

Ceiling-Supported Duct Restraint Arrangements

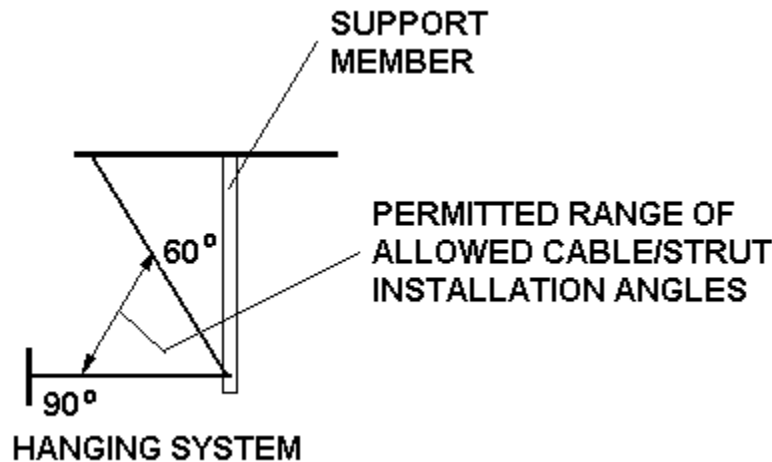
Although the basic principle of diagonal bracing is almost always used to design restraint systems, the actual arrangement of these systems can vary significantly. Despite what looks like substantially different designs, the design forces in the members remain the same, and the same rules apply when 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 run.

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, lateral restraints should be installed perpendicular (± 10 degrees) to the duct in plan. Axial restraints should be in line with the duct, ± 10 degrees, again in the plan view. All restraint cables should be aligned with each other. See the sketch below.

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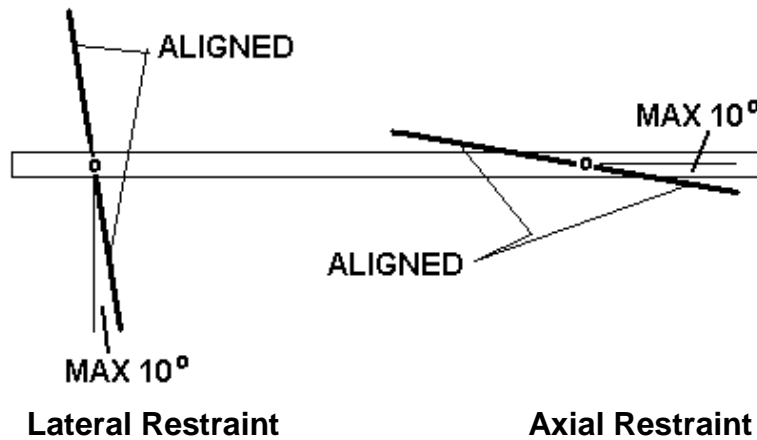
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In general, when restraining ductwork, the component actually being restrained is the support device for the duct. This is normally either a ring clamp made of gauge material, or a trapeze bar. Because the goal is to restrain the actual duct, it is necessary that the restrained element be connected to the duct in such a way as to transfer the appropriate forces between the two.

Based on the Maximum Horizontal Force requirement and Force Class from Section D4, the appropriate size and quantity of fasteners to connect ducts to support/restraint members is as follows:

Force Class	I	II	III	IV	V	VI
Force (Lbs)	250	500	1000	2000	5000	10000
#10 Screw	3	5	10	20		
¼ Screw			3	6	20	40

When firmly connecting restraints to ductwork there are a few general rules that should be followed:

- 1) Attachment screws should be spread evenly either around or along the top and bottom of the duct.
- 2) To minimize wind noise, short screws with minimal projection into the air stream should be selected.
- 3) Trapeze-mounted ductwork must be fully encompassed by a frame or screwed to the trapeze at each lateral restraint point.
- 4) Axially restrained duct connections must be positive and require screws as indicated above.

In addition, when sizing restraint components for multiple ducts, the total weight of all of the restrained ductwork must be considered.

