6801 Crossbow Drive • East Syracuse, New York 13057-1026
Telephone 315.437.1611 • **Toll Free 1-877-Tri-Flex (874-3539)** • Fax 315.437.1903
email:flexhose@flexhose.com

www.flexhose.com

Piping Systems and IBC / ASCE Requirements


SEISMIC MOVEMENT

Seismic Isolation of Piping Systems

- ➢Isolating mechanical equipment from building drift.
- ➢Determining what type of flexible connectors to use and why.
- ➢Seismic restraint of piping and bridging seismic joints in buildings.
- ➢Review of the current International Building Codes and U.S. Corp of Engineers ASCE 7-05 seismic requirements.
- ➢Design considerations for seismic isolation of mechanical piping covering building expansion joints and separations and forces contributed to snubbers and anchors
- ➢Overview of flexible loop technology and requirements to comply with the International Building Code (IBC) & ASCE Standard 7-05

SEISMIC AND WIND RESTRAINT DESIGN

Design and installation of seismic and wind restraints has the following primary objectives:

- To reduce the possibility of injury and threat to life
- To reduce long-term costs due to equipment damage and resultant downtime

ASHRAE 2003 HVAC Applications Chapter #54

Bridging building seismic joints is a major problem confronting engineers designing, installing and maintaining pipe systems.

- Isolating mechanical equipment from building drift
- FEMA #2 cause of property damage is failure of gas/water lines
- Bridging seismic joints with flexible loop technology will improve performance impact UFGS 15070

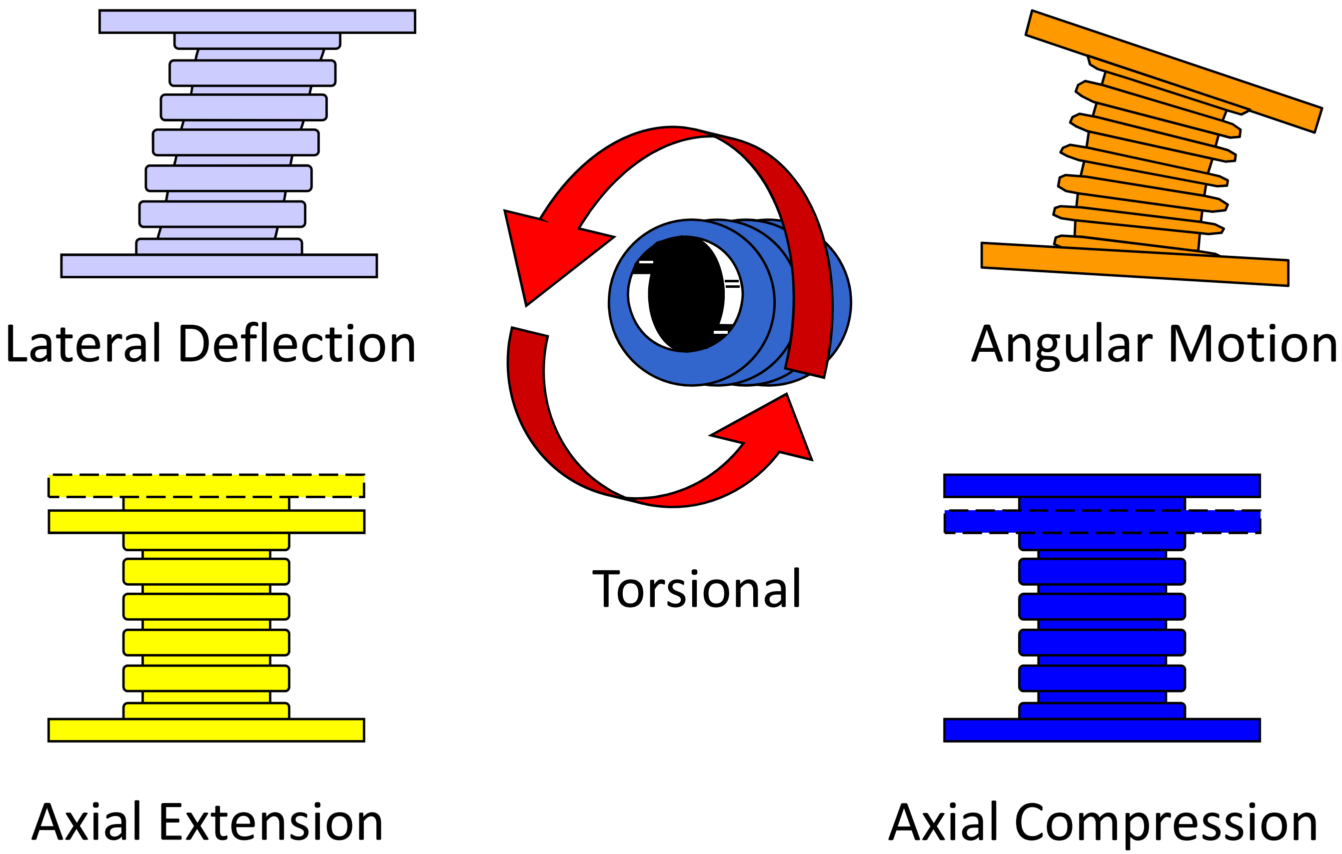
INSTALLATION CONSIDERATIONS

The following should be considered when installing seismic restraints:

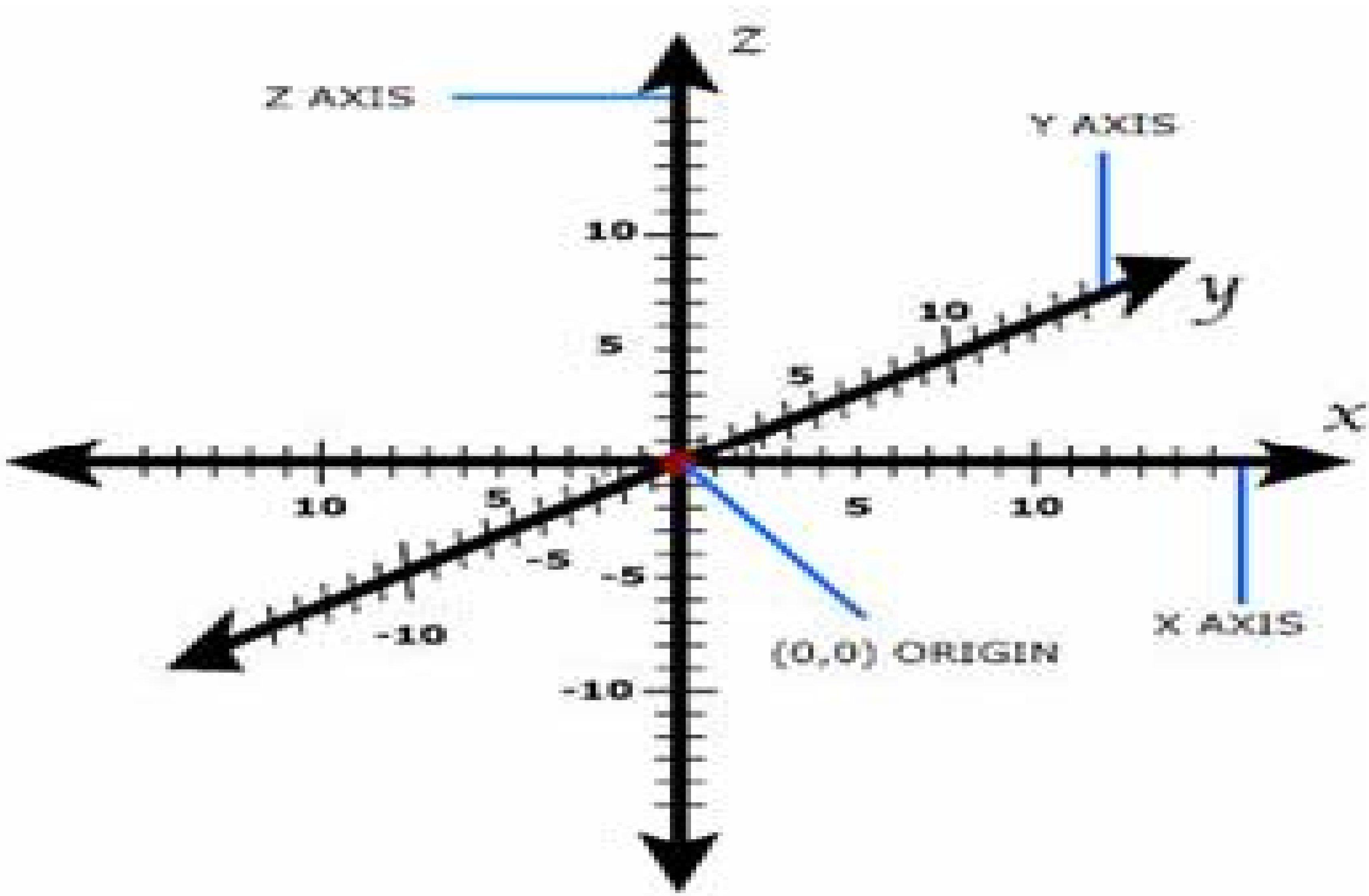
- Flexible connections should be provided between equipment that is braced and piping and ductwork that need not be braced.
- Flexible connections should be provided between isolated equipment and braced piping and ductwork.

ASHRAE 2003 HVAC Applications Chapter #54

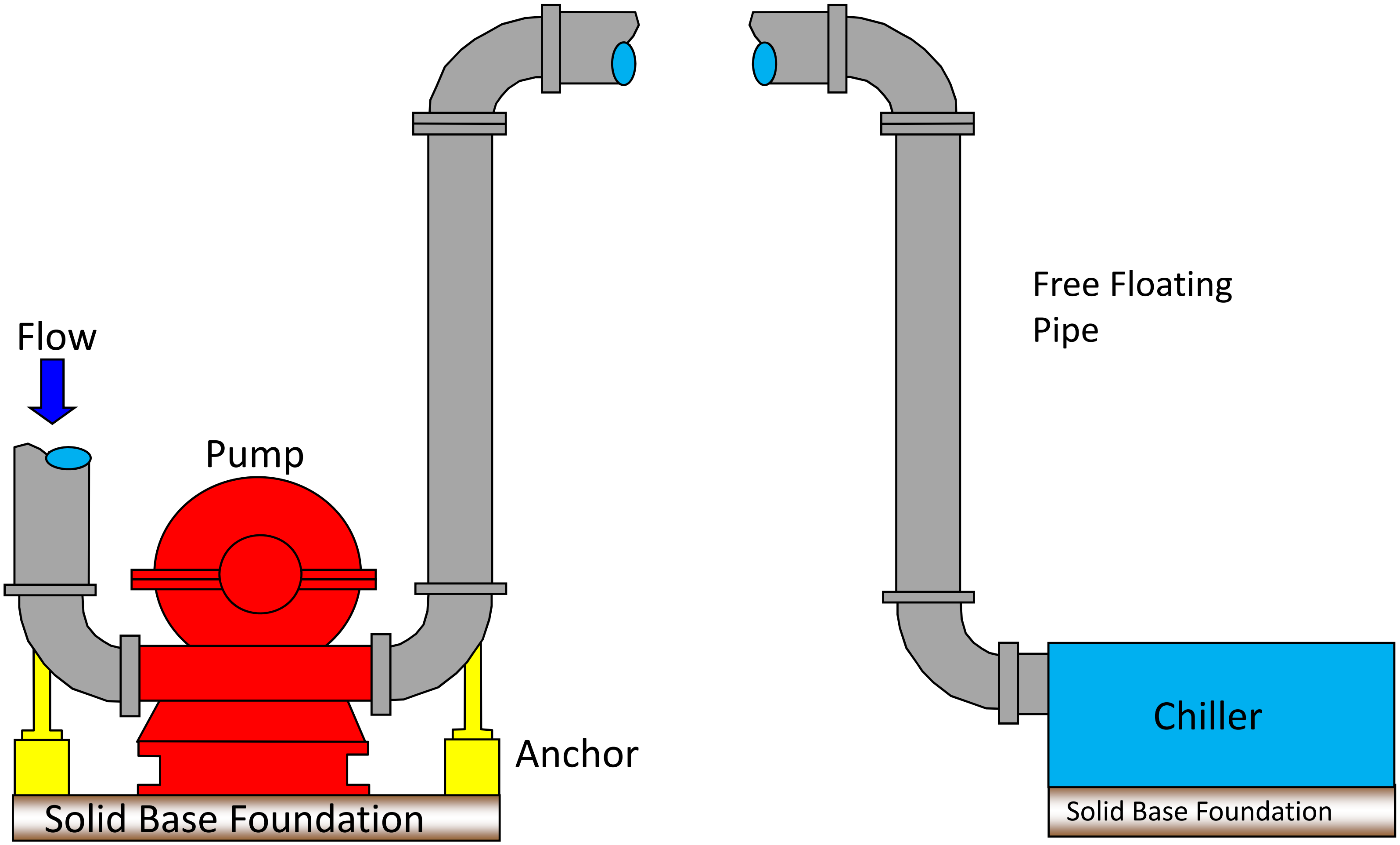
Types of Pipe and Expansion Joint Movement

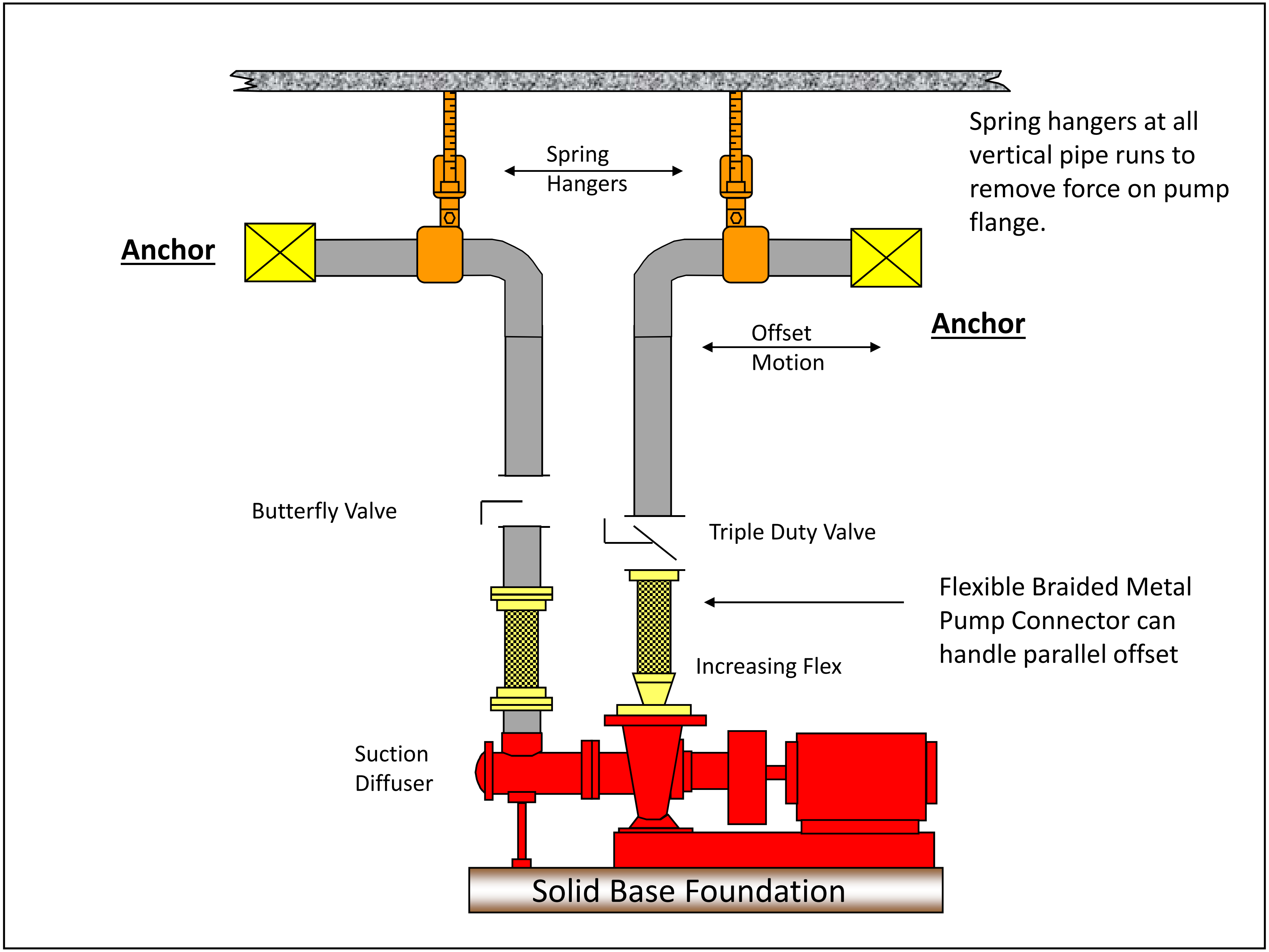


Planes of Motion-X, Y & Z Axis



- Pipe installed without **Flexible Connections.**
  - By default, the **Equipment** will become the **Anchors**.
    - Can your Equipment handle the Stress Loads?




Spring
Hangers
Spring hangers at all vertical pipe runs to remove force on pump flange.
Anchor
Anchor
Offset
Motion
Butterfly Valve
Triple Duty Valve
Flexible Braided Metal Pump Connector can handle parallel offset
Increasing Flex
Suction
Diffuser
Solid Base Foundation

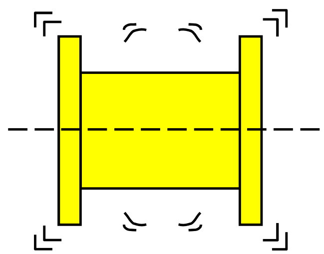
PUMPSAVER™

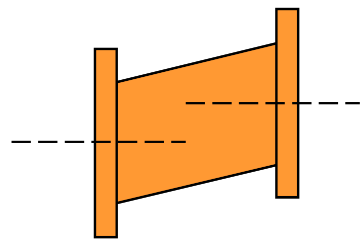
Flexible Braided Metal Pump Connector

Motion Classifications

Flex-Hose Co.'s PUMPSAVER braided pump connectors are capable of handling the following movements.

Vibration





Parallel Offset

Offset Motion:

Motion that occurs when one end of the hose assembly is deflected in a plane perpendicular to the longitudinal axis with the ends remaining parallel. Offset is measured as displacement of the free end centerline from the fixed end centerline.

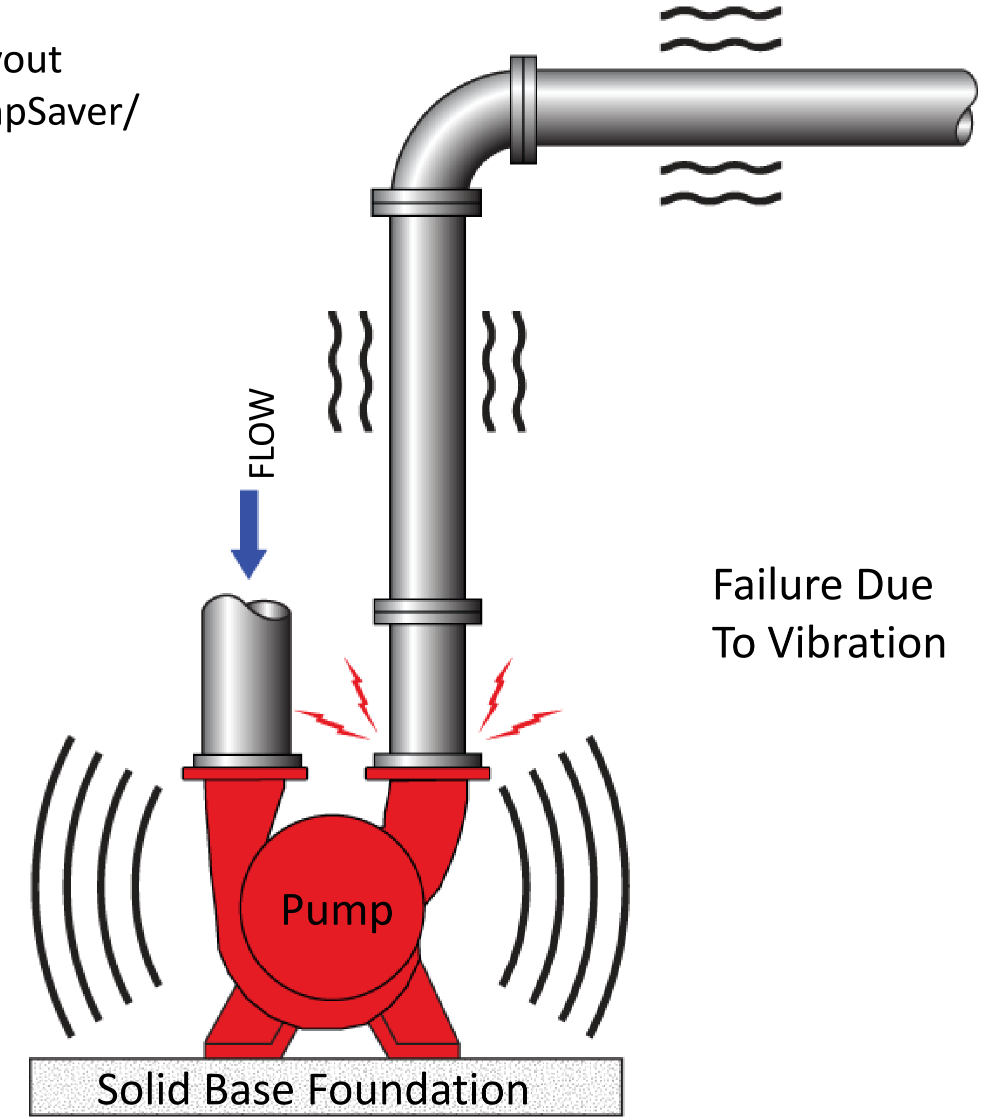
Motion Frequency:

Permanent Offset - The maximum fixed parallel offset to which the corrugated metal hose assembly may be bent without damage to the convolutions. No further motion is to be imposed other than normal vibration.
Intermittent Offset is motion that occurs on a regular or irregular cyclic basis. It is normally the result of thermal expansion and contraction or other non-continuous actions.

