INSTALLATION GUIDELINES FOR AUTOMATIC SPRINKLERS

Table of Contents

Page

1.0 SCOPE 8
1.1 Changes 8
1.2 Superseded Information 8
2.0 LOSS PREVENTION RECOMMENDATIONS 9
2.1 Nonstorage Sprinklers 9
2.1.1 Construction and Location 9
2.1.1.1 General 9
2.1.1.2 Wall or Ceiling Construction Consisting of Plastic Materials 9
2.1.1.3 Exposed Structural Steel 9
2.1.1.4 Open-Grid Ceilings, Mezzanines or Walkways (Open Grids) 9
2.1.1.5 Solid Mezzanines and Walkways 10
2.1.1.6 Ceiling Slope 11
2.1.1.7 Heat and/or Smoke Vents and Other Exhaust Openings at Ceiling Level 11
2.1.1.8 Draft Curtains 13
2.1.2 Occupancy 13
2.1.2.1 Clearance Below Sprinklers 13
2.1.2.2 Conveyors 14
2.1.3 Protection 14
2.1.3.1 General 14
2.1.3.2 Upright and Pendent Nonstorage Sprinklers; Not Including Sidewall Sprinklers 17
2.1.3.3 Sidewall Nonstorage Sprinklers 29
2.2 Storage Sprinklers 39
2.2.1 Construction and Location 39
2.2.1.1 General 39
2.2.1.2 Wall or Ceiling Construction Consisting of Plastic Materials 39
2.2.1.3 Exposed Structural Steel 39
2.2.1.4 Open-Grid Ceilings, Mezzanines or Walkways (Open Grids) 40
2.2.1.5 Solid Mezzanines and Walkways 40
2.2.1.6 Ceiling Slope 41
2.2.1.7 Heat and/or Smoke Vents and Other Exhaust Openings at Ceiling Level 41
2.2.1.8 Airflow Velocities at Ceiling-Level Sprinklers 43
2.2.1.9 Draft Curtains 44
2.2.2 Occupancy 44
2.2.2.1 Clearance Below Sprinklers 44
2.2.2.2 Conveyors 44
2.2.2.3 Aisle Storage 44
2.2.3 Protection 45
2.2.3.1 General 45
2.2.3.2 Linear and Area Spacing of Storage Sprinklers 47
2.2.3.3 Horizontal Distance from Walls to Storage Sprinklers 50
2.2.3.4 Vertical Distance from the Ceiling to Storage Sprinklers 52
2.2.3.5 Obstruction to Discharge Pattern of Storage Sprinklers 55
2.3 Special Protection Sprinklers 62
2.3.1 Construction and Location 62
2.3.2 Occupancy 62
2.3.3 Protection 65
2.4 Sprinkler System Types 65

2.4.1 General 65
2.4.1.1 Selection of Sprinkler System 65
2.4.1.2 New Components for Sprinkler Systems 65
2.4.1.3 Compatibility of Sprinkler System Components With Environment 66
2.4.1.4 Design of Sprinkler Systems 66
2.4.1.5 Hydraulic Calculation of Sprinkler Systems 66
2.4.1.6 Sprinkler System Maximum Area of Coverage 66
2.4.1.7 Arranging Sprinkler Systems for Flushing 66
2.4.1.8 Protection of Sprinkler System from Mechanical and/or Freeze Damage 67
2.4.1.9 Additives and Chemicals for Sprinkler Systems 67
2.4.1.10 Water Supplies for Sprinkler Systems 68
2.4.2 Wet-Pipe Sprinkler Systems 68
2.4.3 Dry-Pipe Sprinkler Systems 68
2.4.3.1 Recommended Ambient Temperature Conditions 68
2.4.3.2 Dry-Pipe Valve in Combination With Other System or Check Valves 68
2.4.3.3 Excessive Water Accumulation Above the Dry-Pipe Valve Clapper 68
2.4.3.4 Sprinklers for Dry-Pipe Sprinkler Systems 68
2.4.3.5 Sprinkler Piping Arrangement of Dry-Pipe Sprinkler Systems 68
2.4.3.6 Accelerators for Dry-Pipe Sprinkler Systems 68
2.4.3.7 Gas Supply for Dry-Pipe Sprinkler Systems 69
2.4.4 Preaction Sprinkler Systems 69
2.4.4.1 General 69
2.4.4.2 Recommended Ambient Temperature Conditions 69
2.4.4.3 Automatic and Manual Release of Preaction Sprinkler Systems 70
2.4.4.4 Preaction Valve in Combination With Other System or Check Valves 70
2.4.4.5 Excessive Water Accumulation Above the Preaction Valve 70
2.4.4.6 Sprinklers for Preaction Sprinkler Systems 70
2.4.4.7 Sprinkler Piping Arrangement of Preaction Sprinkler Systems 70
2.4.4.8 Gas Supply for Preaction Sprinkler Systems 70
2.4.5 Deluge Sprinkler Systems 70
2.4.5.1 General Information 70
2.4.5.2 Sprinkler Piping Arrangement of Deluge Sprinkler Systems 71
2.4.6 Refrigerated-Area Sprinkler Systems 71
2.4.7 Antifreeze Solution Sprinkler Systems 71
2.4.7.1 Recommended Ambient Temperature Conditions 71
2.4.7.2 Compatibility of Antifreeze Solution and Sprinkler System Components 72
2.4.7.3 Documentation of Antifreeze Solution Sprinkler Systems 72
2.4.7.4 Sprinkler Piping Arrangement of Antifreeze Solution Sprinkler Systems 72
2.4.7.5 Antifreeze Solution 73
2.4.8 Exposure-Protection Sprinkler System 73
2.5 Sprinkler Piping: Connection, Hanging, and Bracing 73
2.5.1 General 73
2.5.2 Sprinkler System Piping 74
2.5.2.1 General 74
2.5.2.2 Bending Steel Pipe for Sprinkler Systems 75
2.5.2.3 Minimum Pipe Sizes for Sprinkler Systems 75
2.5.2.4 Pitch of Dry-Type Sprinkler System Piping 75
2.5.2.5 Protection of Sprinkler System Piping 76
2.5.3 Sprinkler System Pipe Connections 76
2.5.3.1 General 76
2.5.3.2 Pipe Connections 76
2.5.3.3 Threaded Pipe Connections 76
2.5.3.4 Grooved Pipe Connections 76
2.5.3.5 Plain-End Pipe Connections 77
2.5.3.6 Welded Pipe Connections 77
2.5.4 Sprinkler System Piping Support 77
2.5.4.1 General 77
2.5.4.2 Pipe Supports 77
2.5.4.3 Pipe Hanger Minimum Load Support Calculations 77

2.5.4.4 Attaching Pipe Hanger Assemblies 78
2.5.4.5 Location and Spacing of Pipe Hangers 80
2.6 Sprinkler System Components 81
2.6.1 General 81
2.6.2 Control Valves 82
2.6.3 Check Valves 82
2.6.4 Waterflow Alarms 82
2.6.5 Inspector's and By-Pass Test Connections 83
2.6.6 Pressure Gauges 83
2.6.7 Fire Service Connections 83
2.6.8 Drain Valves 84
2.6.9 Pressure Relief Valves 84
2.6.10 Pressure Reducing Valves 84
2.7 Plan Review of Sprinkler Systems 84
2.7.1 General 84
2.7.2 Working Drawings 85
2.7.3 Sprinkler System Hydraulic Analysis 86
2.7.4 Specifications 86
2.7.5 Required Documentation 87
2.7.6 Arranging for FM Global Field Acceptance 87
2.8 Sprinkler System Acceptance Tests 87
2.8.1 Test Procedure for Preaction, Deluge, and Refrigerated-Area Sprinkler Systems 88
2.9 Operation and Maintenance 88
2.10 Ignition Source Control 88
3.0 SUPPORT FOR RECOMMENDATIONS 88
3.1 Loss History 89
3.1.1 Loss Examples 89
3.1.1.1 Hot Work at Facility with Sprinklers in the Process of Being Installed 89
3.1.1.2 Arson at a Facility with Newly Installed Sprinklers but Not Yet Connected to Water Supply 90
3.1.1.3 Fire Loss at High-Rise Facility Equipped with Sprinklers but Not in Fire Area 90
4.0 REFERENCES 90
4.1 FM Global 90
4.2 Other 91
4.2.1 American Society of Mechanical Engineers 91
4.2.2 American Welding Society (AWS) 91
APPENDIX A GLOSSARY OF TERMS 91
APPENDIX B DOCUMENT REVISION HISTORY 106
APPENDIX C FORMS 106

List of Figures

Fig. 1a. Quick-Response sprinklers installed under automatic smoke and heat vents. 12
Fig. 1b. Quick-Response sprinklers installed under ceiling-level exhaust devices. 13
Fig. 2. Return bends for Nonstorage sprinklers. 16
Fig. 3. Spacing of Nonstorage sprinklers when installed in every bay channel formed by solid structural members 20
Fig. 4. Maximum increase in linear and area spacing for Nonstorage sprinklers to avoid obstructing sprinkler discharge 21
Fig. 5. Horizontal distance from walls to Nonstorage sprinklers 22
Fig. 6. Location of Nonstorage sprinklers if ceiling slope exceeds 10° 23
Fig. 7. Location of Nonstorage sprinklers under obstructed ceiling construction 25
Fig. 8. Obstruction area to umbrella pattern of pendent and upright Nonstorage sprinklers (excluding Extended-Coverage) 26
Fig. 9. Obstruction area to umbrella pattern of pendent and upright Extended-Coverage Nonstorage sprinklers 26
Fig. 10. Additional sprinklers installed to mitigate obstructed umbrella discharge pattern caused by solid objects at ceiling level 27
Fig. 11. Additional sprinklers installed below flat, continuous, solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide 28

