



Seismic requirements for fire protection systems

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Scope

- Recommendations / requirements for the protection of sprinkler systems against damage in areas subject to earthquakes are intended to:
 - Improve the likelihood that the fire protection systems will remaining in working condition after the earthquake;
 - Minimize potential water damage due to leakages from fire protection systems.

Reference standards

- NFPA 13, 2013 (Sprinkler Systems), Paragraph 9.3
- NFPA 20, 2013 (Fire Pumps), Paragraph 4.28
- NFPA 22, 2008 (Water Tanks), Paragraphs 4.11.4, 5.3, 6.3
- Factory Mutual Datasheet 2-8, 2010 (Earthquake Protection for Water-Based Fire Protection Systems)
- Guida Tecnica “Linee di Indirizzo per la Riduzione della Vulnerabilità Sismica dell’Impiantistica Antincendio”, Dicembre 2011, Ministero dell’Interno

The purpose of this presentation is a focus on requirements for sprinkler systems in areas subject to earthquakes, according to NFPA 13.

When (where) seismic requirements apply

- NFPA standards do not specify where to provide seismic protection geographically
- Criteria to be considered:
 - Site hazardousness (pga);
 - Building characteristics;
 - Highly exposed locations (type of activity, high values, etc.);
 - New constructions / Existing constructions
 - New sprinkler systems / Existing sprinkler systems

Protection of Sprinkler Piping

SEISMIC REQUIREMENTS: 2 OBJECTIVES

MINIMIZE STRESSES IN PIPING

Provide flexibility and clearances where building is expected to move

MINIMIZE DAMAGING

Keep piping fairly rigid, when supported by a building component expected to move as a unit



**THE SYSTEM SHALL MOVE TOGETHER
WITH THE BUILDING**

Protection of Sprinkler Piping

4 categories of requirements:

A. Flexible Joints and Clearances

- Couplings – NFPA 13, Section 9.3.2
- Seismic Separation Assembly – NFPA 13, Section 9.3.3
- Clearance – NFPA 13, Section 9.3.4

B. Sway Bracing – NFPA 9.3.5

C. Restraints of Branch Lines – NFPA 9.3.6

D. Hangers Subject to Earthquakes – NFPA 9.3.7

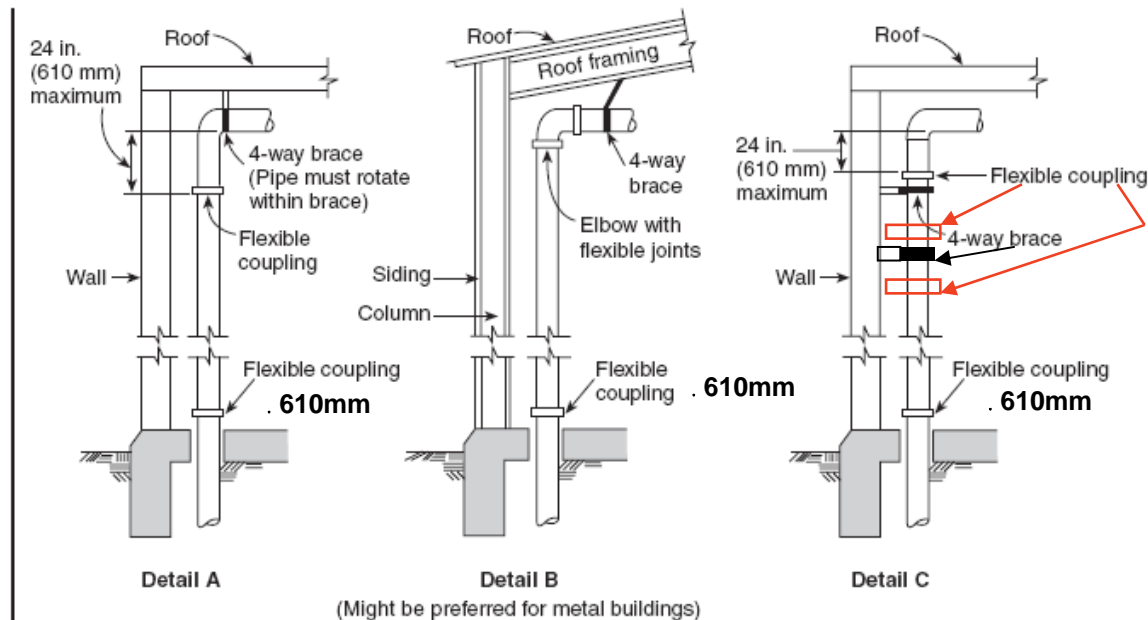
- Important: braces and restraints should comply with the obstruction rules and should not constitute an obstruction to the sprinkler discharge

Flexible Couplings – NFPA 13, Section 9.3.2

- Flexible couplings have to be provided in order to allow individual sections of piping to move differentially with the sections of the building to which are attached
- Flexible couplings are required on pipes ≥ 65 mm, unless specific requirements
- Flexible couplings shall be arranged to coincide with structural separations within a building
- If flexible couplings are provided more than required by the standard, then additional lateral sway bracings have to be provided to improve system stiffness.

Flexible Couplings – Risers (regardless of the size)

- Greater than 2.1m: within 610mm of top and bottom
- Between 0.9 and 2.1m: one flexible coupling
- Less than 0.9m: no flexible couplings
- Within 610mm above and below any further point of support



Note to Detail A: The four-way brace should be attached above the upper flexible coupling required for the riser and preferably to the roof structure if suitable. The brace should not be attached directly to a plywood or metal deck.

FIGURE A.9.3.2(a) Riser Details.

Flexible Couplings – Multistory Buildings

- Within 305mm above and within 610mm below the floor. If the FC is above the tie-in for the main supply for that floor, a further FC shall be provided on the vertical portion of the tie-in piping.

