Seismic Restraint Systems Guidelines

OSHPD Pre-Approved OPA-0300

These guidelines are also adaptable to be used with building codes in regions throughout the U.S. In addition to OSHPD approval, engineering details can be certified for the states shown on the following page.

1375 Sampson Ave. - Corona, CA 92879
Ph: 951.737.5599 - Fax: 951.737.0330
www.tolco.com
# Table of Contents

Forward .................................................................................................................. i  
Forward / CBC 2001 Formula Example ................................................................. ii  
UBC 1997 Formula Example ................................................................................... iii

Section 1 - General Notes

Introduction ............................................................................................................. 1-1  
Building Codes, Standards, & Guidelines ............................................................ 1-4  
Seismic Bracing General Requirements - Piping ............................................... 1-5  
Seismic Bracing General Requirements - Ducts ............................................... 1-8  
Seismic Bracing General Requirements - Electrical Systems ......................... 1-10  
Seismic Bracing Layout - General Requirements ............................................. 1-12  
Seismic Bracing Layout - General Procedure .................................................. 1-14  
General Design Procedure - Single Hanger Bracing ......................................... 1-17  
General Design Procedure - Trapeze Bracing .................................................. 1-20

Section 2 - Single Hanger Rigid Brace Details

Transverse Rigid Brace Details ............................................................................. 2-1  
Longitudinal Rigid Brace Details ...................................................................... 2-9  
Riser Brace Details .............................................................................................. 2-11  
Riser Joint Brace Assembly For No Hub Pipe ................................................... 2-15

Section 3 - Single Pipe Hanger Rigid Brace Spacing Charts

Spacing Charts for Concrete Attachments ............................................................ 3-1  
Spacing Charts for Steel Attachments ................................................................. 3-9  
Spacing Charts for Wood Attachments ............................................................... 3-17

Seismic Restraint Systems Guidelines  
OSHPD Pre-Approved OPA-0300
# Table of Contents (Cont’d)

## Section 4 - Trapeze Rigid Brace Details
- Rigid Bracing for Trapeze Supported Pipe or Conduit Systems ........................................ 4-1
- Rigid Bracing for Trapeze Supported Electrical Cable Tray ........................................... 4-7
- Rigid Bracing for Rectangular Duct .............................................................................. 4-10
- Rigid Bracing for Round Duct .................................................................................... 4-13

## Section 5 - Trapeze Rigid Brace Spacing Charts
- Spacing Charts for Concrete Attachments .............................................................. 5-1
- Spacing Charts for Steel Attachments .................................................................. 5-9
- Spacing Charts for Wood Attachments .................................................................. 5-17

## Section 6 - Single Hanger Cable Brace Details
- Transverse Cable Brace Details ............................................................................. 6-1
- Longitudinal Cable Brace Details .......................................................................... 6-8

## Section 7 - Single Pipe Hanger Cable Brace Spacing Charts
- Spacing Charts for Concrete Attachments .............................................................. 7-1
- Spacing Charts for Steel Attachments .................................................................. 7-9
- Spacing Charts for Wood Attachments .................................................................. 7-17

## Section 8 - Trapeze Cable Brace Details
- Cable Bracing for Trapeze Supported Pipe or Conduit Systems ............................... 8-1
- Cable Bracing for Trapeze Supported Electrical Cable Tray ...................................... 8-7
- Cable Bracing for Rectangular Duct ...................................................................... 8-10
- Cable Bracing for Round Duct .............................................................................. 8-13
Table of Contents (Cont'd)

Section 9 - Trapeze Cable Brace Spacing Charts
  Spacing Charts for Concrete Attachments ........................................ 9-1
  Spacing Charts for Steel Attachments ........................................... 9-9
  Spacing Charts for Wood Attachments .......................................... 9-17

Section 10 - Structural Attachments
  Attachments to Concrete ............................................................. 10-1
  Attachments to Steel ................................................................. 10-9
  Attachments to Wood ................................................................. 10-14
  Wedge Anchor Test Values ......................................................... 10-18

Section 11 - Seismic Brace Components
  Swivel and Multi-Fastener Components ......................................... 11-1
  Rod Stiffener Details and Schedule ............................................. 11-18
  Clevis Bolt Spacer ........................................................................ 11-19
  Maximum Allowable Lengths and Concentric Loads for Brace Members ........................................ 11-20

Section 12 - Hanger Components ..................................................... 12-1

Appendix A
  International Building Code 2000
  Standard Building Code 1999
  BOCA National Building Code 1999

Appendix B
  Seismic Zone Map of the United States
Appendix C

Pipe Weights
Conduit Weights
Rectangular Duct Weights
Round Duct Weights
Metric Conversion Charts
Foreword

TOLCO has been a leading manufacturer and supplier of Seismic Bracing components to the mechanical, electrical and fire protection industries for over 35 years. Known for our innovative designs, our bracing products include break away bolt and nut features to provide the installer the ease of a proper installation 100% of the time. These features also give the IOR (inspector of record) an easy, visual means of verifying that proper installation has been accomplished.

These Seismic Restraint Systems Guidelines show the step by step process of providing the necessary protection against seismic events for pipe, duct and electrical systems. TOLCO also offers total seismic services including brace layout, engineering calculations and stamp where applicable, creative solutions to project specific challenges, and if required, installation certification at the completion of the project. This Total Seismic Support Expertise, and partnering with our customers, has earned us their respect and loyalty.

Over the years our industry has evolved. With each new earthquake we learn more of the effects on non-structural elements of buildings. Due to this growing body of knowledge, building codes used around the country have begun to focus more intently on the standards for seismic bracing systems. The latest versions of the National and International Building codes have revised the calculations for force factors to include soil type, nearness to faults, and elevation with respect to grade etc. (see Appendix A). In addition the State of California Office of Statewide Health Planning and Development (OSHPD) places great importance on certain types of buildings, such as hospitals, and they enforce the highest standards of seismic bracing for these essential facilities.

In addition to the growing complexity of the seismic bracing standards, the issue of seismic bracing is becoming more common in diverse areas of the country. In areas of the south and midwest where earthquake frequency is very low, the potential damage of a single strong quake has spurred the need for bracing. The seismic bracing standards have also been applied to new construction for federal and military projects in non-earthquake zones as an additional protection from terrorist bombing attacks.