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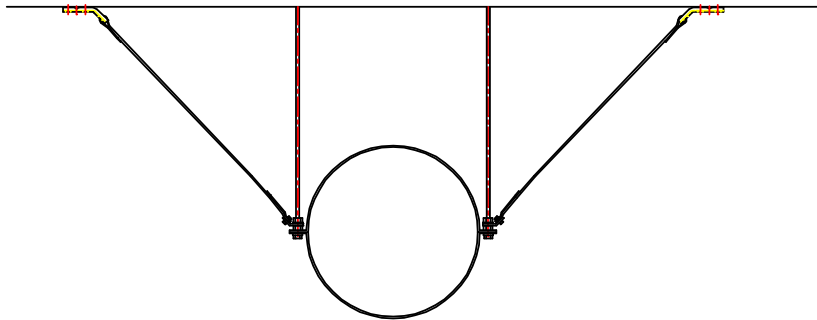
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Hanging Systems Restrained with Cables

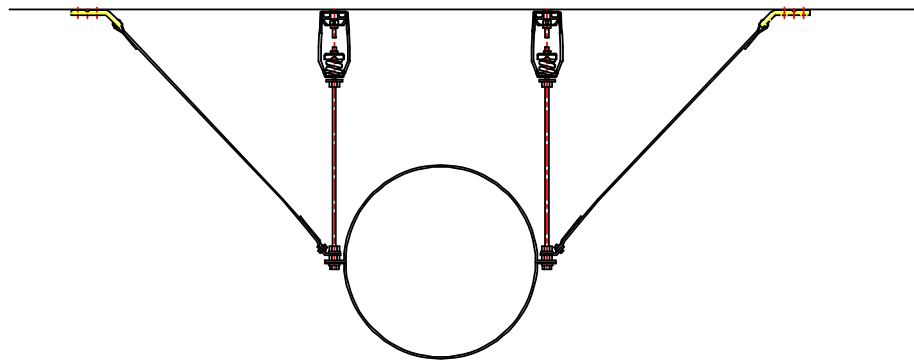
Hanging systems may include supports for single or multiple ducts. Single ducts can be supported using brackets made of gauge material but multiple pipes are normally supported on or suspended from trapeze bars.

Lateral Restraint Examples

For a cable-restrained duct supported by gauge brackets, there is really only one mounting arrangement. It can be used with both isolated and non-isolated systems as shown below. 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.



Lateral Cable Restraints used with a Gauge Material Ring Clamp (Non-isolated)



Lateral Cable Restraints used with a Gauge Material Ring Clamp (Isolated)

There are many options that exist for the arrangements of lateral restraints used in conjunction with trapeze-mounted systems. Shown below are several options for both non-isolated and isolated cable-restrained systems.