Typical Movement	Parallel Offset
6.00 " Flanged	$^{5}/_{8}$" Permanent ¼" Intermittent

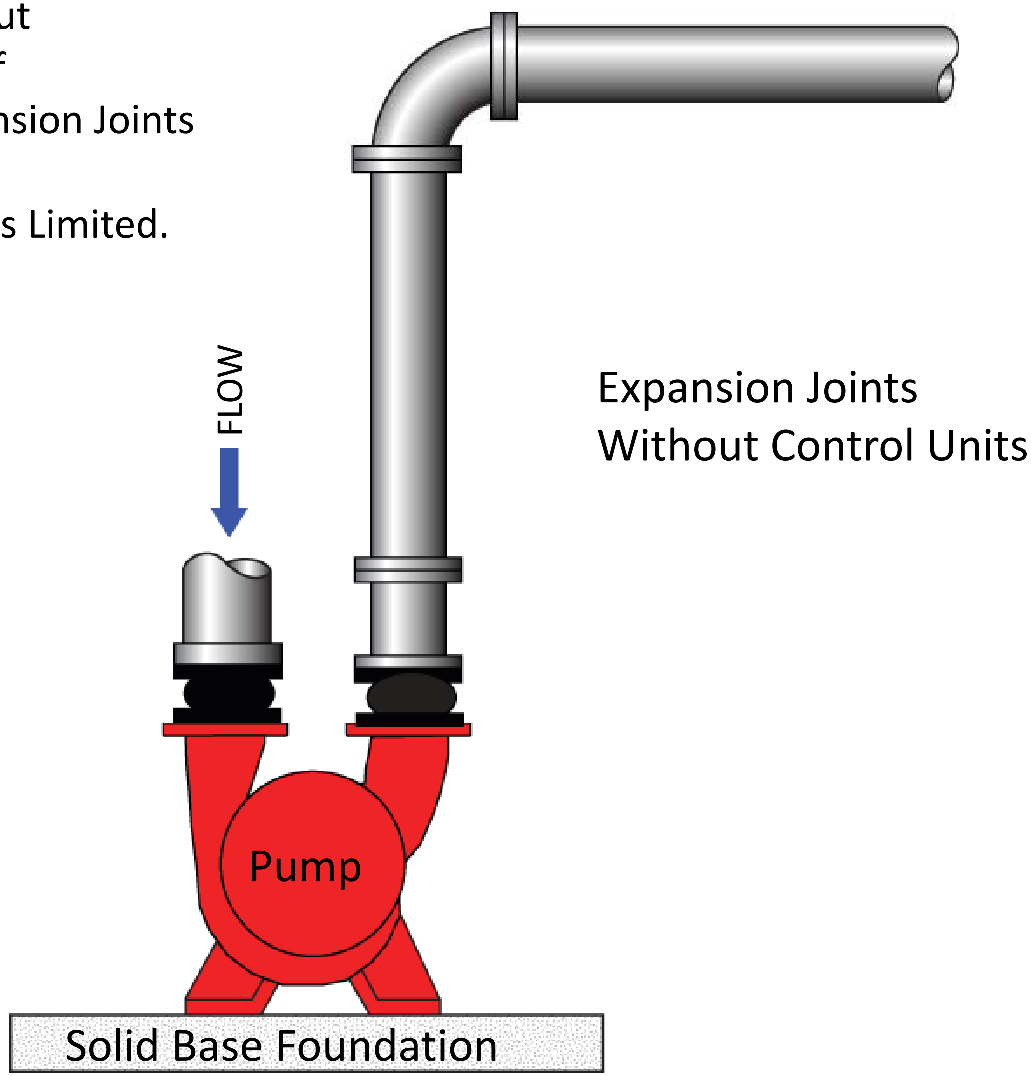
Note: 321 Stainless Steel corrugated Hose 4:1 safety factor

Typical Piping Layout
Not Utilizing PumpSaver/
Flexzorber.

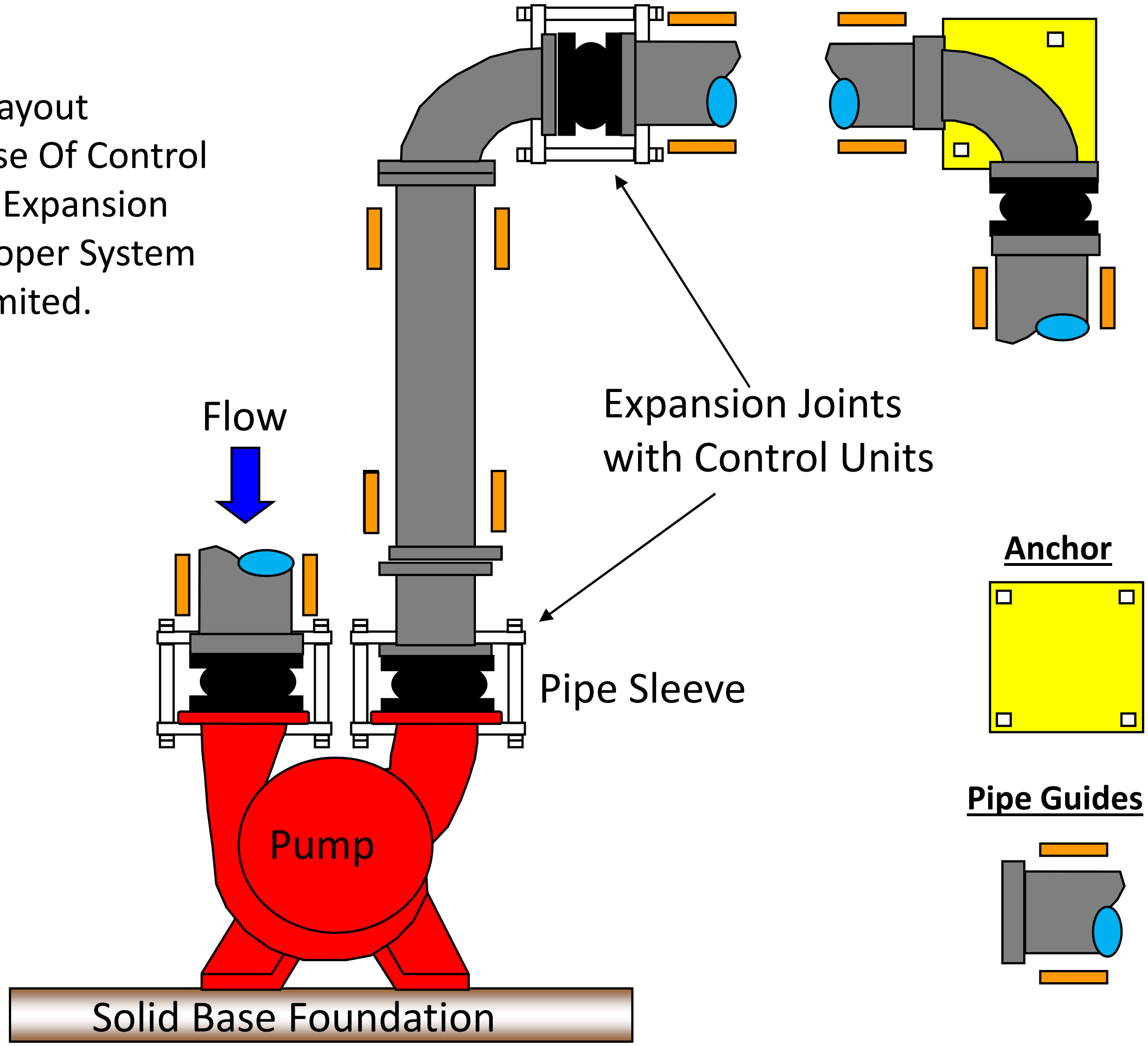


Failure Due
To Vibration

Typical Piping Layout
Showing the Use of
Unrestrained Expansion Joints
When Proper
System Anchoring is Limited.



Typical Piping Layout Showing The Use Of Control Units With The Expansion Joints When Proper System Anchoring Is Limited.



Member of: Hydraulic Institute

American National Standard for Centrifugal Pumps

for Nomenclature, Definitions, Application and Operation

9 Sylvan Way
Parsippany, New Jersey
07054-3802

Member of: Hydraulic Institute

1.4.2.5 Suction and discharge piping-general comments

1.4.2.5.1 Pipe supports/anchors

Suction and discharge piping must be anchored, supported and restrained near the pump to avoid application of forces and moments to the pump except in certain cases, such as API 610 pumps, which are designed to absorb forces and moments. In calculating forces and moments, the weights of the pipe, contained fluid and insulation, as well as thermal expansion and contraction, must be considered.

Member of: Hydraulic Institute

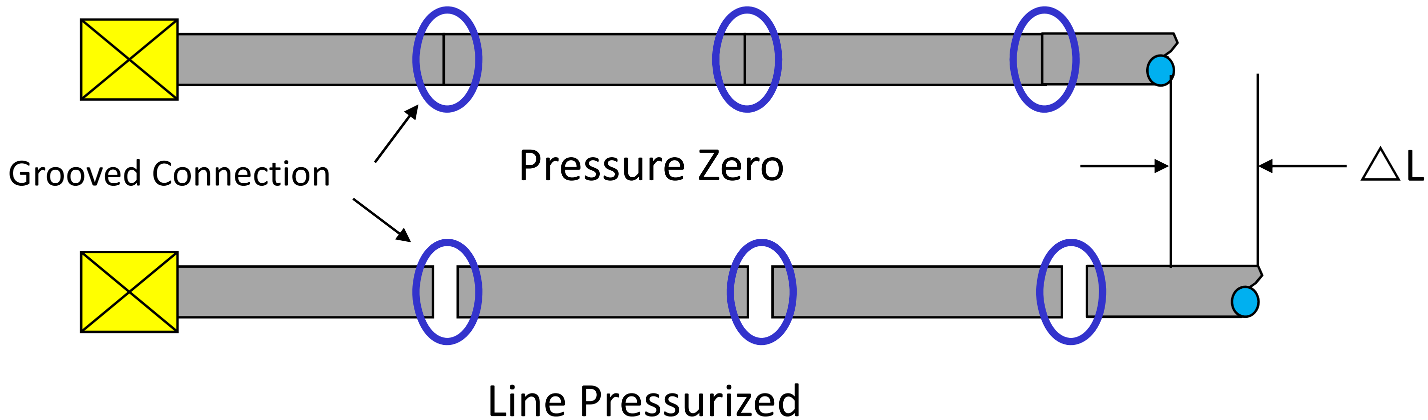
1.4.2.5.2 Expansion joints and couplings

If an expansion joint is installed in the piping between the pump and the nearest anchor in the piping, a force equal to the area of the maximum ID of the expansion joint, times the pressure in the pipe, **will be transmitted to the pump. Pipe couplings which are not axially rigid have the same effect. This force may be larger than can be safely absorbed by the pump or its support system**.

It is therefore recommended that a pipe anchor be installed between an expansion joint and the pump to absorb the axial force.

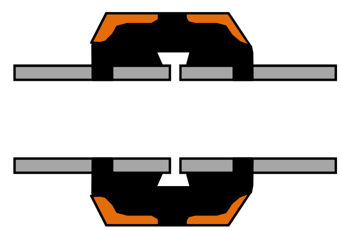
When proper **anchoring cannot be provided, adequate tie rods** must be provided and properly adjusted to **protect the pump** and the expansion joint.

Grooved Pipe Connections are Expansion Joints

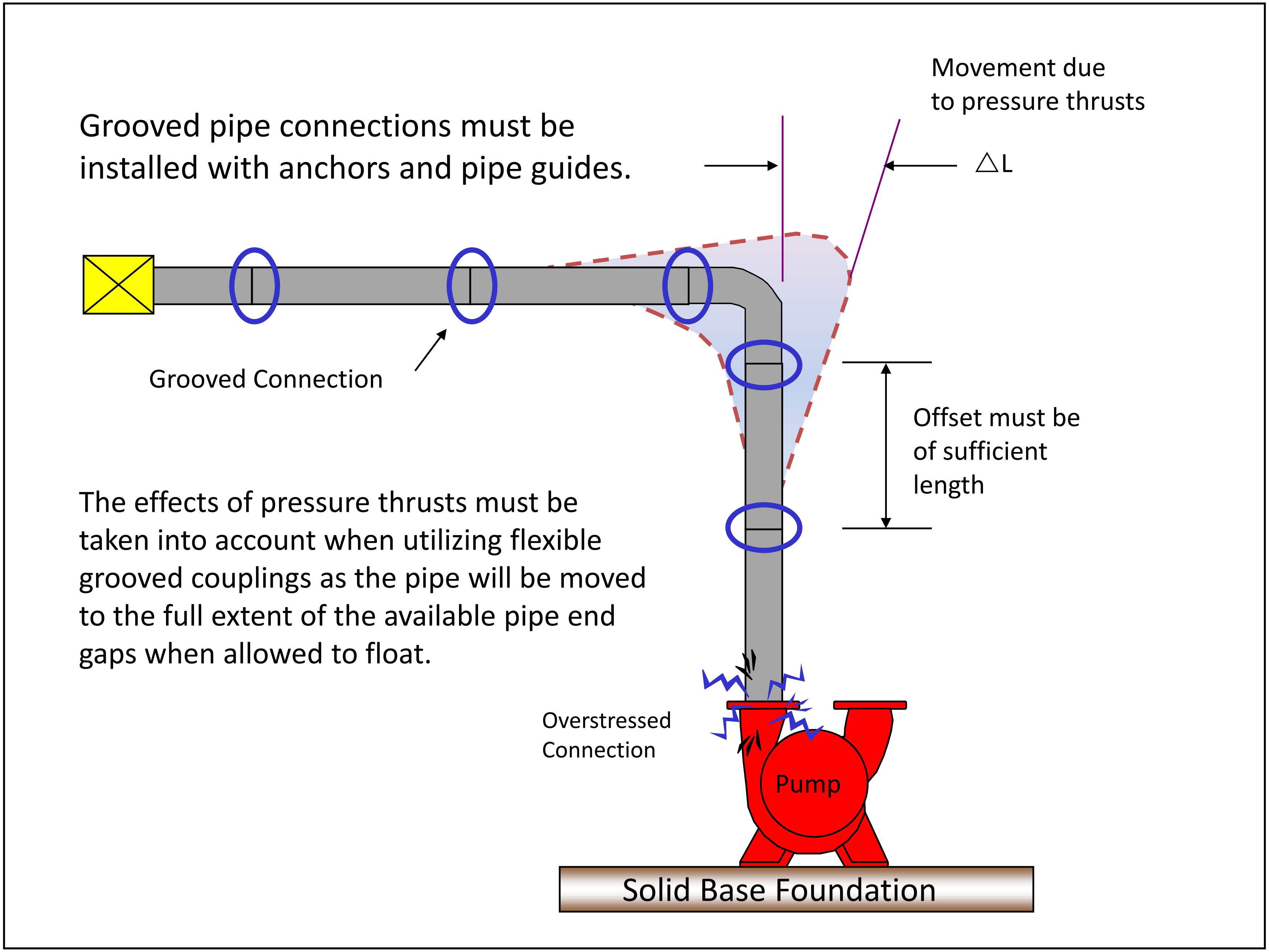


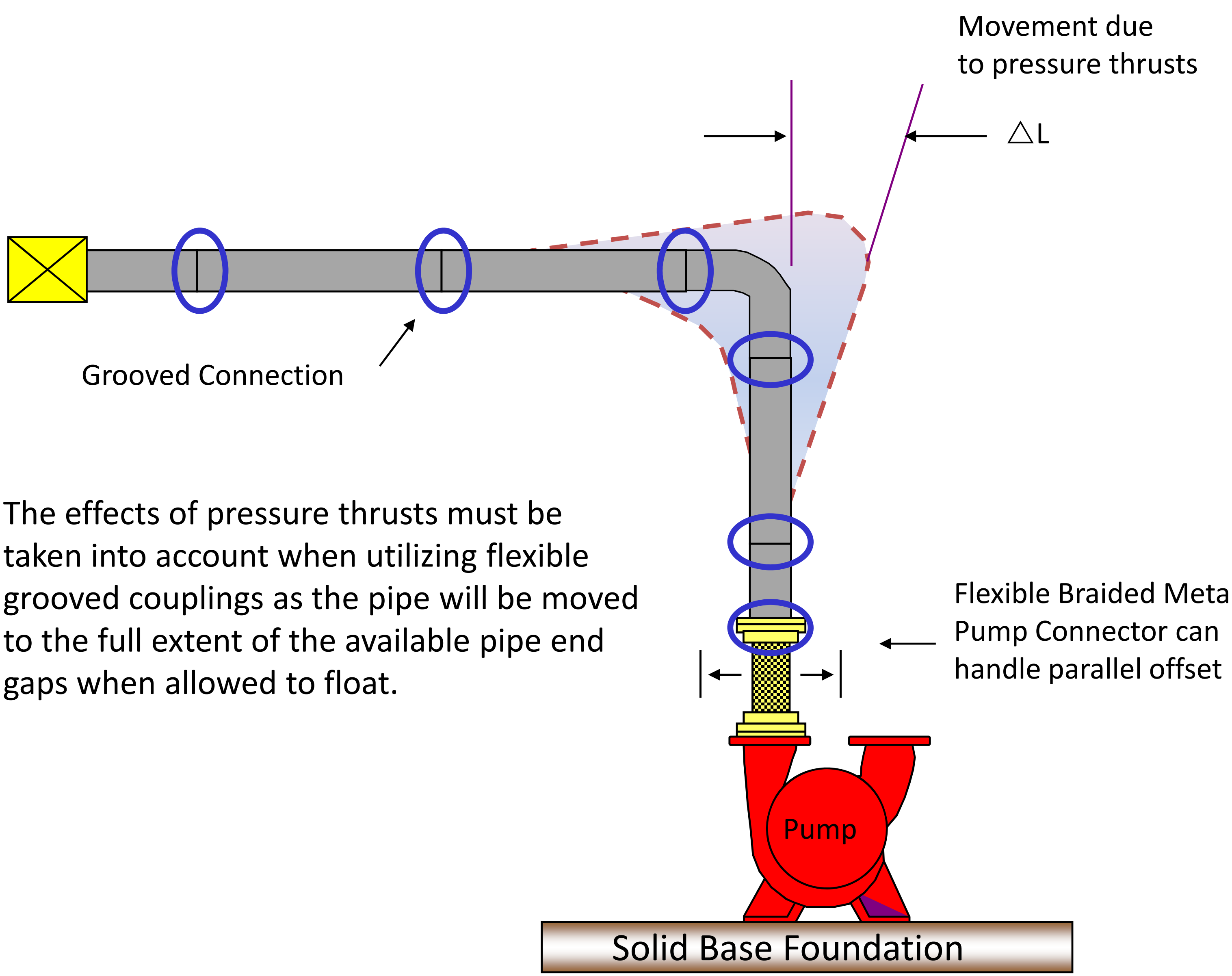
Each grooved joint under pressure will expand approximately ¼".
15 psi internal pipe pressure will create the following activation force.

Nominal Pipe Size (inches)	Activation Force (pounds)
4	240
5	520
8	880
10	1365
12	1915
14	2310



Grooved Connection


Grooved pipe connections must be installed with anchors and pipe guides.
Movement due to pressure thrusts
△L
Grooved Connection
Offset must be of sufficient length
The effects of pressure thrusts must be taken into account when utilizing flexible grooved couplings as the pipe will be moved to the full extent of the available pipe end gaps when allowed to float.
Overstressed Connection
Pump
Solid Base Foundation



The effects of pressure thrusts must be taken into account when utilizing flexible grooved couplings as the pipe will be moved to the full extent of the available pipe end gaps when allowed to float.

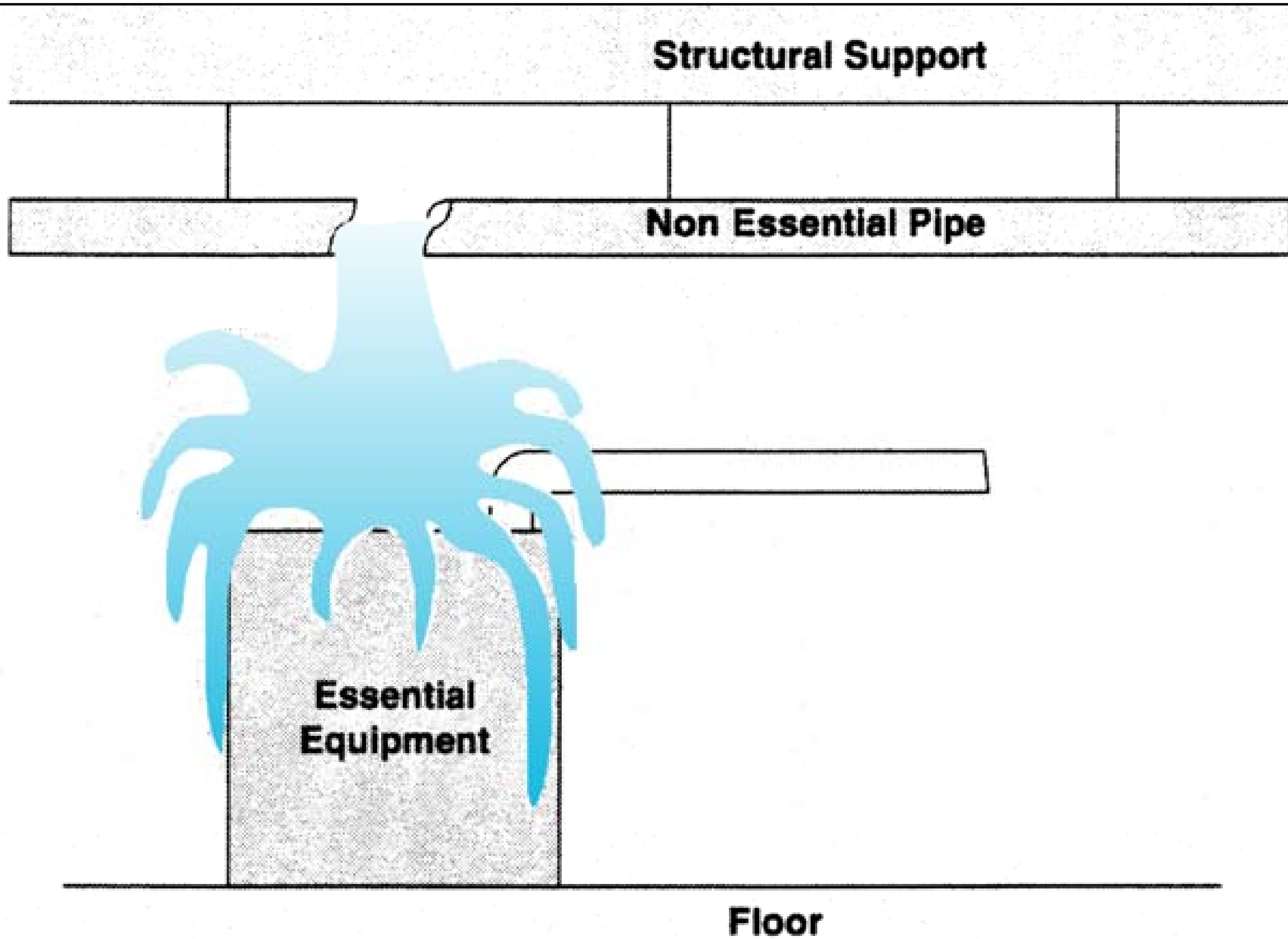


Figure 3 *The failure of nonessential equipment, pipe, or duct can cause the failure of essential equipment.*


SEISMIC MOVEMENT

Component Bracing

- Building Codes require seismic bracing of certain pipes, conduits, or ducts, but questions still persist as to why, how, where, or even if bracing is needed.

