**B-LINE SEISMIC RESTRAINT SYSTEMS** are designed to resist seismic loading while minimizing installation time and providing superior performance. On the following pages, several methods of seismic bracing are illustrated. The choice of brace design should be governed by the system requirements and location of supports.

Actual applications may vary and are not strictly limited to the combinations of fittings and supports shown. Any changes to the depicted designs should be in accordance with standard engineering practices and be approved by OSHPD (California Office of Statewide Health Planning & Development) if necessary.

For additional information on hangers, channels, fittings, and hardware shown, see the latest B-Line Strut Systems Catalog or Pipe Hangers and Supports Catalog.

**Seismic restraints** are designed to resist the horizontal seismic force in two primary directions: Transverse (perpendicular) and Longitudinal (parallel) to the run. The braces are attached to the building with a structure attachment (for concrete, steel, wood, etc.) of various anchor sizes. Typically, the stronger the structure attachment, the greater the brace spacing allowed.

The following steps detail how to use the brochure:

**Step 1:** Select the bracing details for single pipe hangers or trapeze supports.

**Step 2:** Obtain required force level (%g) from applicable code for local jurisdiction or from the structural engineer of record.

Example: 2001 California Building Code
As defined in the 2001 California Building Code, Chapter 16A, Section 1632A, the seismic horizontal force, \( F_p \), may be calculated using the following formula:

\[
F_p = \frac{a_p C_{a_p} W_p}{R_p} (1 + 3 \cdot \frac{h_a}{h_e})
\]

Except that: \( F_p \) shall not be less than 0.7 \( C_a \) \( I_p \) \( W_p \) and need not be more than 4 \( C_a \) \( I_p \) \( W_p \).

Where:
- \( F_p \) = Seismic Force Level
- \( a_p \) = Amplification Factor (Table 16A-O)
- \( R_p \) = Component Response Modification Factor (Table 16A-O)
  - 3.0 for electrical, mechanical and plumbing equipment and associated conduit, ductwork and piping utilizing deeply embedded anchors. (Table 16A-O)
  - 1.5 for installations using concrete anchors with an embedment-to-diameter ratio less than 8.
  - i.e. a \( \frac{1}{2} \)" diameter concrete anchor with an embedment of less than 4" inches.
\[ I_p = \text{Importance Factor (Table 16A-K)} \]
\[ = 1.5 \text{ for Essential facilities such as Hospitals, Fire Stations, Police Stations, Aviation Control Towers, etc. consult Table 16A-K in CBC for a detailed listing.} \]
\[ = 1.0 \text{ for most other occupancies} \]
\[ C_a = \text{Seismic Coefficient. This is a cumulation of several factors: Zone, Soil Properties, and distance from known fault. (Table 16A-I, Table 16A-J, Table 16A-Q, Table 16A-S, and Table 16A-U)} \]
\[ h_x = \text{Element or component attachment elevation with respect to grade. Note: } h_x \text{ shall not be taken less than 0.0} \]
\[ h_r = \text{Structure Roof Elevation with respect to grade.} \]

**Special Note:** This manual is based on allowable stress design (ASD), where as the seismic force level (%g or } F_p) for non-structural components provided in building codes are based on strength design. For use in this manual, the seismic force levels (} F_p) from the building code are converted to allowable stress design by dividing the result by 1.4.

**Example:** If the building code yields, \( (F_p) = 1.4 \text{g} \), this value is converted to allowable stress design (ASD) as used in this catalog as follows: \( F_p = 1.4 \text{g} / 1.4 = 1.0 \text{ g} \)

**Strength Design to Allowable Stress Design Conversions**

\[ .21 \text{g from building code} = .15 \text{g (ASD)} \]
\[ .42 \text{g from building code} = .30 \text{g (ASD)} \]
\[ .63 \text{g from building code} = .45 \text{g (ASD)} \]
\[ .70 \text{g from building code} = .50 \text{g (ASD)} \]
\[ 1.05 \text{g from building code} = .75 \text{g (ASD)} \]
\[ 1.40 \text{g from building code} = 1.00 \text{g (ASD)} \]

**Example One, Deeply Embedded Anchors:**

Cable tray system is installed on the 1st floor of a 40-foot tall, 2-story surgical center in California. The cable tray is actually suspended from the bottom of the 2nd floor, which has an elevation of 20 feet above grade. Location of the surgical center is in seismic zone 4 with a rock soil profile.