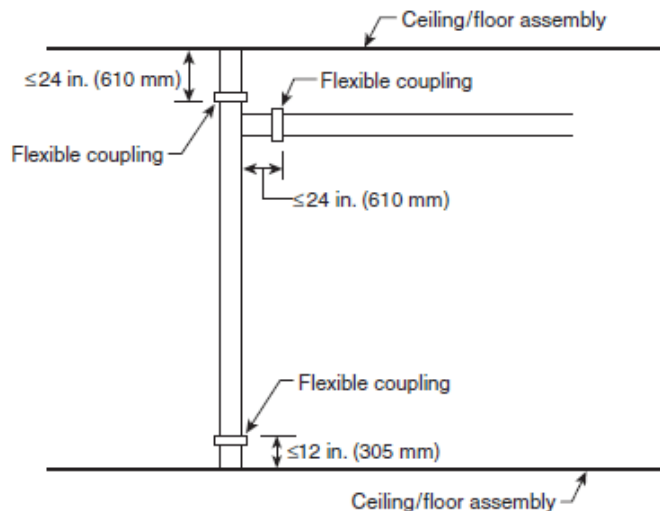


FIGURE A.9.3.2.3(2)(a) Flexible Coupling on Horizontal Portion of Tie-In.

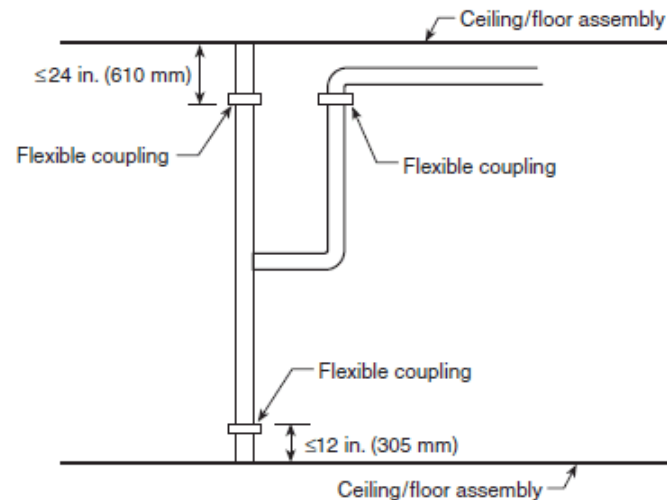


FIGURE A.9.3.2.3(2)(b) Flexible Coupling on Main Riser and Branch Line Riser.

Flexible Couplings – Concrete or Masonry Walls

- On both sides of concrete or masonry walls within 305mm of the wall surface, **unless clearance is provided**

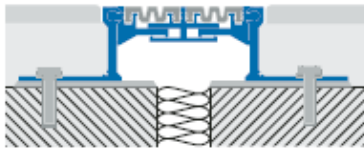


Lack of clearance

Need for FC

Flexible Couplings – Expansion Joints

- Within 610mm of building expansion joints (usually a bituminous fibre strip to separate blocks of concrete to prevent cracking); on one side only.

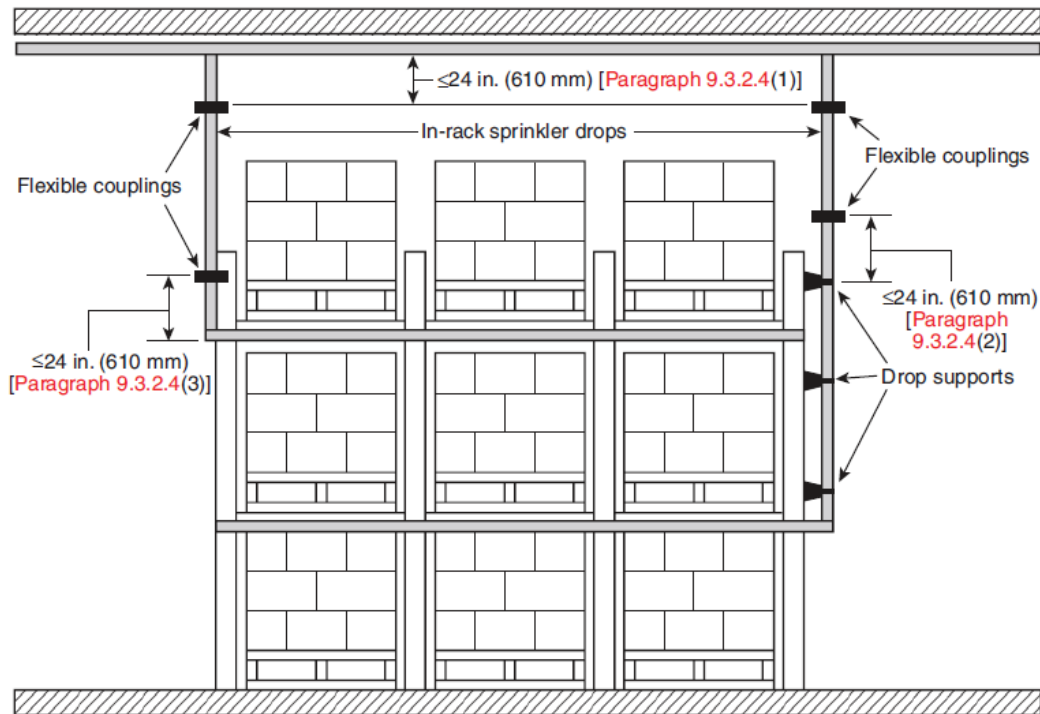


Flexible Couplings – Drops (regardless of pipe size)

- Drops exceeding 4.6 m in length to portions of systems supplying more than one sprinkler:
 - Within 610 mm of the top of the drop
- Drops to hose lines, rack sprinklers, mezzanines, and free-standing structures:
 - Within 610 mm of the top of the drop
 - Within 610 mm above the uppermost drop support attachment, where drop supports are provided to the structure, rack or mezzanine;
 - Within 610 mm above the bottom of the drop, where no additional drop support is provided

Flexible Couplings – Drops

- Drops to hose lines, rack sprinklers, mezzanines, and free-standing structures

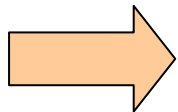
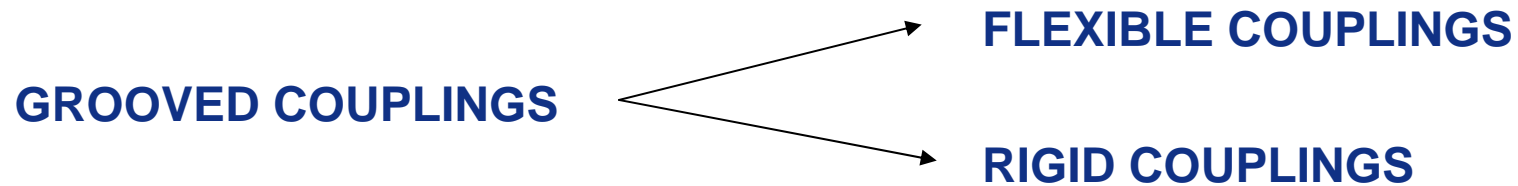


NOTE

1. Where racks are freestanding, that is independent of the building structure, their movement relative to the ceiling can be considerably greater than can be accommodated by a single flexible coupling. In these cases multiple flexible couplings, flexible elbows or similar provisions are needed. A differential lateral movement of 5% of the rack height can indeed be expected
2. Storage racks should be designed to resist lateral forces produced by earthquakes.

