1.0 INTRODUCTION

I. 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, steel beams, bar joists and wood beams.

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

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

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

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

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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, and fittings as well as other miscellaneous hardware see the Tolco Pipe Hanger and Support Catalog or the Tolstrut 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.

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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.)

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2.0 BUILDING CODES, STANDARDS, & GUIDELINES

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

2007 California Building Code (CBC 2007)

2001 California Building Code (CBC 2001)

1998 California Building Code (CBC 1998)

1997 Uniform Building Code (UBC 1997)

2006 International Building Code (IBC 2006)

2003 International Building Code (IBC 2003)

2000 International Building Code (IBC 2000)

1999 National Building Code (NBC 1999)

1999 Standard Building Code (SBC 1999)

2007 National Fire Protection Association Pamphlet 13 (NFPA-13 2007)

2002 National Fire Protection Association Pamphlet 13 (NFPA-13 2002)

1999 National Fire Protection Association Pamphlet 13 (NFPA-13 1999)

1998 Seismic Restraint Manual Guidelines for Mechanical Systems (SMACNA) w/ Addendum No. 1, 2000

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 trapeze 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.

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3.0 SEISMIC BRACING GENERAL REQUIREMENTS - PIPING

I. Seismic restraints are required for the following piping installations

(CBC 2001, CBC 1998, UBC 1997)

a) Medical gas, vacuum pipe, compressed air and other hazardous pipe 1" diameter and larger

b) Fuel piping 1" diameter and larger

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

d) All piping 2 1/2" diameter and larger

e) Trapeze supported pipe weighing 10 lbs/ft or more

f) Trapeze supported piping that would require seismic bracing if supported idividually. (Note: All trapeze assemblies supporting pipes shall be braced considering the total weight of the pipes on the trapeze.)

(CBC 2007, IBC 2006, IBC 2003, IBC 2000)

a) All piping 1 1/4" diameter and larger where Seismic Design Category is D, E or F and Ip is greater than 1.0

b) All piping 3 1/2" diameter and larger where Seismic Design Category is D, E or F and Ip is equal to 1.0

c) All piping 2 1/2" diameter and larger where Seismic Design Category is C and Ip is greater than 1.0

d) All piping and trapeze supported piping weighing more than 10 lbs/ft with Ip of equal to or greater than 1.0 in Seismic Design Category D, E or F or with Ip of greater than 1.0 in Seismic Design Category C

e) Trapeze supported piping that would require seismic bracing if supported individually

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.

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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. 75 Swivel Fitting, Fig. 306 turnbuckle with Swivel or Tolstrut Swivel connections at the building structure connection).

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

VII. 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.

VIII. Single Rigid Braces and Cable Braces shall be located at or within 4" of the vertical pipe support, which may require a rod stiffener (See page 11-20 and 11-21).

IX. 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 on 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.

X. 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 /or two longitudinal braces is required.

XI. Stacked trapezes supported by the same rods shall be braced independently from one another. The rod supports in each section may require stiffening (See page 11-20 and 11-21).

XII. Bracing installed on smaller piping shall not be used to brace larger piping.

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XIII. A piping system shall not be braced to different parts of the building that may respond differently during seismic activity.

XIV. 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.

XV. See page 11-23 for Maximum Brace Member Lengths.

XVI. When using Tolstrut channel nuts to attach to 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" = 19ft./lbs.
1/2" = 50ft./lbs.
5/8" = 100 ft./lbs.
3/4" = 125 ft./lbs.

XVII. 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. 985 & Fig. 986 Swivel Sway Brace Attachments have a break-bolt head & multiple rod size attachment.

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.

XVIII. Refer to the appropriate codes and standards for additional information and requirements.

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4.0 SEISMIC BRACING GENERAL REQUIREMENTS - DUCTS

I. Seismic restraints are required for the following piping installations

(CBC 2001, CBC 1998, UBC 1997)

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 having a cross-sectional area of 6 sq. ft. or larger

d) Equipment installed within a run of duct weighing 50 lbs or more and rigidly attached to duct or weighing 20 lbs or more and flexibly attached to duct.