These guidelines were created to assist the engineer by providing details of bracing attachments, assemblies and spacing charts that guide in the proper design and layout of a seismic bracing system. It is pre-approved by OSHPD and can be used for projects with these strict requirements. However, since the spacing charts can be used with a range of force factors, this guideline can be used nationwide. In addition to the California OSHPD Pre- Approval, this book contains the professional engineering stamps for 13 states (see page i). We are adding new states to this list continuously. Call our Seismic Department for the latest updated list.
The following pages will take you through the process of designing a brace for piping. Worksheets are provided to show proper selection of all brace assembly components and to be used as a project submittal.

This example bracing scenario is for a hospital facility in Los Angeles County. The first step is to use the project Geo-tech report with the CBC building code formula to determine the seismic horizontal force factor. This factor is multiplied by the dead load of our pipe and will give us our Seismic Horizontal Load to be braced.

As stated in the 2001 California Building Code, Chapter 16, Section 1632, the horizontal seismic force ($F_p$) may be calculated using the formula below.

$$F_p = \frac{a_p C_a l_p}{R_p} \left(1 + 3 \cdot \frac{h_x}{h_r} \right) W_p$$

**CBC 2001 FORMULA**

**32A-2**

**Example:** 5 story hospital located in Los Angeles, CA with deep anchor embedment.

<table>
<thead>
<tr>
<th>Building Code</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_p$ = <strong>Horizontal Force Factor</strong> From the Table 16A-O of the CBC 2000 / UBC 1997</td>
<td>In Table 16A-O Row 3.B is used for all electrical, mechanical and plumbing equipment. The table yields a value of 1.0 for $a_p$</td>
</tr>
<tr>
<td>$C_a$ = <strong>Seismic Coefficient</strong> Contact the Geo-Technical Engineer for most accurate calculated number. Can also be taken from Table 16A-Q of CBC 2001/UBC 1997</td>
<td>Table 16A-Q lists the $C_a$ value per the seismic zone of the project location. Southern California is in zone 4 which is represented by the last column of the Table. Without a Geo-Tech report we will default to the highest value which in the case will be <strong>0.44</strong></td>
</tr>
<tr>
<td>$R_p$ = <strong>Anchor Bolt Factor</strong> From Table 16A-O of the CBC 2001 / UBC 1997</td>
<td>In Table 16A-O 3.B the default value for $R_p$ is listed as a default value of 3.0. In the case of shallow anchor embedment this value would drop to 1.5.</td>
</tr>
</tbody>
</table>
**Example: Cont'd**

<table>
<thead>
<tr>
<th>Building Code</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>$l_p$ = Importance Factor  From Table 16A-K of the CBC 2001 / UBC 1997 Essential or Hazardous Buildings use a factor of 1.5. All other facilities use a factor of 1.0 Unless Otherwise Noted.</td>
<td>In Table 16A-K you will find a listing of importance factor values used for various facilities. For our example a hospital would fall under category 1: Essential Facilities where $l$ is equal to 1.5.</td>
</tr>
<tr>
<td>$h_x$ = Mechanical/Electrical System Attachment Elevation with relation to Grade</td>
<td>Input the elevation of the pipe system to be braced. For our example, the pipe elevation is 120'</td>
</tr>
<tr>
<td>$h_r$ = Structure Roof Elevation with relation to Grade</td>
<td>Input the roof elevation. For our example</td>
</tr>
<tr>
<td>(1.4) - A factor given by the CBC 2001 Code which denotes an &quot;Allowable Stress Design&quot; method as identified in section 1612A.3, &quot;Load Combinations Using Allowable Stress Design&quot;.</td>
<td>In order for this formula to yield a value based on allowable loads instead of ultimate loads, we divide by 1.4.</td>
</tr>
</tbody>
</table>

**"G"-Factor** = \( \frac{(1.0)(0.44)(1.5)}{(1.4)3.0} (1 + 3 \cdot \frac{1}{1}) W_p \)

**"G"-Factor** = \( (0.63) W_p \)

* For I.B.C., U.B.C., B.O.C.A. and Standard Building Codes see Appendix A.
After finding your seismic force factor, the next steps are easy

Example: You have a run of 4" Clevis Hung Pipe supported by 5/8" rod. The structure above is metal deck with concrete fill. The distance from the bottom of structure to the top of pipe is 46".

STEP 1: Select Your Assembly Detail

Assembly details can be found in four specific sections as shown below:

<table>
<thead>
<tr>
<th>Section 2: Rigid Braced Single Hung Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 4: Rigid Braced Trapeze, Duct, Cable Tray and Conduit Systems</td>
</tr>
<tr>
<td>Section 6: Cable Braced Single Hung Systems</td>
</tr>
<tr>
<td>Section 8: Cable Braced Trapeze, Duct, Cable Tray and Conduit Systems</td>
</tr>
</tbody>
</table>

For the above example you would turn to section 2 and locate Detail 1 (page 2-1) which depicts a seismic assembly attached to a clevis hung pipe.

STEP 2: Select Your Structural Attachment

Structural Attachments are found in section 10. For the example above you would turn to section 10 and locate the anchor for metal deck with concrete pour which is page 10-2.

STEP 3: Rod Stiffeners

The rod stiffener chart can be found on page 11-18. In the example above the distance from the bottom of structure to the top of pipe is 48" and the rod diameter is 5/8". As shown on page 11-18, 5/8" rod allows 23" between rod stiffeners and 6" from top and from the bottom to the first stiffener. 48" - 6" - 6" = 36", divide the remainder by the maximum spacing and add one. 36" + 23" = 2 + 1 = 3. This brace will require 3 rod stiffeners.

STEP 4: Spacing Charts

Spacing charts are also located in four specific sections as shown below:

<table>
<thead>
<tr>
<th>Section 3: Spacing Charts for Rigid Braced Single Hung Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 5: Spacing Charts for Rigid Braced Trapeze, Duct, Cable Tray and Conduit Systems</td>
</tr>
<tr>
<td>Section 7: Spacing Charts for Cable Braced Single Hung Systems</td>
</tr>
<tr>
<td>Section 9: Spacing Charts for Cable Braced Trapeze, Duct, Cable Tray and Conduit Systems</td>
</tr>
</tbody>
</table>

For the above example you would turn to section 3 and locate the charts that show wedge anchor connections to metal deck with concrete fill, in this scenario page 2-3 or 2-4 will be used depending on your seismic force factor. Locate the 4" pipe size in the charts to determine your spacing, and anchor size.
1.0 INTRODUCTION

This manual is prepared as a guideline for seismic bracing design for piping, ducts, conduits, and cable trays. Following is an outline of the manual:

Section 1 - General Information. Presents general notes and requirements for seismic bracing of mechanical and electrical systems. It also includes a general step by step procedure for seismic bracing design using this manual.

