe.

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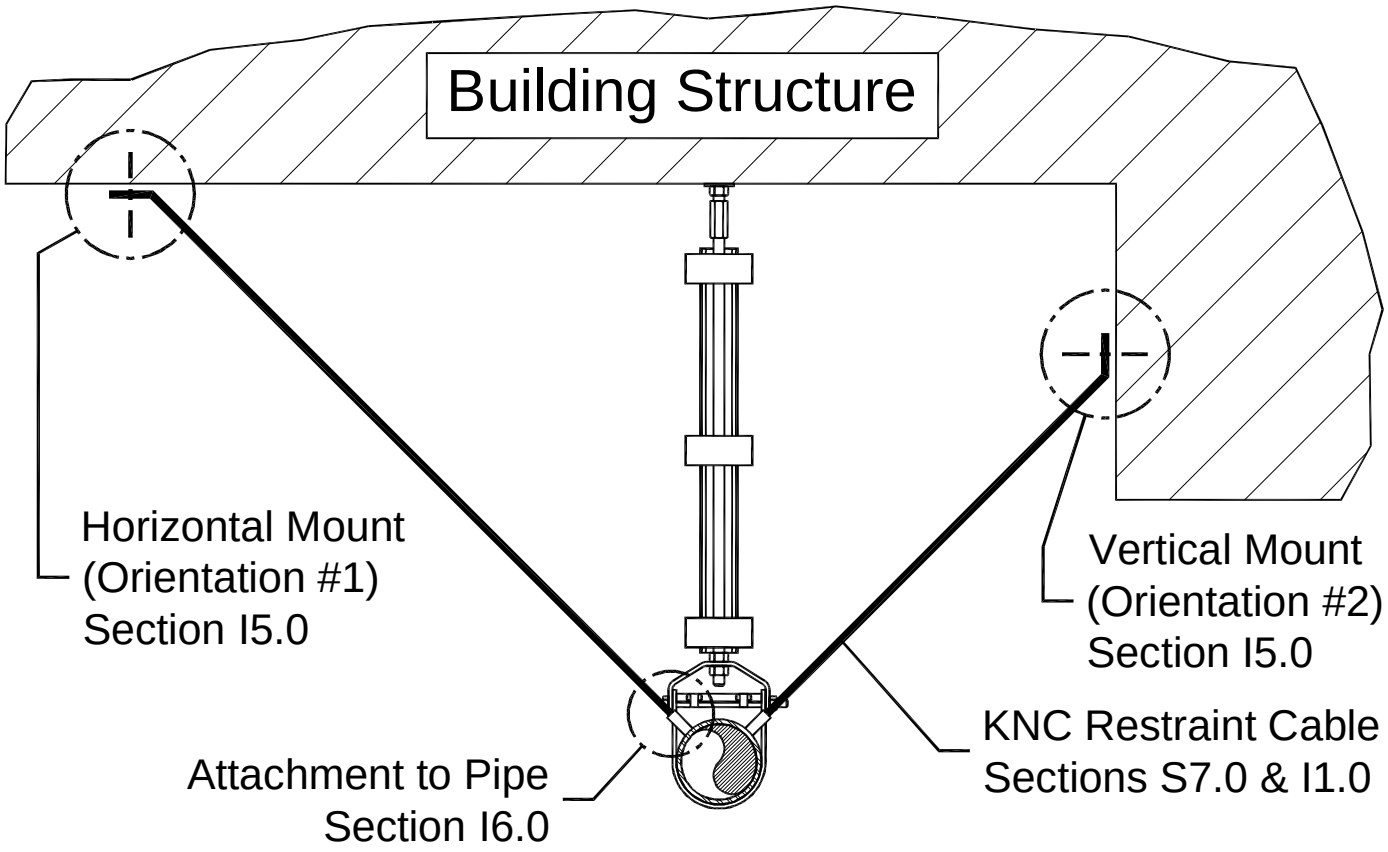

Figure I3-4; Transverse (T) Cable Restraint Schematic Arrangement for Single Clevis Supported Pipe – Cable Restraints Attached Weld to Tabs Immediately Adjacent to the Clevis Hanger

Weld tabs provide a secure means of attaching the seismic restraints to the pipe, especially in high seismic areas where the piping engineer will not allow attachment to the clevis hanger or hanger rod.

The use of weld tabs must be planned for before the pipe is installed and filled. Otherwise, obtaining good welds is nearly impossible due to the heat dissipating properties of the fluid, and the potential orientation of the weld.

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I3.3 – Longitudinal (L) Cable Restraint Schematics for Clevis Supported Pipe:

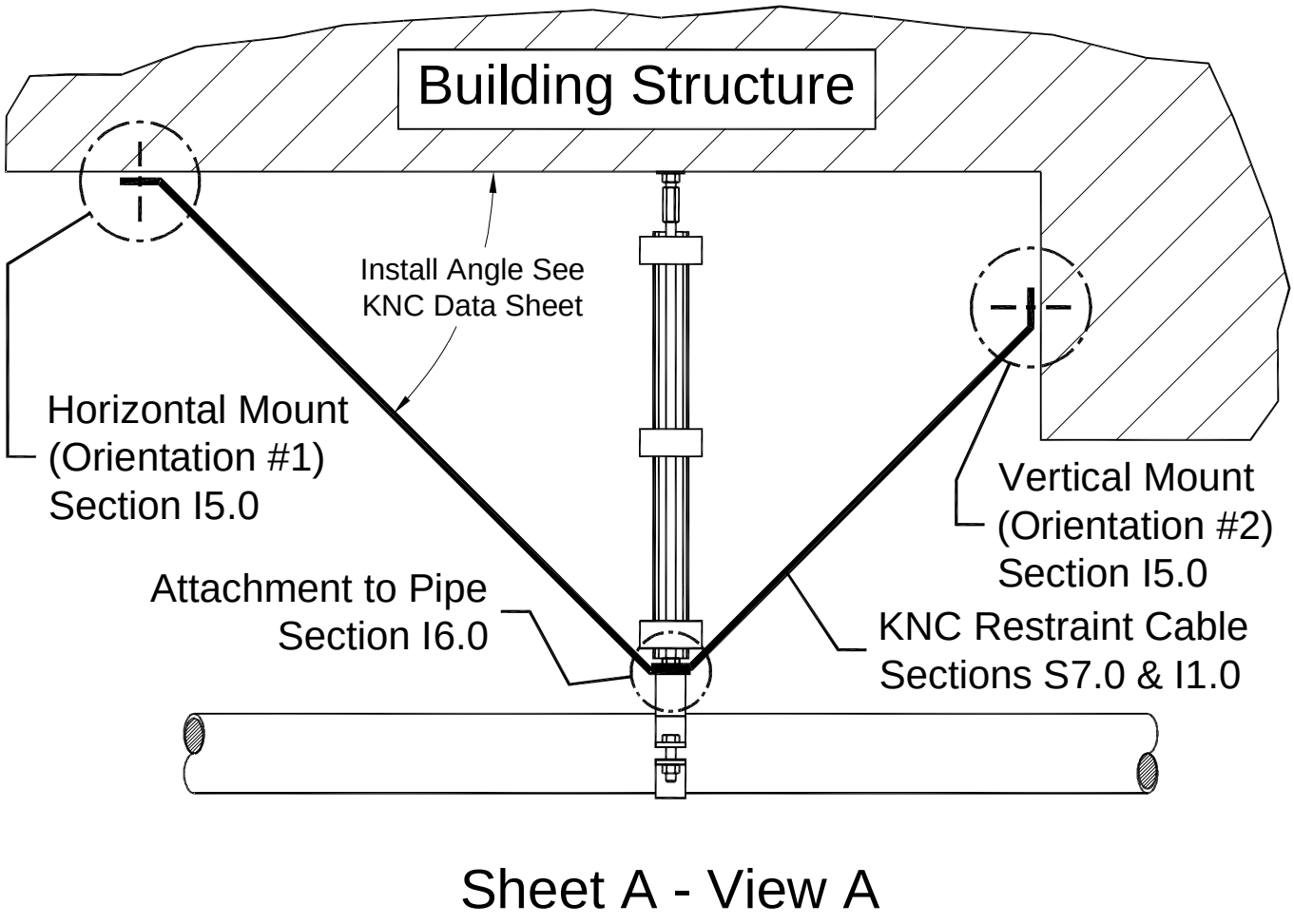

Figure I3-5; Longitudinal (L) Cable Restraint Schematic Arrangement for Single Clevis Supported Pipe – Cable Restraints Attached to a Clamp Type Clevis Hanger

In order for longitudinal seismic restraints to be attached to the clevis hanger or the hanger rod directly above the clevis hanger, the clevis hanger itself ***must*** be a clamping type hanger that firmly secures the pipe in order to transfer the seismic loads from the pipe to the restraints. These are commercially available, but are ***not*** provided by Kinetics Noise Control as part of the standard restraint package..

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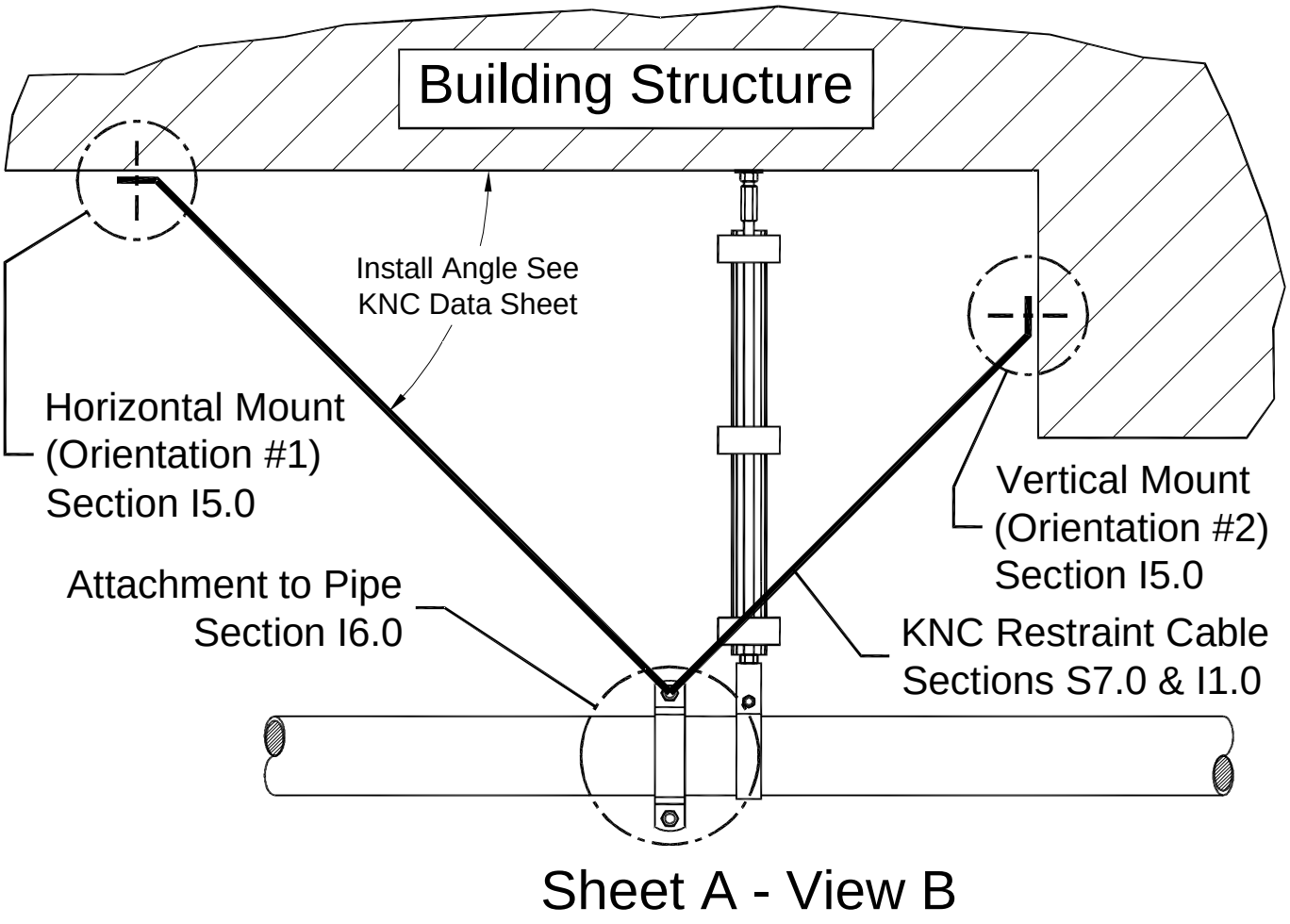

Figure I3-6; Longitudinal (L) Cable Restraint Schematic Arrangement for Single Clevis Supported Pipe – Cable Restraints Attached to a Pipe Riser Clamp Immediately Adjacent to the Clevis Hanger

For this type of installation, a commercially available pipe riser clamp is used to secure the cable restraints to the pipe. The clamp may be rotated slightly to allow the one cable to clear the hanger rod and rod stiffener and clamps, if required. Note that the restraint cables ***must not*** touch the hanger rod, rod stiffener, or the rod stiffener clamps. This could lead to a dangerous overload condition for the hanger rod or damage to the cable during an earthquake.