Fig. 12. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide with flat, continuous, solid barrier provided 28
Fig. 13. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide without a flat, continuous, solid barrier provided 29
Fig. 14. Nonstorage sprinklers under combustible shielded areas more than 8 in. (200 mm) deep 31
Fig. 15. Obstruction area to umbrella pattern away from the mounting wall of sidewall Nonstorage sprinklers (not extended-coverage) 32
Fig. 16. Obstruction area to umbrella pattern away from the mounting wall of extended-coverage sidewall Nonstorage sprinkler 33
Fig. 17. Additional sprinklers installed to account for obstructed umbrella discharge pattern away from the wall caused by solid objects at ceiling level 34
Fig. 18. Obstruction area to umbrella pattern along the mounting wall of sidewall Nonstorage sprinklers on standard spacing 35
Fig. 19. Obstruction area to umbrella pattern along the mounting wall of extended-coverage sidewall Nonstorage sprinklers 35
Fig. 20. Positioning of sidewall Nonstorage Sprinklers to account for obstructed umbrella discharge pattern along the mounting wall caused by solid objects at ceiling level 36
Fig. 21. Additional sprinklers installed below flat, continuous, solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide 38
Fig. 22. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide with flat, continuous, solid barrier provided 38
Fig. 23. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide without a flat, continuous, solid barrier provided 39
Fig. 24a. Quick-Response sprinklers installed under automatic smoke and heat vents 42
Fig. 24b. Quick-Response sprinklers installed under ceiling-level exhaust devices 43
Fig. 25. Return bends for Storage sprinklers 47
Fig. 26. Spacing of sprinklers when installed in every bay channel formed by solid structural members 49
Fig. 27. Maximum increase in linear and area spacing to avoid obstructing sprinkler discharge 50
Fig. 28. Horizontal distance from walls to Storage sprinklers 51
Fig. 29. Location of storage sprinklers if ceiling slope exceeds 10° 52
Fig. 30. Location of Storage Sprinklers Under Obstructed Ceiling Construction 54
Fig. 31. Obstruction Area to Umbrella Pattern of Ceiling-Level Storage Sprinklers on Standard Spacing 55
Fig. 32. Obstruction Area to Umbrella Pattern of Ceiling-Level Extended-Coverage Storage Sprinkler 55
Fig. 33. Installing Additional Sprinklers to Account for Obstructed Umbrella Discharge Pattern Caused by Solid Objects at Ceiling Level 56
Fig. 34. Obstruction area to inner core discharge pattern of pendent Storage sprinklers for objects up to 0.75 in. (20 mm) wide 58
Fig. 35. Obstruction area to inner core discharge pattern of pendent Storage sprinklers for objects over 0.75 in. (20 mm) and up to 1.25 in. (32 mm) wide 58
Fig. 36. Obstruction area to inner core discharge pattern of pendent Storage sprinklers for objects over 1.25 in. (32 mm) and up to 2 in. (50 mm) wide 58
Fig. 37. Obstruction area to inner core discharge pattern of pendent Storage sprinklers for objects over 2 in. (50 mm) and up to 12 in. (300 mm) wide 59
Fig. 38. Obstruction area to inner core discharge pattern of pendent Storage sprinklers for objects over 12 in. (300 mm) and up to 24 in. (600 mm) wide 60
Fig. 39. Additional sprinklers installed below flat, continuous, solid obstructions from over 2 ft (0.6 m) wide to 10 ft (3.0 m) wide 61
Fig. 40. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions more than 2 ft (0.6 m) wide up to 10 ft (3.0 m) wide 62
Fig. 41. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions over 2 ft (0.6 m) and up to 10 ft (3.0 m) wide without a flat, continuous, solid barrier provided 63
Fig. 42. Additional sprinklers installed within storage racks to account for obstructions to the inner core distribution pattern of a sprinkler 64
Fig. 43. Provision for flushing grid-type sprinkler systems 67
Fig. 44. Antifreeze solution sprinkler system piping arrangements connected to a potable water supply 72

Fig. 45. Attachment locations for hangers with C-shaped or Z-shaped purlins 79
Fig. 46. Double-Tee Concrete Slab 93
Fig. 47. Flushing connection with a threaded end cap 97

List of Tables

Table 1. Nominal Temperature Ratings of Sprinklers Based on Maximum Ambient Temperature at Sprinkler Level 15
Table 2. Nominal K-factor Values of FM Approved Nonstorage Sprinklers 15
Table 3. Spacing of Ceiling-Level Pendent and Upright Nonstorage Sprinklers for Hazard Category No. 1 . 18
Table 4. Spacing of Ceiling-Level Pendent and Upright Nonstorage Sprinklers for Hazard Category No. 2 . 19
Table 5. Spacing of Ceiling-Level Pendent and Upright Nonstorage Sprinklers for Hazard Category No. 3 . 19
Table 6. Minimum Horizontal Distance of Ceiling Objects to Avoid Obstructing the Umbrella Pattern of Nonstorage Sprinklers (not Extended-Coverage) 24
Table 7. Minimum Horizontal Distance of Ceiling Objects to Avoid Obstructing the Umbrella Pattern of Extended-Coverage Nonstorage Sprinklers 24
Table 8. Spacing of Ceiling-Level Sidewall Nonstorage Sprinklers for Hazard Category No. 1 30
Table 9. Spacing of Ceiling-Level Sidewall Nonstorage Sprinklers for Hazard Category No. 2 30
Table 10. Minimum Horizontal Distance of Ceiling Objects From the Mounting Wall of Sidewall Nonstorage Sprinklers (not Extended-Coverage) to Avoid Obstructing Umbrella Pattern 32
Table 11. Minimum Horizontal Distance of Ceiling Objects From the Mounting Wall of Extended-Coverage Sidewall Nonstorage Sprinklers to Avoid Obstructing Umbrella Pattern 33
Table 12. Minimum Horizontal Distance of Ceiling Objects Along the Mounting Wall of Sidewall Nonstorage Sprinklers (not Extended-Coverage) to Avoid Obstructing Umbrella Pattern 35
Table 13. Minimum Horizontal Distance of Ceiling Objects Along the Mounting Wall of Extended-Coverage Sidewall Nonstorage Sprinklers to Avoid Obstructing Umbrella Pattern 36
Table 14. Storage Sprinklers Under Sloped Ceilings 41
Table 15. Nominal Temperature Ratings of Sprinklers Based on Maximum Ambient Temperature at Sprinkler Level 45
Table 16. Nominal K-factor Values of FM Approved Storage Sprinklers 46
Table 17. Spacing of Ceiling-Level Storage Sprinklers 48
Table 18. Minimum Horizontal Distance of Ceiling Objects to Avoid Obstructing Umbrella Patterns of Storage Sprinklers (not Extended-Coverage) 55
Table 19. Minimum Horizontal Distance of Ceiling Objects to Avoid Obstructing Umbrella Patterns of Extended-Coverage Storage Sprinklers 56
Table 20. Installation Guidelines to Avoid Obstructions to Inner Core Distribution Pattern of Storage Sprinklers 57
Table 21. Recommended Concentration Levels for Antifreeze Solutions in Water for Ambient Temperature Conditions per Section 2.4.7.5 73
Table 22. Minimum Wall Thickness of Rigid Metallic Sprinkler Piping 74
Table 23. Steel Pipe That Does Not Require Minimum 12-Pipe Diameter Minimum Radius Bend 75
Table 24. Maximum Distance Between Pipe Hangers 80
Table 25. Loss Experience: Causes of Fire by Frequency (1998-2008) 89
Table 26. Ceiling Slope Conversions 93

1.0 SCOPE

This data sheet contains recommendations for the installation of automatic sprinkler systems (sprinklers) and their above-ground supporting components. It is intended to provide guidance on:

- Components used as part of an automatic sprinkler system (system)
- Securing and supporting these components
- The response time of sprinklers to a fire
- The distribution of sprinkler discharge to a fire area
- The documentation required for an FM Global plan review
- The information required for an FM Global acceptance test

This data sheet does **not** provide guidance on:

- Designs for sprinkler systems (see the relevant occupancy-specific data sheet for design guidelines)
- Maintenance required for sprinkler systems (see Data Sheet 2-81, *Fire Safety Inspections and Sprinkler System Maintenance*)
- Detection systems required for sprinkler systems (see Data Sheet 5-48, *Automatic Fire Detection*)
- Underground piping or water supplies for sprinkler systems (see Data Sheet 3-10, *Installation/Maintenance of Private Service Mains and Their Appurtenances*, and other relevant 3-Series data sheets)

In addition to this data sheet, refer to the following for recommendations dealing with specific related subjects:

- For the protection of sprinkler system piping from internal corrosion, see Data Sheet 2-1, *Prevention and Control of Internal Corrosion in Automatic Sprinkler Systems.*
- For the installation of piping in areas designated as 50-year through 500-year earthquake zones (as defined in Data Sheet 1-2, *Earthquakes)*, see Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems.*
- For the maintenance of sprinklers and/or systems, see Data Sheet 2-81, *Fire Safety Inspections and Sprinkler System Maintenance.*
- For the installation of private service mains and water supplies, see Data Sheet 3-10, *Installation/ Maintenance of Private Service Mains and Their Appurtenances*, or the appropriate data sheet dealing with water supply recommendations (3-series data sheet).
- For the installation of refrigerated-area systems, see Data Sheet 8-29, *Refrigerated Storage.*
- For design requirements of systems, see the relevant occupancy-specific data sheet.

Note that many metric values provided in this data sheet are not based strictly on mathematical conversion, but rather on “realistic” and “design-desired” values.

1.1 Changes

January 2014. Correction was made to Table 24, Maximum Distance Between Pipe Hangers.

1.2 Superseded Information

This document supersedes the following:

- Data Sheet 2-2, *Installation Rules for Suppression Mode Automatic Sprinklers*
- Data Sheet 2-7, *Installation Rules for Sprinkler Systems Using Control Mode Ceiling Sprinklers for Storage Applications*
- Data Sheet 2-8N, *NFPA 13, Standard for the Installation of Sprinkler Systems 1996 Edition*

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Nonstorage Sprinklers

2.1.1 Construction and Location

2.1.1.1 General

The two main factors affecting sprinkler system performance are (a) prompt sprinkler operation, and (b) sufficient, unobstructed sprinkler discharge to the fire area. A facility's construction features have a major impact on both of these critical factors.

Ceiling construction has a significant effect on the performance of a sprinkler system. Of particular importance is whether the ceiling construction is "obstructed" or "unobstructed" (see Appendix A: Glossary of Terms for definitions). Recommendations for installing sprinklers under these two types of ceilings can be found in the following sections:

Unobstructed Construction

Nonstorage Sprinkler (excluding Sidewalls): Section 2.1.3.2.4.1

Nonstorage Sidewall Sprinkler: Section 2.1.3.3.4

Obstructed Construction

Nonstorage Sprinkler (excluding Sidewalls): Section 2.1.3.2.4.2

2.1.1.2 Wall or Ceiling Construction Consisting of Plastic Materials

When the interior walls and/or ceiling of a facility contain plastic building materials, see Data Sheet 1-57, *Plastics in Construction*, for sprinkler system design requirements and additional installation recommendations.

2.1.1.3 Exposed Structural Steel

See the relevant occupancy-specific data sheet to determine if protection beyond that offered by the sprinkler system is required for exposed structural steel.

2.1.1.4 Open-Grid Ceilings, Mezzanines or Walkways (Open Grids)

Avoid the installation of open grids because they can obstruct ceiling-level sprinkler discharge. As an alternative, make the mezzanine or walkway solid and protect it in accordance with Section 2.1.1.5.

If open grids cannot be avoided, provide sprinkler protection per the following recommendations.

2.1.1.4.1 Ceiling-Level Sprinklers Above Open Grids

Design ceiling-level sprinklers as recommended in the relevant occupancy-specific data sheet. If the occupancy-specific data sheet does not address open grids, design the system as though no open grid was present.

2.1.1.4.2 Sprinklers Under Open Grids

Unless recommended otherwise in a relevant occupancy-specific data sheet or in Section 2.1.1.4.3 of this data sheet, install sprinkler protection under open grids using 160°F (70°C) nominally rated quick-response sprinklers having the same:

- K-factor,
- orientation, and
- area spacing

as the sprinklers installed at ceiling level.