Section 2 - Single Hanger Rigid Brace Details. Includes seismic bracing details for individually hung piping and conduits using rigid brace members.

Section 3 - Single Hanger Rigid Brace Spacing Charts. Presents seismic brace spacing charts for individually hung piping and conduits using rigid brace members. It includes structural attachments to concrete slabs, steel deck with lightweight concrete, attachments to steel beams and bar joists, and attachments to wood beams.

Section 4 - Trapeze Rigid Brace Details. Includes seismic bracing details for trapeze assemblies for piping, ducts, conduits, and cable trays using rigid brace members.

Section 5 - Trapeze Rigid Brace Spacing Charts. Presents seismic brace spacing charts for trapeze assemblies for piping, ducts, conduits, and cable trays using rigid brace members. It includes structural attachments to concrete slabs, steel deck with lightweight concrete, attachments to steel beams and bar joists, and attachments to wood beams.

Section 6 - Single Hanger Cable Brace Details. Includes seismic bracing details for individually hung piping and conduits using cable braces.

Section 7 - Single Hanger Cable Brace Spacing Charts. Presents seismic brace spacing charts for individually hung piping and conduits using cable braces. It includes structural attachments to concrete slabs, steel deck with lightweight concrete, attachments to steel beams and bar joists, and attachments to wood beams.

Section 8 - Trapeze Cable Brace Details. Includes seismic bracing details for trapeze assemblies for piping, ducts, conduits, and cable trays using cable braces.

Section 9 - Trapeze Cable Brace Spacing Charts. Presents seismic brace spacing charts for trapeze assemblies for piping, ducts, conduits, and cable trays using cable braces. It includes structural attachments to concrete slabs, steel deck with lightweight concrete, attachments to steel beams and bar joists, and attachments to wood beams.

Section 10 - Structural Attachments. Shows structural attachment details and allowable loads for attaching seismic bracing to supporting structure. It includes structural attachments to concrete slabs, steel deck with lightweight concrete, attachments to steel beams and bar joists, and attachments to wood beams.

Section 11 - Seismic Brace Components. Includes details and allowable loads for seismic bracing components used in the seismic bracing design. Components include brace attachment fitting, rod stiffening requirements, clevis bolt spacer details, and others.
Section 12 - Hanger Components. Shows the hanger components for single hanger and trapeze assemblies.

II. Data presented in this manual is representative and is not intended to be exhaustive, precise, or useful for every application. By using this manual, the user assumes all responsibility for its use. Cooper B-Line, Cooper B-Line’s engineers and consultants, and other interested entities do not assume or accept any responsibility or liability, including liability for negligence, for errors or oversight, or for the use of this manual in preparing seismic bracing design.

III. The purpose of this manual is to be used as a guideline for seismic bracing design only. Items that are beyond the scope of this manual include but are not limited to, the design of mechanical and electrical systems, the design of special operational forces supports, thrust supports, riser supports, and design of other elements of the mechanical and electrical systems.

IV. Design of seismic bracing for piping systems with expansion joints, loops, or other systems involving special operational loads and/or displacements, is beyond the scope of this manual. Such systems may require special coordination between operational forces and seismic forces.

V. Seismic bracing design and layout drawings shall be either prepared by a Registered Structural Engineer licensed in the state where the project is located with experience in the design of seismic bracing for mechanical and electrical systems, or prepared by a qualified designer/engineer with experience in the design of seismic bracing for mechanical and electrical systems and reviewed by a Registered Structural Engineer licensed in the state where the project is located with experience in the design of seismic bracing for mechanical and electrical systems.

VI. Seismic bracing design and layout drawings shall be approved by the engineer of record.

VII. For seismic bracing design per this manual, OSHPD to approve the seismic force level used for bracing design.

VIII. Modifications and/or changes to the designs shown in this guideline shall be performed or reviewed by a qualified Registered Structural Engineer and approved by the design engineer of record.

IX. For information on other types of pipe hangers, supports, strut channel and fittings as well as other miscellaneous hardware see the Tolco Pipe Hanger and Support Catalog or the Tolstrut Channel and Fittings Catalog.

X. When more than one criteria is presented, the more stringent criteria shall be used. Changes to the data presented in this manual shall not be made. The data presented in this manual is subject to change without notice. Refer to the appropriate codes and standards for additional information and requirements.

XI. The structural engineer of record shall verify the adequacy of the pipe supports, supporting structure and its components for the loads applied to the supporting structure and its components by the seismic bracing systems, and compliance with the applicable codes and standards.

XII. A copy of this manual and copies of all other details, layouts, and calculations shall be at the jobsite and readily available prior to installing the seismic bracing system.
XIII. Brace spacing charts show spacing for horizontal force factors of 0.5G and 1.0G. Brace spacing for other horizontal force factors can be determined by dividing the spacing for 1.0G by the project horizontal force factor.

Example:
Project horizontal force facor = 0.7G
Brace spacing from spacing chart = 21ft.
Project brace spacing = 21ft / .7 = 30ft
(Brace spacing shall not exceed maximum allowable spacing from general notes.)
2.0 BUILDING CODES, STANDARDS, & GUIDELINES

The Tolco Seismic Restraint Guidelines are designed to meet or exceed the requirements of the following:

2001 California Building Code CBC 2001
1998 California Building Code CBC 98
1997 Uniform Building Code UBC 97
1999 BOCA National Building Code NBC 99
1999 Standard Building Code SBC 99
1999 National Fire Protection Association Pamphlet 13 NFPA-13

Where there is a conflict in requirements between these guidelines and above mentioned codes the more stringent parameters shall prevail.

These guidelines are intended to describe seismic restraints for the piping industry's most commonly used single rod pipe hangers for up to 24-inch pipe and mechanical/electrical trapezes supports up to 12 foot wide. Spacing charts provided show pipe sizes and maximum loads based on the following:

- 1" through 4" sch. 40 steel, water filled w/ 1" insulation
- 5" through 12" sch. 40 steel, water filled w/ 1 1/2" insulation
- 14" through 18" sch. 30 steel, water filled w/ 1 1/2" insulation
- 20" through 24" sch. 20 steel, water filled w/ 1 1/2" insulation

For other piping, piping w/ additional weights such as flanges, and other mechanical/electrical systems, determine bracing design based on maximum weight per foot.
3.0 SEISMIC BRACING GENERAL REQUIREMENTS - PIPING

I. Seismic restraints are required for the following piping installations:

a) All medical gas, vacuum pipe, compressed air and other hazardous pipe, and fuel piping 1" diameter and larger.

b) All piping 1 1/4" diameter and larger in boiler rooms, mechanical equipment rooms and refrigeration mechanical rooms.

c) All piping 2 1/2" diameter and larger.

d) All trapeze assemblies supporting pipes shall be braced considering the total weight of the pipes on the trapeze.

