Suspended Equipment Restraint Arrangements

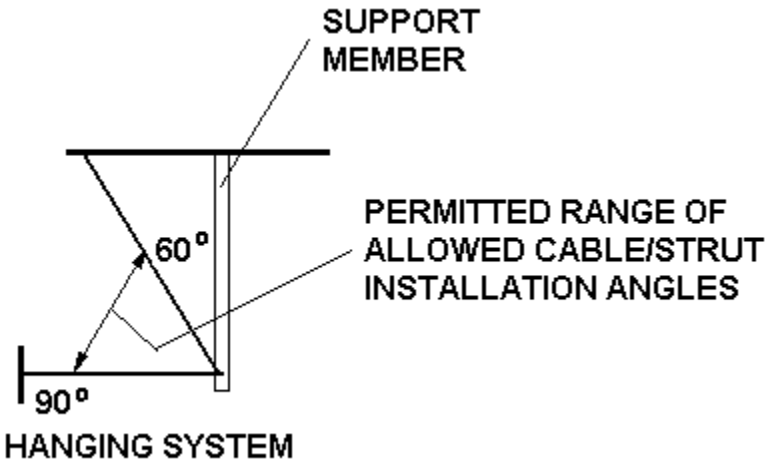
Although the basic principle of diagonal bracing is almost always used to design restraint systems, the actual arrangement of these systems can vary significantly. Despite what looks like substantially different designs, the design forces in the members remain the same, and the same rules apply when sizing components. Illustrated here are many different restraint arrangements, all of which can be used in conjunction with the design "rules" provided in this manual.

Details of the end connections and anchorage hardware are shown in subsequent sections of the manual. It is assumed in this manual that the restraint component is attached to a structural element capable of resisting the design seismic load.

Due to variations in the installation conditions such as structural clearance, locations of structural attachment points, and interference with other pieces of equipment or systems, there will likely be significant benefits to using different arrangements in different locations on the same job.

The only significant caution here is that it is not permissible to mix struts and cables on the same piece of equipment.

This manual addresses diagonal bracing slopes of between horizontal and 60 degrees from the horizontal. Angles in excess of 60 degrees to the horizontal are not permitted.



When installing restraints, each individual restraint should be installed perpendicular (±10 degrees) to the adjacent restraint as viewed from underneath. In addition, the restraints should be approximately aligned with the center of gravity of the piece of equipment being restrained. Although it is typical to install restraints at each corner extending radially outward from the piece of equipment, this arrangement is not

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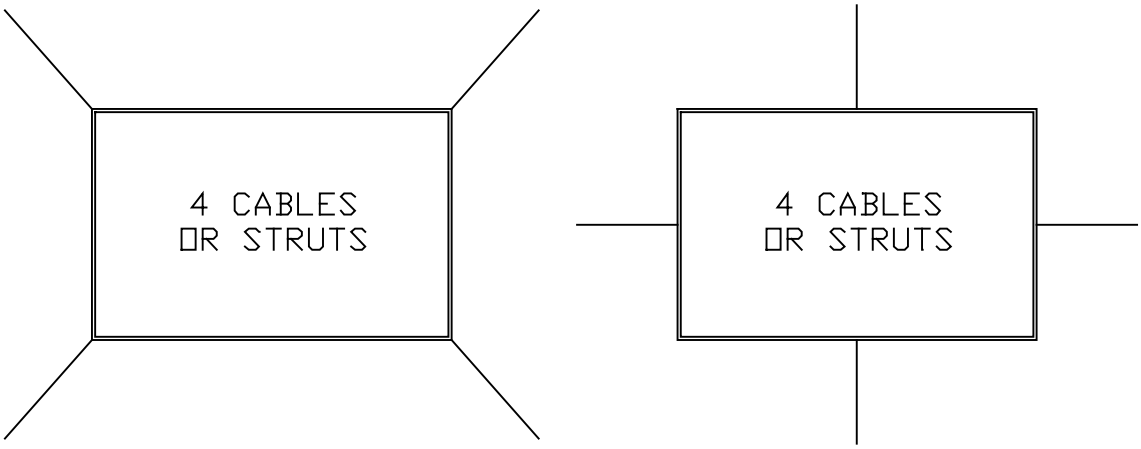
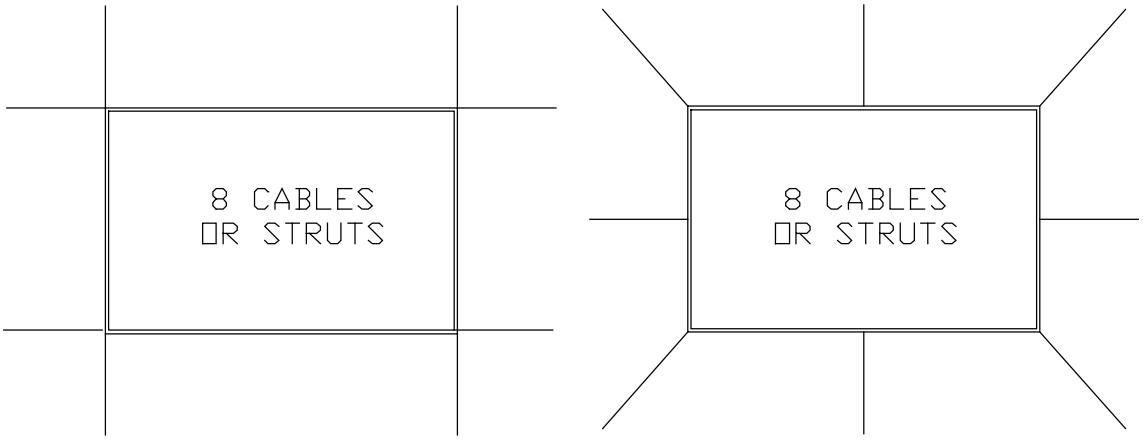
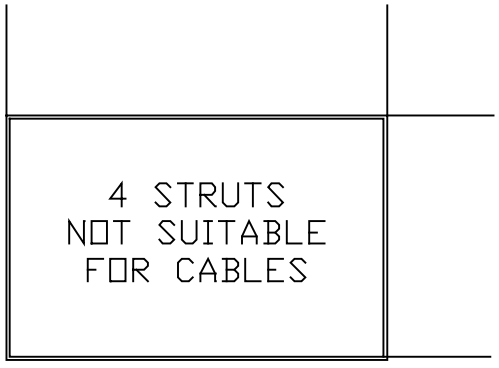
mandatory. See the sketches below.