(IBC 2006, IBC 2003, IBC 2000)

a) All ducts having a cross-sectional area of 6 sq. ft. or larger where Seismic Design Category D, E or F and Ip is equal to 1.0

b) All ducts weighing more than 5 lb/ft where Seismic Design Category C, D, E, or F and Ip is greater than 1.0

c) Equipment installed within a run of duct weighing 75 lbs or more where Seismic Design Category D, E or F and Ip is equal to or greater than 1.0 or where Seismic Design Category C and Ip is greater than 1.0.

(CBC 2007)

a) All ducts having a cross-sectional area of 6 sq. ft. or larger where Seismic Design Category D, E or F and Ip is equal to or greater than 1.0 or where Seismic Design Category C and Ip is greater than 1.0

b) Equipment installed within a run of duct weighing 75 lbs or more where Seismic Design Category D, E or F and Ip is equal to or greater than 1.0 or where Seismic Design Category C and Ip is greater than 1.0.

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.

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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, Tolco Fig. 75 Swivel Fitting or Tolstrut 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. 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.

IX. See page 11-23 for Maximum Brace Member Lengths.

X. When using Tolstrut channel nuts to attach 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" = 19ft./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.

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

Fig. 985 & Fig. 986 Swivel Sway Brace Attachments have a break-off bolt head & multiple rod size attachment.

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.

XII. Refer to the appropriate codes and standards for additional information and requirements.

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5.0 SEISMIC BRACING GENERAL REQUIREMENTS - ELECTRICAL SYSTEMS

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

(CBC 2001, CBC 1998, UBC 1997)
a) All conduits 2-1/2" diameter and larger.

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

(CBC 2007, IBC 2006, IBC 2003, IBC 2000)
a) All conduits 3" diameter and larger where Seismic Design Category is D, E or F and Ip is equal to or greater than 1.0 or where Seismic Design Category is C and Ip is greater than 1.0

b) All conduits, cable trays and trapeze assemblies weighing more than 10 lbs./ft. where Seismic Design Category is D, E or F and Ip is equal to or greater than 1.0 or where Seismic Design Category is C and Ip is greater than 1.0.

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. 306 turnbuckle with Swivel, Tolco Fig. 75 Swivel Fitting 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.

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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. See page 11-23 for Maximum Brace Member Lengths.

X. When using Tolstrut channel nuts to attach 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" = 19ft./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. 985 & Fig. 986 Sway Brace Attachments have a break-off bolt head & multiple rod size attachment.

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.

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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.

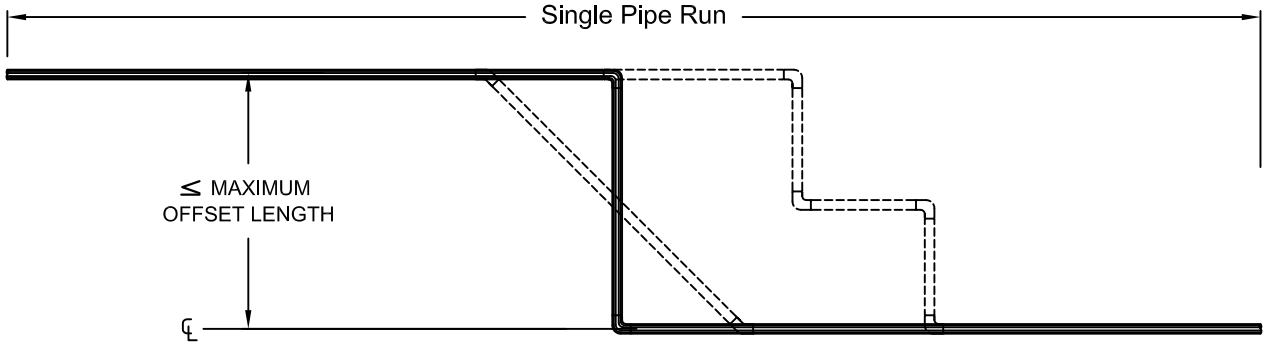
IV. A run of pipe, duct or electrical conduit is defined as a straight length, or one with allowable offsets, that is 10' or greater in length. An allowable offset length for pipe or conduit is the allowable transverse brace spacing divided by 16 or as noted below. Ductwork allowable offset length is two times the duct width.

