Earthquake protection for sprinkler systems

Introduction

The following information reviews some of the potential problems, and prescribed solutions, for fire sprinkler systems located in earthquake prone areas. The indicated protection features, while not all-inclusive, provide some basic guidance. This document does not discuss earthquake protection for other portions of a fire protection system, such as fire pumps, underground water mains, fire hydrants, etc. Illustrations of some basic earthquake protection features are included at the end of this document.

Automatic sprinkler protection is a proven effective tool in limiting the amount of damage incurred in the event of a fire. Earthquake damage to a sprinkler system can both disrupt this valuable fire protection and result in extensive water damage to the building and contents. Therefore, building sprinkler systems in earthquake prone areas should be provided with earthquake protection.

Automatic sprinklers

Automatic sprinklers have been in use for more than 100 years. Their fundamental design directs water, under pressure, to individually operating sprinkler heads through a series of above ground, rigid piping. These are “sealed” systems, designed to release water only in a fire condition.

Earthquake damage to sprinkler piping

There are many ways sprinkler piping can be damaged during an earthquake. Some examples of actions that cause damage:

- Differential movement between the building and sprinkler piping
- Differential movement of building sections at seismic separation joints
- Impact of piping with nearby structural members or other equipment
- Movement of suspended ceilings
- Excessive sway of end sprinkler lines
- Excessive movement of storage racking

Earthquake protection of sprinkler systems

Earthquake protection of sprinkler piping is accomplished in several ways:

- Firmly anchor the piping to the structure so that it moves with the building and does not sway or whip vigorously during an earthquake
- Provide sufficient clearances so that the movement of the building or piping does not damage the piping
- Join sections of pipe using flexible couplings so that, when the piping moves, the joints will flex and not break

Sprinkler piping needs to be protected using all of these protection methods at various points throughout the system. All bracing and flexible couplings used for earthquake protection of sprinkler systems should be listed for their intended purpose.

Sway bracing

Sprinkler piping is generally supported from the ceiling or other building structural members and is subject to severe shaking and movement in an earthquake. This vigorous swaying movement, or whipping of the pipe, can cause the pipe to break or allow the pipe to separate at the joints. This movement can be lessened by using “sway bracing” to firmly attach the piping, or portions of the piping, to the building so that it will not move as violently during an earthquake.

Sway bracing must be designed so that it can withstand forces in both tension and compression. It also needs to be installed at appropriate intervals along the pipe and arranged to resist lateral, longitudinal, and vertical movement of the pipe. To resist vertical movement, and to prevent dislodgement of the brace from the pipe, sway bracing needs to attach firmly, or wrap around, the pipe.

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C-clamps should not be used to attach sway bracing to the building structure. If C-clamps are used for pipe hangers, they should be equipped with restraining straps so that the clamp will not slip off of the structure.

Sway braces and the anchors that affix them to building structural members need to be properly positioned and sized for the anticipated loads of the water-filled piping and seismic forces. See NFPA 13 (National Fire Protection Association) for the calculations to use when designing sway bracing.

Clearance

Sprinkler piping that penetrates walls, floors, platforms, or foundations should be provided with adequate clearance to allow independent movement from the building without damage. One inch to 3.5 inch diameter piping should have penetration openings at least 2 inches in diameter larger. Four inch and larger piping should have openings at least 4 inches in diameter larger than the piping. This clear space can be filled with a flexible material such as Mastic to provide insulation.

If sprinkler piping is equipped with flexible couplings within 1 ft. of each side of a penetrated wall, the clearances listed above can be waived.

In addition, a minimum two-inch clearance should be provided between sprinkler piping and any walls, beams, building columns, building equipment or other structures. The only exception would be when the building structure is being used to support or provide bracing to the sprinkler piping.

Flexible couplings

The couplings that join pipe together are normally rigid. However, it is important to install some flexible couplings in sprinkler piping in earthquake prone areas. Flexible couplings allow for movement of piping without damaging the coupling or disconnecting the piping.

Listed flexible couplings should be provided in strategic areas to join grooved-end pipe that is 2.5 inches nominal diameter or larger. The couplings should be arranged to coincide with structural separations within the building. Flexible couplings should also be provided on vertical runs of pipe (risers) per the requirements of NFPA 13. If flexible couplings are provided on all joints, or in more joints than prescribed by NFPA 13, additional sway bracing should be installed.

Sprinkler risers

The top of all sprinkler risers need to have “four-way” bracing installed so that an earthquake does not cause the riser to sway and result in pipe breakage. Four-way bracing bolts the riser to the adjacent wall to eliminate both back-and-forth and side-to-side movement of the piping. In addition, all risers more than 7 feet in length require flexible couplings installed within 24 inches of the top and bottom of the riser.

Clearance between sprinkler riser piping and any floors or foundations that are penetrated by the piping needs to be provided as noted above. Risers penetrating floors in multiple story buildings need to have flexible couplings installed above and below each floor to allow the piping to move without causing breakage.

Feed mains and cross mains

Lateral (sideways) and longitudinal (lengthwise) earthquake bracing should be provided on feed mains and cross mains (larger piping not containing sprinkler heads). Lateral bracing needs to be provided at a maximum separation of 40 feet. Longitudinal bracing should be provided with a maximum separation of 80 feet. Lateral bracing of feed mains and cross mains should also be provided within 20 feet of the end of the pipe.

Branch lines

Smaller sprinkler branch lines (piping containing sprinkler heads) also need to be provided with lateral and vertical bracing to avoid rapid movement or whipping in an earthquake. Branch line restraining assemblies should be UL listed and installed in accordance with NFPA 13.