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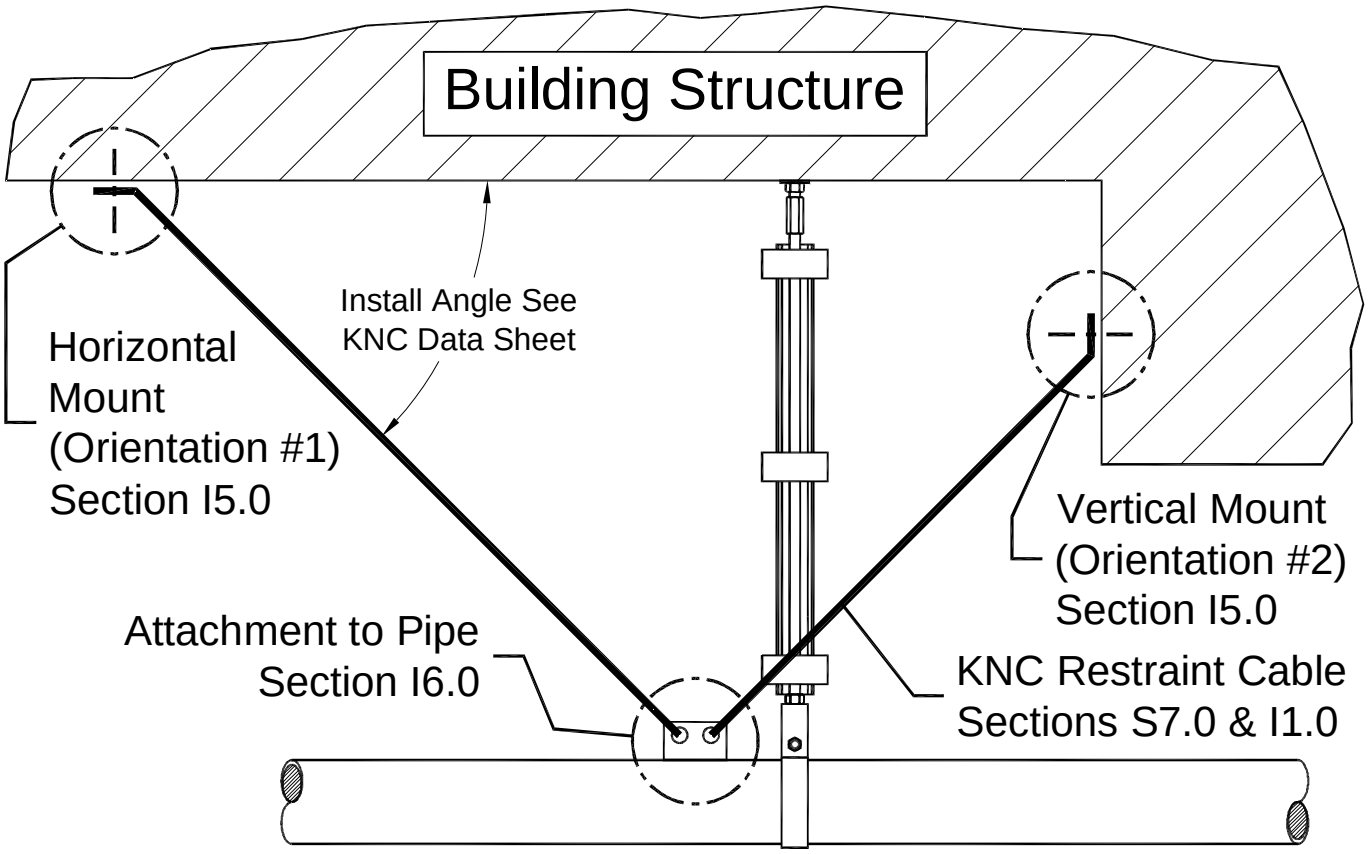

Figure I3-7; Longitudinal (L) Cable Restraint Schematic Arrangement for Single Clevis Supported Pipe – Cable Restraints Attached to Weld Tabs Immediately Adjacent to the Clevis Hanger

As for the transverse restraints, weld tabs provide a secure means of attaching the seismic restraints to the pipe, especially in high seismic areas. The use of weld tabs must be planned for before the pipe is installed and filled. Otherwise, obtaining good welds is nearly impossible due to the heat dissipating properties of the fluid, and the potential orientation of the weld. As with the riser clamps, the restraint cables ***must not*** touch the hanger rod, rod stiffener, or the rod stiffener clamps. This could lead to a dangerous overload condition for the hanger rod or damage the cable during an earthquake.

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I3.4 – Combined Transverse & Longitudinal (TL) Cable Restraint Schematics for Clevis Supported Pipe:

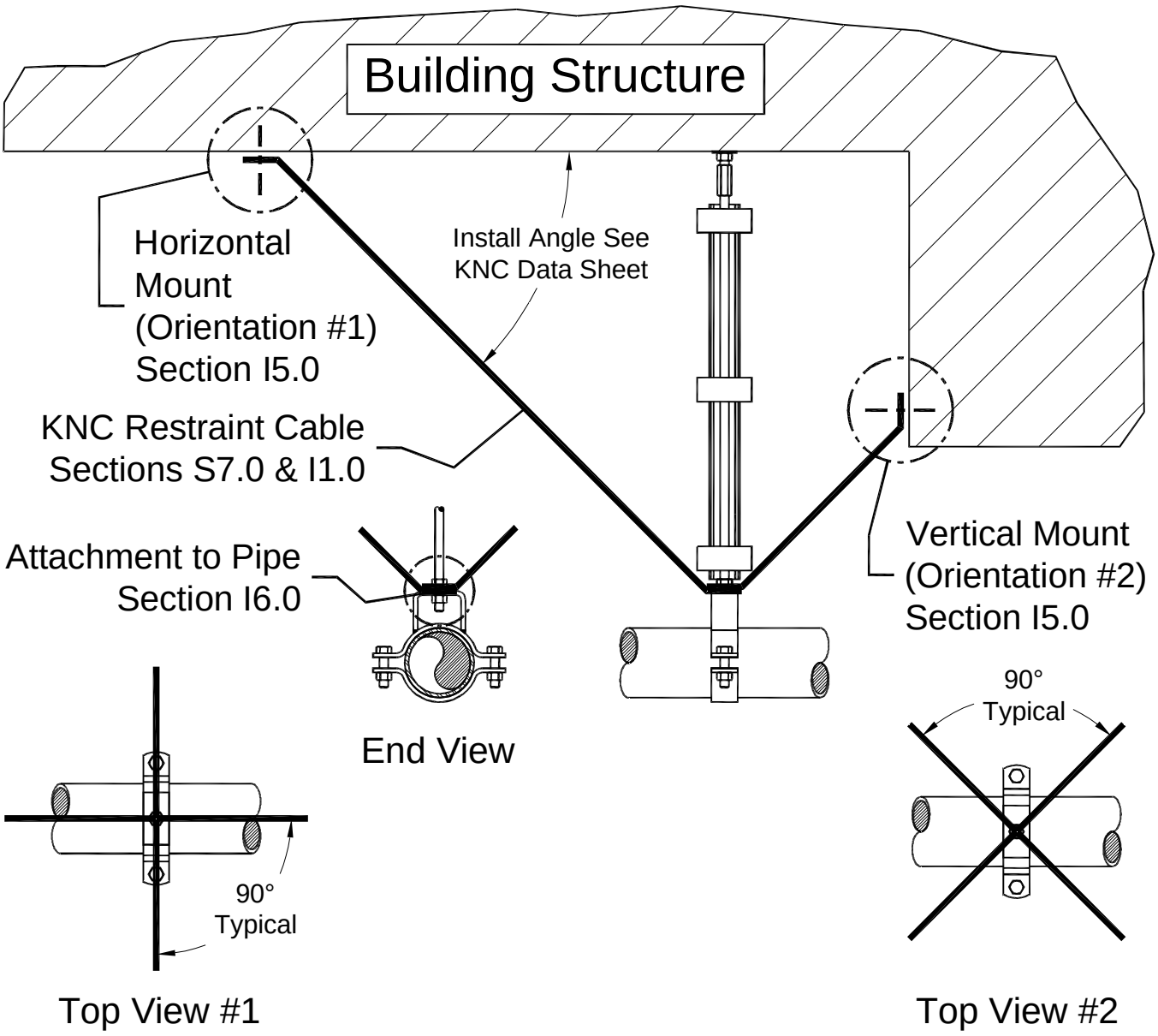

Figure I3-8; Combined Transverse & Longitudinal (TL) Cable Restraint Schematic Arrangement for Single Clevis Supported Pipe – Cable Restraints Attached to a Clamp Type Clevis Hanger

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In order for longitudinal seismic restraints to be attached to the clevis hanger or the hanger rod directly above the clevis hanger, the clevis hanger itself ***must*** be a clamping type hanger that firmly secures the pipe in order to transfer the seismic loads from the pipe to the restraints. These are commercially available, but are not provided by Kinetics Noise Control as part of the standard restraint kit.

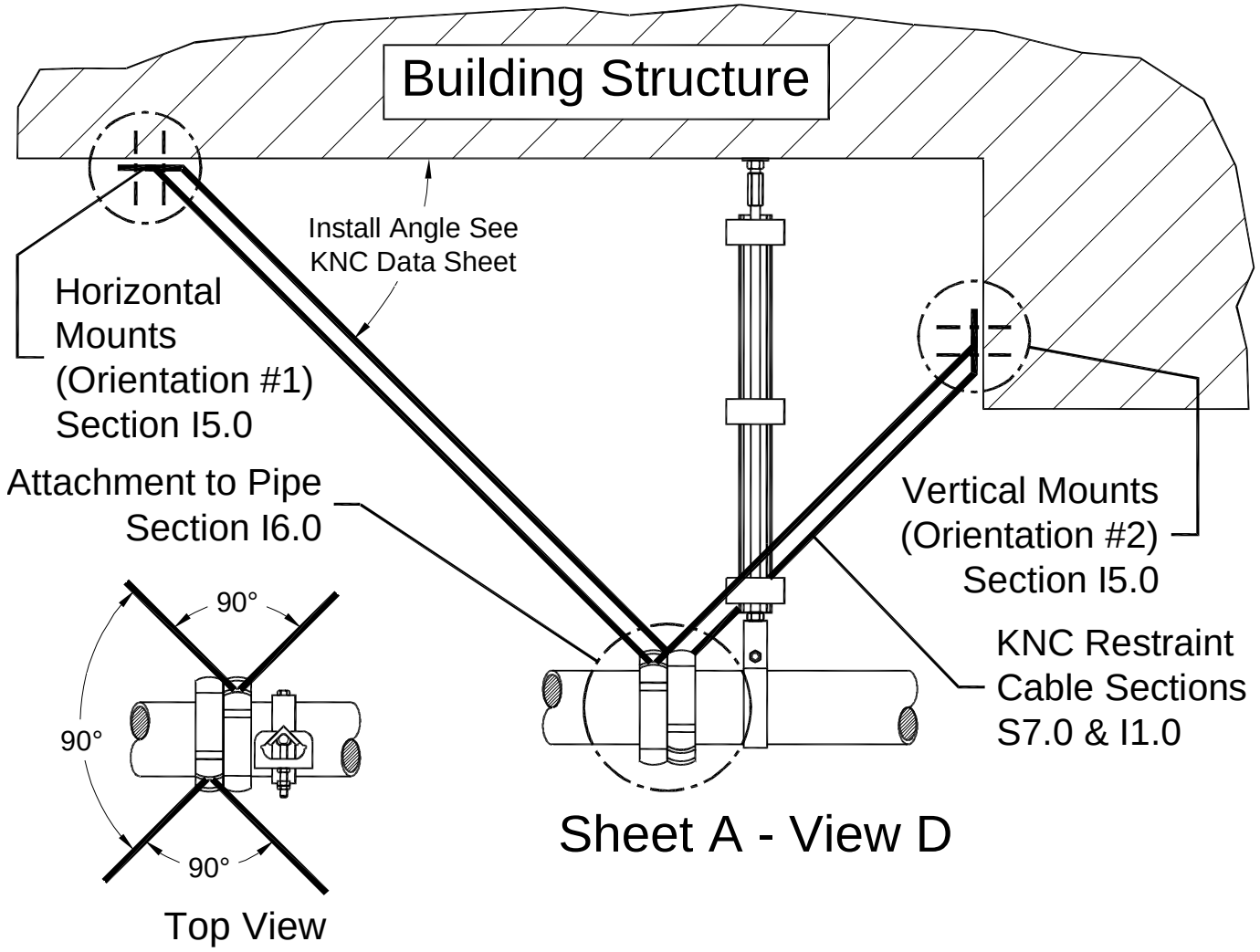

Figure I3-9; Combined Transverse & Longitudinal (TL) Cable Restraint Schematic Arrangement for Single Clevis Supported Pipe – Cable Restraints Attached to Pipe Riser Clamps Immediately Adjacent to the Clevis Hanger

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It is not uncommon to want to use both, the transverse and longitudinal seismic restraints at the same location. The use of riser clamps allows them to be easily attached to the pipe close to a hanger location. The riser clamps can also be replaced with weld tabs as shown in Figure I3-7 above. AS with the independent longitudinal restraints, the restraint cables ***must not*** touch the hanger rod, rod stiffener, or the rod stiffener clamps.

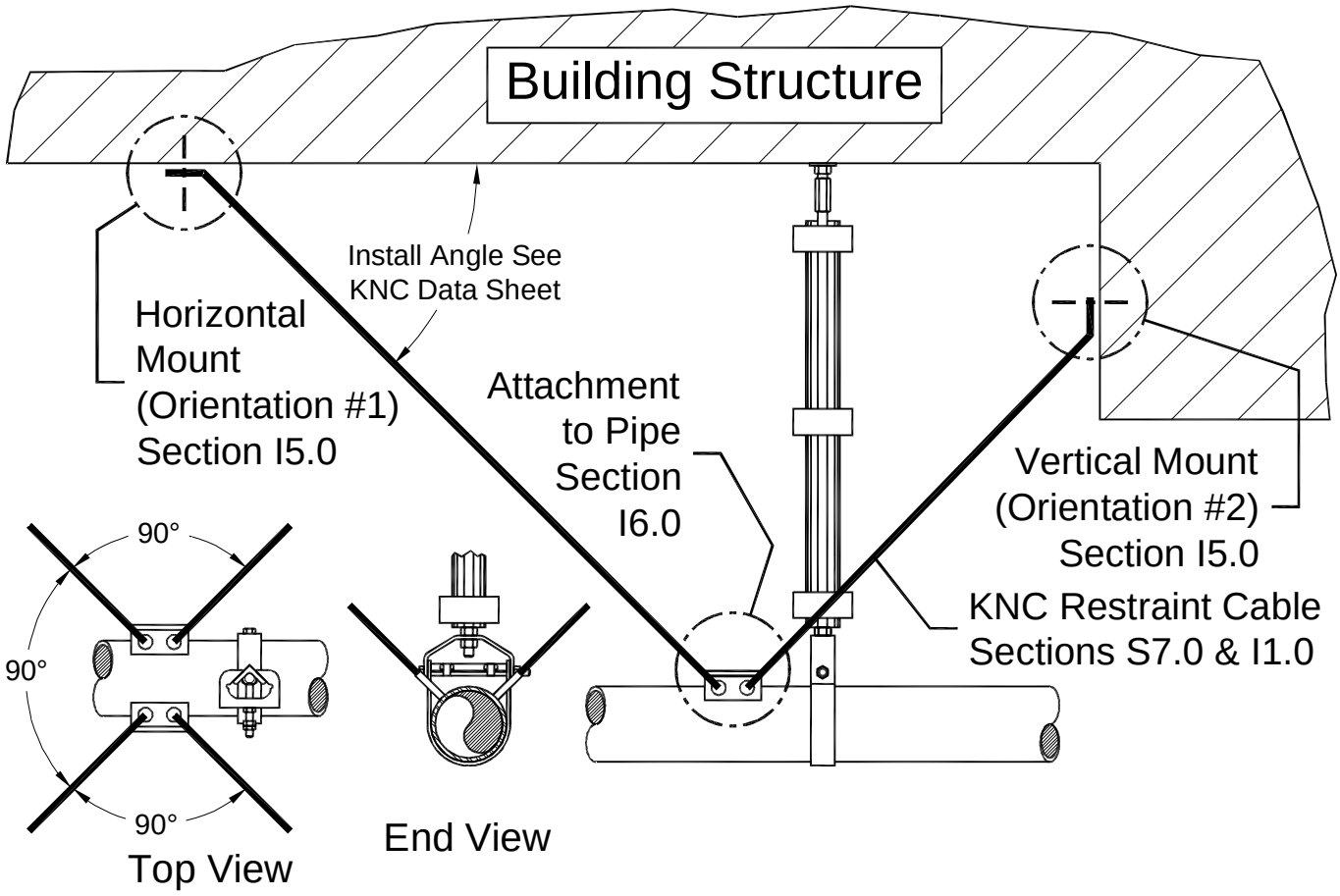

Figure I3-10; Combined Transverse & Longitudinal (TL) Cable Restraint Schematic Arrangement for Single Clevis Supported Pipe – Cable Restraints Attached to Weld Tabs Adjacent to the Clevis Hanger