(4 Restraint Options, Restraint angles can vary 10 degrees from those shown)



(8 Restraint Options, Restraint angles can vary 10 degrees from those shown)



(4 Strut Option, Restraint angles can vary 10 degrees from those shown)

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DOCUMENT:
D10.4.2
VISCMA MEMBER

In general, when restraining equipment, the component actually being restrained is the member that supports the equipment rather than the equipment itself. This is normally a trapeze bar. Because the goal is to restrain the actual equipment, it is necessary that the restrained element be connected to the equipment in such a way as to transfer the appropriate forces between the two.

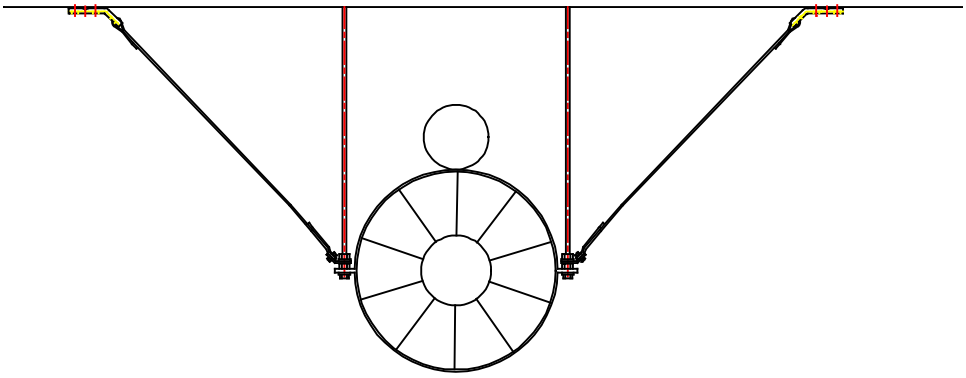
If using the Force Class tables, the minimum bolt size used should equal or exceed the listed bolt size for a "Bolted" type connection for the restraint (Table 5/5a in section D4.8). If using a certified calculation as provided by Kinetics Noise Control, the minimum bolt size will be identified on the calculation document.

Hanging Equipment Restrained with Cables

(Note on these and all sections below, the cables must be oriented in the plan view as identified earlier in the paper.)

Restraint Examples

For some pieces of equipment that are intended to be suspended, mounting points are normally provided. An example is an axial flow fan. For these kinds of equipment the restraints and the supporting hangers are normally connected to these mounting points directly as shown below. This arrangement works with both isolated and non-isolated systems. Note that the isolators are mounted with minimal clearance to the structure and that a travel limiting washer is fitted to the hanger rod just below the isolator in the isolated arrangement.