\[ F_p = \frac{a_p C_a I_p}{R_p} (1 + 3 \cdot \frac{h_x}{h_r}) W_p \]

\[ a_p = 1.0 \text{ from Table 16A-O} \]
GENERAL INFORMATION

\[ C_a = .40Na \text{ from Table 16A-Q, which is a combination of Zone and Soil profile} \]
\[ \text{Zone 4} = .40, \text{ from Table 16A-I} \]
\[ \text{Rock Soil Profile} = \text{SB, from Table 16A-J} \]
\[ \text{Seismic Source Type} = B, \text{ for faults other than Type A & C (Table 16A-U)} \]
\[ \text{Near Source Factor (Na)} = 1.0, \text{ for 5 km from known seismic source (Table 16A-S)} \]
\[ I_p = 1.5 \text{ from Table 16A-K, Occupancies having surgery and emergency treatment areas.} \]
\[ R_p = 3.0 \text{ from Table 16A-O for deep embedded anchors} \]
\[ h_x = 20 \text{ feet} \]
\[ h_r = 40 \text{ feet} \]
\[ F_p = \frac{1.0 \times 0.40(1.0)(1.5)}{3.0} \left(1 + 3 \cdot \frac{20}{40}\right)W_p = 0.50W_p = 0.50g \]

Check if value falls within limits:

\[ F_p \text{ shall not be taken less than, } 0.7C_aI_pW_p = 0.7(0.40)(1.5)W_p = .42g \]
\[ F_p \text{ shall not be greater than, } 4.0C_aI_pW_p = 4.0(0.40)(1.5)W_p = 2.4g \]

\[ 2.4g > .5 > 0.42g \text{ Therefore allowing the use of } 0.50g \]

To convert this \( F_p \) from a strength design to an Allowable Stress Design (ASD) used in this catalog divide by 1.4.

\[ F_p = \frac{0.50g}{1.4} = 0.36g \text{ (ASD)} \]

0.36g is the Allowable Stress Design Seismic Load Factor determined from the 2001 California Building Code.

Special Note: A table for 0.36g (ASD) is not available in this catalog. When seismic force levels (\%g or \( F_p \)) falls between catalog table values (i.e.: .15g, .30g, .45g, etc.) the seismic force level shall be rounded up to the next highest cataloged force level.

Example: If \( F_p = .36g \) (ASD), then use catalog tables for .45g (ASD).

Example Two, Shallow Embedded Anchors:

Special Note: Installations using concrete anchors installed with an embedment length-to-diameter ratio of less than 8, also referred to as shallow embedment anchors, have an adjusted Component Response Factor. The adjusted factor \( R_p = 1.5 \).
Cable tray system is installed on the 1st floor of a 40-foot tall, 2-story surgical center in California. The cable tray is actually suspended from the 2nd floor, which has an elevation of 20 feet above grade. Location of the surgical center is in seismic zone 4 with a rock soil profile, shallow embedment anchors are used for brace locations.

\[ F_p = \frac{a_p C_{ap} I_p}{R_p} (1 + 3 \cdot \frac{h_e}{h_t}) W_p \]

\[ a_p = 1.0 \text{ from Table 16A-O} \]
\[ C_{ap} = 0.4 Na \text{ from Table 16A-Q, which is a combination of Zone and Soil profile} \]

| Zone 4 = 0.4 | from Table 16A-I |
| Seismic Source Type = B for faults other than Type A & C (Table 16A-U) |
| Near Source Factor (Na) = 1.0 for 5 km from known seismic source (Table 16A-S) |

\[ I_p = 1.5 \text{ from Table 16A-K, Occupancies having surgery and emergency treatment areas.} \]
\[ R_p = 1.5 \text{ adjusted for Shallow Embedment Anchors} \]
\[ h_e = 20 \text{ feet} \]
\[ h_t = 40 \text{ feet} \]
\[ F_p = \frac{(1.0)(0.4)(0.4)(1.0)(1.5)}{1.5} (1 + 3 \cdot \frac{20}{40}) W_p = 1.0 W_p = 1.0 g \]

Check if value falls within limits:
- \( F_p \) shall not be taken less than, \( 0.7 C_{ap} I_p W_p = 0.7(0.4)(1.5) W_p = 0.42 g \)
- \( F_p \) shall not be greater than, \( 4.0 C_{ap} I_p W_p = 4.0(0.4)(1.5) W_p = 2.4 g \)

\[ 2.4 g > 1.0 g > 0.42 g \text{ Therefore allowing the use of 1.0 g} \]

To convert this \( F_p \) from a strength design to an Allowable Stress Design (ASD) used in this catalog divide by 1.4.

\[ F_p = \frac{1.0 g}{1.4} = 0.71 g \text{ (ASD)} \]

**0.71g** is the Allowable Stress Design Seismic Load Factor determined from the 2001 California Building Code for shallow embedment anchors.