STEEL PIPE OR CONDUIT

PIPE SIZE	MAX. OFFSET LENGTH		
	0.25g	0.5g	1.0g
1 1/4" - 2"	4' - 0"	2' - 0"	1' - 0"
2 1/2" - 3"	8' - 0"	4' - 0"	2' - 0"
4" - 5"	10' - 0"	6' - 0"	3' - 0"
6"	10' - 0"	10' - 0"	5' - 0"
8"	10' - 0"	10' - 0"	7' - 0"
10" - 12"	10' - 0"	10' - 0"	9' - 0"
14" - 24"	10' - 0"	10' - 0"	10' - 0"

COPPER PIPE

PIPE SIZE	MAX. OFFSET LENGTH		
	0.25g	0.5g	1.0g
2 1/2" - 3"	2' - 0"	1' - 0"	0' - 0"
4" - 5"	4' - 0"	2' - 0"	1' - 0"
6"	8' - 0"	4' - 0"	2' - 0"
8"	10' - 0"	8' - 0"	4' - 0"
10"	10' - 0"	10' - 0"	5' - 0"
12"	10' - 0"	10' - 0"	6' - 0"



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.

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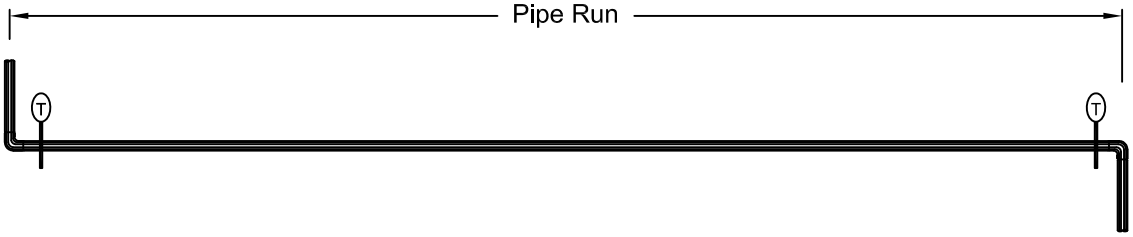
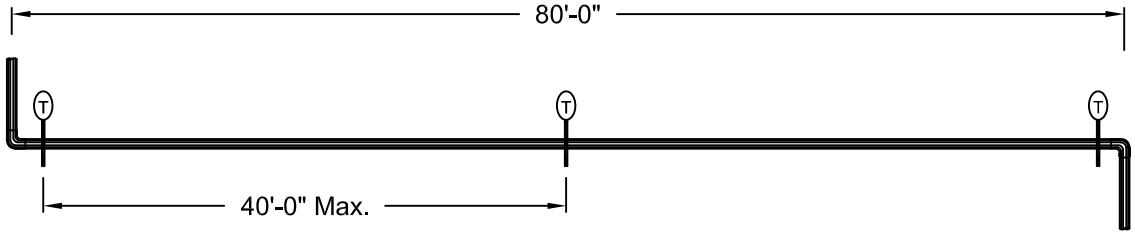
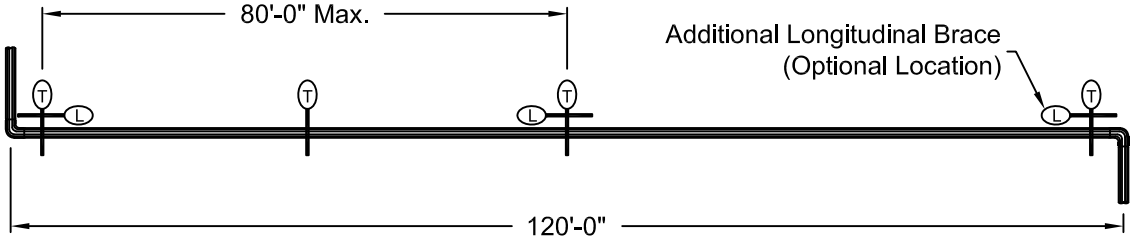
V. Each run of pipe, duct, electrical conduit, or cable tray requires a minimum of two transverse braces at each end of the run.