Install Nonstorage sprinklers under open grids on a maximum linear spacing of 13 ft (3.9 m) and a maximum area spacing of 130 ft^2 (12 m^2), using the same branchline piping installed at ceiling level.

Sprinklers installed under open grids as outlined above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

2.1.1.4.3 Exceptions for Sprinklers Under Open Grids

Sprinklers are not required under an open grid when the following conditions are met:

Exception 1:

- The open grid is a minimum of 70% open, and
- The open grid is a maximum of ½ in. (13 mm) deep, and
- The open grid is at least 3 ft (0.9 m) vertically below the deflector of the ceiling-level sprinklers, and
- Materials that could obstruct sprinkler discharge are not present on top of the open grid, and
- The required minimum flow rate from each individual sprinkler, when divided by the area spacing of the sprinklers, is equal to or less than 0.10 gpm/ft^2 (4 mm/min).

Exception 2:

- The open grid is a minimum of 70% open, and
- The open grid is a maximum of ¼ in. (6 mm) deep, and
- The open grid is at least 3 ft (0.9 m) vertically below the deflector of the ceiling-level sprinklers, and
- Materials that could obstruct sprinkler discharge are not present on top of the open grid, and
- The required minimum flow rate from each individual sprinkler, when divided by the area spacing of the sprinklers, is equal to or less than 0.20 gpm/ft^2 (8 mm/min).

Exception 3:

- The open grid is a minimum of 70% open, and
- The open grid is a maximum of ¼ in. (6 mm) deep, and
- The open grid is at least 3 ft (0.9 m) vertically below the deflector of the ceiling-level sprinklers, and
- It is not possible for materials to fall onto the top of the open grid and obstruct sprinkler discharge during a fire, and
- There is only one open grid ceiling between the solid ceiling and the floor, and
- The ceiling sprinkler system can protect the occupancy in the absence of the open grid.

2.1.1.5 Solid Mezzanines and Walkways

2.1.1.5.1 Solid Mezzanines

Install quick-response sprinklers under solid mezzanines that have combustible construction and/or a combustible occupancy located below them.

Exception: Standard-response sprinklers can be installed under a solid mezzanine when:

(a) Standard-response sprinklers are installed at ceiling level and can protect the occupancy located under the mezzanine, or

(b) A draft curtain is provided around the perimeter of the mezzanine in accordance with Data Sheet 1-10, *Interaction of Sprinklers, Smoke and Heat Vents, and Draft Curtains.*

Install a draft curtain around the perimeter of the solid mezzanine in accordance with Data Sheet 1-10.

Exception: A draft curtain is not required around the perimeter of a solid mezzanine when:

(a) The ceiling sprinkler protection can protect the occupancy located under the solid mezzanine, or

(b) The ceiling-level and mezzanine-level sprinklers are of the same nominal RTI value and the occupancy under the mezzanine is located completely within the sprinklers at the edge of the mezzanine, or

(c) The sprinklers located under the solid mezzanine are quick-response and the sprinklers located at ceiling level are standard-response.

Unless recommended otherwise in a relevant occupancy-specific data sheet, base the design of the mezzanine-level sprinkler protection on the height of the mezzanine and the occupancy located underneath it.

2.1.1.5.2 Solid Walkways

Install quick-response sprinklers under solid walkways over 4 ft (1.2 m) wide that have combustible construction and/or a combustible occupancy located below them. In addition, install quick-response sprinklers under solid walkways of any width that are located between storage racks or similar structures.

For solid walkways up to 10 ft (3.0 m) wide, install a single line of quick-response sprinklers down the center of the walkway on maximum 10 ft (3.0 m) linear spacing.

For solid walkways over 10 ft (3.0 m) wide, treat the walkways as a ceiling and install quick-response sprinklers on their normal allowable linear and area spacing.

Treat the walkway sprinklers as ceiling sprinklers for design purposes.

Example: A 8 ft (2.4 m) wide walkway is located above an occupancy that requires a minimum pressure of 10 psi (0.7 bar) from the most remote 25 sprinklers. The ceiling-level sprinklers have an area spacing of 100 ft^2 (9.3 m^2). A single line of sprinklers is needed under the walkway since the walkway is only 8 ft (2.4 m) wide. The length of the operating area for the walkway sprinklers is therefore based on a shape factor of 1.2 multiplied by the square root of 25 sprinklers x 100 ft^2 [9.3 m^2]/sprinkler), which equals 60 ft (18 m).

Therefore, the design for the walkway sprinklers is based on any sprinkler located within the most remote linear 60 ft (18 m) operating at a minimum pressure of 10 psi (0.7 bar).

2.1.1.6 Ceiling Slope

Unless recommended otherwise by the relevant occupancy-specific data sheet, Nonstorage sprinklers are acceptable under sloped ceilings up to a maximum of 10° if the design is based on a wet sprinkler system; or 20° if the design is based on a dry sprinkler system.

Exception 1: Install extended-coverage Nonstorage sprinklers under a ceiling that has a maximum slope of 10°.

Exception 2: Nonstorage sprinklers, excluding extended-coverage sprinklers, can be installed under a ceiling that has a slope exceeding 20°, if both of the following criteria are met:

- The length of the ceiling in excess of 20° does not exceed 35 ft (10.5 m), and
- The demand area is based on that required for a dry-pipe sprinkler system.

Exception 3: Nonstorage sprinklers, excluding extended-coverage sprinklers, can be installed under a ceiling that has a slope exceeding 20°, if both of the following criteria are met:

- The occupancy does not require a minimum flow rate from each individual sprinkler that, when divided by the area spacing of the sprinklers, is more than 0.15 gpm/ft^2 (6 mm/min), and
- The demand area is based on that required for a dry-pipe sprinkler system.

For ceiling slopes that exceed the maximum allowed, install a flat, continuous false ceiling (see Appendix A for definition) over the affected area and for 20 ft (6.0 m) beyond in all directions. Design the false ceiling in accordance with Data Sheet 1-12, *Ceilings and Concealed Spaces*, and ensure it can withstand a minimum uplift pressure of 3 lb/ft^2 (14.4 kg/m^2). Provide sprinkler protection beneath the false ceiling designed in accordance with the relevant occupancy-specific data sheet.

For ceilings with a slope greater than 5°, locate sprinklers within 3 ft (0.9 m) of a ceiling's peak, measured horizontally along the slope of the ceiling.

2.1.1.7 Heat and/or Smoke Vents and Other Exhaust Openings at Ceiling Level

2.1.1.7.1 Heat and/or Smoke Vents

Do not install automatic smoke and heat vents in facilities equipped with sprinkler protection; manual heat and smoke vents, however, are acceptable. If local codes require the installation of automatic smoke and heat vents, do one of the following:

(a) Install vents that are FM Approved for occupancies protected by quick-response Storage sprinklers.

(b) Install FM Approved vents equipped with a standard-response 360°F (182°C) nominal thermal activating device.

(c) Install quick-response sprinklers directly under the vent opening on a maximum 4 ft (1.2 m) linear and 16 ft^2 (1.5 m^2) area spacing. Position the centerline of the sprinkler's thermal element in accordance with the guidelines outlined in Section 2.1.3.2.4. Ensure these sprinklers have, at a minimum, the same K-factor and orientation as the adjacent ceiling-level sprinklers and are fed by sprinkler piping no smaller than the ceiling level branchlines. Sprinklers located under the ceiling vent and installed as outlined above do not need to be added to the hydraulic design of the ceiling sprinkler system. See Figure 1a for a diagram of this arrangement.

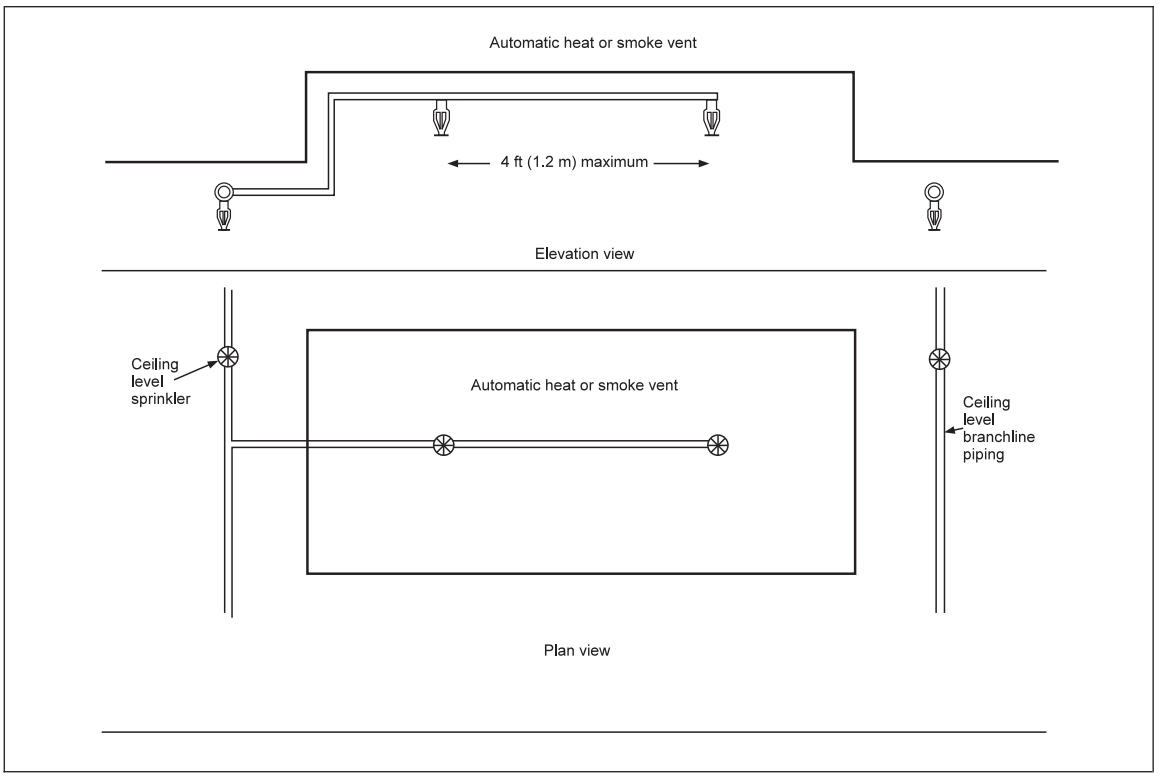

Fig. 1a. Quick-Response sprinklers installed under automatic smoke and heat vents.

2.1.1.7.2 Exhaust Openings at Ceiling Level

Arrange openings at ceiling level, such as exhaust and ridge vents, to close automatically upon early fire detection (prior to first sprinkler operation). If this is not possible, do one of the following:

(a) Install a false ceiling (see Appendix A for definition) under the ceiling opening. Ensure the false ceiling is, at a minimum, the same size as the ceiling opening, and install sprinklers below the false ceiling using the same branchline pipe size and sprinkler spacing installed at ceiling level. Design the false ceiling in accordance with Data Sheet 1-12, *Ceilings and Concealed Spaces*, and ensure it can withstand a minimum uplift pressure of 3 lb/ft^2 (14.4 kg/m^2). Sprinklers located under the false ceiling and installed as outlined above do not need to be added to the hydraulic design of the ceiling sprinkler system.

