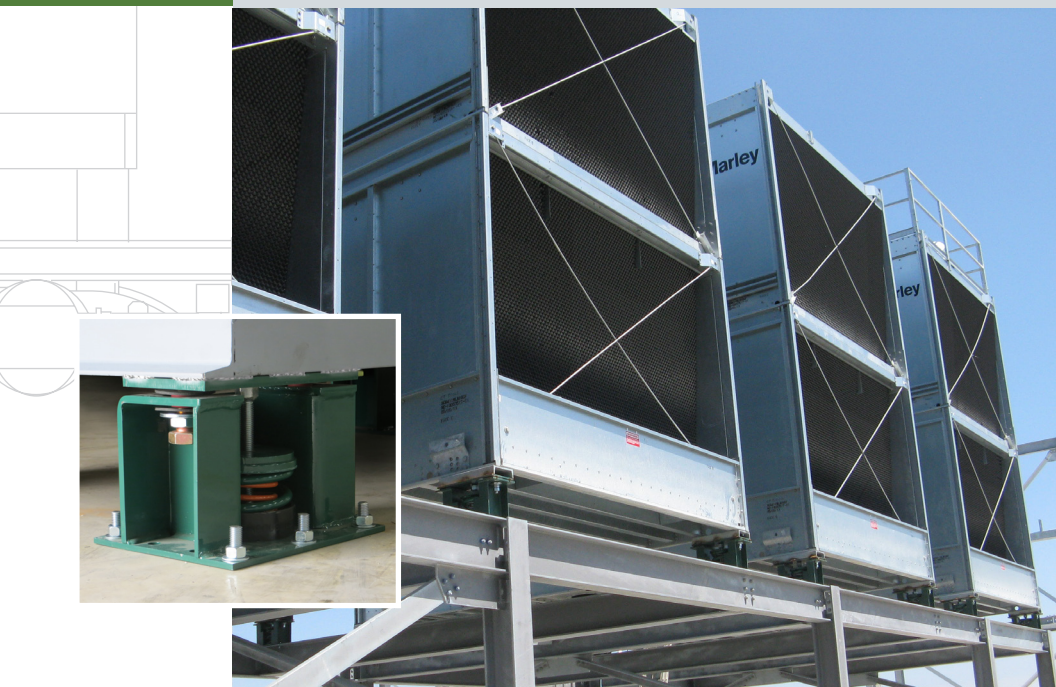


2014 Edition

# Installing Seismic Restraints for Mechanical Equipment



**VISCOMA**

VIBRATION ISOLATION & SEISMIC CONTROL  
MANUFACTURERS ASSOCIATION

412

This guide was originally prepared and published as “FEMA 412” by the Vibration Isolation and Seismic Control Manufacturers Association (VISCMA) under a cooperative agreement between the Federal Emergency Management Agency (FEMA) and the American Society of Civil Engineers (ASCE).

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Additional copies of this guide can be downloaded from [www.VISCMA.com](http://www.VISCMA.com).

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# INSTALLING SEISMIC RESTRAINTS FOR MECHANICAL EQUIPMENT

August 2014



*Developed originally by the Vibration Isolation  
and Seismic Control Manufacturers Association  
under a cooperative agreement between the  
Federal Emergency Management Agency and  
the American Society of Civil Engineers.*

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## INTRODUCTION

This guide shows equipment installers how to attach mechanical equipment to a building to minimize earthquake damage. Many attachment examples are presented, to include anchoring and the use of special devices called *seismic restraint devices*.

Seismic restraint devices include vibration isolation systems, cable or strut suspension systems, roof attachment systems, and steel shapes.

Please note that this guide does not replace:

- Printed instructions shipped with the equipment.
- Instructions in contract drawings/specifications.
- Code-required, industry-accepted practices.
- Orders from your supervisor.
- Seismic Restraint Device Submittals.

Please note that this guide does not cover:

- Non-building structural framing required to elevate equipment above the floor.

**If you have questions about any information in this guide, check with your supervisor.**

This guide contains these sections:

- *Equipment*: Arranged according to different kinds of mechanical equipment such as Air Compressors, Cooling Towers, Pumps, etc.
- *Attachment Types*: Gives instructions on installing equipment in different arrangements known as *attachment types*.
- *Anchors*: Shows many different types of anchors used to connect equipment to a building.
- *Special cases*: Covers housekeeping pads, cable assemblies, support for control panels, and residential equipment.

**Start with the Equipment section that best represents the equipment you are installing.**

- Use the Tables of Contents to find the correct starting page.

- Using the table in the Equipment section, find the type of equipment you are installing in column 1. The method for installing this equipment is shown in column 2 and the attachment type is shown in column 3. An example is shown below:

column 1	column 2	column 3
<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Any box or cabinet fan	Connected to angles mounted to floor	Rigid with angles <i>Go to page 35</i>

- Turn to the page number for the attachment type in column 3.
- If you are not sure which attachment type is correct, ask your supervisor.

**Follow the instructions for the attachment type you have selected. The instructions will refer you to the correct anchor section so you can make the connection to the building structure.**

**All instructions in this guide are arranged in order using numbered steps.**

- Please follow every step in the sequence shown.

**Special precautions are marked:**



A flag means you should take special care before continuing. Read all the information next to a flag before attaching the equipment.



A warning sign means you can cause serious damage to the building, the device, or the equipment if you do not follow the instructions exactly.



A book means you should refer to the manufacturer's printed instructions before continuing.

Note that a Glossary and an Index are also available to facilitate use of this guide.

## EQUIPMENT

### Air Compressors



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

#### Step 1: Identify the compressor



Figure 1: Housed air Compressor (water-cooled).



Figure 2: Air compressor Skid-mounted (water-cooled).



Figure 3: Air compressor with vertical tank (air-cooled).



Figure 4: Reciprocation type air compressor with horizontal tank (air-cooled).



Figure 5: Skid Mounted Equipment Including large filter dryers.

## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is Equipment to be Install</i>	<i>Attachment Type</i>
Any compressor except housed or skid-mounted	Mounted directly to the floor	Rigid <i>Go to page 31</i>
	Floor-mounted on vibration isolators using restrained springs or open springs and snubbers	Vibration-isolated <i>Go to page 76</i>
Housed or skid-mounted compressors	Connected to angles mounted to the floor	Rigid with angles <i>Go to page 35</i>

Table 1: Air compressor installation types.



## Air Conditioning Units and Heat Pumps



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment



Figure 6: Small rooftop air conditioning unit or heat pump (air-cooled).



Figure 7: Large rooftop air conditioning unit (air-cooled).



Figure 8: Indoor air conditioning unit or heat pump (floor-mounted or suspended with remote condenser).



Figure 9: Self-contained water-cooled unit (floor-mounted or raised floor-mounted).



Figure 10: Through-the-wall air conditioning unit, mini split unit or heat pump.

## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Any AC unit or heat pump	Mounted directly to the floor	Rigid <i>Go to page 31</i>
	Connected to angles mounted to the floor	Rigid with angles <i>Go to page 35</i>
	Floor-mounted on vibration isolators using restrained springs or open springs and snubbers	Vibration-isolated <i>Go to page 76</i>
Self-contained unit; use manufacturer's base designed for raised floor	Installed on a raised floor	Raised floor <i>Go to page 42</i>
Any rooftop unit	Roof-mounted on a post and beam	Post and beam <i>Go to page 47</i>
	Connected to a manufactured isolation curb on a post or beam	Isolation curb on a post and beam <i>Go to page 57</i>
	Vibration isolated on a post and beam	Isolation springs on a post and beam <i>Go to page 59</i>
	Directly connected to a sheet metal curb with nailer	Pre-manufactured curb <i>Go to page 50</i>
	Directly connected to a wood roof curb	Wood curb <i>Go to page 56</i>
Indoor AC unit or heat pump	Suspended from building structure above with rods and cables	Rods and cables <i>Go to page 61</i>
	Suspended from building structure above angles	Suspended with angles <i>Go to page 67</i>
	Suspended from building structure above with isolators, rods, and cables	Isolator rods and cables <i>Go to page 79</i>
Through-the-wall unit or mini split	Supported by the structural wall	Wall-mounted with angles <i>Go to page 88</i>

Table 2: AC unit and heat pump installation types.

## Air Handling Units



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment



Figure 11: Small rooftop air handling unit.



Figure 12: Large rooftop air handling unit.



Figure 13: Horizontal indoor air handling unit (floor-mounted or suspended).



Figure 14: Vertical indoor air handling unit (floor-mounted).



Figure 15: Built up air handlers, designed and manufactured for specific requirements.

## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Indoor air handling unit with a rigid base	Mounted directly to the floor	Rigid <i>Go to page 31</i>
Indoor air handling unit	Connected to angles mounted to the floor	Rigid with angles <i>Go to page 35</i>
	Suspended from structure above with rods and cables	Rods and cables <i>Go to page 61</i>
	Suspended from structure above with angles	Suspended with angles <i>Go to page 67</i>
	Suspended from structure above with vibration isolation, rods, and cables	Isolator rods and cables <i>Go to page 69</i>
Weight-limited rooftop unit (see manufacturer's literature)	Directly connected to a sheet metal curb with nailer	Pre-manufactured curb <i>Go to page 50</i>
	Directly connected to a wood roof curb	Wood curb <i>Go to page 56</i>
Any rooftop unit	Connected to a manufactured vibration isolation curb on a post and beam	Isolation curb on a post and beam <i>Go to page 57</i>
	Roof-mounted on a post and beam	Post and beam <i>Go to page 47</i>
Large rooftop unit	Vibration isolation on a post and beam	Isolation springs on a post and beam <i>Go to page 59</i>
Any air handling unit	Floor-mounted on vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated <i>Go to page 76</i>

Table 3: Air handling unit installation types.

## Air Separators



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment



Figure 16: Air separator (floor-mounted).



Figure 17: Air separator (suspended).

### Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Any unit	Connected to angles mounted to the floor	Rigid with angles <i>Go to page 31</i>
	Suspended from the structure above with rods and cables	Rods and cables <i>Go to page 52</i>
	Suspended from the structure above with angles	Suspended with angles <i>Go to page 57</i>
	Supported from the wall with angles	Wall-mounted with angles <i>Go to page 74</i>

Table 4: Air separator installation types.

## Boilers, Furnaces, Humidifiers and Water Heaters



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment



Figure 18: Small boiler.



Figure 19: Humidifier.



Figure 20: Water tube (shown) or fire-tube boiler.



Figure 21: Flextube boiler.



Figure 22: Furnace.



Figure 23: Water heater.

## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Any boiler or humidifier	Mounted directly to the floor	Rigid <i>Go to page 31</i>
Any boiler, hot water heater, or furnace	Connected to angles mounted to the floor	Rigid with angles <i>Go to page 35</i>
Residential furnace	Furnace supported and restrained by rigid ductwork connections	Strap down similar to water heater <i>Go to page 89</i>
Residential water heater	Strapped to the wall	Wall-mounted with straps <i>Go to page 89</i>
Humidifier	Mounted directly to the wall	Wall-mounted <i>Go to page 87</i>

Table 5: Boiler, furnace, humidifier, and water heater installation types.

## Chillers



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment



Figure 24: Centrifugal chiller (water-cooled).



Figure 25: Chiller with screw compressors (air-cooled).

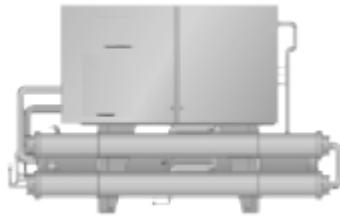


Figure 26: Indoor chillers with scroll or screw compressors (water-cooled).



Figure 27: Small chiller with scroll and compressors (air-cooled).



## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Any chiller	Mounted directly to the floor or concrete pad	Rigid <i>Go to page 32</i>
	Floor-mounted vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated <i>Go to page 76</i>
Roof-mounted unit	Roof-mounted on a post and beam	Post and beam <i>Go to page 47</i>
	Vibration isolation on a post and beam	Vibration-isolated on a post and beam <i>Go to page 59</i>

Table 6: Chiller installation types.

## Coils and Heat Exchangers



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment

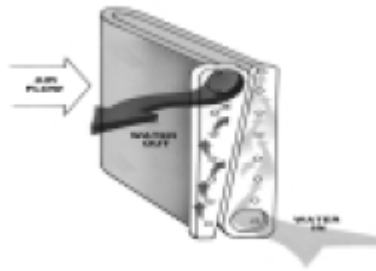


Figure 28: Duct-mounted coil.



Figure 29: A-coil.



Figure 30: Plate and frame heat exchanger.



Figure 31: Shell and tube heat exchanger.

## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Heat exchangers <sup>1</sup>	Mounted directly to the floor or concrete pad	Rigid <i>Go to page 31</i>
Duct mounted coil	Suspended from the building structure above with angles	Suspended with angles <i>Go to page 67</i>
A-coil	Sheet metal screws to furnace and sheet metal ducts	N/A

<sup>1</sup> This guide does not address structural frames required to elevate the heat exchanger above the floor.

Table 7: Coil and heat exchanger installation types.

## Condensers and Condensing Units



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment



Figure 32: Condenser/Condensing unit (side condenser).



Figure 33: Condensing/condensing unit (totally enclosed).



Figure 34: Indoor condenser/Condensing unit (see Air Handling Units for installation options).

## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Any condensing or condenser unit	Mounted directly to the floor or concrete pad	Rigid <i>Go to page 31</i>
	Floor-mounted vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated <i>Go to page 76</i>
Roof-mounted unit	Roof-mounted on a post and beam	Post and beam <i>Go to page 47</i>
	Connected to a manufactured vibration isolation curb on a post and beam	Isolated curb on a post and beam <i>Go to page 57</i>
Small rooftop unit	Directly connected to a wood roof curb	Wood curb <i>Go to page 56</i>

Table 8: Condenser and condensing unit installation types.

## Cooling Towers, Evaporative Coolers, and Fluid Coolers



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment



Figure 35: Fluid cooler cross flow with self-contained sump.



Figure 36: Cooling tower with self-contained sump.



Figure 37: Evaporative cooler.



Figure 38: Large cooling tower.

## Step 2: Select the type of attachment to building

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is Equipment to be Install</i>	<i>Attachment Type</i>
Any unit with a rigid base or pedestal	Mounted directly to floor or concrete sump	Rigid <i>Go to page 31</i>
Any unit with a self-contained sump	Roof-mounted on a post and beam	Post and beam <i>Go to page 47</i>
Fluid cooler, evaporative cooler, or cooling tower with a self-contained sump	Vibration isolated on a post and beam	Vibration-isolated on a post and beam <i>Go to page 59</i>
Any unit with a structural base	Floor-mounted vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated <i>Go to page 76</i>
Evaporative cooler	Connected to angles mounted to the floor	Rigid with angles <i>Go to page 35</i>
Roof-mounted evaporative cooler	Directly connected to a sheet metal curb with nailer	Pre-manufactured curb <i>Go to page 50</i>

Table 9: Cooling tower, evaporative cooler, and fluid cooler installation types.

## Fans



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment



Figure 39: Wall Propeller fan.



Figure 40: Rooftop fan.



Figure 41: Indoor box fan.



Figure 42: Indoor ceiling fan.



Figure 43: Axial fan. remote mounted.



Figure 44: Axial fan with motor.



Figure 45: Centrifugal fan.



Figure 46: Industrial skid-mounted blower.



## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Centrifugal or industrial skid-mounted blower	Mounted directly to floor	Rigid <i>Go to page 31</i>
Any box or cabinet fan	Connected to angles mounted to the floor	Rigid with angles <i>Go to page 35</i>
Rooftop fans	Directly connected to a sheet metal curb with nailer	Pre-manufactured curb <i>Go to page 50</i>
	Directly connected to a wood roof curb	Wood curb <i>Go to page 56</i>
	Vibration isolation on a post and beam	Vibration-isolated on a post and beam <i>Go to page 59</i>
	Vibration isolation with guy wires	
Any propeller, box, cabinet, or axial fan	Suspended from the building structure above with rods and cables	Rods and cables <i>Go to page 61</i>
	Suspended from the building structure above with angles	Suspended with angles <i>Go to page 67</i>
	Suspended from the building structure above with isolators, rods and cables	Isolator rods and cables <i>Go to page 69</i>
Centrifugal or skid-mounted blower unit	Floor-mounted vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated <i>Go to page 76</i>
Propeller fans	Mounted directly to the wall	Wall-mounted <i>Go to page 87</i>
	Vibration isolation from the building structure	Vibration-isolated off the wall <i>Go to page 92</i>

Table 10: Fan installation types.

## Heaters



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment



Figure 47: Electric unit heater.



Figure 48: Water or steam unit heater.



Figure 49: Gas unit heater.



Figure 50: Gas-fired unit heater (see Air Handling Units for installation options).

## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Any unit heater	Suspended from the building structure above with rods and cables	Rods and cables <i>Go to page 61</i>
	Suspended from the building structure above with angles	Suspended with angles <i>Go to page 67</i>
	Suspended from the building structure above with isolators, rods, and cables	Isolator rods and cables <i>Go to page 69</i>
	Supported off the wall with a bracket	Wall-mounted with angles <i>Go to page 89</i>
Relatively thin unit heaters	Suspended from the building structure with two rods and cables	Double rods and cables <i>Go to page 74</i>

Table 11: Heater installation types.

## Pumps



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment

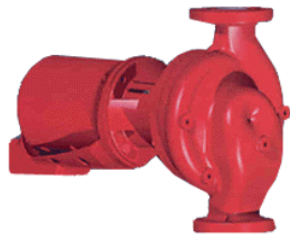


Figure 51: In-line pump.

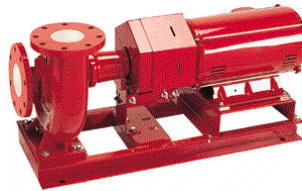


Figure 52: Horizontal end-Suction or split-case pump.

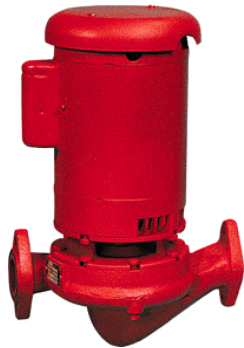


Figure 53: Closed-coupled Pump.



Figure 54: Vertical pump.

## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment</i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Base-mounted pump including end-suction pump and vertical pump	Mounted directly to floor	Rigid <i>Go to page 31</i>
Base-mounted pump including end-suction pump	Connected to angles mounted to the floor	Rigid with angles <i>Go to page 35</i>
	Floor-mounted vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated <i>Go to page 76</i>
In-line or close coupled pumps	Supported off the floor with a steel angle	Rigid with angles <i>Go to page 35</i>
	Suspended from the building structure above with rods and cables	Rods and cables <i>Go to page 61</i>
	Suspended from the building structure above with angles	Suspended with angles <i>Go to page 67</i>
	Suspended from the building structure above with isolators, rods and cables	Isolator rods and cables <i>Go to page 69</i>
	Mounted directly to the wall	Wall-mounted <i>Go to page 87</i>
	Supported off the wall with an angle bracket	Wall-mounted with angles <i>Go to page 89</i>

Table 12: Pump installation types.

## Tanks and Gas Cylinders



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment:



Figure 55: Small expansion tanks or water tanks (with rolled steel plate base).



Figure 56: Expansion tanks, water storage tanks, expansion tanks on legs.



Figure 57: Water Softeners.



Figure 58: Vertical tanks.



Figure 59: Horizontal tanks including concrete-lined tanks.



Figure 60: Gas Cylinders.

## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

<i>Typical Equipment<sup>1</sup></i>	<i>How is equipment to be installed?</i>	<i>Attachment Type</i>
Tanks with attachment stands, legs, or brackets	Mounted directly to the floor	Rigid <i>Go to page 31</i>
Tanks with rolled steel plate bases	Connected to angles mounted to the floor	Rigid with angles <i>Go to page 35</i>
Tanks less than 4 feet in diameter with a flat bottom or gas cylinders	Tanks built into a plate and frame	Strut and frame <i>Go to page 45</i>
Tanks less than 2 feet in diameter	Attached to the wall with straps	Wall-mounted with angles or straps <i>Go to page 89</i>

<sup>1</sup> This guide does not address structural frames required to elevate tanks.

Table 13: Tank installation types.

## VAV Boxes (Terminal Units), Duct Silencers, and Fan-coil Units



Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

### Step 1: Identify equipment



Figure 61: VAV damper.



Figure 62: VAV box with fan (series or parallel).



Figure 63: Dual duct box.

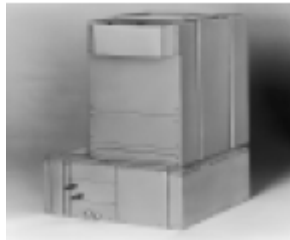


Figure 64: Vertical fan-coil unit.



Figure 65: Horizontal fan-coil unit.



Figure 66: Duct silencer.



## Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type

<i>How is Equipment to be Install</i>	<i>Typical Equipment</i>	<i>Attachment Type</i>
Fan-coil units	Mounted directly to floor	Rigid <i>Go to page 31</i>
	Connected to angles mounted to the floor	Rigid with angles <i>Go to page 35</i>
Any VAV box or Fan-coil unit	Suspended from the building structure above with rods and cables	Rods and cables <i>Go to page 61</i>
	Suspended from the building structure above with angles	Suspended with angles <i>Go to page 67</i>
	Suspended from the building structure above with isolators, rods and cables	Isolator rods and cables <i>Go to page 69</i>
Any VAV box, duct silencer, or fan-coil unit weighing less than 150 pounds	Suspended from the building structure above with two attachment angles	Suspended with two angles <i>Go to page 74</i>

Table 14: VAV box (terminal unit), duct silencer, and fan-coil unit installation types.

## ATTACHMENT TYPES

This section gives instructions on attaching equipment in many different arrangements. These attachment types are:

- Rigid Floor-mounted/Pad-mounted (this page).
- Roof-mounted (page 47).
- Suspended (page 61).
- Vibration-isolated/Floor-mounted (page 76).
- Wall-mounted (page 87).

### Rigid Floor-mounted/Pad-mounted Attachment

The six ways to rigidly attach equipment to a floor are:

- Directly to the floor/pad (this page).
- Using additional structural steel shapes that transfer load to the building floor (page 35).
- Using bumpers to restrict horizontal movement (page 40).
- Beneath a raised floor (page 42).
- At a single point—light equipment only (page 44).
- Using a strut and plate frame—tanks and gas cylinders only (page 45).

#### **Directly to the floor/pad**

Equipment may be bolted or welded to the building floor or pad. To bolt to concrete, use post-installed anchors, embedded headed studs or embedded j-bolts.

Attachment of equipment with sheet steel housings is shown in Figure 68 (page 32).

Attachment of equipment with a steel structural framing or base is shown in Figure 69 (page 33).

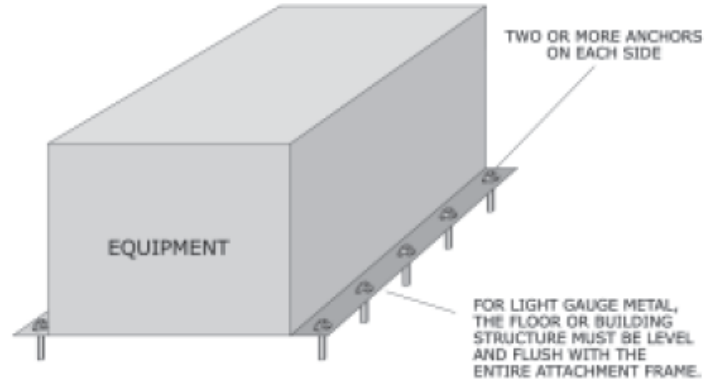



Figure 67: Direct attachment of equipment with sheet steel housing to a building.

 **Do not add shims under equipment with sheet steel housings as shown in Figure 67 above. If concrete floor/pad is irregular, reinforce housing with angles as shown in Figure 71 (page 36).**

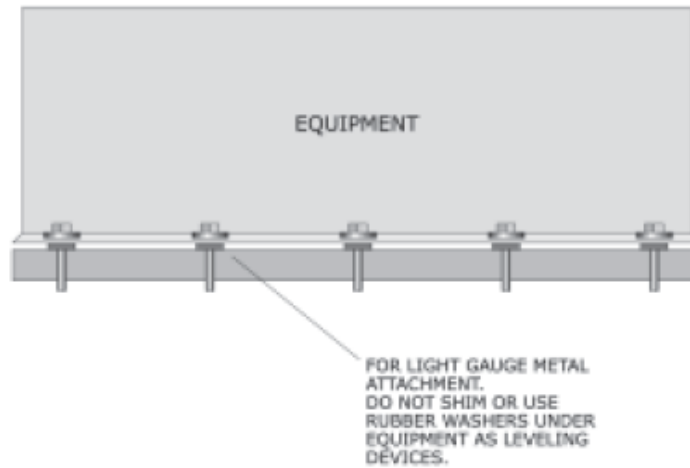


Figure 68: Side view of equipment with sheet steel housing.