Cable Restraints used to restrain an Axial Flow Fan (Non-isolated)

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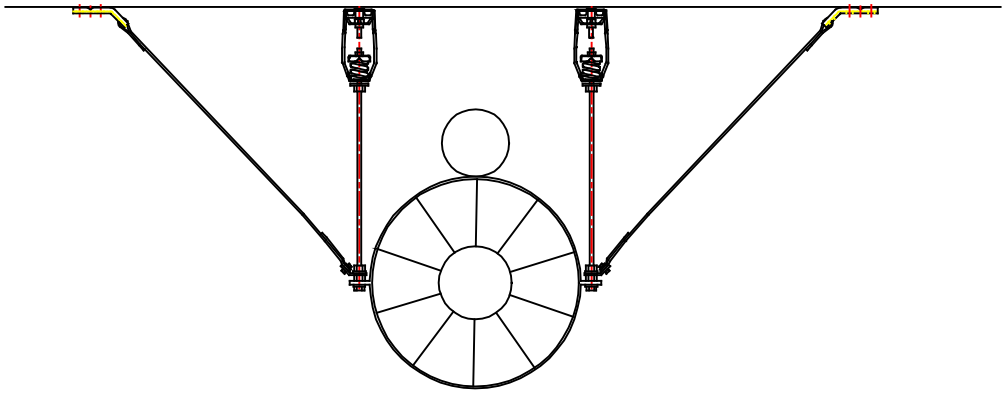
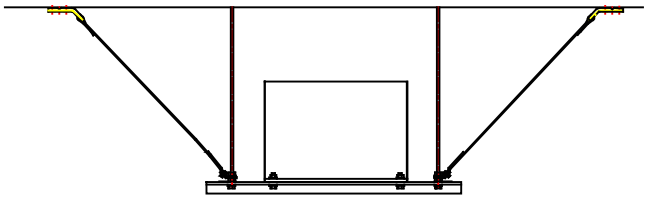


Cable Restraints used to restrain an Axial Flow Fan (Isolated)

Most equipment however is mounted using a trapeze bar arrangement. There are many options that exist for the arrangements of restraints used in conjunction with trapeze-mounted systems. Shown below are several options for both non-isolated and isolated cable-restrained systems.

_/ (BOTTOM)



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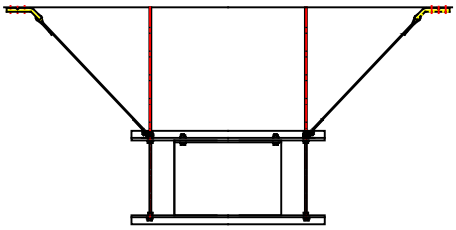

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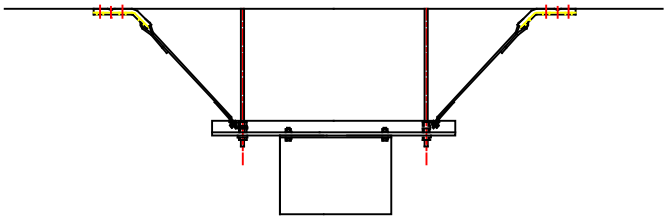

Typical Cable Restraint Arrangements Mounted to a Trapeze (Non-isolated)

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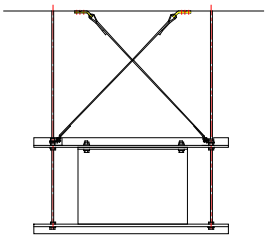
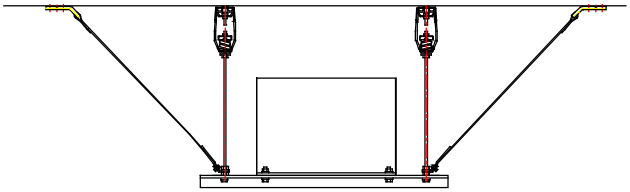
In addition to the conventional _/ mounting arrangement, where there is sufficient room above the equipment, and X type of arrangement shown below can often be an attractive alternative.