Flexible Joints

- Paragraph 9.3.2.1 – **Listed** flexible pipe couplings joining grooved end pipe shall be provided as



NOT ALL THE GROOVED COUPLINGS ARE FLEXIBLE !!!!

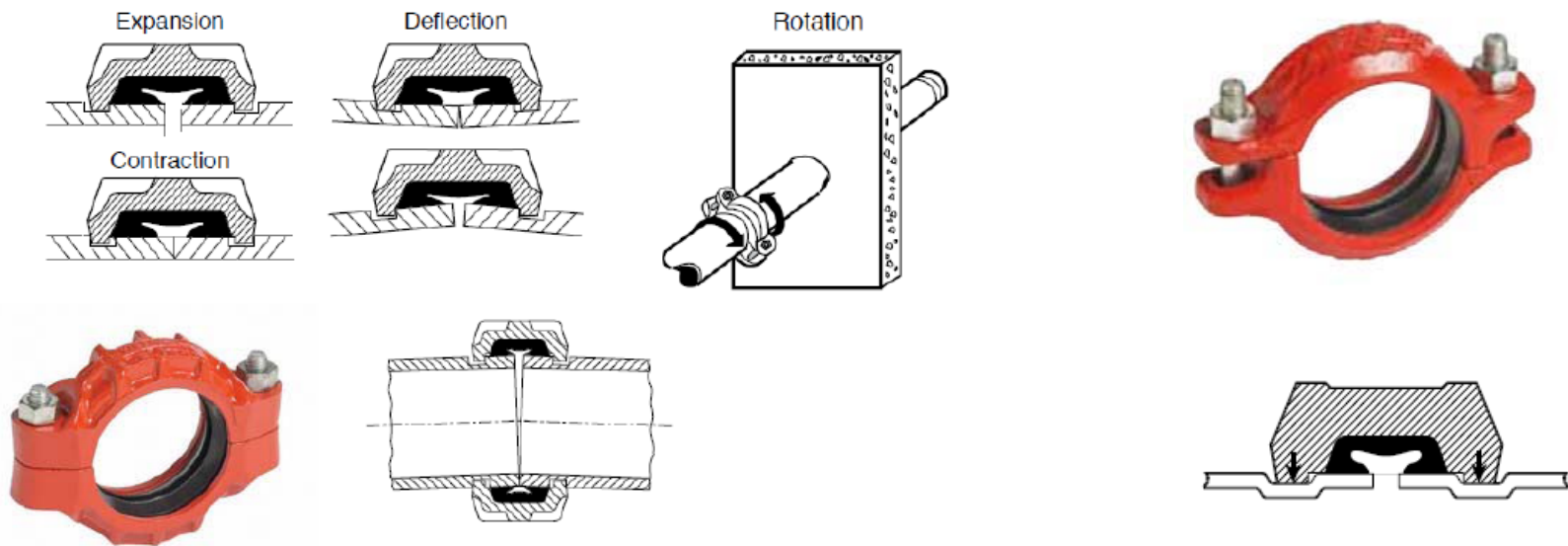
NFPA 13 – A9.3.2: *“Rigid-type” couplings that permit less than 1 degree of angular movement at the grooved connections are not considered to be flexible couplings »*

Flexible Joints

- The term flexible coupling is defined as a coupling or fitting that allows axial displacement, rotation, and at least 1 degree on angular movement of the pipe without inducing harm on the pipe

Flexible coupling

Rigid coupling



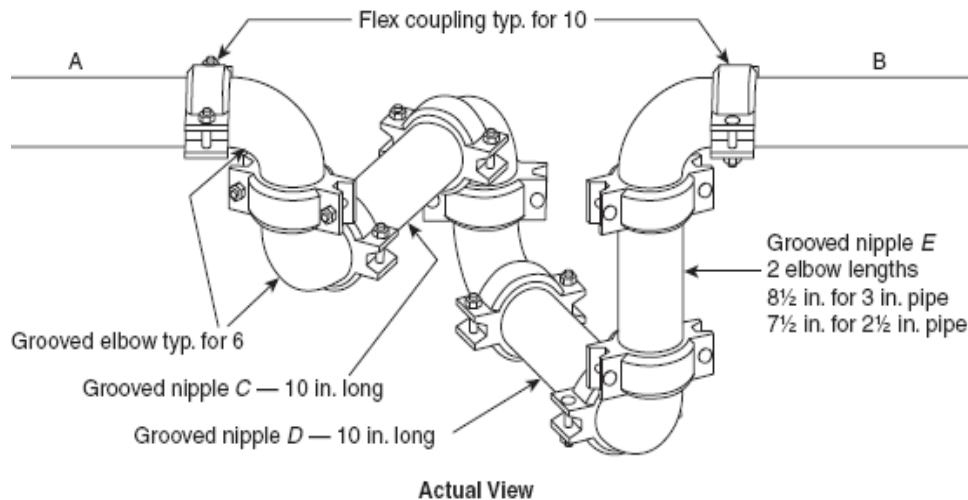
Seismic Separation Assembly – NFPA 13, Section 9.3.3

- Buildings, in seismic areas shall be structurally separated once they reach a specific length and/or square footage. Where a building is separated, no part of the structure is connected at that point, therefore the two parts move independently of each other.
- Separations can be found where there are 2 columns grid, very close to each other, and two structural beams very close to each other.
- Seismic Separation Assembly vs expansion joint. Movement admitted by separation are much greater than ones admitted by expansion joint.