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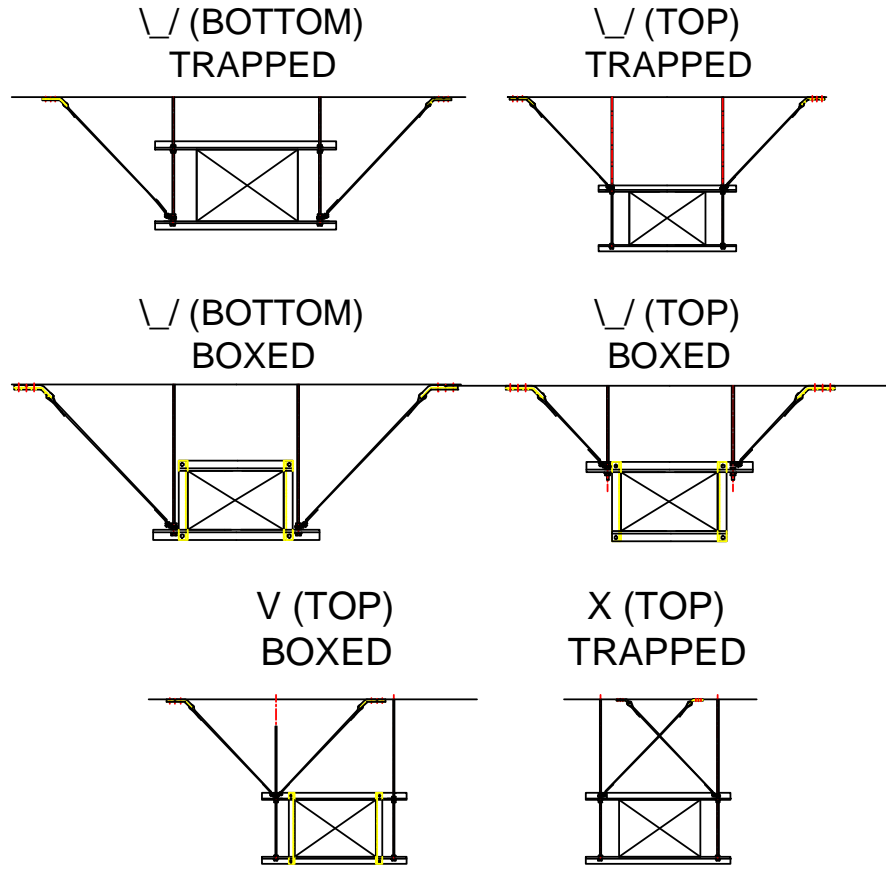
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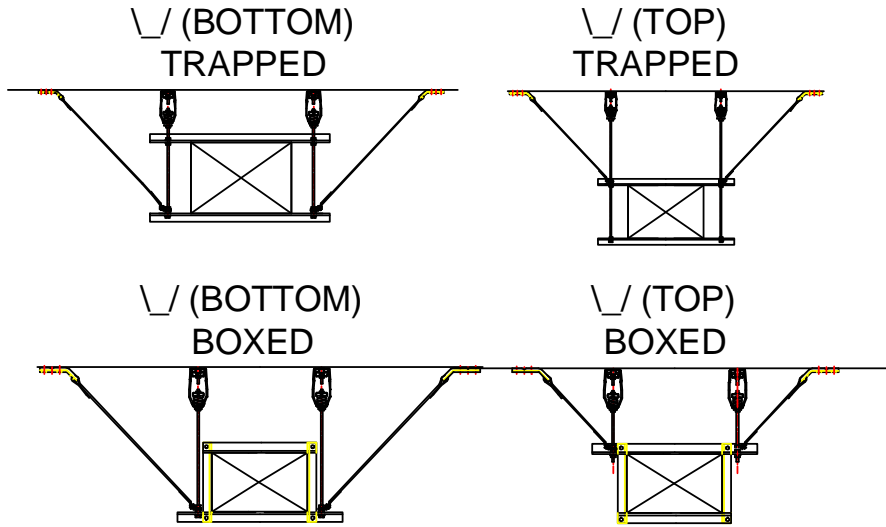


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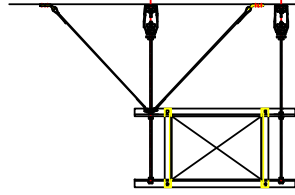


Lateral Cable Restraints Mounted to a Trapeze (Non-isolated)

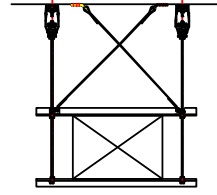


CEILING-SUPPORTED DUCT RESTRAINT ARRANGEMENTS

V (TOP)
BOXED



X (TOP)
TRAPPED

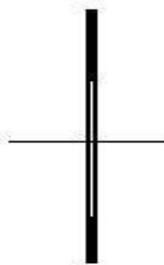


Lateral Cable Restraints Mounted to a Trapeze (Isolated)

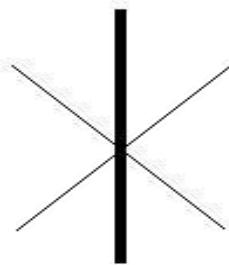
Axial Restraint Examples

When axially restraining ductwork, a perimeter metal strap or angle tightly screwed to the duct is the most common device used to retain the duct to the support bar. Occasionally welded tabs or connections to flanges are used. (Caution: Connections to flanges should only be used with the flange manufacturer's concurrence that the flange can withstand the seismic forces.) Details on these connections will be addressed in later sections.