X (TOP)
BOXED



X Type Cable Restraint Arrangement Mounted to a Trapeze (Non-isolated)

_/ (BOTTOM)



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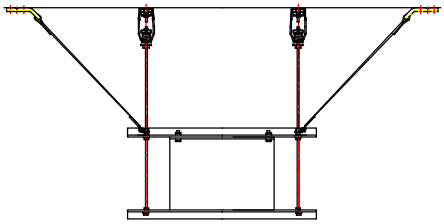

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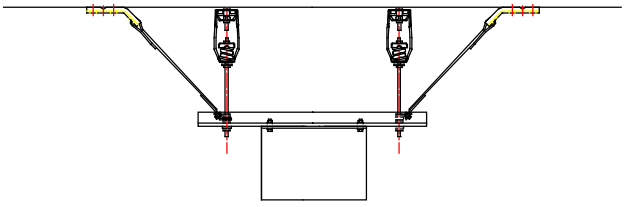

Typical Cable Restraint Arrangements Mounted to a Trapeze (Isolated)

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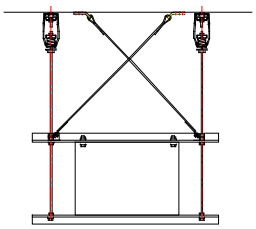
X (TOP)
TRAPPED



X Type Cable Restraint Arrangements Mounted to a Trapeze (Isolated)

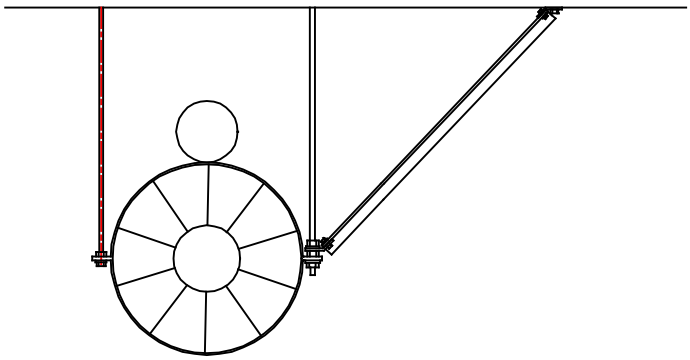
Hanging Equipment Restrained with Struts

(Note on these and all sections below, the cables must be oriented in the plan view as identified earlier in the paper.)

It is recommended that struts not be used to restrain isolated equipment. Struts will generate hard connections between the equipment and structure and will greatly reduce the efficiency of the isolation system. Having said that, in some special situations it may be possible to design restraint struts with integral isolation elements, but this is tedious and should be avoided unless drastic measures are required.

Restraint Examples

For a strut-restrained piece of equipment with integral attachment points located away from the top surface, there is only one common arrangement. It is to connect the restraint and the support to the attachment point as shown below.



Strut Restraint Arrangement for Axial Fan (Non-Isolated only)

If the connection points for the equipment are on the top surface, the strut can be angled in the opposite direction as shown below.

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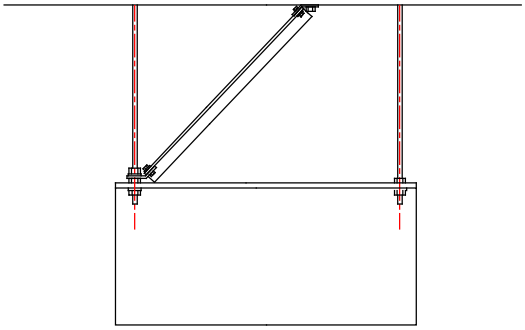
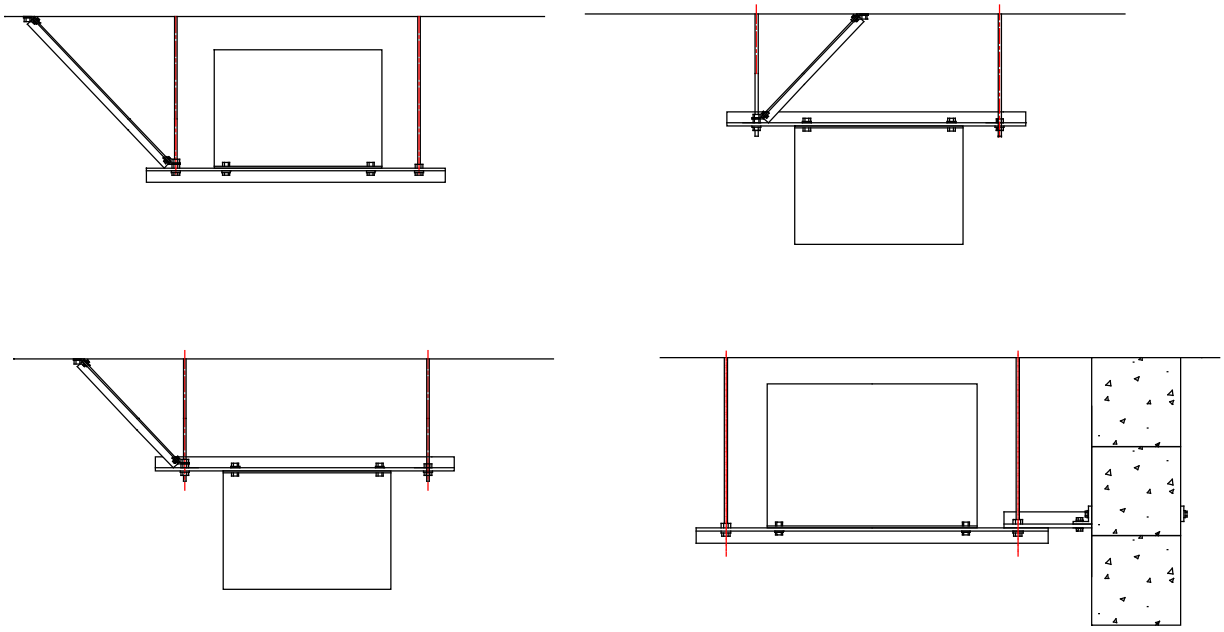