Exceptions

All piping suspended by individual hanger rods 12 inches or less in length from the top of pipe to the bottom of the support structure where hanger is connected.

Trapeze supported systems suspended 12 inches or less from the top of the trapeze to the bottom of the support structure where trapeze is connected, provided that any changes in direction allow for flexibility in the system. Examples would be flexible connections to equipment or long offsets.

In both exceptions above, all of the hangers of a run must comply with the 12 inch rule or bracing is required.

The 12 inch rod rule exception has additional requirements, they are as follows:

a) Lateral motion of the piping will not cause damaging impact with other systems (e.g. other pipe, duct, or electrical systems, equipment, structural members etc., or fragile appurtenances such as sprinkler heads or lighting fixtures) or loss of system vertical support.

b) Piping must be made of ductile material with ductile connections (e.g. welded steel pipe, brazed copper pipe etc.)

c) Vertical rod hanger top connections to the building structure cannot develop moments (this can be accomplished by using a Tolco Fig. 102L Linked Eye Rod, Fig. 306 turnbuckle with Swivel or Tolstrut Swivel connections at the building structure connection).

Trapeze supported systems that satisfy all of the following requirements:

a) None of the pipes would need to be braced if they were supported individually

b) Total weight of the pipes does not exceed 10lbs per ft. The weight shall be determined assuming all pipes are filled with water.
II. Transverse bracing shall be provided at 40 ft. maximum spacing for welded steel pipe, brazed copper pipe or grooved piping with UL 213 listed connections. Threaded steel or copper pipe or NON-LISTED UL grooved connections shall not exceed 20 ft. maximum.

III. Longitudinal bracing shall be provided at 80 ft. maximum spacing for welded steel pipe, brazed copper pipe or grooved piping with UL 213 listed connections. Threaded steel or copper pipe or NON-LISTED UL grooved connections shall not exceed 40 ft. maximum.

IV. Cast iron, No-Hub, Plastic, FRP and other pipe or constructed of non-ductile material, shall have the maximum brace spacing reduced to one-half of the maximum brace spacing for welded steel or brazed copper pipe. Due to differences in pipe manufacturing and pipe connection types, maximum spacing may vary depending on pipe manufacturers' requirements.

V. Brace No-Hub piping each side of 90 degree horizontal change in direction.

VI. Fuel gas and oil, medical gas, vacuum and compressed air piping shall have transverse bracing provided at 20 ft. maximum and longitudinal bracing provided at 40 ft. maximum.

VII. When determining horizontal load requirements, consider all pipes full of water unless calculated for other substances.

VIII. Seismic bracing shall not limit the expansion and contraction of the piping system. When thermal expansion or contraction is involved, longitudinal bracing shall be designed at the anchor point of the piping system. The longitudinal bracing and the connections must be capable of resisting the additional force induced by expansion and contraction.

IX. All braces shall be located at or within 4" of the vertical pipe support, which may require a rod stiffener.

X. When bracing is required for insulated pipe the transverse brace may be attached to the single pipe hanger that is oversized to accommodate the insulation insert or attached to the trapeze member with pipe straps or 2-pc clamps oversized to accommodate the insulation insert. Longitudinal bracing shall be attached directly to the pipe or single pipe hangers, but for trapeze hangers, bracing should attach to the trapeze member, with pipe straps or 2-pc clamps attached directly to all pipes. Re-insulate all pipes where braces are attached directly to pipe.

XI. When bracing trapeze supports, the bracing shall be attached directly to the trapeze with piping secured to the trapeze with pipe straps or 2-pc clamps. A minimum of one transverse brace and for two longitudinal braces is required.

XII. Stacked trapezes supported by the same rods shall be braced independently from one another. The rod supports in each section may require stiffening.

XIII. Branch line piping shall not be used to brace main piping.

XIV. A piping system shall not be braced to different parts of the building that may respond differently during seismic activity.
XV. At pipe risers, provide lateral restraint at the top and bottom of the riser, and intermediate points not to exceed 30 ft. spacing. For multiple floors, provide lateral restraint at each floor, not to exceed 30 ft. spacing. No-Hub Cast Iron pipe shall have riser joint brace assembly installed at each unsupported joint between floors. Individual vertical and lateral supports shall be designed for pipe risers in buildings with 6 or more floors.

XVI. Maximum brace member length when using Tolstrut A12 channel is 9'-6", Maximum brace member length when using 1" sch. 40 pipe is 7'-0"; 1 1/4" sch. 40 pipe is 9'-0"; 1 1/2" sch. 40 pipe is 10'-4" and 2" sch. 40 pipe is 13'-1".

XVII. When using Tolstrut channel nuts to attach to Tolstrut channel bracing, tighten the bolts and nuts to the following torques. Hex nuts on braced trapeze hanger rods must also be torqued to these values.

1/4" = 5ft./lbs. 3/8" = 19ft./lbs. 1/2" = 50ft./lbs. 5/8" = 100 ft./lbs. 3/4" = 125 ft./lbs.

XVIII. The following Tolco products were engineered with torque indicators to ensure proper installation:

Fig. 907 & Fig. 909 No-Thread Swivel Sway Brace Attachments have a connecting bolt head that bottoms out.

Fig. 980 & Fig. 981 Universal Swivel Sway Brace Attachments have a break-off bolt head.

Fig. 990 & Fig. 991 Cable Sway Brace Attachments have break-off nuts.

Fig. 1000, Fig. 2001 & Fig. 2002 Sway Brace Attachments have material that flattens out or comes together to ensure proper engagement.

Fig. 1001 Sway Brace Attachment has bolt heads that bottom out.

Fig. 800 & Fig. 825 Adjustable Sway Brace Attachment to Steel and Bar Joist have break-off head bolts.

XIX. Refer to the appropriate codes and standards for additional information and requirements.
4.0 SEISMIC BRACING GENERAL REQUIREMENTS - DUCTS

I. Seismic restraints are required for the following duct installations:

a) All ducts containing hazardous gases or exhaust unless exempt by specification or engineer of record.

b) All round ducts 28" in diameter and larger.

c) All square and rectangular ducts 6 sq. ft. in cross sectional area and larger.

Exceptions

All ducts suspended by hanger straps 12 inches or less in length from the top of the duct to the bottom of the support structure where the hanger is connected. The strap hangers must be attached within 2 inches of the top of the duct with a minimum of two #10 sheet metal screws.