Restraining or bracing assemblies should be provided on all branch lines that are 30 ft. or longer. The bracing should be provided at the end of the branch line on tree-shaped systems and in the middle on grid-shaped systems. Branch lines should be restrained against lateral movement, as well as vertical movement. Pipe hangers can be used to restrain vertical movement if they are designed to accomplish this task. Any piping that extends sprinkler heads up or down

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(sprigs) a distance of 4 ft. or greater requires a separate restraining device attached at the end to avoid lateral movement.

Wire sway bracing assemblies can be used provided they are UL listed and installed within 2 ft. of pipe hangers and the hangers are the type that resist upward movement of the pipe.

Wrap-around type U-hangers can be used for branch line sway bracing if they meet the following criteria:

- Have both legs bent out at least 30 degrees from vertical
- Have the proper diameter and length per NFPA 13
- Are properly anchored to the building per NFPA 13
- There is no more than ½ inch of space between the top of the pipe and the wrap-around portion of the U-hanger
- Many times branch line supports or hangers are attached to building structural members using C-clamps. If C-clamps are used, they should be equipped with listed restraining straps so that the clamp will not slip off of the structure.

Piping between buildings

Piping that runs above ground between two buildings or across seismic separation joints within a building should be equipped with a seismic separation assembly. This type of pipe assembly uses a strategically arranged grouping of elbows and flexible couplings to allow for differential movement between the two building sections. It allows for both lateral and longitudinal movement of the piping. See NFPA 13 for more information.

Conclusion

In order to help insure operational fire protection following an earthquake, and avoid extensive water damage as a result of an earthquake, proper bracing, flexibility, and clearances are required for fire sprinkler systems located in earthquake prone areas.

For a more in-depth explanation of automatic sprinkler system protection as it applies to your facility, please contact your local Risk Control consultant at Travelers.

References

National Fire Protection Association, *Fire Protection Handbook*

National Fire Protection Association, NFPA Standard 13, *Standard for the Installation of Sprinkler Systems*

Factory Mutual Datasheet 2-8, Earthquake Protection for Water-Based Fire Protection Systems

Note: A “Protection illustrations” section begins on the following page

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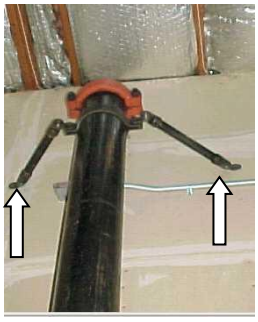
Protection illustrations

Sprinkler riser(s)
1. Need to provide adequate clearance between sprinkler pipe and concrete floors or foundations. Holes should be 4" larger than the pipe for 4” diameter or greater pipes and 2" larger than the pipe for less than 4" pipes.
2. Need to provide a 4-way brace at the top of riser piping.
3. Need flexible couplings above and below floors in multiple story buildings.
Feed mains/cross mains
4. Provide longitudinal bracing on feed mains and cross mains at a maximum separation of 80 feet on center.
5. Provide lateral bracing at a maximum separation of 40 feet on center.
Piping through masonry walls
6. Clearance or flex couplings.
C- clamps
7. C-clamps should be provided with restraining straps to prevent slippage.
8. C-clamps should not be used to attach braces to the building.

1.



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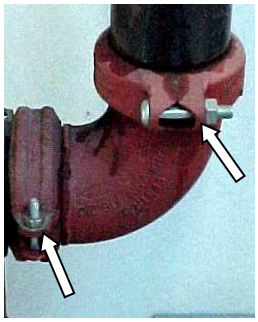

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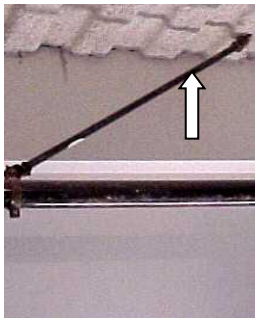

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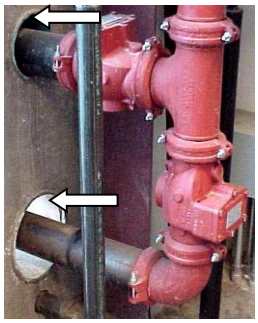

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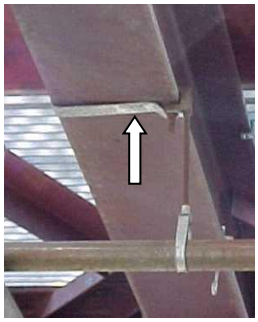

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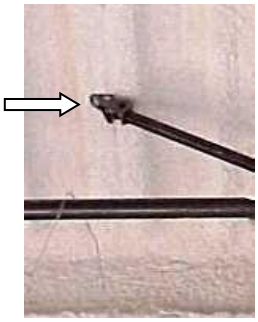

8.

1. This picture shows a sprinkler riser through the floor with adequate clearance. The form remaining in place is acceptable.
2. The two braces at the top of the sprinkler riser are securely braced to the wall and the riser.
3. This Victaulic® coupling containing rubber gaskets allows the pipe to flex at the joints.
4. These longitudinal braces run parallel to the feed and cross-mains to prevent movement.
5. The lateral brace shown is at a 90-degree angle to the main.
6. Where piping passes through a concrete or masonry wall, there should be adequate clearance or flexible couplings as noted in #3.
7. Hanger clamps should be secured to the support structure as shown to prevent them from dislodging.
8. Bracing should not use clamps for support. They should be firmly bolted to the structure as shown.

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