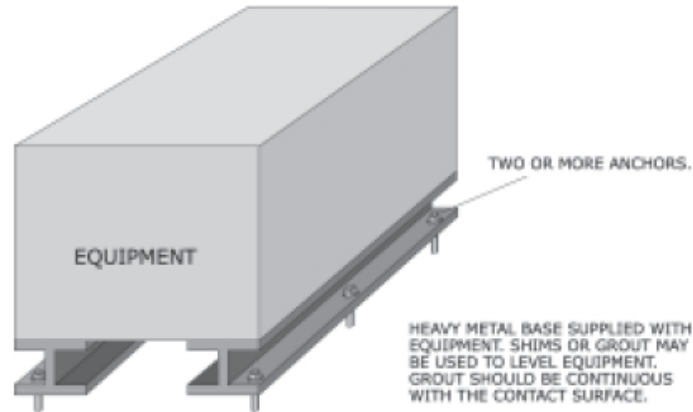


Figure 69: Direct attachment of equipment with structural steel frame or base to a building.

## Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor, concrete pad, or steel beams using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and shop drawings to lay out the bolt hole pattern.

You may drill additional holes into the equipment assembly or building steel beams as shown on construction drawings or the manufacturer's instructions.



**USE CAUTION WHEN DRILLING INTO EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided. DO NOT DRILL OVERSIZED HOLES.**



**New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 70 (page 34), if necessary.**

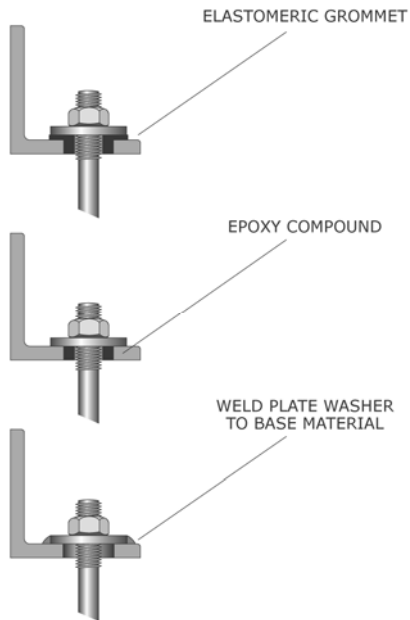


Figure 70: Three options to repair oversized holes.

## Step 2: Install anchors

If the equipment is to be anchored to concrete, drill and install post-installed anchors or pour concrete with cast-in-place studs or J-bolts (see Anchors, page 94).



**If the equipment is to be bolted to steel, drill holes in the steel as shown on construction drawings or the manufacturer's instructions.**

## Step 3: Move equipment into place



**BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT.**

## Step 4: Attach nuts or weld equipment

Attach nuts to the anchor/bolt and torque.

Weld equipment to steel beams or embedded plates (page 116).

Piping, ductwork, and raceways may be connected.

**END OF ATTACHMENT.**

## Using additional structural steel shapes

Attach additional structural shapes to the equipment with bolts and then attach steel shapes to the building with concrete anchors, steel bolts or welding. When bolting to concrete, use post-installed anchors, embedded headed studs, or embedded J-bolts.

Five different configurations for using angles to attach equipment to the building structure are shown in the following figures.

- Full-size angles on each side of equipment: Figure 71 (page 36).
- Four or more angles on each side of equipment bolted to the concrete floor/pad: Figure 72 (page 37).
- Four or more angles welded to equipment and bolted to the floor/pad: Figure 73 (page 37).
- Four or more angles on each side of equipment welded to embedded plates: Figure 74 (page 38).
- Three or more angles used to bolt down equipment with a round base: Figure 75 (page 38).

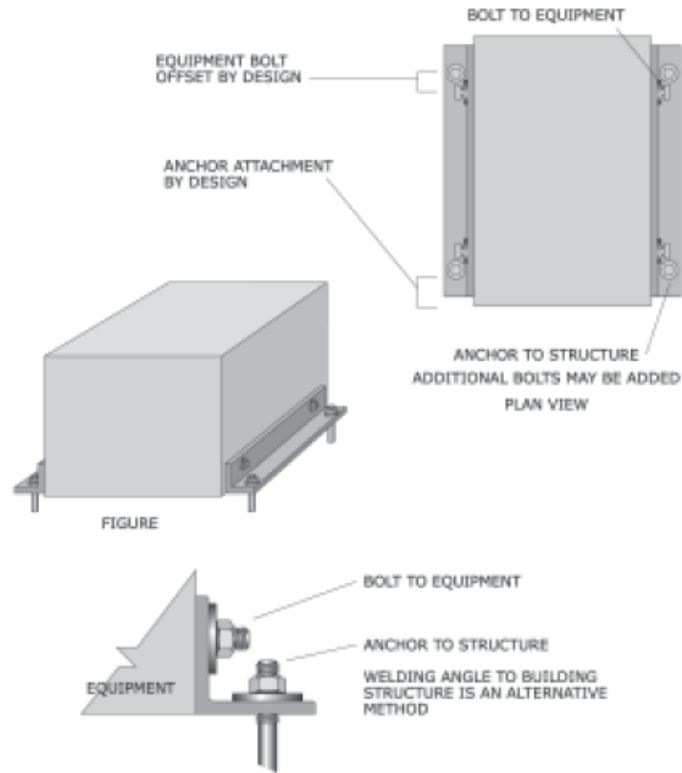


Figure 71: Two angles used to attach the equipment to the building.





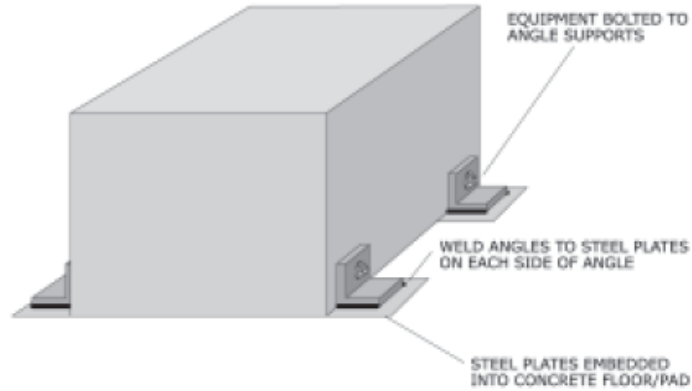


Figure 74: Four or more angles on each side of equipment welded to embedded plates. Figure 149 (page 116) gives examples of embedded steel plates.

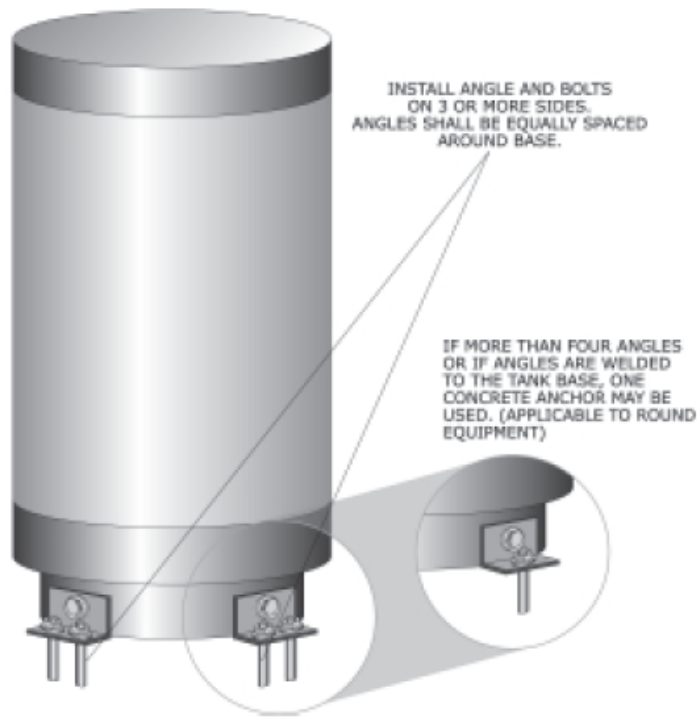


Figure 75: Three or more angles used to bolt down equipment with a round base.

## Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor, concrete pad, or steel beams using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and shop drawings to lay out the bolt hole pattern.



**You may drill additional holes into the equipment assembly or building steel beams as shown on construction drawings or the manufacturer's instructions.**



**USE CAUTION WHEN DRILLING INTO EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided. DO NOT DRILL OVERSIZED HOLES.**



**New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 70 (page 34), if necessary.**

## Step 2: Install anchors

If the equipment is to be anchored to concrete, drill and install post-installed anchors or pour concrete with embedded studs or J-bolts (see Anchors, page 94).



**If the equipment is to be bolted to steel, drill holes in the steel as shown on construction drawings or the manufacturer's instructions.**

## Step 3: Move the equipment into place



**BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT.**

You may bolt or weld angles to the equipment before moving the equipment into place.

## Step 4: Attach nuts or weld equipment

Attach nuts to the anchor/bolt and torque (see Anchors, page 94 or Welding, page 116).

Piping, ductwork, and raceways may be connected.

**END OF ATTACHMENT.**

## Using bumpers to restrict horizontal movement

Use this type of attachment when equipment is mounted to a concrete inertia base or steel frame, but:

- The base is not attached to the building, or
- The equipment has a rigid base with a flat surface near the bottom.

Bumpers are used to restrain the base from moving horizontally when there is no chance that the equipment will tip over. Bumpers are only bolted to the building structure. Use post-installed anchors to bolt to concrete, as shown in Figure 76 and 77 (below).

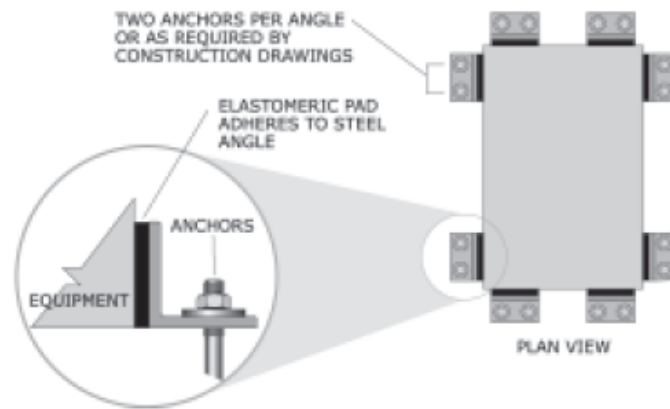


Figure 76: Equipment installed with bumpers.



**If anchors are near a joint in the concrete, see detail in Figure 77.**

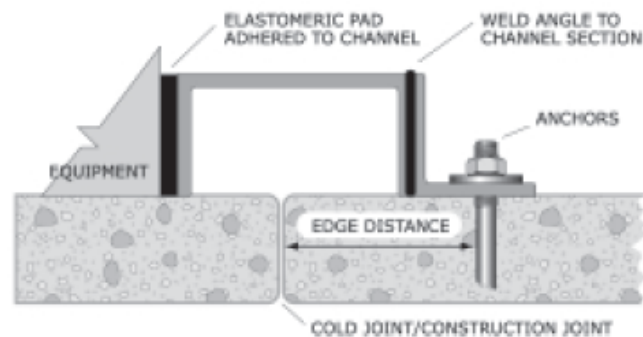


Figure 77: Alternate installation detail of bumpers installed near a concrete joint.

## Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor, concrete pad, or steel beams using one of the following methods:

- Set bumpers in place and mark holes.
- Use measurements and construction drawings to lay out the bolt hole pattern.

## Step 2: Install anchors

See Anchors (page 94). If the anchors are near a concrete joint, refer to the detail in Figure 77 (page 40).

## Step 3: Install bumpers

## Step 4: Attach nuts to the anchor/bolt and torque

See Anchors (page 94). Figure 77 shows equipment restrained with bumpers next to a cold joint. Notice in Figure 78 below that the application is near a concrete joint.

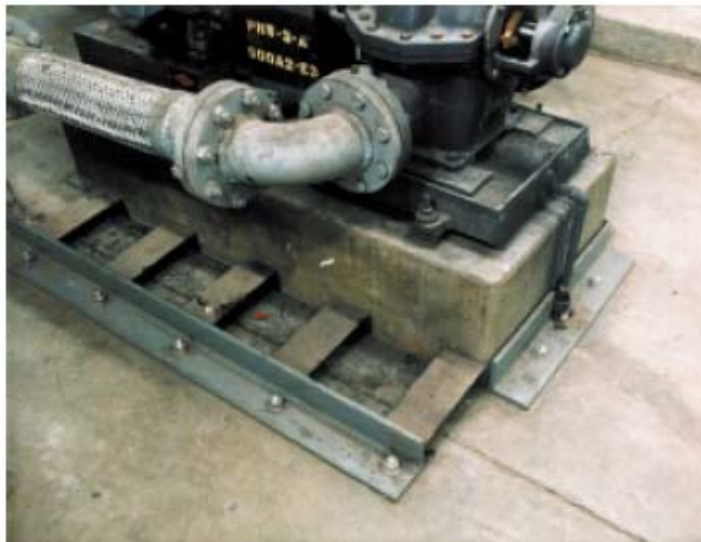


Figure 78: Equipment restrained with bumpers next to cold joint.

**END OF ATTACHMENT.**

## Beneath a raised floor

Air conditioning units for computer spaces typically move air through a raised floor. A stand rated for the weight of the air conditioning unit and laterally braced to withstand seismic loads must be provided. Equipment is rigidly attached to the stand and the stand is rigidly bolted to the floor beneath the raised floor. Portions of the raised floor are removed to allow installation of the stand and equipment as shown in Figure 79 (below).

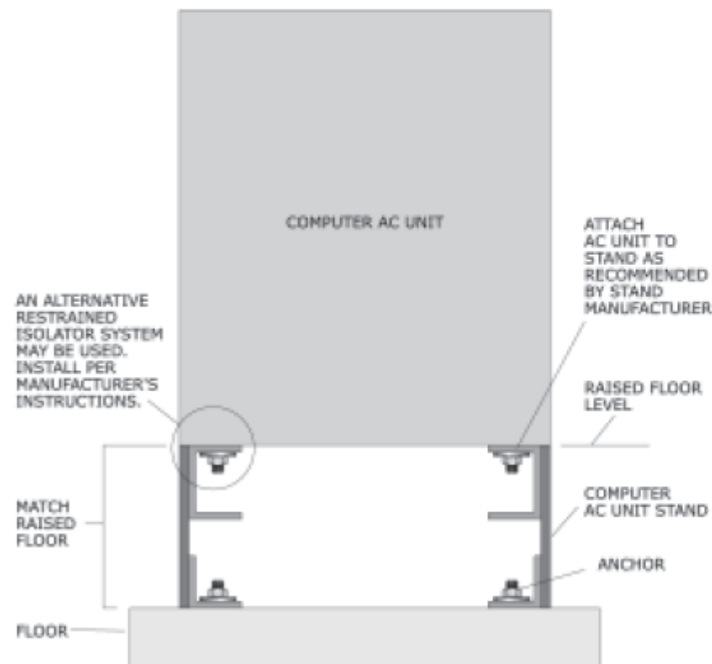


Figure 79: Air conditioning unit for a raised floor.

## Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor using one of the following methods:

- Set the frame in place and mark the holes.
- Make a template.
- Use measurements and construction drawings to lay out the bolt hole pattern.

## Step 2: Install anchors

See Anchors, page 94. Set the frame in place and apply nuts to the anchor/bolt and torque.

## Step 3: Move the equipment into place

Bolt equipment to the frame. (See Steel Bolt Connections, page 111). You may drill additional holes into the equipment assembly or building steel beams but only as shown on construction drawings or the manufacturer's instructions. Any holes added to the building structure must be approved by the Structural Engineer of Record.



**New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 70 (page 34), if necessary.**

Piping, ductwork, and raceways may be connected.

**END OF ATTACHMENT.**

**At a single point – light equipment only**

Air separators or inline pumps weighing less than 400 pounds may be supported on the both inlet and outlet using a floor support as shown in Figure 80 (below). A single support may be used if the equipment weighs less than 150 pounds. A rigid connection with rods and cables supported from the building structure above is optional.

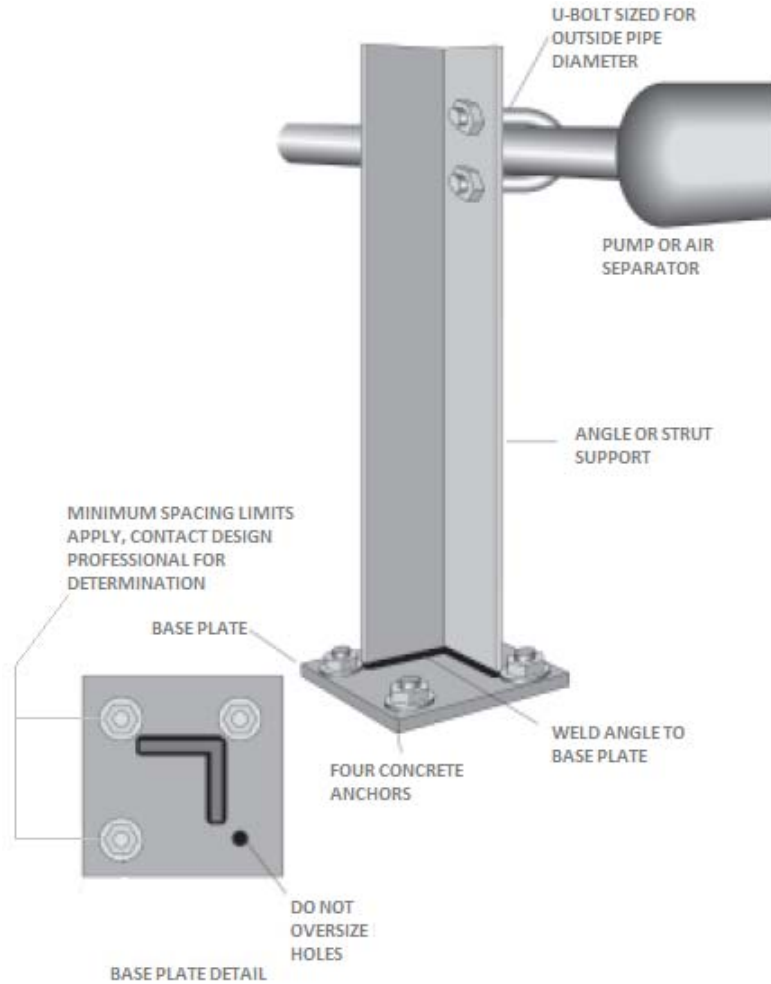


Figure 80: Angle floor support.

## Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern of the base plate on the floor using one of the following methods:

- Set the base plate and mark the holes.
- Make a template.
- Use measurements and construction drawings to lay out the bolt hole pattern.

## Step 2: Install anchors

Install post-installed anchors as described in Anchors (page 94). Set the base plate with the angle support in place. Apply nuts to the anchor/bolt and torque.

## Step 3: Attach piping

Attach piping to the angle with a U-bolt. (See Steel Bolt Connections, page 111).

**END OF ATTACHMENT.**

**Using a strut and plate frame – tank and gas cylinders only. Details of design to be determined by design professional.**



Figure 81: Small gas cylinder storage.



## Step 1: Determine where to bolt the equipment

Accurately draw bolting pattern of the strut frame on the floor using one of the following methods:

- Set the base plate in place and mark the holes.
- Make a template.
- Use measurements and construction drawings to lay out the bolt hole pattern.

## Step 2: Install anchors

Install post-installed anchors as described in Anchors (page 94). Set the bottom frame in place. Apply nuts to the anchor/bolt and torque.

## Step 3: Complete frame and plate assembly

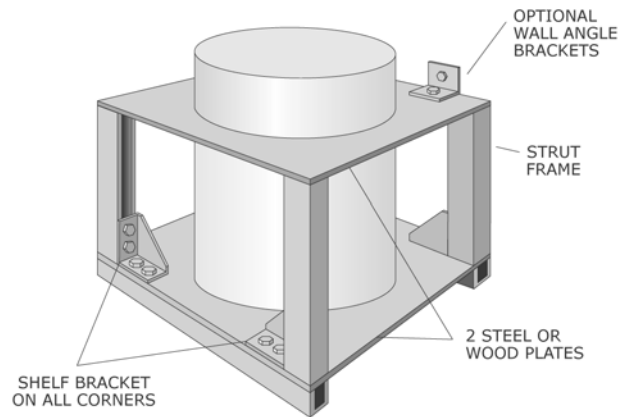


Figure 82: Tank and gas cylinder support.  
Cap and strap should be considered for fiberglass tanks.

## Step 4: Install additional anchors

Additional anchors may be installed in the wall for extra support. See Anchors (page 94) or Masonry Anchors (page 104).

Tanks and gas cylinders may be attached.

**END OF ATTACHMENT.**

## Roof-mounted Attachment

The five ways to rigidly attach equipment to a roof are:

- Using leveling stanchions—also called post and beam (this page).
- To seismic built-up or seismic pre-manufactured curb (page 50).
- To wood frame (page 56).
- Using a pre-manufactured seismic vibration isolation curb or leveling stanchions with equipment support frame (page 57).
- Using restrained springs on leveling stanchions (page 59).

### Using leveling stanchions—post and beam

#### Step 1: Attach posts or stanchions

Bolt or weld stanchions to the building structure. To attach stanchions to the different building structure types, see the detail in Figure 83 (page 48)

Support stanchions can be made from many different structural shapes.



**Coordinate attachment points with the general contractor. Additional intermediate building structure beams may be required to accommodate the equipment.**



**The building structure must be capable of supporting the point load of the stanchions.**

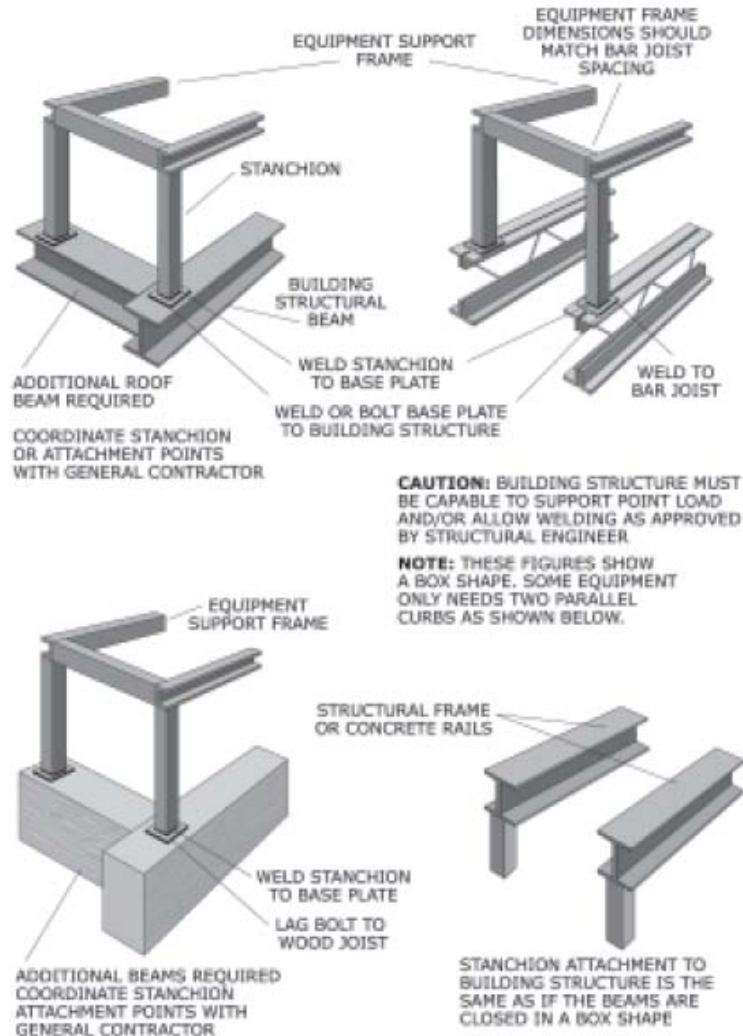


Figure 83: Attaching a stanchion to a building.

## Step 2: Apply flashing to stanchions

Use standard details to flash around pipe stanchions or steel tubing. For flashing around a stanchion, which may not be uniform like an angle, channel, or I-beam steel shape, see Figure 84 (page 49).