VI. If the distance between the two transverse braces exceeds the maximum allowable spacing, add transverse braces as needed.

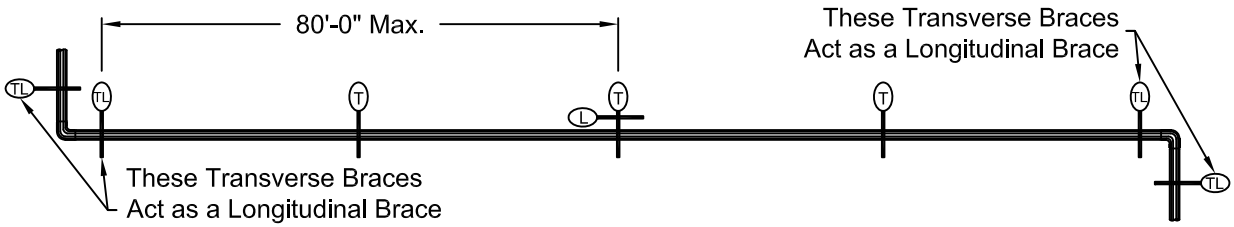


VII. Each pipe run must have at least one longitudinal brace. If the maximum allowable longitudinal spacing is exceeded then add longitudinal braces to meet the spacing requirement.



VIII. 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 example below.

a) Longitudinal and "DUAL USE" braces on single supported pipe or conduit shall be attached directly to the pipe or conduit.
b) Bracing installed to smaller piping shall not be used to brace larger piping.



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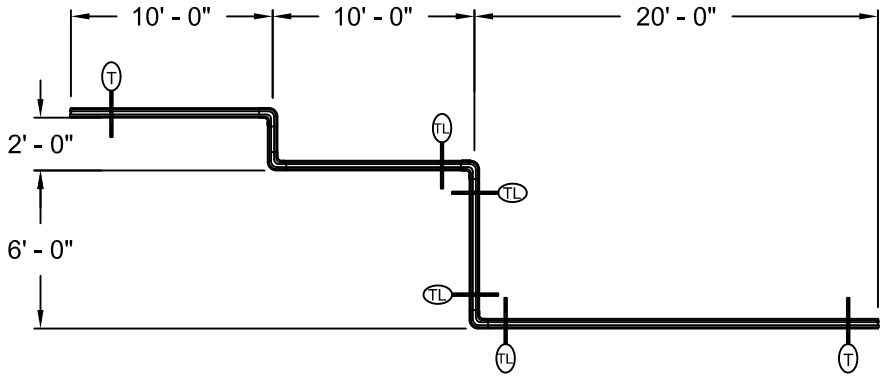
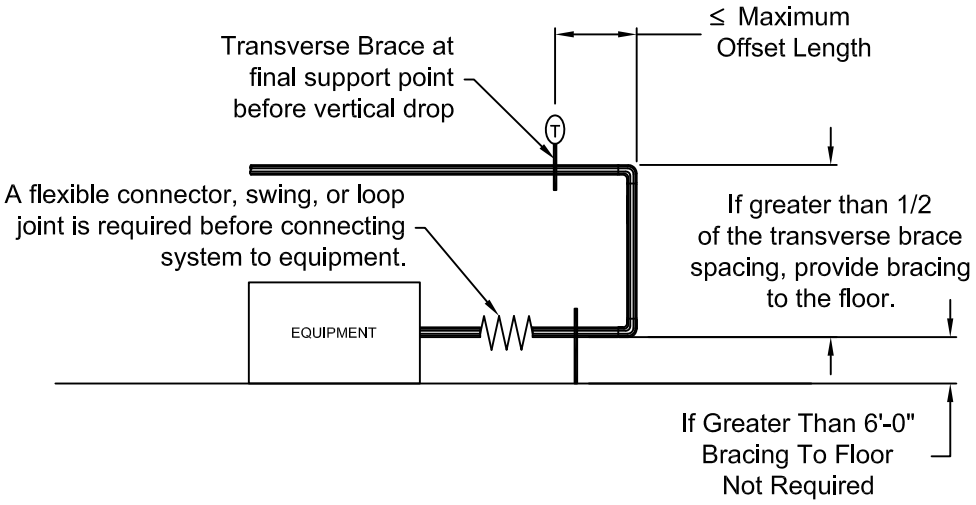
IX) In some cases several short runs may occur in close proximity. By following the preceding guidelines each run should have longitudinal and transverse bracing. Transverse bracing may be used as longitudinal bracing and vice versa on runs adjacent to each other as long as the total length of pipe tributary to the brace does not exceed the maximum allowable spacing. In cases where it does, additional braces are required.



