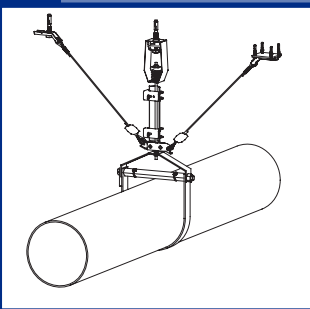
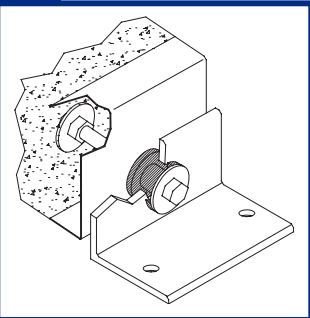
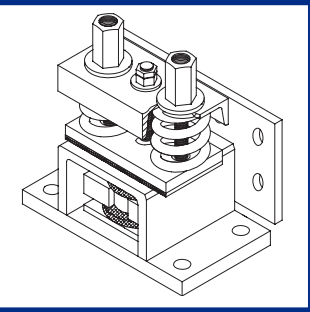


KINETICS NOISE CONTROL



SEISMIC
RESTRAINT
CAPABILITIES

 **KINETICS**
Noise Control

WHY IS SEISMIC RESTRAINT NEEDED?

The damaging effects of earthquakes are of significant concern in many areas of the world. Earthquake damage to inadequately restrained mechanical and electrical systems within buildings can be extensive. Mechanical and electrical equipment knocked off of its supporting structure due to earthquake-related building movement can threaten both life and property. The cost of properly restraining this equipment is insignificant compared to the associated costs of replacing or repairing the equipment and to the cost of system down-time as a result of seismic damage to the building services.

This brochure presents restraint systems which serve to limit the movement of equipment and to keep the equipment captive during a seismic event. Proper utilization of these systems can reduce the threat to life and minimize long-term costs due to equipment damage and associated loss of service.

A thorough analysis of seismic restraint hardware and seismic rated vibration isolators requires the consideration of four (4) aspects of the system:

1) Attachment of the Equipment to the Restraint.

The equipment must be securely attached to the restraint, and this attachment must demonstrate sufficient strength to withstand the imposed forces and to allow for transfer of seismic forces into the restraint.

2) Restraint Design.

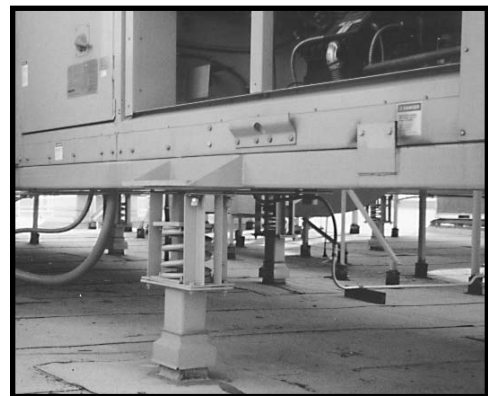
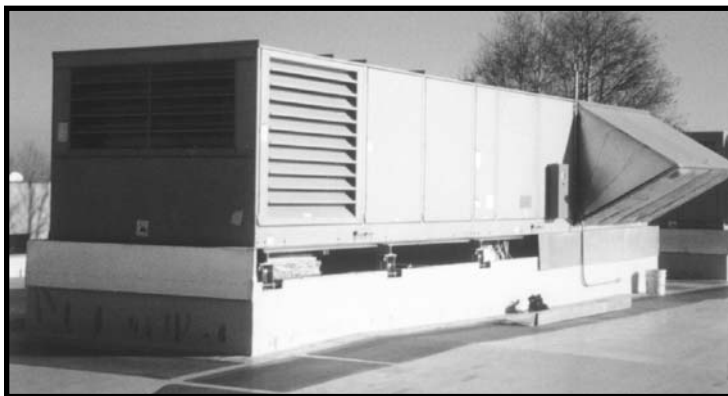
The strength of the seismic restraint must be sufficient to withstand the equipment imposed forces. Kinetics offers a wide variety of restraints suitable for many different applications.

3) Attachment of Restraint to the Building Structure.

This attachment is typically via bolts, welds, or concrete anchors. In addition, the building attachment interface must be reviewed to ensure that it is capable of withstanding the imposed seismic forces. Typically this attachment is the 'weakest link' of the overall design, especially when embedded concrete anchors are used.

4) Equipment Fragility.

The ability of the equipment to continue to operate after being subjected to seismic force. Fragility information must be obtained from the equipment manufacturer and is not covered in this brochure.



Examples of properly restrained HVAC equipment surviving the 1994 Northridge earthquake unscathed. On the left is a rooftop installation directly next door to the collapsed parking garage in Northridge. On the right is a rooftop installation across from the I-10 collapse.

BUILDING CODE REVIEW

The equations used to determine Seismic Design Forces throughout the United States as well as the rest of the world are based on historical data that has been collected during past earthquakes. As the level of knowledge and data collected increases, these equations are modified to better represent these forces. The heavily instrumented San Francisco (1989-Loma Prieta) and Los Angeles (1994-Northridge) earthquakes increased this knowledge dramatically. Major shortcomings in the force levels predicted by the codes in effect at the time have led to the development of considerably more complex equations that more accurately address items such as equipment locations within a building, soil factors, etc.

Historically, there have been three independent codes used in various areas of the United States. In the Northeast, the Building Officials Code Administration (BOCA), developed to address concerns local to the area such as high snow loads, was the predominate code. In the Southeast, the Southern Building Code Congress International (SBCCI), developed the Standard Building Code (SBC), which tended again to focus on local concerns like wind, is the most common building code. While seismic requirements were addressed by these codes, the design criteria were not particularly severe. West of the Mississippi and more commonly used internationally is the Uniform Building Code or UBC. Because of the more severe conditions present in the western United States, the UBC was required to address snow, wind, and seismic loads on a more equal footing.

The first code version significantly affected by the seismic data collected in the early 1990's was the 1997 UBC. Several new factors were introduced to the design equations to account for soil, fault proximity and type, specifics of the equipment location within the structure, and typical dynamic response characteristics for particular kinds of equipment.