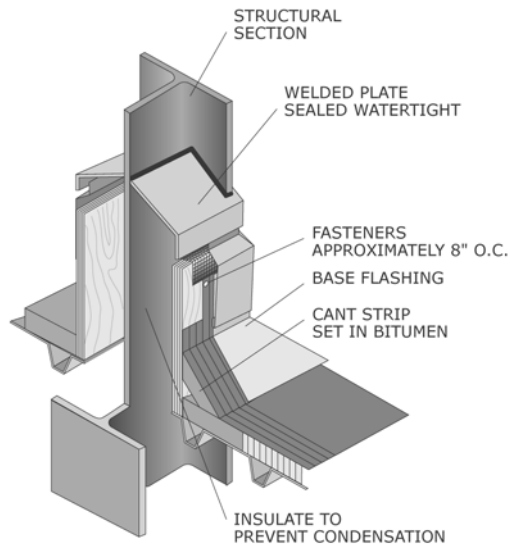


Figure 84: Flashing around a stanchion.

### Step 3: Weld/bolt equipment support frame to stanchion

The equipment support frame may be box-shaped or have two parallel beams. The equipment support frame may be made from steel shapes such as angles, tubes, channels, or I-beams.

### Step 4: Attach equipment

To rigidly attach the equipment to equipment support frame, see Figure 85 (page 50).

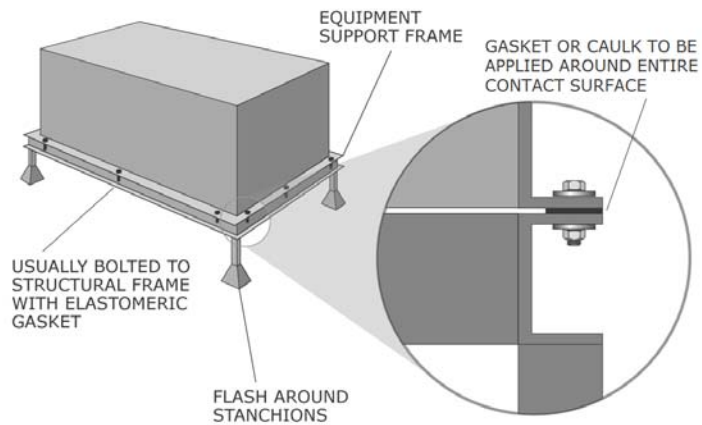


Figure 85: Rigid attachment of equipment to a support frame.

**END OF ATTACHMENT.**

## **To seismic built-up or seismic pre-manufactured curb**

### **Step 1: Attach curb to roof or building structure**

To attach the curb to the building structure, see Anchors (page 94).

To attach seismic-rated built-up curb to a roof structure, see Figure 86 (page 51) for one method of building a curb.

To attach seismic-rated pre-manufactured curb:

- Directly to the roof, see Figure 87 (page 52).
- To the building structure, see Figure 88 (page 53).

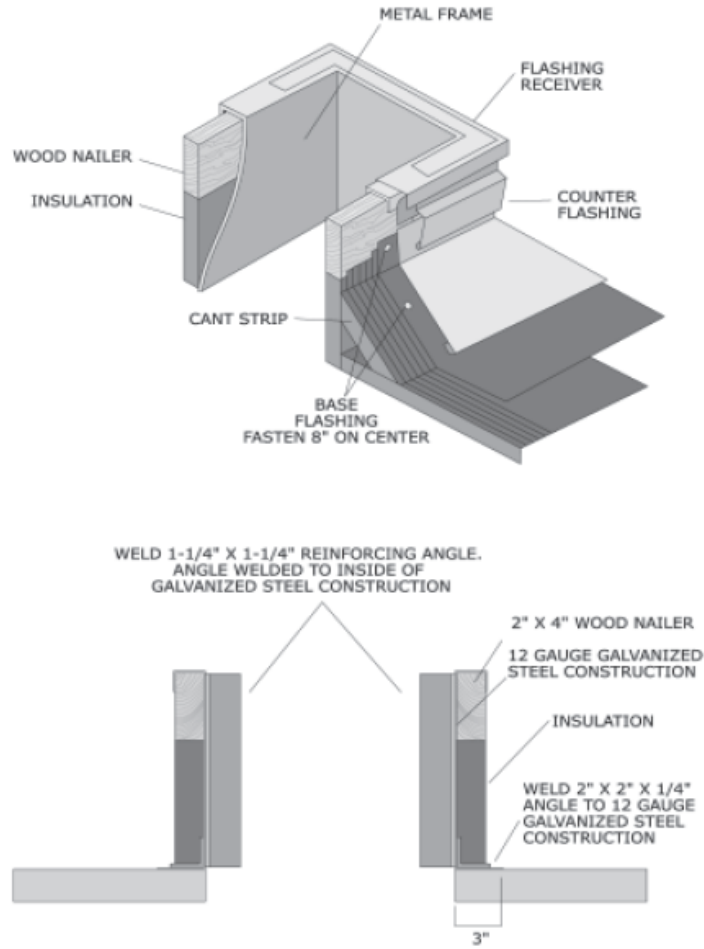


Figure 86: Seismic built-up curb details.

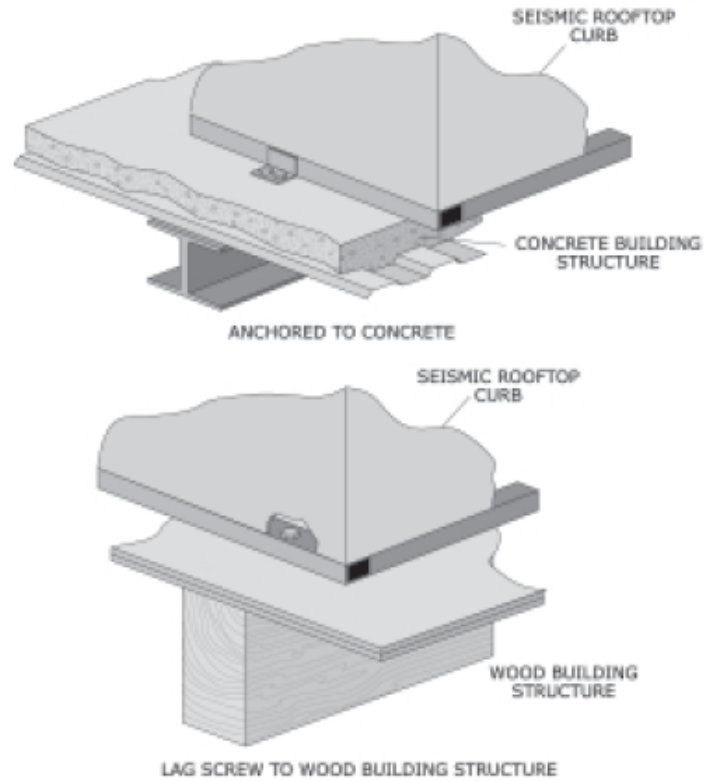


Figure 87: Pre-manufactured curb attached to roof.



**Follow the manufacturer's instructions for installing all seismic pre-manufactured curbs.**

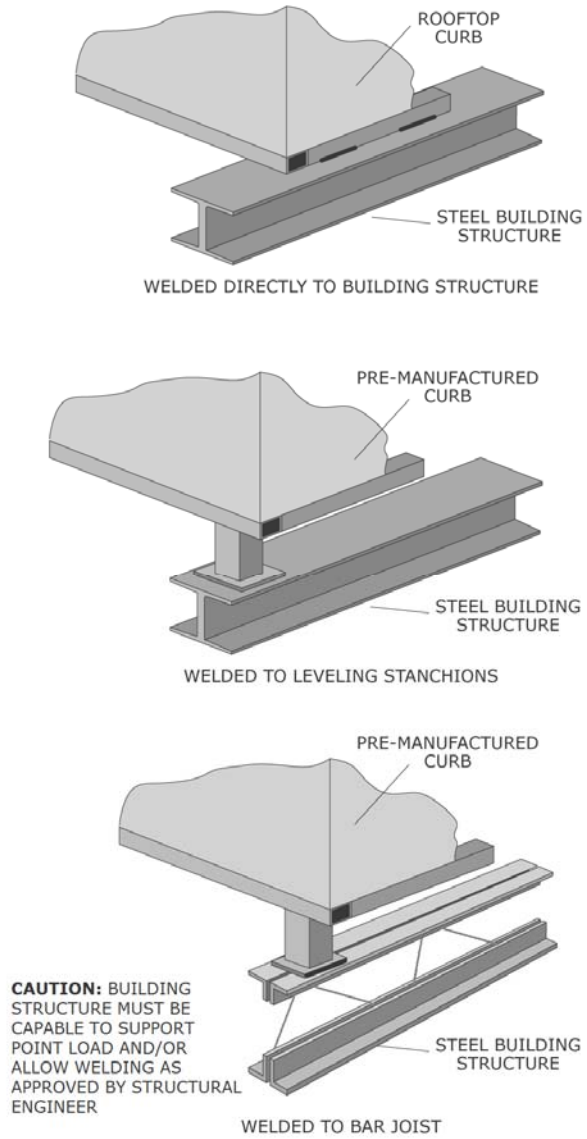


Figure 88: Pre-manufactured curb attached to building structure.



## **Step 2: Weld reinforcing angles**

For built-up curb, weld reinforcing angles to the metal frame as shown in Figure 86 (page 51).

## **Step 3: Install flashing**

Figure 86 shows the flashing for built-up curbs. This may be used for pre-manufactured curbs.

## **Step 4: Attach equipment**

Attach the equipment to seismic rated curb using screws as shown in Figure 89 (page 55). Space the screws according to the manufacturer's instructions.

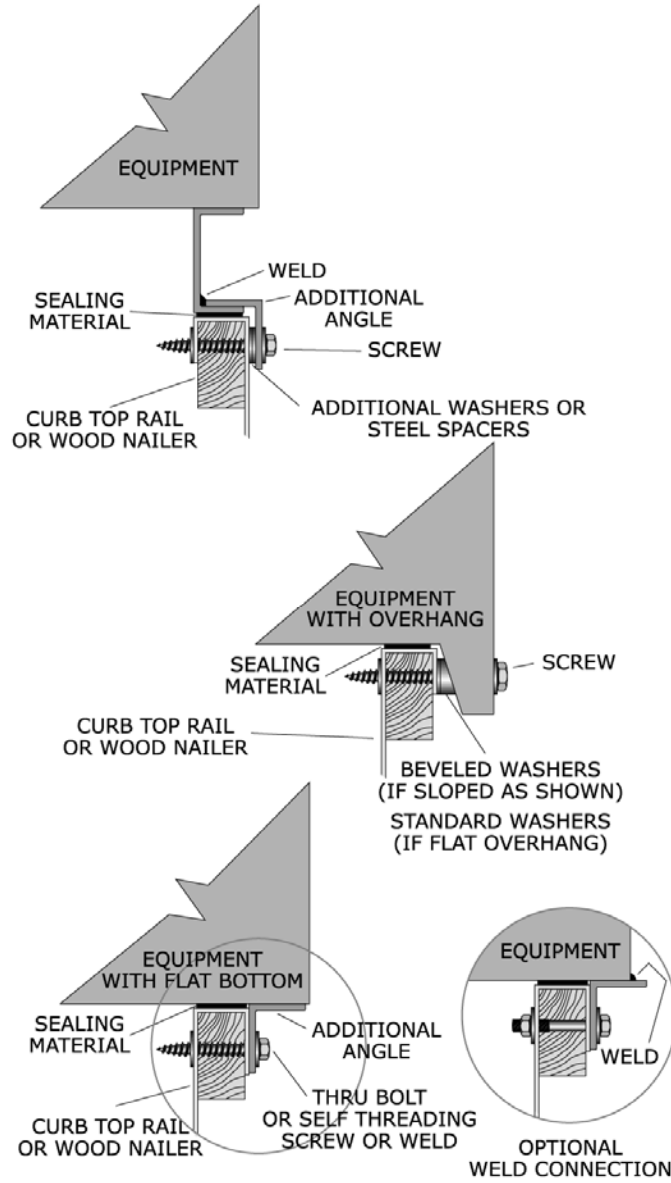


Figure 89: Attachment of equipment to a built-up curb or pre-manufactured curbs.

**END OF ATTACHMENT.**

## To a wood frame

### Step 1: Attach wood frame to building structure

Figure 90 (below) shows a typical wood frame attachment.

### Step 2: Install Flashing

Figure 90 (below) shows typical flashing.



**Use contract documents for flashing details.**

### Step 3: Attach equipment to the wood frame

Attach equipment directly to the wood frame as shown below. Wood frames can restrain equipment with internal frames or with support legs as shown.

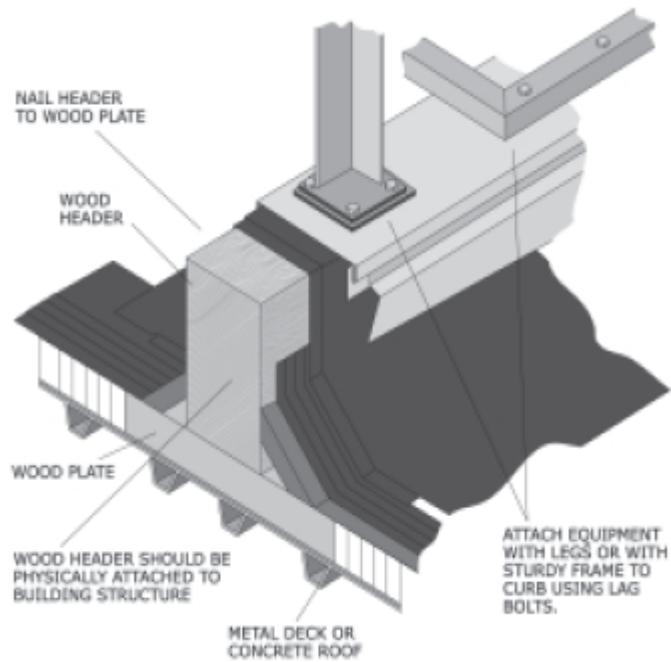


Figure 90: Attachment of equipment to wood frame.

**END OF ATTACHMENT.**

## Using a seismic pre-manufactured vibration isolation curb

Figure 91 (below and next page) shows the vibration isolation curb attached to a structure. The vibration isolation curb may be a continuously supported type as shown in Figure 91 or a point loaded frame (See Figure 83, page 48).

### Step 1: Attach curb or post and beam with equipment support frame to building structure

If a continuously supported curb is the base of the vibration isolation curb, go to page 50 and follow instructions for attaching equipment to a built-up or pre-manufactured curb.

If a post and beam is the base of the vibration isolation curb, go to page 47 and follow instructions for rigidly attaching equipment with leveling stanchions.

### Step 2: Install flashing

Install flashing for a continuously supported curb as shown in Figure 86 (page 51) or flash the stanchions as shown in Figure 84 (page 49).

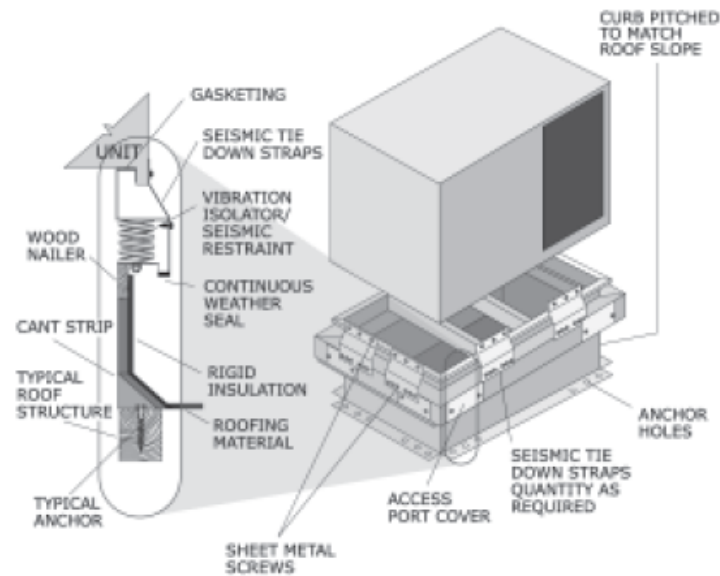


Figure 91: Various types of manufactured isolator systems (continued on next page).

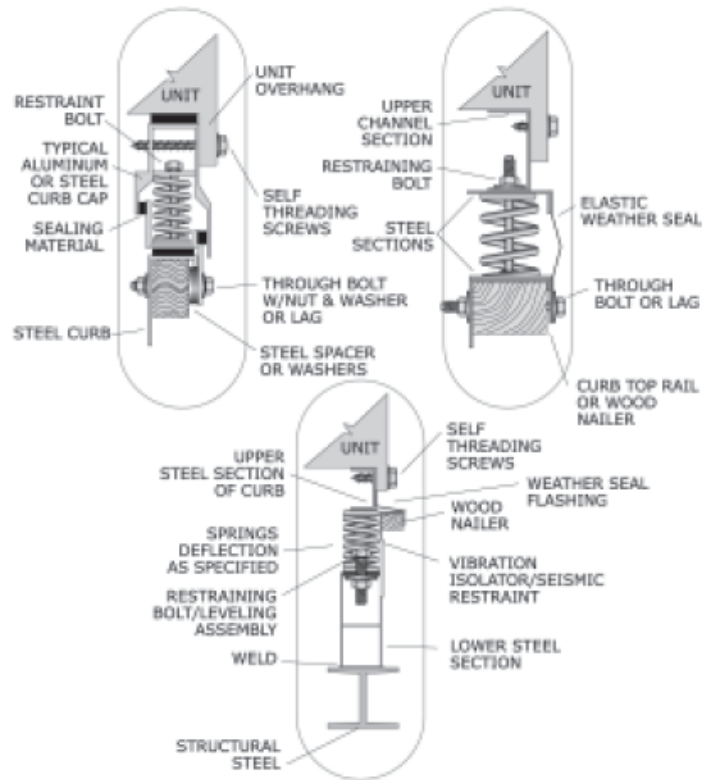


Figure 92: Various types of manufactured isolator systems.

### Step 3: Attach vibration isolation curb to structure

Figure 88 (page 53) shows options used to attach curb to structure.



Use contract documents for flashing details.

### Step 4: Attach equipment to the vibration isolation curb

Figure 91 & 92 (page 57 and above on this page) show various seismic attachment methods used to attach equipment to a vibration isolation curb.

**END OF ATTACHMENT.**

## Using restrained springs on leveling stanchions

Figure 93 (below) shows a typical installation of restrained spring vibration isolated equipment on stanchions and an equipment support frame.

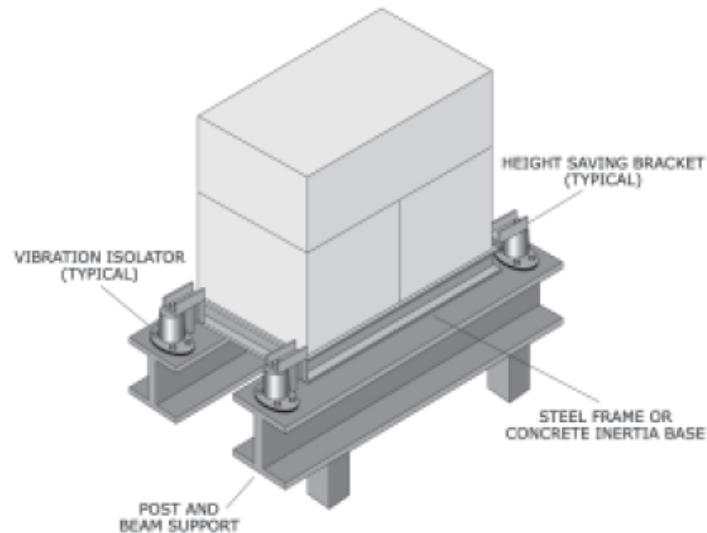




Figure 93: Equipment attached using restrained springs on a post and beam.

-  **More than four restrained springs may be required. See the manufacturer's instructions.**
-  **Verify that the spring is properly aligned according to the manufacturer's recommended clearances. If the spring shaft rubs against the snubber element, a short-circuit may occur, causing noise problems.**

### Step 1: Attach posts or stanchions

Bolt or weld stanchions to the building structure. Refer to the detail in Figure 83 (page 48) for attaching stanchions to different building structure types. Support stanchions can be made from many different structural shapes.



**Coordinate attachment points with general contractor. Additional intermediate building structure beams may be required to accommodate the equipment.**



**THE BUILDING STRUCTURE MUST BE CAPABLE OF SUPPORTING THE POINT LOAD OF THE STANCHIONS.**

## Step 2: Apply flashing to stanchions

Use standard details to flash around pipe stanchions or steel tubing. For flashing around a stanchion, which may not be uniform like an angle, channel, or I-beam steel shape, refer to Figure 84 (page 49).

## Step 3: Weld/bolt equipment support frame to stanchion

The equipment support frame may be box-shaped or have two parallel beams. The equipment support frame may be made from steel shapes such as angles, tubes, channels, or I-beams.

## Step 4: Attach restrained springs

Attach restrained springs to the steel frame using steel bolts.



**The support frame should be as wide or wider, if welded, than the base plate of the component fitted with the restraint device.**

## Step 5: Install equipment on springs

Install equipment on springs with attachment nuts and level.



**Bases are required for mounting equipment with restrained springs. Do not use restrained springs on a built-up curb.**

**END OF ATTACHMENT.**

## Suspended Attachment

The four ways to suspend equipment are by:

- Rigid connection to the building structure using four threaded vertical rods with horizontal cable supports (this page).
- Rigid connection to the building structure using angle/strut supports (page 67).
- Isolated connection to the building structure using four threaded vertical rods and horizontal cable supports (page 69).
- Double angle attachment-bolted or welded to the building (page 72).
- Double rod attachment-bolted to the building (page 74).

### Rigid connection to the building structure using four threaded vertical rods with horizontal cable supports

Equipment should have pre-installed brackets that can support attachment to the building.

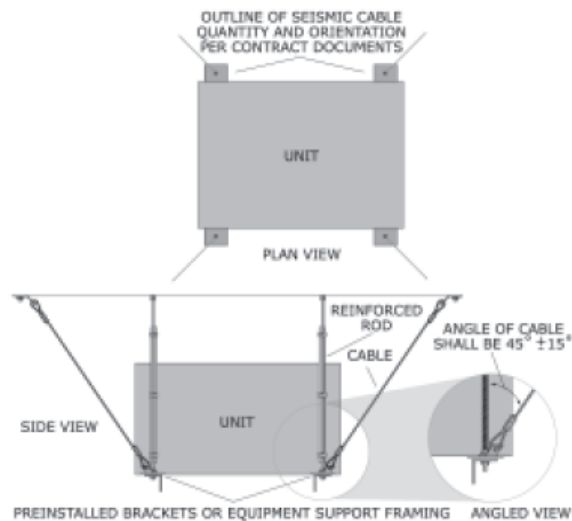


Figure 94: Rigid connection to the building structure.





**Cables provide horizontal restraint for seismic loads and should not be used to support the equipment weight.**

**Step 1: Attach the equipment to the building structure using threaded rods and anchors**

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 95-100 (below and page 63-64). For instructions on bolting directly to the building structure, see Steel Bolt Connections (page 111).

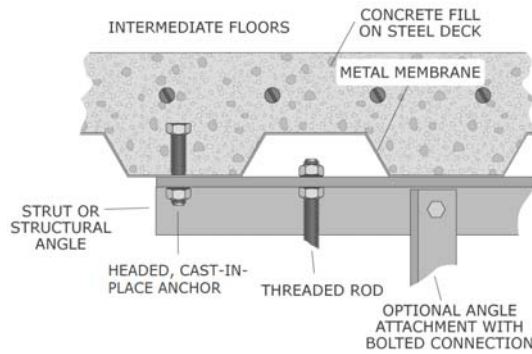


Figure 95. Cast-in-place anchor; concrete fill on steel deck.

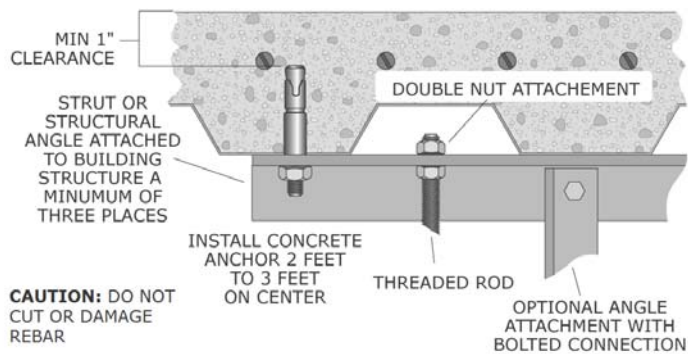


Figure 96. Post-installed anchor; concrete fill on steel deck.