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I3.5 – Some Common Types of Clevis Hangers:

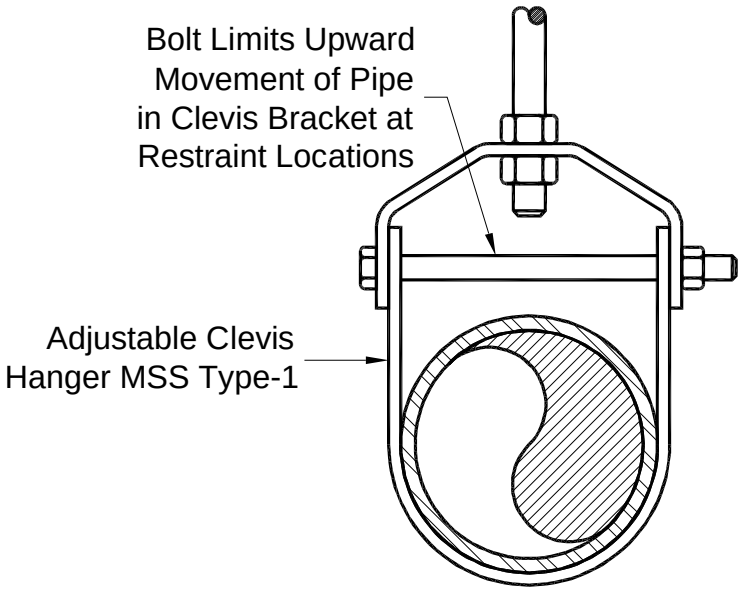

Figure I3-11; Standard Adjustable Clevis Hanger

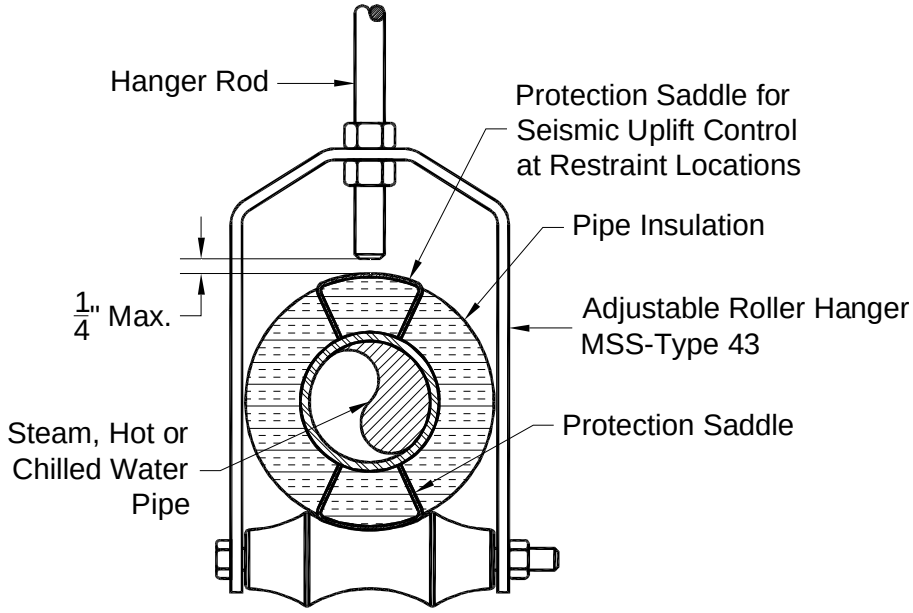

Figure I3-12; Roller Type Clevis Hanger Used for Hot and Cold Fluid Lines

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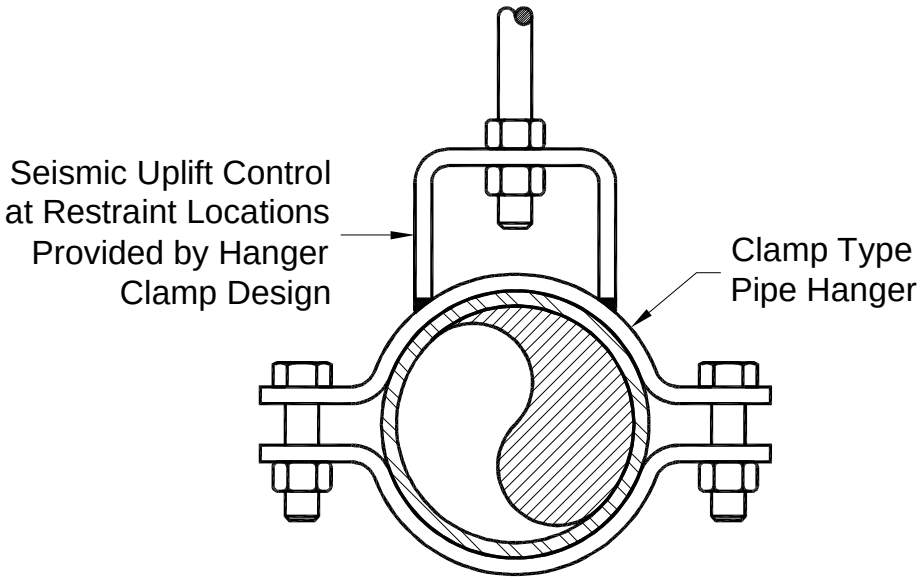

Figure I3-13; Commercially Available Clamp Type Clevis Hanger

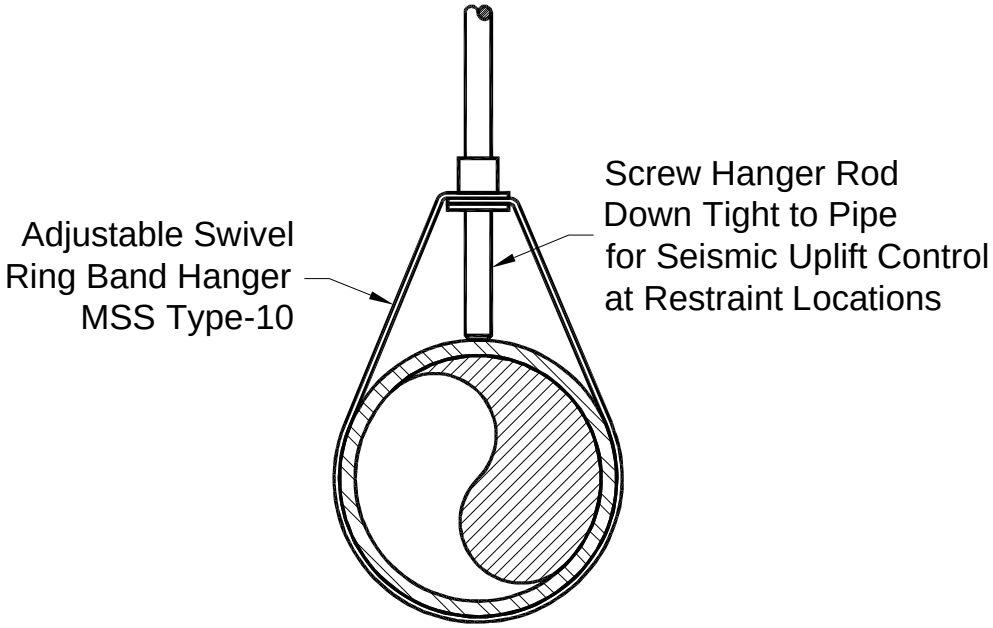

Figure I3- 14; Adjustable Swivel Ring Band Pipe Clevis Hanger – Typically Used for Fire Protection Piping

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I3.6 – Transverse (T) Cable Restraint Schematics for Trapeze Supported Pipe:

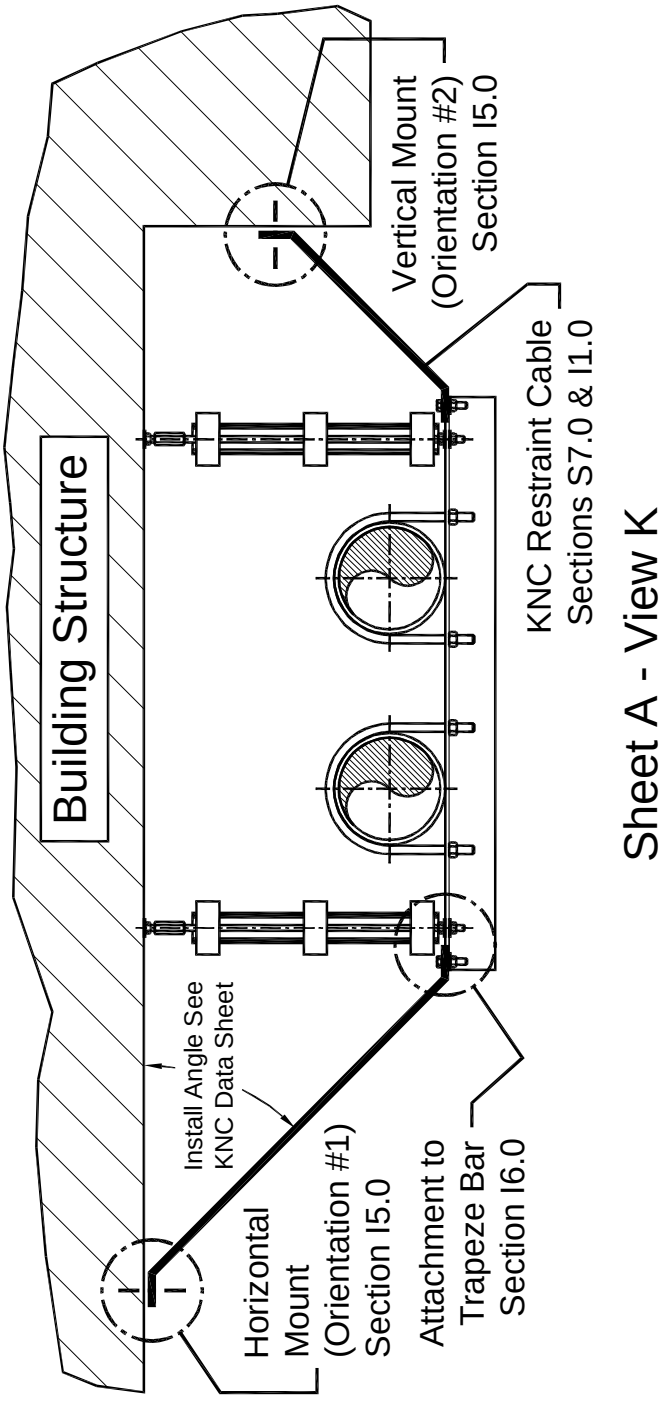

Figure I3-15; Transverse (T) Cable Restraint Schematic Arrangement for Trapeze Supported Pipe – Cable Restraints Attached to Both Ends, or Hanger Rods, of the Trapeze Bar and Directed Outside the Trapeze

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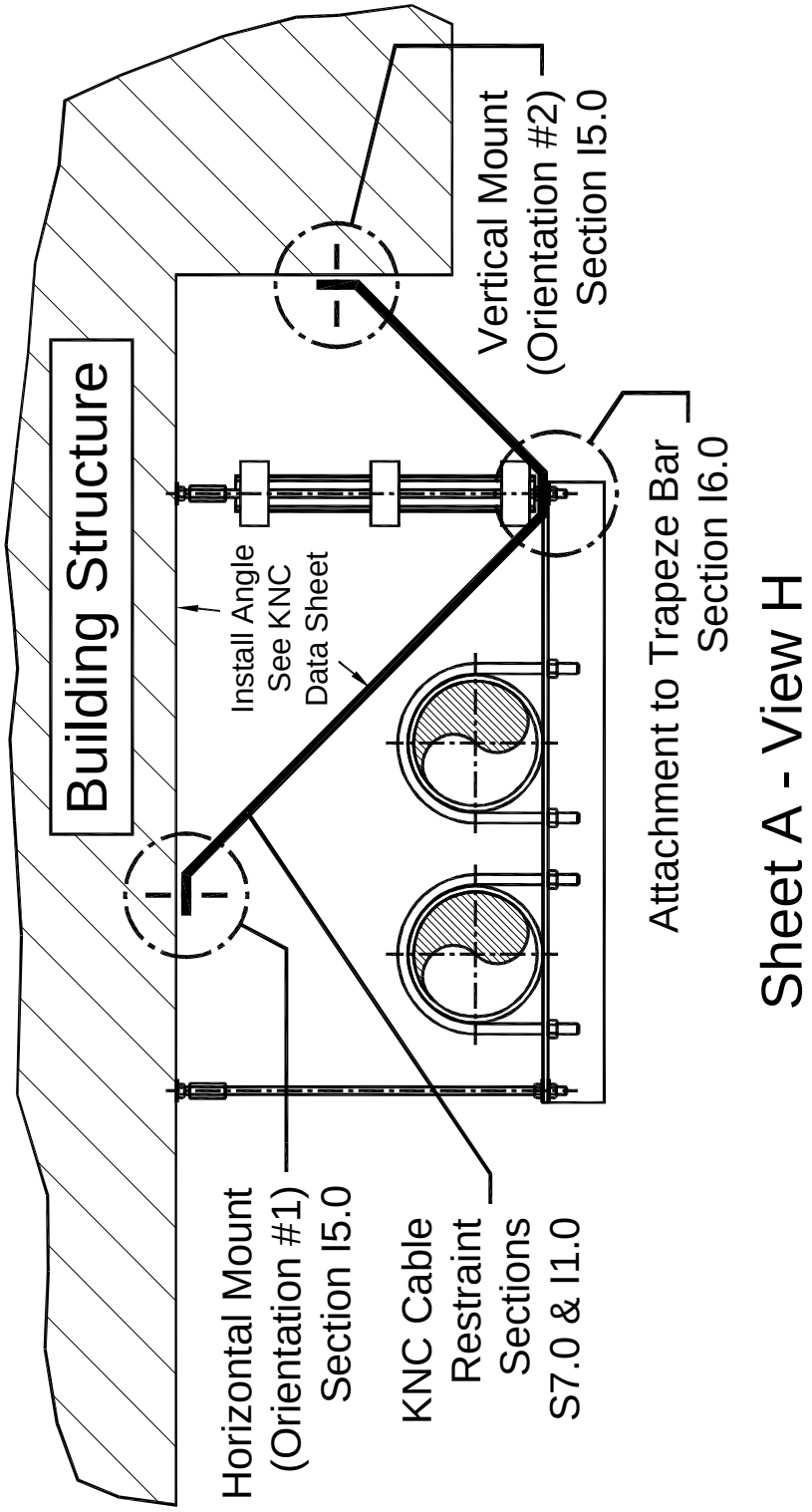