**Special Note:** A table for .71g (ASD) is not available in this catalog. When seismic force levels (.7g or \( F_p \)) falls between catalog table values (i.e.: .15g, .30g, .45g, etc.) the seismic force level shall be rounded up to the next highest cataloged force level.

**Example:** If \( F_p = .71 g \) (ASD), then use catalog tables for .75g (ASD).

**Note:** For other Code examples see Appendix 4
Step 3: With required force level (\%g), obtain the transverse and longitudinal brace spacing from Appendix 1 (single pipe) or Appendix 2 (trapeze hanger). The following notes shall be followed:

a) Break the length of pipe into separate straight runs, which are considered to be a single straight section between any bends in the pipe except where the bend is at an offset of less than the maximum offset length as defined below.

<table>
<thead>
<tr>
<th>Table 1 - Steel Pipe or Conduit</th>
<th>Table 2 - Copper Tubing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Pipe Size</td>
<td>Max. Offset Length (ft)</td>
</tr>
<tr>
<td></td>
<td>0.15g</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: The tabulated values represent pipe and tubing with moment and shear transferring joints. Therefore, for use of these tables pipes shall have welded, brazed, or UL Listed grooved joints. Pipe and tube sizes not listed above or joined as required shall be limited to a maximum offset length of 2 ft.

b) Brace each straight run in the transverse direction at both ends. Where several short runs occur, see note e) on the following page.
c) Check the required spacing for transverse bracing (Appendixes 1 & 2) and compare it to the length of the straight run. If the length of the straight run is greater than the allowable distance for transverse bracing add transverse braces until the spacing does not exceed the allowable transverse brace distance.

![Diagram showing Straight Run and Additional Transverse Braces](image)

d) Each straight run must have at least one longitudinal brace. Add longitudinal braces so that the spacing does not exceed the allowable longitudinal brace spacing in Appendixes 1 & 2.

![Diagram showing Straight Run, Longitudinal Brace (Transverse brace for the adjacent run), and Longitudinal Brace](image)

24” (610mm) Max.

Note: A transverse brace may dually act as a longitudinal brace for an adjacent run when it is located within 24” of the adjacent straight run. However, Appendixes 1 & 2 shall be reviewed to use the stronger of the longitudinal or transverse brace requirements, i.e. anchor and other component sizes.
e) In many cases, several short runs occur one after the other. Based on previous requirements, each straight run requires a longitudinal brace when the adjacent short runs exceed the maximum offset length (ft.). When the adjacent short runs do not exceed the maximum offset length (ft.) the longitudinal braces can act as transverse braces as long as the allowable transverse brace spacing (Appendixes 1 & 2) is not exceeded.

In the following layout, transverse braces are used as longitudinal braces when the straight runs are less than the maximum offset length (ft.). When a straight run exceeds the maximum offset length (ft.) additional braces are required.

Multiple offsets can be treated as a single run when the total offset is less than the maximum offset length (ft.).
f) When a flexible connection or swing joint is used, such as at a pipe drop to mechanical equipment, the pipe may cantilever at a length equal to or less than half the allowable transverse brace spacing (Appendixes 1 & 2). When greater than half the allowable transverse brace spacing, support to the floor is required as shown below.

![Diagram of structural connection](image)

Transverse brace at the end of horizontal run
Allowable Transverse Brace Spacing
If < 6 ft, Support to Floor is Required.

**Step 4:** Note the structure connection type (brace anchor requirements) from the Appendix, and select the brace anchorage detail to suit (pages 23 thru 38).

**Step 5:** Note the hanger rod load from the Appendix, and select a rod attachment to structure to suit (pages 39 thru 56).