Trapeze supported systems suspended 12 inches or less from the top of the trapeze to the bottom of the support structure where trapeze is connected provided that any changes in direction allow for flexibility in the system. Examples would be flexible connections to equipment or long offsets.

In both exceptions above, all of the hangers in a run must comply with the 12 inch rule or bracing is required.

The 12 inch rod rule exception has additional requirements, they are as follows:

a) Lateral motion of duct will not cause damaging impact with other systems (e.g. other duct, pipes or electrical systems, equipment, structural members etc., or fragile appurtenances such as sprinkler heads or lighting fixtures) or loss of system vertical support.

b) Duct must be made of ductile material with ductile connections.

c) Vertical hanger top connections to the building structure cannot develop moments (this can be accomplished by using a Tolco Fig. 102L Linked Eye Rods, Fig. 306 turnbuckle with Swivel or Toitnut Swivel Connections at the building structure connection).

II. Transverse bracing shall be provided at 30 ft. maximum spacing for ducts conforming to SMACNA standards.

III. Longitudinal bracing shall be provided at 60 ft. maximum spacing for ducts conforming to SMACNA standards.

IV. Fiberglass, Plastic or other duct constructed of non-ductile material, shall have the brace spacing reduced to one-half of the maximum spacing for transverse and longitudinal braces listed above.

V. Duct bracing for square, rectangle or oval duct consists of a trapeze support with two support rods to carry the gravity dead load. The trapeze must have a support member connected to the top of the duct and to the bottom of duct. Both trapeze members are connected to the duct with #10 sheet metal screws spaced at maximum 12" O.C. Support rods may need to be stiffened. Transverse and/or longitudinal bracing is then attached to the top of the upper trapeze member.
VI. Wall penetrations may be considered transverse bracing where duct is framed tight and secure.

VII. Ducts may be combined on a single support and braced based on their combined weight.

VIII. Equipment or devices installed within a run of duct shall be braced separately from the duct when weighing 50 lbs. or more and rigidly attached to duct, or weighing 20-49 lbs. and is connected to the duct with flexible connection.

IX. Floor penetrations may be considered transverse and longitudinal bracing when duct is framed tight and secure and change in direction does not exceed the maximum allowable offset length of two times the duct width as measured from the floor penetration to the inside of a 90 degree turn.

X. Maximum brace member length when using Tolstrut A12 channel is 9'-6". Maximum brace length when using 1" sch. 40 pipe is 7'-0"; 1 1/4" sch. 40 pipe is 9'-0"; 1 1/2" sch. 40 pipe is 10'-4"; 2" sch. 40 pipe is 13'-1".

XI. When using Tolstrut channel nuts to attach Tolstrut channel bracing tighten the bolts and nuts to the following torques. Hex nuts on braced trapeze hanger rods must also be torqued to these values.

1/4" = 6 ft./lbs. 3/8" = 19 ft./lbs. 1/2" = 50 ft./lbs. 5/8" = 100 ft./lbs. 3/4" = 125 ft./lbs.

XII. The following Tolco products were engineered with torque indicators to ensure proper installation:

Fig. 907 & Fig. 909 No-Thread Swivel Sway Brace Attachments have a connecting bolt head that bottoms out.

Fig. 980 & Fig. 981 Universal Swivel Sway Brace Attachments have a break-off bolt head.

Fig. 990 & Fig. 991 Cable Sway Brace Attachments have break-off nuts.

Fig. 1000, Fig. 2001 & Fig. 2002 Sway Brace Attachments have material that flattens out or comes together to ensure proper engagement.

Fig. 1001 Sway Brace Attachment has bolt heads that bottom out.

Fig. 800 & Fig. 825 Adjustable Sway Brace Attachment to Steel and Bar Joist have break-off head bolts.

XIII. Refer to the appropriate codes and standards for additional information and requirements.
5.0 SEISMIC BRACING GENERAL REQUIREMENTS - ELECTRICAL SYSTEMS

I. Seismic restraints are required for the following electrical installations:

a) All conduits 2 1/2" trade size and larger.

b) All conduits, cable trays, and trapeze assemblies weighing 10 lbs./ft. or greater.

Exceptions

All conduit or cable trays suspended by individual hanger rods 12 inches or less in length from the top of the conduit to the bottom of the support structure where hanger is connected.

Trapeze supported systems suspended 12 inches or less from the top of the trapeze to the bottom of the support structure where trapeze is connected, provided that any changes in direction allow for flexibility in the system. Examples would be flexible connections to equipment or long offsets.

In both exceptions above, all of the hangers of a run must comply with the 12 inch rule or bracing is required.

The 12 inch rod rule exception has additional requirements, they are as follows:

a) Lateral motion of the electrical system will not cause damaging impact with other systems (e.g. other electrical systems, piping, duct, equipment, structural members etc., or fragile appurtenances such as sprinkler heads or lighting fixtures) or loss of system vertical support.

b) Electrical system must be made of ductile material with ductile connections.

c) Vertical hanger top connection to the building structure cannot develop moments (this can be accomplished by using a Tolco Fig. 102L Linked Eye Rods, Fig. 308 turnbuckle with Swivel or Tolstrut Swivel Connections at the building structure connection).

II. Transverse bracing shall be provided at 40 ft. maximum spacing.

III. Longitudinal bracing shall be provided at 80 ft. maximum spacing.

IV. Conduits constructed of non-ductile materials shall have the brace spacing reduced to one half of the maximum spacing for transverse and longitudinal braces listed above.

V. All braces shall be located at or within 4" of a vertical support, which may require a rod stiffener.

VI. When bracing trapeze supports, the bracing shall be attached directly to the trapeze, with conduits or cable trays secured to the trapeze with straps, conduit clamps, or cable tray clips bolted to Tolstrut. A minimum of one transverse brace and/or two longitudinal braces is required.
VII. Stacked trapezes supported by the same rods shall be braced independently from one another. The rod supports in each section may require stiffening.

VIII. At conduit risers, provide lateral restraint at the top and bottom of the riser, and intermediate points not to exceed 30 ft. Individual vertical and lateral supports shall be designed for conduit risers in buildings with 6 or more floors.

IX. Maximum brace member length when using Tolstrut A12 channel is 9'-6". Maximum brace member length when using 1" sch. 40 pipe is 7'-0"; 1 1/4" sch. 40 pipe is 9'-0"; 1 1/2" sch. 40 pipe is 10'-4"; 2" sch. 40 pipe is 13'-1".

X. When using Tolstrut channel nuts to attach Tolstrut channel bracing tighten the bolts and nuts to the following torques. Hex nuts on braced trapeze hanger rods must also be torqued to these values.