Figure I3-16; Transverse (T) Cable Restraint Schematic Arrangement for Trapeze Supported Pipe – Cable Restraints Attached to One End, or Hanger Rod, of the Trapeze Bar

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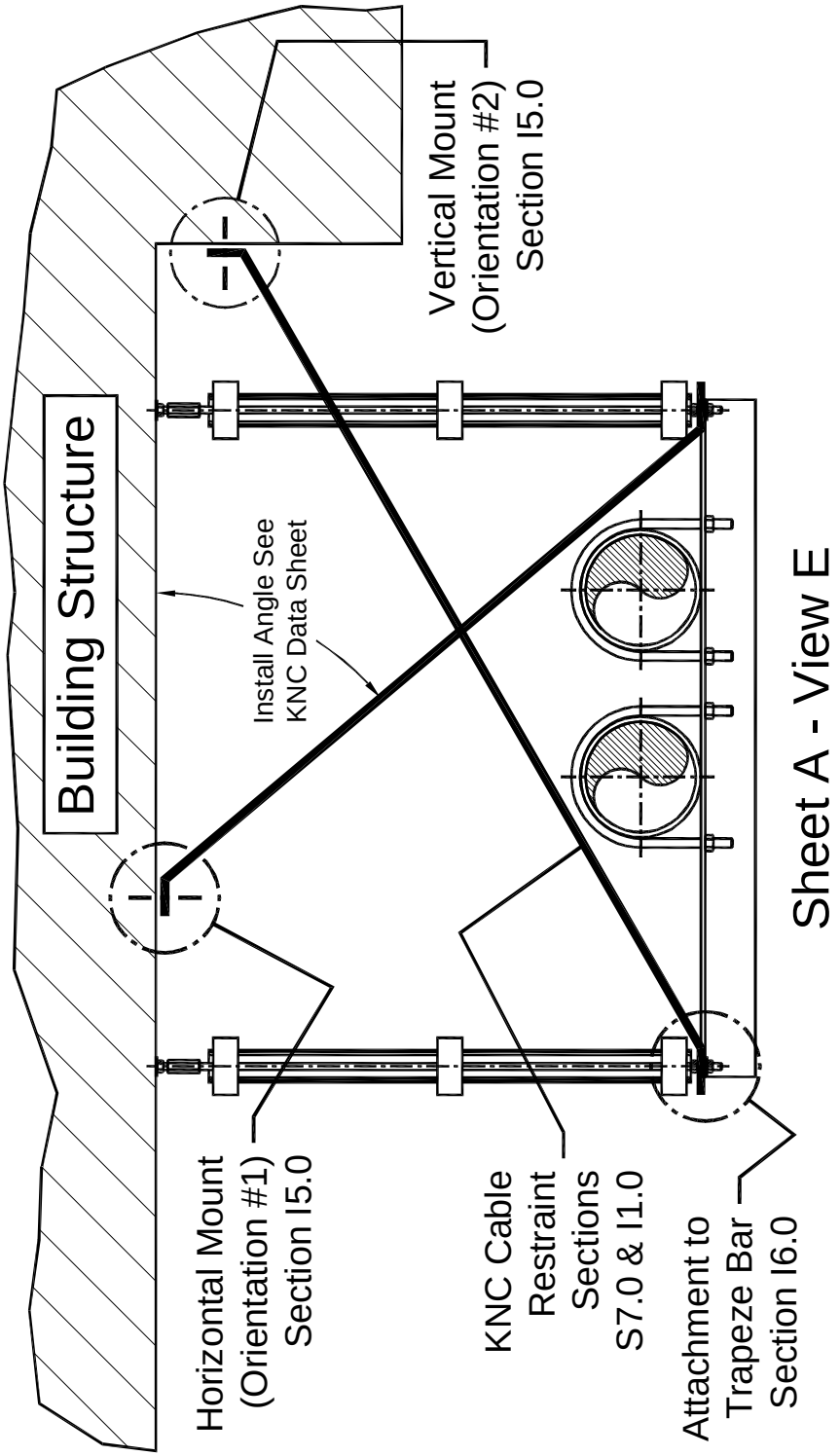

Figure I3-17; Transverse (T) Cable Restraint Schematic Arrangement for Trapeze Supported Pipe – Cable Restraints Attached to Both Ends, or Hanger Rods, of the Trapeze Bar and Directed Inside the Trapeze

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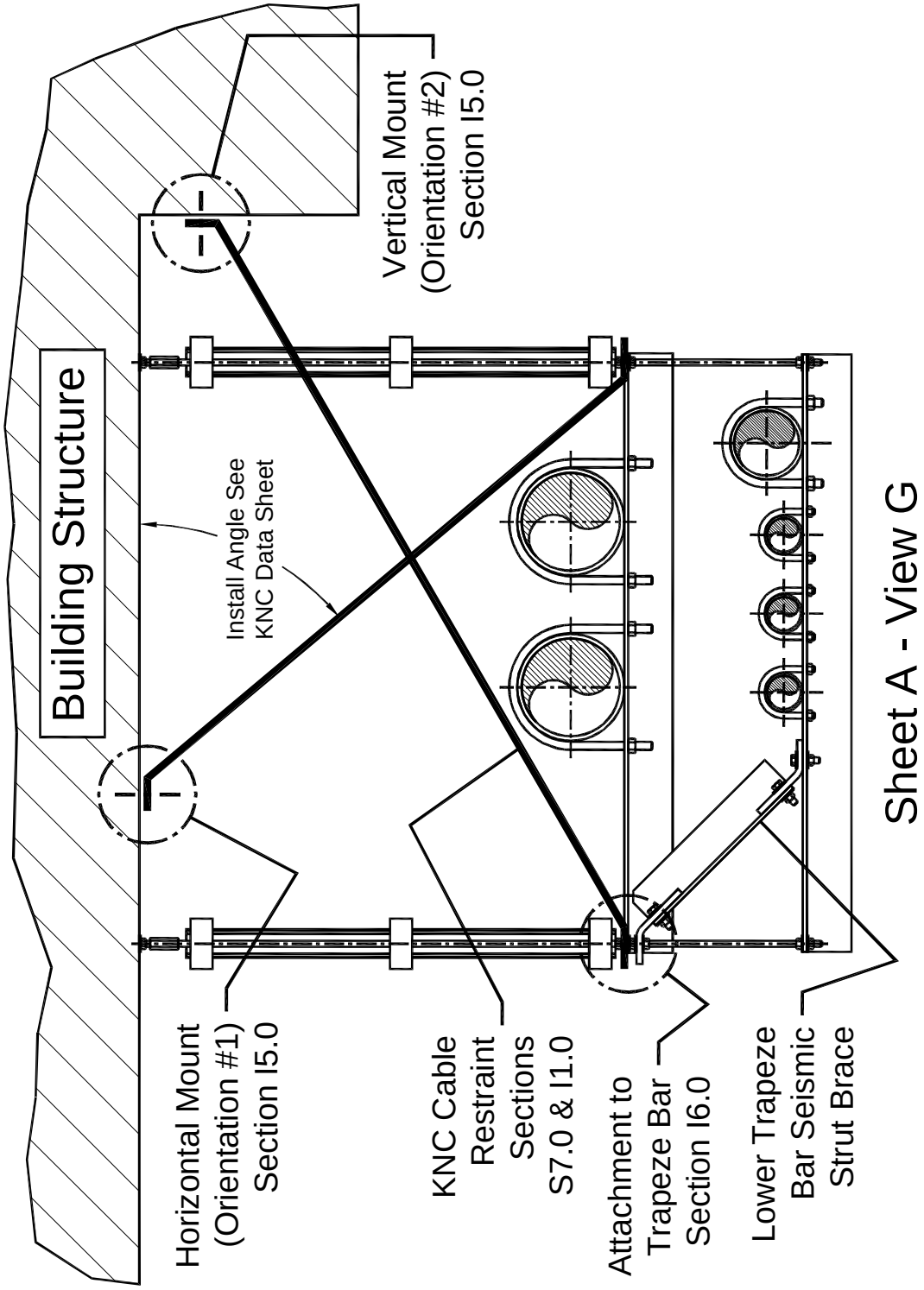

Figure I3-18; Transverse (T) Cable Restraint Schematic Arrangement for Trapeze Supported Pipe – Cable Restraints Attached to Both Ends, or Hanger Rods, of the Trapeze Bar and Directed Inside the Trapeze with a Second Tier Trapeze Support for Additional Pipes.

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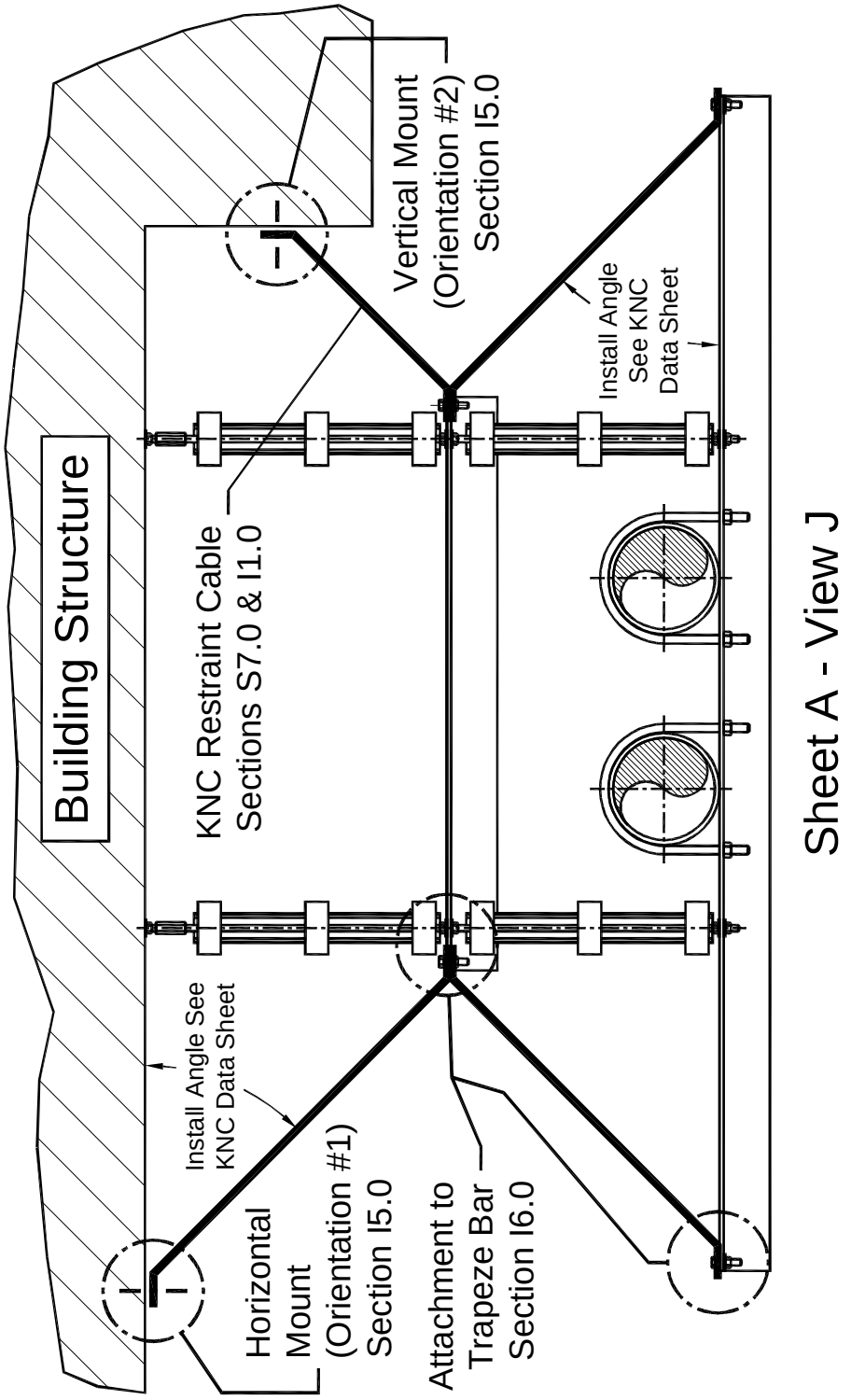

Figure I3-19; Transverse (T) Cable Restraint Schematic Arrangement for Trapeze Supported Pipe – Cable Restraints Attached to Both Ends, or Hanger Rods, of the Trapeze Bar and Directed Outside the Trapeze for Use in Tight Space Situations