(b) Install quick-response sprinklers directly under the ceiling opening on a maximum 4 ft (1.2 m) linear and 16 ft^2 (1.5 m^2) area spacing. Ensure these sprinklers have, at a minimum, the same K-factor and orientation as the adjacent ceiling-level sprinklers, and are fed by sprinkler piping no smaller than the ceiling-level branchlines. Sprinklers located under the ceiling opening and installed as outlined above do

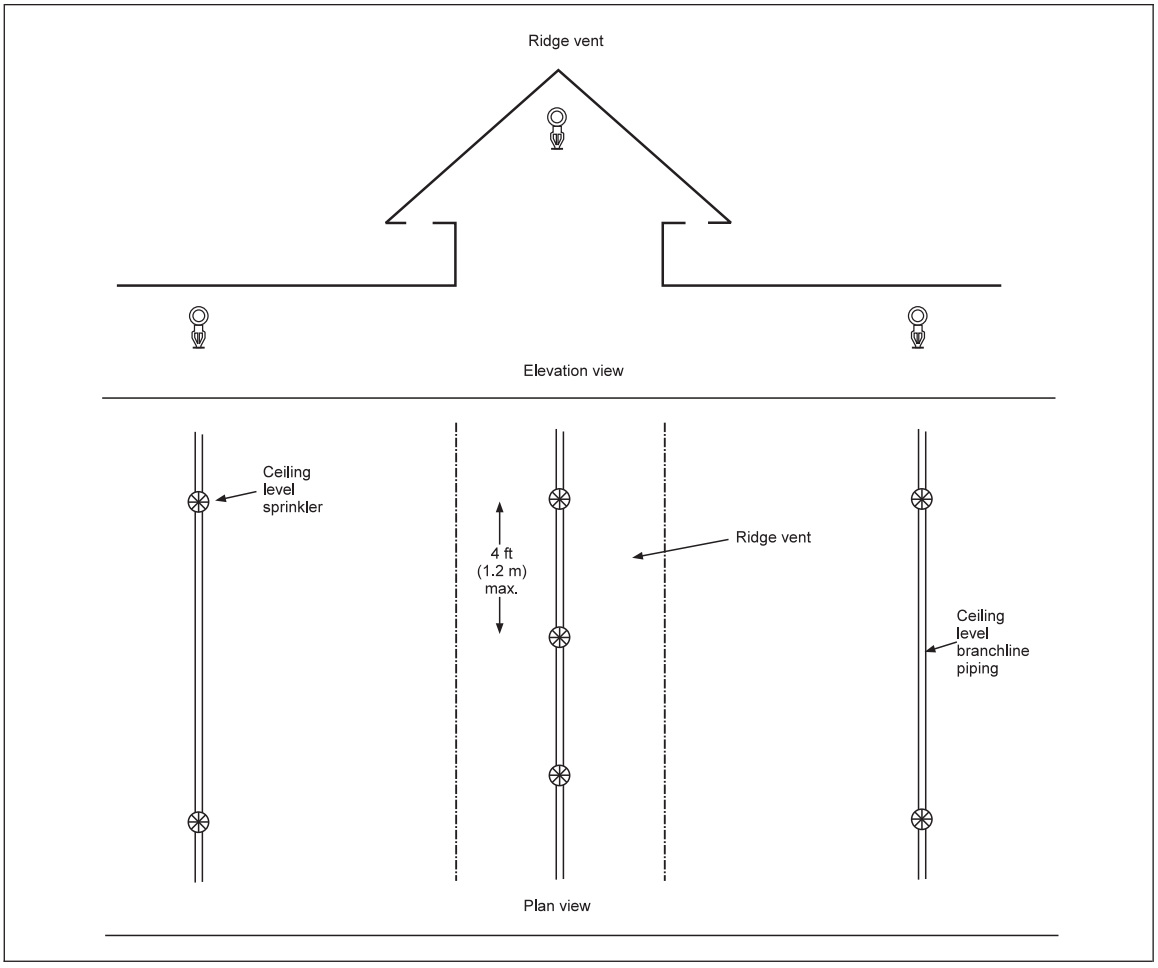

Fig. 1b. Quick-Response sprinklers installed under ceiling-level exhaust devices.

not need to be added to the hydraulic design of the ceiling sprinkler system. See Figure 1b for a diagram of this arrangement.

2.1.1.8 Draft Curtains

Do not install draft curtains in buildings protected by sprinklers unless they are (a) specifically used to separate areas protected by quick-response ceiling-level Storage sprinklers from areas protected by standard-response ceiling-level sprinklers, or (b) recommended by other sections of this data sheet, or (c) recommended by the relevant occupancy-specific data sheet.

If draft curtains are recommended, install the draft curtain in accordance with Data Sheet 1-10, *Interaction of Sprinklers, Smoke and Heat Vents, and Draft Curtains*. Solid beams, girders, or other structural features that meet the criteria outlined in Data Sheet 1-10 can be considered the equivalent of a draft curtain. Extend the draft curtain at least 2 ft (0.6 m) below the ceiling, and position the sprinklers horizontally from the draft curtain based on the installation guidelines for obstructed construction as outlined in Section 2.1.3.2.5.1.

2.1.2 Occupancy

2.1.2.1 Clearance Below Sprinklers

Maintain a minimum 3 ft (0.9 m) clearance between the deflector of a sprinkler and any combustibles located below it.

2.1.2.2 Conveyors

Provide sprinkler protection under belt-type or other solid-type conveyor systems having combustible construction and/or a combustible occupancy below them as follows:

2.1.2.2.1 Belt or Similar Solid-Type Conveyors

Treat belt-type and similar solid-type conveyor systems the same as a solid walkway and provide sprinkler protection in accordance with Section 2.1.1.5.2.

2.1.2.2.2 Roller and Similar Open-Type Conveyors

Sprinklers are not required below conveyor systems that are a minimum of 70% open, or below roller-type conveyors that are at least 50% open. If these conditions cannot be met, treat conveyors as open-grid ceilings and adhere to the recommendations in Section 2.1.1.4.

2.1.2.2.3 Automatic Shutdown of Conveyor Systems

Arrange conveyor systems to automatically shut down in the event of sprinkler water discharge. See Data Sheet 7-11, *Conveyors*, for other guidelines regarding the presence of conveyor systems in buildings equipped with sprinkler protection.

2.1.3 Protection

2.1.3.1 General

2.1.3.1.1 Where Sprinklers Are Needed

Install sprinkler protection wherever there is combustible construction or a combustible occupancy. Refer to any relevant occupancy-specific data sheets to determine if exceptions to this recommendation exist.

See Data Sheet 1-12, *Ceilings and Combustible Spaces*, for recommendations related to installing sprinklers within combustible ceilings or concealed spaces.

Install sprinkler protection under any fixed object more than 4 ft (1.2 m) wide in its least horizontal dimension and beneath which combustible construction or a combustible occupancy is located.

Provide exposure protection when exterior hazards, such as large oil-filled transformers, exterior loading docks, and yard storage, are located in close proximity to a building that either has or requires sprinkler protection. See Data Sheet 1-20, *Protection Against Exterior Fire Exposure*, for additional guidelines.

Do not use fixed special protection extinguishing systems as an alternative to sprinklers unless recommended by the relevant occupancy-specific data sheet.

2.1.3.1.2 Sprinkler Applications

The recommendations in this section address the installation of Nonstorage sprinklers (see Appendix A, Glossary of Terms, for the definition of a Nonstorage sprinkler). The goal of these recommendations is to ensure prompt actuation of sprinklers and a sufficient flow of unobstructed water to the fire.

For sprinklers to perform properly during a fire, the appropriate sprinkler must be chosen for the fire hazard. In addition, proper installation is required to allow the sprinkler to operate in a timely fashion and deliver an adequate amount of unobstructed water to the fire.

When choosing a sprinkler for the protection of a given fire hazard, see the relevant occupancy-specific data sheet to determine the following:

(a) The types of sprinklers that can be installed.

(b) The sprinkler's recommended nominal temperature rating. If the ambient temperature exceeds 100°F (38°C), see Table 1 for the recommended nominal temperature rating of a sprinkler based on the maximum expected ambient temperature at sprinkler level.

(c) The sprinkler's recommended K-factor, RTI, and orientation. See Table 2 for nominal K-factor values of FM Approved automatic sprinklers.

(d) The sprinkler's recommended minimum and maximum linear horizontal spacing, as well as the minimum and maximum area spacing. Note that the linear distance between sprinklers is measured along the slope of the ceiling, not on the viewpoint from floor level.

Table 1. Nominal Temperature Ratings of Sprinklers Based on Maximum Ambient Temperature at Sprinkler Level

Maximum Ambient Temperature at Sprinkler Level, °F (°C)	*Nominal Temperature Rating of Sprinkler, °F (°C)*	*Temperature Classification of Sprinkler*	*Color of Sprinkler Glass Bulb*
100 (38)	135 (55)	Ordinary	Orange
100 (38)	160 (70)	Ordinary	Red
150 (66)	175 (80)	Ordinary	Yellow
150 (66)	212 (100)	Intermediate	Green
225 (107)	280 (140)	High	Blue
300 (149)	350 (175)	Extra High	Mauve
375 (191)	425 (220)	Very Extra High	Black
475 (246)	525 (275)	Ultra High	Black
625 (329)	650 (345)	Ultra High	Black

In several countries, the arm frames of the sprinkler are provided with a color coding to represent the temperature classification of the sprinkler. Check the local country code to determine the temperature classification for the sprinkler based on the sprinkler's arm-frame color.

Table 2. Nominal K-factor Values of FM Approved Nonstorage Sprinklers

Nominal K-factor Values, gpm/(psi)$^{0.5}$ (L/min/[bar]$^{0.5}$)	*K-factor Range Values, gpm/(psi)$^{0.5}$*	*K-factor Range Values, L/min/[bar]$^{0.5}$*	*Nominal Pipe Thread Size, in. (mm)*
2.8 (40)	2.6 – 2.9	38 – 42	½ or ¾ (15 or 20)
5.6 (80)	5.3 – 5.8	76 – 84	½ or ¾ (15 or 20)
8.0 (115)	7.4 – 8.2	107 – 118	½ or ¾ (15 or 20)
11.2 (160)	11.0 – 11.5	159 – 166	½ or ¾ (15 or 20)*
14.0 (200)	13.5 – 14.5	195 – 209	¾ (20)
16.8 (240)	16.0 – 17.6	231 – 254	¾ (20)
19.6 (280)	18.6 – 20.6	269 – 297	1 (25)
22.4 (320)	21.3 – 23.5	307 – 339	1 (25)
25.2 (360)	23.9 – 26.5	344 – 382	1 (25)

* The use of K11.2 (K160) sprinklers having nominal ½ in. (15 mm) npt threaded connections is acceptable only when they are being considered as a retrofit option for the replacement of existing K8.0 (K115) or smaller sprinklers.