- In 2000, the International Building Code or IBC was released. This new code was developed as a collective effort by the three independent code bodies. The IBC was intended to, and has been replacing the three independent codes countrywide. The driving force behind the development of this code has been FEMA. While this code most closely resembles the 1997 UBC, it is a considerably refined version using, among other things, new and considerably more comprehensive seismic hazard maps.
- BOCA and SBC will not be updated. Instead, these older generation codes and the smaller seismic design loads predicted by them are being phased out during the next ratification cycle.
- Within the Western Hemisphere, the other code that is most frequently used is the Canadian National Building Code or NBC. The 1995 version of this code, when introduced, was ahead of the U.S. building codes in addressing the location of equipment in buildings. While not currently listing requirements as severe as those identified in the 1997 UBC or IBC, the force development equations specified by the code are quite similar to those of the newer U.S. codes.

It is important to recognize that the newer codes predict a significantly higher seismic design load than past codes. This is particularly true for equipment located in upper levels of buildings. In some instances using the newer code criteria it will be found that attaching heavy, unstable equipment located on an upper floor will not be practical with concrete anchorage. A connection directly to steel will be required.

Depending on the geology of the installation site, a vertical force component may also need to be considered when evaluating seismic loads. When incurred in the codes, this force is typically a fixed percentage of the horizontal seismic load.

SEISMIC FORCE COMPUTATION FOR EQUIPMENT

Within this brochure, it is not practical to offer the details of all of the various methods used by the different codes to compute the design load. These details are available in the specific code documentation. We will discuss the two typical seismic force equation formats.

1) First Typical Seismic Force Equation: Used by all codes prior to 1994 as well as by the latest versions of the BOCA and SBC. It is also used to establish a maximum and minimum boundary condition for the 1997 UBC and 2000 IBC:

$$F_p = (A_v C_1 C_2 \dots) W$$

Where F_p is the Seismic design force, A_v is the ground acceleration coefficient for the equipment site, C_1 , C_2 , etc., are coefficients drawn from various tables based on building importance, type of equipment and type of attachment and/or other factors, and W is the equipment weight.

2) Second Typical Seismic Force Equation: Used by the 1995 NBC, and is the basic formula used in the 1997 UBC and the 2000 IBC. The format used is:

$$F_p = \frac{A_p C_1 C_2 \dots}{R_p} \left(1 + D_1 = \left(\frac{H_x}{H_r} \right) \right) W$$

Where F_p is the Seismic design force, A_p is the ground acceleration coefficient for the equipment site tailored for soil or fault proximity conditions. C_1 , C_2 , etc., are coefficients drawn from various tables based on building importance, type of equipment and type of attachment and/or other factors. R_p is a ductility factor representing the ability of the anchorage to survive repeated impacts (it is again drawn from a table). D_1 is a constant and varies from code to code (For the NBC = 1, for 1997 UBC = 3 and for the IBC = 2). H_x and H_r are the height above ground of the equipment and of the structure's roof, respectively, and W is the equipment weight.

While the general application of these equations is relatively straightforward, it is important to review all of the footnotes in the tables to ensure that the appropriate factors are being applied.

3) Sample Computation: Using the 1997 UBC, 2000 or 2003 IBC would look something like this:

$$F_p = \frac{0.38 * 1.0 * 1.5}{3.0} \left(1 + 3 = \left(\frac{45}{60} \right) \right) 2500 \text{ lbs.} = 1544 \text{ lbs.}$$

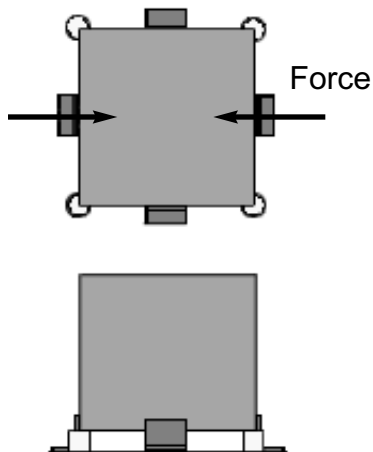
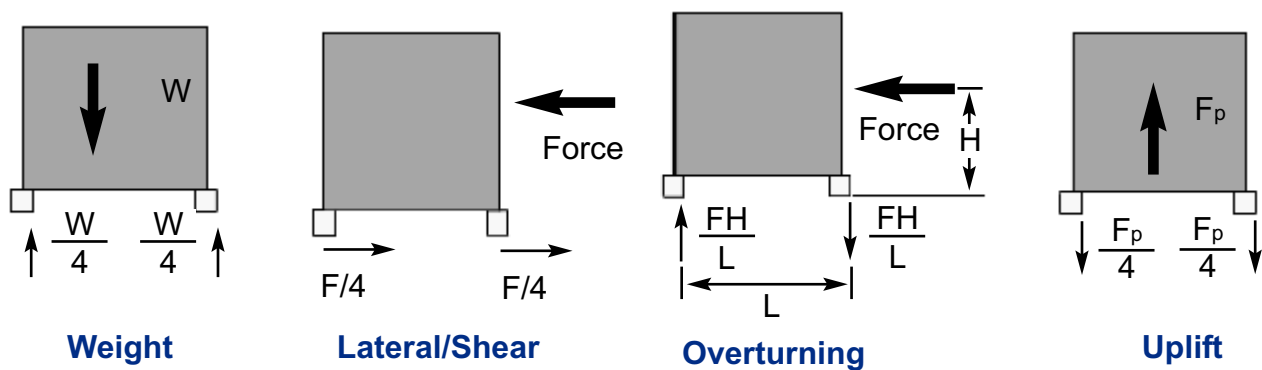
Where:

- 0.38 is the ground acceleration coefficient;
- 1.0 is the component amplification factor;
- 1.5 is the importance factor;
- 2.0 is the component response modification factor;
- 45 ft. is the elevation of the equipment;
- 60 ft. is the roof elevation;
- 2500 lbs. is the weight of the equipment.

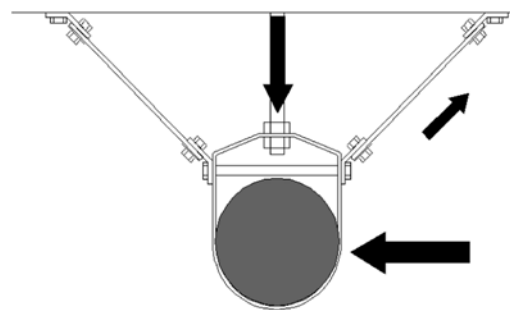
FORCE DISTRIBUTION FOR EQUIPMENT

In order to conduct a complete analysis on a piece of equipment, the anchorage loads for that equipment must be determined and the equipment itself must be capable of resisting the design forces. In order to determine if the anchorage is adequate, the worst case forces at the mounting points of the equipment resulting from the design force must be determined. Because equipment geometry, restraints and attachment hardware vary considerably, the analysis must be tailored to the specific application.