Seismic Separation Assembly

- In correspondence of seismic separation, regardless of pipe size, an approved seismic separation assembly shall be provided.
- It consists of an assembly of fittings, pipe and couplings that permits movements in all direction

Flexible fittings and couplings



Seismic Separation Assembly

Flexible Piping

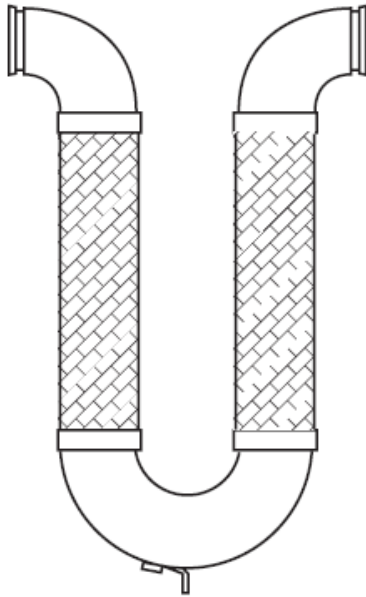
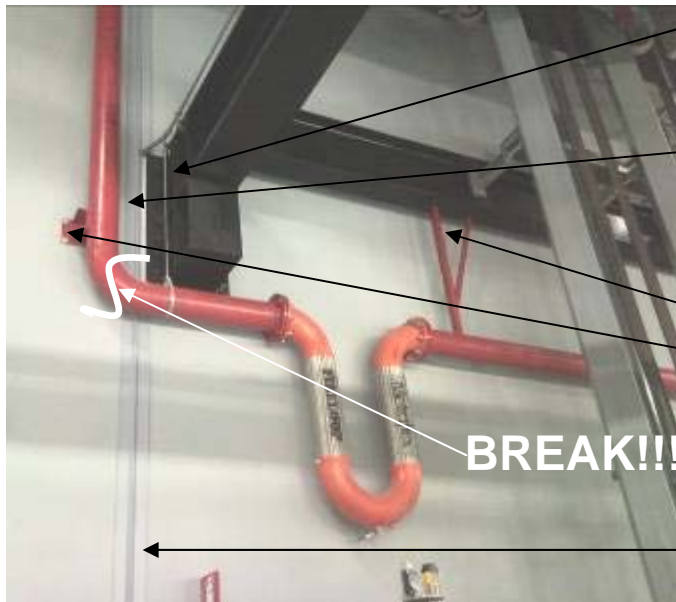


FIGURE A.9.3.3(b) Seismic Separation Assembly Incorporating Flexible Piping.



Seismic Separation Assembly

- Bracing of seismic separation assembly:
 - The seismic separation assembly should include a four-way brace upstream and downstream within 1.8 m of the seismic separation assembly. Bracing should not be attached to the seismic separation assembly.



Between SS and
seismic assembly
NO SUPPORTS!!

FC missing!!!

Supports welded to
the pipe!!!

Seismic
separation

Seismic Separation Assembly



NOT FLEXIBLE !!!

Clearance – NFPA 13, Section 9.3.4

- Clearance should be provided around all piping extending through walls, floors, platforms and foundations.
- Size of the holes:
 - 50 mm larger than the pipe, for pipe sizes 25 mm to 90 mm
 - 100 mm larger than the pipe, for pipe sizes 100 mm and larger
- Main Exceptions
 - Clearance provided by pipe sleeves (same specifications as per holes)
 - No clearance is required for piping passing through frangible construction (gypsum board or equally frangible material)
 - No clearance is required if flexible couplings are located within 305 mm of each side of a wall, floor, platform or foundations

Clearance

- Where required, the clearance should be filled with only weak-frangible material (sand, mortar...) which can break if stressed during an earthquake
- Clearance from structural members, not used to support the piping, should be at least 50 mm

Clearance



MISTAKES !!!



2 SOLUTIONS: FC or CLEARANCE

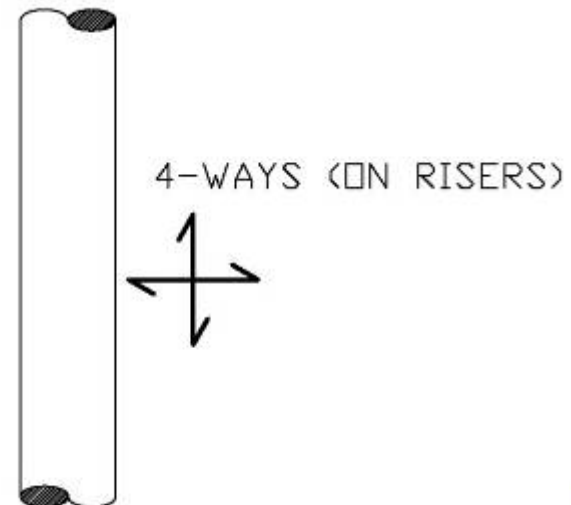
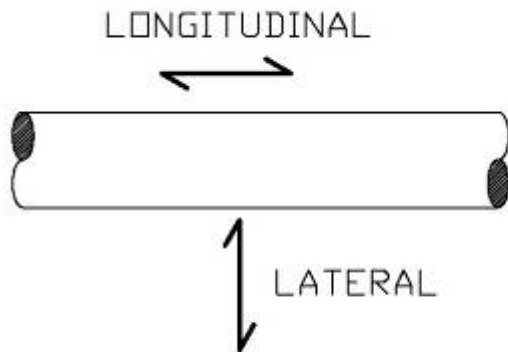
Sway Bracing – NFPA 13, Section 9.3.5

- Sway bracing is provided to prevent excessive movement of system piping (horizontal and vertical). Shifting of large pipe as a result of earthquake motion has led to the pull-out of hangers and fracture of fittings. With some exceptions, bracing is required for the following:
 1. Top of the system riser,
 2. All feed and cross mains regardless of size,
 3. Branch lines 65 mm (2½”) in diameter and larger (lateral bracing only).

- Branch line piping 50 mm in diameter and smaller is considered capable of considerable movement without damage.