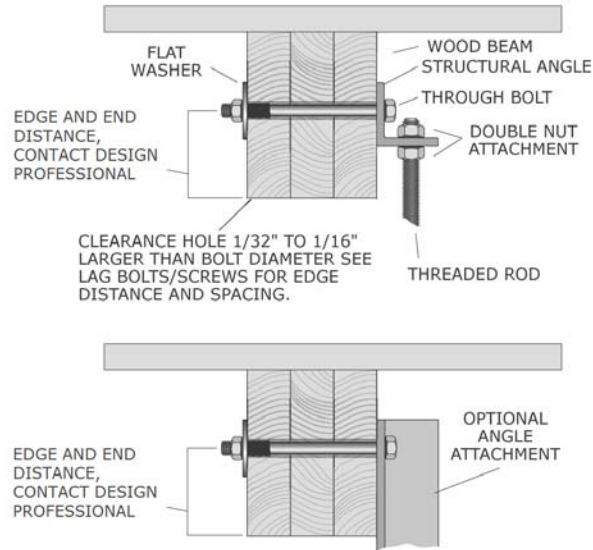



Figure 97: Wood beam construction.

 **For edge distances and spacing, see Lag Bolts (page 102).**

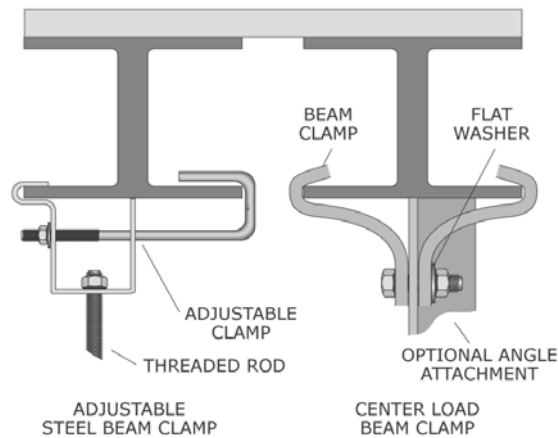



Figure 98: Steel beam construction.

 **Use center load beam clamps for vertical loads. Do not use for cables, rods, or structural members positioned at an angle.**

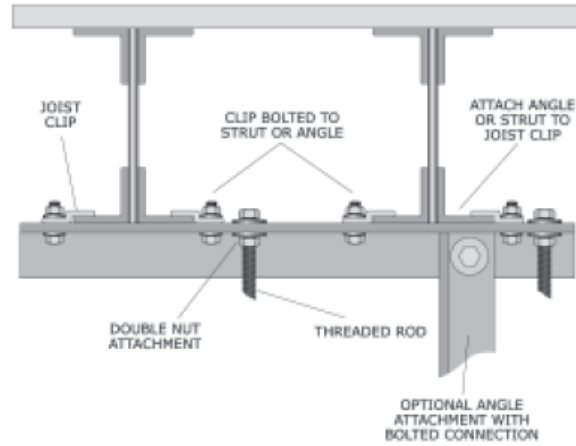


Figure 99: Bar joist construction.

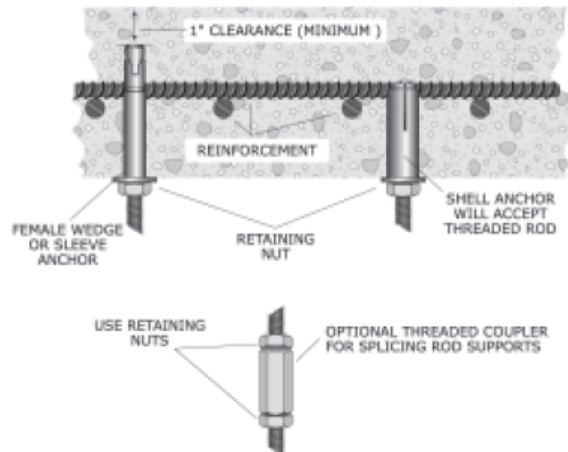


Figure 100: Concrete slab construction.

## Step 2: Add rod stiffeners

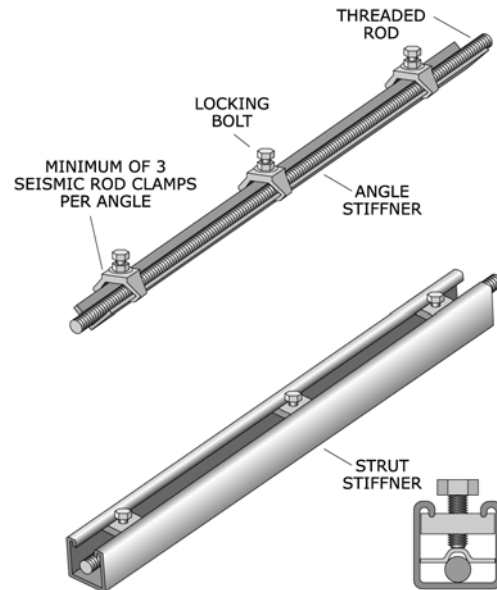


Figure 101: Rod stiffeners.

## Step 3: Attach anchors to the building structure for cable attachment

Figure 102 (page 66) shows typical anchorage to different building construction. See Anchors, page 96.

## Step 4: Attach cable to the building structure.

For cable assembly instructions, see Cables, (page 118).

For details on attaching cable to the building structure, see Figure 102 (page 66).

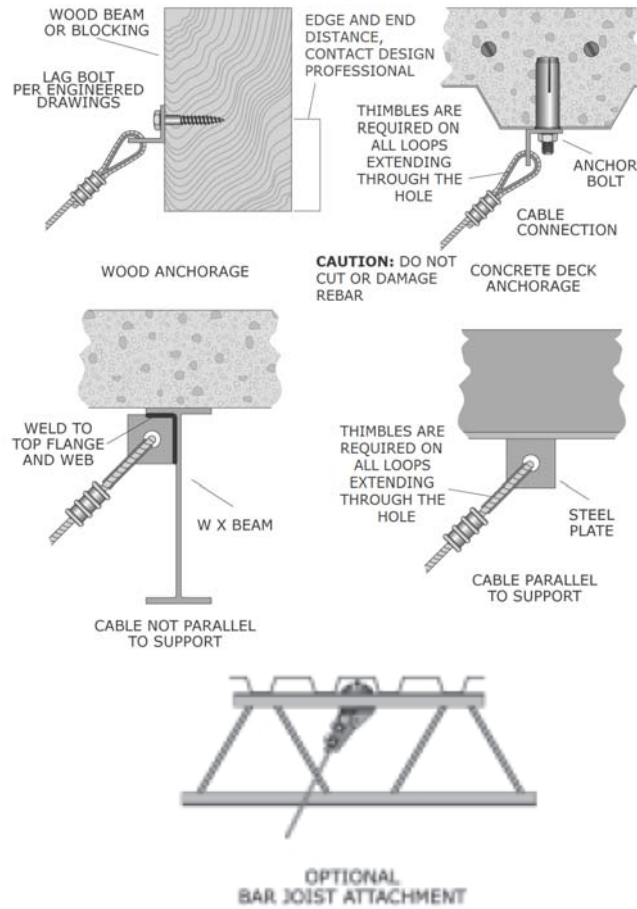


Figure 102: Attachment of cable to the building structure.

## Step 5: Attach cables to equipment

For details on attaching cable to the equipment, see Figure 103 (page 67).

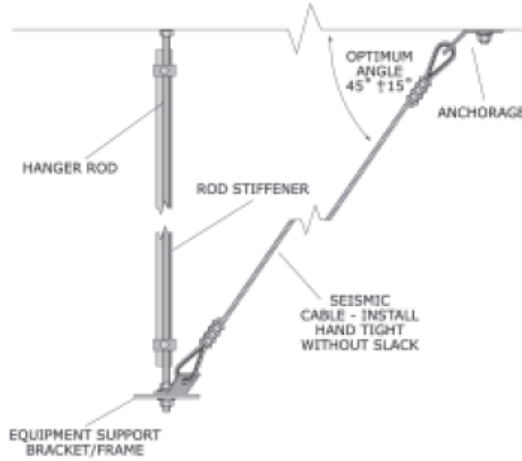


Figure 103: Attachment of cable to equipment.

**END OF ATTACHMENT.**

**Rigid connection to the building structure using angle/ strut supports**

Equipment may have pre-installed brackets for angle support attachments as shown below in Figure 104.

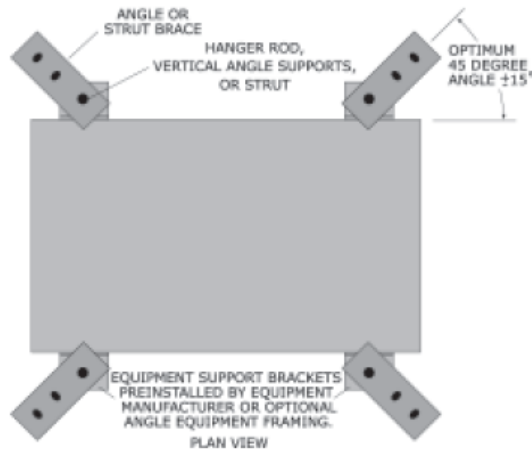


Figure 104: Rigid connection to building structure using angles.

**Step 1: Attach the equipment to the building structure using threaded rods and anchors**

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 95-100 (pages 62-64). See Anchors (page 94). Rod stiffeners are not required.

**Step 2: Attach anchors to the building structure for angle or strut supports**

For building structure attachment details, see Figures 95-100 (pages 62-64). See Anchors (page 94).

**Step 3: Attach angles or strut supports to the building structure**

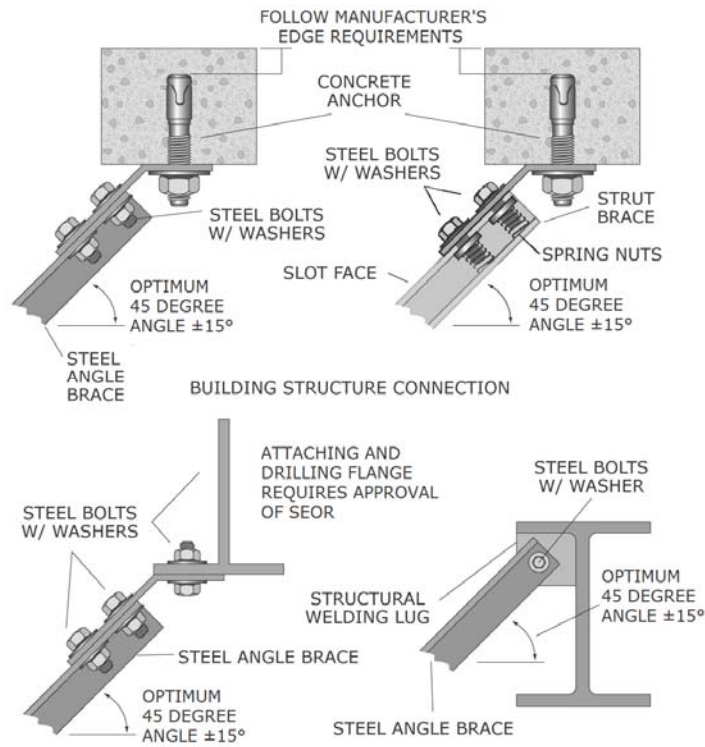


Figure 105: Attachment of angle or strut to the building structure.

**Step 4: Attach angle or strut to equipment**

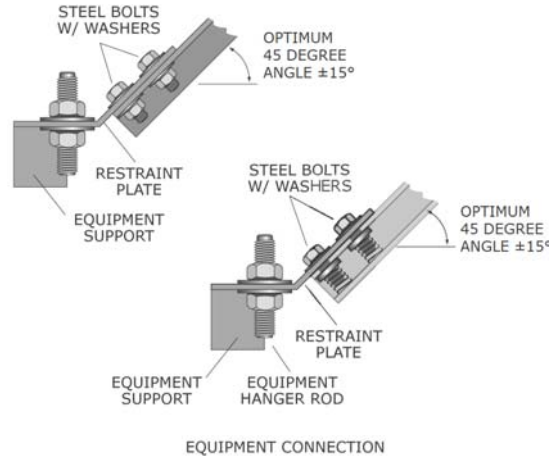


Figure 106: Attachment of angle or strut to equipment.

**END OF ATTACHMENT.**

**Isolated connection to the building structure using four threaded vertical rods and horizontal cable restraints**

Equipment may have pre-installed brackets for angle support attachments. See Figure 107 (below) and Figure 108 (page 70).

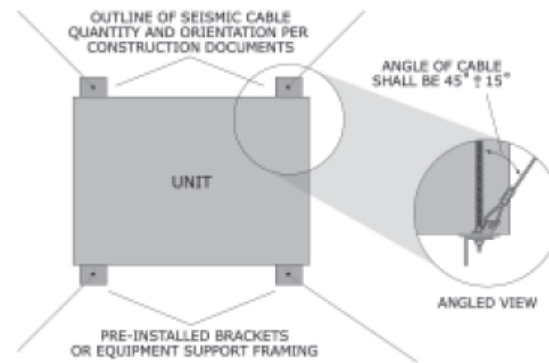


Figure 107: Plan view of vibration isolation suspended attachment to the building structure.



Side view shows vibration isolators, rods (without rod stiffeners), and cables.

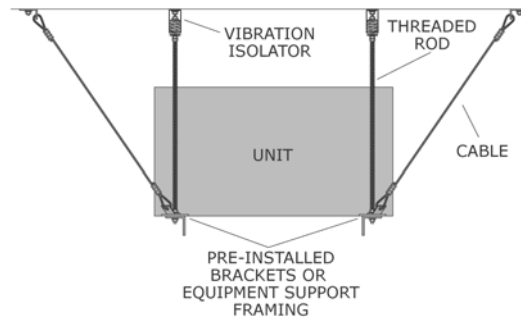


Figure 108: Side view of vibration isolation suspended attachment to the building structure.

**Step 1: Attach the equipment to the building structure using threaded rods, isolators and anchors**

For the isolator detail, see Figure 109 (below). For building structure attachment details, see Figures 95 to 100 (pages 62-64).

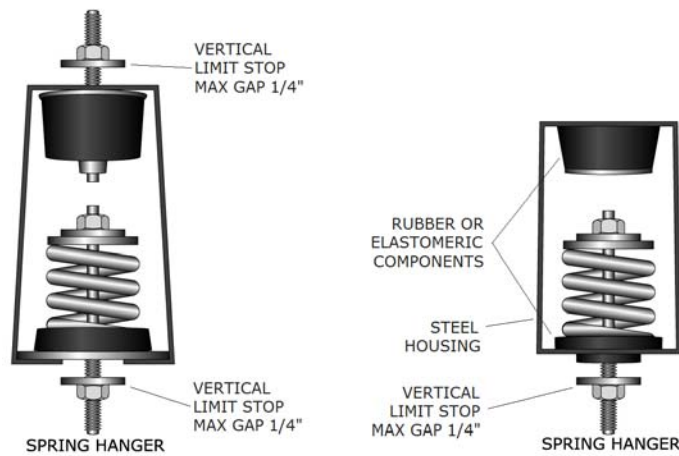


Figure 109: Isolator detail.

## Step 2: Attach anchors and cable to the building structure

For details on anchorage and cable connection to the building structure, see Figure 102 (page 66).

## Step 3: Attach cables to equipment

For cable assembly, see Cables (page 118). For cable attachment to equipment, see Figure 110 (below).

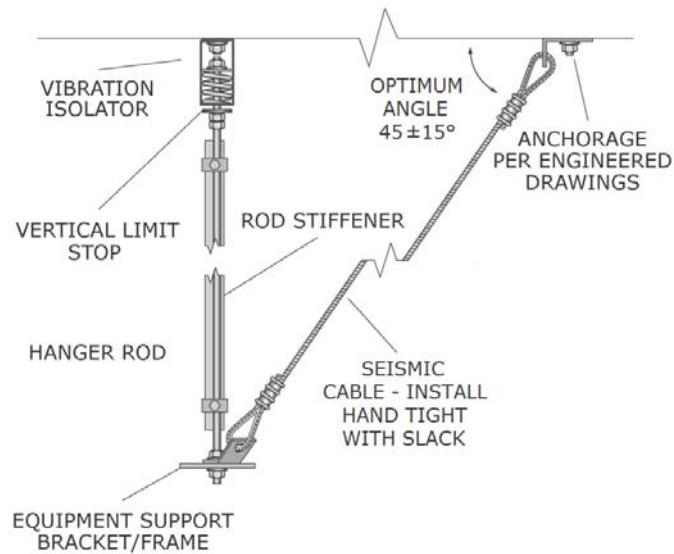


Figure 110: Attachment of cable/rod assembly to the equipment.

**END OF ATTACHMENT.**

## Double angle attachment - bolted or welded to the building

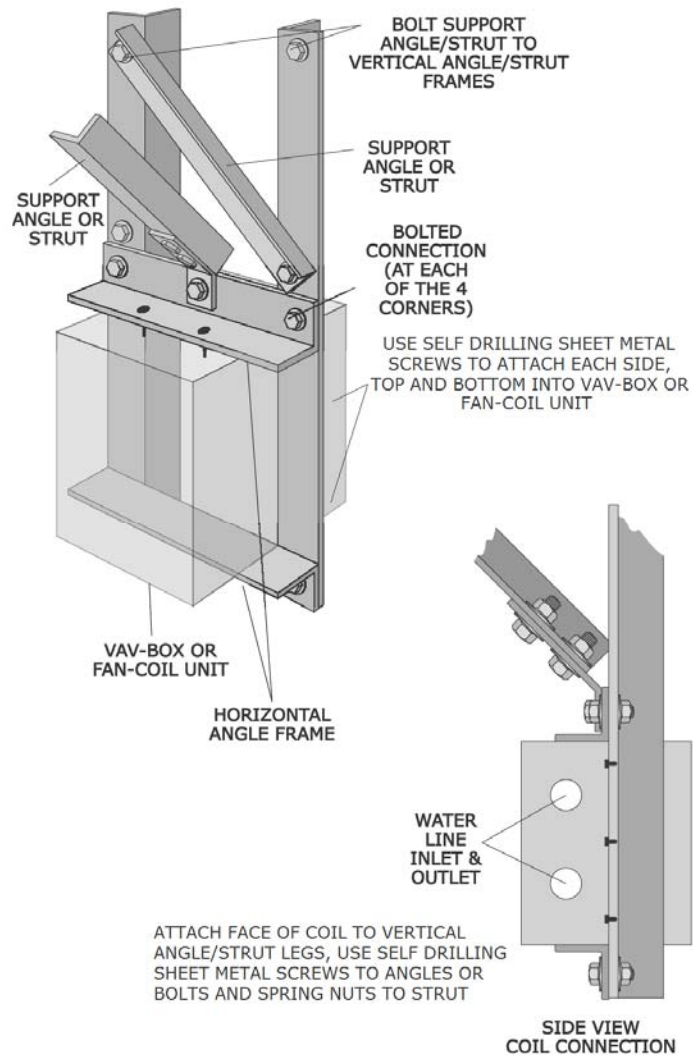


Figure 111: Attachment of double angle for equipment support.

Use this type of installation for duct-mounted coils, VAV boxes, or fan-coil units weighing less than 150 pounds.

## **Step 1: Attach anchors and vertical angles or strut to the building structure**

For building structure attachment details, see Figures 95 to 100 (pages 62-64).

## **Step 2: Attach horizontal framing**

For attachment details, see Figure 111 (page 72).

## **Step 3: Attach anchors to the building structure for angle or strut restraints**

For building structure attachment details, see Figure 105 (page 68). See Anchors (page 94).

## **Step 4: Attach support angles or struts**

One support is attached to the two vertical angles or struts. One support is attached to the building structure and to the top horizontal frame. For details on angle or strut attachment, see Figure 111 (page 72).

## **Step 5: Attach equipment**

Attach equipment to the support assembly as shown in Figure 111 (page 72).

**END OF ATTACHMENT.**

## Double rod attachment - bolted to the building

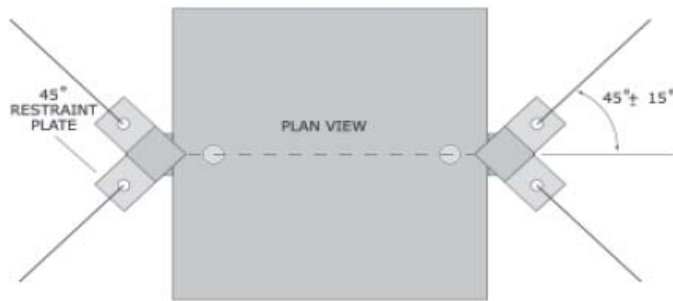
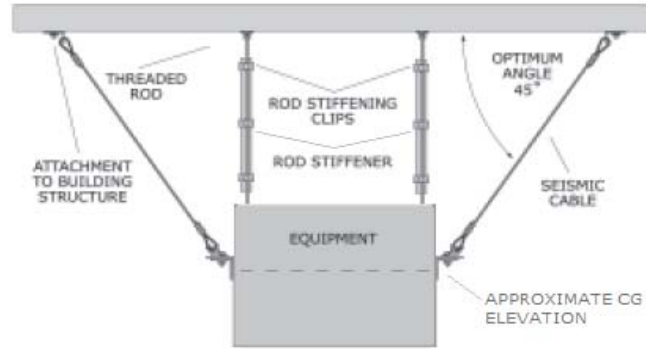


Figure 112: Equipment attachment for double rod support. If bracket not provided by manufacturer, attach at equipment centerline.

Use this type of installation for unit heaters.

## Step 1: Attach anchors and vertical rods to the building structure

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 95 to 100 (pages 62-64). Attach equipment to the vertical rods.



**The attachment should be located just above the center of gravity or the equipment should be fitted with an anti-moment plate to minimize swinging. It should be a rigid attachment with brackets to the equipment using double nuts, especially if connected at the top as shown in Figure 112 (page 74).**

## Step 2: Attach rod stiffeners

For attachment details, refers to Figure 101 (page 65).

## Step 3: Attach anchors to the building structure for cable attachment

Figure 102 (page 66) shows typical anchorage to different building construction. See Anchors (page 94).

## Step 4: Attach cable to the building structure

For cable assembly see Cables (page 118).

For details on attaching cable to the building structure, see Figure 102 (page 66).

## Step 5: Attach cables to equipment

The detail in Figure 112 (page 74) shows the attachment to the equipment.

## Vibration-isolated Floor-mounted Attachment

Vibration isolation uses springs in many different shapes to isolate equipment vibrations from the building structure. Their shapes are open (see Figure 113 below left), housed (see Figure 113 below right), and restrained (see Figure 114, page 77).

**!** **NEVER USE HOUSED SPRINGS FOR SEISMIC RESTRAINT APPLICATIONS. Housed springs cannot resist uplift.**

Snubbers (see Figure 115, page 77) are restraint devices to limit the movement of equipment that is isolated. Bumpers (see Figure 116, page 78) also limit the movement of equipment and are similar to snubbers.

**!** **NEVER USE SNUBBERS THAT ARE NOT SPECIFIED. Some snubbers only restrict movement in one direction.**

**!** **NEVER USE OPEN SPRINGS WITHOUT SNUBBERS OR BUMPERS. Equipment mounted on open springs without snubbers or bumpers will fail.**

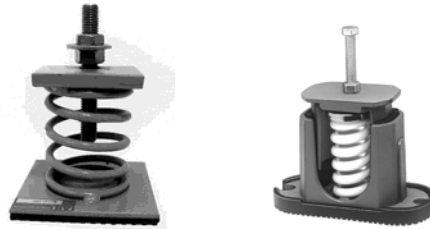



Figure 113: Open spring and housed spring.



Figure 114: Four types of restrained springs.



Figure 115: Two examples of snubbers.

 **Verify that the spring is properly aligned according to the manufacturer's clearances. If the spring shaft rubs against the snubber element, a short-circuit may occur, causing noise problems.**



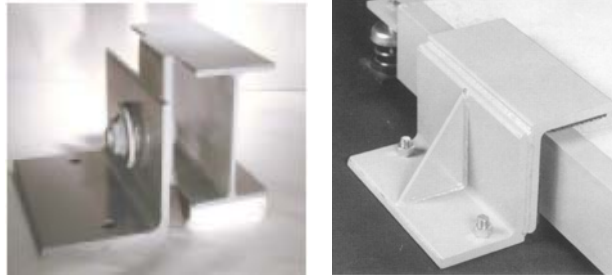



Figure 116: Two examples of bumpers.

Bases are steel structures made from angles, channels, or I-beams.

 **Bases are required for mounting isolated equipment. The equipment manufacturer or the isolator manufacturer may provide the bases.**

The two ways of attaching vibration-isolated/floor-mounted equipment are on:

- Restrained springs (this page).
- Open springs combined with snubbers (page 82).