Shown below are 4 options for trapeze-mounted equipment. All are equivalent.



4 Arrangements for the restraint of Trapeze mounted equipment with Struts

Special Cases

Equipment Supported at 2 points

When equipment is supported on only 2 points, caution must be used to ensure that the restraints are connected in such a way as to prevent lateral motion of the equipment without allowing it to sway and put undo stress on the hanger rods. Classic examples of this type of equipment are Unit Heaters.

The condition of concern is illustrated below.

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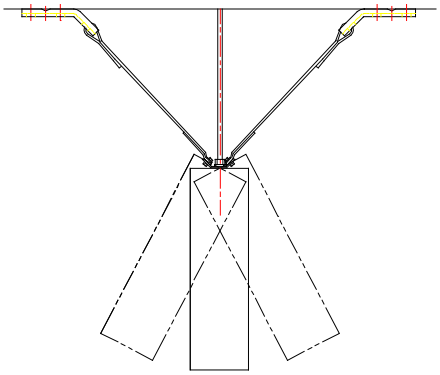
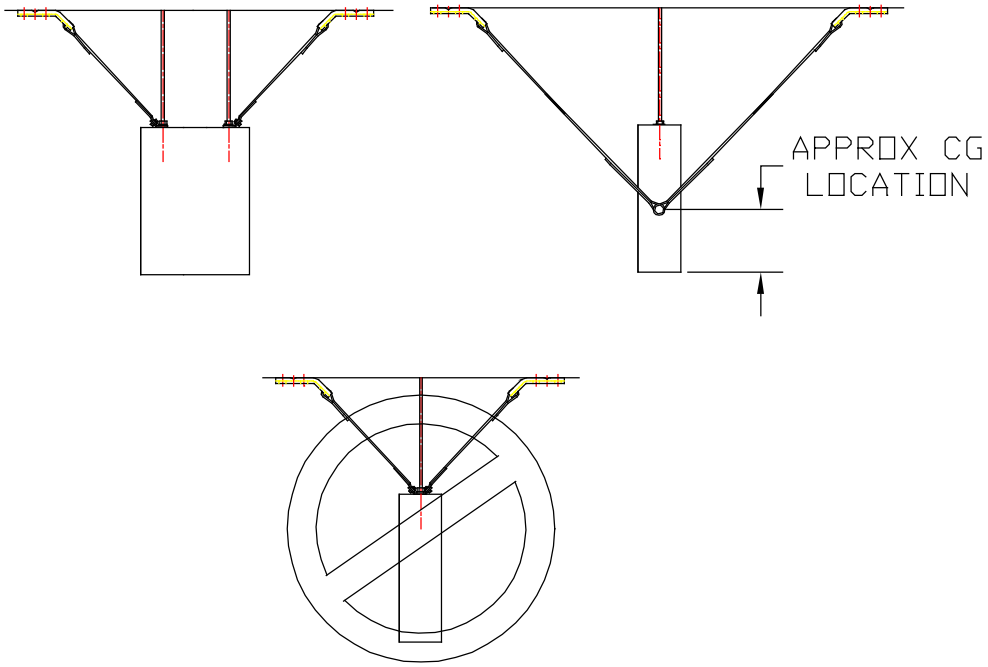


Possible Sway in Equipment Mounted on 2 Support Hanger Rods

In order to keep this swaying motion from occurring, it is necessary to ensure that on the axis where swaying can occur, the restraints connect to the equipment at its vertical center of gravity (approx). This is not necessary on the opposite axis. See Below.



Acceptable Restraint Attachment Elevations for Double Rod Supported Equipment

SUSPENDED EQUIPMENT RESTRAINT ARRANGEMENTS

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