There are four primary forces that must be analyzed (indicated below). The equipment center of gravity will affect the magnitude of these forces at the individual restraint locations. When computing reaction loads, the worst case approach direction of the seismic force must be determined and used in the analysis.



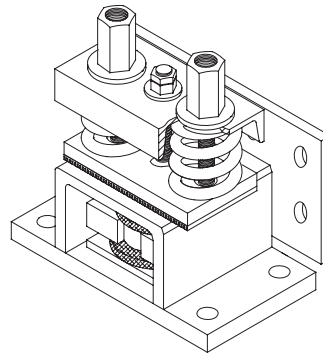
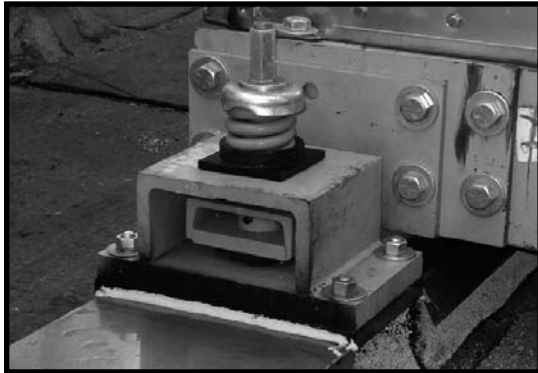
Single directional restraints (Kinetics HS-1) will only share loads if the seismic force is directed along an axis on which they are applied.



Compressive or tensile loads can develop in hanger rods as a result of lateral loads imposed on cable or rigid diagonal braces.

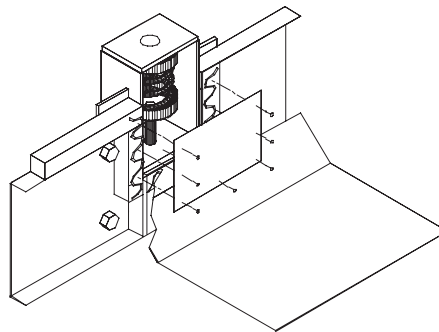
Kinetics Noise Control is available as a resource to compute these forces, size generic attachment hardware as well as to evaluate the applicability of Kinetics-provided Restraints or Seismically rated isolators for particular applications. Contact your local Kinetics Noise Control Representative for details.

FLOOR MOUNTED EQUIPMENT ISOLATION/RESTRAINT



KINETICS MODEL FMS

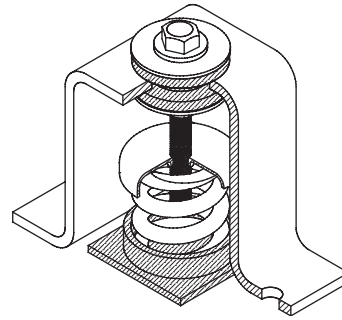
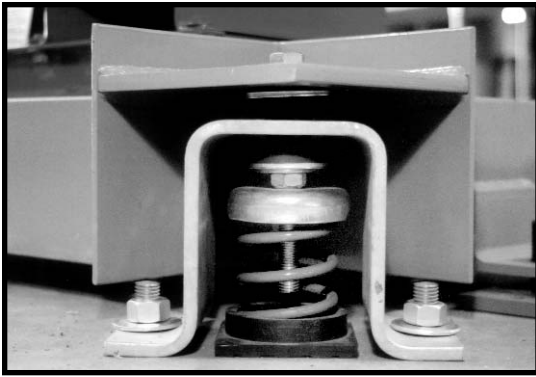
- The unique design of the Kinetics FMS restraint module minimizes the seismic loads transmitted into the anchors or other attachment hardware. As a result, considerably higher seismic ratings are possible versus conventional designs using similar sized connection hardware.
- Restraint capacities to meet all building code requirements*
- Horizontal force capacity ratings ranging to 70,000 lbs.
- Easy to install, adjust and inspect



KINETICS MODEL ESR VIBRATION ISOLATION CURB FOR ROOF-MOUNTED AHU EQUIPMENT

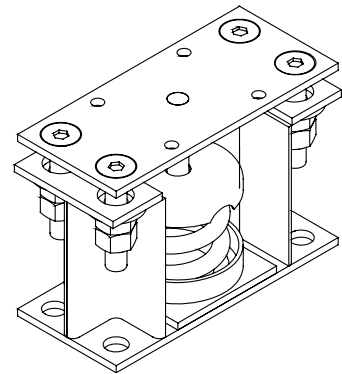
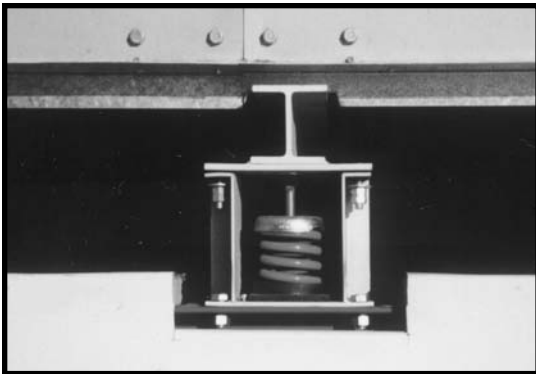
- Structural steel isolated curb with wood nailer
- Provides seismic and wind restraint required by current building codes*
- Access ports for each coil spring isolator
- Available static deflection from 1" to 4"
- Options: Sloped Roof
Acoustical Insulation
External Thermal Insulation

*Equipment geometry, attachment and anchorage may affect restraint capacity.



KINETICS MODEL FHS

- Combination coil spring isolator and seismic restraint for indoor and outdoor floor mounted fans, pumps, air compressors and other mechanical equipment
- All-directional restraint with vertical limit stops
- Field interchangeable spring coils
- Galvanized housing and epoxy powder coated coils
- Constant free height and operating height
- Equipment motion limited to 0.2" in all directions, at the isolator
- Provides seismic and wind restraint required by current building codes*
- Available static deflection from 1" to 4"
- OSHPD Preapproval Number R-0433