2.1.3.1.3 Mixing of Different Types of Sprinklers

Do not mix the following types of sprinklers on the same sprinkler system protecting the same hazard area unless otherwise recommended in the relevant occupancy-specific data sheet:

(a) Storage, Nonstorage, and Special Protection sprinklers

(b) Sprinklers having different K-factors

(c) Sprinklers having different orientation

(d) Sprinklers having different nominal temperature ratings

(e) Sprinklers having different nominal RTI values

(f) Sprinklers having different linear and/or area spacing requirements (e.g., extended-coverage and non-extended-coverage sprinklers)

Exception No. 1: Install individual sprinklers having a higher temperature rating as needed based on ambient temperature conditions (such as near unit heater outlets). Ensure the higher-temperature sprinklers are of the same make, model, type, K-Factor, RTI, and orientation as the lower-temperature sprinklers.

Exception No. 2: An upright sprinkler may be substituted for an obstructed pendent sprinkler provided it has the same K-factor, nominal temperature rating, nominal RTI, and recommended sprinkler spacing as the pendent sprinkler and is compatible for the occupancy hazard.

Exception No. 3: Sprinklers installed under lower ceilings are not considered “on the same system.” See recommendations in Section 2.1.1.4 if the lower ceiling is open-grid, or Section 2.1.1.5 if the lower ceiling is solid.

Exception No. 4: When two different occupancy hazards are adjacent to each other and are not separated by a wall or draft curtain, extend the design of the sprinkler system protecting the higher-hazard occupancy a minimum of 20 ft (6.0 m) in all directions beyond the perimeter of the higher-hazard occupancy area.

2.1.3.1.4 Return Bends for Sprinklers

Provide individual return bends for all K11.2 (K160) or smaller pendent sprinklers that are supplied from a raw water source, mill pond, or from open-top reservoirs. The size of the return bend can be either the same size of the branchline that feeds the return bend or one pipe diameter size smaller, but not less than 1 in. (25 mm).

Exception No. 1: Return bends are not necessary on sprinkler systems equipped with an FM Approved strainer.

Exception No. 2: Return bends are not necessary for deluge systems.

Exception No. 3: Return bends are not necessary where dry pendent sprinklers are used.

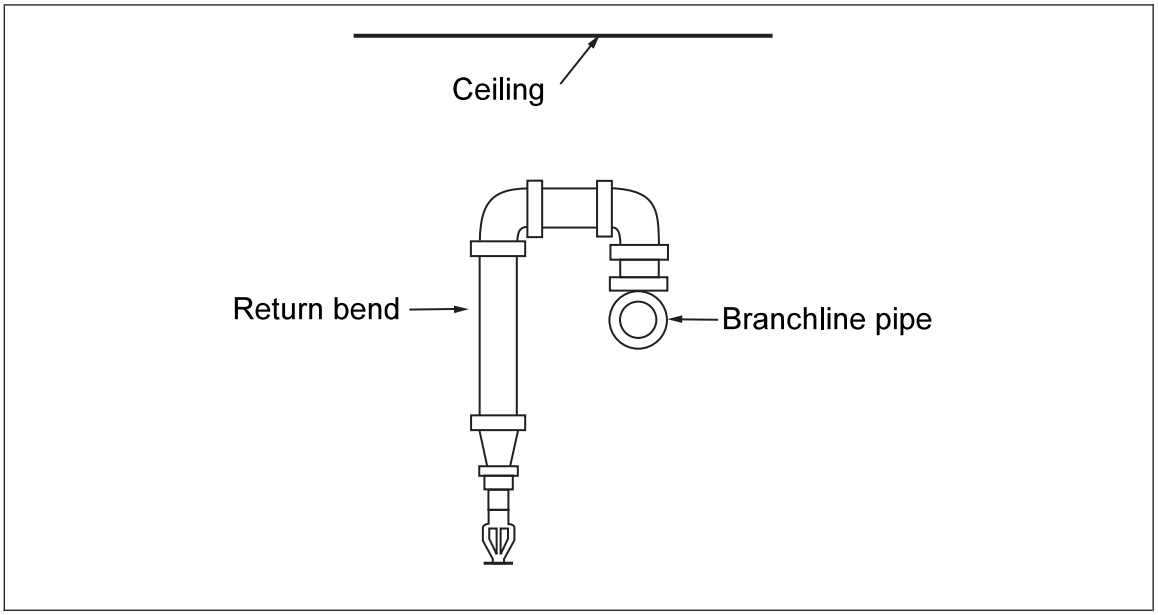

Fig. 2. Return bends for Nonstorage sprinklers.

2.1.3.1.5 Protection of Sprinklers from Damage

Provide protection for sprinklers that are subject to mechanical damage. Ensure the protection does not degrade the performance of the sprinkler.

2.1.3.1.6 Sprinklers Having a K-Factor Value Less Than 2.8 (40)

Install an FM Approved strainer upstream of any sprinklers having a K-Factor value less than 2.8 (40).

2.1.3.1.7 Spare Sprinklers

Maintain a supply of spare sprinklers on site for each type of sprinkler installed, as well as any equipment required for installing them. Base the minimum number of spare sprinklers required of each type on their largest demand area.

Example: A facility has two types of sprinklers; a Nonstorage sprinkler for the manufacturing area, and a Storage sprinkler for the warehouse area. The largest sprinkler system demand area for the manufacturing area is 25 sprinklers, and for the warehouse area it is 15 sprinklers. Therefore, the minimum number of spare sprinklers is 25 Nonstorage sprinklers and 15 Storage sprinklers.

2.1.3.2 Upright and Pendent Nonstorage Sprinklers; Not Including Sidewall Sprinklers

2.1.3.2.1 General

See the relevant occupancy-specific data sheet or the *Approval Guide* to ensure the construction type (obstructed or unobstructed) is compatible with the sprinkler.

Install upright Nonstorage sprinklers so their frame arms are parallel to the branchline.

Install upright and pendent Nonstorage sprinklers so their deflector is parallel to the floor.

Exception: The deflector of the sprinkler may be installed parallel to the ceiling if the ceiling slope is 5° or less.

2.1.3.2.2 Linear and Area Spacing of Nonstorage Sprinklers

Install upright and pendent Nonstorage sprinklers under unobstructed ceiling construction in accordance with the minimum and maximum linear and area spacing recommendations listed in Tables 3, 4 or 5, unless indicated otherwise in the relevant occupancy-specific data sheet.

Install upright and pendent Nonstorage sprinklers under obstructed ceiling construction in accordance with the minimum and maximum linear and area spacing recommendations listed in Tables 3, 4 or 5 as well as those in Section 2.1.3.2.4.2 of this document, unless indicated otherwise in the relevant occupancy-specific data sheet.

See the relevant occupancy-specific data sheet for the definitions of Hazard Category numbers 1, 2, and 3, and to determine which Hazard Category Number is appropriate for the area to be protected.

Table 3. Spacing of Ceiling-Level Pendent and Upright Nonstorage Sprinklers for Hazard Category No. 1

Ceiling Height, ft (m)	*Ceiling Type*	*K-Factor*	*Orientation*	*Response*	*Linear Spacing, ft (m)*		*Area Spacing, ft² (m²)*	
					Min.	Max.	Min.	Max.
Up to 30 (9.0)	Noncombustible Unobstructed, Noncombustible Obstructed, or Combustible Unobstructed	5.6 (80), 8.0 (115), or 11.2 (160),	Pendent or Upright	Quick or Standard	7 (2.1)	15 (4.5)	70 (6.5)	225 (21.0)
		14.0 (200), 16.8 (240), 19.6 (280), 22.4 (320) or 25.2 (360)	Pendent or Upright	Quick	7 (2.1)	15 (4.5)	64 (6.0)	225 (21.0)
			Pendent	Standard	7 (2.1)	15 (4.5)	64 (6.0)	225 (21.0)
			Upright	Standard	7 (2.1)	15 (4.5)	70 (6.5)	225 (21.0)
		*5.6EC (80EC), 8.0EC (115EC), 11.2EC (160EC), or 14.0EC (200EC)	Pendent or Upright	Quick	10 (3.0)	20 (6.0)	100 (9.0)	400 (36.0)
		*25.2EC (360EC)	Pendent or Upright	Quick	10 (3.0)	14 (4.2)	100 (9.0)	196 (18.0)
	Combustible Obstructed	5.6 (80), 8.0 (115), 11.2 (160)	Pendent or Upright	Quick or Standard	7 (2.1)	15 (4.5)	70 (6.5)	169 (15.5)
		14.0 (200), 16.8 (240), 19.6 (280), 22.4 (320) or 25.2 (360)	Pendent or Upright	Quick	7 (2.1)	15 (4.5)	64 (6.0)	169 (15.5)
			Pendent	Standard	7 (2.1)	15 (4.5)	64 (6.0)	169 (15.5)
			Upright	Standard	7 (2.1)	15 (4.5)	70 (6.5)	169 (15.5)
		*5.6EC (80EC), 8.0EC (115EC), 11.2EC (160EC), or 14.0EC (200EC)	Pendent or Upright	Quick	10 (3.0)	20 (6.0)	100 (9.0)	400 (36.0)
		*25.2EC (360EC)	Pendent or Upright	Quick	10 (3.0)	14 (4.2)	100 (9.0)	196 (18.0)
Over 30 (9.0)	Noncombustible Unobstructed	8.0 (115) 11.2 (160)	Pendent or Upright	Quick or Standard	8 (2.4)	12 (3.6)	80 (7.5)	120 (11.0)
		14.0 (200), 16.8 (240), 19.6 (280), 22.4 (320), or 25.2 (360)	Pendent or Upright	Quick	8 (2.4)	12 (3.6)	64 (6.0)	120 (11.0)
			Pendent or Upright	Standard	8 (2.4)	12 (3.6)	80 (7.5)	120 (11.0)
		*25.2EC (360EC)	Upright or Pendent	Quick	10 (3.0)	14 (4.2)	100 (9.0)	196 (18.0)

*Applies where extended coverage sprinklers are acceptable in the presence of obstructed type construction. Such construction may require the sprinklers be installed in every channel formed by the obstructed ceiling construction.