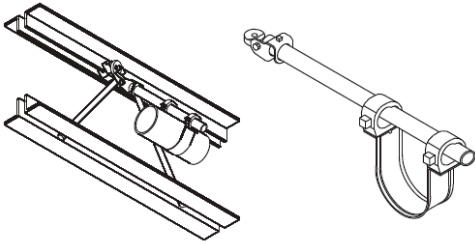
Sway Bracing

- Three types of Sway Braces:
 - LATERAL sway braces – Preventing movements in an axis perpendicular to pipe)
 - LONGITUDINAL sway braces – Preventing movements in an axis parallel to pipe)
 - FOUR-WAY braces – Intended to resist differential movement of the piping system in all horizontal directions (typically used on vertical pipe / risers)

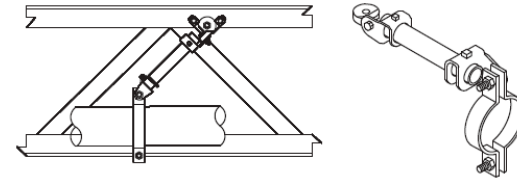


Sway Bracing

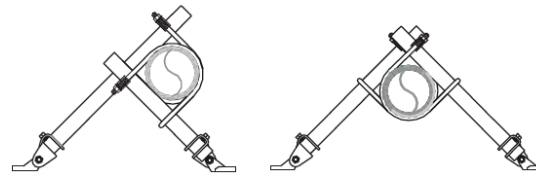
Lateral Sway Brace



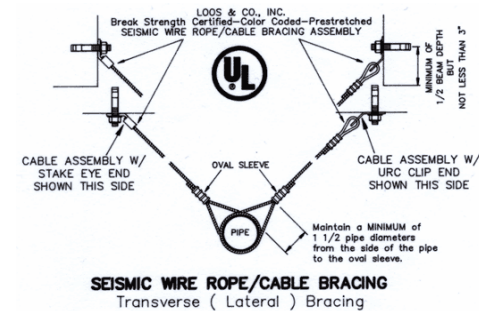
Longitudinal Sway Brace



Four-Way Bracing



Lateral and Longitudinal Sway Braces



Tension-only Bracing System

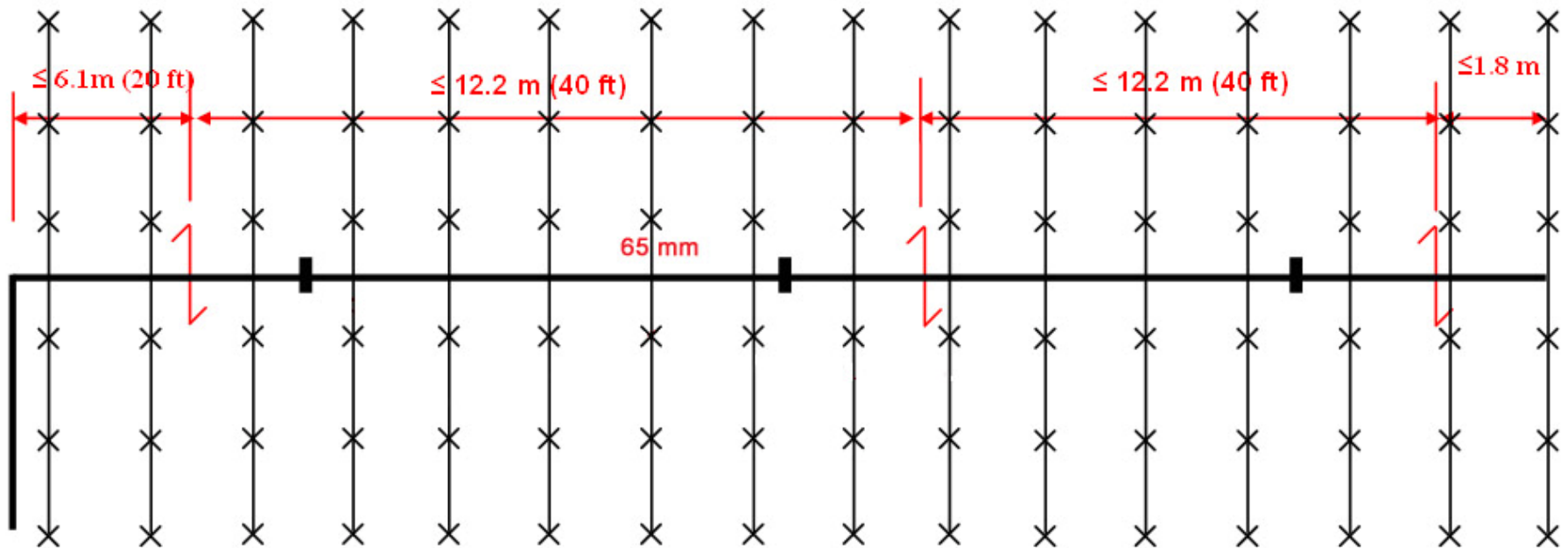
Lateral Sway Bracing – Requirements

- On all feed and cross mains regardless of size.
- On branch lines and other piping with a diameter $\geq 65\text{mm}$.
- Not required for 65 mm starter piece that is the first section of pipe on branch lines from a cross main provided it does not exceed 3.6 m in length.
- The spacing should never exceed 12.2 m; it might have to be reduced according to size and schedule of the pipe being braced and the load of the piping in the zone of influence (NFPA 13, Tables 9.3.5.5.2(a)).
- The distance between the last brace and the end of the pipe should not exceed 1.8 m.
- The last length of pipe at the end of a feed or cross main should be provided with a lateral brace.