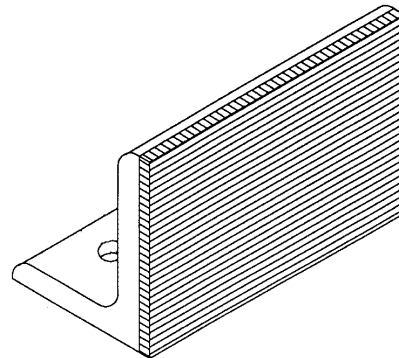
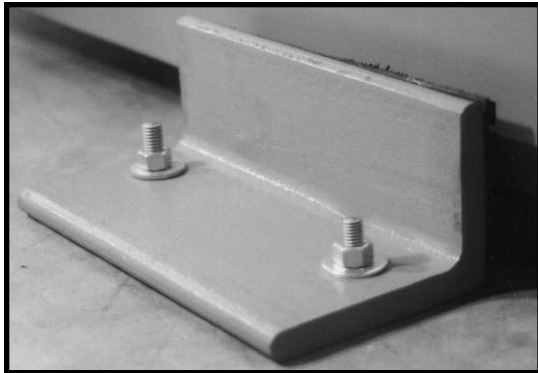


KINETICS MODEL FLSS

- Combination coil spring isolator and seismic restraint for indoor and outdoor floor mounted cooling towers, chillers and boilers
- All-directional restraint with adjustable vertical limit stops
- Field interchangeable spring coils
- Galvanized housing and epoxy powder coated coils
- Constant free height and operating height
- Equipment motion limited to 0.2" in all directions at the isolator
- Provides seismic and wind restraint required by current building codes*
- Available static deflection from 1" to 4"

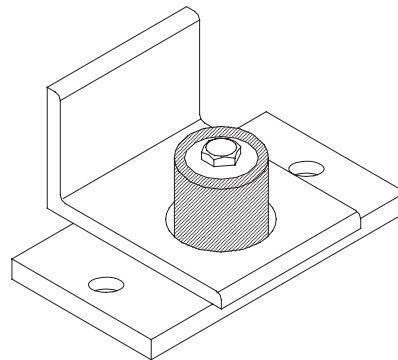
*Equipment geometry, attachment and anchorage may affect restraint capacity.

FLOOR MOUNTED EQUIPMENT RESTRAINT



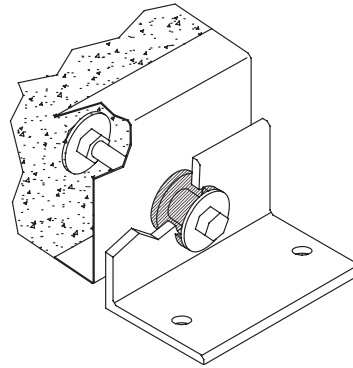
KINETICS HS-1 SEISMIC SNUBBER

- Single axis horizontal seismic restraint
 - Standard capacities of up to 5,000 pounds force
 - May be bolted or welded in place
 - Replaceable neoprene elements
 - Easily Inspected for short circuits
-



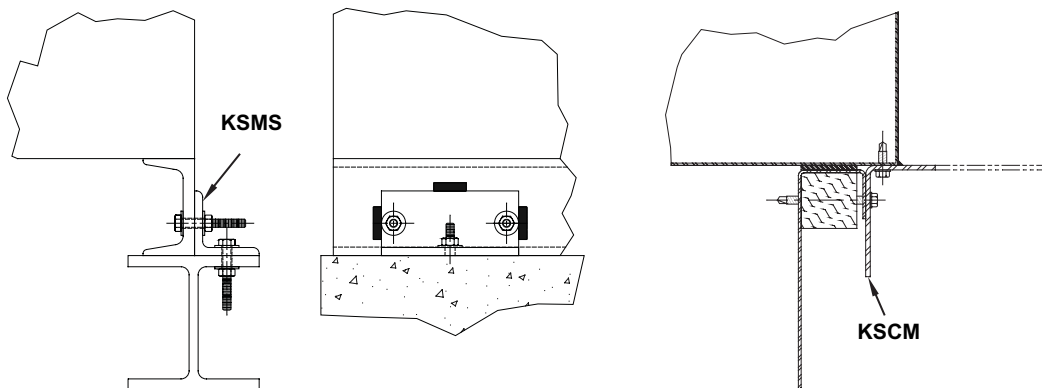
KINETICS HS-2 SEISMIC SNUBBER

- Double axis horizontal seismic restraint
- Standard capacities up to 6,500 pounds force
- May be bolted or welded in place
- Replaceable neoprene elements
- Easily Inspected for short circuits



KINETICS HS-5 SEISMIC SNUBBER

- Double axis horizontal and vertical seismic restraint
- Standard capacities from 250 to 3,275 pounds force
- Restraint capacities to meet all building code requirements
- May be bolted or welded in place
- Replaceable neoprene elements
- Easily inspected for short circuits



KINETICS SEISMIC BRACKETS FOR FLOOR AND CURB MOUNTED EQUIPMENT

• Model KSMS Seismic Equipment Mounting Clips

Seismic and wind restraint brackets used to solid-mount equipment to the building structure. The clips can be bolted or welded to the equipment and attached to the structure by anchoring to concrete or bolting to steel.

• Model KSCM Seismic Brackets for Curb Mounted Equipment

Seismic and wind restraint brackets used to solid-mount equipment to a roof curb. The clips can be bolted to the equipment and the roof curb. The attachment of the curb to the building structure is the responsibility of others.

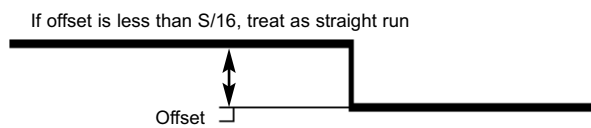
SEISMIC RESTRAINT OF SUSPENDED EQUIPMENT, PIPING AND DUCTWORK

Failures in piping systems that have led to the release of water or other fluids have been found to be the cause of most of the monetary damage to buildings and contents during seismic events. The most frequent occurrence of these failures has been in systems that were not restrained to the standards set forth in the building codes or the guidelines issued by SMACNA (Sheet Metal and Air Conditioning Contractors National Association).

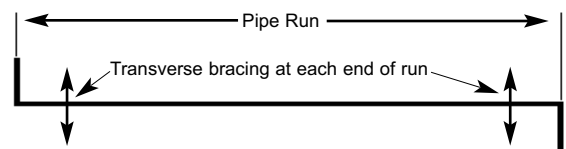
The code bodies have revised their focus in these areas, ensuring that the current Code and Guideline information is followed.

Broadly stated, in applications where significant motion can occur, the restraint requirements for piping and ductwork systems are to be adequately sized in both the lateral and axial directions. These restraints must be used with spacings short enough to prevent local failures in the pipe/duct runs between restraints.