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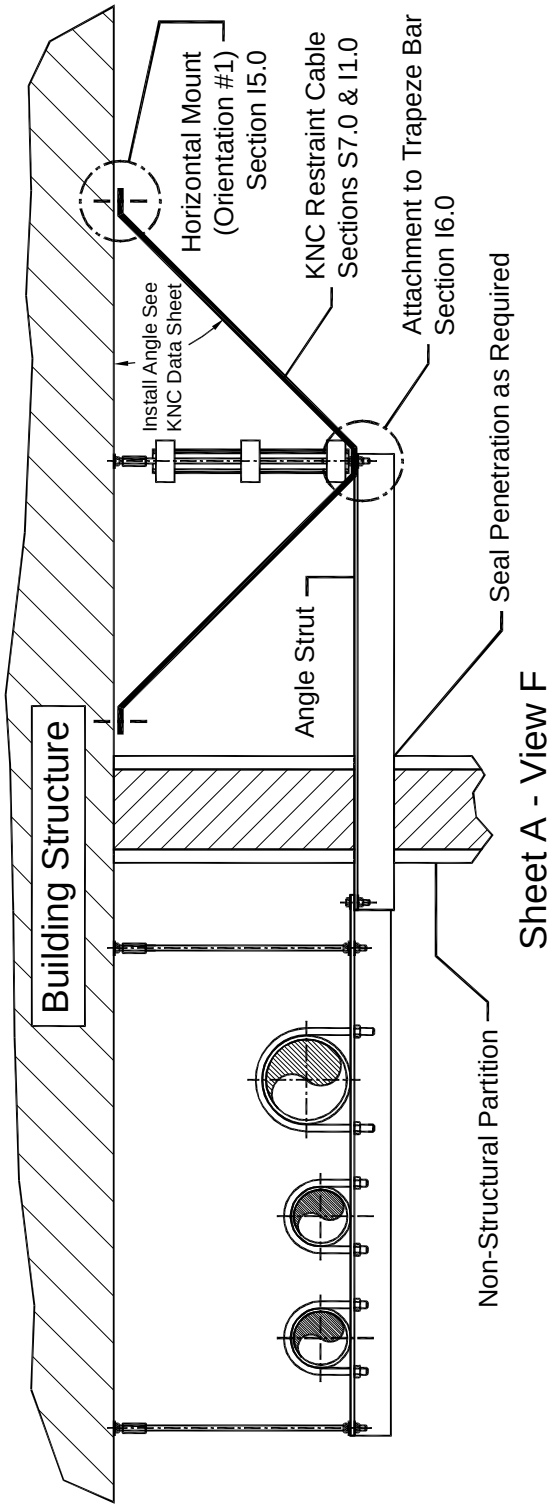

Figure I3-20; Transverse (T) Cable Restraint Schematic Arrangement for Trapeze Supported Pipe – Trapeze Bar Is Too Close to a Wall to Allow a Normal Restraint Arrangement – Obtain Permission from the Structural Engineer and Architect Before Penetrating the Wall

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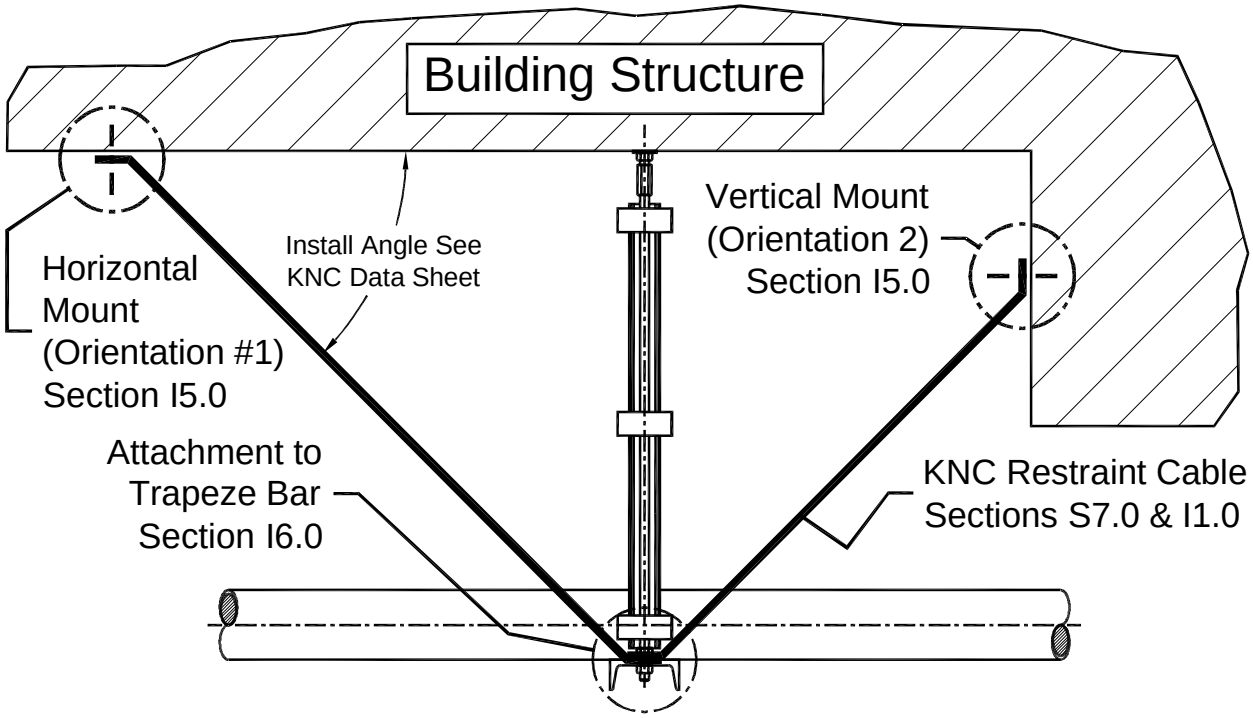
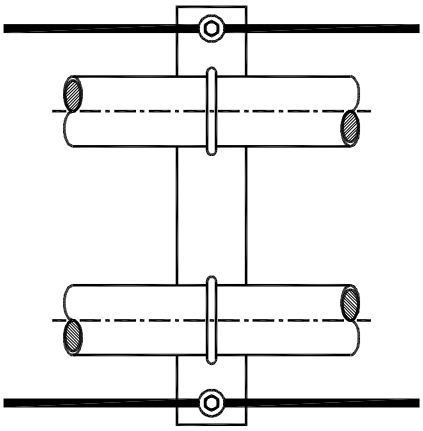
I3.7 – Longitudinal (L) Cable Restraint Schematics for Trapeze Supported Pipe:



Sheet A - View M
Side View Opt. #1



Top View Opt. #1

Figure I3-21; Longitudinal (L) Cable Restraint Schematic Arrangement for Trapeze Supported Pipe – Restraint Forces are Balanced Side-to-Side – Requires One (1) Extra Restraint Cable Kit beyond KNC Material Required List per Longitudinal Restraint Location

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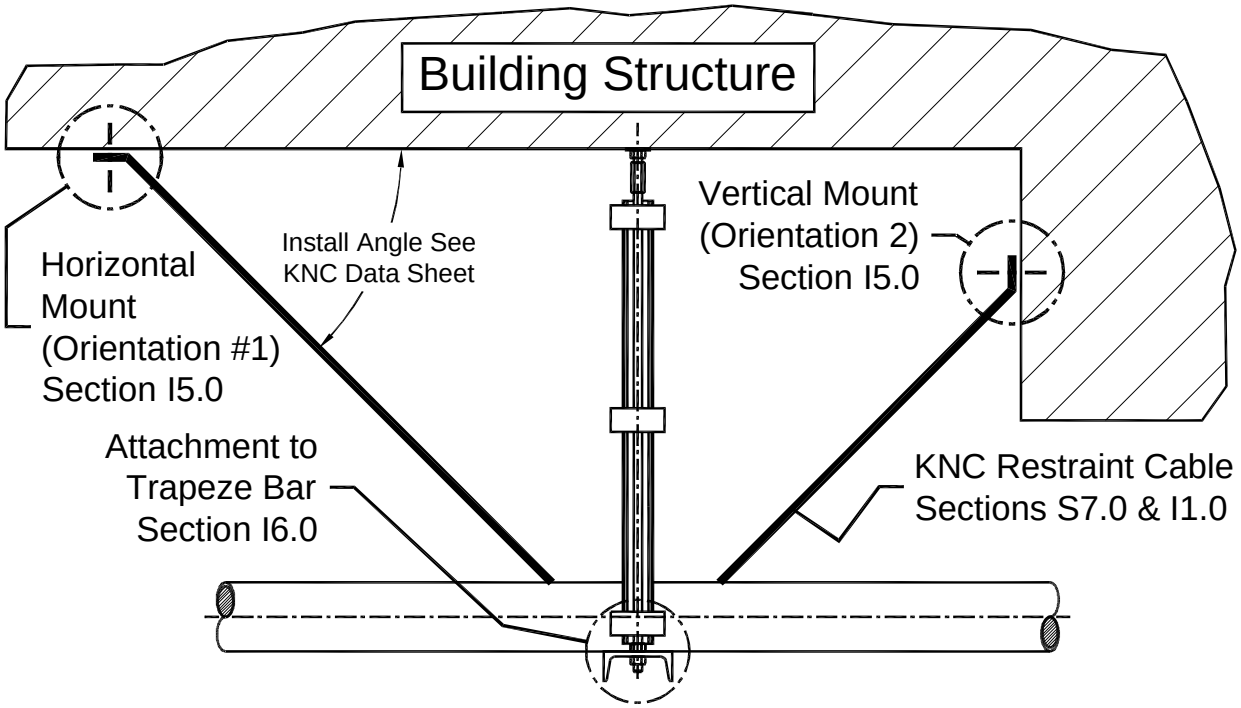
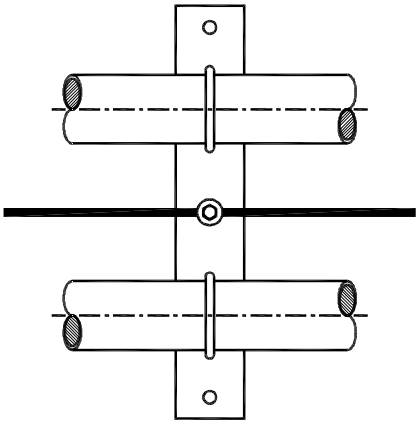


Sheet A - View M
Side View Opt. #2



Top View Opt. #2

Figure I3-22; Longitudinal (L) Cable Restraint Schematic Arrangement for Trapeze Supported Pipe – Restraint Forces are Balanced Side-to-Side – Requires No Addition Cable Kits Other Than Those on the KNC Material Required List per Longitudinal Restraint Location

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I3.8 – Transverse (T) Cable Restraint Schematics for Floor or Roof Mounted Pipe:

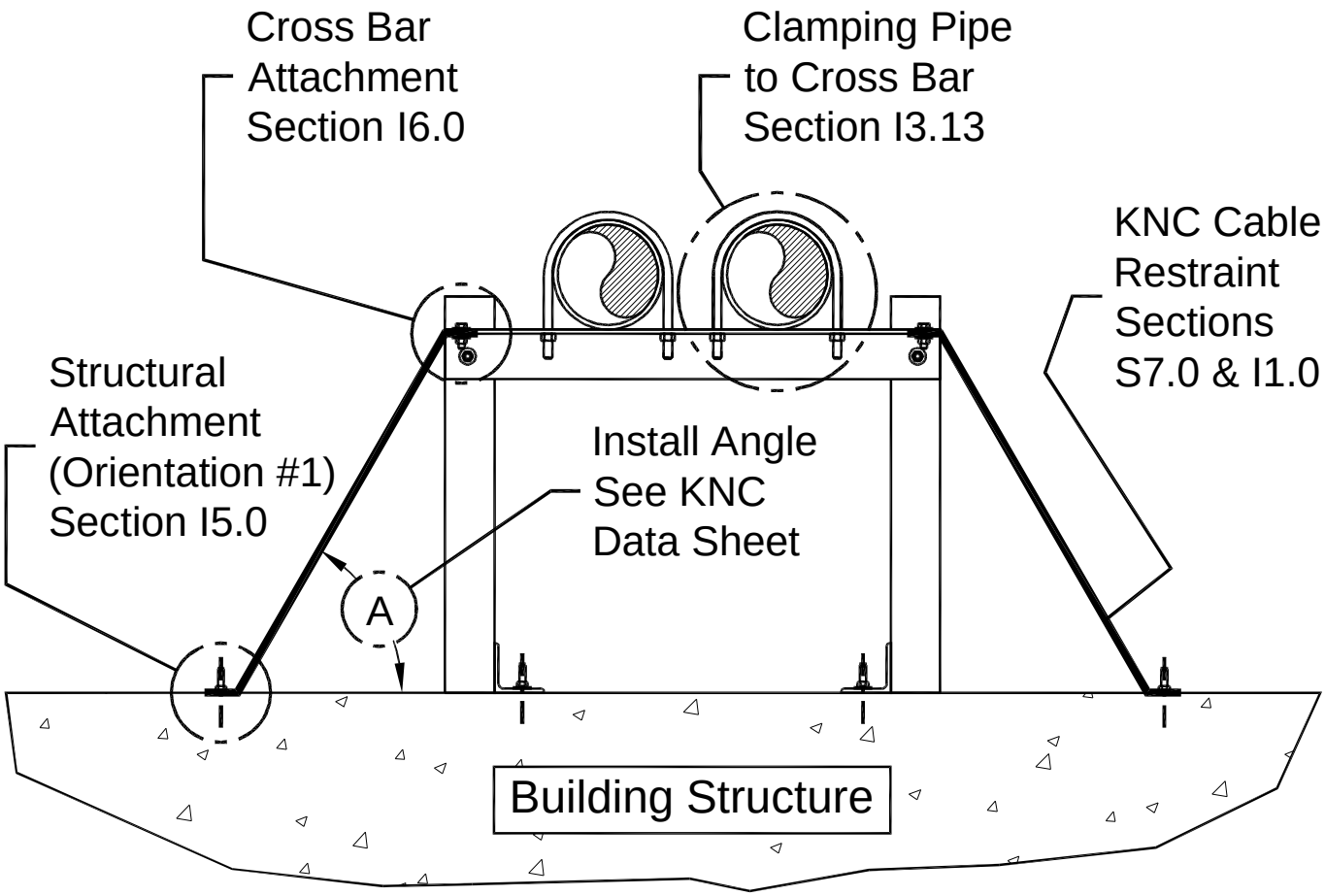

Figure I3-23; Transverse (T) Cable Restraint Schematic Arrangement for Floor or Roof Mounted Pipe – One Restraint Attached to Each Side of the Cross Bar at the Vertical Legs Directed Outward from the Floor Stand