1/4" = 6ft./lbs. 3/8" = 10ft./lbs. 1/2" = 50ft./lbs. 5/8" = 100 ft./lbs. 3/4" = 125 ft./lbs.

XI. The following Tolco products were engineered with torque indicators to ensure proper installation:

Fig. 907 & Fig. 909 No-Thread Swivel Sway Brace Attachments have a connecting bolt head that bottoms out.

Fig. 980 & Fig. 981 Universal Swivel Sway Brace Attachments have a break-off bolt head.

Fig. 990 & Fig. 991 Cable Sway Brace Attachments have break-off nuts.

Fig. 1000, Fig. 2001 & Fig. 2002 Sway Brace Attachments have material that flattens out or comes together to ensure proper engagement.

Fig. 1001 Sway Brace Attachment has bolt heads that bottom out.

Fig. 800 & Fig. 825 Adjustable Sway Brace Attachment to Steel and Bar Joist.

XII. Refer to the appropriate codes and standards for additional information and requirements.
6.0 SEISMIC BRACING LAYOUT - GENERAL REQUIREMENTS

I. The Tolco Seismic Restraint Guidelines provides for the protection of suspended pipe, ducts and electrical systems against excessive movement due to seismic forces.

II. The seismic restraint assemblies in this guideline are designed to simultaneously resist vertical and seismic horizontal loads.

III. Horizontal loads are braced with two types of seismic restraints;

   a) Transverse Brace to protect pipe, duct, or electrical conduit and cable tray against movement perpendicular to its run.

   b) Longitudinal Brace to protect pipe, duct, or electrical conduit and cable tray against movement parallel to its run.

IV. A run of pipe, duct or electrical conduit is defined as a straight length or one with allowable offsets. An allowable offset length for pipe or conduit is the allowable transverse brace spacing divided by 15. Ductwork allowable offset length is two times the duct width.

NOTE: When a run of pipe, duct or electrical conduit that requires bracing transitions down to a size that does not, the point of transition is considered the end of the run and will require a transverse brace.

V. Each run of pipe, duct, electrical conduit, or cable tray requires a minimum of two transverse braces. However, a longitudinal brace placed on the run section at the opposite side of an elbow or tee within 24" may act as a transverse brace, and is labeled a "DUAL USE" brace. See layout examples in the following pages.

VI. Each run of pipe, duct, electrical conduit, or cable tray requires a minimum of one longitudinal brace. However, a transverse brace placed on the run section at the opposite side of an elbow or tee within 24" may act as a longitudinal brace, and is labeled a "DUAL USE" brace. See layout examples in the following pages.

   a) Longitudinal and "DUAL USE" braces on single supported pipe or conduit shall be attached directly to the pipe or conduit.

   b) Branch lines of smaller diameter shall not be used to brace larger piping.

VII. When pipe, duct or electrical systems cross a building seismic separation or seismic joint they must be capable of accommodating the joint displacements as specified by the engineer of record.

VIII. A rigid pipe, duct or electrical system shall not be braced to dissimilar parts of a building structure or two dissimilar building systems that may move differentially from one another during an earthquake. Bracing should be attached to the part of the building structure that is supporting the pipe, duct or electrical conduit.
IX. Transverse and longitudinal braces shall be installed as shown in this guideline up to 45° from horizontal, or 1 (vert.): to 1 (horiz.) brace angle ratio. Spacing for additional brace angles may be achieved by the following:

For up to 1.5 (vert.):1 (horiz.), divide brace spacing by 1.67.
For up to 2 (vert.):1 (horiz.), divide brace spacing by 2.33.

Example: A 45° or 1 (vert.):1 (horiz.) brace angle ratio maximum allowable transverse spacing of 40 ft. divided by 1.67 = 23 ft. for a 1.5 (vert.):1 (horiz.) brace angle ratio.

X. All transverse and longitudinal braces utilizing Tolstrut channel or sch. 40 steel pipe with Tolco Fig. 900 series fittings on both ends have an alignment tolerance of 2-1/2" from center without adversely affecting the given loads. This applies to single hanger pipe, duct or electrical conduit supports as well as trapeze hanger supports.

XI. The seismic brace assemblies in this guideline consist of three important components: Anchorage and connections to building structure, brace member such as strut, pipe or angle iron, and seismic brace attachments. For details and load information of structural attachments see "Structural Attachments" section. For details of brace assemblies see applicable "Brace Details" section(s).

XII. Seismic brace locations are required to be at or within 4 inches of a vertical hanger assembly to protect against vertical movement. When the vertical hanger assembly consists of threaded rod for support it may be necessary to provide a stiffener. An exception to this would be the use of two opposing rigid braces at the same location. In this case no additional vertical support is necessary.

XIII. At a rigid brace location, threaded rod and their building attachment components used in a vertical hanger assembly may need to be increased in size due to the additional seismic tension loads placed upon them. To determine if the vertical hanger assembly is adequate, make sure that the maximum allowable load of its components is greater than or equal to the pipe, duct or electrical system gravity load plus any additional seismic loads.

Example: Vertical hanger assembly for 6" sch. 40 water filled pipe supported from concrete slab at 15 ft. spacing.

Gravity load = 473 lbs.
Longitudinal brace spaced at maximum 80 ft.
Using .5g, horizontal seismic load = 1,250 lbs.
Total tension load = 1,733 lbs

Allowable Load
Concrete attachment is the Tolco Figure 109F Concrete Insert for 3/4" = 2,560 lbs
3/4" all thread rod, Tolco Figure 100 = 2,710 lbs
Pipe hanger is Tolco Figure 1 Clevis Hanger = 1,940 lbs

Total tension load is 1,733 lbs. The weakest component load of the vertical hanger assembly is 1,940 lbs. Therefore no additional support is necessary.
7.0 SEISMIC BRACING LAYOUT - GENERAL PROCEDURE

The following pages outline the steps to take when laying out the placement of seismic bracing for a mechanical or electrical system. Refer to the appropriate codes and standards for additional information and requirements.

I) Begin by separating the system to be braced into individual runs of pipe, conduit or duct. A run is defined as a section between two changes in direction. A single run may have an offset or several offsets. These minor directional changes may be ignored if the overall distance perpendicular to the run does not exceed 1/16 of the maximum allowable transverse spacing.

Example: If you have a pipe run of that does not exceed 40' and your maximum allowable transverse spacing is 40', you can have an offset in this pipe run up to 2'-6" (40'/16). For pipe of non-ductile material including threaded steel or copper pipe, or pipe with non-listed grooved connections, you can have an offset of up to 1'-3" (20'/16).