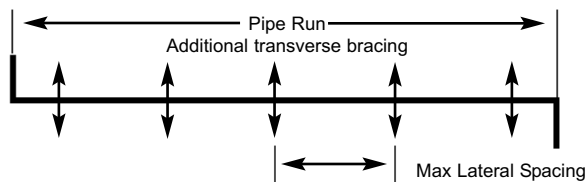
In the field, seismic restraint systems must attach and interface with numerous piping, ductwork, and electrical systems. It is difficult if not impossible to specify locations for these restraints prior to completion of the runs since the routes of these systems frequently changes over the course of construction. It is recommended that the seismic restraint be installed after the installation of the mechanical and electrical systems. The SMACNA Seismic Restraint Manual offers general guidance for field installation of these restraints. It includes tables with maximum spacing and restraint component sizes for various sizes of piping and ductwork in the various seismic zones. The SMACNA manual is easily understood and can be effectively used by installation contractors on systems already in place. The value listed as "S" in the drawings below comes from tabulated data from SMACNA and computation sheets provided by Kinetics Noise Control for case specific applications.



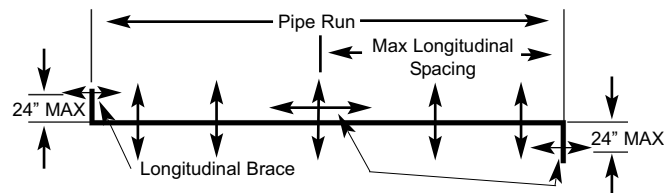
Definition of a pipe "run"



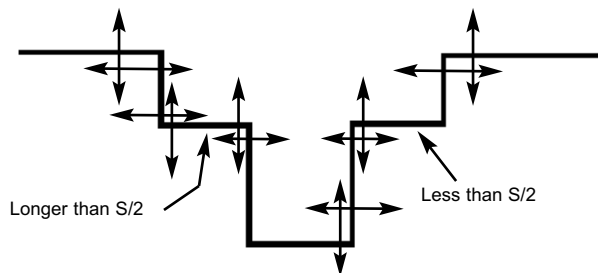
Minimum number of lateral restraints on a "run"



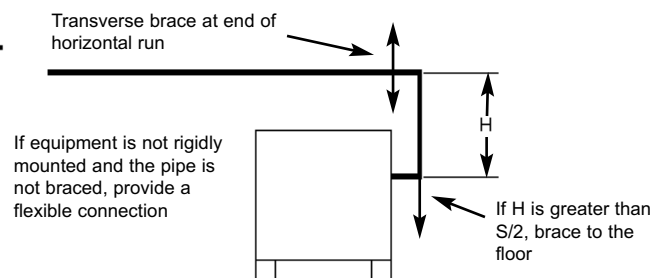
Additional lateral restraints



Minimum number of lateral restraints on a "run"



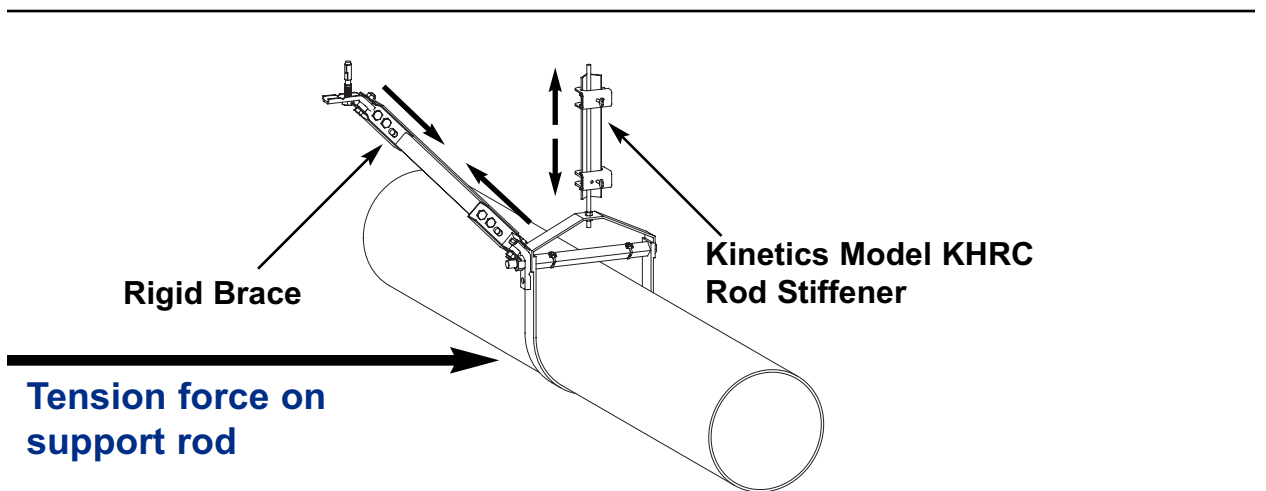
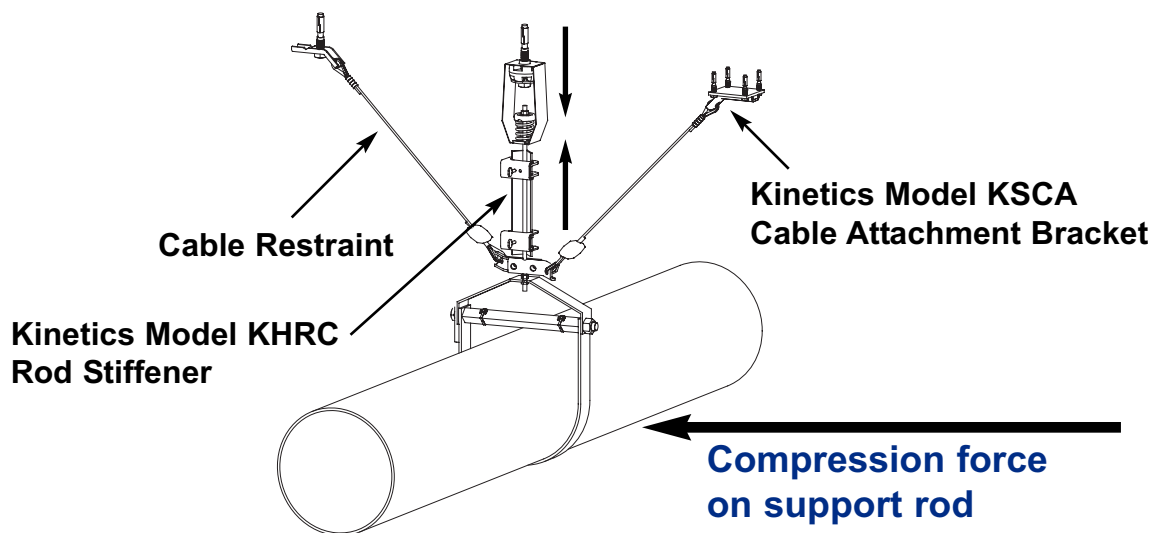
Restraining a series of short jogs