- The following is a broad overview of requirements, methods, and options for obtaining the necessary restraint.

Main Topics

- Why brace against earthquakes?
- Ultimate goal of seismic restraints
- Available methods — pros and cons
- Designing for seismic loads
- International Building Codes (2000)
- The “40/80” Rule
- Best brace locations

Why Brace?

- No part of the world is truly safe from earthquake
- Fire Protection Systems have been bracing for decades for Life Safety
- Building owners also want their building to be functional after event
- Damage occurs when pipes/ducts move independently of building

The following should be considered when installing seismic restraints

- Snubbers used with spring mounts should withstand motion in all directions. Some snubbers are only designed for restraint in one direction; sets of snubbers or snubbers designed for multidirectional purposes should be used.
- Flexible connections should be provided between equipment that is braced and piping and ductwork that need not be braced.
- Flexible connections should be provided between isolated equipment and braced piping and ductwork.

1995 ASHRAE Handbook page 50.9

Ultimate Goal

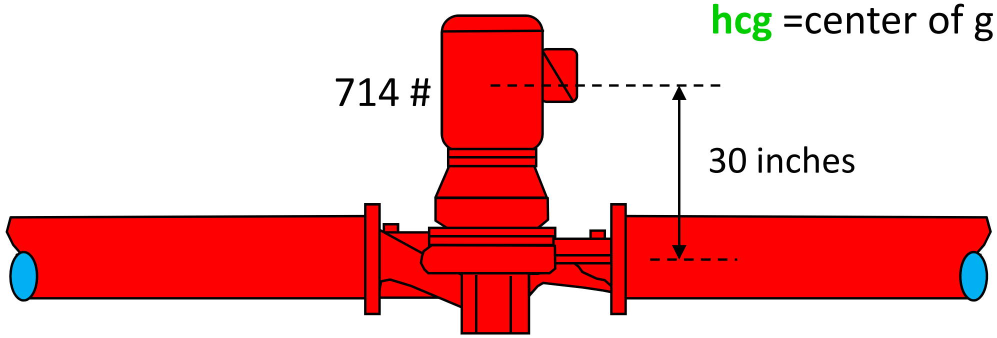
- **Prevent lateral damage by forcing pipe/duct to move with building**
- **Prevent uplift damage by preventing vertical movement**
- **Maintain alignment with equipment**
- ***LIFE SAFETY!!!***

The "40/80" Rule

- 40 feet Transverse and 80 feet Longitudinal, maximum brace spacing for steel pipe per SMACNA
- 40 feet Transverse and 80 feet Longitudinal, maximum brace spacing for duct per SMACNA
- Brace or anchor capacities govern actual max brace spacing

Lateral Seismic Force Example

Vertical Mounted Inline Pump

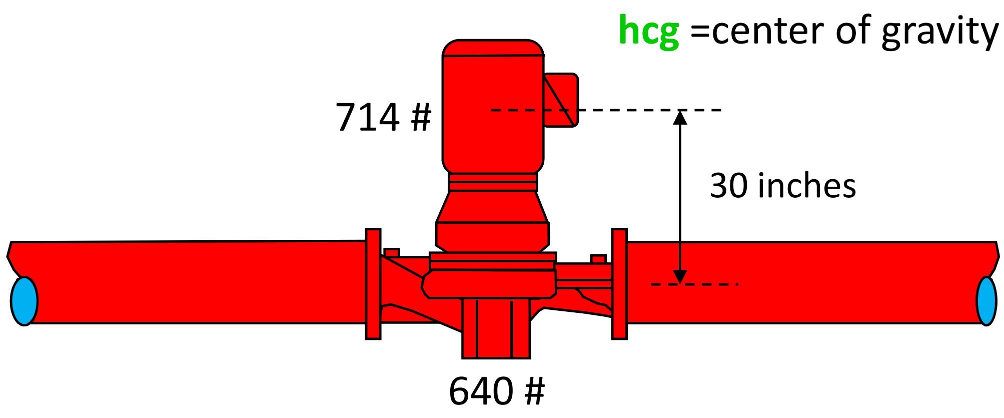


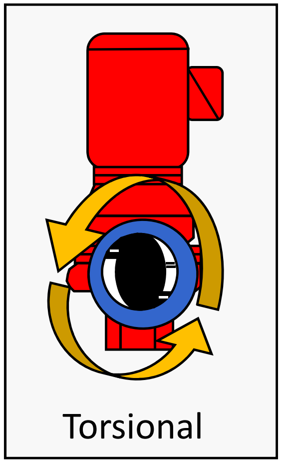
$$F_p = ZI_pC_pW_p$$

$$F_p = (.15)(1.5)(.75)(1354\ \text{lb}) = 228\ \text{lb}$$

$$F_p = \text{Lateral Force} = 228\ \text{lb}$$

Overturning Moment (OTM)





$$OTM = F_p hcg = 228 \text{ lb } (30 \text{ in}) = 6840 \text{ in. lb}$$

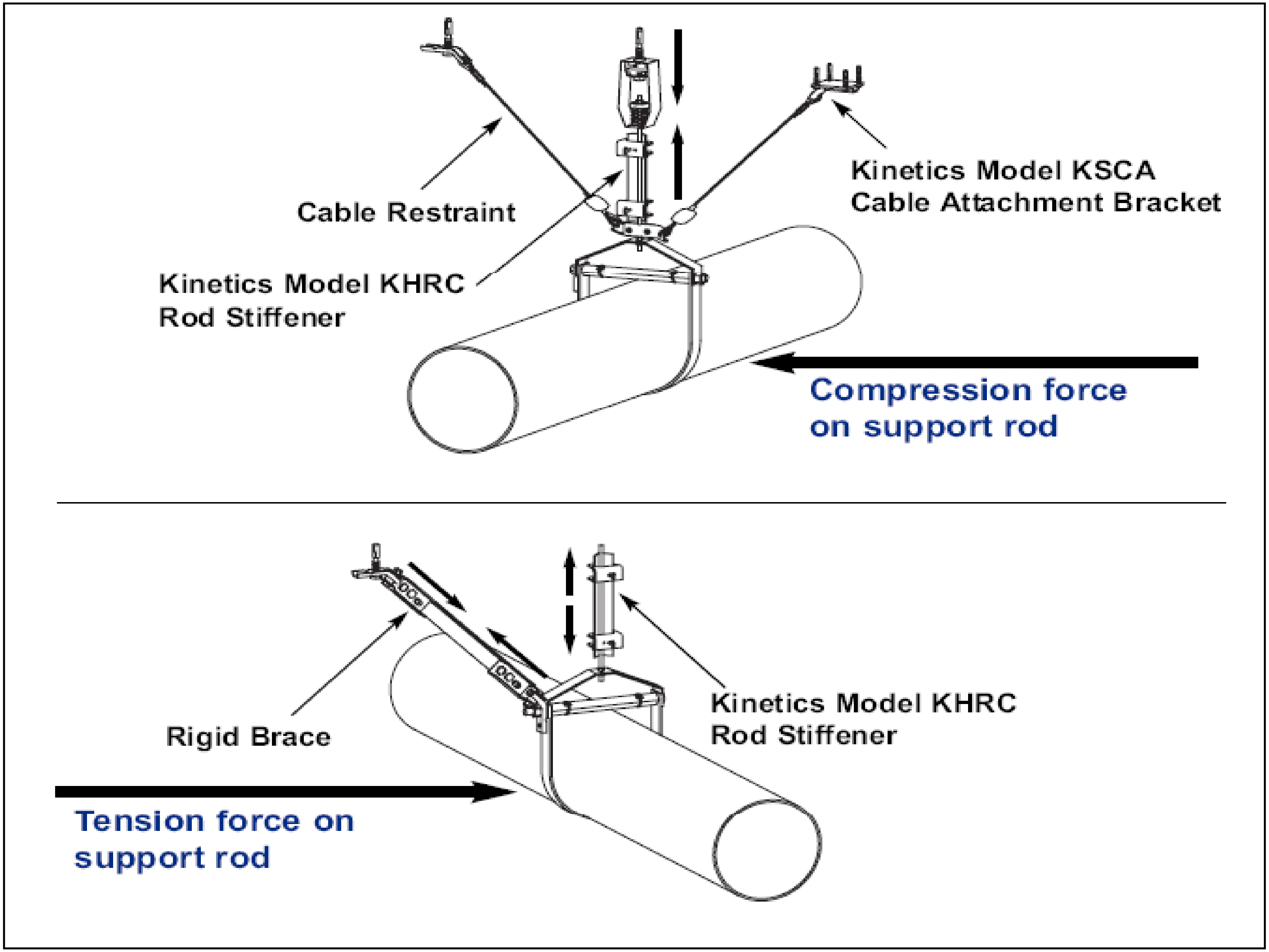
(This force will be on the pump flange and bolts)

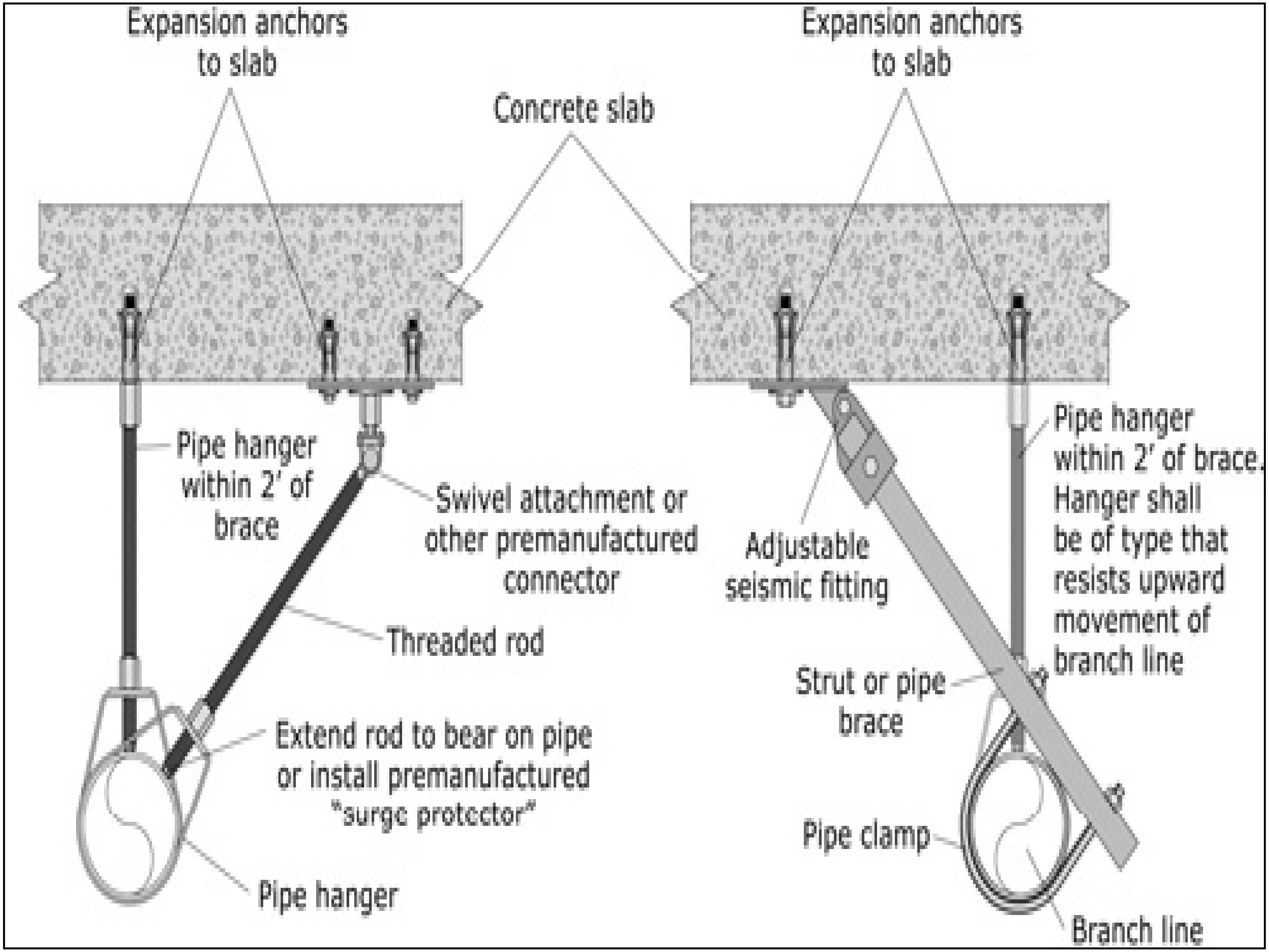
1995 ASHRAE Handbook page 50.6

Overturning Moment (OTM)
Pump Considerations

All vertical Turbine CAN, vertical mounted inline and vertical mounted HSC pumps being applied on seismic restricted projects require a careful review of the following:

- Total pump and motor weight
- Total pump and motor height
- Center of gravity
- Allowable Moment (in. lb) on pump flanges
- Pumps will need a concrete base or a rigid structural steel support


Cable Restraint
Kinetics Model KSCA
Cable Attachment Bracket
Kinetics Model KHRC
Rod Stiffener
Compression force
on support rod
Rigid Brace
Kinetics Model KHRC
Rod Stiffener
Tension force on
support rod


Expansion anchors to slab
Concrete slab
Expansion anchors to slab
Pipe hanger within 2' of brace
Swivel attachment or other premanufactured connector
Threaded rod
Extend rod to bear on pipe or install premanufactured "surge protector"
Pipe hanger
Adjustable seismic fitting
Pipe hanger within 2' of brace. Hanger shall be of type that resists upward movement of branch line
Strut or pipe brace
Pipe clamp
Branch line

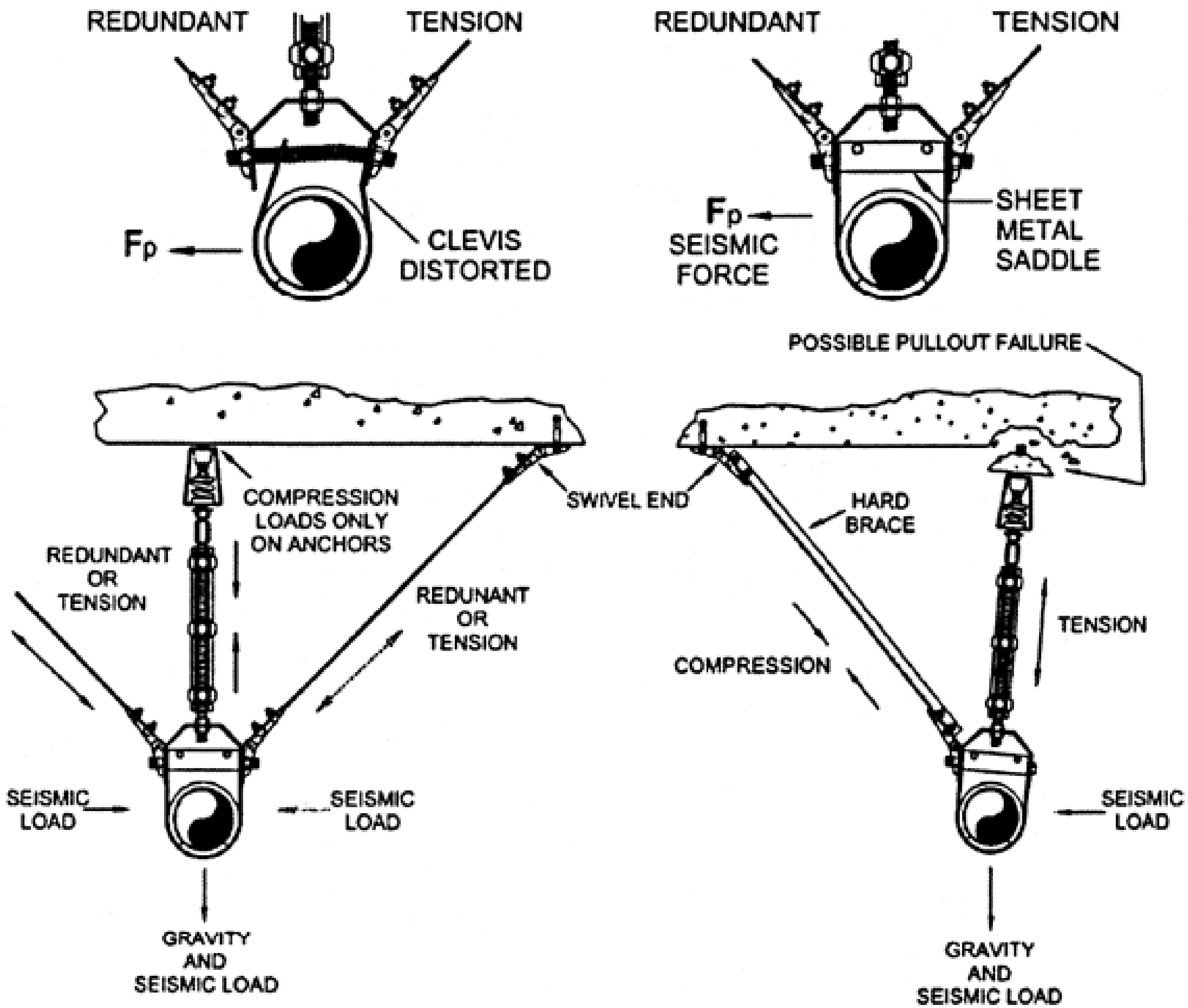


***Figure 4** Pipe sway brace techniques and possible failures.*

Building Codes

Chapter 2

In 1999, there are currently three model building codes in the United States: the *BOCA National Building Code 1996,* Building Officials Code Administration (BOCA); the *1997 Standard Building Code,* Southern Building Code Congress International (SBCCI); and the *Uniform Building Code* (UBC), International Conference of Building Officials. In the year 2000, the three model codes will be merged and modified to form the International Building Code (IBC).

ASHRAE – A Practical Guide to Seismic Restraint

Building Codes

Why have we adopted the IBC?

Chapter 2

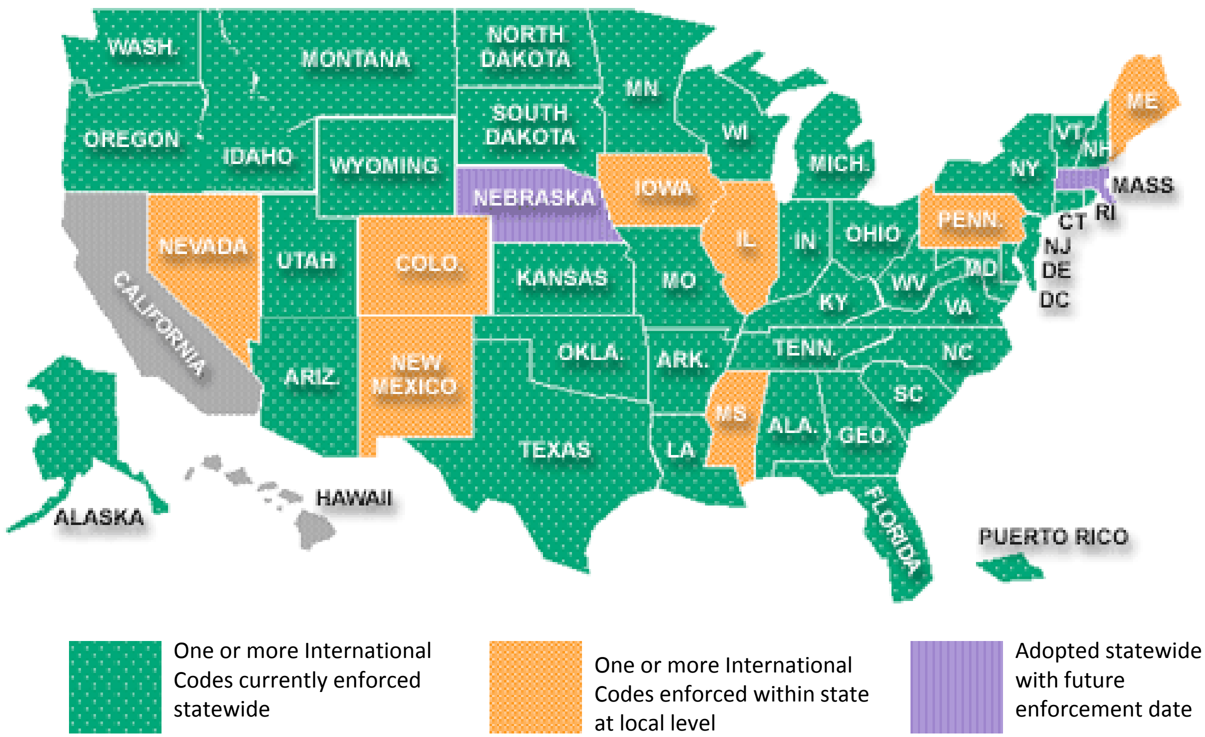
National Earthquake Hazards Reduction Program (NEHRP). NEHRP is a division of the Building Seismic Safety Council (BSSC) and is funded by the Federal Emergency Management Agency (FEMA). The IBC will be drawn from the NEHRP 2000 provisions. Most U.S. jurisdictions will adopt the IBC 2000 code to ensure financial backing from FEMA following an earthquake.