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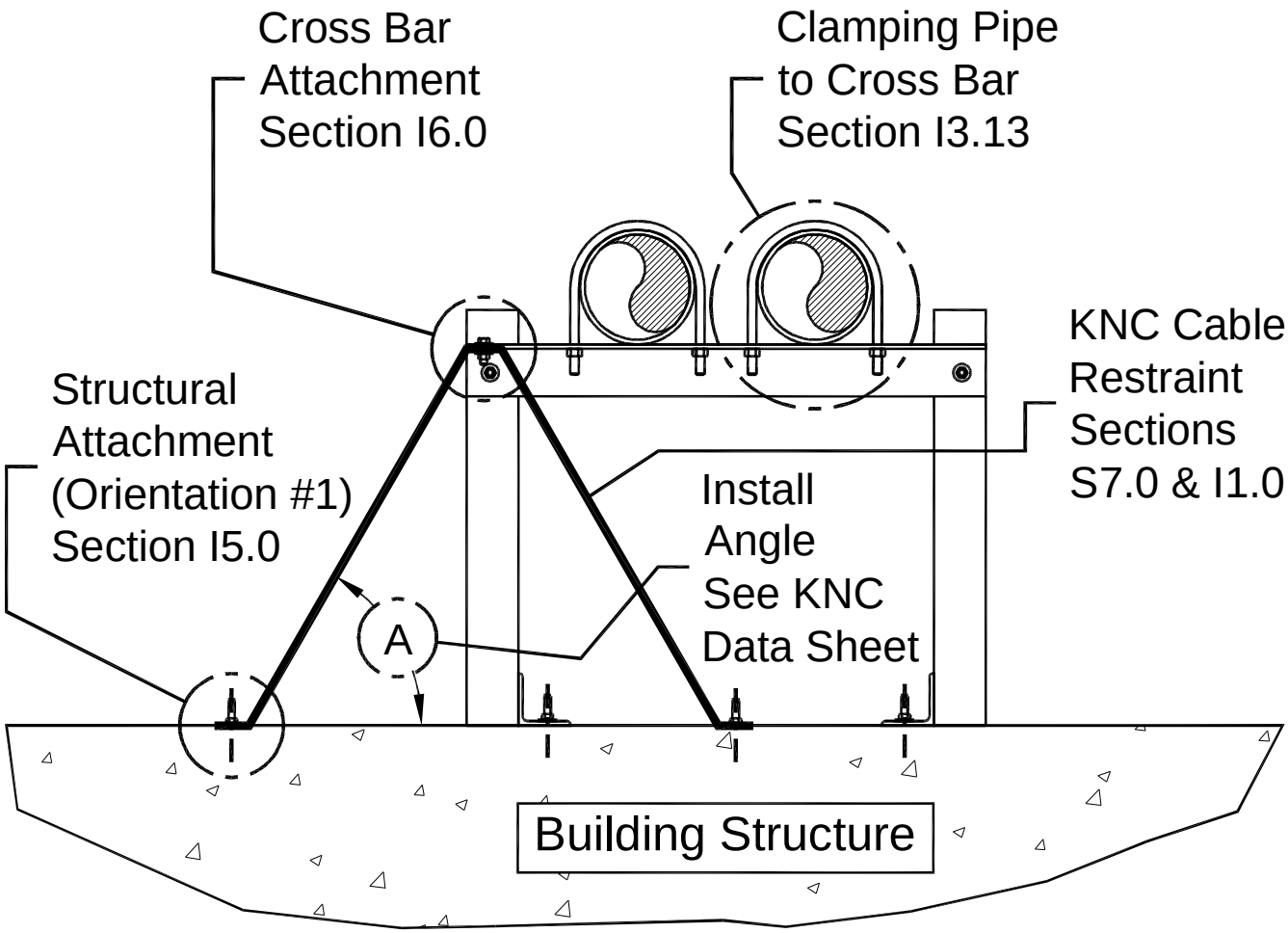

Figure I3-24; Transverse (T) Cable Restraint Schematic Arrangement for Floor or Roof Mounted Pipe – Both Restraints Attached to One Side of the Cross Bar at the Vertical Leg

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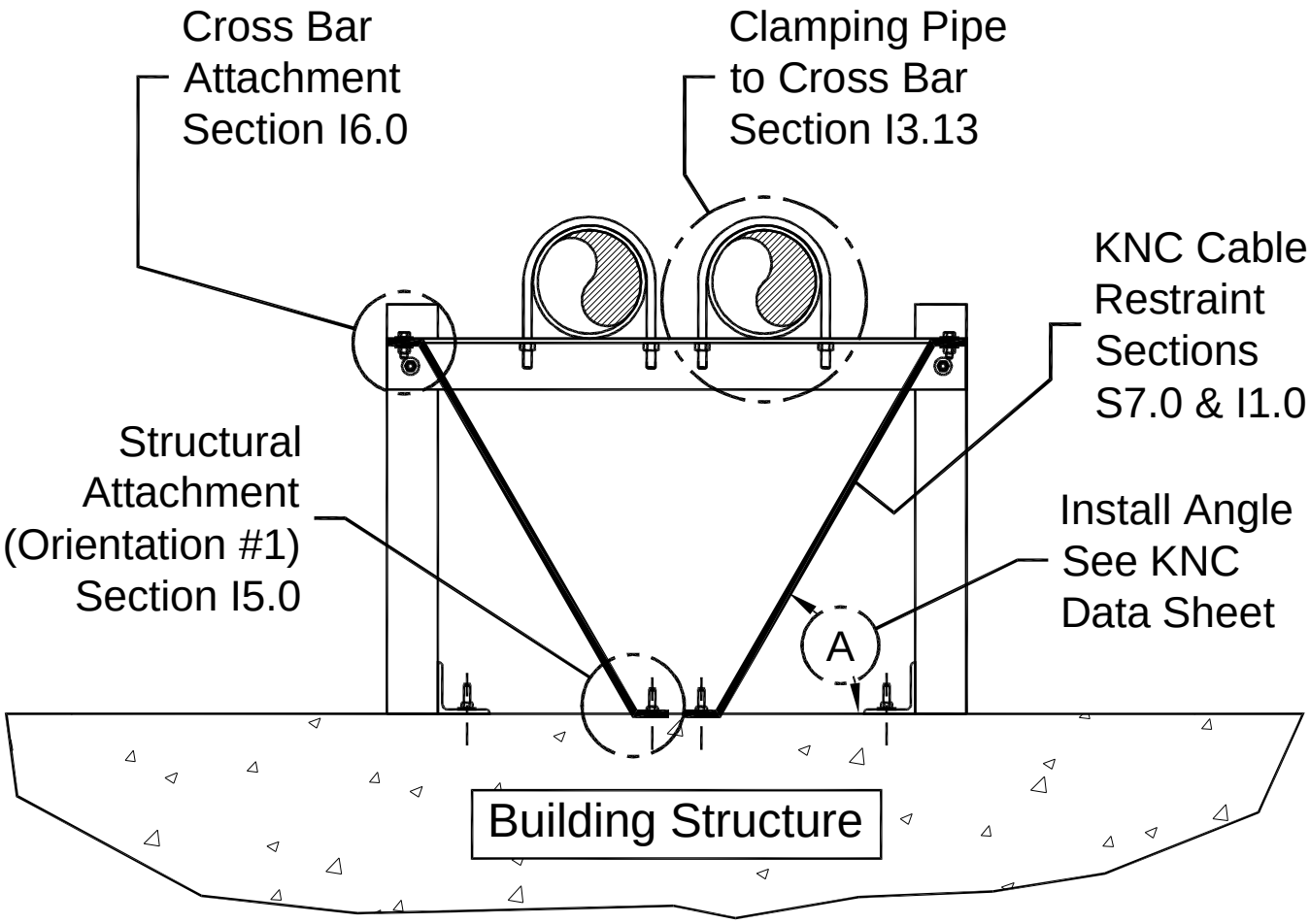

Figure I3-25; Transverse (T) Cable Restraint Schematic Arrangement for Floor or Roof Mounted Pipe – One Restraint Attached to Each Side of the Cross Bar at the Vertical Legs Directed Inward

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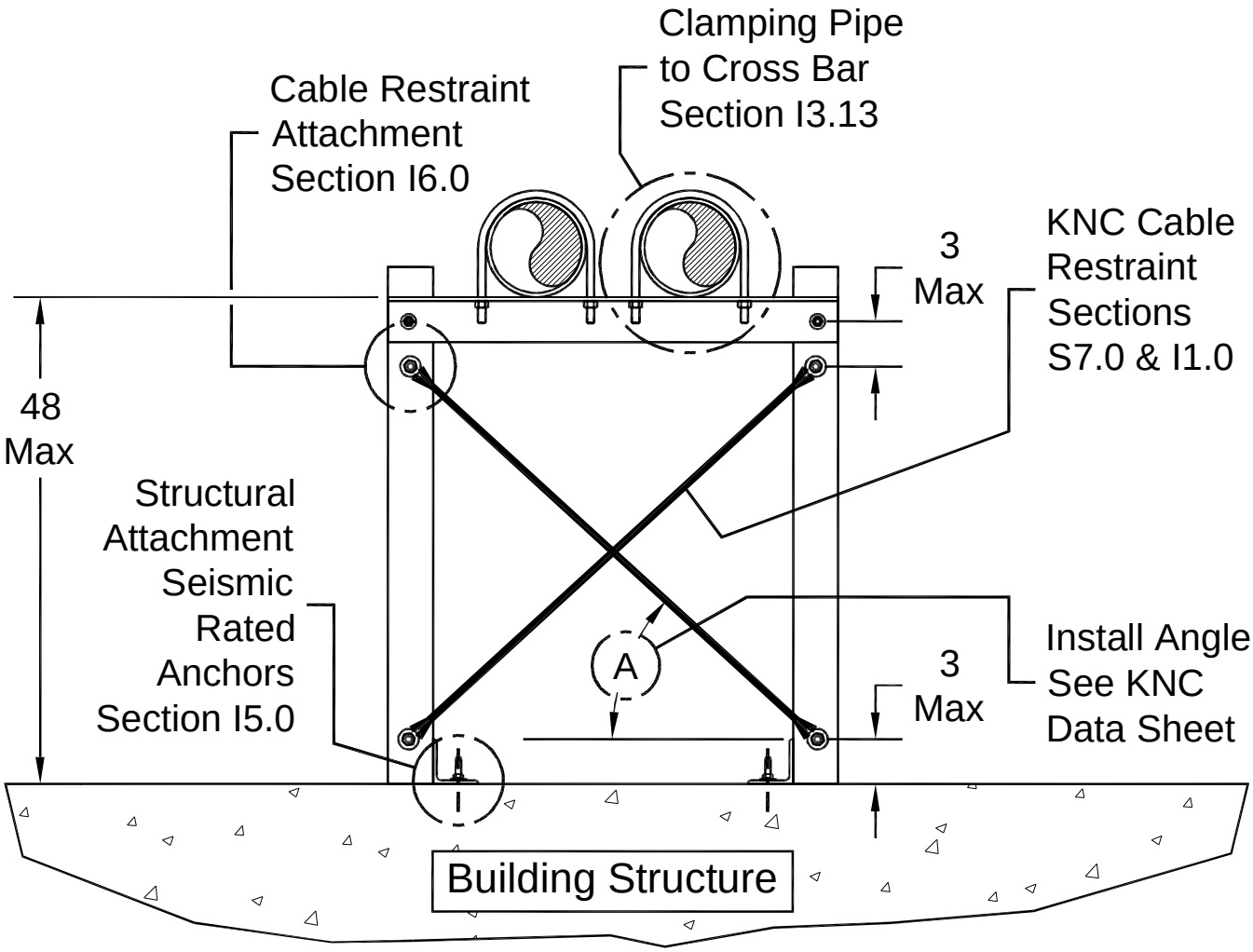

Figure I3-26; Transverse (T) Cable Restraint Schematic Arrangement for Floor or Roof Mounted Pipe – Two Restraints Attached to the Vertical Legs Acting as Cross Braces – The Anchors Attaching the Stand to the Floor Must be Seismically Rated Cracked Concrete Anchors with a Current ICC-ESR Number

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I3.9 – Longitudinal (L) Cable Restraint Schematics for Floor or Roof Mounted Pipe:

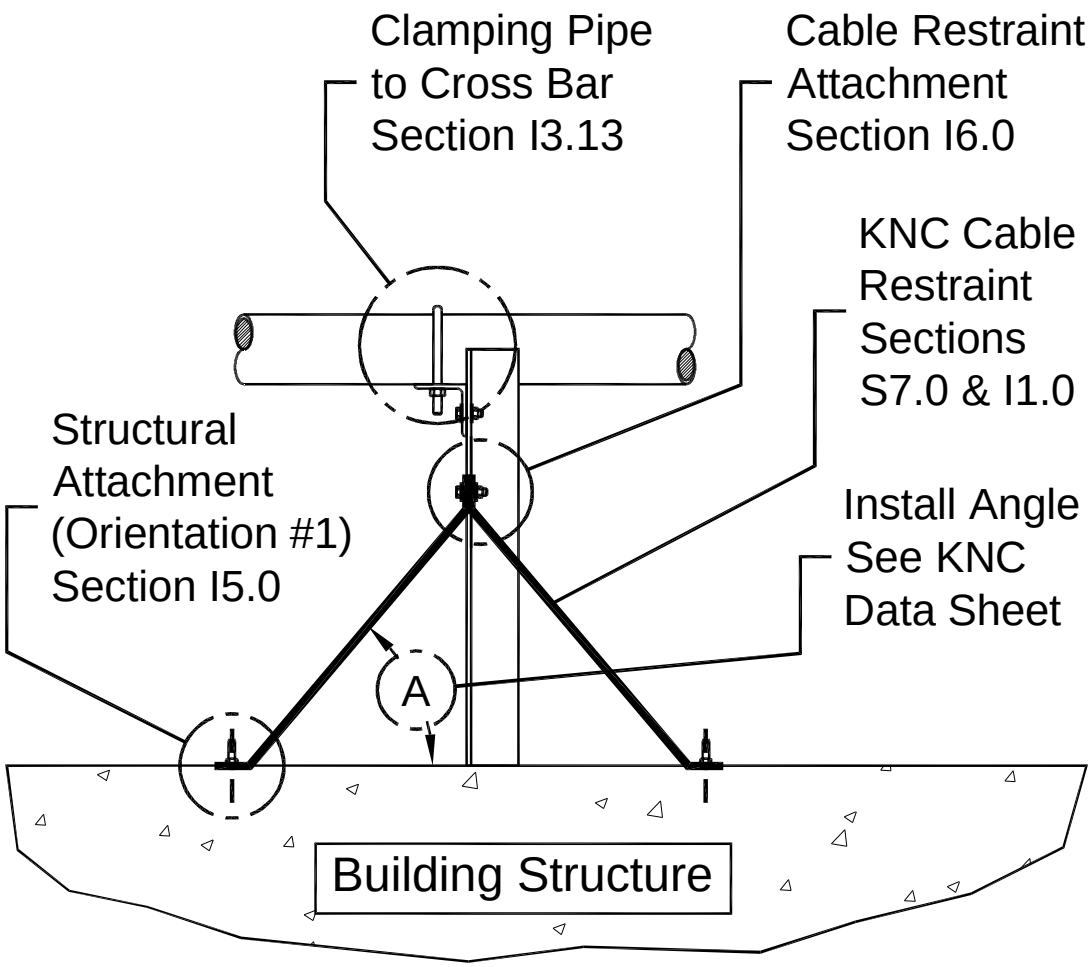

Figure I3-27; Longitudinal (L) Cable Restraint Schematic Arrangement for Floor or Roof Mounted Pipe – Restraints Attached to the Floor Stand or Support

