SEISMIC CONTROL MEASURES
By Richard Lévesque, ing., P.Eng., LEED AP
Outline

- What and Why of Seismic Restraint
- Applicable Codes & Standards for Seismic Restraint
- Where and When of Seismic Restraint
- General restraint rules
  - Pipe and Duct
  - Suspended, Base Mounted and Wall Mounted Units
  - Conduits and Cable Tray
- Information on shop drawings
- Renovation and Retrofit work
- Example of Seismic Restraint Installation
What is Seismic Restraint?

Bracing of pipe, duct, conduit, cable tray & suspended equipment
What is Seismic Restraint?

Anchorage of roof & base mounted equipment
Why Provide Seismic Restraint?

- Restraints are required by the National Building Code (NBC) since 1965 and the Ontario Building Code (OBC)
  
  Provides life safety for building occupants
  Minimizes damage to mechanical systems & adjacent components
  Maintains performance of equipment after seismic event

- 1994 Northridge (California) Earthquake
  
  $20 Billion Damage
  77% of damage is attributed to non-structural components.

Applicable Codes & Standards for Seismic Restraint

Building Codes
Cl.4.1.8.18 (OBC 2012)
Cl.4.1.8.18 (NBC 2010)

CSA S832-14
Seismic Risk Reduction of operational and functional components of buildings

ASHRAE
NFPA
SMACNA
Applicable Codes & Standards for Seismic Restraint

ASHRAE - Practical Guide to Seismic Restraint
Second Edition

SMACNA – Seismic Restraint Manual
Guidelines for Mechanical Systems

ASCE/SEI 7-10
Minimum Design loads for Buildings and Other Structures
Where & When is Seismic Restraint Required?
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Where & When is Seismic Restraint Required?

- From OBC 2012 & NBC 2010 (Clause 4.1.8.18)

\[ I_E \times F_a \times S_a(0.2) > 0.35 \]

- Building Importance Factor (1.0, 1.3, or 1.5)
- Acceleration Response (function of site class/characteristics)
- Spectral Response Acceleration (function of location)

When building is classified as **post disaster** \( (I_E = 1.5) \), seismic restraint **MUST** be provided.

*That information is found on the structural drawings general notes.*
### Where & When is Seismic Restraint Required?

<table>
<thead>
<tr>
<th>Location (ON)</th>
<th>Importance Factor (I_F) and Site Class</th>
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Pipe & Duct Restraint

• **Pipe/duct does not require restraint when:**

  smaller 3.0” Ø for pipe in general areas

  smaller than 1.25” Ø in mechanical rooms

  smaller than 1.25” Ø for pipe containing hazardous materials and medical piping (i.e., gas, oil, medical vacuum)

  smaller than 6 sq. feet face area for rectangular duct

  smaller than 28” diameter for round duct
Pipe & Duct Restraint

Pipes on a trapeze with combined weight less than 10lb/foot does not require seismic restraint.
Pipe & Duct Restraint

General Restraint Rules:

Standard pipe: 40ft transverse / 80ft longitudinal

Drainage Pipe (MJ Type): 20ft transverse / 40ft longitudinal

Hazardous pipe/duct: 20ft transverse / 40ft longitudinal

Standard duct: 30ft transverse / 60ft longitudinal

Note: Capacity of seismic restraint system may required smaller spacing than the typical maximum spacing above.
Pipe & Duct Restraint
General Restraint Rules

Duct/pipe must be restrained to prevent transverse and longitudinal movement.
Pipe and Duct Run needs a minimum of 2 lateral restraints and 1 longitudinal restraint.
A run is length of pipe between two elbows or ends and is over 2’-0” long.