### Restrained springs

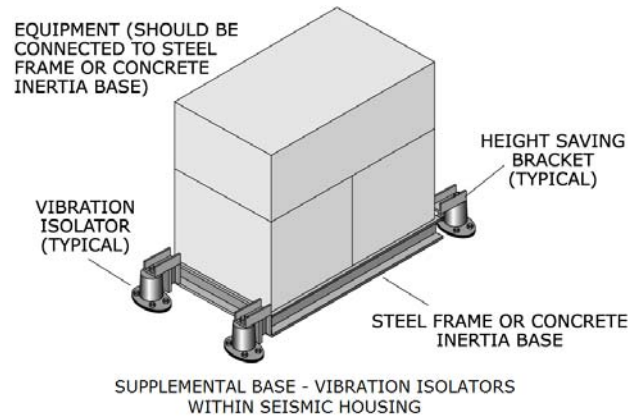


Figure 117: Typical installation of restrained spring installation.



**More than four restrained springs may be required. See the manufacturer's instructions.**

## **Step 1: Determine where to bolt the equipment**

Accurately draw the bolt pattern on the floor or pad using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and shop drawings to lay out the bolt hole pattern.

## **Step 2: Install anchors**

Drill and install post-installed anchors or pour concrete with embedded studs or headed cast-in-place anchors (see Anchors, page 94).

## **Step 3: Set restrained spring isolators and bolt to anchors**

Install restrained springs to building structure as shown in Figure 118 (page 80). Attach nuts to the anchor. Use bolts for shell-type anchors or internally threaded wedge or chemical anchors. Torque as recommended by the anchor manufacturer.



**BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT OR ISOLATOR.**

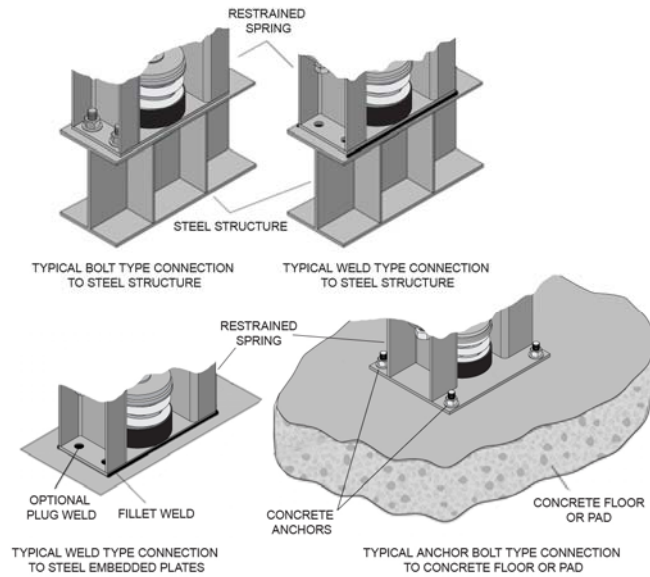


Figure 118: Attachment of restrained springs to building structure.

#### Step 4: Move the equipment into place over the isolators

Use leveling nuts to level the equipment. Use attachment nuts to attach the base of the equipment to the isolator. Figure 119 (page 81) shows typical ways to connect the equipment to the restraints.

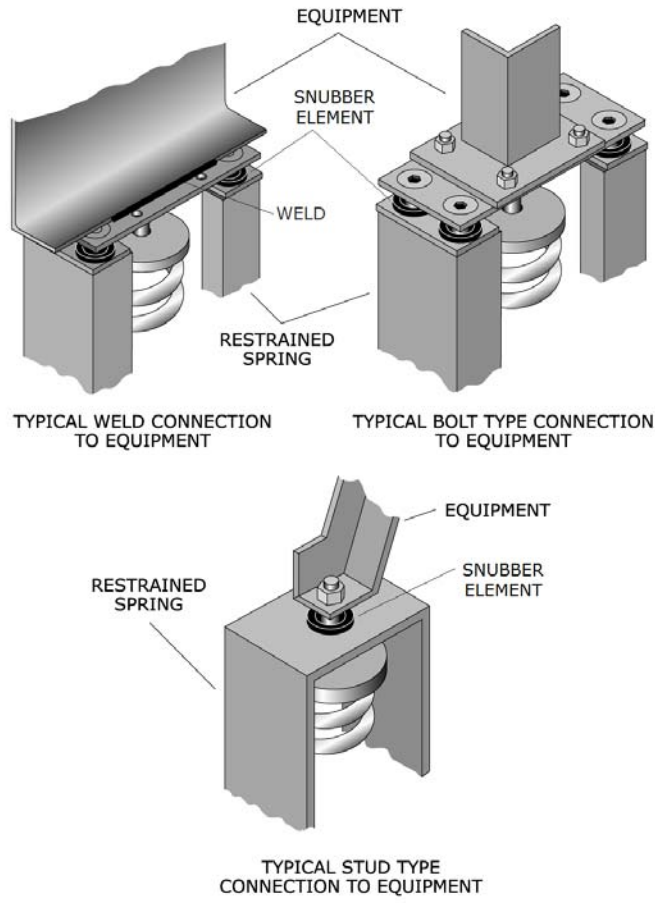


Figure 119: Attachment of equipment to restrained springs.

**END OF ATTACHMENT.**

## Open springs combined with snubbers

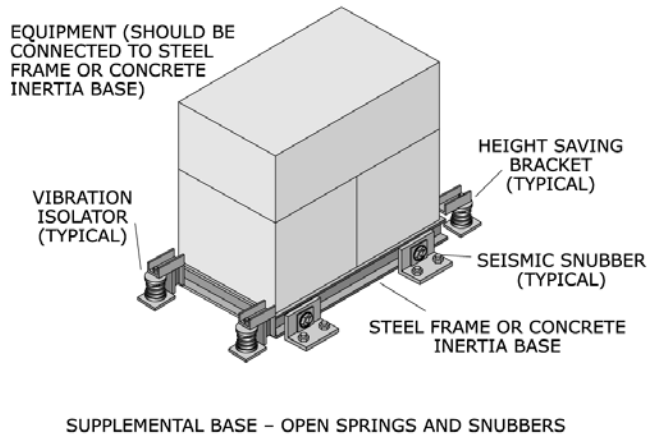



Figure 120: Typical installation of open springs and snubbers.

 **Additional snubbers may be required. See the manufacturer's instructions.**

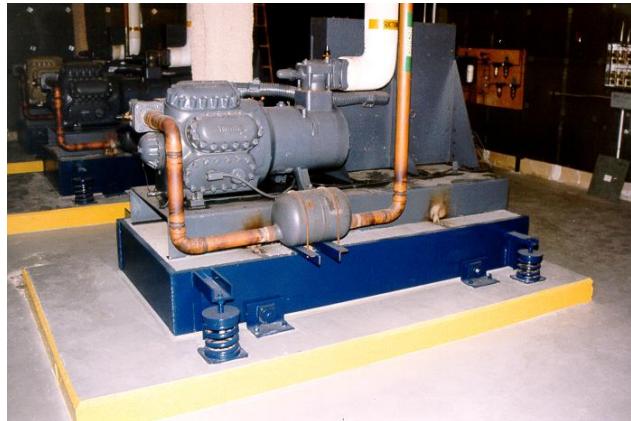


Figure 121: Typical installation of an open spring arrangement with snubbers.

## Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern for the open spring mounting plate on the floor or pad using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and shop drawings to lay out the bolt hole pattern.

## Step 2: Install post-installed anchors for open springs only (snubbers are covered in later steps)

Drill and install post-installed anchors for spring isolators (see Anchors, page 94).

## Step 3: Attach open spring isolators to concrete floor or pad with anchors installed in step 2



Set isolator, apply nuts and torque. Use bolts for shell-type anchors or internally threaded wedge or chemical anchors. Install according to the anchor manufacturer's instructions.



**BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE ISOLATOR.**

## Step 4: Set equipment on open springs

Set equipment on isolators but do not level or torque attachment nuts.



**Equipment must have a structural frame capable for point load at the open spring isolators.**

Some installations require the base to be concrete-filled. See Figure 122 (page 84) for a typical concrete-filled installation.



**Coordinate the location of equipment attachment points and snubber attachment points before filling with concrete.**

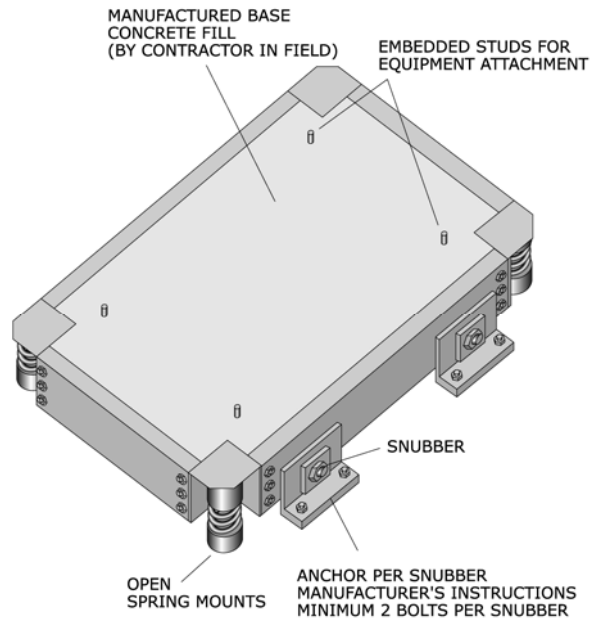


Figure 122: Concrete-filled inertia base.

### Step 5: Determine where to attach snubber

A snubber has two assemblies: the snubber equipment assembly and the snubber base assembly.

Level the equipment. Final leveling will be required in later steps. Accurately draw the bolt pattern for the snubber mounting plate on the floor or pad and on the equipment.



**All snubber clearance requirements for aligning the snubber must be met. Shims may be provided.**

## Step 6: Attach snubber equipment assembly to equipment

Attach the snubber equipment assembly to the equipment by bolting it to embedded bolts in a concrete-filled base (see Figure 122, page 84), or by bolting or welding to a steel base.

## Step 7: Determine where to bolt snubber base

Accurately draw the bolt pattern for the snubber mounting plate on the floor or pad.

## Step 8: Drill and install post-installed anchors

See Anchors (page 94).

## Step 9: Raise the equipment

Raising the equipment allows the snubber base assembly to be placed over the anchors installed in Step 6.

## Step 10: Lower the equipment



**Level equipment and connect the two snubber assemblies as specified in the manufacturer's instructions. Verify that spacing requirements are met. Complete final attachment to open springs.**



**DO NOT INSTALL THE ISOLATOR OR SNUBBERS IN ANY CONFIGURATION OTHER THAN THAT SHOWN IN THE MANUFACTURER'S INSTRUCTIONS.**

The equipment is now installed to resist earthquakes. Flexible piping connections, flexible ductwork connections, and flexible conduit connections must be used when connecting systems to isolated equipment.

Figure 123 (page 86) is an example of the requirements for flexible system connections.



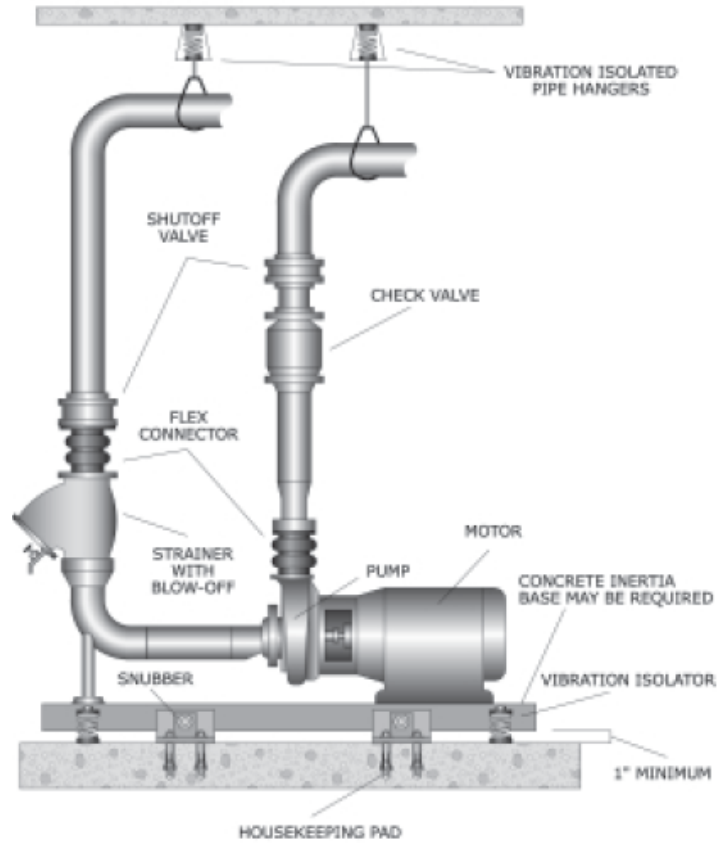


Figure 123: Typical pump installation.

**END OF ATTACHMENT.**

## Wall-mounted Attachment

The four types of wall mounting are:

- Directly to the wall (this page).
- To additional structural steel shapes attached to the wall (page 89).
- Vibration-isolated off the wall (page 92).

### Directly to the wall

Equipment should have pre-installed brackets that can support attachment to the building as shown in Figure 124 (below).

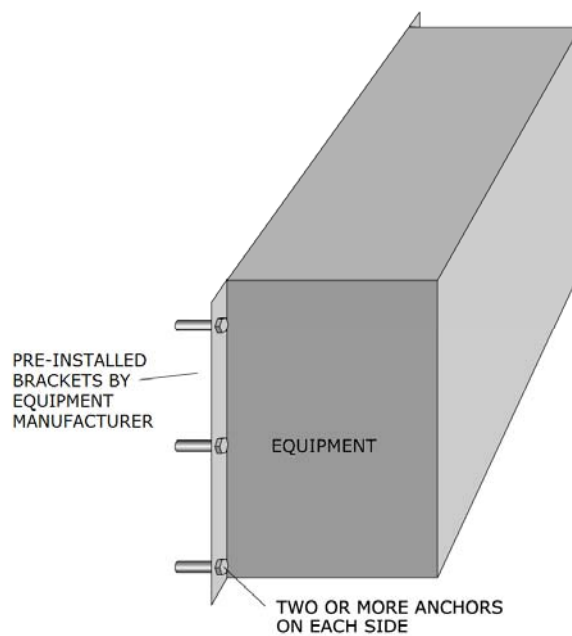


Figure 124: Direct attachment to a wall.

## Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the wall using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and construction drawings to lay out the bolt hole pattern.

Masonry walls may require additional holes in equipment attachment brackets as shown on construction drawings or in the equipment manufacturer's instructions.



**ONLY USE MOUNTING BRACKETS PROVIDED. DO NOT DRILL INTO THE EQUIPMENT HOUSING.**



**New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 70 (page 34).**

## Step 2: Install post-installed anchors

If anchoring to concrete, install post-installed anchors (see Anchors, page 94, or Masonry Anchors, page 104).

## Step 3: Move the equipment into place



**BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT.**

## Step 4: Attach nuts



**Attach nuts to the anchor or bolt and torque according to the manufacturer's instructions.**

Piping, ductwork, and raceways may be connected.

**END OF ATTACHMENT.**

## To additional structural steel shapes attached to the wall

Equipment attaches to the wall with additional structural steel shapes and bolts. Shapes may be welded. These steel shapes are attached to the building using concrete anchors, or masonry anchors.

Figures 125 to 127 (pages 89-91) show how straps, angles and struts can be used for attachment to a wall. Angles and strut must accommodate wall construction attachment points and obstructions. Figure 158 (page 127) shows a strut attachment for equipment.

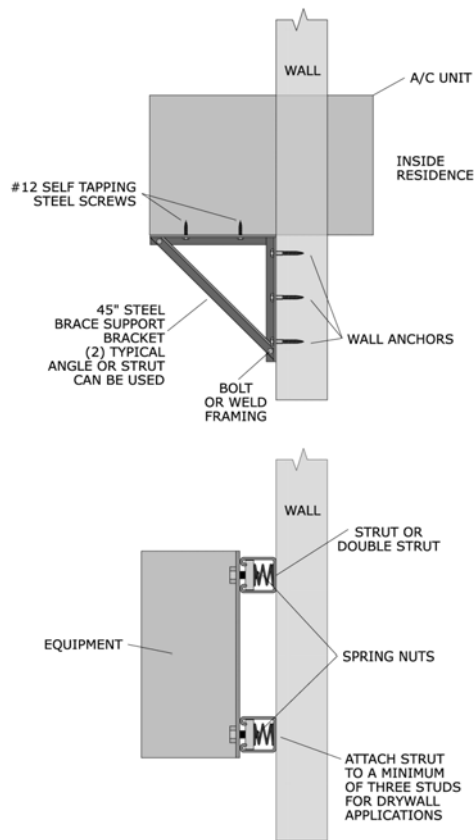


Figure 125: Angle or strut support.

A versatile attachment is an angle welded to a base plate, as shown in Figure 126 (below). This can be used for in-line piping specialties or for equipment. Two supports on each side of equipment may be required. Rigid connection with rods and cables supported from the building structure above is optional.

NOTE: MINIMUM ANCHOR SPACING WILL APPLY, CONTACT DESIGN PROFESSIONAL FOR MINIMUM DIMENSIONS.

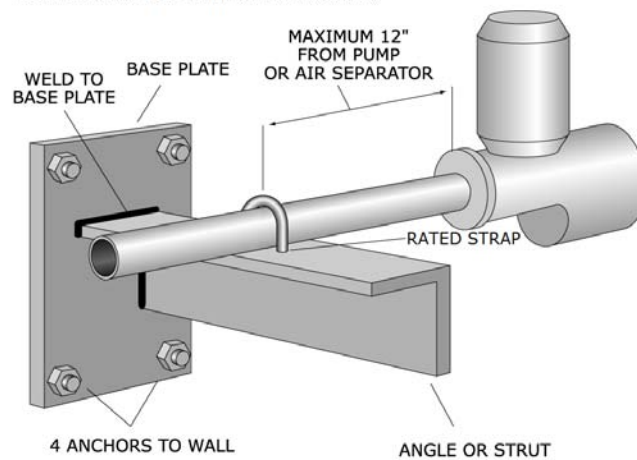


Figure 126: Angles welded to a base plate.

Water heaters or water tanks may be attached to the wall with a simple strap arrangement, as shown in Figure 127 (page 91).

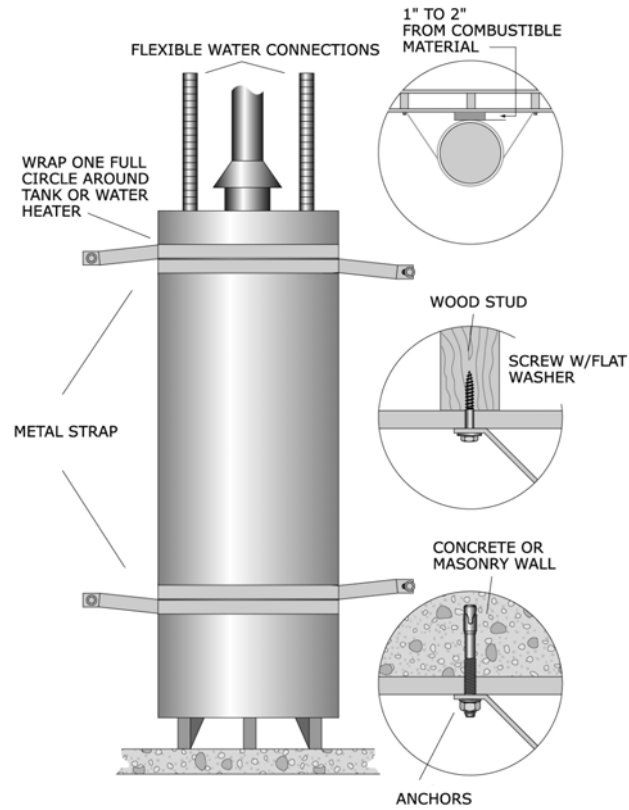


Figure 127: Water heater or water tank attachment.

### Step 1: Determine the anchor locations

Find studs in drywall. Use measurements and construction drawings to lay out the bolt hole pattern and mark the anchor locations.

## Step 2: Install anchors

If anchoring to concrete, install post-installed anchors (see Anchors, page 94, or Masonry Anchors, page 104).

## Step 3: Move equipment into place and bolt to frame



**You may drill additional holes into the equipment assembly or building steel beams as shown on construction drawings or the manufacturer's instructions.**



**New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 70 (page 34).**

Piping, ductwork, and raceways may be connected.

## Vibration-isolated off the wall

Equipment attaches to the wall with additional structural steel shapes, threaded rods and vibration isolators. Shapes may be welded. These steel shapes are attached to the building using concrete anchors, or masonry anchors.

Figure 128 (page 93) shows how rods, angles and struts can be used to isolate equipment attached to a wall. Angles and strut accommodate wall construction attachment points.

Vibration-isolated equipment prevents the transmission of noise and vibration into the building structure. See Figure 109 (page 71) for isolator detail.

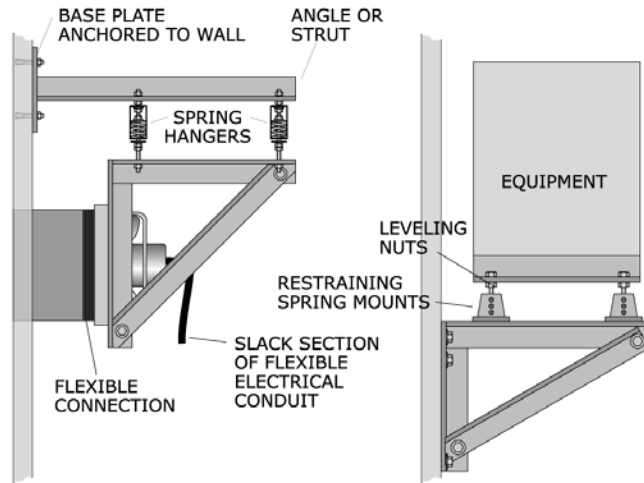


Figure 128: Wall-mounted, vibration-isolated equipment.

### Step 1: Assemble wall frame with isolators

Accurately draw the bolt pattern on the wall using one of the following methods:

- Set the frame in place and mark the holes.
- Make a template.
- Use measurements and construction drawings to lay out the bolt hole pattern.

### Step 2: Install anchors

If anchoring to concrete, install post-installed anchors (see Anchors, page 94, or Masonry Anchors, page 104).

### Step 3: Attach isolators, rod, and hang equipment

Attach the isolators to framing. Attach the equipment to the isolators using threaded rod.

Piping, ductwork, and raceways may be connected.

**END OF ATTACHMENT.**



## Anchors General Anchors



**IMPORTANT:** Installation methods depend on the type of anchor and the particular application. Always follow the anchor manufacturer's installation instructions.

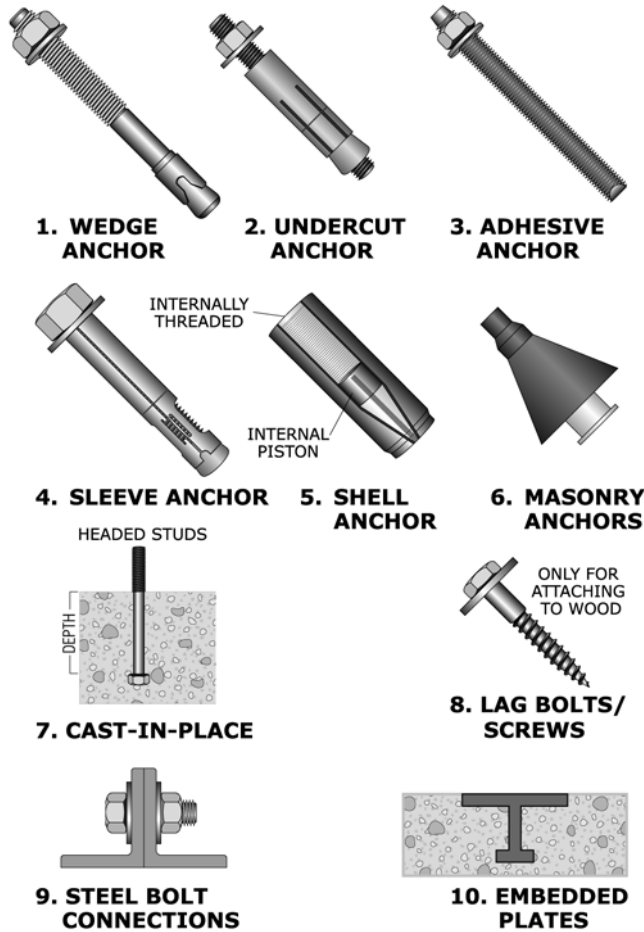


Figure 130: Types of anchors.

## Step 1: Determine the type of anchor

Using Figure 130 (page 95), identify the anchor recommended for your installation. Anchors 1-5 are post-installed anchors and instructions for installing them begin on this page. Anchors 6-10 are specialty anchors and instructions are shown on pages 101-117.