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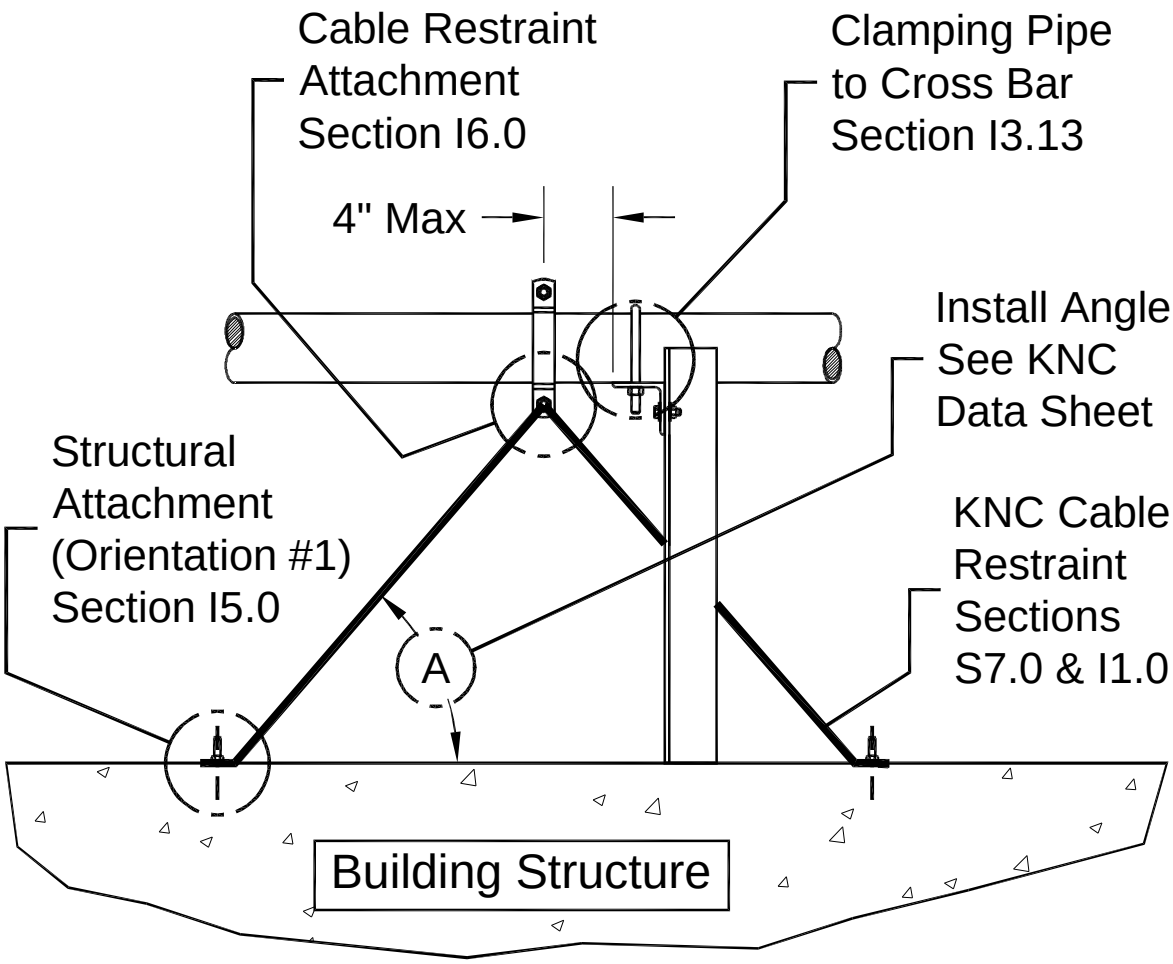

Figure I3-28; Longitudinal (L) Cable Restraint Schematic Arrangement for Floor or Roof Mounted Pipe – Restraints Attached to the Pipe – Each Pipe Must be Individually Restrained

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I3.10 – Combined Transverse & Longitudinal (TL) Cable Restraint Schematics for Trapeze Supported Pipe:

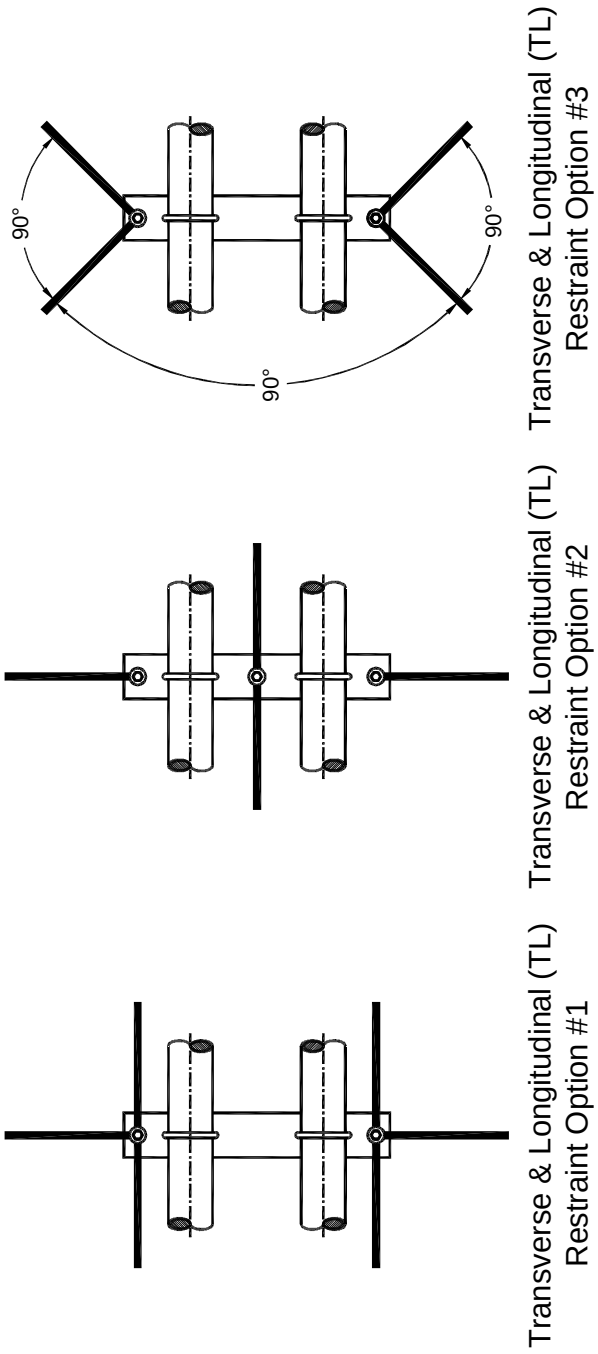

Figure I3-29; Combined Transverse & Longitudinal (TL) Cable Restraint Schematics for Trapeze Supported Pipe – All of the Options Shown Offer Balanced Longitudinal Restraint Forces Side-to-Side – Options #2 and #3 Do Not Require Extra Cable Restraint Kits While Option #1 Does Require One (1) Extra Restraint Cable Kit Beyond Those Listed in the KNC Material Required List per Combined Transverse & Longitudinal Seismic Restraint Location

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I3.11 – Some Common Trapeze Bar Configurations:

The design of trapeze bars used in the support of pipe is varies by trade, the standard used for designing the piping, engineering company, and design requirements. There are no “off the shelf” trapeze bars available as there are clevis hangers. Each trapeze bar is designed for the specific application, and the design of the trapeze bar structural members from which it is constructed are generally specified by the design professional of record for the system being installed.

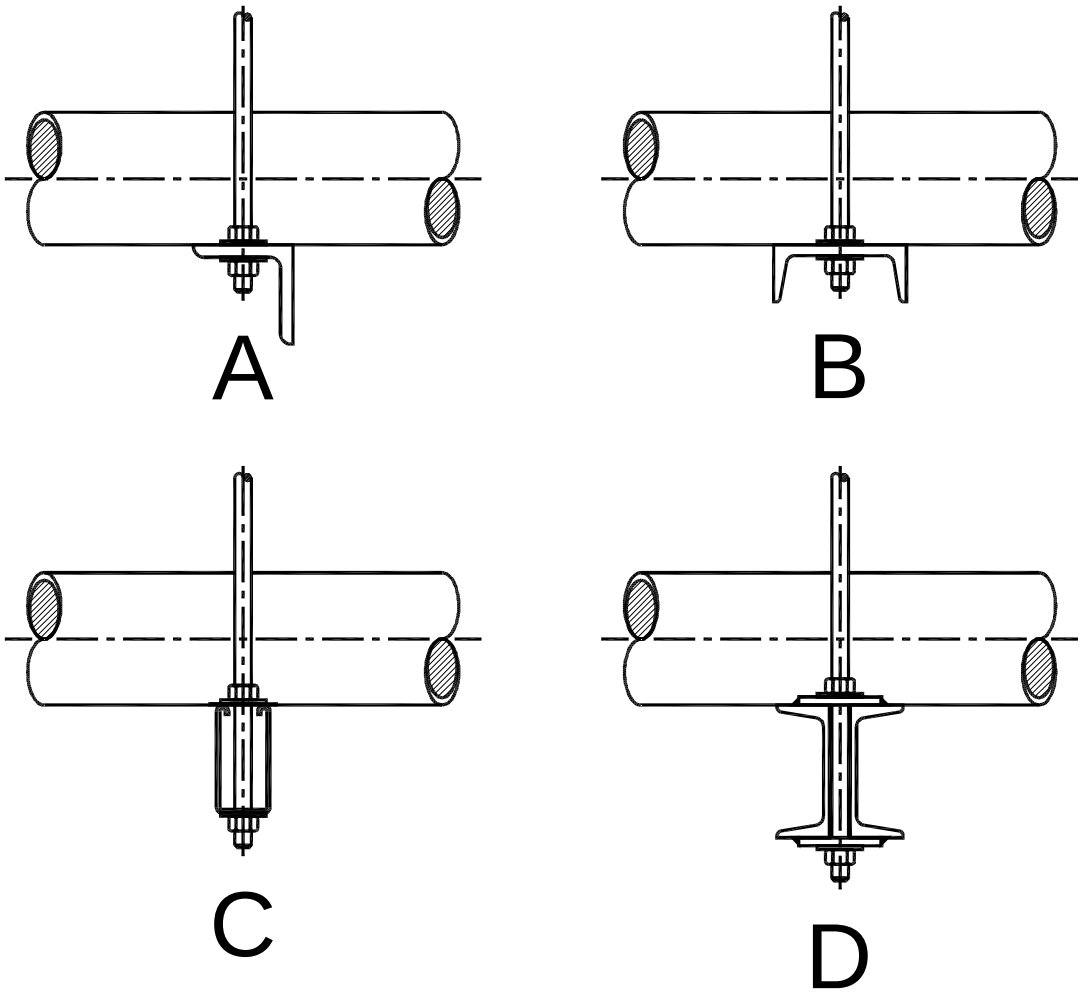

Figure I3-30; Some Common Trapeze Bar Design Configurations Used for Supporting Pipe

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Some common structural members used to construct trapeze bars used for pipe supports are shown in Figure I3-30. Figure I3-30 A is a typical trapeze bar constructed from AISI structural angle that is cut and drilled in the field for the hanger rods and pipe clamps. Figure I3-30 B is a single structural channel that mounted horizontally, and is cut and drilled in the field for the hanger rods and pipe clamps. Figure I3-30 C is a strut channel similar to a UNISTRUT® P5000 which is also cut in the field. Strut channels may be purchased pre-pierced with holes and/or slots to aid in mounting the hanger rods and clamps for the piping. Strut manufacturers also have special pipe clamps that are design to work in the open slot of the strut channel. Figure I3-30 D is a trapeze bar that is made of a weldment consisting of two standard channels back-to-back. In this configuration two drilled plates on welded on each end provide the mounting locations for the hanger rods. Pipe clamps would need to have drilled plates welded to the tops of the channels, or have holes drilled in the flanges of the channels. If the flange holes are used to mount the pipe clamps tapered structural washers should be used against the bottom of the flange to prevent bending of the clamp bolts. This design is used to carry very large and heavy pipes such as chilled water supply and return lines.

I3.12 – Trapeze Bar Design Loads:

Typically trapeze bars are designed to carry the dead weight loads of the pipes that they are supporting, and for non-seismic applications this is more than sufficient. However with the introduction of significant seismic loads, the trapeze bars at the seismic restraint locations may need to become more “beefy” to carry the horizontal seismic loads generated by the pipes they are supporting.

At transverse (T) seismic restraint locations, the seismic loads will act along the trapeze bar, which is its strong direction. The trapeze bar will only need to be strong enough to support the dead weigh load of the pipes, and to not buckle under the transverse seismic loads generated by the pipes that it is supporting.

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At longitudinal (L) and combined transverse & longitudinal (TL) seismic restraint locations, the situation is very different. The longitudinal restraints may be resisting the seismic loads generated by as much as ***eight times*** the length of pipe as they are supporting. The longitudinal seismic forces will act perpendicular to the trapeze bar and will place it in bending. Typically the strong bending direction for a trapeze bar is chosen to resist the dead weight load of the pipe which is acting 9ertically against the bar. As a result, the longitudinal seismic forces are typically applied in the weak bending direction of the trapeze bar. Since the dead weight loads and the longitudinal seismic restraint loads can act concurrently (at the same time), those trapeze bars located at longitudinal seismic restraint locations may require a stronger section to resist the expected load combination. ***This is a situation that should be addressed before the installing contractor is confronted by it in the field***!

Note for Installing Contractors: If a similar trapeze bar design is being used throughout a project, the following situations will warrant a question back to the design professional of record for the system being installed.

1. The project is located in a high seismic area such as;
    a. Los Angeles, CA
    b. San Francisco, CA
    c. Seattle, WA
    d. Portland, OR
    e. Salt Lake City, UT
    f. Memphis, TN
    g. Charleston, SC
2. Large piping is being supported on trapeze bar designs that are also used for smaller pipes.
3. The same trapeze bar design is being used on the top floor and in the basement to carry the same number and size of pipes.

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The seismic design forces acting on the pipe, and the seismic restraint locations and spacings are discussed in the Sections S5.0 and S7.0 respectively. It is the responsibility of the design professional of record for the system being installed to ensure that the trapeze bars at each seismic restraint location are capable of carrying the dead weight loads of the pipe as well as the design seismic loads specified by the code for the project.