**Step 6:** Check if rod stiffeners are required (pages 57 & 58) to prevent the hanger rod from buckling.

---

**Seismic restraints may typically be omitted for the following conditions where flexible connectors are provided between components and the associated ductwork, piping, and conduit:**

1. Fuel, medical gas, and vacuum piping less than 1 inch (25 mm) inside diameter.
2. All other piping less than 2 1/2 inches (64 mm) diameter, or:
   - All piping suspended by individual hangers 12 inches (305 mm) or less in length from the top of the pipe to the bottom of the structural support for the hanger
   - All electrical conduit less than 2 1/2 inches (64 mm) trade size
3. All rectangular air-handling ducts less than 6 ft² (0.56 m²) in cross sectional area or:
   - All round air-handling ducts less than 28 inches (711 mm) in diameter
   - All ducts supported by hangers 12 inches (305 mm) or less from the top of the duct to the bottom of the structural support for the hanger; where the hangers are detailed to avoid bending of the hangers and their connections. (To eliminate bending moment, flexible connections may be used. See B752 on page 49 or B446 & B446C on page 56)

Where lateral restraints are omitted, the piping, ducts, or conduit shall be installed such that lateral motion of the piping, duct, or conduit will not cause damaging impact with other systems or structural members, or loss of vertical support.

**NOTE:** Reference building code enforced by local authority with jurisdiction for specific requirements, and verify all omissions or exemptions with structural engineer of record.
GENERAL NOTES FOR SEISMIC BRACING

A) The seismic restraint assemblies shown in this pre-approval document are designed to resist vertical loading simultaneously with seismic loading (transverse & longitudinal loading). Design recommendations shown are for single standard weight steel pipes filled with water. Contents other than water shall be evaluated by the user. Pipes of other approved materials shall be supported in accordance with their approved installation standards. Details not shown in this pre-approval shall be submitted to OSHPD for approval before installation if necessary.

B) This bracing system is limited to the pipe sizes and support details shown. Special consideration must be given for pipe material and connections, insulation, thermal movement, vibration, and building seismic joints.

C) Transverse and longitudinal braces shall be no more than 45° above or below the centerline of the pipe, duct, or tray.

D) All channel and pipe clamp nuts and bolts shall be tightened to the following torques:

- 1/4"-20 to 6 ft.-lbs. (8 N•m)
- 3/8"-16 to 19 ft.-lbs. (26 N•m)
- 1/2"-13 to 50 ft.-lbs. (68 N•m)
- 5/8"-11 to 65 ft.-lbs. (88 N•m)
- 3/4"-10 to 75 ft.-lbs. (101 N•m)

E) The transverse and longitudinal bracing spacing listed in Appendix 1 & 2 is based on ductile piping (steel, copper, etc.) with ductile connections (welded, brazed, etc.) and has the following limitations:

1) Transverse bracing shall not exceed 40'-0" (12.2 m). Longitudinal bracing shall not exceed 80'-0" (24.4 m).

2) Fuel piping shall have transverse bracing 20'-0" (6.1 m) o.c. maximum and longitudinal bracing 40'-0" (12.2 m) o.c. maximum.

3) Non-ductile piping, and piping with non-ductile connections shall have transverse bracing 20'-0" (6.1 m) o.c. maximum and longitudinal bracing 40'-0" (12.2 m) o.c. maximum or 1/2 of the calculated brace spacing indicated in Appendix 1 or 2, whichever is more restrictive.

F) Transverse bracing for one pipe section may also act as longitudinal bracing for the pipe section connected to it, if the bracing is installed within 24 inches (609 mm) of the elbow or tee of similar size. Figures 2 and 4 do not serve as adequate longitudinal braces.
G) Branch lines of a smaller diameter shall not be used to brace main lines.

H) Where rod stiffeners are required a minimum of two hanger rod stiffener assemblies shall be installed. (Part number SC-228 or SC-UB)

I) It is important to check anchorage details against the applicable building code requirements. Seismic design forces may increase substantially when anchors are considered “shallow” (embedded less than 8 times the anchor diameter).

J) When bracing trapeze type hangers, the bracing shall be attached directly to the trapeze hanger assembly and piping secured to the trapeze assembly with pipe straps.

K) A rigid piping system shall not be braced to different parts of a building that may respond differently during an earthquake. Example: Solid concrete wall and a roof (metal deck filled with lightweight concrete). Special care should be taken to avoid bracing rigid pipe on both sides of a building seismic joint without allowing for pipe and building movement.

L) The pre-approval document is based on British Units (Inches & Pounds) and values noted in parenthesis (Metric or S.I. Units) are equivalent values. In case of conflicts, British Units will be the standards for evaluating the proper application of pre-approvals.

M) The designer of the structure shall determine the adequacy of the support structure to carry the load of the piping and equipment. Engineer of record for a site specific project shall verify that the structure can support the connection loads of the hanger rod and the bracing attachments in addition to all other loads. This pre-approval document is not intended for the seismic design of the piping itself. The dynamic properties of the building structure and piping should be considered when selecting the type of piping to be installed.