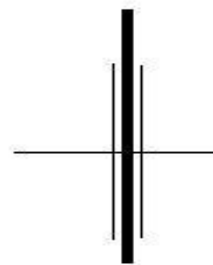
Axial restraints offset from the centerline of restrained ductwork will generate additional bending forces in the duct. Because of the nature of ducts, unless restraints are fit on both sides, there will be an offset. Provisions should be made to avoid offsetting axial restraints when restraining a single duct. This requires either that the restraint be attached to the centerline of the duct, that the axial restraint be combined with a lateral restraint to form an "X" arrangement or that 2 axial restraints be fitted, one on either side of the duct (See also the Figure below). (Note that when specifying and providing restraints, KNC assumes one of the 2 former arrangements are used, if the latter case is used, the installation contractor will have to procure and additional restraint set from KNC.) For cases where multiple ducts are being supported on a common structure, the axial restraint should be between ducts in line with the approximate side-to-side center of Gravity location.



**CENTERED AXIAL
TRANSVERSE RESTRAINT**



**"X" AXIAL/TRANSVERSE
RESTRAINT**



**DOUBLED AXIAL
TRANSVERSE RESTRAINT**

Various Acceptable Axial Restraint Arrangements

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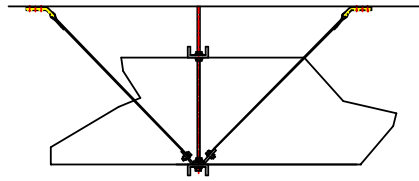


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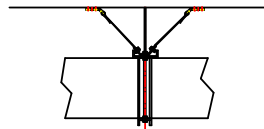
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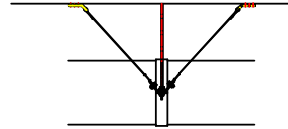
V (BOTTOM)
TRAPPED



V (TOP)
BOXED

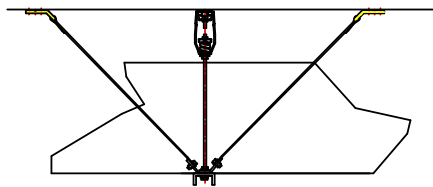


GAUGE BRACKET
SUPPORTED

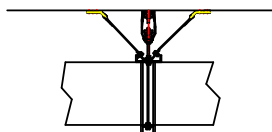


Axial Cable Restraints (Non-isolated)

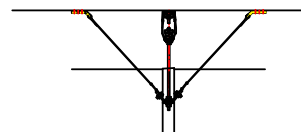
V (BOTTOM)
TRAPPED



V (TOP)
BOXED



GAUGE BRACKET
SUPPORTED



Axial Cable Restraints (Isolated)

Hanging Systems Restrained with Struts

It is recommended that struts not be used to restrain isolated ductwork. Struts will generate hard connections between the duct 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

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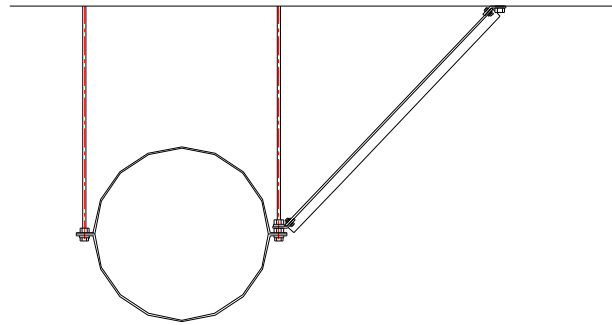
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should be avoided unless drastic measures are required.

As with cable restraints, hanging systems may include supports for single ducts or multiple ducts. Single ducts can be supported using a bracket made of gauge material, but multiple ducts are normally supported on trapeze bars.