Table 4. Spacing of Ceiling-Level Pendent and Upright Nonstorage Sprinklers for Hazard Category No. 2

Ceiling Height, ft (m)	*K-Factor*	*Orientation*	*Response*	*Linear Spacing, ft (m)*		*Area Spacing, ft² (m²)*	
				Min.	Max.	Min.	Max.
Up to 30 (9.0)	5.6 (80), 8.0 (115), or 11.2 (160)	Pendent or Upright	Quick or Standard	7 (2.1)	12 (3.6)	70 (6.5)	130 (12.0)
	14.0 (200), 16.8 (240), 19.6 (280), 22.4 (320), or 25.2 (360)	Pendent or Upright	Quick	7 (2.1)	12 (3.6)	64 (6.0)	130 (12.0)
		Pendent	Standard	7 (2.1)	12 (3.6)	64 (6.0)	130 (12.0)
		Upright	Standard	7 (2.1)	12 (3.6)	70 (6.5)	130 (12.0)
	*11.2EC (160EC) or 14.0EC (200EC)	Pendent or Upright	Quick	10 (3.0)	20 (6.0)	100 (9.0)	400 (36.0)
	*25.2EC (360EC)	Pendent or Upright	Quick	10 (3.0)	14 (4.2)	100 (9.0)	196 (18.0)
Over 30 (9.0)	11.2 (160)	Pendent or Upright	Quick or Standard	8 (2.4)	10 (3.0)	80 (7.5)	100 (9.0)
	14.0 (200), 16.8 (240), 19.6 (280), 22.4 (320), or 25.2 (360)	Pendent or Upright	Quick	8 (2.4)	10 (3.0)	64 (6.0)	100 (9.0)
		Pendent or Upright	Standard	8 (2.4)	10 (3.0)	80 (7.5)	100 (9.0)
	*25.2EC (360EC)	Pendent or Upright	Quick	10 (3.0)	14 (4.2)	100 (9.0)	196 (18.0)

*Applies where extended coverage sprinklers are acceptable in the presence of obstructed type construction. Such construction may require the sprinklers be installed in every channel formed by the obstructed ceiling construction.

Table 5. Spacing of Ceiling-Level Pendent and Upright Nonstorage Sprinklers for Hazard Category No. 3

Ceiling Height ft (m)	*K-Factor*	*Orientation*	*Response*	*Linear Spacing, ft (m)*		*Area Spacing, ft² (m²)*	
				Min.	Max.	Min.	Max.
Up to 30 (9.0)	5.6 (80), 8.0 (115), 11.2 (160)	Pendent or Upright	Standard or Quick	8 (2.4)	12 (3.6)	80 (7.5)	120 (11.0)
	14.0 (200), 16.8 (240), 19.6 (280), 22.4 (320), 25.2 (360)	Pendent or Upright	Quick	8 (2.4)	12 (3.6)	64 (6.0)	120 (11.0)
		Pendent	Standard	8 (2.4)	12 (3.6)	64 (6.0)	120 (11.0)
		Upright	Standard	8 (2.4)	12 (3.6)	80 (7.5)	120 (11.0)
	*11.2EC (160EC)	Upright or Pendent	Quick	10 (3.0)	16 (4.8)	100 (9.0)	256 (25)
	*14.0EC (200EC)	Upright or Pendent	Quick	10 (3.0)	20 (6.0)	100 (9.0)	400 (36.0)
	*25.2EC (360EC)	Upright or Pendent	Quick	10 (3.0)	14 (4.2)	100 (9.0)	196 (18.0)
Over 30 (9.0)	11.2 (160)	Pendent or Upright	Quick or Standard	8 (2.4)	10 (3.0)	80 (7.5)	100 (9.0)
	14.0 (200), 16.8 (240), 19.6 (280), 22.4 (320), 25.2 (360)	Pendent or Upright	Quick	8 (2.4)	10 (3.0)	64 (6.0)	100 (9.0)
		Pendent or Upright	Standard	8 (2.4)	10 (3.0)	80 (7.5)	100 (9.0)
	*25.2EC (360EC)	Upright or Pendent	Quick	10 (3.0)	14 (4.2)	100 (9.0)	196 (18.0)

*Applies where extended coverage sprinklers are acceptable in the presence of obstructed type construction. Such construction may require the sprinklers be installed in every channel formed by the obstructed ceiling construction.

Exception: When sprinklers are provided in every channel bay formed by obstructed construction, the minimum linear and area spacing recommendations listed in Tables 3, 4 and 5 do not apply to the sprinklers located in adjacent channel bays. See Figure 3 for a diagram of this arrangement.

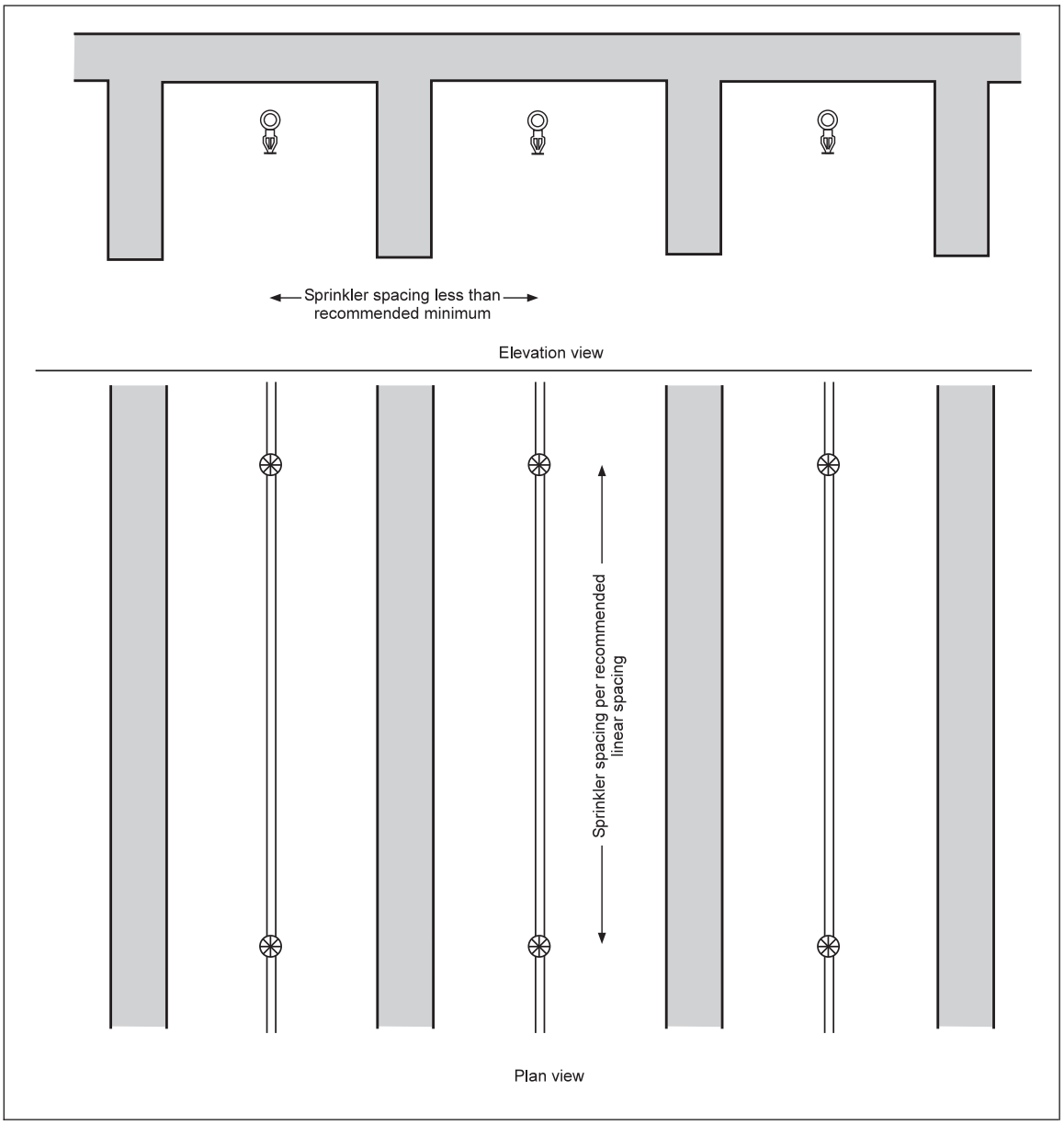

Fig. 3. Spacing of Nonstorage sprinklers when installed in every bay channel formed by solid structural members

The maximum linear and area spacing of a Nonstorage sprinkler can be increased by 1 ft (0.3 m) and 20 ft^2 (2 m^2) respectively to avoid obstructing sprinkler discharge as outlined in Section 2.1.3.2.5.

Note that the extension in Nonstorage sprinkler spacing applies only to a maximum of two adjacent sprinklers on the same branchline or to two adjacent branchlines. See Figure 4 for a diagram of this arrangement.

2.1.3.2.3 Horizontal Distance from Walls to Nonstorage Sprinklers

Install pendent and upright Nonstorage sprinklers horizontally from walls, measured perpendicular to the wall, as follows:

- Minimum horizontal distance: 4 in. (100 mm)

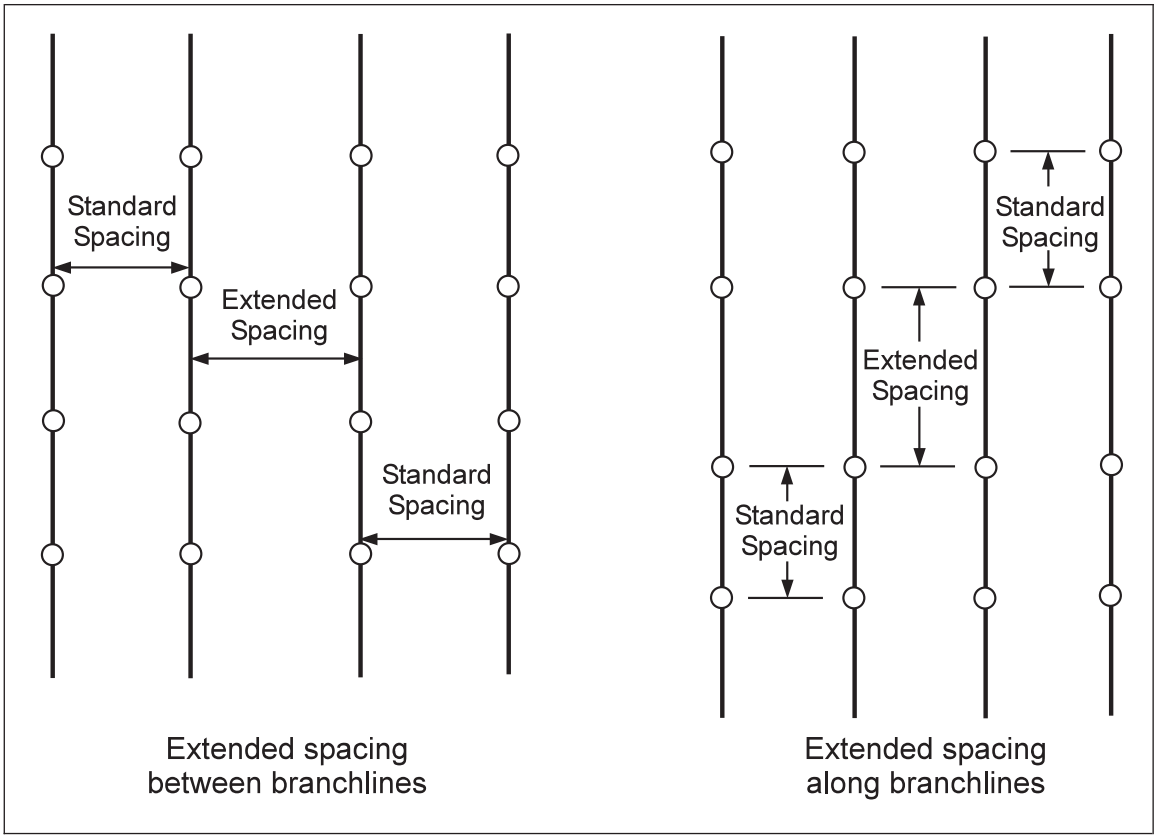

Fig. 4. Maximum increase in linear and area spacing for Nonstorage sprinklers to avoid obstructing sprinkler discharge

- Maximum horizontal distance unless recommended otherwise in either the relevant occupancy-specific data sheet or the *Approval Guide*:

  (a) Wall angle greater than 90°: 50% of the recommended maximum linear spacing of the sprinkler as outlined in the relevant occupancy-specific data sheet.