II) Each run must be braced in the transverse direction at each end of the run.

If the distance between the two transverse braces exceeds the maximum allowable spacing, add transverse braces as needed.
Example: If you have a run to brace that is 80 ft. long, first place transverse braces at each end. One more brace is required along this run so that the maximum spacing of 40 ft. is not exceeded.

III) Each pipe run must have at least one longitudinal brace. If the maximum allowable longitudinal spacing is exceeded then add longitudinal braces to meet the spacing requirement.

Example: If you have a pipe run that is 120 ft. long, first place one longitudinal brace along the run, then place additional longitudinal braces so the maximum allowable spacing is not exceeded.

To increase the efficiency of your bracing, a "DUAL USE" transverse brace within 24" of a 90 degree elbow on an adjacent run can be used as a longitudinal brace for the run being considered.

A "DUAL USE" brace must:

a) Have a capacity exceeding the combined total of applied transverse and longitudinal loads

b) Be designated as a "DUAL USE" brace by detail note (brace attached directly to pipe).

Example: If you have a pipe run that is 120 ft long, an adjacent "DUAL USE" transverse brace acts as a longitudinal brace for this run. The spacing is half the distance to the next longitudinal brace plus half the distance to the adjacent transverse brace plus 2 feet, total 62 ft.
IV) In some cases several short runs may occur in close proximity. By following the preceding guidelines each run should have longitudinal and transverse bracing. Transverse bracing may be used as longitudinal bracing and vice versa on runs adjacent to each other as long as the total length of pipe tributary to the brace does not exceed the maximum allowable spacing. In cases where it does, additional braces are required.

Example: If the offsets are greater than the allowable length, the pipe sections cannot be treated as one run. However, the number of braces can be minimized by using transverse braces as longitudinal braces and vice versa.

V) At vertical pipe drop to mechanical equipment, where pipe is connected to the equipment using a flexible connection, provide transverse bracing before the vertical drop. The total length from the transverse brace to the vertical drop should not be more than the allowable offset previously determined. Provide transverse bracing at the floor after the vertical drop if the total length of the pipe from the transverse brace before the vertical drop to the flexible connection is greater than ½ of the maximum transverse brace spacing.
8.0 GENERAL DESIGN PROCEDURE - SINGLE HANGER BRACING

The following presents a general procedure for design of seismic bracing for single rod hangers for piping and conduit. The following assumes that a piping, duct, or conduit design layout has been provided, and that gravity hanger supports have been designed by others. The following also assumes that seismic bracing has been determined to be required. Refer to the appropriate codes and standards for additional information and requirements.

I. Seismic Force Coefficient

Determine the total design lateral seismic force coefficient based on the applicable code, project drawings, and specifications. This coefficient is commonly referred to as the "G-factor"; i.e. \( F_p = .5G \). In case of a conflict, use the more stringent criteria. The total design lateral seismic force coefficient, when multiplied by the weight of the piping, duct, or conduit, represents the total design lateral seismic force.

According to the California Building Code, CBC 2001 (use appropriate formula for other codes including the International Building Code, IBC 2000), the total design lateral seismic force, \( F_p \), shall be determined from the following formula. The final \( F_p \) shall be divided by 1.4 to convert the strength based seismic force to the allowable stress based seismic force. This is necessary because the loads and brace spacing in this manual are based on the allowable stress design.

\[
F_p = \frac{a_p \, C_a \, I_p}{R_p} \left( 1 + 3 \, \frac{h}{r} \right) \, W_p
\]

Except that:

- \( F_p \) shall not be less than 0.7 \( C_a \, I_p \, W_p \) and
- \( F_p \) shall not be more than 4.0 \( C_a \, I_p \, W_p \)

\( C_a \) is the Seismic Coefficient and shall be taken from Table 16A-Q.

\( I_p \) is the Importance Factor and shall be taken from Table 16A-K.

\( W_p \) is the operating weight.

\( a_p \) is the in-structure Component Amplification Factor that varies from 1.0 to 2.5. It shall be taken from Table 16A-O.

\( R_p \) is the Component Response Modification Factor that shall be taken from Table 16A-Q, except that \( R_p \) for anchorages shall equal 1.5 for shallow expansion anchor bolts, shallow chemical anchors or shallow cast-in-place anchors. Shallow anchors are those with an embedment depth less than 8 times its diameter. When anchorage is constructed of non-ductile materials, or by use of adhesive, \( R_p \) shall equal 1.0.
hx is the element or component attachment elevation with respect to grade. hx shall not be taken less than 0.0. The value of hx/hr need not exceed 1.0.

hr is the structure roof elevation with respect to grade.

Refer to CBC 2001, other appropriate code, or standard, for additional information and requirements.

II. Seismic Bracing Detail

Select a seismic bracing detail from the section "Single Hanger Rigid Brace Details" or "Single Hanger Cable Brace Details".

III. Structural Attachment Detail

Select a structural attachment detail from the section "Single Hanger Rigid Brace Spacing Charts", "Single Hanger Cable Brace Spacing Charts", and/or "Structural Attachments".

IV. Brace Spacing

Determine the maximum transverse and longitudinal brace spacing from the section "Single Hanger Rigid Brace Spacing Charts", "Single Hanger Cable Brace Spacing Charts", and/or "Structural Attachments". This brace spacing is based on the allowable loads for the specific structural attachment detail previously selected, or the weakest component of the brace assembly.

The brace spacing listed is based on the pipe size, maximum pipe weight per ft., and the total design lateral seismic force coefficients of 0.5G and 1.0G. To determine the maximum allowable spacing for other G-factors, use the spacing charts provided for 1.0G and divide the spacing given for the applicable pipe size or weight per ft. by the project specific G-factor, as previously determined.

The brace spacing shall not exceed the maximum allowable brace spacing based on the requirements listed in the general notes section. When using components other than those shown in the bracing details, components must be checked for adequacy to support the applied loads. Maximum allowable loads of these components are listed in the section "Seismic Bracing Components".