Run 1
20’ or 40’ max [Pipe]
30’ max [Duct]

Run 2
24” max

Run 3

For transverse restraint to act as a longitudinal restraint in the adjacent run, it must be installed within 24” of the end of the run.
Pipe & Duct Restraint

• **What is a Restraint for pipes and duct:**
Pipe & Duct Restraint

- Rod Stiffeners:

With seismic restraint cables installed, when a seismic event occurs, it creates compression forces in the hanger rod.
Rod Stiffeners

ROD STIFFENER DETAILS

Stiffened Rod

Rod Stiffener Clamp
Pipe & Duct Restraint

“12 inch Rule”
Pipe & Duct Restraint

Transverse bracing will occur at the interval specified in the tables in Chapters 5, 6, 7, or 8 at both ends if the duct run is less than the specified interval. Transverse bracing will be installed at each duct turn and at each end of a duct run, with a minimum of one brace at each end.

Longitudinal bracing will occur at the interval specified in the tables in Chapters 5, 6, 7, or 8 with at least one brace per duct run. Transverse bracing for one duct section may also act as longitudinal bracing for a duct section at 90 degrees turns if the bracing is installed within 24 in. (600 mm) of the inside intersection of the ducts and the bracing is sized for the larger duct, see Figure 4-1. Duct joints will conform to SMACNA duct construction standards.

A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected. (Example: To brace a 30 x 30 in. duct beside a 54 x 28 in. duct, select bracing for an 84 x 42 in. duct. The horizontal dimension of the 84 x 42 in. duct is equal to the combined ducts, and its weight is greater than their combined weights.)

Walls (including gypsum board non-load bearing partitions) that have ducts running through them may replace a typical transverse brace. Provide solid blocking around duct penetrations at all stud wall construction.

3.4 GENERAL REQUIREMENTS FOR BRACING OF PIPES

Pipes and their connections constructed of ductile materials (copper, ductile iron, steel, or aluminum with brazed or welded connections) shall be braced as indicated in this manual. Pipes and their connections constructed of non-ductile materials, or with screwed connections shall have the brace spacing reduced to one-half of the spacing allowed in this manual.

This manual does not apply to fire sprinkler piping.

Seismic supports are not required for piping systems where one of the following conditions is met:

a. 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.

b. 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 requirements are satisfied:
   1. For Seismic Design Categories D, E, or F where Lp is greater than 1.0, the nominal pipe size shall be 1 in. (25 mm) or less.
   2. For Seismic Design Category C, where Lp is greater than 1.0, the nominal pipe size shall be 2 in. (51 mm) or less.
   3. For Seismic Design Categories D, E, or F where Lp equals 1.0, the nominal pipe size shall be 3 in. (76 mm) or less.

Transverse bracing will be at 40 ft (12.2 m) maximum except where a lesser spacing is indicated in the tables for bracing of pipes.

Longitudinal bracing will be at 80 ft (24.4 m) maximum except where a lesser spacing is indicated in the tables. For pipes where thermal expansion is a consideration, an anchor point may be used as the specified longitudinal brace provided it has a capacity equal to, or greater than, a longitudinal brace. The longitudinal braces and connections must be capable of resisting the additional force induced by expansion and contraction.

Longitudinal bracing shall be attached to the pipes by pipe clamps. Do not attach longitudinal bracing to the pipe hangers. Pipe clamps shall be properly sized and
Pipe & Duct Restraint

EXCEPTIONS FROM SWAY BRACING

Some piping may not require sway bracing. The applicable code for the project may list some minimum requirements, as shown in Chapter 2. Some building codes allow for exceptions based on pipe diameter. In all cases, the life safety implications should be considered when determining bracing exceptions. Following is a list of suspended piping installations that the engineer of record may consider excluding from bracing unless specifically addressed in local codes:

1. All gas piping with a nominal diameter less than 1 in. (25 mm).
2. All other steel and copper piping throughout the building with a nominal diameter less than 2 in. (50 mm).
3. Any individually supported pipe run where the distance, as measured from the top of the pipe to the structure to which it is attached, is less than 12 in. (305 mm) for the entire length of the run. Trapeze-supported pipe runs may also be excluded from bracing, provided the distance as measured from the top of the trapeze to the structure to which it is attached is less than 12 in. (305 mm) for the entire length of the run. In addition, the hanger connection to the structure should be free to pivot so as to not develop a moment. This can be done with the addition of a swivel, eye bolt, or vibration isolation hanger connection.