Lateral Sway Bracing – Exceptions

- Requirements for Lateral Sway Bracing do not apply when:
 - Pipes are individually supported by rods less than 150 mm long, measured between the top of the pipe and the point of attachment to the building structure. *This exception is not accepted by FM Global.*
 - U-type hooks of the wraparound type or those U-type hooks arranged to keep the pipe tight to the underside of the structural element are permitted to be used to satisfy the requirements for lateral sway bracing, provided the legs are bent out at least 30 degrees from the vertical and the maximum length of each leg and the rod size satisfies the conditions of Tables 9.3.5.11.8. *This exception is admitted by FM Global only for branch lines that need sway bracing; for feed and cross mains U-bolt hangers may be used while U-type hangers, including wraparound type shall not be used.*

Lateral Sway Bracing – Example



Note: The 65 mm starter piece on branch lines does not require lateral sway bracing as its length is $\leq 3.6\text{ m}$

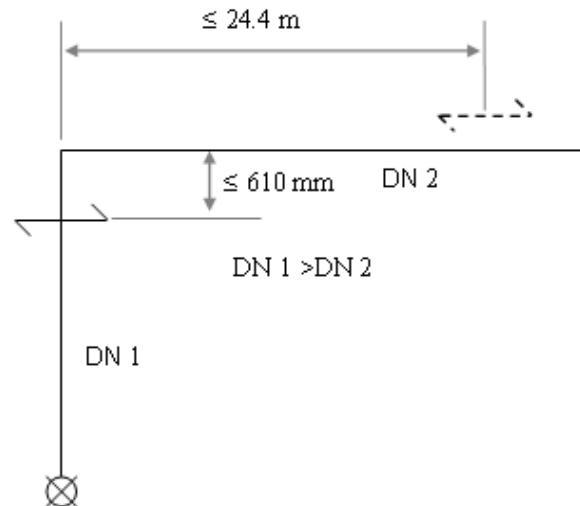
Unnecessary Flexible Couplings and Lateral Sway Bracing

- Where flexible couplings are installed on mains other than as required in Section 9.3.2, lateral brace should be provided within 610 mm of every other coupling but not more than 12.2 m on center
- The intent of this is to prevent excessive movement of the mains, possibly resulting in “accordion” effect. This additional bracing is not required where rigid-type mechanical couplings are used
- This requirement applies only to horizontal mains and branch lines required to be braced as mains. It does not apply to other branch lines or to vertical piping such as risers

- **Conclusion:** As a general rule, rigid mechanical couplings should be used throughout except where flexible couplings are recommended

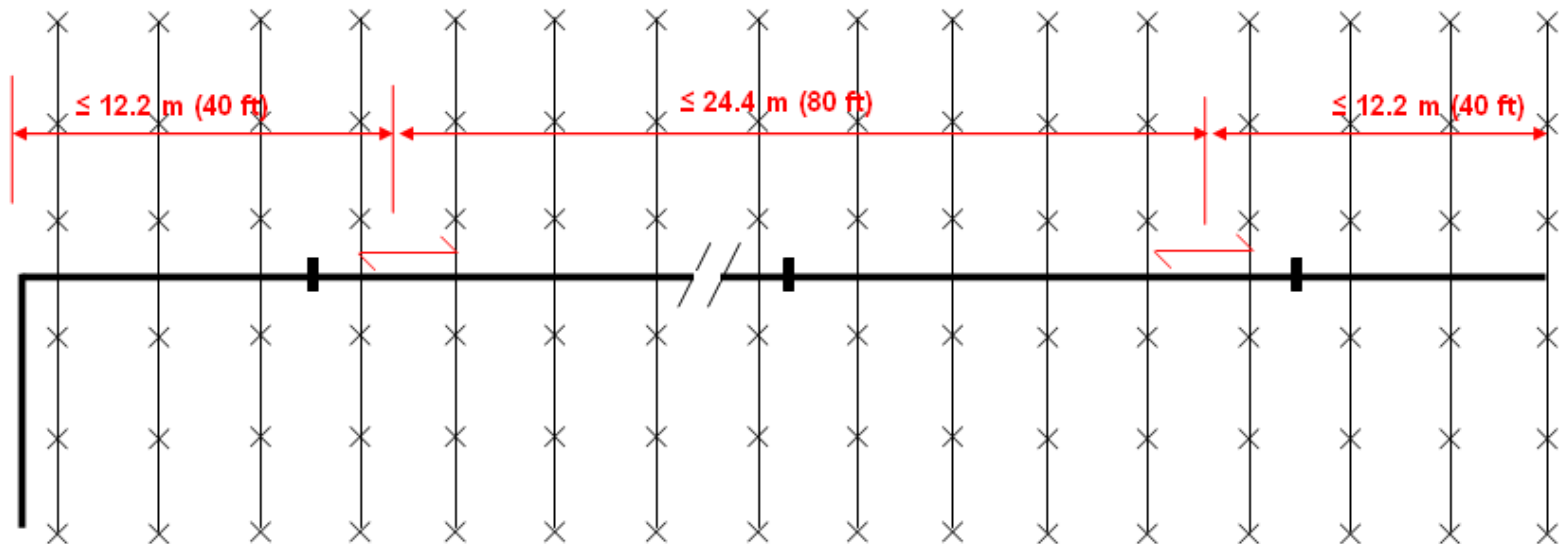
Lateral Brace as Longitudinal Brace

- Lateral braces are allowed to act as longitudinal braces if they are within 610 mm of the center line of the piping braced longitudinally and the lateral brace is on a pipe of equal or greater size than the pipe being braced longitudinally