The various methods for installing anchors into concrete, brick, and concrete block anchors are shown below.

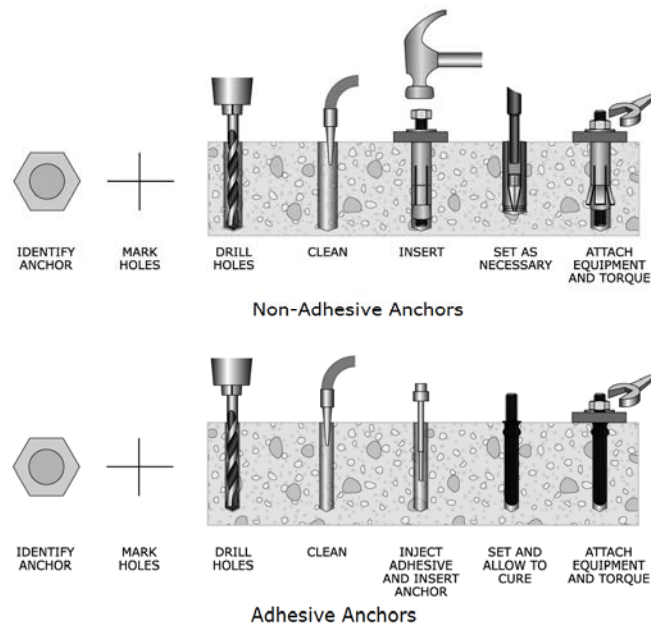



Figure 131: Summary of installation steps.

 **Contract documents may require special inspection to torque anchors or for proof load using hydraulic rams.**

## Step 2: Determine where to drill the hole

To determine anchor locations for the equipment you are installing, follow the instructions for the Attachment Type you are using (pages 31-93). Coordinate the equipment connections and hole locations with the location of any steel reinforcement or tendons.

Determine the depth and location of any steel reinforcement or tendons *before* drilling. This may require relocating equipment slightly to avoid the reinforcement.



**FOR POST-TENSIONED BUILDINGS,  
LOCATE THE TENDONS BEFORE DRILLING.  
EXTREME DAMAGE MAY OCCUR IF A  
TENDON IS NICKED OR CUT.**

When using electronic locating devices to find reinforcement and tendons, make sure you know the limitations of the device. Calibrate and test with a known standard or location to confirm accuracy. Check the area of concern in two directions. Inform the contractor performing the work of the precision of the test unit and record results For example: *agreed upon mark +/- 1/4" location vertical, horizontal, and depth +/- 1/2"*.

Coordinate the location of anchors with the edge of the concrete, construction joints, and other anchors.



**Do not install the anchor too close to the edge of the concrete base. Typically the anchor's distance from the edge is 1½ times the embedment depth.**



**Do not install an anchor too close to another anchor. Typically the minimum spacing between anchors is two times the anchor's embedment depth.**

### Step 3: Drilling the hole



**Drill the right-sized hole for the anchors. Use the appropriate ANSI-rated drill bit for the application.**



**Do not drill holes into concrete at an angle.**

For wedge, undercut and sleeve anchors, drill the hole deeper than the required embedment depth.



**The required hole depth may be different from the embedment depth. See Figure 132 (page 97).**

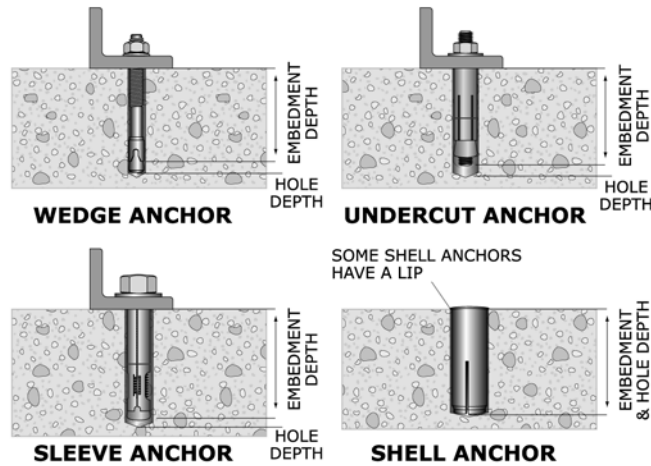




Figure 132: Embedment depth and hole depth of four anchor types.

The depth of the concrete base must be at least one inch greater than the hole you are drilling.

 **Some undercut anchors require an even deeper concrete base.**

 **If you strike steel reinforcement when drilling, you must have damage inspected. As directed, fill hole with approved grout and select a new location according to minimum spacing requirements. Drill a new hole (see below).**

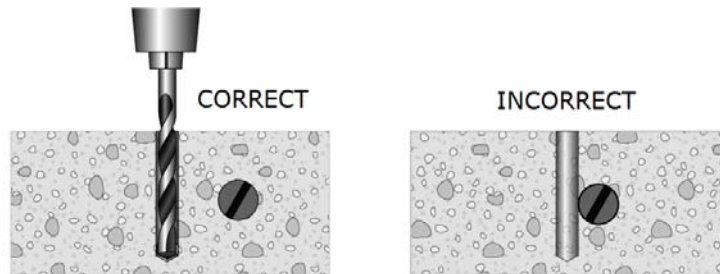


Figure 133: Drilling into concrete with rebar.

## Step 4: Clean out the hole

Drilled holes must be cleaned before you can insert the anchor. Use clean, dry compressed air to blow out dust and debris. The type of anchor or application also may require you to use water or a brush.



**See the anchor manufacturer's instructions for cleaning the hole.**



**Cleaning is important: a "dirty" hole can significantly reduce the anchor's performance.**

## Step 5: Insert the anchor

If you are installing any anchor *other than* an adhesive anchor, drive the anchor into the hole with a hammer.



**IMPORTANT: DO NOT DAMAGE THREADS DURING INSTALLATION. DO NOT FORCE THE ANCHOR. If you use a larger hammer than recommended by the manufacturer, you may damage the anchor.**

If you are installing an adhesive anchor, insert the capsule or inject non-capsule adhesive into the hole. Slowly rotate the anchor into place as shown below.

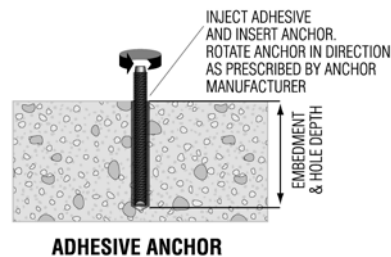



Figure 134: Adhesive anchor installation.

If you have installed a wedge or sleeve anchor, go to Step 7.

**Step 6: Setting shell, adhesive and undercut anchors ONLY**

 **Shell Anchor:** Drive the prescribed setting tool into the anchor until the setting tool shoulder meets the edge of the anchor, as shown below.

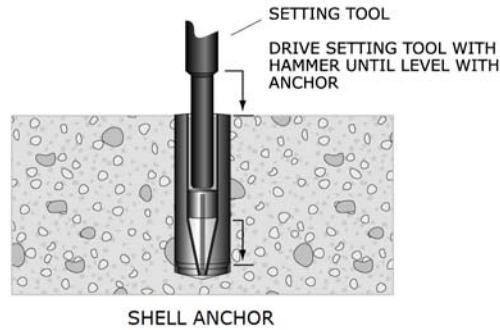




Figure 135: Set shell anchors.

 **Adhesive Anchor:** Allow enough time for the adhesive to fully cure. The curing process may take a long time. See the manufacturer's instructions.

 **Undercut Anchor:** Use special tools provided by the anchor manufacturer to set the anchor, as shown below.

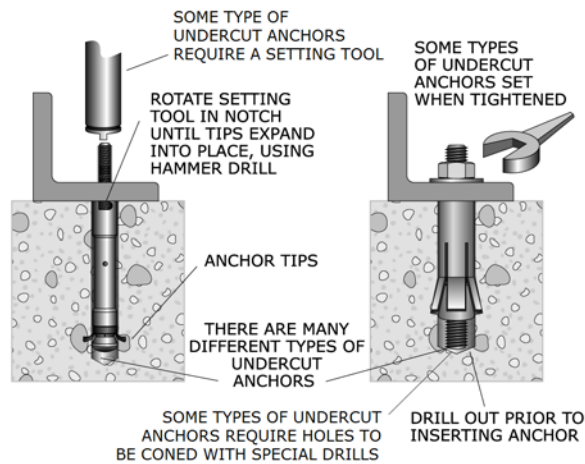


Figure 136: Set undercut anchors.

## Step 7: Set the equipment and tighten the anchors

Set the equipment in place. Check for gaps. Gaps under the equipment must not be greater than 1/8" as shown below. If the gap is greater than 1/8", dry pack the gap and repeat this step.

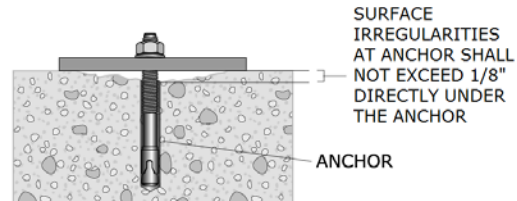


Figure 137: Acceptable gap for grouted plate.



**Do not bolt equipment directly to concrete anchors where equipment sheet metal is less than 16 gauge if the anchor is larger than 3/8" in diameter.**

For anchor bolts larger than 3/8", the equipment housing should be reinforced using a structural angle bracket as shown in Figure 138 (below).

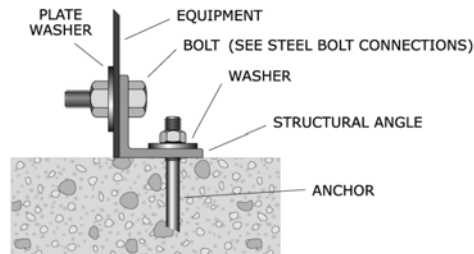


Figure 138: Installing a reinforcing angle bracket to equipment.



**Tighten the anchor bolt to the correct torque setting in the manufacturer's instructions or construction drawings. Use a calibrated torque wrench.**

## Cast-in-place Anchors

Cast-in-place anchors are embedded in the concrete when the floors or walls are poured. Bolts are firmly held in place while the concrete is poured to maintain proper alignment and position. The size and location of the anchors can be determined from construction drawings.

### Step 1: Move the equipment into place and attach the bolts

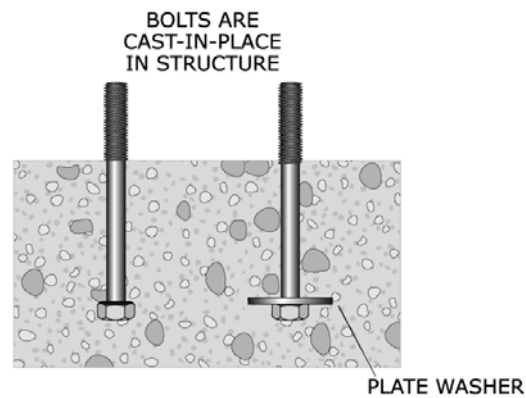


Figure 139: Bolting equipment to cast-in-place anchors.

### Step 2: Place and secure equipment

Once the equipment is in place, apply washers and nuts and then tighten.



**Tighten the anchor bolt to the correct torque setting in the manufacturer's instructions or on the construction drawings.**

Use a calibrated torque wrench or turn-of-nut method (see Table 15, page 112).



## Lags Bolts

Lag bolts are used to attach equipment or steel shapes to wood structures. The size and location of the anchors can be determined from construction drawings (see Figure 140, below).

- The edge distance is  $1\frac{1}{2}$  times the bolt diameter.
- The spacing between bolts is 4 times the bolt diameter.
- The end distance is 7 times the bolt diameter.

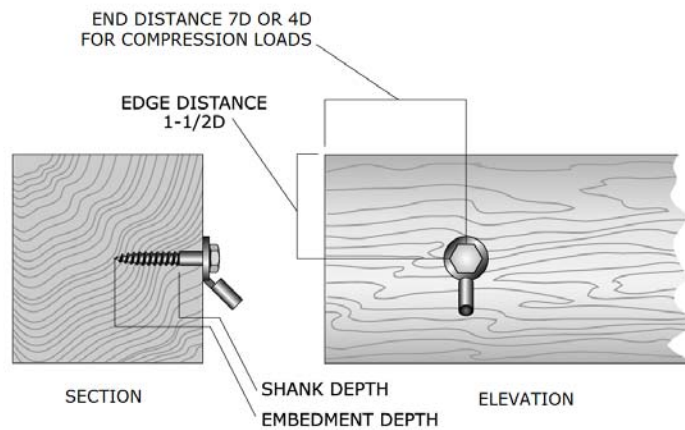


Figure 140: Spacing requirements for wood lag bolts.

### Step 1: Mark the location of the lag bolts

Lead holes and clearance holes are not required for lag bolts that are  $\frac{3}{8}$ " or smaller. If the lag bolt is smaller than  $\frac{3}{8}$ ", go to Step 4.

### Step 2: Drill a clearance hole

Drill a hole with a drill bit the same size as the shank of the bolt. The depth of the hole is the same as the length of the unthreaded shank that will extend into the wood (see Figure 140, above).

### Step 3: Drill a lead hole

Drill a hole with a drill bit that is 60 to 70% of the diameter of the shank of the bolt. The depth of the hole is the same as the embedment depth of the bolt (see Figure 140, page 102).

### Step 4: Move the equipment or steel shape into place

### Step 5: Drive the lag bolt in with a wrench

You may use soap or other lubricant on the lag bolt.



**DO NOT USE A HAMMER TO DRIVE IN LAG BOLTS.**

### Step 6: Tighten the bolt

Hand-adjust the lag bolt where there is firm contact between the lag bolt and connected metal components. Tools may be used to bring the lag bolt and metal components into contact until the components are snug tight.

## Masonry Anchors

### Step 1: Determine the type of anchor

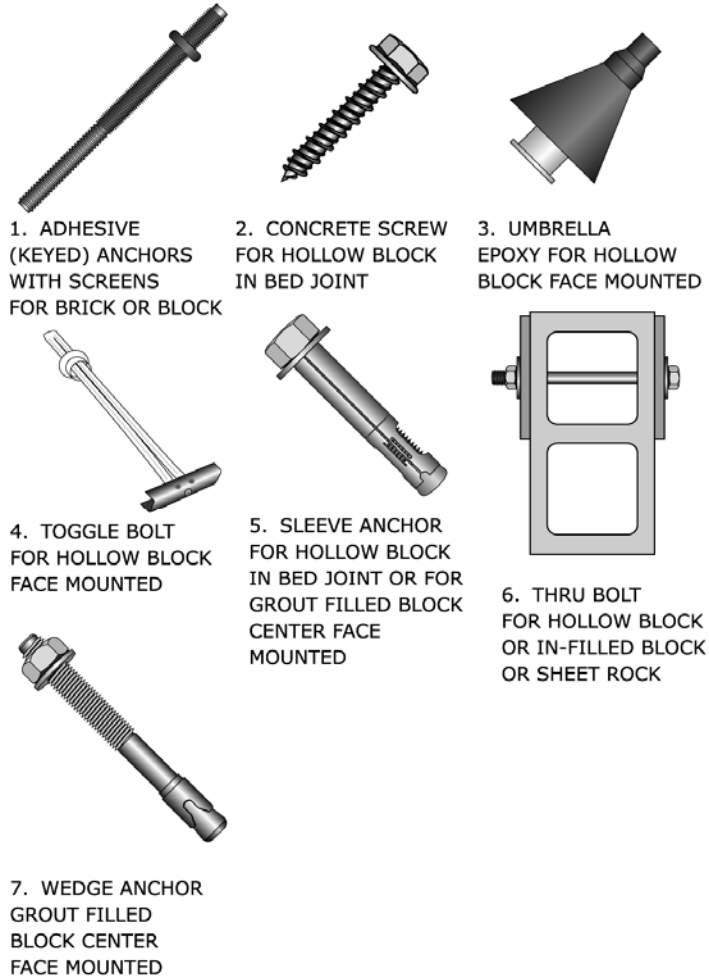


Figure 141: Types of masonry anchors.

## Step 2: Determine where to drill the hole

Anchors shown in Figure 141 (page 104) must be installed in specific areas of hollow block and in-filled block. See Figure 142 (below) for approved anchor hole locations when using any of the concrete block anchors shown in Figure 141.

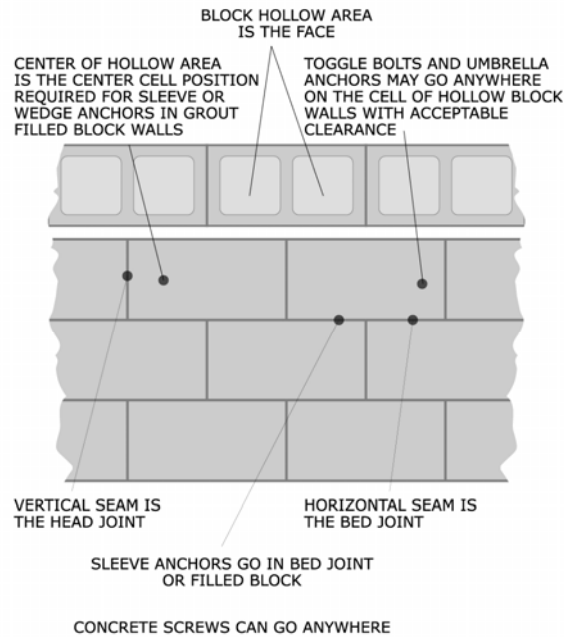


Figure 142: Block wall locations.

The location of the anchors should be coordinated with the block webs, or centered in the cell face, *and properly spaced from other anchors.*



**DO NOT POSITION THE HOLES IN THE HEAD JOINT.** Carefully note the location of anchors in the face location, centered face location, and bed joint as they apply to different anchors.



Find webs in block walls, reinforcement in grout-filled walls, or studs in drywall. Location of through-bolts: Avoid webs in concrete block and studs in drywall walls.



Determine the depth and location of any steel reinforcement in grout-filled block walls or brick before drilling. This may require relocating equipment slightly to miss reinforcement.

When using electronic locating devices to find reinforcements and tendons, make sure you know the limitations of the device. Calibrate and test with a known standard or location to confirm accuracy. Check the area of concern in two directions. Inform the contractor performing the work of the precession of the test unit and record the results. For example: *agreed upon mark +/- 1/4" location vertical, horizontal, and depth +/- 1/2"*.

### Step 3: Drill the hole



Drill the right-sized hole for the anchors. Use the appropriate ANSI-rated drill bit for the application.

Use masonry drill bits for brick and block.



**DO NOT CUT STEEL REINFORCING WHEN DRILLING HOLES.**



If you strike steel reinforcement when drilling, you must have damage inspected. As directed, fill the hole with approved grout and select a new location according to minimum spacing requirements. Drill a new hole (see Figure 133, page 95).



Holes for concrete screws are smaller than screw size. See the manufacturer's instructions for specific requirements.

## Step 4: Clean out the hole

Drilled holes must be cleaned before you can insert the anchor. Use clean, dry compressed air to blow out dust and debris. The type of anchor or application also may require you to use water or a brush.



**See the anchor manufacturer's instructions for cleaning the hole.**



**Cleaning is important: a "dirty" hole can significantly reduce an anchor's performance.**

## Step 5: Insert the anchor

The following anchors use different insertion methods.

- Adhesive screen anchor in a brick wall or hollow block wall (this page).
- Adhesive anchor in a hollow block wall (page 108).
- Concrete screw (page 109).
- Toggle bolt (page 109).

### Adhesive screen anchor in a brick wall or hollow block wall



**See the anchor manufacturer's instructions before connecting the anchor to a brick or hollow block wall.**

A screen insert is shown in Figure 143 (page 108). Insert the screen in the wall. Inject the adhesive. Slowly insert the anchor with a twisting motion.



**Screens may be filled with adhesive before inserting the screen into the hole.**

For details on installing adhesive anchors in a brick wall, see Figure 144 (page 108). Similar installation applies to hollow block walls. Adjust the anchor by hand while the adhesive sets.



**DO NOT TOUCH THE ANCHOR WHILE THE ADHESIVE IS CURING.**



METAL SCREEN TUBES

Figure 143: Brick/block wall insert.

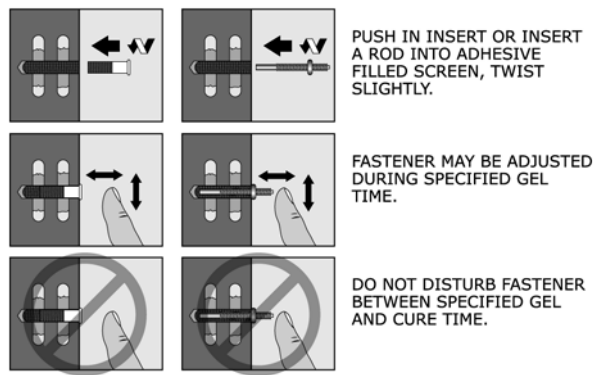


Figure 144: Brick wall adhesive anchor.

### Adhesive anchor in a hollow block wall



**See the anchor manufacturer's instructions before connecting the anchor to a hollow block wall.**

Push an umbrella anchor into the hole until the umbrella unfolds in the block cavity. Inject adhesive into the umbrella. Slowly insert stud or fastener with a twisting motion.



**DO NOT LEAK ADHESIVE ON THE THREADED PORTION OR CLEAN WITH SOLVENT. The threaded area must be free of debris to attach to a threaded rod or steel bolt.**

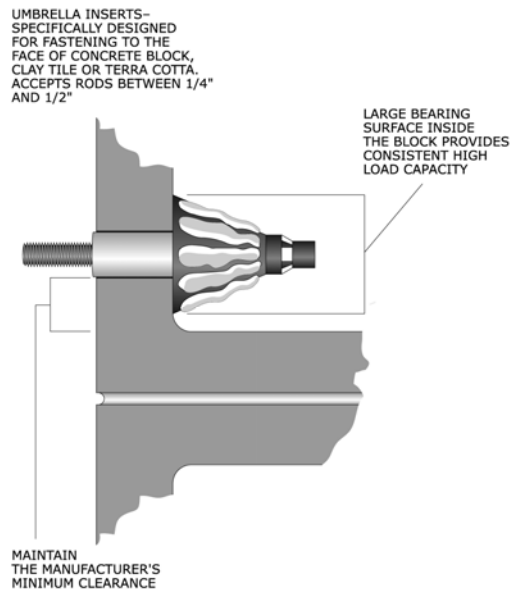


Figure 145: Umbrella anchor in a hollow block wall.

## Concrete screw

Drill bits may be specifically sized for each manufacturer, and typically are smaller diameter than nominal or fractional diameter of a screw. Install a concrete screw with a rotary drill and bolt the head attachment.

## Toggle bolt

Hold the toggle flat alongside the plastic straps and slide the channel through the hole. Slide the holding ring toward the wall until the channel is flush with the wall. Cut off the straps at the holding ring. Insert the bolt with a rotary drill over the bracket or equipment mounting.



## Step 6: Set the anchor (adhesive only)

Allow enough time for the adhesive to harden and adhere to the concrete. *This may take several hours.*

## Step 7: Set the equipment and tighten the anchors



**Tighten the anchor bolt to the proper torque setting shown in the anchor manufacturer's instructions or construction drawings.**

In-filled block walls will have gaps in the grout fill or the grout will slightly crack, requiring anchors to be installed in the center of the cell.



**If the grout cracks severely, or if you miss a grouted block, the anchor will not tighten and will pull out. If it pulls out, move the anchor to a new centered cell location.**

## Steel Bolt Connections

The three ways to attach bolted connections are:

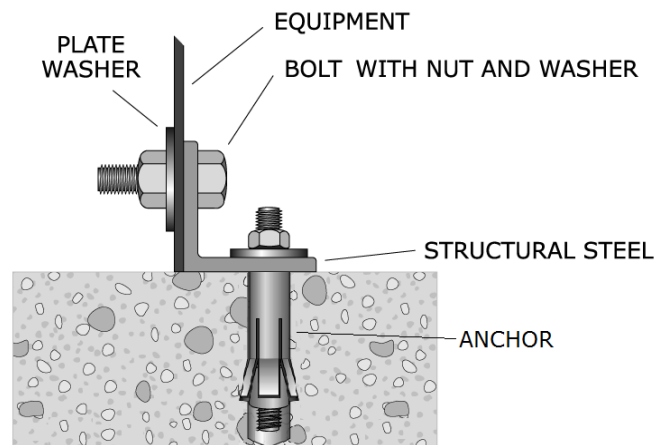
- Connecting the base of the equipment to an angle bolted to a concrete floor (this page).
- Bolting two structural steel shapes together (page 113).
- Bolting a threaded rod to steel shapes or strut (page 113).