  (b) Wall angle equal to or less than 90°: 70% of the recommended maximum linear spacing of the sprinkler as outlined in the relevant occupancy-specific data sheet.

See Figure 5 for a representation of the wall angles outlined above.

2.1.3.2.4 Vertical Distance from the Ceiling to Nonstorage Sprinklers

Vertical distance is measured perpendicular to the floor, between the centerline of the sprinkler's thermal element to the uppermost portion of the underside of the ceiling. This vertical distance can be measured to the underside of the lowermost portion of the ceiling when this section of the ceiling is flat, smooth, and at least 3 in. (75 mm) wide in its least dimension, as well as at least twice as wide as the vertical distance between the uppermost and lowermost ceilings. In addition, the horizontal gap between lowermost ceiling sections (i.e., the width of the flute area) cannot be more than 3 in. (75 mm) wide.

Install pendent and upright Nonstorage sprinklers under ceilings in accordance with Section 2.1.3.2.4.1 for unobstructed ceiling construction, and Section 2.1.3.2.4.2 for obstructed ceiling construction. If the ceiling slope exceeds 10°, in addition to the following guidelines ensure sprinklers are within a 3 ft (0.9 m) vertical plane of the peak of the ceiling.

See the relevant occupancy-specific data sheet or the *Approval Guide* to ensure the construction type (obstructed or unobstructed) is compatible with the sprinkler.

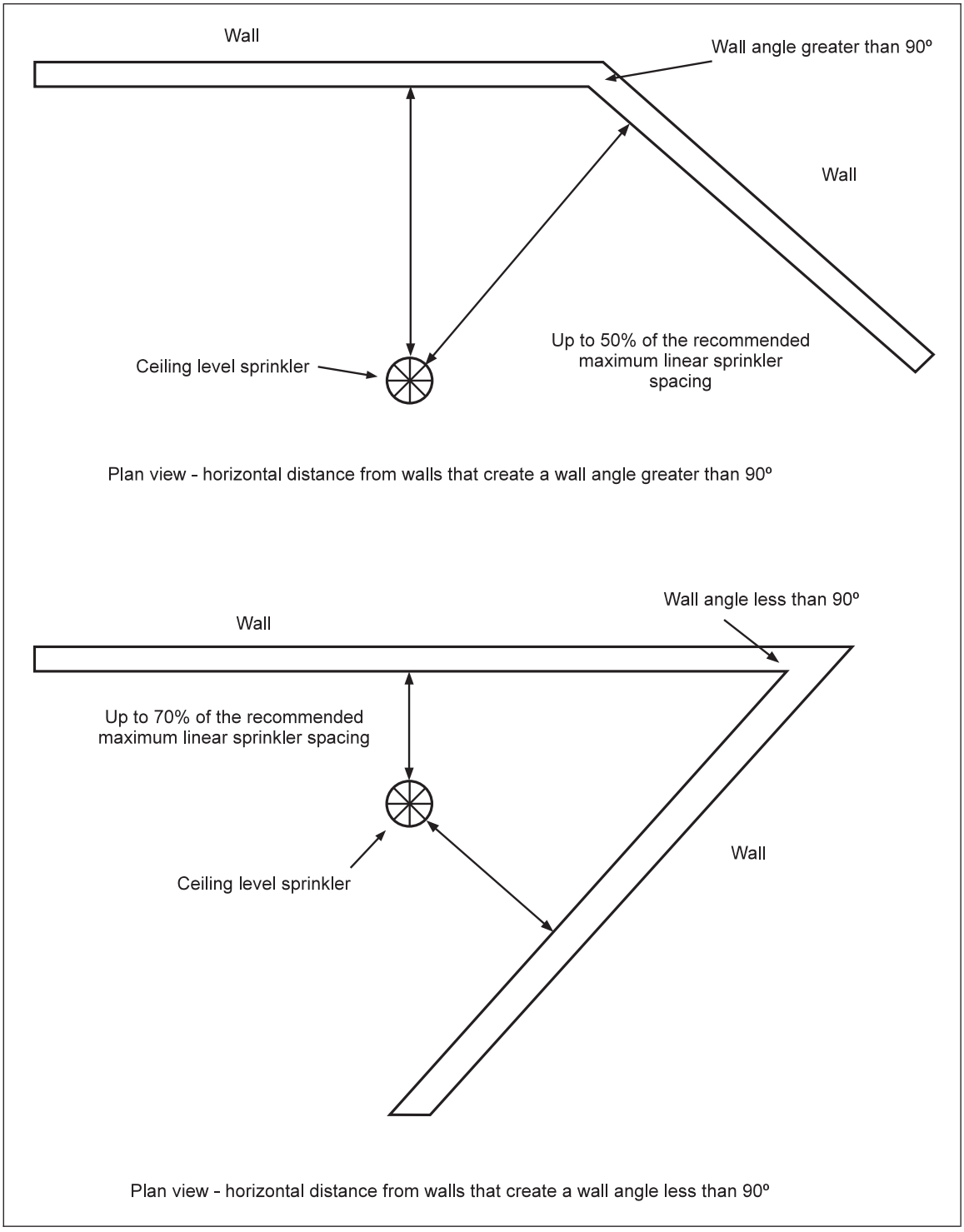

Fig. 5. Horizontal distance from walls to Nonstorage sprinklers

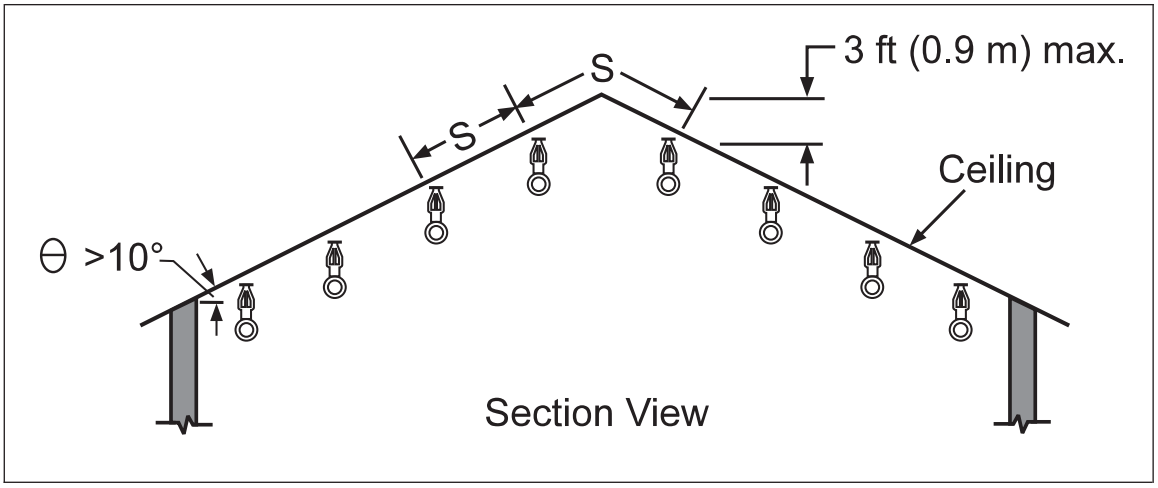

Fig. 6. Location of Nonstorage sprinklers if ceiling slope exceeds 10°

2.1.3.2.4.1 Unobstructed Ceiling Construction

Install pendent and upright Nonstorage sprinklers under unobstructed ceiling construction so the centerline of the sprinkler's thermal sensing element is a minimum of 1 in. (25 mm) and a maximum of 12 in. (300 mm) vertically below the underside of the ceiling. Ensure the location of the sprinkler deflector meets the recommendations for obstructions in Section 2.1.3.2.5.1.

Exception to minimum vertical distance: The minimum vertical distance of 1 in. (25 mm) may be ignored when installing FM Approved flush, recessed, or concealed sprinklers that are recommended for the occupancy hazard being protected.

2.1.3.2.4.2 Obstructed Ceiling Construction

Install pendent and upright Nonstorage sprinklers in every channel bay formed by obstructed ceiling construction, and position the centerline of the sprinkler's thermal sensing element a minimum of 1 in. (25 mm) and a maximum of 12 in. (300 mm) vertically below the underside of the ceiling.

Exception to minimum vertical distance: The minimum vertical distance of 1 in. (25 mm) may be ignored when installing FM Approved flush, recessed or concealed type sprinklers that are recommended for the hazard being protected.

Exception to installing sprinklers in every channel bay formed by obstructed ceiling construction (excluding extended-coverage Nonstorage sprinklers): Nonstorage sprinklers are not necessary in every channel bay formed by obstructed ceiling construction and can have a maximum recommended area spacing of 130 ft^2 (12 m^2) when the following criteria are met:

(a) Noncombustible solid structural members extend up to 21 in. (525 mm) from the underside of the ceiling, or

(b) Combustible solid structural members extend up to 21 in. (525 mm) from the underside of the ceiling and form channel bays not exceeding 300 ft^2 (28 m^2) in area, or

(c) The stems of concrete tee construction are spaced up to 7.5 ft (2.3 m) apart on centers and extend up to 21 in. (525 mm) from the underside of the ceiling, or

(d) Noncombustible solid structural members (including concrete tees) extend more than 21 in. (525 mm) from the underside of the ceiling. For this exception to apply, however, the sprinkler's thermal sensing element cannot be located more than 22 in. (550 mm) below the underside of the ceiling, and the guidelines for obstructions in Section 2.1.3.2.5.1 must be met. See Figure 7 for a diagram of this arrangement.

For exceptions (a) and (c), locate the centerline of the sprinkler's thermal sensing element on a horizontal plane no more than 6 in. (150 mm) vertically below the underside of the solid structural members or concrete tee stems, and no more than 22 in. (550 mm) below the underside of the ceiling. See Figure 7 for a diagram of this arrangement.

For Exception (b), vertically install the centerline of the sprinkler's thermal sensing element within 1 in. (25 mm) directly below the underside of the solid structural members See Figure 7 for a diagram of this arrangement.