Restrains at termination points

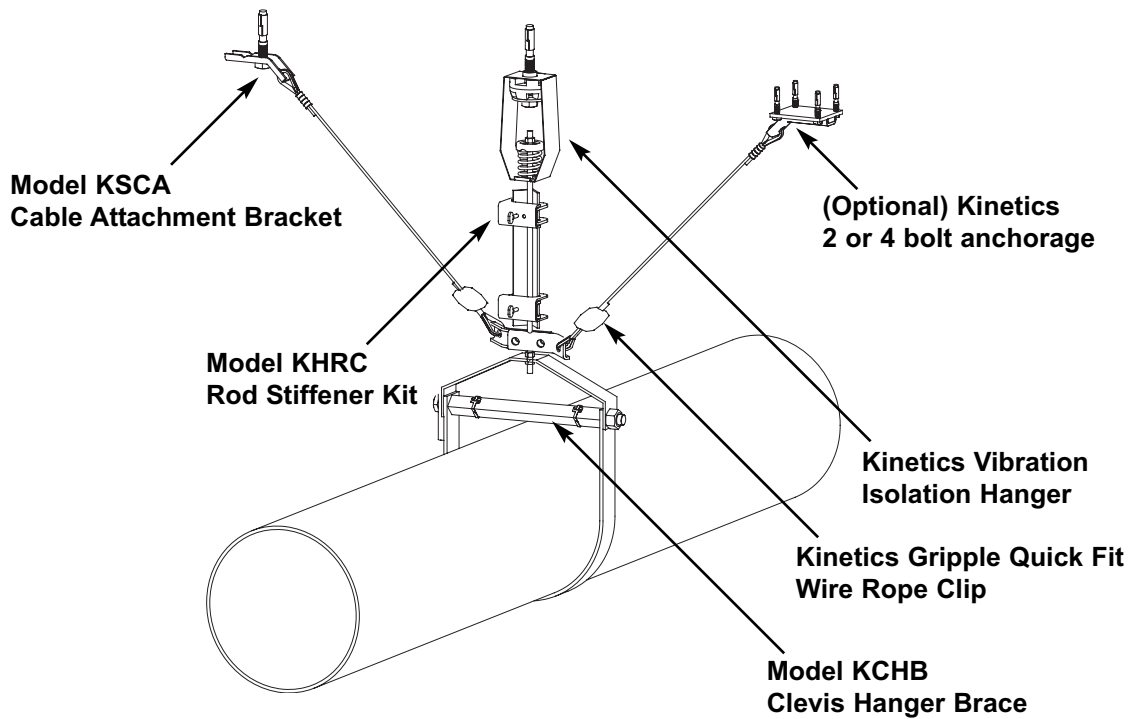
Typically piping/ductwork systems are restrained either with cable restraints or rigid braces that run upward at an angle from the pipe/duct to the ceiling. Because these links run at an angle, the application of a horizontal load generates a vertical load component on the hanger rod which supports the pipe or duct. This vertical component can frequently be as large as double the horizontal force. This vertical force needs to be taken into account when designing the anchorage.

When using cable restraint systems, the secondary vertical force component generated by the horizontal load is always directed upward, loading the support hanger rod in compression. With rigid braces, the vertical force component can be either in compression or tension, depending on the direction of the seismic load. To resist the compressive load, a stiffener is required on the hanger rod when the critical buckling length of the hanger rod is exceeded. This dimension is tabulated in the SMACNA guidelines for various piping configurations. Where a rigid brace is used, not only does the long hanger rod require a stiffener, the anchor itself must also be capable of taking a downward load comprised of both the weight load of the pipe and the downward force generated by the seismic event.



It has been found that piping or ductwork that is hung on rods such that the dimension from the top of the pipe/duct to the underside of the supporting surface is 12" or less will not be excessively excited by a seismic event. It has also been found that pipes under 2-1/2" in diameter are sufficiently small and ductile such that they will flex and not be damaged by an earthquake. The same holds true for ducts that are under 6 ft in cross-sectional area. Most of the codes exclude such systems from seismic restraint requirements.

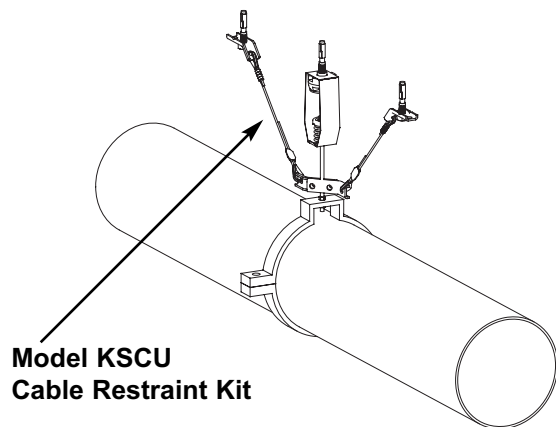
SUSPENDED EQUIPMENT EXAMPLES



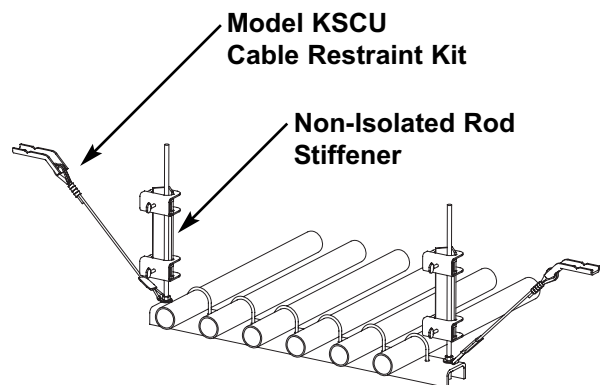
ISOLATED SUSPENDED PIPING LATERAL BRACING