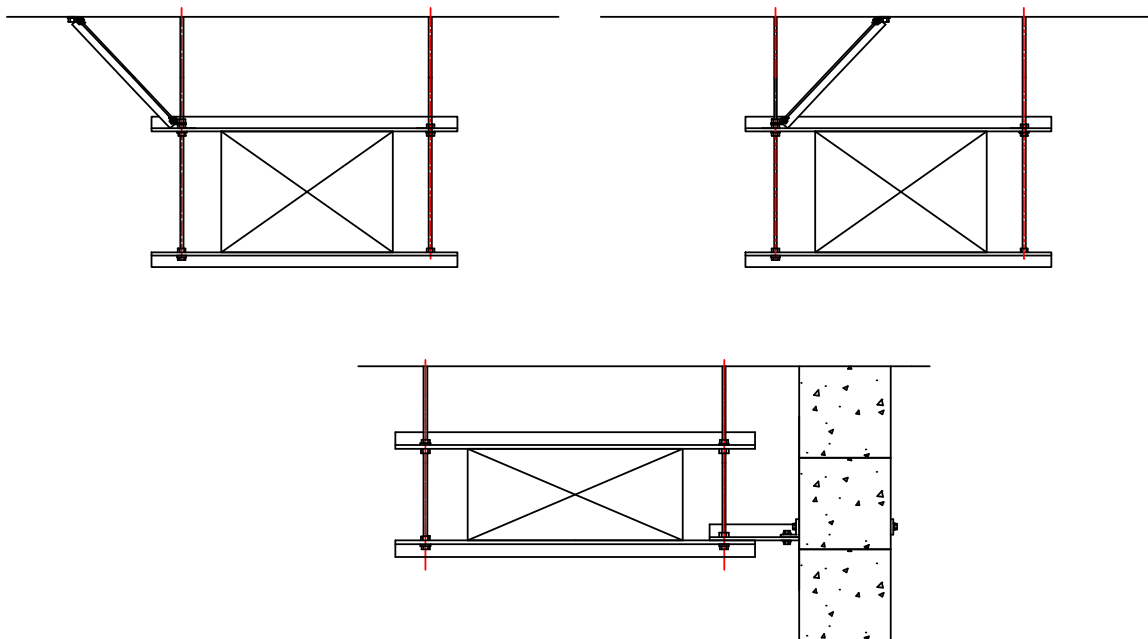
Lateral Restraint Examples

For a strut-restrained duct supported by a bracket made from gauge material there is only one common arrangement. It is to connect the restraint to the base of the hanger rod at the attachment point to the bracket. It is shown below.



Typical Lateral Restraint Strut Arrangements for Gauge Bracket Supported Duct

Shown below are 3 options for trapeze-supported ductwork. All are equivalent.



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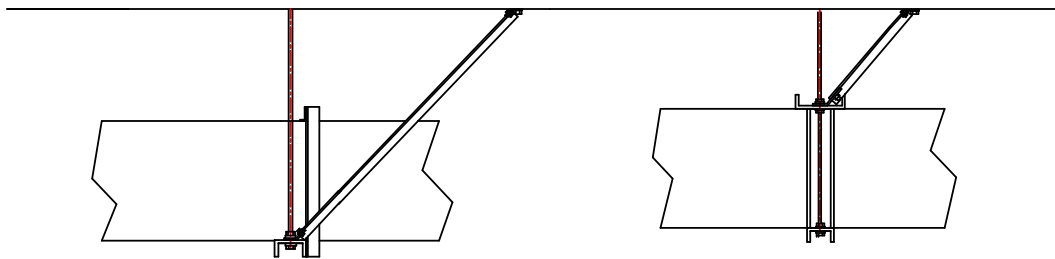
3 Arrangements for Laterally Restrained Trapezes with Struts

Axial Restraint Examples

When axially restraining ductwork with struts, a perimeter metal strap or angle tightly screwed to the duct is the most common device used to retain the duct to the support bar. Occasionally welded tabs or connections to flanges are used. (Caution: Connections to flanges should only be used with the flange manufacturer's concurrence that the flange can withstand the seismic forces.) Details on these connections will be addressed in later sections.

As with cables, struts offset from the centerline of restrained ductwork will generate additional bending forces in the duct. Because of the nature of ducts, unless restraints are fitted on both sides, there will be an offset. Provisions should be made to avoid offsetting axial restraints when restraining a single duct. This requires either that the restraint be attached to the centerline of the duct, that the axial restraint be combined with a lateral restraint to form an "X" arrangement or that 2 axial restraints be fitted, one on either side of the duct. (Note that when specifying and providing restraints, KNC assumes one of the 2 former arrangements are used, if the latter case is used, the installation contractor will have to procure and additional restraint set from KNC.) For cases where multiple ducts are being supported on a common structure, the axial restraint should be between ducts in line with the approximate side-to-side center of gravity location.

Ignoring the details of the connection at this point, common axial restraint arrangements recognized in this manual are illustrated below.



Ductwork Axially Restrained with Struts

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