ASHRAE – A Practical Guide to Seismic Restraint

Structural Design

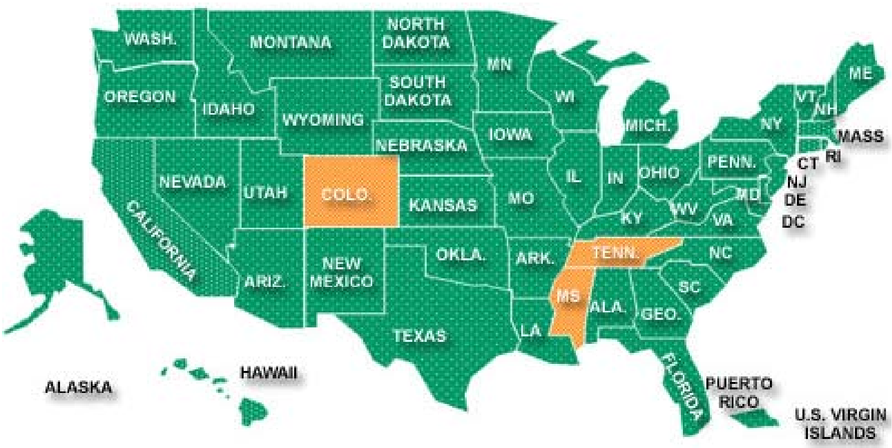
International Code Adoptions

•44 states and the Department of Defense use the *International Building Code*
•32 states use the *International Fire Code*
•32 states use the *International Building Code* and *International Fire Code*
•43 states use the *International Residential Code*



International Building Code (IBC 2000)

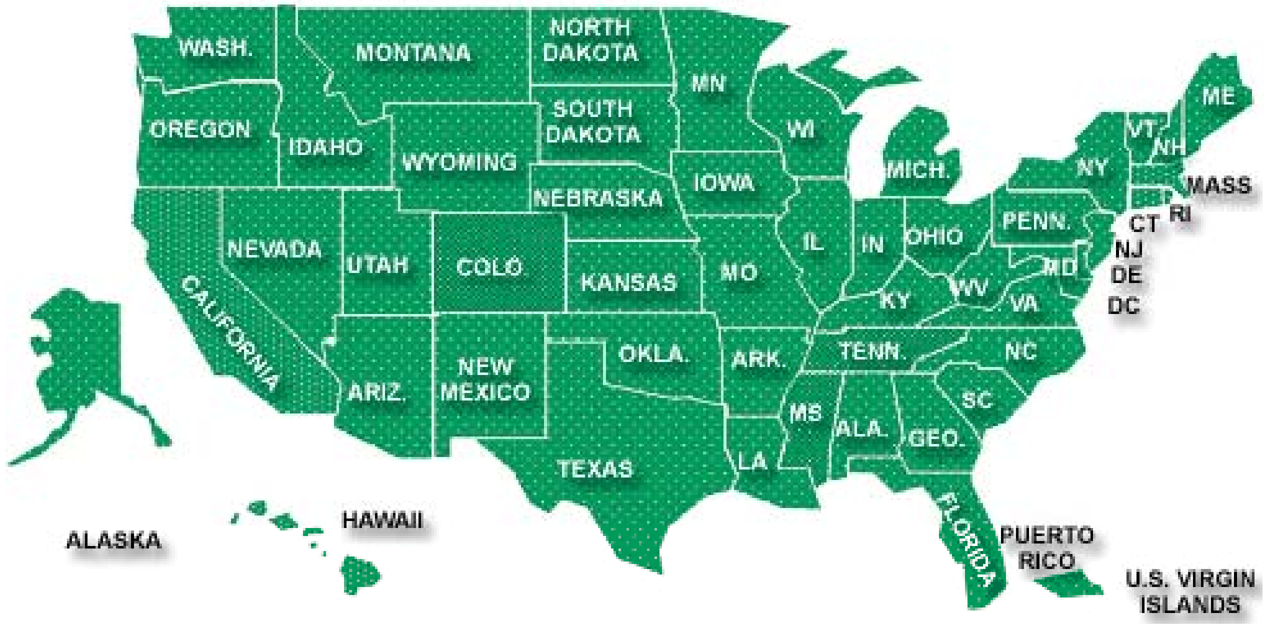
IBC-2006 Update

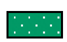


One or more International Codes® currently used statewide

One or more International Codes® used within state at local level

IBC-2009 Update





One or more International Codes® currently used statewide

2009 INTERNATIONAL BUILDING CODE

PREFACE

CHAPTER 16-STRUCTURAL DESIGN

Chapter 16 prescribes minimum structural loading requirements for use in the design and construction of buildings and structural components. It includes minimum design loads, as well as permitted design methodologies. Standards are provided for minimum design loads (live, dead, snow, wind, rain, flood and earthquake as well as load combinations). The application of these loads and adherence to the serviceability criteria will enhance the protection of life and property. The chapter references and relies on many nationally recognized design standards. A key standard is the American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures (ASCE 7).* Structural design needs to address the conditions of the site and location. Therefore maps of rainfall, seismic, snow and wind criteria in different regions are provided.

1604.3 Serviceability

Structural systems and members thereof shall be designed to have adequate stiffness to limit deflections and lateral drift. See section 12.12.1 of ASCE 7 for drift limits applicable to earthquake loading.

IBC-2009-Chapter 16-Structural Design-page 305

TABLE 1604.5
OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES

OCCUPANCY CATEGORY	NATURE OF OCCUPANCY
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural facilities. • Certain temporary facilities. • Minor storage facilities.
II	Buildings and other structures except those listed in Occupancy Categories I, III and IV
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300. • Buildings and other structures containing elementary school, secondary school or day care facilities with an occupant load greater than 250. • Buildings and other structures containing adult education facilities, such as colleges and universities with an occupant load greater than 500. • Group I-2 occupancies with an occupant load of 50 or more resident patients but not having surgery or emergency treatment facilities. • Group I-3 occupancies. • Any other occupancy with an occupant load greater than 5,000[a]. • Power-generating stations, water treatment facilities for potable water, waste water treatment facilities and other public utility facilities not included in Occupancy Category IV. • Buildings and other structures not included in Occupancy Category IV containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released.
IV	Buildings and other structures designated as essential facilities, including but not limited to: • Group I-2 occupancies having surgery or emergency treatment facilities. • Fire, rescue, ambulance and police stations and emergency vehicle garages. • Designated earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communications and operations centers and other facilities required for emergency response. • Power-generating stations and other public utility facilities required as emergency backup facilities for Occupancy Category IV structures. • Structures containing highly toxic materials as defined by Section 307 where the quantity of the material exceeds the maximum allowable quantities of Table 307.1(2). • Aviation control towers, air traffic control centers and emergency aircraft hangars. • Buildings and other structures having critical national defense functions. • Water storage facilities and pump structures required to maintain water pressure for fire suppression.

a. For purposes of occupant load calculation, occupancies required by Table 1004.1.1 to use gross floor area calculations shall be permitted to use net floor areas to determine the total occupant load.

OCCUPANCY CATEGORY I

Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to :

- Agricultural Facilities
- Certain Temporary Facilities
- Minor Storage Facilities

2009 International Building Code-Chapter 16-Structural Design-Table 1604.5~ page 307

OCCUPANCY CATEGORY II

Buildings and other structures except those listed in Occupancy Categories I, III, and IV

2009 International Building Code-Chapter 16-Structural Design-Table 1604.5~ page 307

OCCUPANCY CATEGORY III

Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to:

- Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300

- Buildings and other structures containing elementary school, secondary school or day care facilities with an occupant load greater than 250.

- Buildings and other structures containing adult education facilities, such as colleges and universities with occupant load greater than 500.

- Group I-2 occupancies with an occupant load of 50 or more resident patients but not having surgery or emergency treatment facilities.

- Group I-3 occupancies.

- Any other occupancy with an occupant load greater than 5,000.

- Power-generating stations, water treatment facilities for potable water, waste water treatment facilities and other public utility facilities not included in Occupancy Category IV.

- Buildings and other structures not included in Occupancy Category IV containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released.

2009 International Building Code-Chapter 16-Structural Design-Table 1604.5~ page 307

OCCUPANCY CATEGORY IV

Buildings and other structures designated as essential facilities, including but not limited to:

- Group I-2 occupancies having surgery or emergency treatment facilities.
- Fire, rescue, ambulance, and police stations and emergency vehicle garages.
- Designated earthquake, hurricane, or other emergency shelters.
- Designated emergency preparedness, communications and operations centers and other facilities required for emergency response.
- Power-generating stations and other public utility facilities required as emergency backup facilities for Occupancy Category IV structures.
- Structures containing highly toxic materials as defined by section 307 where the quantity of the material exceeds the maximum allowable quantities of Table 307.1 (2).
- Aviation control towers, air traffic control centers, and emergency aircraft hangars.
- Buildings and other structures having critical national defense functions
- Water storage facilities and pump structures required to maintain water pressure for fire suppression.

2009 International Building Code-Chapter 16-Structural Design-Table 1604.5~ page 307

1.5 CLASSIFICATION OF BUILDINGS AND OTHER STRUCTURES

1.5.1 Nature of Occupancy. Buildings and other structures shall be classified, based on the nature of occupancy, according to Table 1-1 for the purposes of applying flood, wind, snow, earthquake, and ice provisions. The occupancy categories range from I to IV, where Occupancy Category I represents buildings and other structures with a low hazard to human life in the event of failure and Occupancy Category IV represents essential facilities.
Each building or other structure shall be assigned to the highest applicable occupancy category or categories. Assignment of the same structure to multiple occupancy categories based on use and the type of load condition being evaluated (e.g., wind or seismic) shall be permissible.

When buildings or other structures have multiple uses (occupancies), the relationship between the uses of various parts of the building or other structure and the independence of the structural systems for those various parts shall be examined. The classification for each independent structural system of a multiple-use building or other structure shall be that of the highest usage group in any part of the building or other structure that is dependent on that basic structural system.

ASCE Standard 7-05 Chapter 1-General ~ page 2

SEISMIC DESIGN DEFINITIONS

COMPONENT: A part or element of an architectural, electrical, mechanical, or structural system.

Component, Equipment: A mechanical or electrical component or element that is part of a mechanical and/or electrical system within or without a building system.

COMPONENT SUPPORT: Those structural members or assemblies of members, including braces, frames, struts, and attachments that transmit all loads and forces between systems, components, or elements and the structure.

DESIGNATED SEISMIC SYSTEMS: The seismic force resisting system and those architectural, electrical, and mechanical systems or their components that require design in accordance with Chapter 13 and for which the component importance factor, *Ip, is greater than 1.0.*

ASCE Standard 7-05-Chapter 11-Seismic Design Criteria-Page 110

DISPLACEMENT RESTRAINT SYSTEM: A collection of structural elements that limits lateral displacement of seismically isolated structures due to the maximum considered earthquake.

ISOLATION INTERFACE: The boundary between the upper portion of the structure, which is isolated, and the lower portion of the structure, which moves rigidly with the ground.

ISOLATOR UNIT: A horizontally flexible and vertically stiff structural element of the isolation system that permits large lateral deformations under design seismic load. An isolator unit is permitted to be used either as part of, or in addition to, the weight-supporting system of the structure.

ASCE Standard 7-05-Chapter 17-Seismic Design Requirements for Seismically Isolated Structures-Page 177

OCCUPANCY IMPORTANCE FACTOR. A factor assigned to each structure according to its Seismic Use Group as prescribed in Table 1604.5-of IBC-2009~page 307

SITE CLASS. A classification assigned to a site based on the types of soils present and their engineering properties as defined in Section 1613.5.2 of the International Building Code-2009~page 341

SEISMIC DESIGN CATEGORY. A classification assigned to a structure based on its Seismic Use Group and the severity of the design earthquake ground motion at the site. IBC 2009~1613.2

SEISMIC FORCE RESISTING SYSTEM. The part of the structural system that has been considered in the design to provide the required resistance to the prescribed seismic forces. IBC 2009~1613.2

STORY DRIFT RATIO. The story drift divided by the story height

International Building Code-2009 Chapter 16-Structural Design

ASCE-7-05-17.1.2 Definitions

DISPLACEMENT:

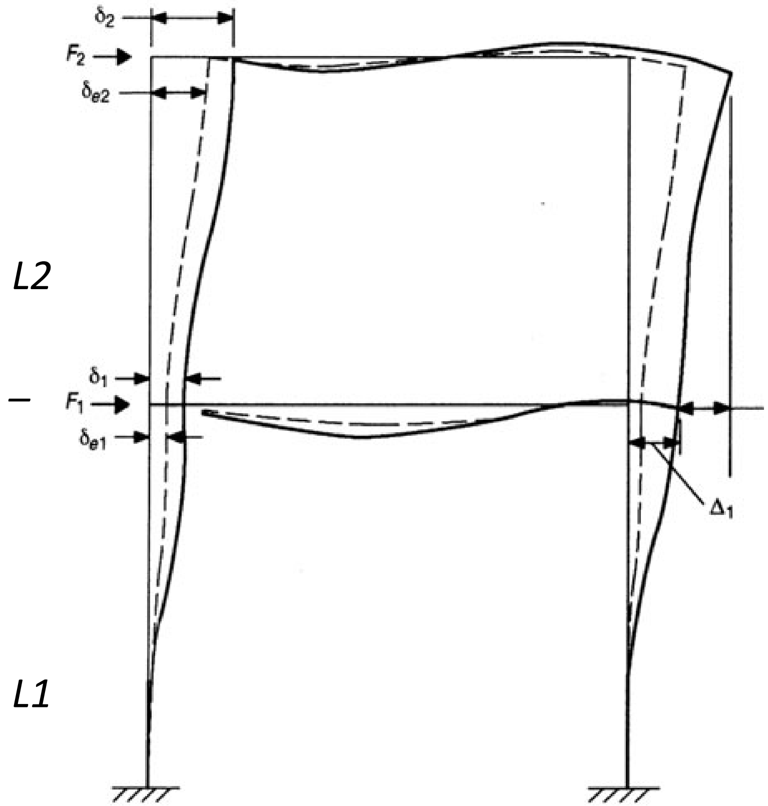
Design Displacement: The design earthquake lateral displacement, excluding additional displacement due to actual and accidental torsion, required for design of the isolation system.

Total Design Displacement: The design earthquake lateral displacement, including additional displacement due to actual and accidental torsion, required for design of the isolation system or an element thereof.

Total Maximum Displacement: The maximum considered earthquake lateral displacement, including additional displacement due to actual and accidental torsion, required for verification of the stability of the isolation system or elements thereof, design of structure separations, and vertical load testing of isolator unit prototypes.

ASCE Standard 7-05-Chapter 17-Page 177

STORY DRIFT



Story Level 2

F2 = strength-level design earthquake force

be2 = elastic displacement computed under strength-level design earthquake forces

b2 = Cd δe2/IE = amplified displacement

Δ2 = (δe2 - δe1) Cd /IE ≤ Δa (Table 12.12-1)

Story Level 1

F1 = strength-level design earthquake force

be1 = elastic displacement computed under strength-level design earthquake forces

b1 = Cd δe1/IE = amplified displacement

Δ1 = δ1 ≤ Δa (Table 12.12-1)

Δi = Story Drift

Δi/Li = Story Drift Ratio

b2 = Total Displacement

ASCE STANDARD 7-05-FIGURE 12.8-2 STORY DRIFT DETERMINATION ~ PAGE 131

SECTION 1613-EARTHQUAKE LOADS

1613.1 Scope. Every structure and portion thereof, including nonstructural components that are permanently attached to structures and their supports and attachments, shall be designed and constructed to resist the effects of earthquake motions in accordance with ASCE 7, excluding Chapter 14 and Appendix 11A. The *seismic design category* for a structure is permitted to be determined in accordance with section 1613 or ASCE 7.

2009 International Building Code-Chapter 16- Structural Design~ Page 340

ASCE 7-05-Chapter 11

11.1.2 Scope. Every structure, and portion thereof, including non-structural components, shall be designed and constructed to resist the effects of earthquake motions as prescribed by the seismic requirements of this standard. Certain non-building structures, as described in Chapter 15, are also within the scope and shall be designed and constructed in accordance with the requirements of Chapter 15. Requirements concerning alterations, additions, and change of use are set forth in Appendix 11B. Existing structures and alterations to existing structures need only comply with the seismic requirements of this standard where required by Appendix 11B.

ASCE Standard 7-05-Chapter 11-Seismic Design Criteria ~ page 109

1613.5.2 Site Class Definitions. The site shall be classified as one of the site classes defined in Table 1613.5.2 of IBC-2009. When the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the building official determines that Site Class E or F soil is likely to be present at the site.

1613.5.2-Site Class Definitions. Based on the site soil properties, the site shall be classified as either *Site Class* A, B, C, D, E or F in accordance with Table 1613.5.2. When the soil properties are not known in sufficient detail to determine the site class, *Site Class* D shall be used unless the *building official* or geotechnical data determines that *Site Class* E or F soil is likely to be present at the site.

International Building Code-2009-Chapter 16-structural Design ~ page 340

TABLE 1613.5.2
SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 feet, SEE SECTION 1613.5.5		
		Soil shear wave velocity, $\bar{v}_s$, (ft/s)	Standard penetration resistance, $\bar{N}$	Soil undrained shear strength, $\bar{s}_u$, (psf)
A	Hard rock	$\bar{v}_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \bar{v}_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \bar{v}_s \leq 2{,}500$	$\bar{N} > 50$	$\bar{s}_u \geq 2{,}000$
D	Stiff soil profile	$600 \leq \bar{v}_s \leq 1{,}200$	$15 \leq \bar{N} \leq 50$	$1{,}000 \leq \bar{s}_u \leq 2{,}000$
E	Soft soil profile	$\bar{v}_s < 600$	$\bar{N} < 15$	$\bar{s}_u < 1{,}000$
E	—	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\bar{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2, 1 pound per square foot = 0.0479 kPa. N/A = Not applicable

2009 International Building Code- Chapter 16 ~ Structural Design, Section : 1613.5.2 (table). ~Page 341~


GEOLOGIC HAZARDS
➢ Liquefaction
➢ Slope Failure
➢ Surface Fault Rupture
➢ Foundation Performance
➢ Deterioration
➢ Capacity of Foundations

ASCE 7-05

13.6.6 Utility and Service Lines. At the interface of adjacent structures or portions of the same structure that may move independently, utility lines shall be provided with adequate flexibility to accommodate the anticipated differential movement between the portions that move independently. Differential displacement calculations shall be determined in accordance with Section 13.3.2.

ASCE Standard 7-05-Chapter 13-Structural Design Requirements For Nonstructural Components ~ Page 150

ASCE 7-05

17.2.6.2 Components Crossing the Isolation Interface. Elements of seismically isolated structures and nonstructural components, or portions thereof, that cross the isolation interface shall be designed to withstand the total maximum displacement.

ASCE Standard 7-05-Chapter 17-Seismic Design Requirements For Seismically Isolated Structures ~ pages 179-180

ASCE-7-05-17.1.2 Definitions.

DISPLACEMENT:

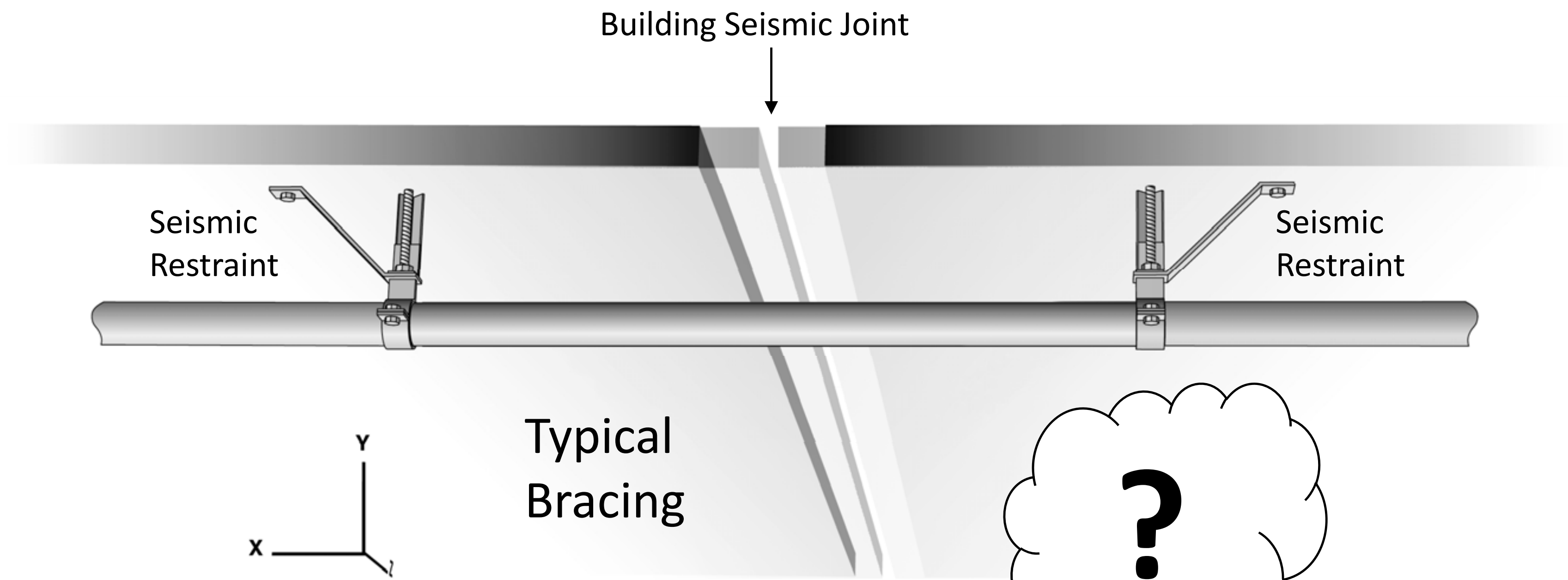
Design Displacement: The design earthquake lateral displacement, excluding additional displacement due to actual and accidental torsion, required for design of the isolation system.

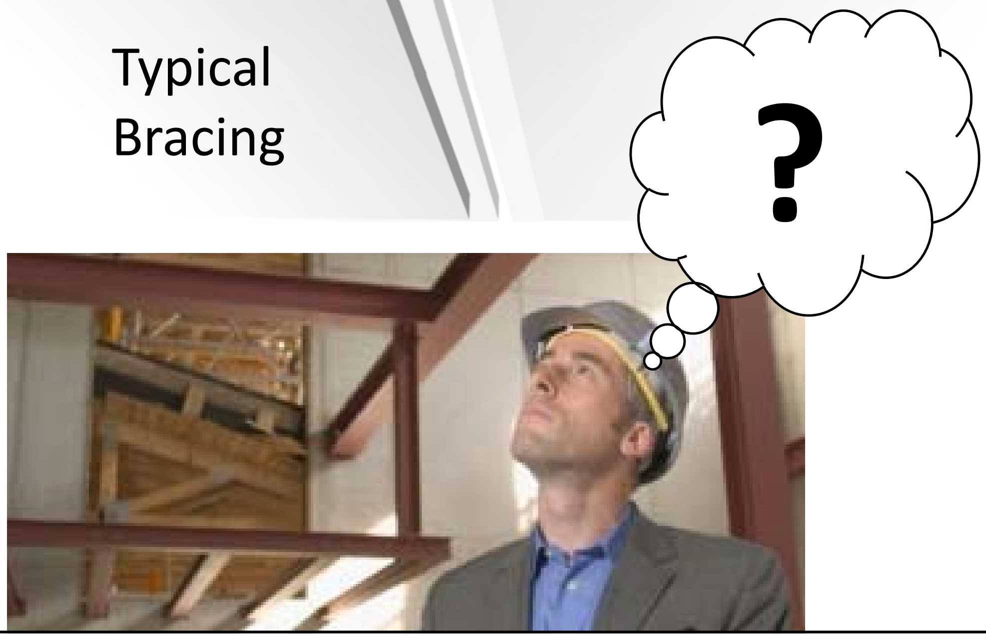
Total Design Displacement: The design earthquake lateral displacement, including additional displacement due to actual and accidental torsion, required for design of the isolation system or an element thereof.

Total Maximum Displacement: The maximum considered earthquake lateral displacement, including additional displacement due to actual and accidental torsion, required for verification of the stability of the isolation system or elements thereof, design of structure separations, and vertical load testing of isolator unit prototypes.