### Connecting the base of the equipment to an angle bolted to a concrete floor

#### Step 1: Preparation



Determine the bolt size or sheet metal screw and material requirements from construction drawings or printed instructions supplied by the manufacturer.



USE PLATE WASHER TO REINFORCE  
LIGHT SHEET METAL HOUSINGS

Figure 146: Bolting equipment to an angle.

## Step 2: Locate holes

Use pre-drilled holes wherever possible. Holes may not have been pre-drilled at the attachment locations shown in the instructions. In these cases, carefully drill new holes in the correct locations.



**Use caution when drilling into equipment. Internal components can be damaged. DO NOT DRILL OVERSIZED HOLES. See Figure 70 (page 34) for repair of oversized holes.**

## Step 3: Install bolts, washers, and nuts

Once the equipment is in place, apply washers and nuts and then tighten.



**Tighten the anchor bolt to the correct torque setting in the manufacturer's instructions or on the construction drawings.**

For turn-of-nut tightening, hand-adjust the bolt snug tight where there is firm contact between the bolt and connected metal components. Tools may be used to bring the bolt and metal components into contact. Following contact, tighten the nut as shown below.

<i>Length of bolt</i>	<i>Additional tightening</i>
Up to and including 4 diameters	1/3 turn
Over 4 diameters and not more than 8 diameters	1/2 turn
Over 8 diameters and not more than 12 diameters	5/6 turn

Table 15: Hand-adjusted tightening.

## Bolting two structural steel shapes together

### Step 1: Preparation



Determine the bolt size and material requirements from construction drawings or the manufacturer's instructions.

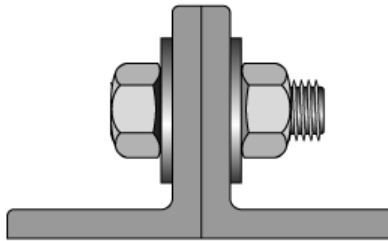


Figure 147: Bolting structural shapes.

### Step 2: Locate holes

Carefully drill new holes in the structural steel shapes.

### Step 3: Install bolts, washers, and nuts

Apply washers and nuts, then tighten.



Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or the construction drawings. Use a calibrated torque wrench or turn-of-nut method (see Table 15, page 112).

## Bolting a threaded rod to steel shapes or strut

A threaded rod is used with suspended equipment. This section includes attachment to the equipment and attachment at the top (see Suspended Attachment, page 61).

## Step 1: Preparation



**Determine the threaded rod size from construction drawings or printed instructions supplied by the manufacturer.**

The three different ways to attach the threaded rod are shown in Figure 148 (below).

## Step 2: Attach the top connection of the threaded rod

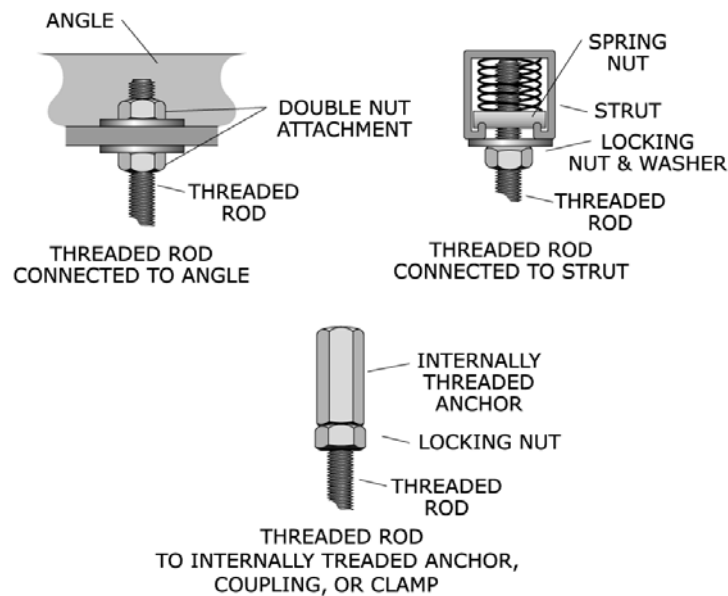


Figure 148: Attaching the top of threaded rod.

Apply washers and nuts, then tighten.



**Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or the construction drawings. Use a calibrated torque wrench or turn-of-nut method (see Table 15, page 112).**

### Step 3: Attach threaded rods to equipment brackets

Equipment without attachment brackets requires additional steel shapes for connections to the building structure and/or roof.

Once the equipment is in place, apply washers and nuts, then tighten.



**Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or the construction drawings. Use a calibrated torque wrench or turn-of-nut method (see Table 15, page 112).**

## Welding



Before welding, refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

**Attaching equipment to embedded plates:** Plates are embedded in the concrete during the floor or wall pour. Plates are firmly held in place while the concrete is poured to maintain proper alignment and position. The size and location of the plate can be determined from construction drawings. See Figure 149 (below) for weld locations.

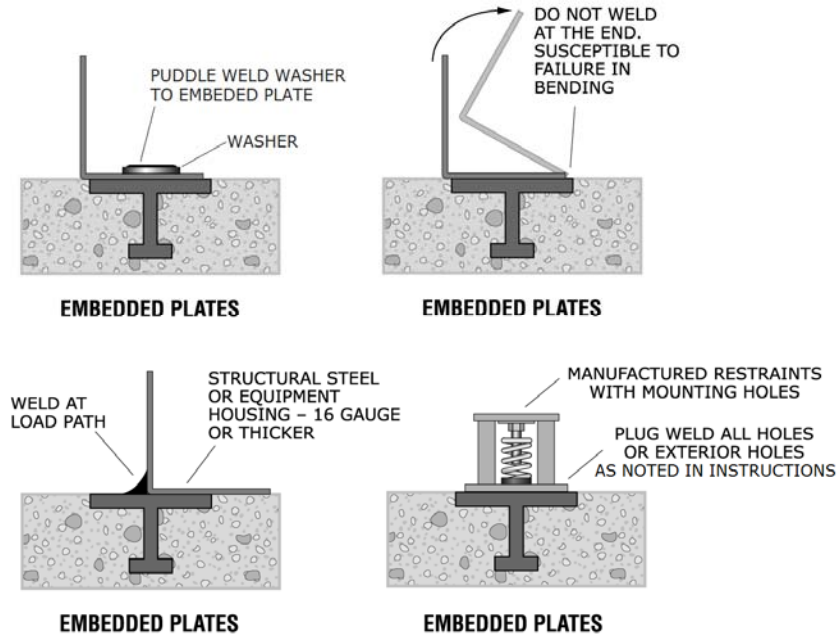


Figure 149: Welding to embedded plates.

**Attaching structural shapes and plates:** Shapes and plates are welded to provide equipment attachment. All weld base material must be thick enough for the weld size specified.

**Step 1: Determine the weld material, shape, and dimensions for each piece**

## Step 2: Fit the material to ensure proper weld joint preparation

## Step 3: Clean the surfaces

Surfaces must be dry and free of galvanized coating, hot-dipped or rust inhibitor, paint, scale, rust, oil, grease, water, and other foreign material for a minimum of one inch from the estimated toe of the weld.

## Step 4: Weld the materials

The weld must be as prescribed in the welding procedure specifications (WPS).

WPS for shop and field pre-qualified weld joints and weld joints qualified by test must be prepared for review and approval before fabrication. All welding procedure items such as base metals, welding processes, filler metals and joint details that meet the requirements of AWS D1.1 Section 5.1 will be considered as prequalified. Any change or substitution that is beyond the range or tolerance or requirements for pre-qualification will be qualified by test pre-AWS D1.1 Section 5 part B.



**DO NOT WELD OVER PAINT. You may paint after welding has cooled to room temperature.**

## Step 5: Inspect the weld

Make sure the surface is free of slag, dirt, grease, oil, scale, or other contaminants.

Welds cannot have cracks. Adjacent layers of weld metal and base metal must be thoroughly fused together.

All craters must be filled to the full cross-section except outside the effective weld length.

Underrun must not exceed 1/16". Undercut must not exceed 1/16" for any 2" per 12" weld or 1/32" for the entire weld.

Surfaces must be free of coarse ripples, grooves, abrupt ridges and valleys. The faces of fillet welds must be flat or slightly convex.



## Special Cases:

### Cables

The three ways to assemble a cable connection are by using:

- Bolts with center holes (page 119).
- Ferrule clamps (page 120).
- Wire rope grips (page 122).

Other end fittings may be acceptable.

Cables should be installed at a 45-degree slope. Where interferences are present, the slope may be a minimum of 30 degrees or a maximum of 60 degrees.

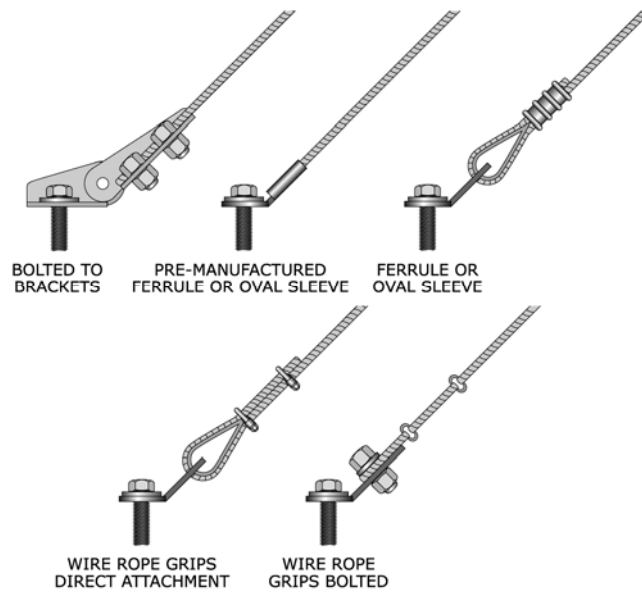


Figure 150: Cable attachments.

## Bolts with center holes

The manufacturer provides this type of cable assembly, along with the cables, mounting bolts with holes, and brackets that attach directly to the building structure or equipment frame. Assemble the cable as shown below. Torque bolts per manufacturer's recommendations.

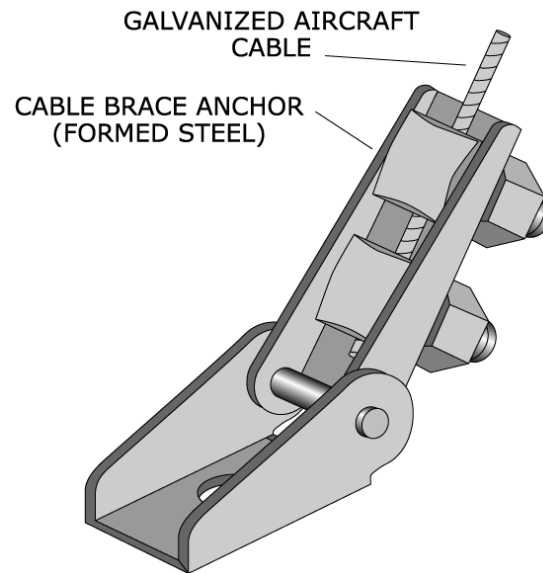


Figure 151: Cable attached with bolts to bracket.

**Step 1: Drill anchor holes in the building structure as required**

**Step 2: Attach brackets to both the building and the equipment frame**

**Step 3: Cut the cable to desired length and slide it through the holes in the bolts**

**Step 4: Tighten the cable**

For rigid connections, pull the cable hand tight. Pull the cable hand-tight and let out 1/8" for vibration-isolated components. Avoid using too much tension or too much slack.

## Step 5: Torque bolts



Refer to the manufacturer's instructions.

## Ferrule clamps

Ferrule clamps may be connected to various types of attachments. Figures 152 (below) and Figure 153 (page 121) show attachments and identify the parts ferrules or sleeve and thimbles used in the assembly.



**Ferrules must be qualified by testing for use in seismic applications.**

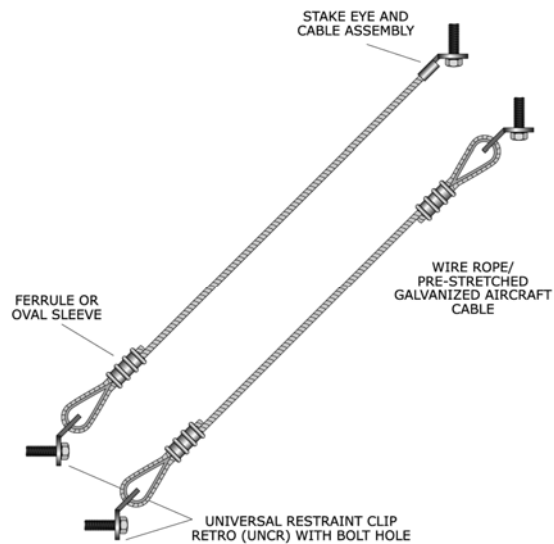


Figure 152: Ferrule assemblies.

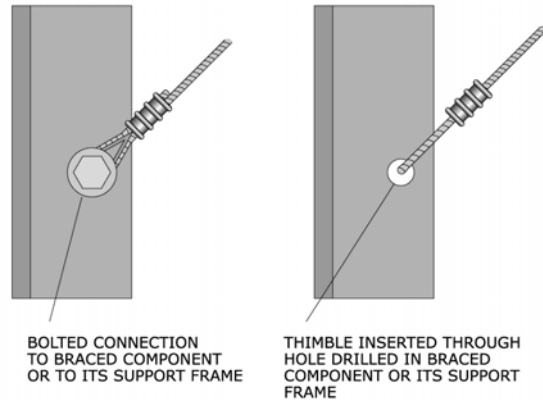


Figure 153: Ferrule attachments.

**Step 1: Install brackets with mounting holes, eye-bolts, or drill mounting holes**

Install brackets with mounting holes to the structure. Attach cables to the top of cord angles. See Suspended Attachment (page 61).

**Step 2: Cut the cable to the desired length and slide the oval ferrule (sleeve) onto the cable**

**Step 3: Wrap the cable around the thimble and pass it through the mounting bolt or holes and back through the ferrule**

**Step 4: Tighten the cable**

For rigid connections, pull the cable tight. For isolated components, leave a small amount of slack. Avoid using too much tension or too much slack.

**Step 5: Crimp the ferrule or oval sleeve two or three times as specified in the cable or ferrule manufacturer's instructions**

Use crimp tools and gauges specified by the manufacturer. Crimp and verify the depth of the crimp using a gauge.

## Wire rope grips

Installing cables attached with wire rope grips is similar to attaching ferrule clamps, as shown below.

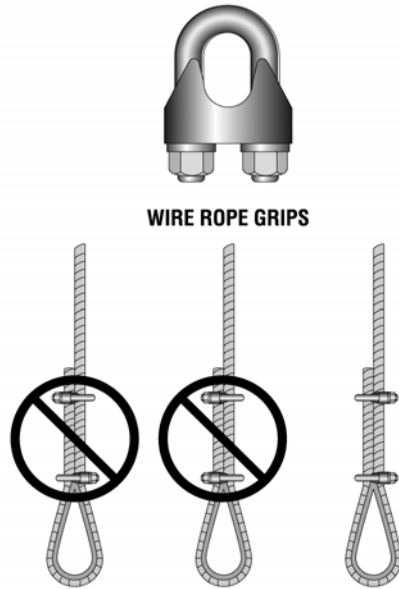


Figure 154: Wire rope grip assemblies.

**Step 1: Install brackets with mounting holes, eye-bolts, or drill mounting holes**

**Step 2: Cut cable to the desired length and slide three wire rope grips and thimbles onto the cable**

**Step 3: Pass the cable through the mounting bolt or holes provided and then back through each of the wire rope grips**



**Use thimbles for all cable installations with wire rope grips.**

## Step 4: Tighten the cable

For rigid connections, pull the cable tight. For isolated components, leave a small amount of slack. Avoid using too much tension or too much slack.

## Step 5: Torque all bolts evenly

Use the turn-of-nut tightening method described in Steel Bolt Connections (page 111).



**DO NOT OVER-TIGHTEN.**

## Control Panels

Control panels may be built into units, mounted in a separate electrical panel attached to equipment assemblies, or mounted as a separate electrical panel attached to the building structure.



**Be sure to refer to construction drawings and specifications, seismic restraint submittals, and the manufacturer's instructions.**



**If an electrical panel is mounted separately from the unit and the unit is vibration-isolated, use flexible electrical connections to allow for differential movement.**

### Step 1: Select control panel support configuration

If the control panel is:

- Built into the equipment, no other action is needed.
- An electrical panel attached to the assembly, check that the attachment is rigid and tight. No other action is needed.
- A remote panel attached directly to the building structure or attached using support angles or strut, continue with the following instructions.

The four ways of supporting control panels are by attaching them to:

- Walls with wall anchors as shown in Figure 158 (page 127).
- Vertical angles or strut extending down to the floor with angles slanted back to the floor as shown in Figure 155 (page 125). This is the typical method. Details are shown in Figure 157 (page 126).
- A double-strut support spanning the floor and ceiling as shown on the right in Figure 156 (page 125). Struts are attached to the building structure with small angle clips.
- An aluminum plate extending from the floor to the ceiling. The aluminum plate is attached to the floor and ceiling with angles, as shown on the left in Figure 156 (page 125).



Figure 155: Typical control panel support using angles. Additional angle supports may be required (see below).



Figure 156: Two different ways to support control panels: using a metal plate attached to floor and ceiling with steel angles (left); using struts extending to floor and ceiling (right).



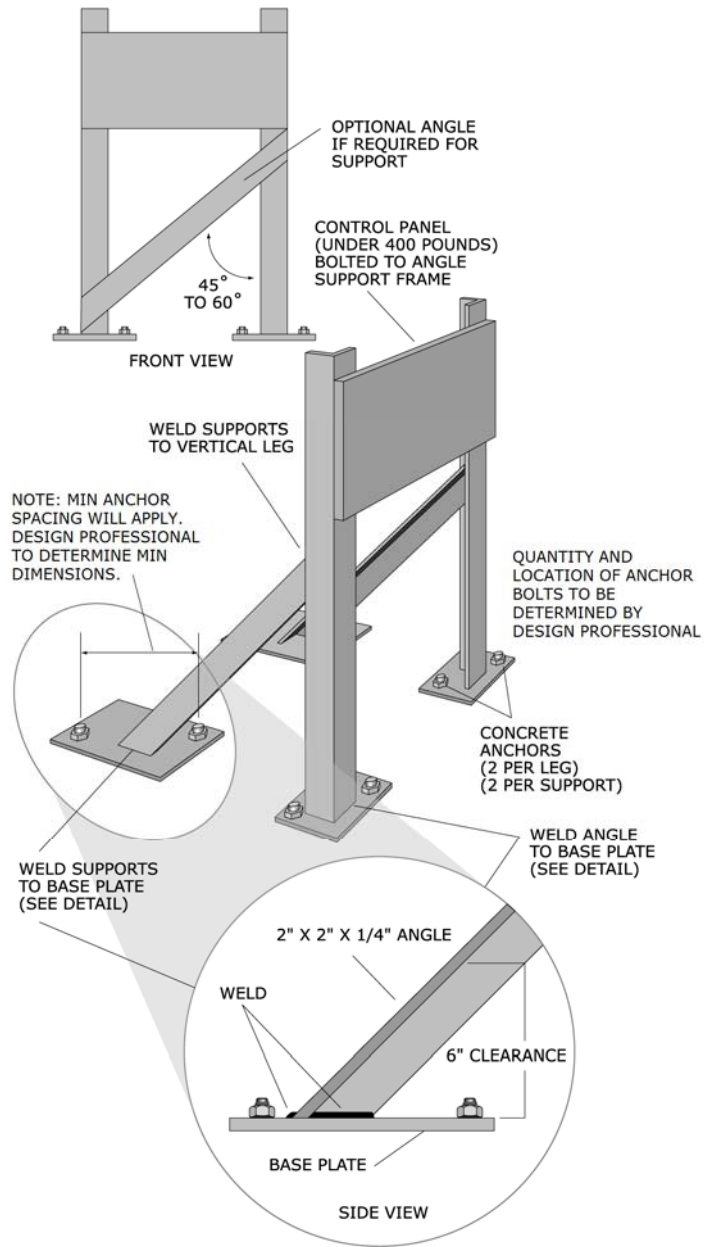


Figure 157: Angle assembly support from floor.

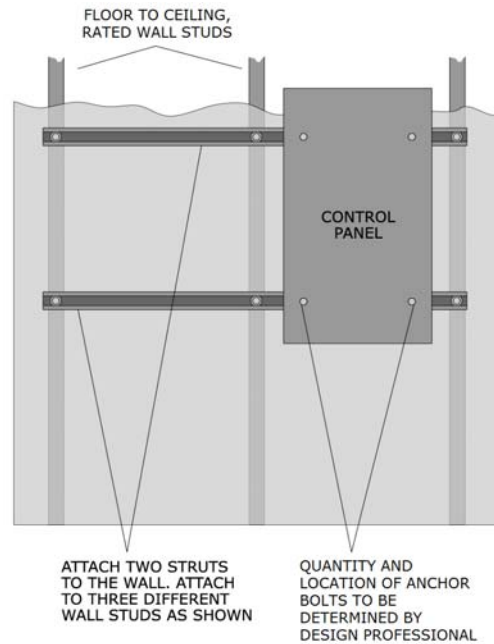


Figure 158: Direct attachment of a strut assembly support to fire rated wall.

### Step 2: Assemble the mounting frame

Use bolts or weld support framing together as shown in Figures 155 to Figure 158 (pages 125-127). See Steel Bolt and Sheet Metal Screw Connections (page 111), or Welding (page 116) for more information.

### Step 3: Attach mounting frame to floor or wall with anchors

Locate and mark hole locations in the building structure. Install the anchors. See Anchors (page 94) for more information.

Attach the mounting frame to the building structure.

- To attach strut angles for strut floor mounted supports, see Figure 156 (page 125).
- To attach bases for angle floor-mounted supports, see Figure 157 (page 126)
- To attach strut to wall studs, see Figure 158 (above).

**Step 4: Attach control panel to frame with a minimum of 4 steel bolts**

See Steel Bolt Connections (page 111).

## Housekeeping Pads



**Be sure to refer to contract drawings, specifications and the manufacturer's instructions.**

The construction of housekeeping pads is shown below.

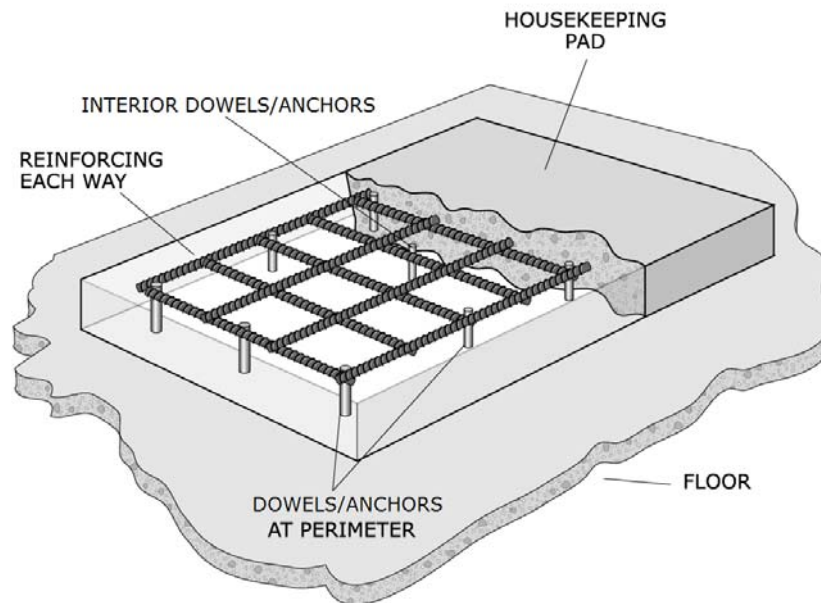


Figure 159: Housekeeping pad.

The housekeeping pad must be a minimum of one inch thicker than the anchor hole depth, or as required for the concrete anchors shown in Figure 160 (page 130).



**Housekeeping pads must be designed for the equipment weight and seismic load.**

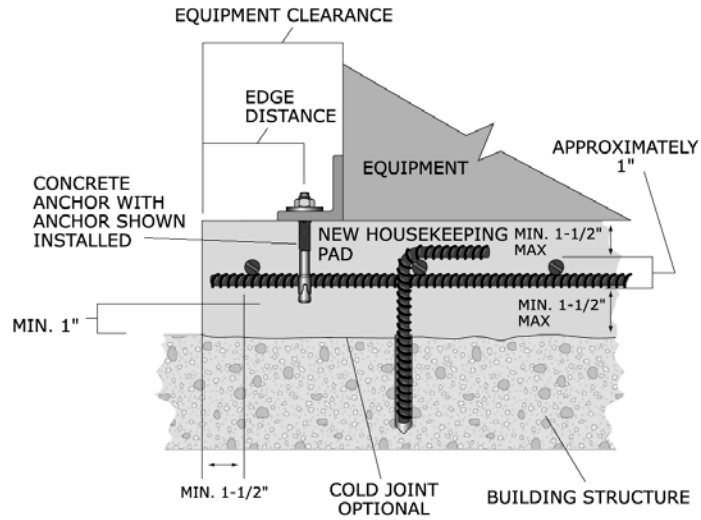


Figure 160: Housekeeping pad in section view.