When using single brace rigid bracing, brace spacing may be limited by the gravity hanger support system and its attachment to the structure due to the additional vertical load which is equal to the horizontal seismic load (for brace at 45 degrees; for other angles calculate appropriate vertical component based on the angle) applied by the seismic bracing on the gravity hanger support system. Verify that the hanger support system and its attachment to the structure are adequate for the applied gravity load plus vertical seismic force equal to the maximum horizontal seismic force (for brace at 45 degrees; for other angles calculate appropriate vertical component based on the angle), and any other vertical seismic force required per the seismic criteria. The maximum horizontal seismic load is equal to the G-factor x maximum weight per foot x brace spacing.
V. Brace Member

Select a brace member and determine its total length. A brace member may be Tolstrut channel or sch. 40 steel pipe. Maximum allowable horizontal seismic loads and maximum allowable lengths for the different brace members are listed in the section "Seismic Brace Components". The maximum applied horizontal seismic load shall be equal to or less than the maximum allowable horizontal seismic loads. The maximum applied horizontal seismic load is equal to the G-factor x maximum weight per foot x brace spacing.

VI. Rod Stiffener

Determine if rod stiffener is required. Maximum rod lengths for various rod diameters are listed in the section "Seismic Bracing Components". Rod stiffener may not be required when using double brace rigid bracing.

VII. Bracing Layout

Layout the seismic bracing as explained in the previous section "Seismic Bracing Layout Procedure".
9.0 GENERAL DESIGN PROCEDURE - TRAPEZE BRACING

The following presents a general procedure for design of seismic bracing for trapeze for piping, HVAC ducts, conduits and cable trays. The following assumes that a piping, duct, conduit, or cable tray design layout has been provided, and that gravity trapeze supports have been designed and located by others. Larger piping and heavier electrical systems may require special trapeze support design for gravity and seismic loads beyond the scope of this manual. The following also assumes that seismic bracing has been determined to be required. Refer to the appropriate codes and standards for additional information and requirements.

I. Seismic Force Coefficient

Determine the total design lateral seismic force coefficient based on the applicable code, project drawings, and specifications. This coefficient is commonly referred to as the "G-factor"; i.e. Fp = .5G. In case of a conflict, use the more stringent criteria. The total design lateral seismic force coefficient, when multiplied by the weight of the piping, duct, or conduit, represents the total design lateral seismic force.

According to the California Building Code, CBC 2001 (use appropriate formula for other codes including the International Building Code, IBC 2000), the total design lateral seismic force, Fp, shall be determined from the following formula. The final Fp shall be divided by 1.4 to convert the strength based seismic force to the allowable stress based seismic force. This is necessary because the loads and brace spacing in this manual are based on the allowable stress design.

\[ F_p = apCaIp/Rp \left(1 + 3\frac{hxhr}{Wp}\right) \]

Except that:

Fp shall not be less than 0.7 Ca Ip Wp and
Need not be more than 4.0 Ca Ip Wp

Ca is the Seismic Coefficient and shall be taken from Table 16A-Q.

Ip is the Importance Factor and shall be taken from Table 16A-K.

Wp is the operating weight.

ap is the in-structure Component Amplification Factor that varies from 1.0 to 2.5. It shall be taken from Table 16A-O.

Rp is the Component Response Modification Factor that shall be taken from Table 16A-O, except that Rp for anchorages shall equal 1.5 for shallow expansion anchor bolts, shallow chemical anchors or shallow cast-in-place anchors. Shallow anchors are those with an embedment depth less than 8 times its diameter. When anchorage is constructed of non-ductile materials, or by use of adhesive, Rp shall equal 1.0.
hx is the element or component attachment elevation with respect to grade. hx shall not be taken less than 0.0. The value of hx/hr need not exceed 1.0.

hr is the structure roof elevation with respect to grade.

Refer to CBC 2001, other appropriate code, or standard, for additional information and requirements.

II. Seismic Bracing Detail

Select a seismic bracing detail from the section "Trapeze Rigid Brace Details" or "Trapeze Cable Brace Details".

III. Structural Attachment Detail

Select a structural attachment detail from the section "Trapeze Rigid Brace Spacing Charts", "Trapeze Cable Brace Spacing Charts", and/or "Structural Attachments".

IV. Brace Spacing

Determine the maximum transverse and longitudinal brace spacing from the section "Trapeze Rigid Brace Spacing Charts", "Trapeze Cable Brace Spacing Charts", and/or "Structural Attachments". This brace spacing is based on the allowable loads for the specific structural attachment detail previously selected, or the weakest component of the brace assembly.

The brace spacing listed is based on the pipe size, maximum pipe weight per ft., and the total design lateral seismic force coefficients of 0.5G and 1.0G. To determine the maximum allowable spacing for other G-factors, use the spacing charts provided for 1.0G and divide the spacing given for the applicable pipe size or weight per ft by the project specific G-factor, as previously determined.

The brace spacing shall not exceed the maximum allowable brace spacing based on the requirements listed in the general notes section. When using components other than those shown in the bracing details, components must be checked for adequacy to support the applied loads. Maximum allowable loads of these components are listed in the section "Seismic Bracing Components".

When using trapeze rigid bracing, brace spacing may be limited by the gravity trapeze support system and its attachment to the structure due to the additional vertical load which is equal to the horizontal seismic load (for brace at 45 degrees; for other angles calculate appropriate vertical component based on the angle) applied by the seismic bracing on the gravity trapeze support system. Verify that the trapeze support system and its attachment to the structure are adequate for the applied gravity load plus vertical seismic force equal to the maximum horizontal seismic force (for brace at 45 degrees; for other angles calculate appropriate vertical component based on the angle), and any other vertical seismic force required per the seismic criteria. The maximum horizontal seismic load is equal to the G-factor x maximum weight per foot x brace spacing.
V. Attachment to Toistrut

Verify the adequacy of the pipe, duct, conduit, or cable tray attachment to the strut. The attachment must be adequate to transfer transverse, longitudinal, and vertical seismic loads to the strut.

VI. Trapeze Support Member

Determine the adequacy of the trapeze to carry the seismic loads in addition to the gravity loads. The trapeze has been designed previously to carry the gravity loads only. The transverse seismic loads will apply an axial load and an additional bending. The longitudinal seismic loads will also apply additional bending. The trapeze support member may need to be increased in size.

VII. Brace Member

Select a brace member and determine its total length. A brace member may be Toistrut channel or sch. 40 steel pipe. Maximum allowable seismic horizontal loads and maximum allowable lengths for the different brace members are listed in the section "Seismic Brace Components". The maximum applied horizontal seismic load shall be equal to or less than the maximum allowable horizontal seismic loads. The maximum applied horizontal seismic load is equal to the G-factor x maximum weight per foot x brace spacing.

VIII. Rod Stiffener

Determine if rod stiffeners are required. Maximum rod lengths for various rod diameters are listed in the section "Seismic Bracing Components". Rod stiffener may not be required when using double brace rigid bracing.

IX. Bracing Layout

Layout the seismic bracing as explained in the previous section "Seismic Bracing Layout Procedure".