Note: A single support location that meets the 12 in. (305 mm) rule above does not constitute a seismic sway brace location. The purpose of this exception is to allow the piping to swing over a short distance of 12 in. (305 mm), which, in most cases, will not result in piping damage or the piping striking another system or piece of equipment.

Two additional special conditions can be considered:

a. The trapeze may support multiple small-diameter pipes that would be bracing exceptions according to the list above.

b. One pipe of many on a trapeze would not be a bracing exception according to the list above.

The following notes address these special conditions.

1. Any combination of small piping supported on a trapeze where the total weight exceeds 10 lb/ft (14.9 kg/m) should be sway braced regardless of pipe size.

Note: If directional changes or offsets to equipment connections allow for flexibility of the trapeze system (e.g., long offsets or flexible connectors), the system can be excluded from bracing as long as all pipes supported by the trapeze are listed in exceptions 1 and 2 above.

2. If only one pipe supported on a trapeze requires sway bracing, consider the total combined weight of all pipes on the trapeze to determine sway brace components and anchorage for the entire trapeze.

3. The 12 in. (305 mm) rule can still be used in these situations.
CHAPTER 13 SEISMIC DESIGN REQUIREMENTS FOR NONSTRUCTURAL COMPONENTS

13.6.8.1 ASME Pressure Piping Systems

Pressure piping systems, including their supports, designed and constructed in accordance with ASME B31 shall be deemed to meet the force, displacement, and other requirements of this section. When specific force and displacement requirements provided in ASME B31, the force and displacement requirements of Section 13.3 shall be used. Materials meeting the toughness requirements of ASME B31 shall be considered high-deformability materials.

13.6.8.2 Fire Protection Sprinkler Piping Systems

Fire protection sprinkler piping, pipe hangers, and bracing designed and constructed in accordance with NFPA 13 shall be deemed to meet the force and displacement requirements of this section. The exceptions of Section 13.6.8.3 shall not apply.

13.6.8.3 Exceptions

Design of piping systems and attachments for the seismic forces and relative displacements of Section 13.3 shall not be required where one of the following conditions apply:

1. Trapeze assemblies are used to support piping whereby no single pipe exceeds the limits set forth in 3a, 3b, or 3c below and the total weight of the piping supported by the trapeze assemblies is less than 10 lb/ft (146 N/m).

2. The piping is supported by hangers and each hanger in the piping run is 12 in. (305 mm) or less in length from the top of the pipe to the supporting structure. Where pipes are supported on a trapeze, the trapeze shall be supported by hangers having a length of 12 in. (305 mm) or less. Where rod hangers are used, they shall be equipped with swivels, eye nuts, or other devices to prevent bending in the rod.

3. Piping having an \( R_c \) in Table 13.6.1 of 4.5 or greater is used and provisions are made to avoid impact with otherstructural or nonstructural components or to protect the piping in the event of such impact and where the following size requirements are satisfied:
   a. For Seismic Design Category C where \( I_r \) is greater than 1.0, the nominal pipe size shall be 2 in. (50 mm) or less.
   b. For Seismic Design Categories D, E, or F and \( I_r \) is greater than 1.0, the nominal pipe size shall be 1 in. (25 mm) or less.
   c. For Seismic Design Categories D, E, or F where \( I_r = 1.0 \), the nominal pipe size shall be 3 in. (76 mm) or less.
Pipe & Duct Restraint

• The “12 inch Rule” is defined in the following:
  
  ASHRAE: Chapter 7/8 (Exceptions from Sway Bracing)
  SMACNA (3rd Edition): Chapter 3 – Sections 3.3 & 3.4
  ASCE 7-10: Chapter 13