X) 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.



XI. 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.

XII. 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.

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XIII. 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.)

XIV. All transverse and longitudinal braces utilizing strut 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 support. See page 11-23 for more information.

XV. 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 Section 10, for details of brace assemblies see applicable "Brace Details" section(s).

XVI. Single Rigid and Cable Bracing 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 (see page 11-20 and 11-21). 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.

XVII. 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 = 1,260 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.

XVII. Steel bolt connections to steel structure or components shall not have a diameter less than 1/16" less than the mounting hole. Steel bolt connections to concrete structure shall not have a diameter less that 1/8" less than the mounting hole.

XVIII. Bracing shall be omitted on runs less than 10ft. in total length.

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7.0 GENERAL DESIGN PROCEDURE - SINGLE HANGER AND TRAPEZE 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. 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 CBC 2001, CBC 1998 and UBC 1997 the total design lateral seismic force, Fp, and the total horizontal seismic force, Fv, shall be determined by from the following formulas. The final Fp or Fv 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.

Horizontal Seismic Force
Fp = ap Ca Ip/Rp (1 + 2 hx/hr) Wp

Except that:

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

Vertical Seismic Force
Fv = 0.35 Ca Ip Wp

Ca - Seismic Coefficient

Ip - Importance Factor

Wp - Operating weight.

ap - In-structure Component Amplification Factor

Rp - Component Response Modification Factor

hx - 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 - Structure roof elevation with respect to grade.

Refer to CBC 2001, CBC 1998 and UBC 1997 codes for additional information and requirements.

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According to the CBC 2007, IBC 2006, IBC 2003 and IBC 2000 the total design lateral seismic force, Fp, and the total horizontal seismic force, Fv, shall be determined from the following formulas. The final Fp, Fv 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.

Horizontal Seismic Force
Fp = 0.4 ap Sds Wp/Rp Ip(1 + 2(z/h)) Wp

Except that:

Fp shall not be less than 0.3 Sds Ip Wp and
Need not be more than 1.6 Sds Ip Wp

Vertical Seismic Force
Fv = 0.2 Sds Wp

Sds - Design spectral acceleration for short periods

ap - Component amplification factor

Ip - Component importance factor

Wp - Component operating weight

Rp - Component response modification factor

z - Height of structure at point of attachment with respect to the base

h - Average roof height of structure with respect to the base

Refer to CBC 2007, IBC 2006, IBC 2003, and IBC 2000 codes 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". Verify that the applied seismic force as calculated above is less than the allowable load noted in the detail.

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.

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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. Attachment to Strut (Trapeze Supported Systems Only)

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

VI. Trapeze Support Member (Trapeze Supported Systems Only)

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 Tolstrut channel or sch. 40 steel pipe. Maximum allowable horizontal seismic loads and maximum allowable lengths for the different brace members are listed on page 11-23. 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 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.

VIX. Bracing Layout

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

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