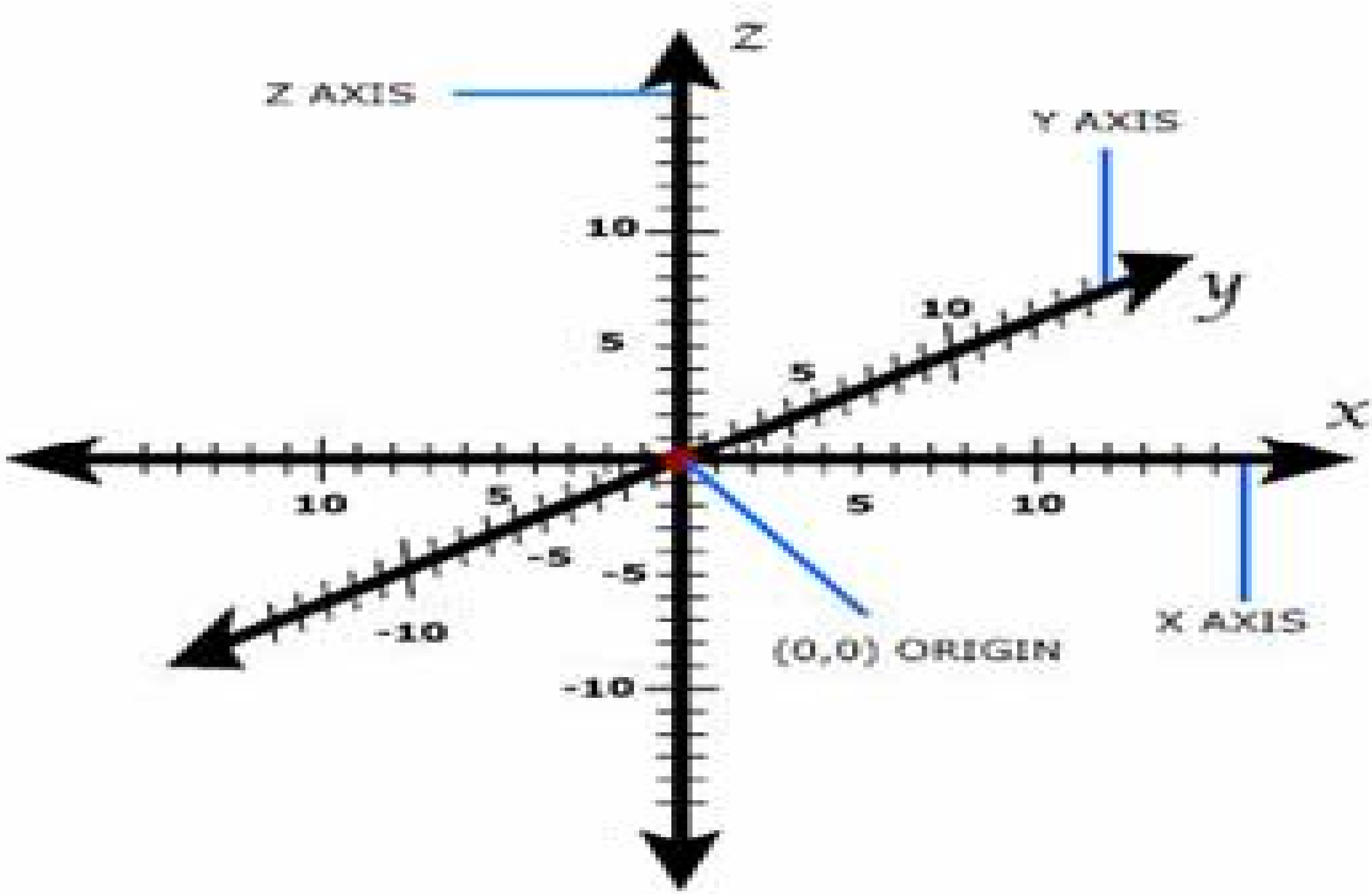
ASCE Standard 7-05-Chapter 17-Page 177

Isolating Building Joints?