I3.13 – "Clamping" the Pipe to the Trapeze Bar – When and How:

When the seismic restraints are attached to either the trapeze bar or the hanger rod(s), the pipes themselves must be clamped, or otherwise positively attached to the trapeze bar to ensure that the seismic loads from the pipes is indeed passed through to the seismic restraints. There can be no relative motion between the pipe and the trapeze bar. Clamps such as U-bolt clamps do rely on friction to hold the pipe in place, but the normal force depends on the torque applied to the nuts rather than the gravity load from the dead weight of the pipe. Therefore, the clamping force may be increased to the point where slippage between the pipe and the trapeze bar is not possible. There are many other types of clamps that may be employed such as the strut type clamps made to work with strut channels such as those manufactured by UNISTRUT® and Cooper B-Line. It is the responsibility of the design professional of record responsible for the system to determine if the clamps specified will be adequate to transmit the expected seismic loads, and to specify the proper torque values required.

When working with steam lines, hot or chilled HVAC water lines, and domestic hot water lines a means to deal with the thermal growth and shrinkage of the pipes must be used that will properly limit the relative movement between the pipe and the trapeze bar at the restraint locations. Pipes such as steam lines and hot or chilled HVAC lines typically are insulated to maintain system thermal efficiency. The insulation presents some particular issues when the relative motion between the pipe and trapeze bar must be kept to zero. Figure I3-31 shows one means of allowing thermal growth or shrinkage while preventing transverse movement of the pipe, and

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providing uplift control. Note, some means of protecting the insulation such as protection saddles must be used to prevent it from being crushed during an earthquake.

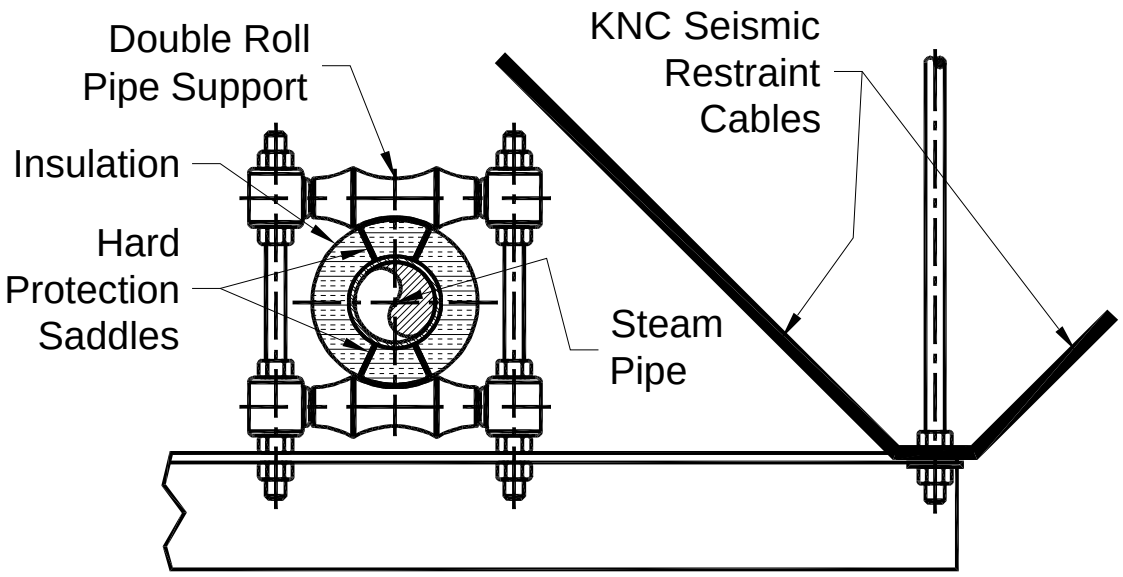

Figure I3-31; Transverse (T) Cable Restraint Location for Trapeze Supported Steam Line – Insulated Steam Pipe Is Trapped in the Transverse Direction and Uplift Is Prevented, While Thermal Growth Is Allowed by a Double Roll Pipe Support

Figure I3-32 shows a hot or chilled HVAC water line supported by a trapeze bar at a transverse seismic restraint location. Here the pipe is loosely restrained to the trapeze bar by a U-Bolt that is slightly wider than the insulation, and is not tightened down. The clearance between the pipe and the U-Bolt must not exceed 1/4″. This arrangement will allow the pipe to grow or shrink without affecting the trapeze bar, or overloading the pipe. Here again, some means of protecting the insulation must be used. Shown in Figure I3-32 are protection saddles, however in lighter seismic conditions, insulation protection shields may serve just as well. Figure I3-33 shows a steam line, or a hot or chilled HVAC water line supported by a trapeze bar at a longitudinal seismic restraint location. Here the pipe is clamped to the trapeze bar firmly enough to prevent slippage between the pipe and the trapeze bar in the longitudinal direction. Great care must be taken that the insulation, and in some cases, the pipe are not crushed when the U-Bolt is tightened down. Typically, there will be only one longitudinal seismic restraint location for this type of pipe per run.

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If more longitudinal seismic restraints are required, expansion/contraction joints will be needed between adjacent longitudinal restraints, see Section S9.0 of this manual.

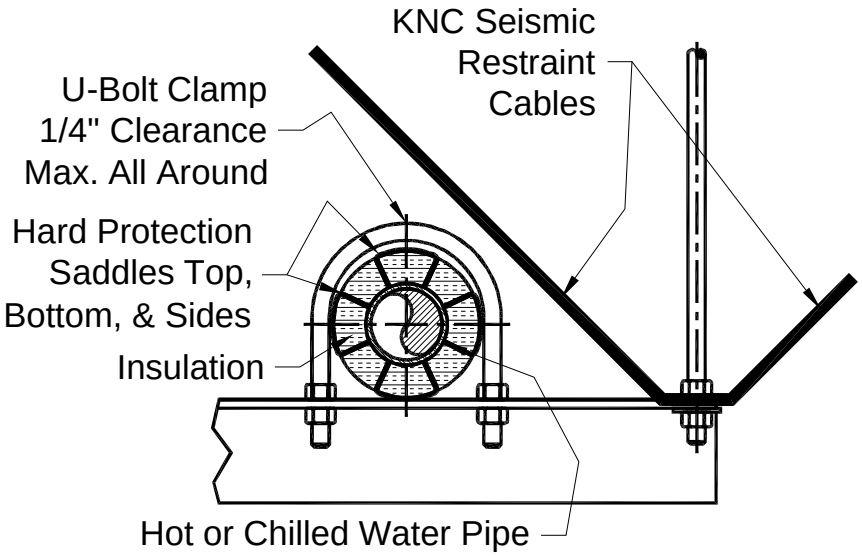

Figure I3-32; Transverse (T) Cable Restraint Location for Trapeze Supported Hot or Chilled Water Line – Insulated Water Pipe Is Trapped in the Transverse Direction and Uplift Is Prevented, While Thermal Growth Is Allowed by a U-Bolt which is Slightly Wider than the Insulation, and which Is Not Tightened Down

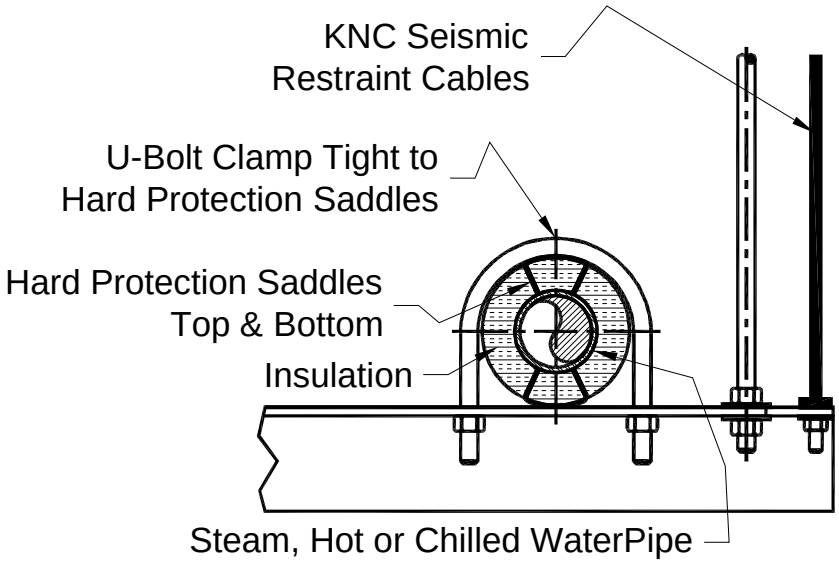

Figure I3-33; Longitudinal (L) Cable Restraint Location for Trapeze Supported Steam Line, or Hot or Chilled Water Line – Insulated Pipe Is Trapped in the Longitudinal Direction and Uplift Is Prevented by a U-Bolt which Fits the Insulation Snuggly, and which Is Tightened Down Sufficiently to Prevent Longitudinal Motion of the Pipe Relative to the Trapeze Bar

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Figures I3-34 and I3-35 show the clamping arrangements for domestic hot water lines to a trapeze bar at the transverse and longitudinal seismic restraint location respectively. Extra care must be taken with domestic hot water piping because the pipes are usually thin wall copper tubing, or are PVC or CPVC. These pipes are easily crushed; therefore, torque values for tightening the U-Bolt clamps on the pipes supported by trapeze bars at longitudinal seismic restraint locations must be closely monitored.

There will probably be only one longitudinal seismic restraint location per run for domestic hot water pipes, and it will typically be located in the middle of the run to balance the thermal growth in the pipe. Also, the last transverse seismic restraint location must be far enough away from a corner so that the pipes do not fail in bending when they grow in service, see Section S9.0 of this manual.

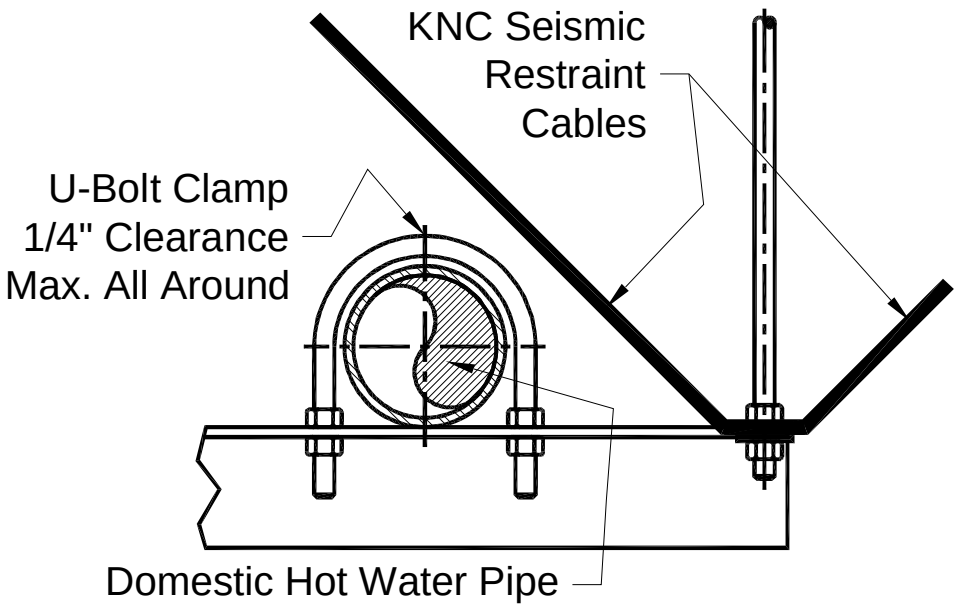

Figure I3-34; Transverse (T) Cable Restraint Location for Trapeze Supported Domestic Hot Water Line – Water Pipe Is Trapped in the Transverse Direction and Uplift Is Prevented, While Thermal Growth Is Allowed by a U-Bolt which is Slightly Wider Than the Pipe, and which Is Not Tightened Down

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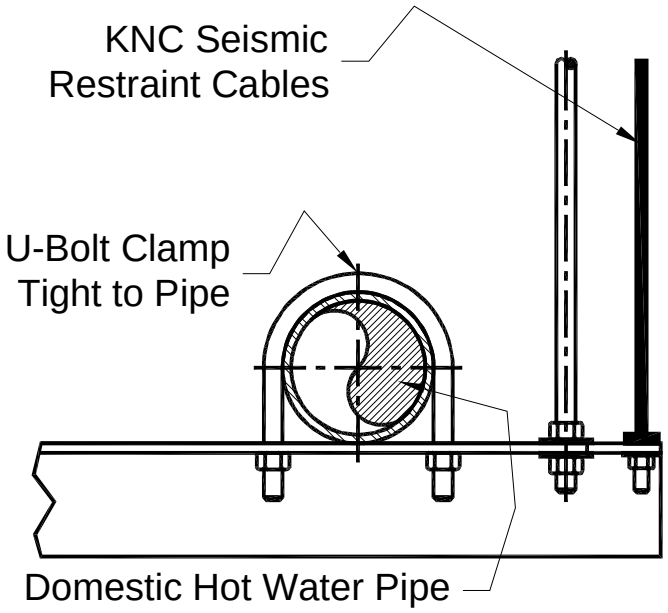

Figure I3-35; Longitudinal (L) Cable Restraint Location for Trapeze Domestic Hot Water Line – Water Pipe Is Trapped in the Longitudinal Direction and Uplift Is Prevented by a U-Bolt Which Fits the Pipe Snuggly, and Which Is Tightened Down Sufficiently to Prevent Longitudinal Motion of the Pipe Relative to the Trapeze Bar

I3.14 – Summary for Seismic Cable Restraints for Piping:

1. The schematics and arrangements presented in this section are intended to be used as guidelines for the installation of seismic restraints for piping. They do not represent fully engineered designs for specific projects. The specific design details of each installation are the responsibility of the design professional of record for the systems that are being installed.
2. A ***minimum of two seismic restraint cables acting 180° apart*** are required for each transverse and each longitudinal seismic restraint location.
3. When locating and specifying seismic restraints for a project, Kinetics Noise Control will list the minimum required number of seismic restraint kits required under ideal conditions for the project. The actual installation circumstances may require additional restraint kits at certain locations.

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4. Clevis hangers, trapeze bars, and hanger rods at seismic restraint locations must be properly sized and specified by the design professional of record for the system to handle the expected seismic forces as well as the dead weight loads from the pipe.
5. Attachment of seismic restraints to the piping, clevis hangers, trapeze bars, and hanger rods must be approved by the design professional of record for the system.
6. For floor or roof mounted pipe where the restraints are installed as shown in Figure I3-26, the anchors attaching the stand or support to the building structure form part of the seismic load path. As such, these anchors must be seismically rated anchors for use in cracked concrete, and must have a current ICC-ESR number.
7. Attachment of seismic restraints to the building structure must be approved by the structural engineer and/or the architect or record.

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