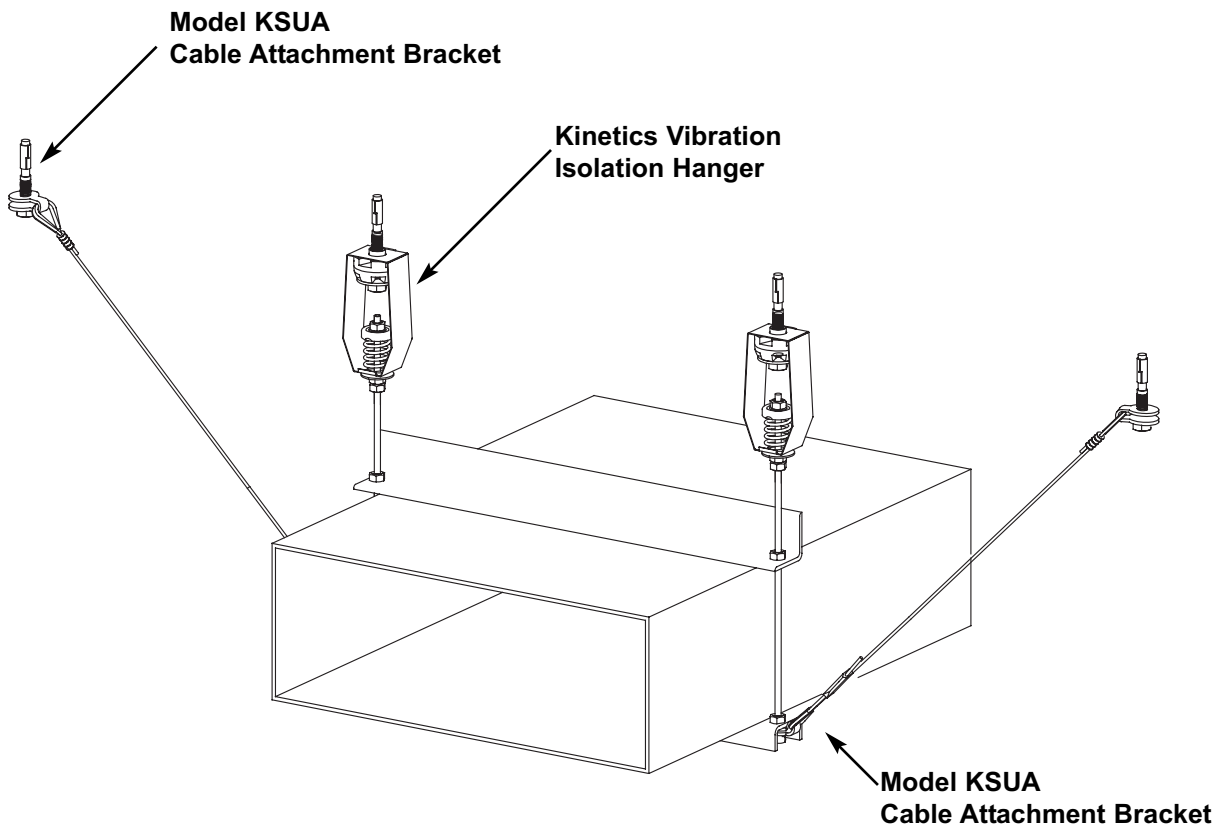
Kinetics Wire Rope Cable Restraints are to be installed slightly loose so as not to short-circuit the Isolation Hanger (when used).