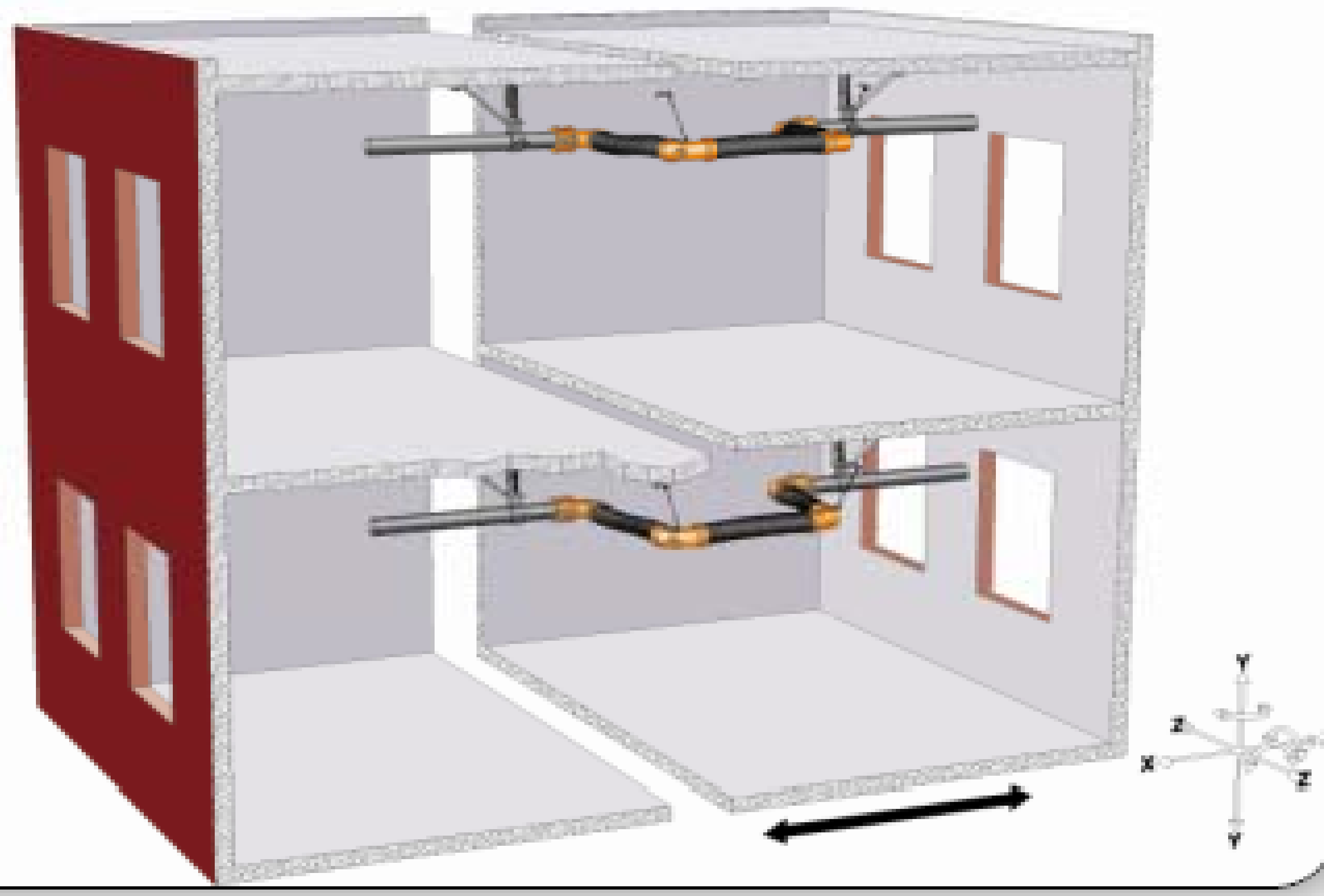




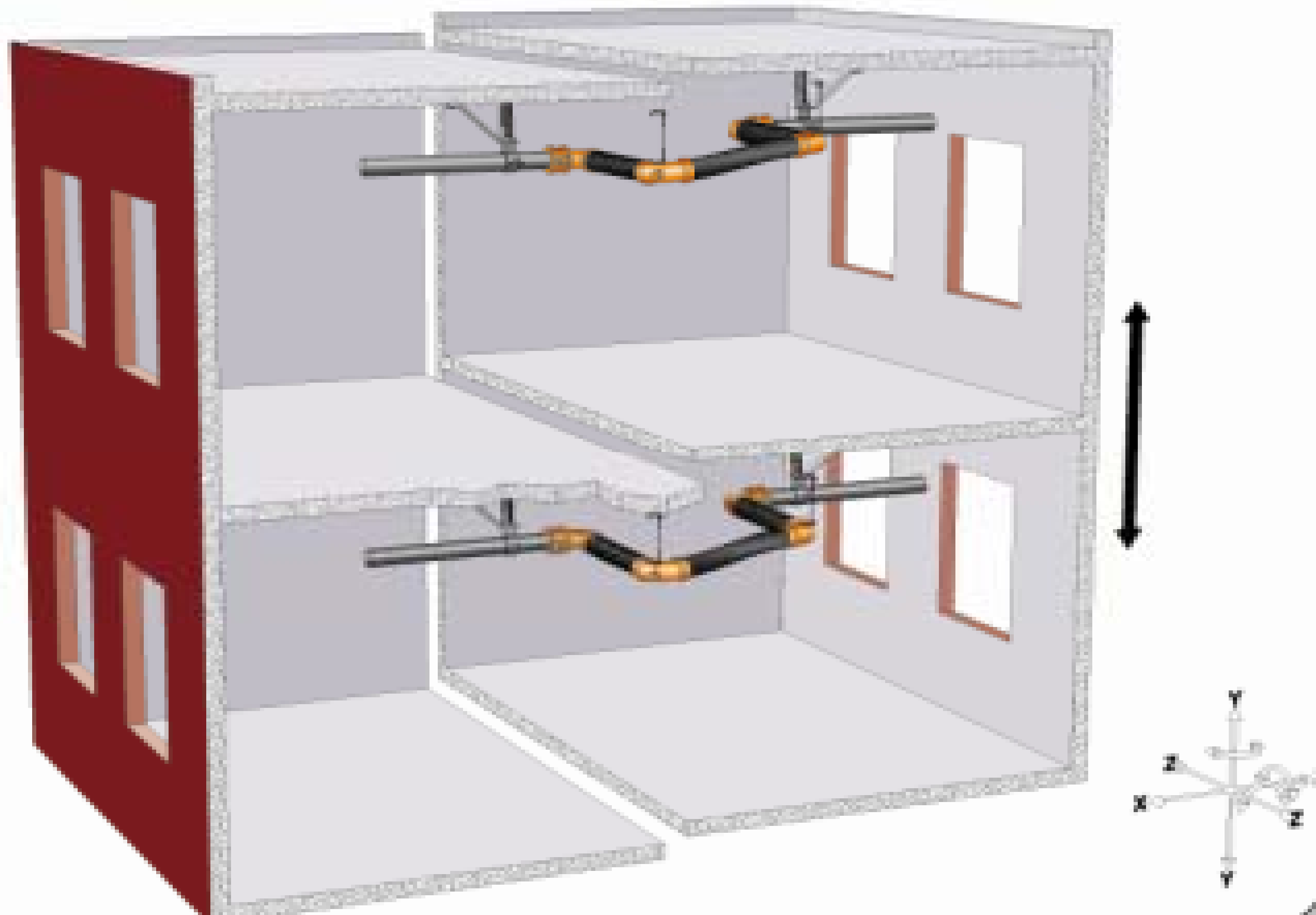
Planes of Motion-X, Y & Z Axis



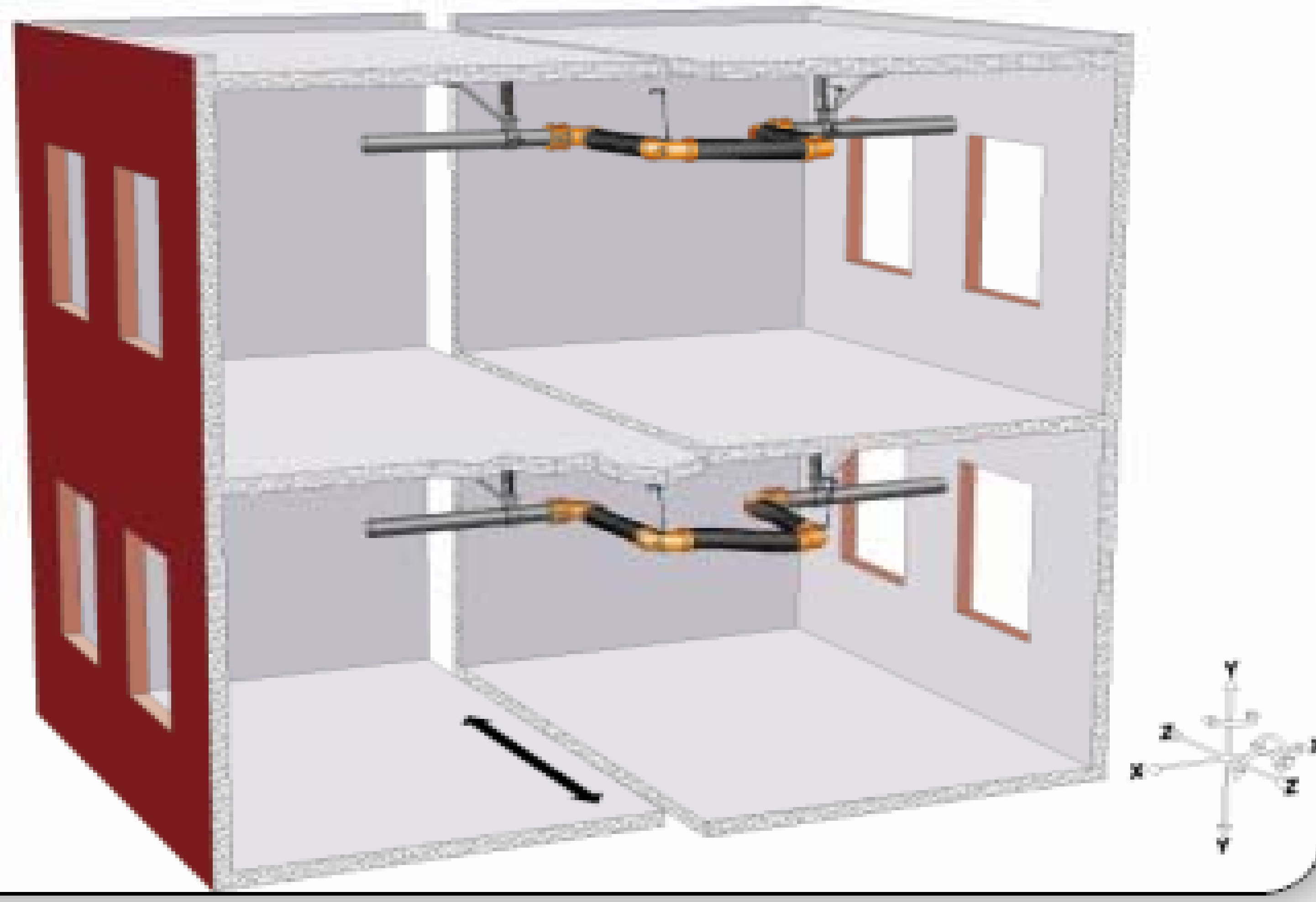
Horizontal Displacement on "X" Axis



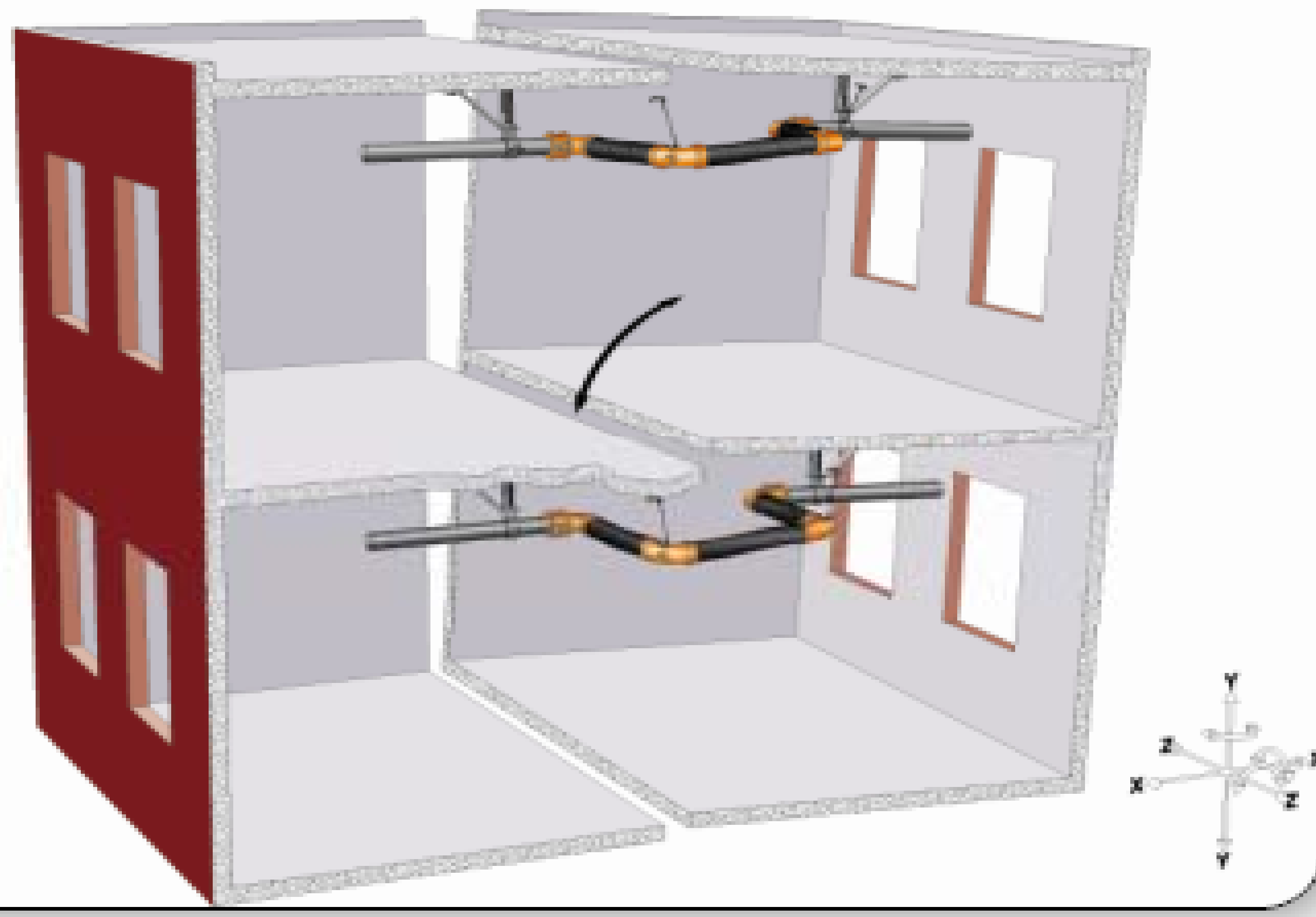
Vertical Displacement on "Y" Axis



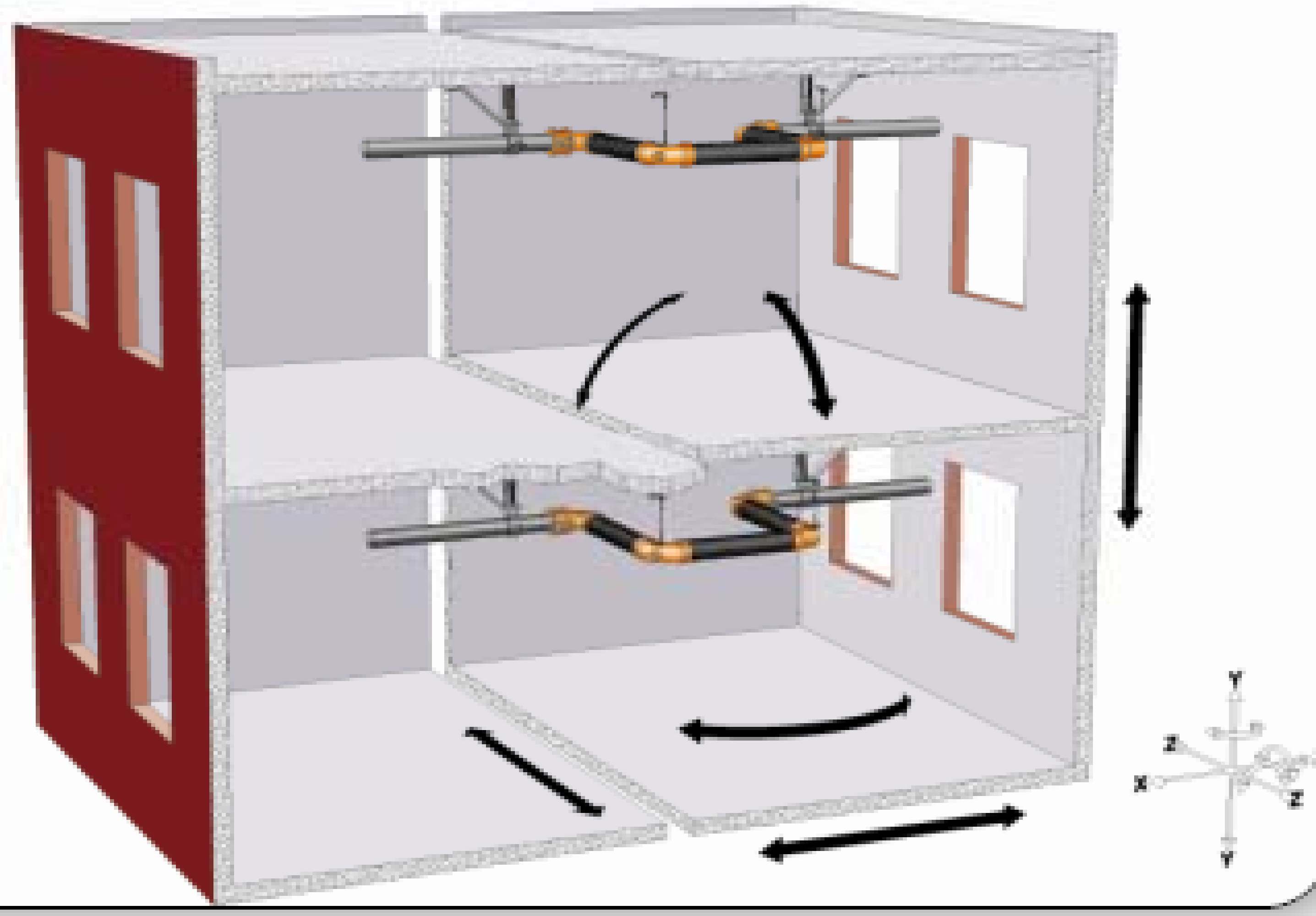
Horizontal Displacement on “Z” Axis

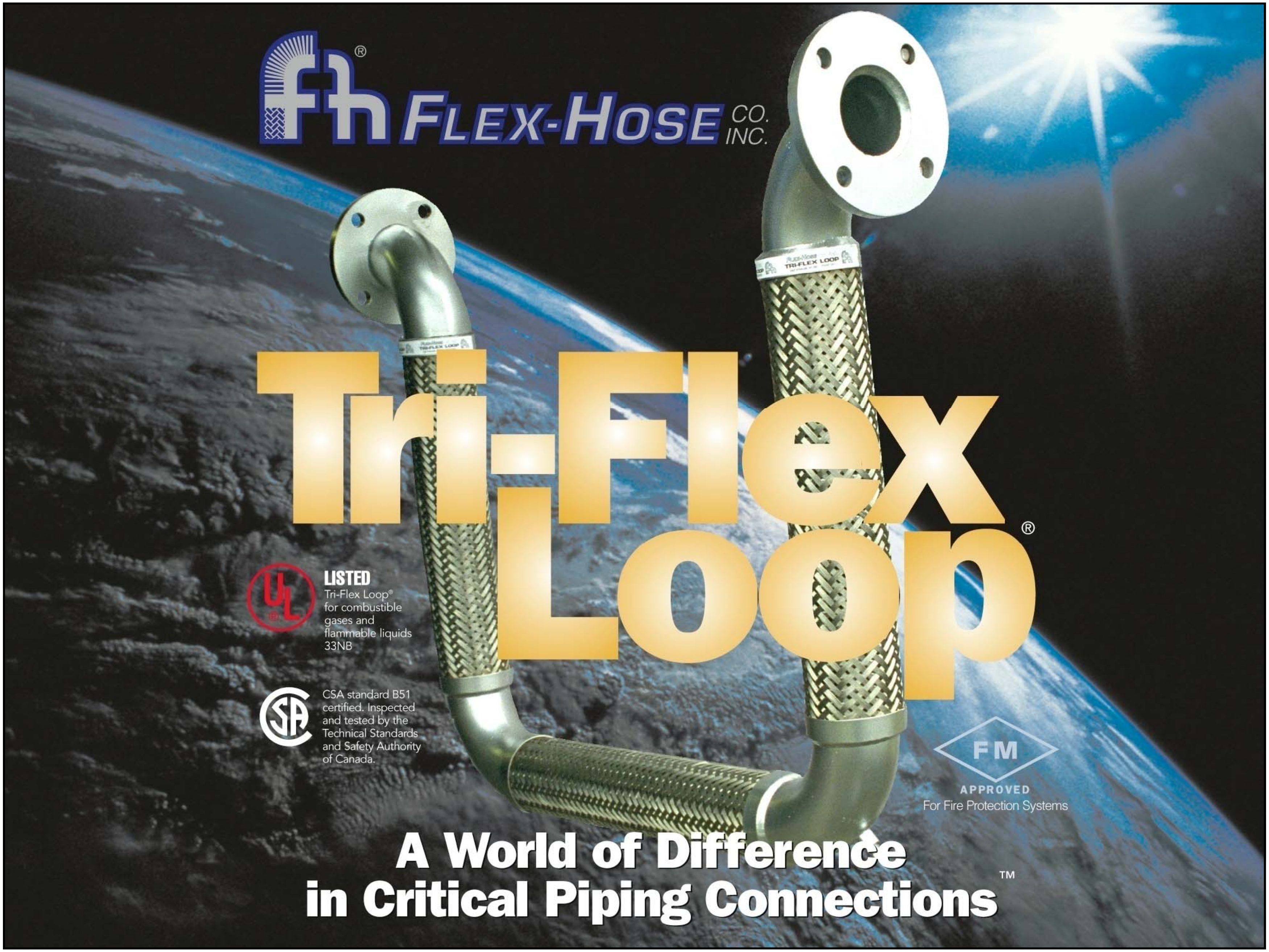


Isolating Building Drift with Rotation



Random Displacement




FLEX-HOSE CO. INC.
Tri-Flex Loop®
LISTED
Tri-Flex Loop®
for combustible
gases and
flammable liquids
33NB
CSA standard B51
certified. Inspected
and tested by the
Technical Standards
and Safety Authority
of Canada.
FM
APPROVED
For Fire Protection Systems
A World of Difference
in Critical Piping Connections™

Tri-Flex Loop®: What is it?

The Tri-Flex Loop is the only flexible pipe loop that absorbs and compensates pipe movement in six degrees of freedom. (three coordinates axes, plus rotation about those axes simultaneously.)

Simplifies Piping Design

The Tri-Flex Loop does not impose pressure thrust on the piping system. The braid is designed to take the stress of pressurization containing the core, reducing anchor loads by 93% compared to mechanical pipe loops and 98% less than expansion joints.

Flexible loops are pipe loops that absorb and compensate multi-plane movements simultaneously and reduce piping stress. They also simplify installation,which reduces system cost. Flexible loops are available in stainless steelor bronze annular close pitch flexible hose, in 1/2" - 18" inside diameter with several types of end fittings.

Standard Sizes
½" to 12" I.D.

Custom sizes available to 30" I.D.
Other alloys and custom styles available. Please consult factory.

Applications

Flex-Hose Co.'s UL536 listed Tri-Flex Loop and sesimic connectors are approved for flammable and combustible gases and liquids. Other common applications for the Tri-Flex Loop include steam, condenser water, hot water, domestic hot water and chilled water.

Tri-Flex Loop makes a world of difference in your critical piping connections. They are designed to handle working pressures up to 1325 psi, or full vacuum and operating temperatures of -400°F to 1500°F.

LISTED
Tri-Flex Loop®
for combustible gases
and flammable liquids
33NB

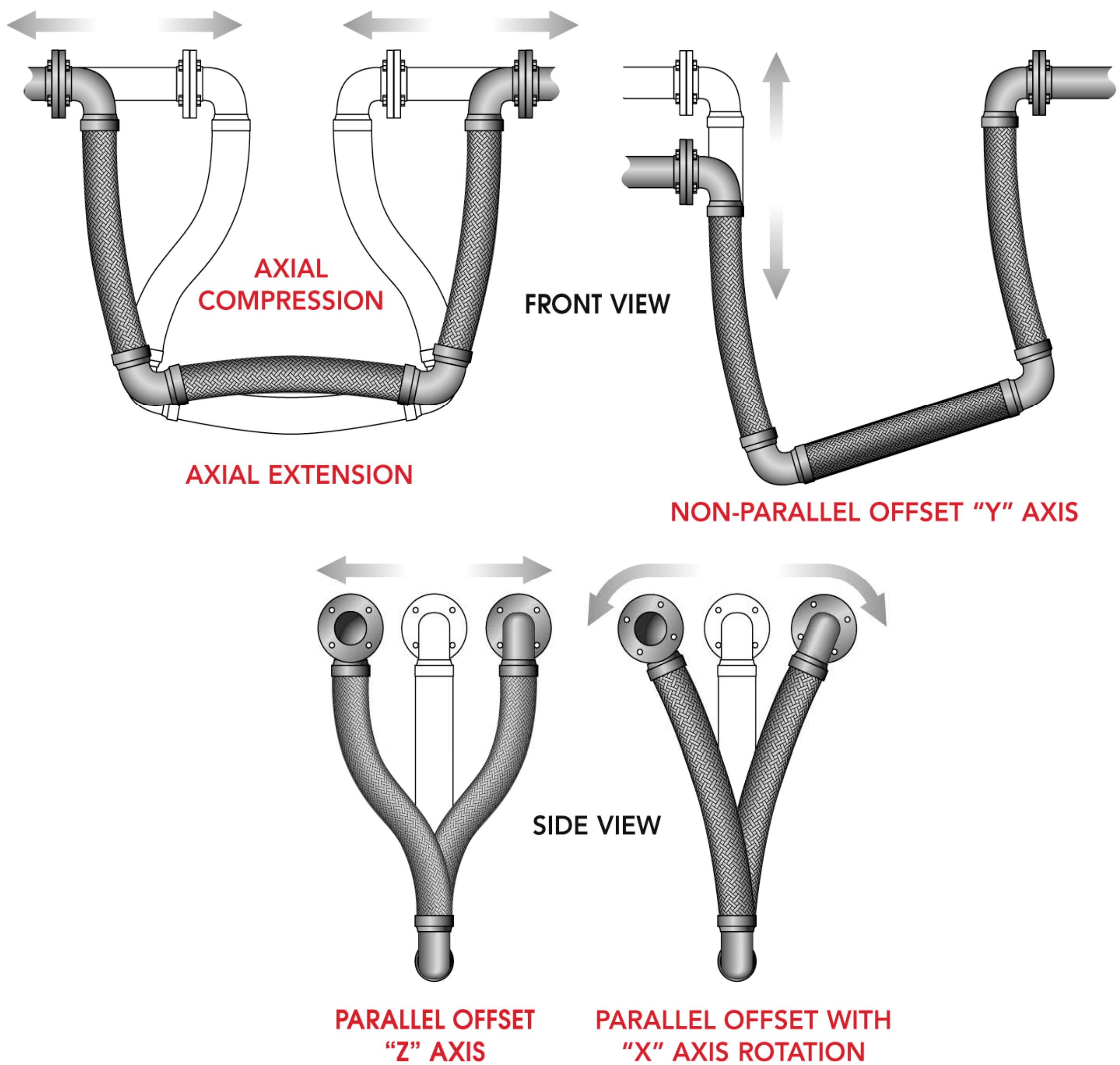
APPROVED
For Fire Protection Systems

Cycle Testing:

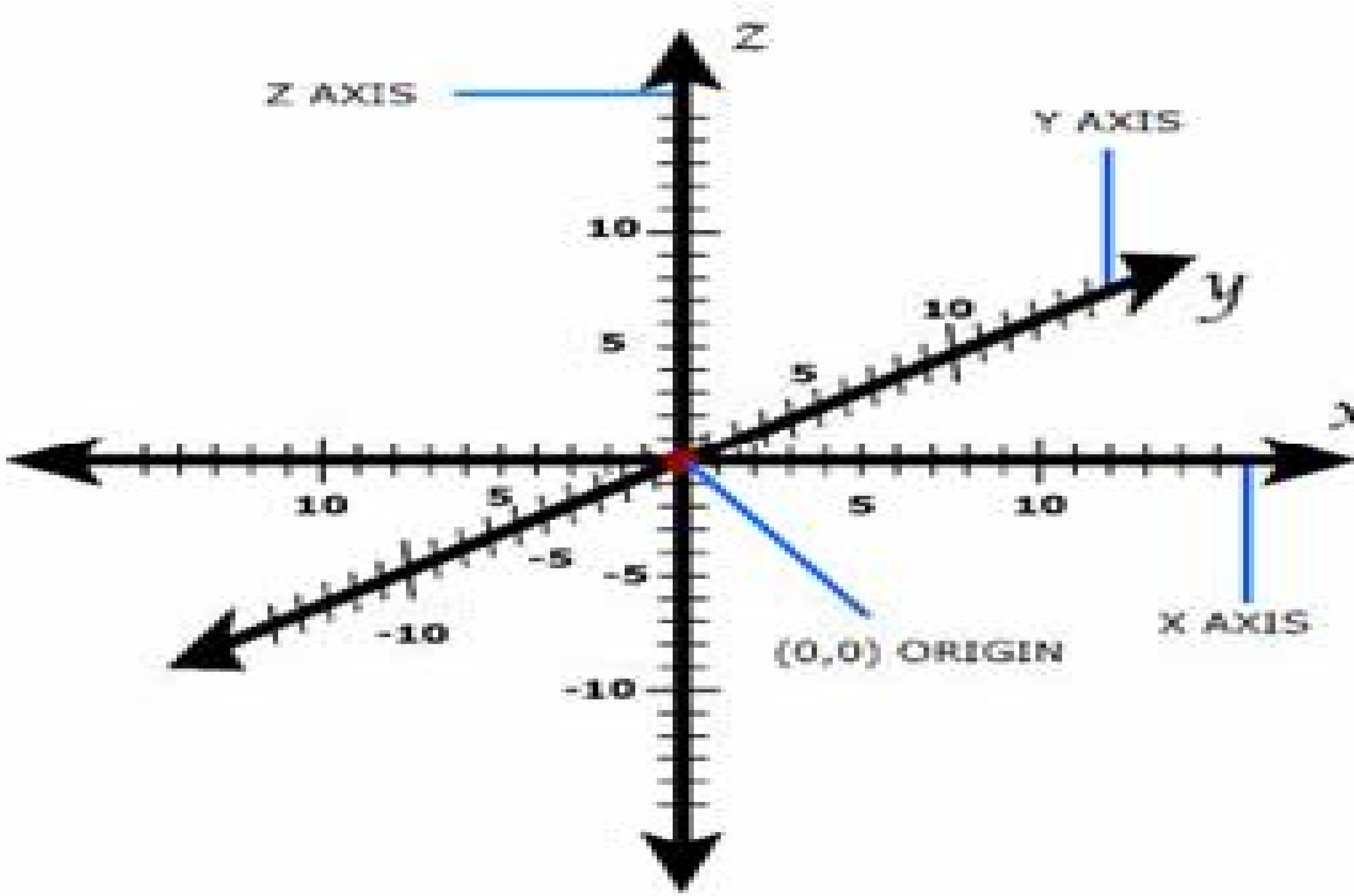
One of the rigorous requirements of UL 536 testing was flexure testing to **20,000 cycles** while under pressure!

Tri-Flex Loop® Movement Capabilites

Tri-Flex Loop is capable of handling the following movements simultaneously:



Planes of Motion-X, Y & Z Axis



LISTED

TRI-FLEX LOOP® for combustible gases and flamma liquids 33NB

No. 5,803,506

13.6.8.4 Other Piping Systems. Piping not designed and constructed in accordance with ASME B31 or NFPA 13 shall comply with the requirements of Section 13.6.11.

13.6.11 Other Mechanical and Electrical Components.
Mechanical and electrical components, including distribution systems, not designed and constructed in accordance with the reference documents in Chapter 23 shall meet the following:

1. Components, their supports and attachments shall comply with the requirements of Sections 13.4, 13.6.3, 13.6.4, and13.6.5.

2. Where mechanical components contain a sufficient quantity of hazardous material to pose a danger if released, and for boilers and pressure vessels not designed in accordance with ASME BPVC, the design strength for seismic loads in combination with other service loads and appropriate environmental effects shall be based on the following material properties.
a. For mechanical components constructed with ductile materials (e.g., steel, aluminum, or copper), 90 percent of the minimum specified yield strength.
b. For threaded connections in components constructed with ductile materials, 70 percent of the minimum specified yield strength.
c. For mechanical components constructed with non ductile materials (e.g., plastic, cast iron, or ceramics), 10 percent of the material minimum specified tensile strength.
d. For threaded connections in piping constructed with non ductile materials, 8 percent of the material minimum specified tensile strength.

ASCE Standard 7-05 Chapter13-Seismic Design Loads For Nonstructural Components ~ page 151

13.6.8.2 Fire Protection Sprinkler Systems in Seismic Design Category C. In structures assigned to Seismic Design CategoryC, fire protection sprinkler systems designed and constructed inaccordance with NFPA 13 shall be deemed to meet the other requirements of this section.

13.6.8.3 Fire Protection Sprinkler Systems in Seismic Design Categories D through F. In structures assigned to Seismic Design Categories D, E, or F, the following requirements shall be satisfied:1. The hangers and sway bracing of the fire protection sprinkler systems shall be deemed to meet the requirements of this section if both of the following requirements are satisfied:

1. The hangers and sway bracing of the fire protection sprinkler systems shall be deemed to meet the requirements of this section if both of the following requirements are satisfied:
a. The hangers and sway bracing are designed and constructed in accordance with NFPA 13.
b. The force and displacement requirements of Sections 13.3.1 and 13.3.2 are satisfied.

2. The fire protection sprinkler system piping itself shall meet the force and displacement requirements of Section 13.3.1 and 13.3.2.

3. The design strength of the fire protection sprinkler system piping for seismic loads in combination with other service loads and appropriate environmental effects shall be based on the following material properties:
a. For piping and components constructed with ductile materials (e.g., steel, aluminum, or copper), 90 percent of the minimum specified yield strength.
b. For threaded connections in components constructed with ductile materials, 70 percent of the minimum specified yield strength.
c. For piping and components constructed with non ductile materials (e.g., plastic, cast iron, or ceramics), 10 percent of the material minimum specified tensile strength.

ASCE Standard 7-05 Chapter13-Seismic Design Loads For Nonstructural Components ~ page 151


AnvilStar™
Fire Products Division of Anvil International
FM
APPROVED

Tri-Flex Loop®: Passing the Test

The New York State Center for Advanced Technology (CAT) at Rensselaer Polytechnic Institute, Troy, NY
Tri-Flex Loop Flexible Coupling for Seismic Applications Testing Project No. A70614, October 1998

Conclusions

The Finite Element analysis predicts significantly higher strain energy, and therefore greater likelyhood of failure, in the national competitor's than in the Flex-Hose Tri-Flex Loop coupling for a given displacement. Tri-Flex Loop will withstand limited application of displacements in excess of those published by the manufacturer without failure.

The New York State Center for Advanced Technology (CAT) concluded the Flex-Hose Tri-Flex Loop is found to be more likely to survive a seismic event where large, three dimensional relative displacements of the ends of the coupling are involved


A Purely Technical Experience.
Yours for the Asking!
Tri-Flex Loop® Thermal Expansion Loops and Seismic Connectors - NewProject1
Expansion Loop Sizing Program
PROGRAM FEATURES
• Calculates pipe thermal expansion; various alloys for chilled water, condenser water, hot water, domestic hot water, saturated steam
• Calculates nesting of expansion loops
• Building seismic joints
• Calculates spring rates of expansion loops
• Automatically selects UL Listed hanger assemblies
• Creates detailed schedule or submittals
• Allows saving of projects, opening new projects, and editing of projects
• Specifications
• Industry terminology
• Application examples
A World of Difference...
Tri-Flex Loop® Sizer
PIPING CONNECTIONS

Tri-Flex Loop

System Savings

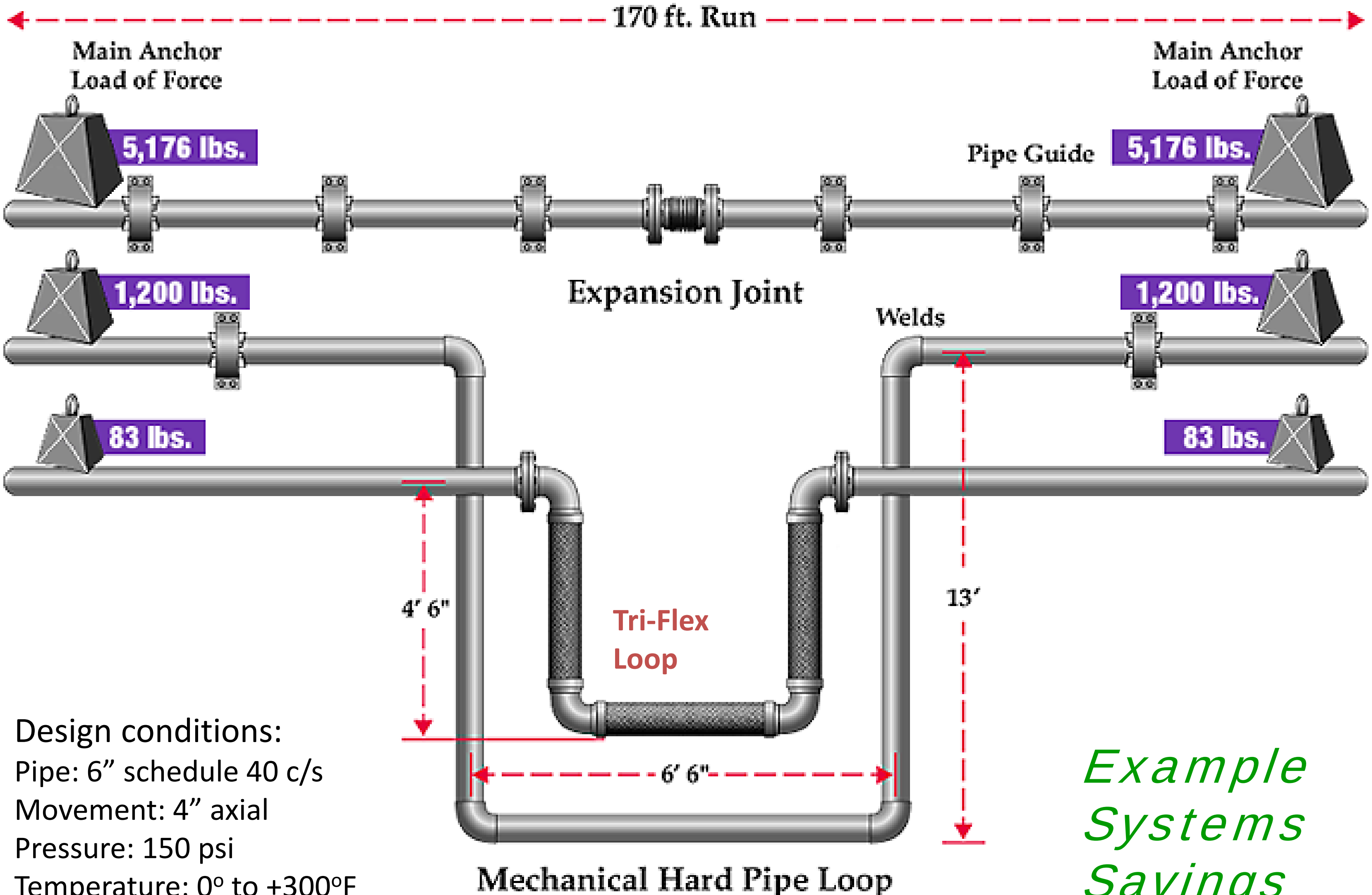
- **Reduced** space requirements
- **Reduced** anchor load
- **Reduced** installation expenses:

  Eliminates pipe guides and expansion joints
  Fewer fittings
  Eliminates massive anchors
  Eliminates mechanical pipe loop

Tri-Flex Loop

Features and Benefits

- Reduces system cost
  - No thrust load, reduces piping stress
  - Reduces anchors needed
- First design to handle multi-plane movement
  - Reduces compensating apparatus required in each pipe run
  - Absorbs up to 4” of movement
  - Eliminates pipe guides
- Compact design increases usable space
  - Requires 64% less space than mechanical pipe loop
- 4:1 safety factor



Design conditions:

Pipe: 6” schedule 40 c/s

Movement: 4” axial

Pressure: 150 psi

Temperature: 0º to +300ºF

Length of run: 170 ft

Example Systems Savings

13.6.8 Piping Systems. Piping systems shall satisfy the requirements of this section except that elevator system piping shall satisfy the requirements of Section 13.6.10. Except for piping designed and constructed in accordance with NFPA 13, seismic supports shall not be required for other piping systems where one of the following conditions is met:

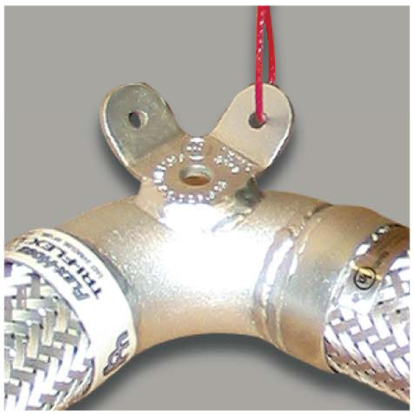
1. Piping is supported by rod hangers; hangers in the pipe run are 12 in. (305 mm) or less in length from the top of the pipe to the supporting structure; hangers are detailed to avoid bending of the hangers and their attachments; and provisions are made for piping to accommodate expected deflections.