• Pipe/duct meeting ALL of the following does not require restraint:
  
  - All hanger rods in a run are less than 12 inches in length
  - 12 inches clearance on each side to allow free motion
  - Non-moment generating connection at all hanger rod locations

• 12” rule does not apply to hung mechanical equipment.
Pipe & Duct Restraint

Rod Length:
Pipe & Duct Restraint

Non Moment Generating Connection:
Suspended Equipment

• Hung Equipment does not require restraint when:

  Rigidly attached to pipe or duct and is less than 75lbs (silencers, pumps, fan with no flex connection, etc.)

  Flexibly attached to pipe or duct and is less than 20lbs (fans with flex connection, etc.)

  Equipment hung independently that is less 20lbs
Wall Mounted Equipment

• **Equipment does not require restraint when:**
  Weight is 20lb or less

• **Wall to which equipment is mounted must be designed to resist seismic loads from equipment:**
  Connection to drywall and plaster is not acceptable
  Anchorage to structural wall is recommended (metal studs, blockwall, concrete wall)
  Wall capacity to resist the loads highlighted in seismic restraint calculations is by others
Base Mounted Equipment

• Base mounted equipment does not require seismic restraint if all of the following items are met:
  
  Does not connect to or contain hazardous materials

  No overturning moment due to seismic loads

  Weighs less than 400lbs

  Mounted on a stand 4 feet or less from the floor

• Base mounted equipment housekeeping pad:
  Minimum edge distance for anchors to be considered.
Base Mounted Equipment

• Base mounted equipment housekeeping pad:

Minimum edge distance for anchors.

Good practice to keep the house keeping pad 12” bigger than the unit on all 4 sides.
Roof Mounted Equipment

- **Roof Mounted Equipment and Equipment Curbs:**

  Curbs must be seismically rated (we provide that service)

  Friction due to gravity does not provide seismic restraint (can’t rely on self weight of the unit)

  Transfer of the Seismic loads to the structures need to be considered.

  Roof slopes - wood shims are not recommended
Roof Mounted Duct and Pipe

- Pipe and duct requiring seismic restraint must be positively connected to the structure.
- Gluing items to the roof membrane is not acceptable.
Cable Tray and Electrical Conduits

Cable Trays and Conduits do not require seismic restraint if:

- Cable Tray total weight (self weight and content) is less 10 lb./ft.
- Conduit individually hung (less than 3” diameter)
- Conduits on the same trapeze (conduits and their content) weight less than 10 lb/ft.

General Restraint Rules:

- Cable Tray: 40ft transverse / 80ft longitudinal
- Conduits: 40ft transverse / 80ft longitudinal

Note: Capacity of seismic restraint system may required smaller spacing than the maximum spacing.
Information on Shop Drawings

• The following information should appear on your shop drawings:

  Engineer’s stamp
  Seismic forces (for base building designer)
  Drawing & Equipment List
  Pipe/Duct/Conduits/Cable Tray:
    Restraint layout drawings
    Restraint system
    Anchorage details (to pipe/duct, to structure)
    Maximum unbraced hanger rod lengths
    Rod stiffening details
  Equipment:
    Unit/curb, curb/structure anchorage details
    Restraint locations and quantities
Renovation and Retrofit Work

• Part 11 of the OBC 2012, clause 11.3.1.2 (1):

11.3.1.2. New Building Systems and Extension of Existing Building Systems

(I) Except as provided in Article 11.3.3.1. and Section 11.5., the design and construction of a new building system or the extension of an existing building system, shall comply with all other Parts. (See Appendix A.)

• Appendix A:

A-11.3.1.2.(1) New and Extension of Existing Building System.
Generally, new or extended building systems should follow the Building Code for new construction, and where necessary, may seek some relief through compliance alternatives, alternative measures or match existing.
Example of Seismic Restraint Installation
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Thank you!