Longitudinal Sway Bracing – Requirements

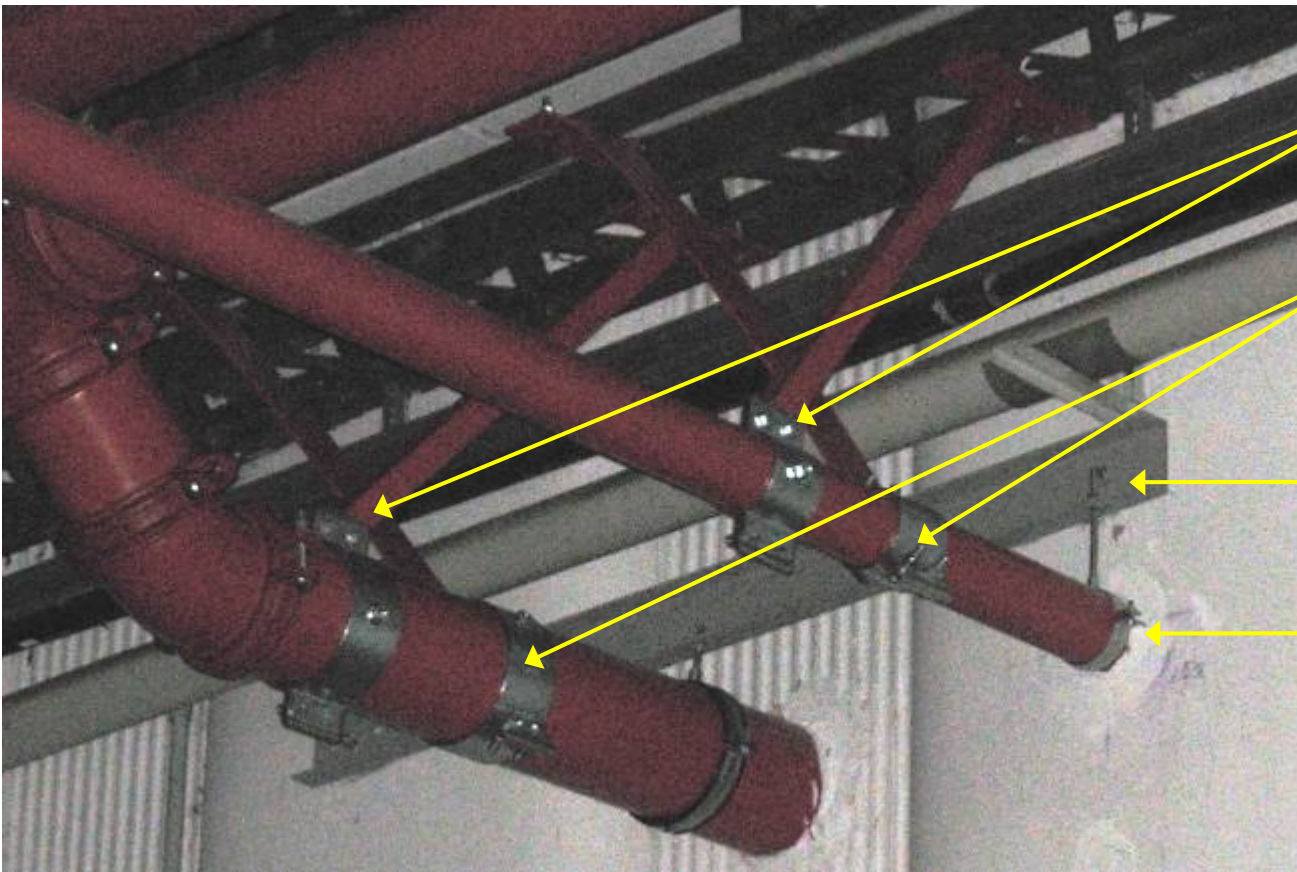
- On all feed and cross mains regardless of size.
- The spacing should never exceed 24.4 m on center.
- The distance between the last brace and the end of the pipe should not exceed 12.2 m.



- Longitudinal braces are allowed to act as lateral braces if they are within 610 mm of the center line of the piping braced laterally

Sway Bracing – Example

EXAMPLE



LONG. SB

LAT. SB

HANGER

CLEARANCE

Sway Bracing of Risers – Requirements

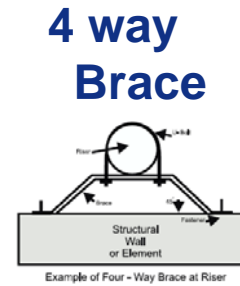
- A four-way brace should be provided at top of risers exceeding 0.9 m in length.
- Distance between four-way braces for risers should not exceed 7.6 m.
- When a four-way brace is attached on the horizontal piping it should be within 610 mm of the centreline of the riser.
- No four-way brace are required on riser nipples even if they exceed 1 m in length (*riser nipples = vertical pieces of pipe connecting mains to branch lines at different, usually higher, elevations*).
- Four-way bracing is not required where risers penetrate intermediate floors in multi-storey buildings where the clearance does not exceed the limits.

Sway Bracing of Risers – Example

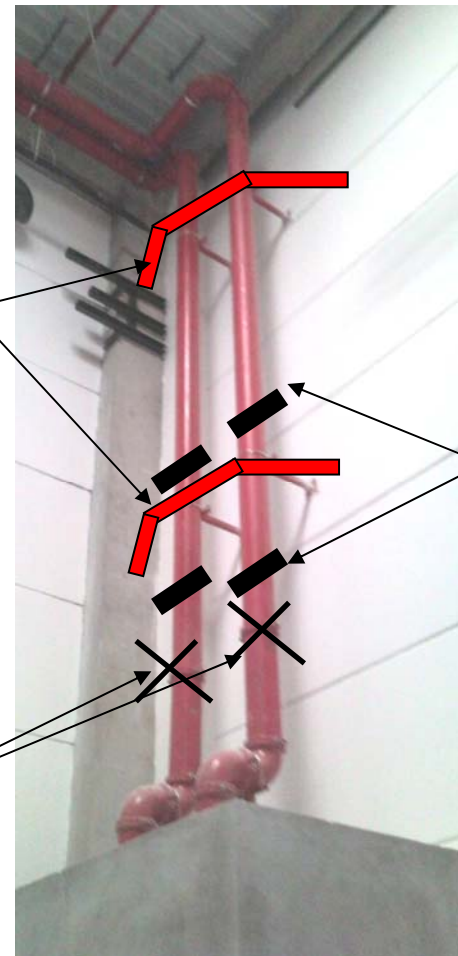


NO 4 way Brace!!