ISOLATED SUSPENDED PIPING LONGITUDINAL BRACING



RIGIDLY SUSPENDED PIPE TRAPEZE

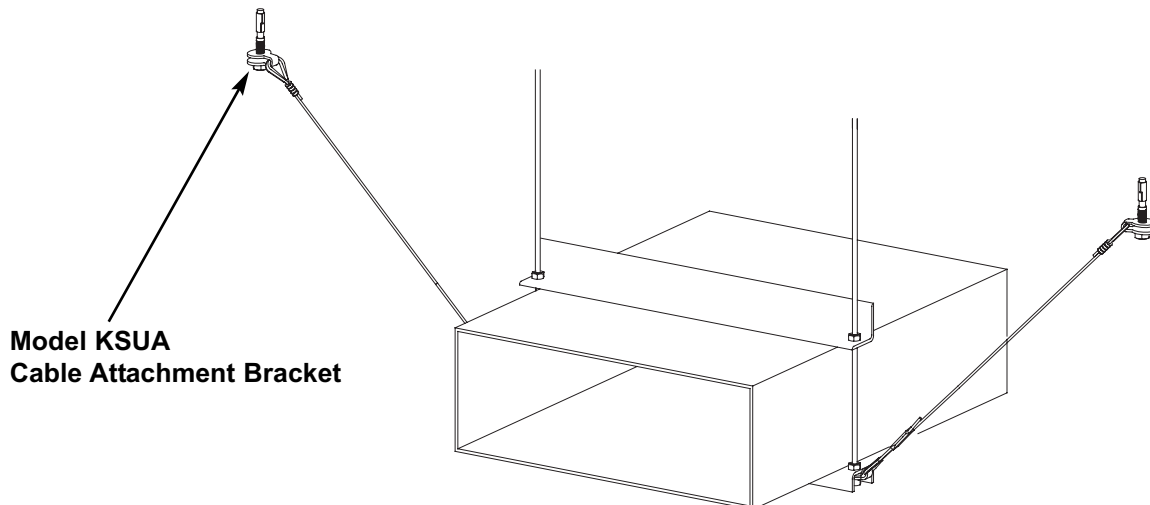


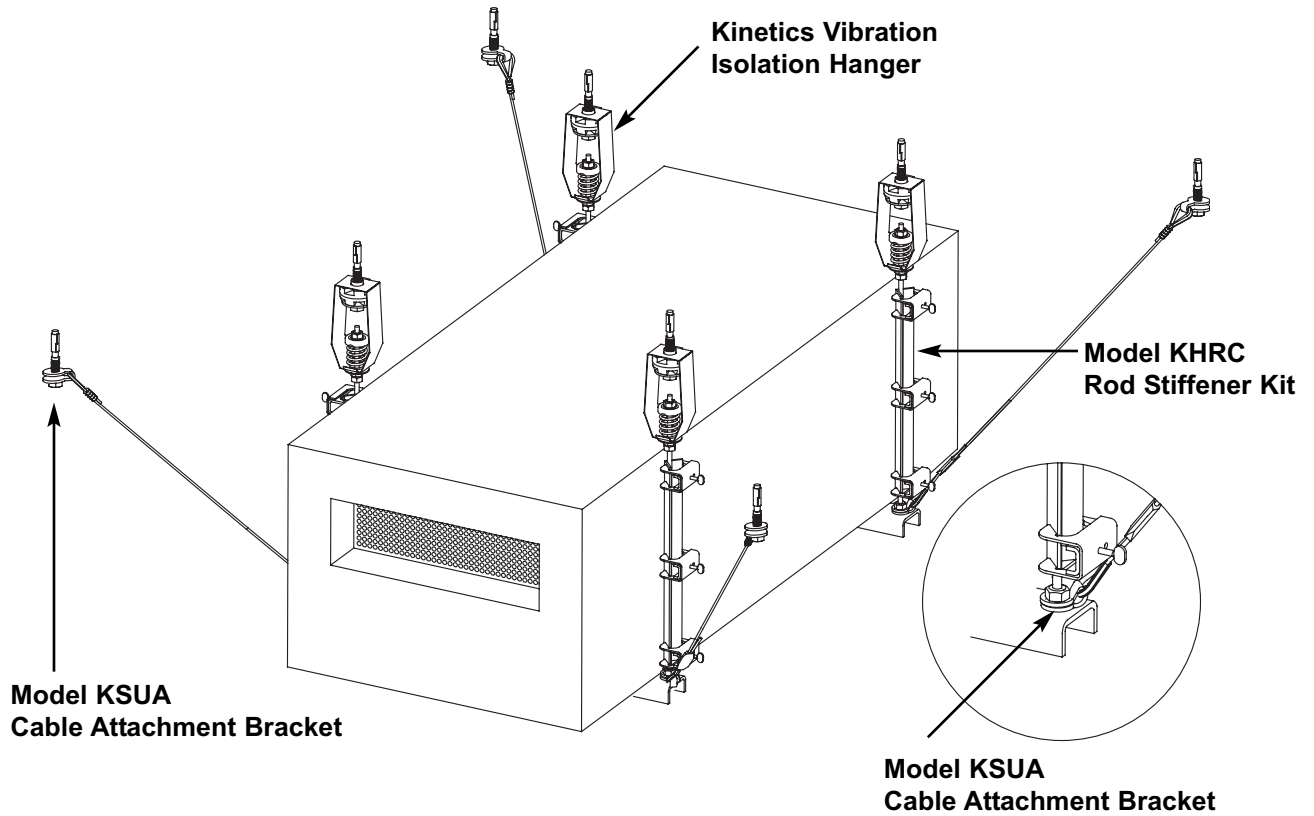


ISOLATED SUSPENDED DUCT

Kinetics Wire Rope Cable Restraints are to be installed slightly loose so as not to short-circuit the Isolation Hanger (when used).

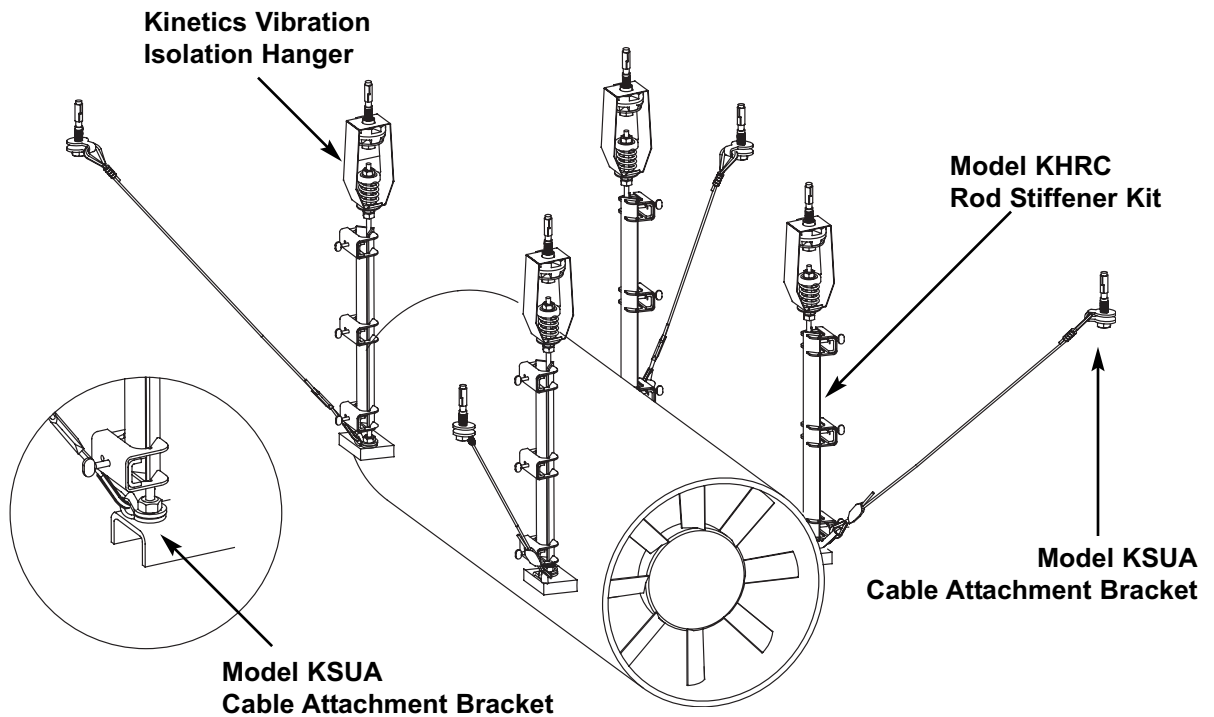
RIGIDLY SUSPENDED DUCT





ISOLATED SUSPENDED EQUIPMENT

Kinetics Wire Rope Cable Restraints are to be installed slightly loose so as not to short-circuit the Isolation Hanger (when used).



SEISMIC SPECIFICATIONS

Download your copy of Kinetics Noise Control's Seismic Restraint Specifications today at www.kineticsnoise.com!

ADDITIONAL INFORMATION AVAILABLE AT WWW.KINETICSNOISE.COM

- Application Details for all Kinetics Products
- Installation Instructions
- HVAC Vibration Isolation CAD Details and Specifications
- Submittal Drawings
- "Isoguide" HVAC Vibration Isolation Selection Software
- Architectural CAD Details
- Complete Specifications for all Kinetics Products
- Global Directory of Independent Acoustical Consultants
- Global Directory of Kinetics Noise Control Representatives
- Seismic Design Manual
- Technical Papers

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- HVAC Vibration Isolation
- Isolated Floors, Walls and Ceilings
- Vibron Silencers, Metal Acoustical Panels, and Enclosures
- Architectural Interior Acoustic Treatments
- Industrial Noise and Vibration Control
- Precision Isolation Systems



Kinetics engineers will work closely with you and your design team to provide the most effective, efficient, and economical engineered solution to your noise, vibration, or seismic problems.

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