**If edge distance is not met, get an evaluation.**

Dimensions for the pad footprint must be large enough for the equipment, attachment steel (as required), and the edge distance of concrete anchors (see Anchors, page 94), as shown in Figure 161 (below).

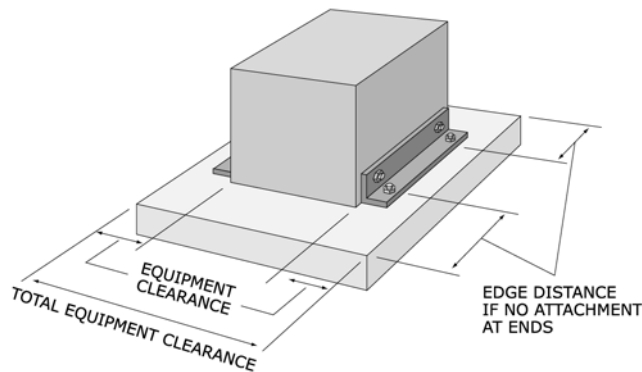


Figure 161: Housekeeping pad dimensions.

## Step 1: Install dowels into the floor

Attachment details for dowels are shown in Figure 162 (below).

- Use measurements and shop drawings to lay out the size of the dowels and the dowel pattern.
- Coordinate the location of embedded "Z" bar shown in Figure 162 with the concrete subcontractor.

Obtain the size of doweling and reinforcement from contract drawings, specifications or the manufacturer's printed instructions. Exterior dowels must be ½" to 1" in diameter. Interior dowels must be ½" to ¾" in diameter.

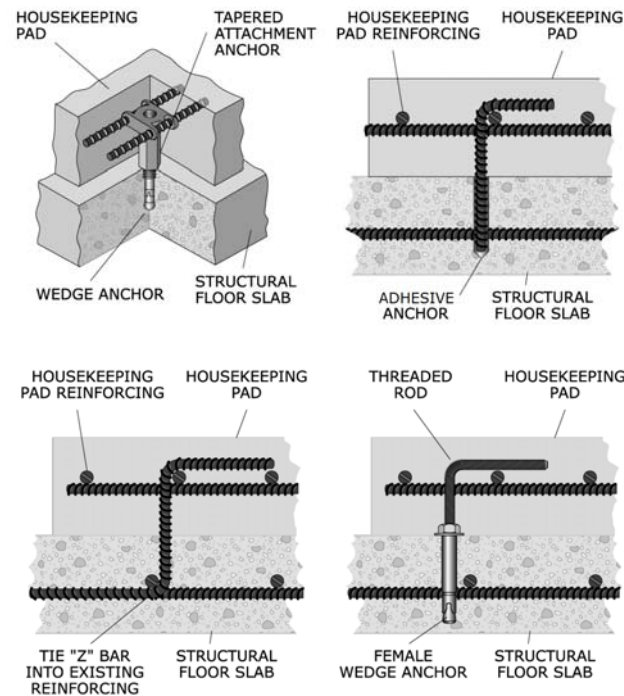


Figure 162: Doweling to the building floor.

## **Step 2: Assemble reinforcement**

Assemble the reinforcement as shown in Figure 159 (page 129). Connect the dowels using wire.

## **Step 3: Pour concrete and allow to cure**

## **Step 4: Drill holes and attach the equipment to concrete after the concrete has cured**

## Residential Equipment

Mechanical equipment in residential applications should be rigidly attached to the building structure or concrete pad. The types of equipment used for residential HVAC include:

- Water heater
- Furnace
- Condensing unit with an indoor A-coil attached to a furnace
- Through-the-wall air conditioner

### **Water Heater**

A water heater may be bolted to the residential structure with straps (see Figure 127, page 91). For gas water heaters below 100,000 BTUH, use flexible pipe to attach the water heater to the gas piping.

### **Furnace**

A furnace may be bolted to the residential structure with straps and/or restrained at the bottom with bumpers. Straps may be attached to the residential structure in a manner similar to that of water heaters.

To use bumpers, see Figure 77 (page 40). To use straps see Figure 127 (page 91). Bumpers may be constructed using wood studs for furnaces inside a raised closet.

For gas furnaces below 100,000 BTUH, use flexible pipe to attach the furnace to the gas piping.

### **Condensing unit**

A condensing unit may be bolted to a concrete pad outside and next to the residential structure or mounted on the roof of the structure.

- For a condensing unit mounted on the roof, use a sheet metal curb with a wood nailer to attach the unit on the roof. See Figure 86 (page 51) for instructions on installing the curb. The curb must be firmly attached to the roof structure with lag bolts. Attach the condensing unit to the curb with lag bolts.



- For a condensing unit bolted to a concrete pad outside, attach the equipment using angles. See Figure 71 (page 36), Figure 72 (page 37), or Figure 75 (page 38).

## **A-coil**

An A-coil may be attached on top of a furnace with sheet metal screws.

## **Through-the-wall air conditioner**

An air conditioner should be attached to the residential structure. Some air conditioners have brackets used to directly attach the unit to the structure using lag bolts. A bracket support may be provided as shown in Figure 125 (page 89).

## ANCHOR SELECTION GUIDE

Powder-Actuated	
Description	Warning
<p><b>Threaded Studs</b> Used in cases where the fastened equipment is to be removed later, or where shimming is required.</p> <p>Threaded studs for concrete have a 0.140" to 0.180" shank diameter, with typical penetration of 3/4" (minimum) to 1-1/2" into concrete.</p> <p>Threaded studs for steel plate applications have a 0.140" to 0.180" shank diameter when the steel plate thickness is 3/16" or greater.</p>	<p><b>Safety is the primary concern when using powder-actuated tools (PAT). PAT tools pose the greatest risk to the operator and others in the area of use. Observe the following safety precautions:</b></p> <p>Typically not used for equipment weighing more than 40 pounds. Never allow a tool to be used until the operator is properly trained for the specific tool and application.</p> <p>Never use a tool unless all safety features are functioning properly. Always have the operator and others around wear the proper safety devices.</p> <p>Never use more powerful loads than required for the particular application.</p> <p>Always be aware of the potential of the fastener passing through the substrate or being deflected from its intended target. Make sure that all areas are clear behind and around the target area.</p> <p>Have an action plan in place to properly handle and dispose of misfired loads. Always make sure the tools are low velocity and not standard velocity. (Standard velocity tools are not typically allowed on most jobsites because of the danger.)</p>
<p><b>Drive Pins</b> Used to directly fasten equipment for permanent installation.</p> <p>Drive pins used for concrete have a 0.140" to 0.180" shank diameter, with typical penetration of 3/4" minimum to 1-1/2" into concrete.</p> <p>Drive pins for Steel plate applications have a 0.140" to 0.180" shank diameter when the steel plate thickness is 3/16" or greater.</p>	

Adhesive	
Description	Warning
<p><b>Capsule Spin-In</b>                      Adhesive mixes in hole when anchor is drilled by a rotary hammer drill only. Various strengths and types of rods or fasteners can be used. Multiple types of coating on rods are available. Most commonly used in concrete; some might be suitable for use in other substrates. Most capsules cure quickly compared to epoxy.</p>	<p>Do not over-spin during installation. The rod must have a roof cut end with a single or double 45-degree angle/bevel for mixing. The hole must be clean and dry to achieve the maximum strength. Rod must be clean and must not be disturbed during curing. Many capsules produce strong odors during the curing process.</p>
<p><b>Capsule Hammer-in</b>                      Adhesive mixes in hole when a rod is driven by a hammer. Various strengths and types of rods or fasteners can be used. Multiple types of coatings on rods are available. Most commonly used in concrete; some might be suitable for use in other substrates. Most capsules cure quickly compared to epoxy.</p>	<p>The hole must be clean and dry to achieve the maximum strength. Rod must be clean and must not be disturbed during curing. Many capsules produce strong odors during the curing process.</p>

<b>Adhesive (cont.)</b>	
Description	Warning
<p><b>Epoxy</b> Used by mixing two or more components with a mixing nozzle at the point of application. Can be used with multiple forms of fasteners or as an adhesive. Many brands can be used in wet, damp, or dry conditions. Many formulas are allowed for use for USDA food processing areas. Some may be able to be used overhead. Permitted many times in freeze-thaw and severe weather conditions. Allows minimal edge distance and anchor spacing. Typical shelf life greater than that of other adhesives used for anchoring. Not as susceptible to damage from high storage temperatures.</p>	<p>Typically requires long curing times compared to that of other adhesives. Can be virtually odor free or can emit a strong odor, depending on the formula. Can be difficult to apply if the epoxy is thick. Generally not suggested for use at temperatures below 32 degrees F. Most epoxies require holes to be cleaned to obtain maximum values.</p>
<p><b>Acrylic Adhesive</b> Dispenses and cures quickly. Some adhesives can be used overhead. Some adhesives can be installed in damp or water-filled holes. Typically can be used with many fastening devices such as threaded rod, dowels, and anchors.</p>	<p>Many types of acrylics produce a strong odor during the curing process. Others have a minimal odor.</p>
<p><b>Adhesive Undercut Anchors</b> Used in heavy-duty applications where substrate is of poor quality.</p>	<p>Generally purchased from the manufacturer as a complete anchoring system. Any substitution of materials must be authorized before installation.</p>

Externally Threaded	
Description	Warning
<p><b>Heavy Duty Undercut</b> Used in heavy-duty applications. Typically two types: self-undercutting and adhesives. Self-undercutting types use a special undercutting drill bit are similar to heavy-duty sleeve anchors except they fill a cavity greater than the initial hole diameter.</p>	<p>May require special tools and specific drill bits. Typically cannot be used at variable embedment depths. Can be complicated to install. May be difficult to verify proper installation.</p>
<p><b>Wedge Anchor</b> The most common concrete anchor for heavy- to light- duty applications. Many configurations are available for most applications. Made from a variety of materials.</p>	<p>Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.</p>
<p><b>Heavy Duty Sleeve Anchor</b> Expansion anchor for heavy-duty requirements.</p>	<p>A large hole is required for this anchor. Some anchors have metric diameters. Some have multiple parts that can be unassembled. If reassembled improperly, the anchor may not perform properly. If the nut is removed after the stud is inserted in the hole, the stud could be partially separated from the expansion cone, causing a reduction in anchor strength, or be detached from the expansion cone, requiring anchor replacement. These conditions are not visible.</p>

Externally Threaded (cont.)	
Description	Warning
<p><b>Center Pin Anchor</b>                      Medium-duty expansion anchor. The anchor is correctly installed when the pin is completely inserted. Installation procedures are simple; no torque is required to set the anchor.</p>	<p>Typically designed for static loads and not used with reciprocating engines, motors or in situations where vibrations are present.</p>
<p><b>Sleeve Anchor</b>                      Universal anchor for light- to medium-duty applications. Multiple head designs fit many applications and can be installed in masonry.</p>	<p>A large hole is required for this anchor. Some anchors have metric diameters. Some have multiple parts that can be unassembled. If reassembled improperly, the anchor may not perform properly. If the nut is removed after the stud is inserted in the hole, the stud could be partially separated from the expansion cone, causing a reduction in anchor strength, or be detached from the expansion cone, requiring anchor replacement. These conditions are not visible.</p>

Internally Threaded	
Description	Warning
<p><b>Internally Threaded Undercut Anchor</b> Used in heavy-duty applications. Typically come in two types: self-undercutting and those using a specialized undercutting drill bit. Anchors have internal threads. Shallow embedment and small edge distances and spacing are possible.</p>	<p>May require special tools and specific drills bits. Typically cannot be used at variable embedment depths. Can be complicated to install. May be difficult to verify proper installation.</p>
<p><b>Shell Anchor</b> Flush-mount or sub-surface internally threaded anchor for medium- to light-duty applications. Comes in fractional and metric sizes and is available in a variety of materials.</p>	<p>A special setting tool is required and must be supplied by the anchor manufacturer. The setting tool is designed for each anchor size and style.</p>
<p><b>Others</b> Similar to the wedge concrete anchor and used in heavy- to light-duty applications. Many configurations are available to fit most applications. Made from a variety of materials.</p>	<p>Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.</p>

Light Duty Fastenings	
Description	Warning
<p><b>Drive Pin (nail) Anchors (metal and plastic)</b> Light-duty anchor with fast and easy installation in many substrates.</p>	<p>Use only for static loads. Typically not used in overhead applications.</p> <p><b>DO NOT USE FOR SEISMIC RESTRAINT</b></p>
<p><b>Concrete Screws Medium- to Light-Duty</b> A variety of lengths and diameters are available. Often used for temporary anchorage.</p>	<p>Typically not used in situations where extensive vibrations are present. Requires the use of a special drill bit (some metric) supplied by the anchor manufacturer.</p>
<p><b>Special Style head Wedge (ring) anchor</b> Wedge anchor with integrated connection (head) designed for tie wires or suspended ceilings.</p>	<p>Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.</p>
<p><b>Single and Double Expansion Shields</b> Multi-purpose anchor used in concrete, Concrete Masonry Unit (CMU), brick, or stone. This anchor distributes fairly even pressure making its use popular in CMU, brick, and natural stone. Typically use in conjunction with machine bolts, which can be removed and replaced.</p>	<p>Anchor material is malleable and the threads can be stripped.</p> <p><b>DO NOT USE FOR SEISMIC RESTRAINT</b></p>



Light Duty Fastenings (cont.)	
Description	Warning
<p><b>Lead Expansion Anchors</b>            Similar to expansion shields, but typically considered light-duty. Many can be used with a variety of screws or bolts. Quick and simple to install. Can be used in concrete, CMU, brick, or stone.</p>	<p>Anchor material is malleable and the threads can be stripped. Anchor should not be used in any applications.</p> <p style="text-align: center;"><b>DO NOT USE FOR SEISMIC RESTRAINT</b></p>
<p><b>Toggle or “Molly”-type Anchors</b>            Light- to medium-duty anchor with easy installation in many substrates. No drilling is required for some anchor types or in some substrates. Some anchors are supplied with bolts or screws. Anchors are made from variety of materials and colors including plastic, zinc alloys, and steel.</p>	<p>May require a large hole. Anchor may or may not be reusable if the bolt is removed. Severe damage to the substrate can result if these anchors are removed after installation.</p>

## GLOSSARY

**A** **Adhesive anchor** – An anchor designed to bond directly to concrete within a pre-drilled hole using epoxy or other adhesive.

**Anchor** – A device for connecting equipment and attachments to the building structure.

**Attachments** – Support systems used to connect equipment, pipe, conduit, or ductwork to the building.

**Attachment type** – Use of attachments to floors, walls, roofs, ceilings, and vibration isolators.

**B** **Bar joist** – Ceiling joists supporting intermediate floors or roof made from steel angles and steel bars.

**Base plate** – A steel plate used for support and anchorage of an angle support or vibration isolator.

**Bed joint** – A horizontal seam in a brick or concrete block wall. Also see **Head joint**.

**Bolt diameter** – Thickness or width of the outside of the threaded portion of the bolt.

**BTUH** – The heating and cooling capacities of equipment in British Thermal Units per Hour.

**Building structure** – Steel, concrete, masonry and wood members or surfaces that transfer the weight of the building and equipment to the ground.

**Bumpers** – Angles or other steel shapes with elastomeric padding rigidly mounted to the building structure in a pattern around the equipment base to limit horizontal movement.

**Busbars** – A conducting bar (usually made of copper) that carries current to various electric circuits.

**C** **Cabinet** – An enclosure designed for surface mounting or flush mounting that houses controls and electrical components.

**Cable brace** – A steel cable designed for use as a seismic sway brace for suspended equipment,

pipng, ductwork, or raceways. Also see **Pre-stretched cable**.

**Cant strip** – A material used to fill voids in roof flashing.

**Cantilevered** – A support member connected at one end and unsupported at the other end.

**Cast-in-place** – A steel shape embedded into concrete.

**Cast-in-place anchor** – A headed steel bolt set within a concrete form before concrete is poured.

**Cold joint** – An edge between two concrete surfaces.

**Construction documents** – Drawings, specifications, and manufacturer's instructions that define the scope of a project and provide detailed information to seismically restrain the equipment, piping, ductwork, or raceways.

**Counter flashing** – A light-gauge sheet metal folded support or equipment frame to shed water or snow onto the roof.

**Curb** – Raised or enclosed framework that supports equipment.

**Cure** – To gain internal strength over time to withstand external forces.

**Cure time** – The total time it takes for the material to be at an absolute full load capacity.

**D Differential movement** – The movement between two objects or surfaces.

**E Edge distance** – The distance between a concrete anchor and the edge of a concrete surface or concrete cold joint.

**Elastomeric** – A material with flexibility in all directions that will return to its original shape if removed from its environment.

**Embedded** – Fixed firmly in the surrounding material.

**Embedment** – How far a post-installed anchor is inserted into a hole in concrete or wood after the anchor is set in place and torqued.

**Embedment depth** – See **Embedment**.

**Enclosure** – A case or housing to protect electrical components.

**Equipment** – Any mechanical or electrical component.

**Expansion anchor** – A post-installed anchor that uses some form of wedge or shell held against the edge of a drilled hole with friction.

**F** **Ferrule** – A small metal tube that can be crimped around steel cables.

**Fillet weld** – A weld between two pieces of steel where the welded surfaces are at right angles.

**Flashing** – Metal, asphalt, or elastomeric material with one or more layers surrounding a roof penetration specifically designed to weatherproof the building.

**Flexible connector** – A connector designed to allow slight movement between a piece of equipment, component, or system and another system in the amount of relative movement in the event of an earthquake.

**Flexible mounted equipment** – A piece of equipment supported on or from a vibration isolator.

**G** **Gel time** – A specified amount of time for an adhesive to form a jelly-like substance with strength to hold its own weight or the weight of a light steel anchor.

**Grommet** – A rubber or elastomeric bushing-shaped ring that may be used in restrained springs, snubbers, or with bolts to provide a cushioned or flexible connection.

**Groove joint** – A mechanical connection between two pipe sections using a tongue-and-groove configuration and elastomeric gasket.

**H Hand tight** – The force applied by hand to bring two or more materials together without a space and without the use of tools.

**Head joint** – A vertical joint between two concrete blocks in a block wall or two bricks in a brick wall. Also see **Bed joint**.

**Headed stud** – A large bolt with a threaded shaft and a hexagonal shaped bolt head typically used for embedment into concrete surfaces or in-filled concrete walls.

**Height-saving bracket** – A bracket used to accommodate the height of spring isolators without raising the equipment base more than a few inches.

**Housed spring** – A spring isolator with steel guides usually separated by an elastomeric sheet located on two opposite sides of the spring.

**Housekeeping pad** – A concrete pad under equipment that raises the elevation of the equipment above the building structure or structural slab. Also called plinths.

**I Inertia base** – A heavily weighted base, usually made of concrete, that weighs more than the equipment it supports.

**In-filled block** – A concrete block wall whose cells are reinforced with rebar and filled with a sand-grout mixture.

**Inlet** – The location or connection to equipment where a substance such as water or air enters the equipment.

**Isolation curb** – See **Manufactured isolation curb**.

**Isolators** – See **Vibration isolators**.

**L Leveling stanchions** – See **Stanchions**.

**Load path** – Seismic support of equipment and internal components that can be traced through connections and support steel to the building structure.

**Load transfer angles** – Angles bolted to equipment and to the building structure, transferring the weight and earthquake load through the angles to the building structure.

**Longitudinal brace** – A brace that restrains pipes, ducts, or raceways parallel to the longitudinal direction of the pipe, duct run, or raceway.

**M** **Manufactured isolation curb** – A factory-built curb designed to attach equipment to a roof and containing vibration isolators, which allow for slight movement of the equipment.

**N** **No-hub pipe** – Pipe designed for connections that do not interlock or permanently join.

**Nominal diameter** – The diameter across the outer-most edges of a bolt or threaded rod.

**O** **Open spring** – A spring isolator with a bolt attachment at the top of the spring for connecting to equipment without any horizontal support.

**Outlet** – The location or connection to equipment where a substance such as water or air exits the equipment.

**P** **Plenum** – An enclosed space usually made from galvanized sheet steel allowing airflow from one duct system to another; the entrance to and/or exit from a fan or air handling unit.

**Plug weld** – The weld of a plate or base plate to another metal surface where a plate is perforated with one or more holes, which are then filled with the weld filler material.

**Point Load** – Weight and seismic forces that are focused to a single point connection to the building structure.

**Post and beam** – An elevated structure usually made from beams resting on posts or stanchions connected to the building structure.

**Post-installed anchor** – Anchors installed after the building structure is completed.

**Post-tension building** – A concrete building structure surface with internal steel cables that are stretched and restrained to permanently compress the concrete surface.

**Pre-manufactured curb** – A sheet metal curb manufactured at a factory and sent to the job site.

**Pre-stretched cable** – Cable that is stretched after it is manufactured.

**R Raceway** – A channel (conduit or open raceway) designed to hold wires and cables or busbars.

**Rated spring deflection** – The dimension a spring will compress when the weight of equipment is applied.

**Rehabilitation** – A new installation within an existing facility.

**Restrained spring** – A vibration isolator containing a spring enclosed in a welded or bolted steel housing that limits the movement of the spring equipment attachment in all directions.

**Rigid-mounted equipment** – Equipment solidly braced or bolted directly to the building structure without vibration isolation.

**S Screen** – A tube of steel wire mesh used as an adhesive anchor for anchoring to block or brick walls.

**Seismic cable** – A steel or stainless steel braided rope.

**Seismic restraint device** – An attachment device designed to restrict movement of equipment during an earthquake.

**Seismic restraint device submittals** – Documents created by contractors or vendors describing the means and methods for installing seismic restraint devices and submitted for design approval.

**Seismic rod clamp** – A clamping device for attaching rod stiffeners to a vertical threaded rod.

**Self-drilling** – A special type of concrete shell anchor with cutting teeth for drilling into concrete.

**Self-tapping** – Either a sheet metal screw with blades on the end (similar to a drill bit), allowing the screw to drill a hole and embed itself into a steel shape, or a concrete screw with a point and specially designed threads allowing the screw to grip the concrete and embed itself into the concrete.

**Set time** – The specific time required for material to harden when a light load may be applied.

**Shallow concrete anchor** – Any anchor with an embedment depth measuring less than 1/8th of its diameter.

**Sheet metal curb** – A square or rectangular box made from galvanized steel sheets used to connect equipment to a roof.

**Sheet steel housings** – Sheet steel that fully or partially encloses a piece of equipment.

**Shim** – A thin wedge or material used to fill a space.

**Snubber** – A seismic restraint device used on isolated systems with an air gap and elastomeric bushing or oil-filled hydraulic cylinder (shock absorber) restricting rapid motion of a pipe.

**Snug tight** – The force applied by hand to bring two or more materials together without a space and without the use of tools.

**Solid brace** – A steel angle or strut channel designed for use as a seismic sway brace for suspended equipment, piping, ductwork, or raceways.

**Spring isolated** – See **Vibration isolated**.

**Stanchions** – Columns or short structural steel shapes placed vertically that connect to equipment bases or horizontal structural steel frames to provide equipment support.



**Structural steel shapes** – A manufactured steel component in a variety of shapes.

**Strut** – A manufactured steel shape in various U-shaped patterns and sizes.

**Strut frame** – Steel framing made from strut members that act as a support to transfer the equipment weight to the building structure. See **Strut**.

**Sway brace** – Solid braces or cable braces that provide seismic restraint.

**T Tendons** – Steel cables used in post-tension buildings. Also see **Post-tension buildings**.

**Thimble** – A metal spacer used on a cable to protect it from being bent and damaged.

**Transverse brace** – A brace that restrains pipes, ducts, or raceways perpendicular to the longitudinal direction.

**Toe of the weld** – The edge of a fillet weld.

**Torque** – A turning force around a bolt applied by twisting a bolt head or nut so the components will not separate.

**Turn-of-the-nut method** – A process to properly torque a bolt without a special tool like a calibrated torque wrench.

**V VAV boxes** – A terminal unit or plenum with an internal damper and control actuator that can vary airflow quantities.

**Vibration-isolated** – Allows flexible motion between equipment, piping, ductwork, or raceways and the building structure.

**Vibration isolators** – Components containing springs used to separate equipment from the building structure.

**W Webs** – A thin metal strip in a structural steel shape.

**Weld base material** – The material composition of an item being welded.

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