**Wrong
FC!!!**

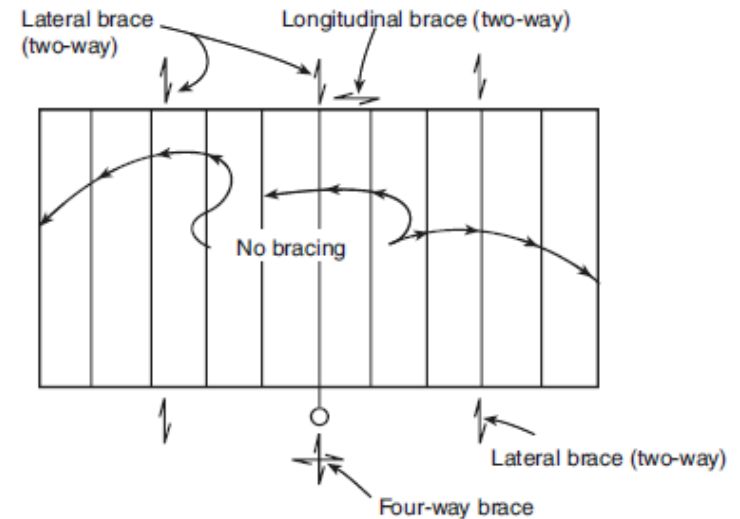
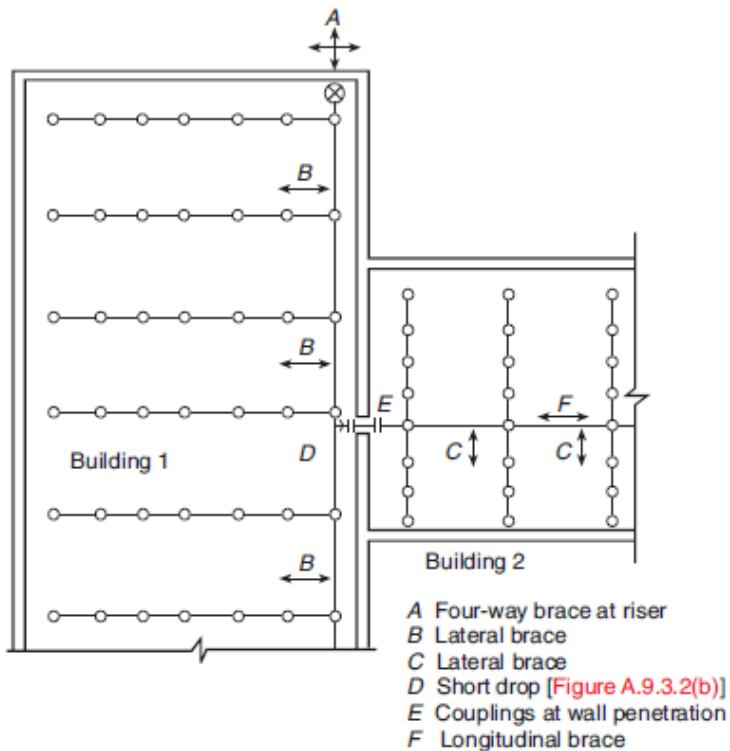


Remove FC



**new
FC**

Examples of sprinkler systems with lateral, longitudinal and four-way braces



Sway Brace Design and Installation

- Sway braces should be designed to withstand forces in tension and compression. *Tension-only bracing systems are accepted by NFPA where listed for this service and installed according listing limitations. They are not accepted by FM Global.*
- Sway braces should be UL listed or FM approved. The horizontal load applied to the brace should not exceed the maximum allowable load provided in the listing for the weakest component of the brace.
- Bracing shall be attached directly to the system pipe.
- C-clamps should not be used to attach braces to the building structure.
- The type of fasteners used to secure bracing assembly to the structure should be limited to listed devices or those reported in NFPA 13, Fig 9.3.5.12.1.

Restraint of Branch Lines – NFPA 13, Section 9.3.6

- Restraint is required for all branch lines that are not otherwise required to be laterally braced:
 - The end sprinkler on a branch line should be restrained against excessive vertical and lateral movement.
 - Branch lines longer than 8 m might require additional restraints (spacing should follow the limits of NFPA 13, Tables 9.3.6.4).

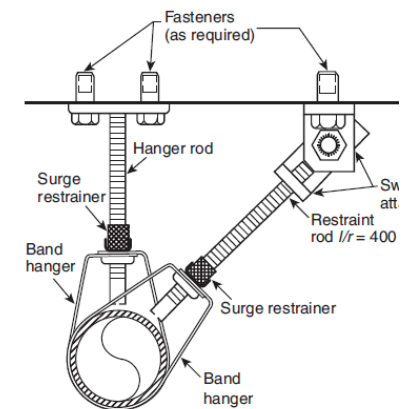
- Restraint is NOT required for branch lines supported by rods less than 150 mm long measured between the top of the pipe and the point of attachment to the building structure.

Restraint of Branch Lines

- Restraint should be provided by use of one of the following:
 - A listed sway brace assembly
 - A wraparound U-hook in accordance with NFPA 13, 9.3.5.5.10
 - 200 kg wire installed at least 45 degrees from the vertical plane and anchored on both sides of the pipe. Wire used for restraint should be located within 610 mm of a hanger. That hanger should be of a type that resists upward movement of a branch line.
 - A hanger not less than 45° from vertical installed within 152 mm (6") of the vertical hanger arranged for restraint against upward movement (see picture below).



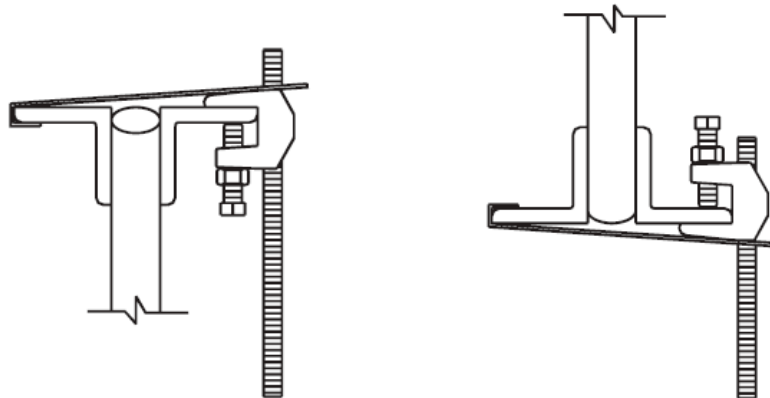
Wrap around U-hook



Branch line restraint

Hangers Subject to Earthquakes – NFPA 13, Section 9.3.7

- Where seismic protection is provided, C-type clamps used to attach hangers to the building structure should be equipped with a restraining strap.
- The restraining strap should be listed or not less than 1.6 mm thick and not less than 25 mm wide for pipe diameters 200 mm or less and 2 mm thick and not less than 32 mm wide for pipe diameters greater than 200 mm.





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