N) Seismic bracing shall not limit the expansion and contraction of the piping system. Always consider thermal movements when selecting brace locations and materials. The design for thermal movements is beyond the scope of OSHPD pre-approval.

P) No portion of this pre-approval shall be taken out of context and used in other systems, design or purpose.

Q) On transverse bracing, the pipe insulation material may be part of the brace assembly (i.e) in the load path. In this case the insulating material shall be capable of withstanding the lateral forces without damage and shall include a pipe shield for hangers or a pipe saddle for rollers. For longitudinal bracing, clamping must be applied directly to the pipe with any insulation being installed directly over the hanger and brace assembly. In these applications the mechanical engineer of record shall be contacted for insulating recommendations.
The following B-Line channels may be used as brace members for Figures 1 - 11 using the following structure connection types:

<table>
<thead>
<tr>
<th>Channel Type</th>
<th>Maximum Structure Connection Type</th>
<th>Maximum Brace Length</th>
<th>Channel Height</th>
<th>Channel Width</th>
<th>Material Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>B54</td>
<td>IV</td>
<td>4'-10&quot; (1.47)</td>
<td>13/16&quot; (20.6)</td>
<td>1 5/8&quot; (41.3)</td>
<td>14 Ga. (1.9)</td>
</tr>
<tr>
<td>B52</td>
<td>IV</td>
<td>4'-8&quot; (1.42)</td>
<td>13/16&quot; (20.6)</td>
<td>1 5/8&quot; (41.3)</td>
<td>12 Ga. (2.6)</td>
</tr>
<tr>
<td>B42</td>
<td>V</td>
<td>5'-10&quot; (1.78)</td>
<td>1&quot; (25.4)</td>
<td>1 5/8&quot; (41.3)</td>
<td>12 Ga. (2.6)</td>
</tr>
<tr>
<td>B32</td>
<td>V</td>
<td>8'-0&quot; (2.44)</td>
<td>1 5/8&quot; (34.9)</td>
<td>1 5/8&quot; (41.3)</td>
<td>14 Ga. (1.9)</td>
</tr>
<tr>
<td>B24</td>
<td>IV</td>
<td>9'-7&quot; (2.92)</td>
<td>1 5/8&quot; (41.3)</td>
<td>1 5/8&quot; (41.3)</td>
<td>12 Ga. (2.6)</td>
</tr>
<tr>
<td>B22</td>
<td>V</td>
<td>9'-5&quot; (2.74)</td>
<td>1 5/8&quot; (41.3)</td>
<td>1 5/8&quot; (41.3)</td>
<td>12 Ga. (2.6)</td>
</tr>
<tr>
<td>B22A</td>
<td>V</td>
<td>10'-10&quot; (3.30)</td>
<td>3 1/4&quot; (82.5)</td>
<td>1 5/8&quot; (41.3)</td>
<td>12 Ga. (2.6)</td>
</tr>
<tr>
<td>B11</td>
<td>IV</td>
<td>11'-7&quot; (3.53)</td>
<td>3 1/4&quot; (82.5)</td>
<td>1 5/8&quot; (41.3)</td>
<td>12 Ga. (2.6)</td>
</tr>
</tbody>
</table>

*Slotted channel (SH) versions of all the above types may also be used for brace members. See page 21 for channel details.

**The Structure Connection Type is the brace anchorage requirement. See pages 23 - 38 for brace attachment details.

**Note:** Do not exceed the maximum brace length or maximum structure connection type for the channels listed.

Commentary:

Appendix 1 & 2 list the allowable structure connection type (I, II, III, IV, or V) for each brace spacing listed. The structure connection type limits the amount of axial load (in tension or compression) which is applied to the brace member. The axial load is listed for each structure connection detail on pages 23 - 38, and is as follows:

<table>
<thead>
<tr>
<th>Structure Connection Type</th>
<th>Maximum Axial Load in Brace Member</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>175 lbs. (0.78 kN)</td>
</tr>
<tr>
<td>II</td>
<td>300 lbs. (1.33 kN)</td>
</tr>
<tr>
<td>III</td>
<td>450 lbs. (2.00 kN)</td>
</tr>
<tr>
<td>IV</td>
<td>675 lbs. (3.00 kN)</td>
</tr>
<tr>
<td>V</td>
<td>975 lbs. (4.33 kN)</td>
</tr>
</tbody>
</table>

The B-Line channel brace member must have a capacity greater than the value listed in the above table for the maximum recommended brace length.