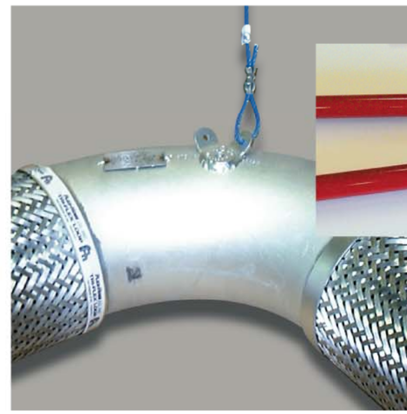
2. High-deformability piping is used; provisions are made to avoid impact with larger piping or mechanical components or to protect the piping in the event of such impact; and the following size requirements are satisfied:
a. For Seismic Design Categories D, E, or F where *I p is* greater than 1.0, the nominal pipe size shall be 1 in. (25 mm) or less.
b. For Seismic Design Category C, where *Ip is greater than* 1.0, the nominal pipe size shall be 2 in. (51 mm) or less.
c. For Seismic Design Categories D, E, or F where *Ip is* equal to 1.0, the nominal pipe size shall be 3 in. (76 mm) or less.

ASCE Standard 7-05 Chapter13-Seismic Design Requirements For Nonstructural Components ~ page 151

Simple & Reliable.

The UL Listed Seismic Wire Rope/Cable™ used in our hanger assemblies conform to the requirements of the ASCE (American Society of Civil Engineers) guidelines for structured applications of wire rope, in that the cable is pre-stretched and the permanent end fittings maintain the breakstrength of the cable with a safety factor of two.

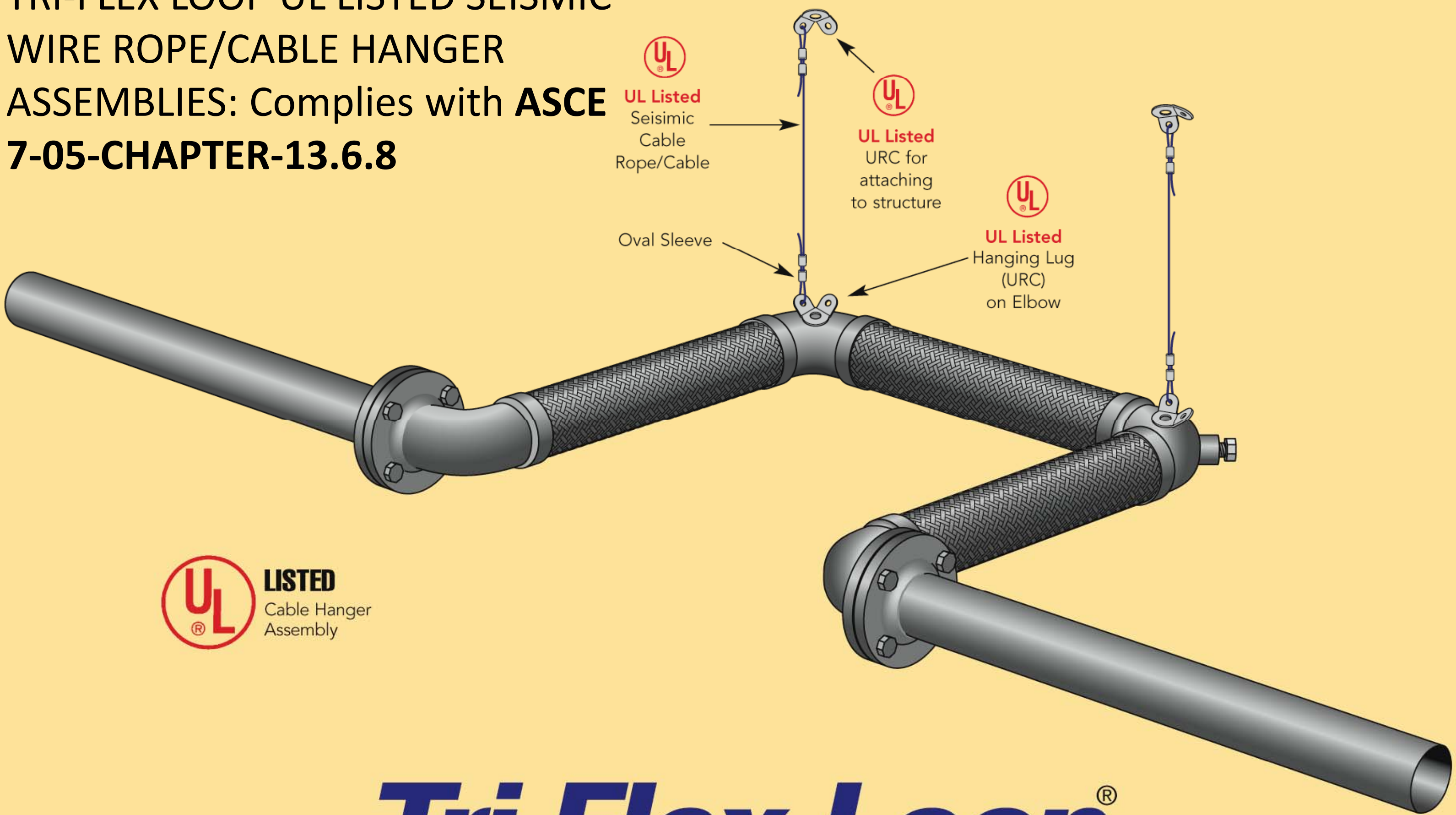




Use **RED CABLE** kit for installing all Tri-Flex Loops up to 8" in diameter.

Use **BLUE CABLE** kit for installing all Tri-Flex Loops of 10" and 12" in diameter.

TRI-FLEX LOOP UL LISTED SEISMIC WIRE ROPE/CABLE HANGER ASSEMBLIES: Complies with **ASCE 7-05-CHAPTER-13.6.8**



LISTED
Cable Hanger
Assembly

Tri-Flex Loop®
Hanger Assembly Kit

13.6.9 Boilers and Pressure Vessels. Boilers or pressure vessels

designed in accordance with ASME BPVC shall be deemed to meet the force, displacement, and other requirements of this section. In lieu of the specific force and displacement requirements provided in the ASME BPVC, the force and displacement requirements of Sections 13.3.1 and 13.3.2 shall be used.
Other boilers and pressure vessels designated as having an *Ip = 1.5, but not constructed in accordance with the requirements* of ASME BPVC shall comply with the requirements of Section 13.6.11.

ASCE Standard 7-05 Chapter13-Seismic Design Requirements For Nonstructural Components ~ page 151

13.6.11 Other Mechanical and Electrical Components.

Mechanical and electrical components, including distribution systems, not designed and constructed in accordance with the reference documents in Chapter 23 shall meet the following:

1. Components, their supports and attachments shall comply with the requirements of Sections 13.4, 13.6.3, 13.6.4, and13.6.5.
2. Where mechanical components contain a sufficient quantity of hazardous material to pose a danger if released, and for boilers and pressure vessels not designed in accordance with ASME BPVC, the design strength for seismic loads in combination with other service loads and appropriate environmental effects shall be based on the following material properties.

a. For mechanical components constructed with ductile materials (e.g., steel, aluminum, or copper), 90 percent of the minimum specified yield strength.

b. For threaded connections in components constructed with ductile materials, 70 percent of the minimum specified yield strength.

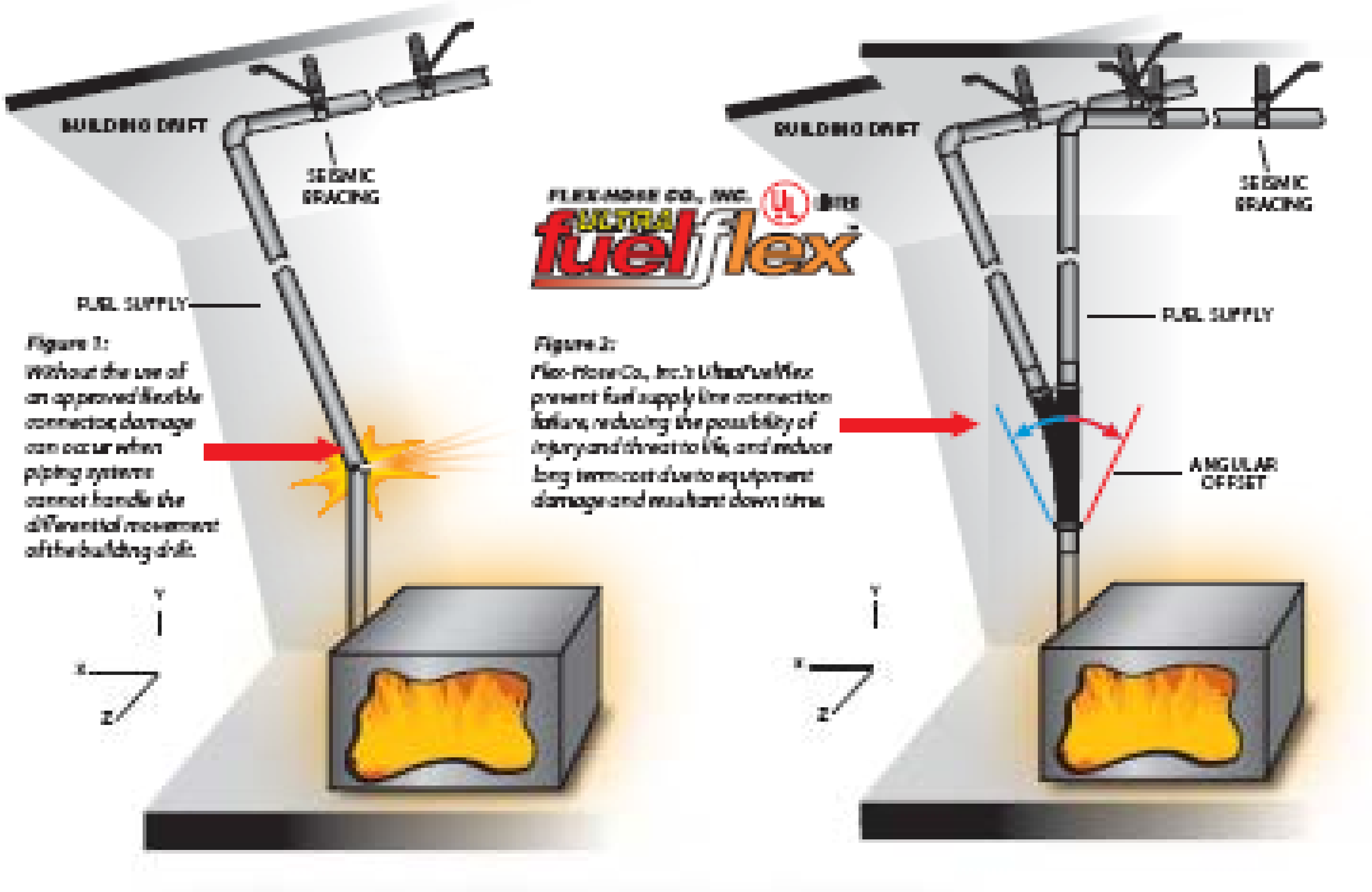
c. For mechanical components constructed with non ductile materials (e.g., plastic, cast iron, or ceramics), 10 percent of the material minimum specified tensile strength.

d. For threaded connections in piping constructed with non ductile materials, 8 percent of the material minimum specified tensile strength.

ASCE Standard 7-05 Chapter 13-Seismic Design Requirements For Nonstructural Components-Page ~ 152


AN INDUSTRY LEADER
40
FOR FORTY YEARS
FLEX-HOSE CO. INC.
MADE IN THE U.S.A. WITH PRIDE
ULTRA fuelflex™
Protecting Your Fuel Fired Equipment to meet the new International Building Code Requirements
CYCLE TESTED FOR 20,000 cycles
www.flexhose.com • 1.877.Tri.Flex

Gas Fired Equipment



Building Drift: Why Isolate Gas/Fuel Fired Equipment?

Flex-Hose Co. Inc.'s UltraFuelFlex meets the International Building Code 1621.3.11 Boilers and pressure vessels and is designed to meet the force and displacement requirements of Sections 1621.1.4 and 1621.1.5.

All current building codes for seismic and wind restraint design have the primary objectives: reduce the possibility of injury and threat to life, reduce long term cost due to equipment damage and resultant downtime.

FEMA (Federal Emergency Management Act) has identified one of the primary causes of property damage from earthquakes is the mechanical failure of gas and water lines contributing to fires.

The majority of U.S. jurisdictions have adopted the new International codes to insure financial backing from FEMA following an earthquake. All current building codes require seismic bracing of certain pipes. Damage occurs when pipes move independently of the building (see Figure 1). The ultimate goal of seismic bracing is to prevent damage to the pipe system by forcing it to move with the building. Other potential problems that occur are the incompatibility of piping systems with differential movement of the structure (drift) and bracing of piping with short/stiff service connections to equipment.

Fitting failures generally occur at or near equipment connections. The HVAC Industry suggests the following should be considered when installing seismic restraints:

- *Flexible connections should be provided between equipment that is braced and piping that need not be braced.*
- *Flexible connections should be provided between isolated equipment and braced piping.*

The International Building Code realizes the critical importance of protecting piping systems conveying flammable and combustible gases. Flex-Hose Co., Inc.'s UltraFuelFlex UL536 Listed connectors are approved for flammable and combustible gases and liquids. They are the ultimate protection for isolating critical gas/fuel fired equipment.

Standard Sizes 1" to 4" I.D.

LISTED UltraFuelFlex for combustible gases and flammable liquids 536B

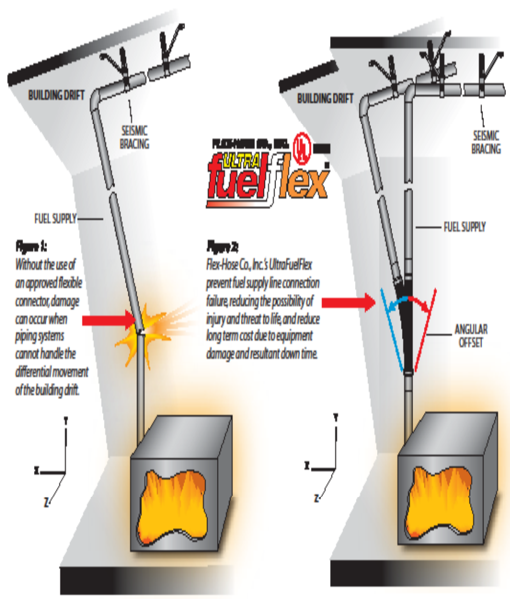


Figure 1: *Without the use of an approved flexible connector, damage can occur when piping systems cannot handle the differential movement of the building drift.*

Figure 2: *Flex-Hose Co., Inc.'s UltraFuelFlex prevent fuel supply line connection failure, reducing the possibility of injury and threat to life, and reduce long term cost due to equipment damage and resultant down time.*

ULTRA fuelflex™

Protecting Your Fuel Fired Equipment

www.flexhose.com

UFFMN-UL 1"-4" I.D. (Threaded Ends)

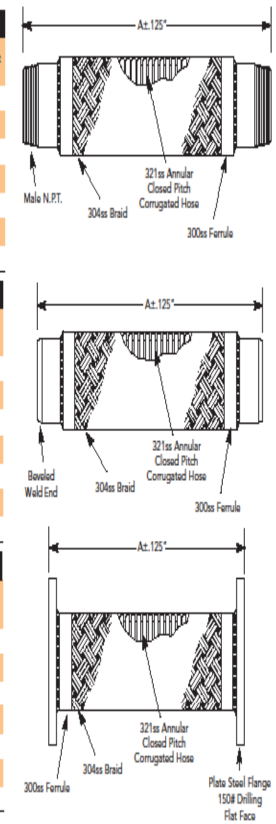
I.D. (In.)	A (In.)	Pressure (PSI) 70°F	Parallel Offset (In.) Permanent	Parallel Offset (In.) Intermittent	Angular Deflection (Deg.)	Weight (Lb.)
1.00	16.00	175	1.75	1.12	80°	1.40
1.25	16.00	175	1.75	1.00	50°	1.78
1.50	16.00	175	1.75	.75	50°	2.20
2.00	21.00	175	2.75	1.12	60°	3.76
2.50	22.00	175	2.50	.75	60°	5.60
3.00	22.00	175	1.75	.62	50°	7.68
4.00	25.00	175	2.00	.75	40°	10.70

UFFWN-UL 1"-4" I.D. (Weld Ends)

I.D. (In.)	A (In.)	Pressure (PSI) 70°F	Parallel Offset (In.) Permanent	Parallel Offset (In.) Intermittent	Angular Deflection (Deg.)	Weight (Lb.)
1.00	18.00	175	1.75	1.12	80°	1.68
1.25	18.00	175	1.75	1.00	50°	2.16
1.50	19.00	175	1.75	.75	50°	2.89
2.00	22.00	175	2.75	1.12	60°	4.07
2.50	23.00	175	2.50	.75	60°	6.08
3.00	24.00	175	1.75	.62	50°	8.94
4.00	27.00	175	2.00	.75	40°	13.50

UFFMP-UL 1"-4" I.D. (Flanged Ends)

I.D. (In.)	A (In.)	Pressure (PSI) 70°F	Parallel Offset (In.) Permanent	Parallel Offset (In.) Intermittent	Angular Deflection (Deg.)	Weight (Lb.)
1.00	14.00	175	1.75	1.12	80°	5.00
1.25	14.00	175	1.75	1.00	50°	6.00
1.50	14.00	175	1.75	.75	50°	7.00
2.00	17.00	175	2.75	1.12	60°	11.00
2.50	17.00	175	2.50	.75	60°	14.00
3.00	17.00	175	1.75	.62	50°	16.00
4.00	20.00	175	2.00	.75	40°	23.00



NOTE: Assembly lengths are the minimum required to achieve movements noted on charts. Movements can increase by adding to the overall length. Please consult factory. Manufactured with 5:1 safety factor.

Motion Classifications

Flex-Hose Co.'s UltraFuel Flex UL536 listed connectors are capable of handling the following movements:

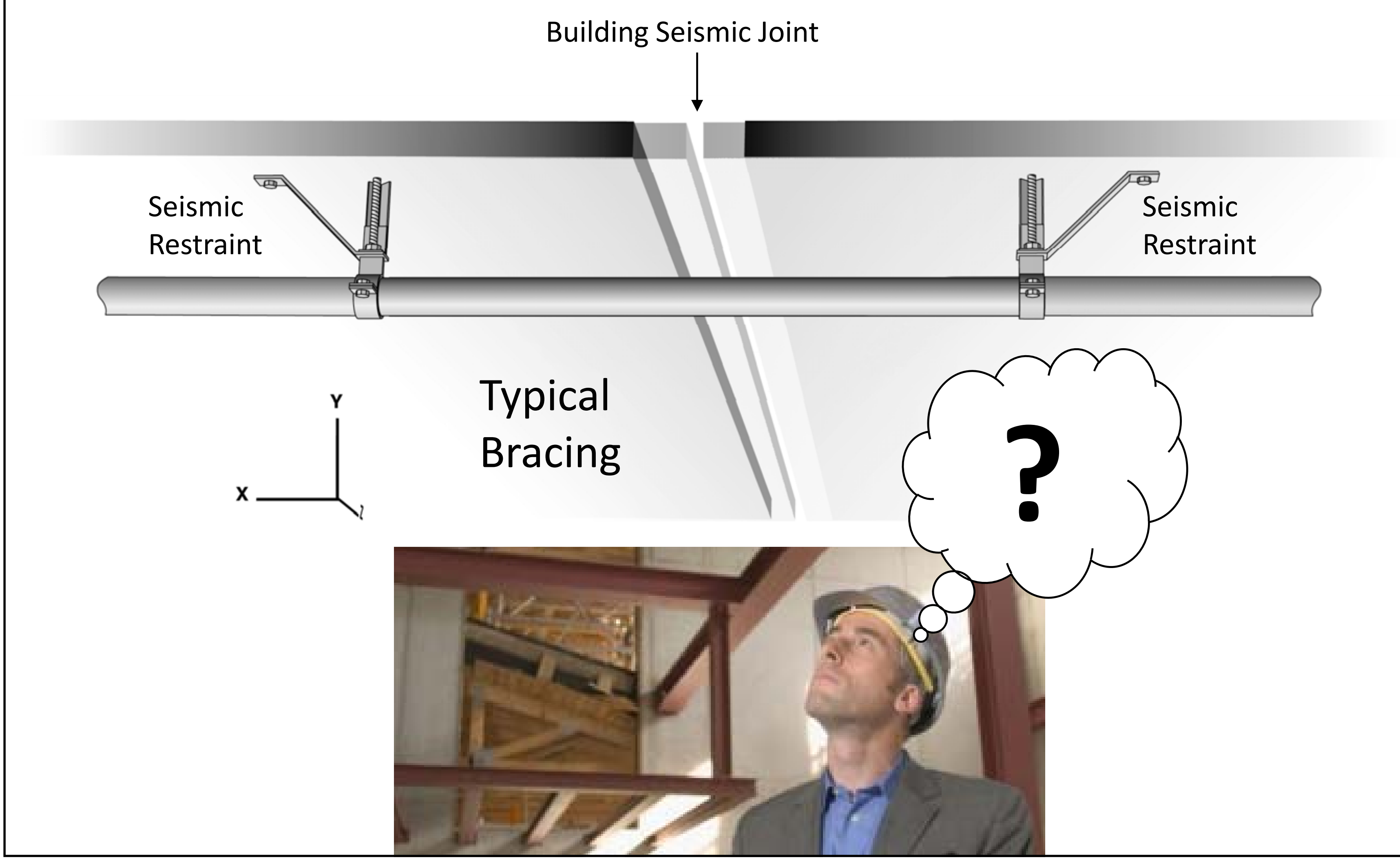
Parallel Offset:
Motion that occurs when one end of the hose assembly is deflected in a plane perpendicular to the longitudinal axis with the ends remaining parallel. Offset is measured as displacement of the free end centerline from the fixed end centerline.

Angular Offset:
Angular movement is defined as the bending of the hose so that the ends are no longer parallel. Amount of movement is measured in degrees from centerline of the hose if were installed straight.

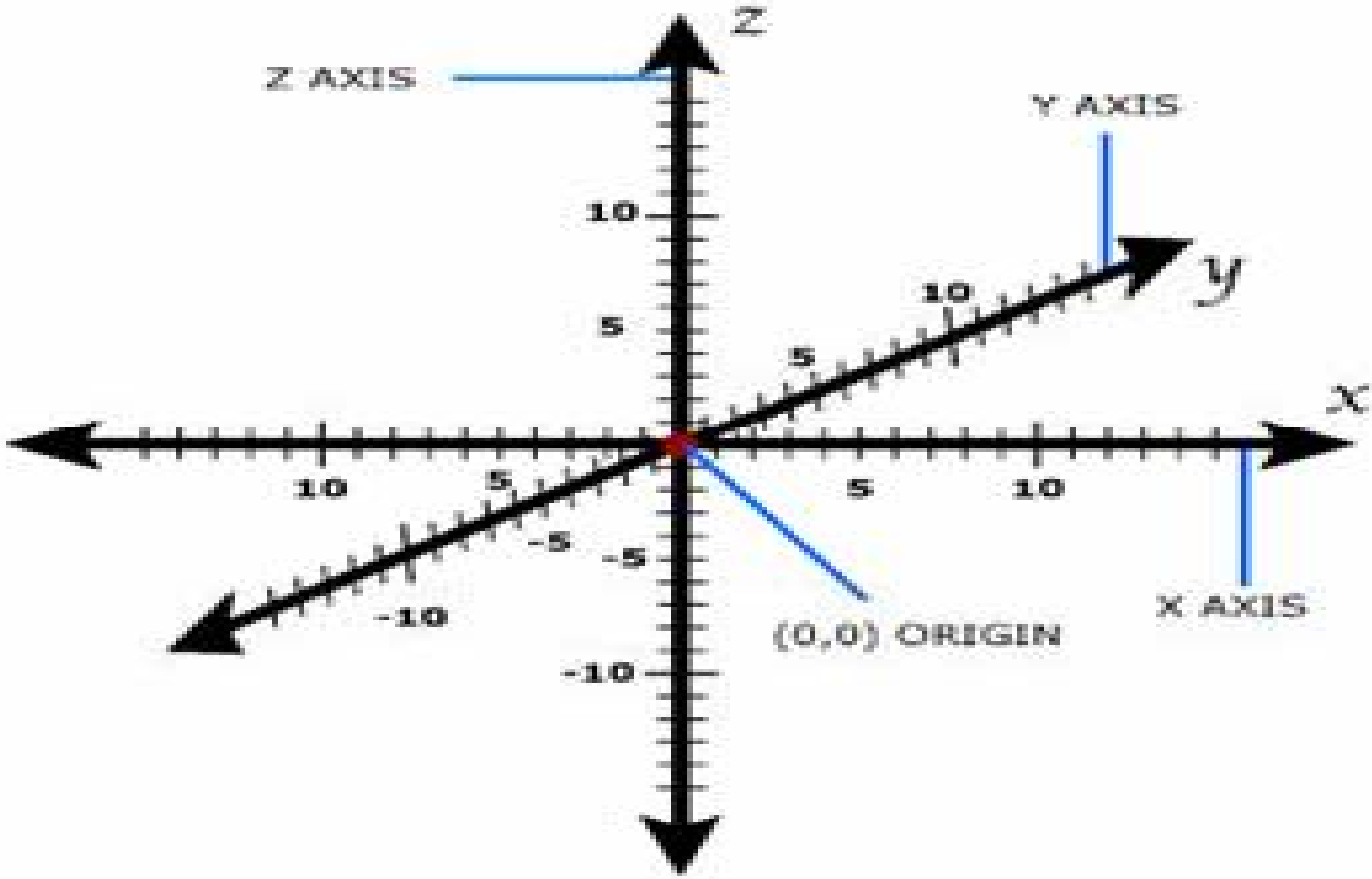
Motion Frequency:
Permanent Offset - The maximum fixed parallel offset to which the UltrFuel Flex assembly may be bent without damage to the convolutions. No further motion is to be imposed other than normal vibration.

Intermittent Offset is motion that occurs on a regular or irregular cyclic basis. It is normally the result of seismic motion, or other non-continuous actions such as thermal expansion and contraction.

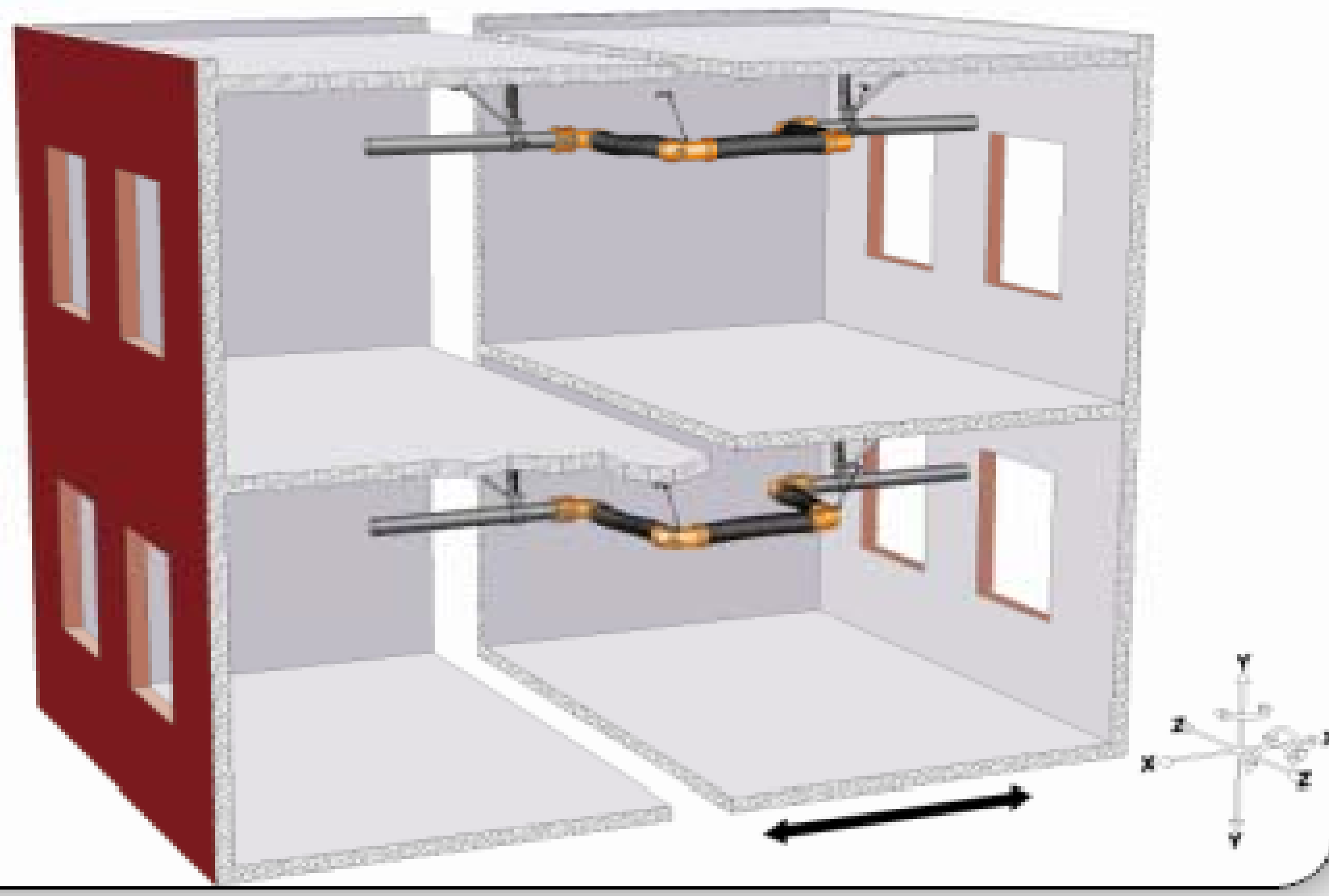
Isolating Building Joints?



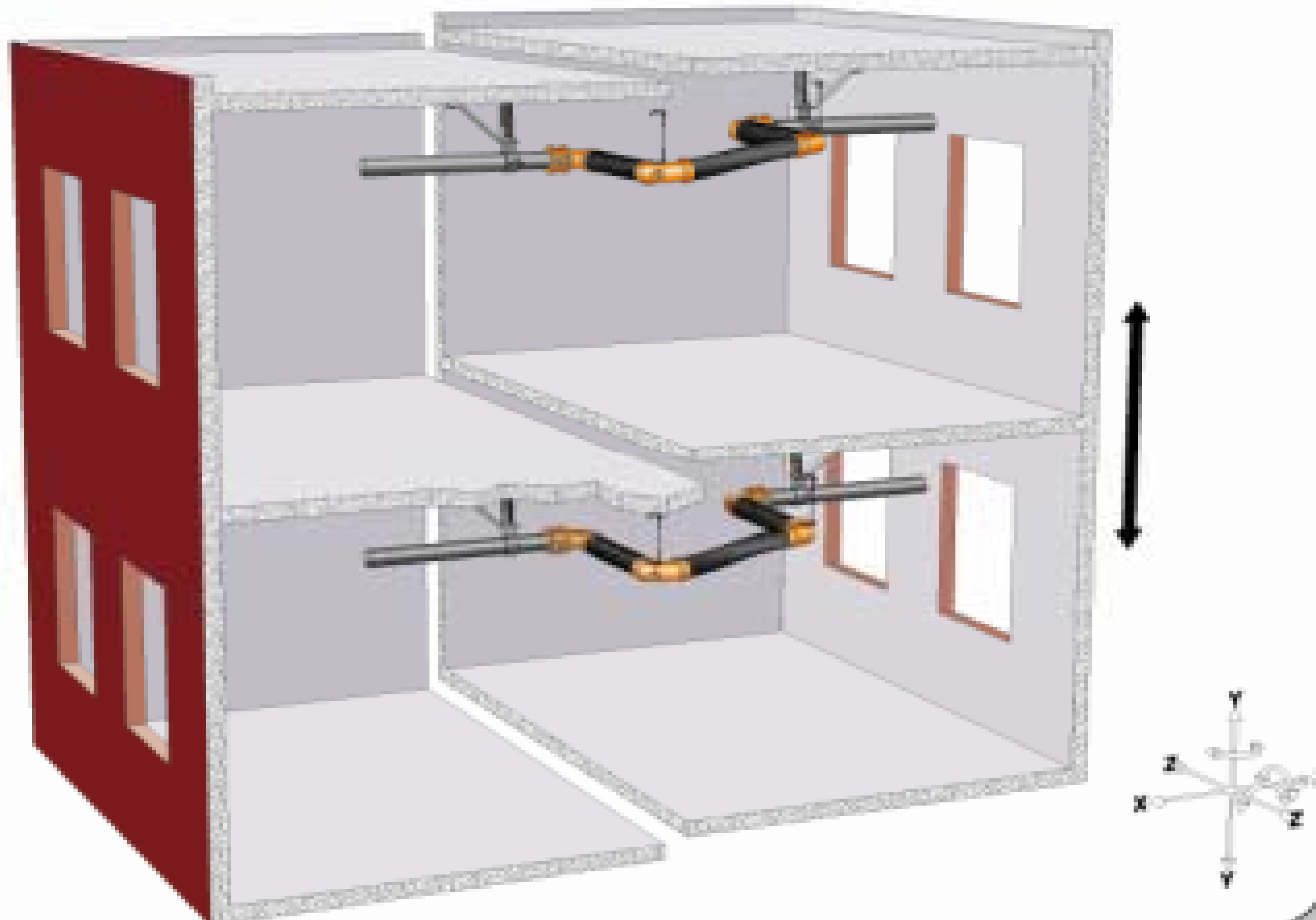
Planes of Motion-X, Y & Z Axis



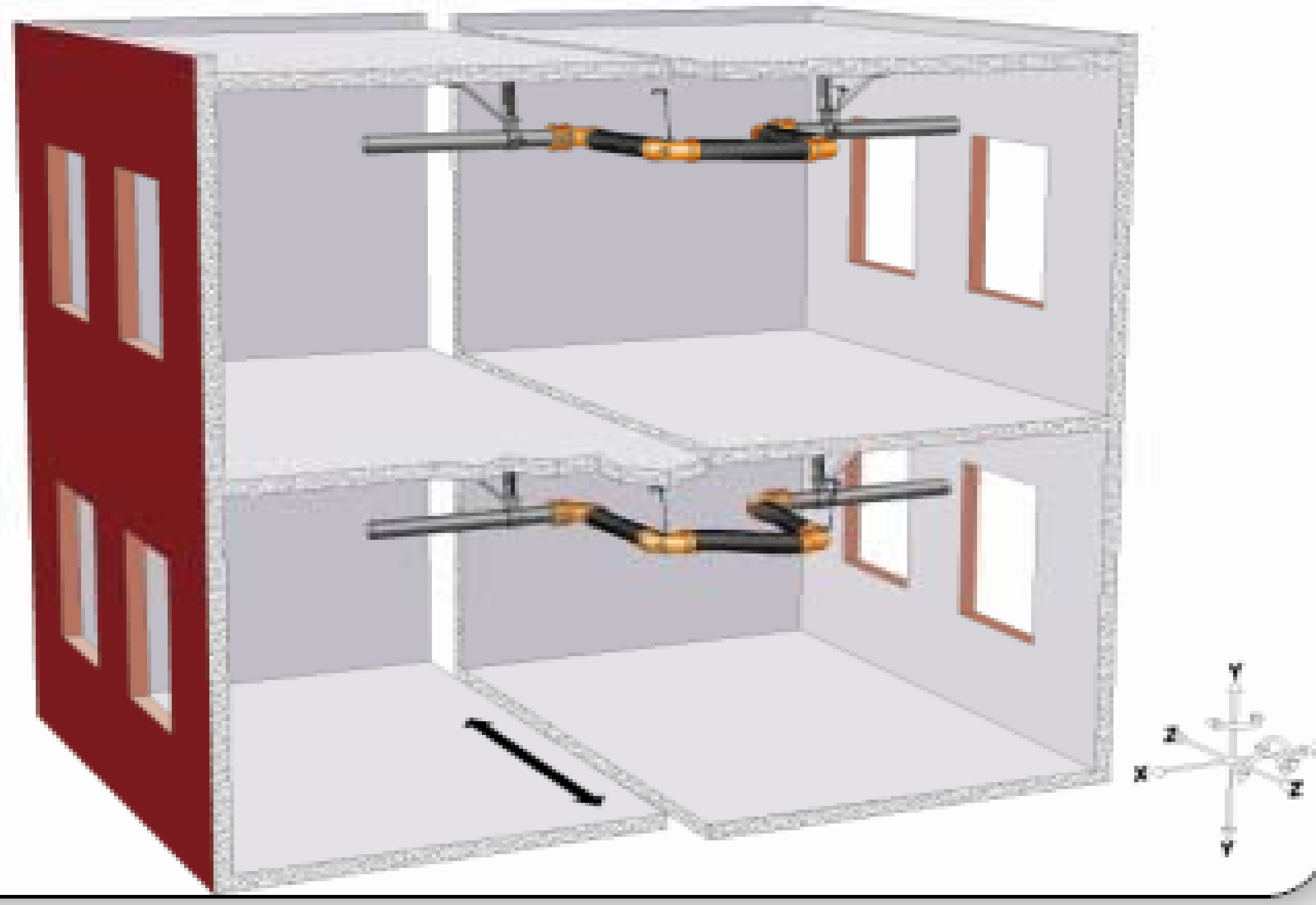
Horizontal Displacement on “X” Axis



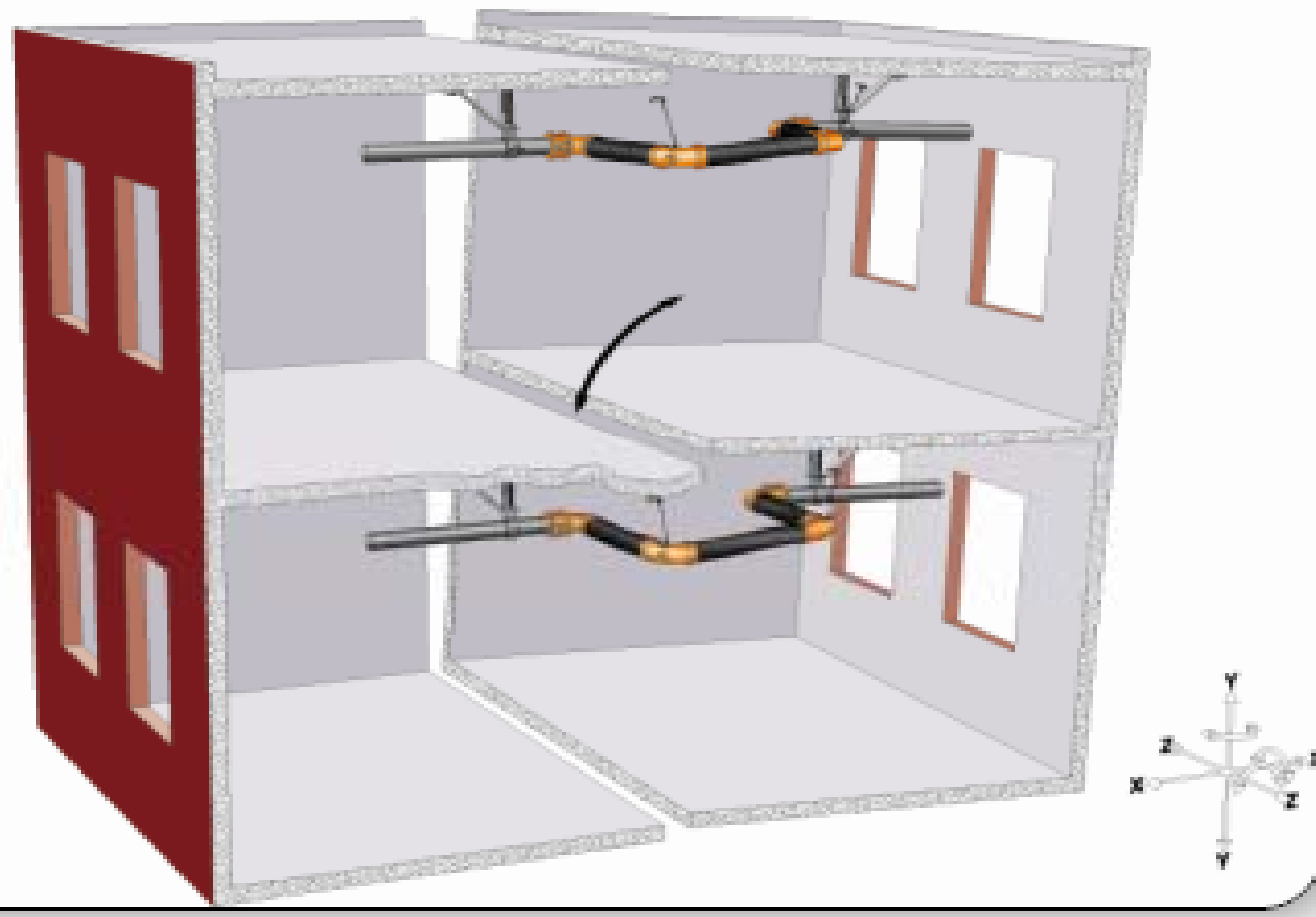
Vertical Displacement on "Y" Axis



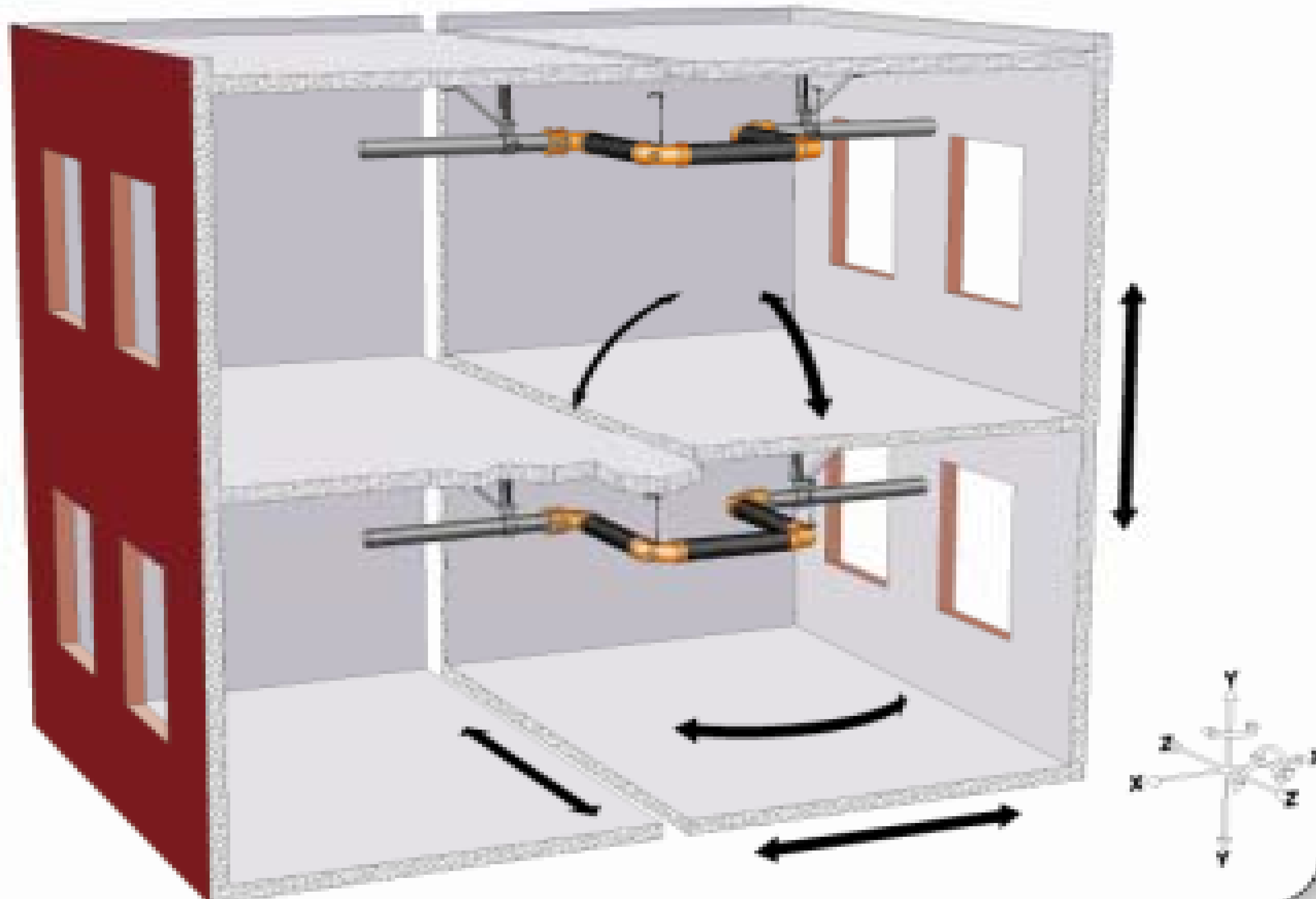
Horizontal Displacement on "Z" Axis



Isolating Building Drift with Rotation



Random Displacement

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Questions?
Thank You

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