2.1.3.2.5 Obstructions to Discharge Pattern of Pendent and Upright Nonstorage Sprinklers

Install Nonstorage sprinklers in accordance with the recommendations in Sections 2.1.3.2.5.1 and 2.1.3.2.5.2 to ensure the water discharged from the sprinkler is not significantly obstructed.

2.1.3.2.5.1 Obstruction to Umbrella Discharge Pattern of Pendent and Upright Nonstorage Sprinklers

In addition to the recommendations in Sections 2.1.3.2.1 through 2.1.3.2.4, install pendent and upright Nonstorage sprinklers on standard spacing in accordance with Figure 8 and Table 6 to avoid the sprinkler's umbrella pattern being obstructed by an object located at or near ceiling level. Ensure objects located less than 12 in. (300 mm) horizontally from the sprinkler are above the horizontal plane of the sprinkler's deflector.

Table 6. Minimum Horizontal Distance of Ceiling Objects to Avoid Obstructing the Umbrella Pattern of Nonstorage Sprinklers (not Extended-Coverage)

Maximum Vertical Distance of Ceiling Object Located Below Sprinkler Deflector; in. (mm)	*Minimum Horizontal Distance From Sprinkler to Avoid Obstructing Umbrella Pattern; in. (mm)*
2 (50)	12 (300)
4 (100)	20 (500)
6 (150)	28 (700)
8 (200)	32 (800)
12 (300)	40 (1000)
20 (500)	52 (1300)
36 (900)	72 (1800)

In addition to the recommendations in Sections 2.1.3.2.1 through 2.1.3.2.4, install pendent and upright extended coverage Nonstorage sprinklers in accordance with Figure 9 and Table 7 to avoid the sprinkler's umbrella pattern being obstructed by an object located at or near ceiling level. Ensure objects located less than 18 in. (450 mm) horizontally from the sprinkler are above the horizontal plane of the sprinkler's deflector.

Table 7. Minimum Horizontal Distance of Ceiling Objects to Avoid Obstructing the Umbrella Pattern of Extended-Coverage Nonstorage Sprinklers

Maximum Vertical Distance of Ceiling Object Located Below Sprinkler Deflector; in. (mm)	*Minimum Horizontal Distance From Sprinkler to Avoid Obstructing Umbrella Pattern; in. (mm)*
2 (50)	18 (450)
4 (100)	48 (1200)
6 (150)	60 (1500)
8 (200)	72 (1800)
12 (300)	84 (2100)
20 (500)	108 (2700)
36 (900)	132 (3300)

An object located at or near ceiling level that is entirely within the checkerboard pattern shown in Figures 8 or 9 is not considered an obstruction to the sprinkler's umbrella pattern.

An object located at or near ceiling level that extends downward into the area located below the checkerboard pattern in Figures 8 and 9 is considered an obstruction to the sprinkler's umbrella pattern, except under the following conditions:

(a) The object located at or near ceiling level is a structure member or similar that is at least 70% open.

(b) The object located at or near ceiling level is no wider than 3 in. (75 mm) in its least dimension and is separated from other objects by a minimum of 12 in. (300 mm).

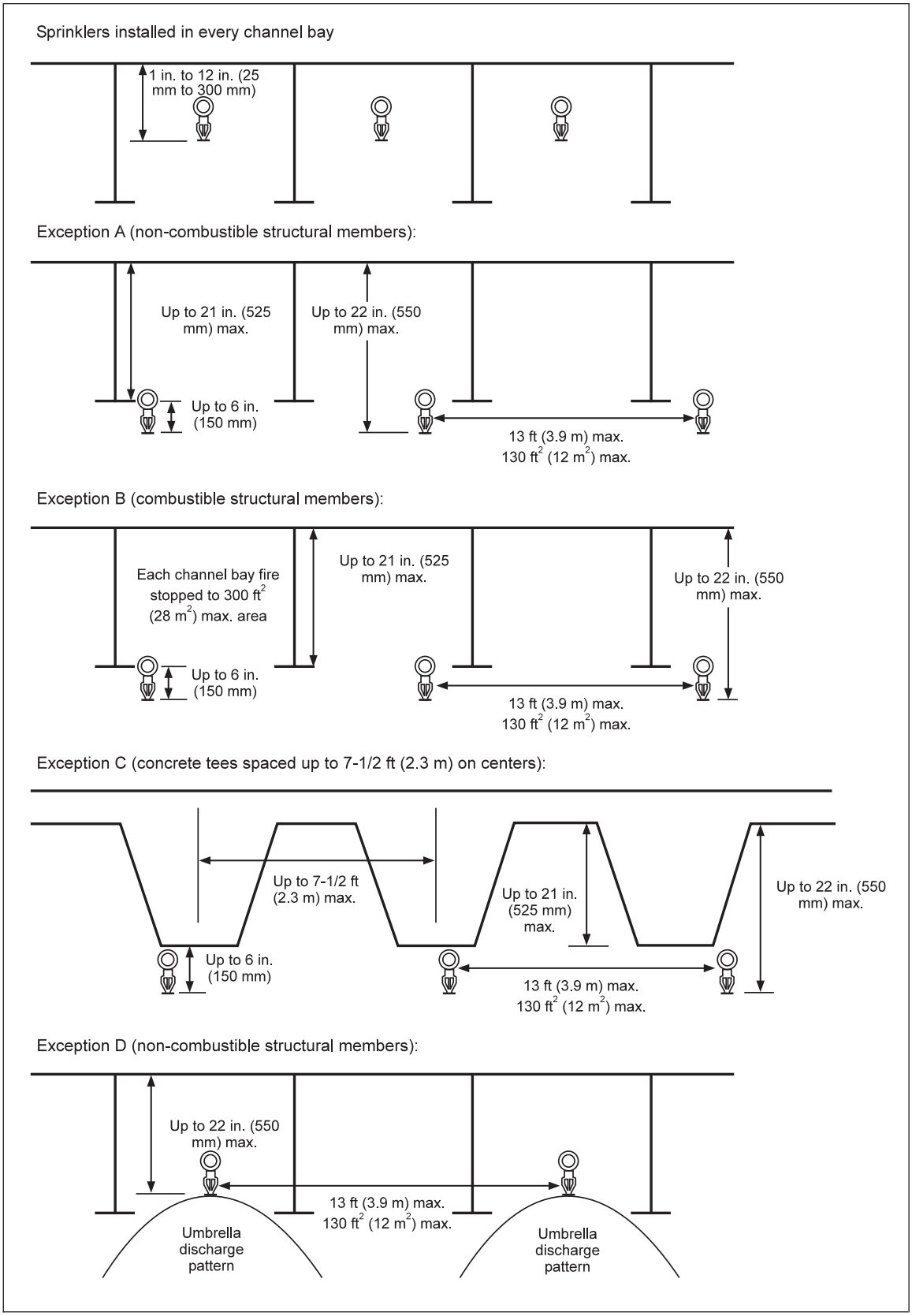

Fig. 7. Location of Nonstorage sprinklers under obstructed ceiling construction

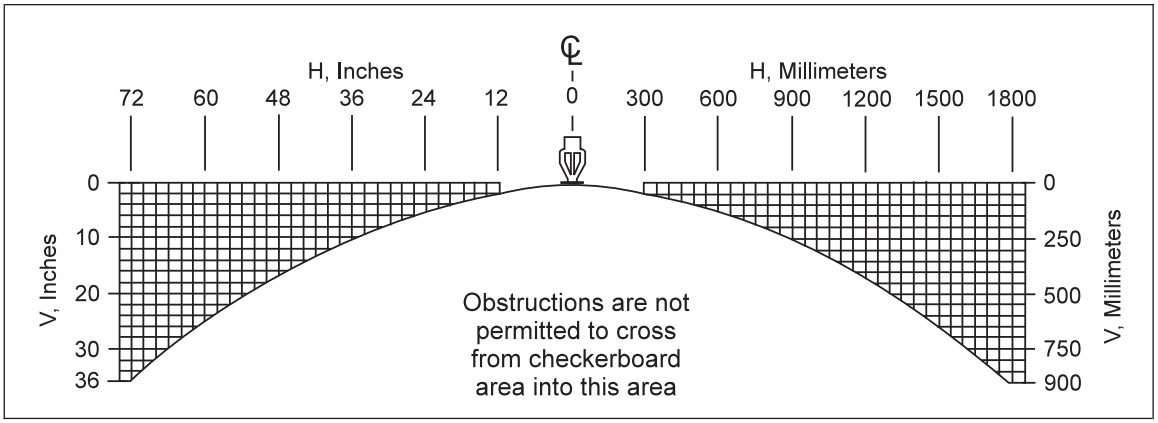

Fig. 8. Obstruction area to umbrella pattern of pendent and upright Nonstorage sprinklers (excluding Extended-Coverage)

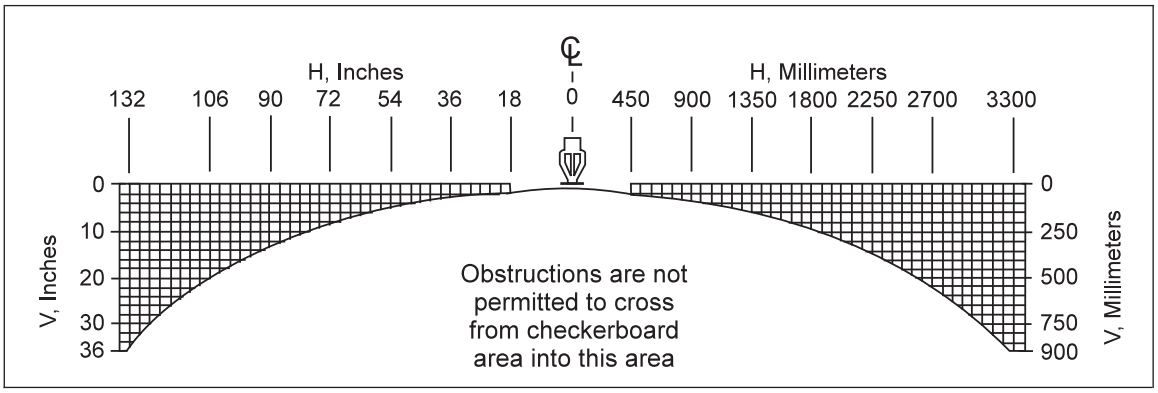

Fig. 9. Obstruction area to umbrella pattern of pendent and upright Extended-Coverage Nonstorage sprinklers

Mitigate obstructions by using either of the two following methods:

(a) Relocate the obstructed sprinkler so it complies with the horizontal and vertical distances recommended in Figure 8 or Figure 9, while still meeting the installation guidelines in Sections 2.1.3.2.1 through 2.1.3.2.4.

(b) Install sprinklers on both sides of the obstruction at equal horizontal distances, minimum 12 in. (300 mm), as demonstrated in Figure 10.

If the width of the obstruction is more than 4 ft (1.2 m) but less than 10 ft (3.0 m), install a single line of ceiling-level sprinklers centered under the obstruction on a linear spacing not exceeding the maximum recommended for the sprinkler being used.

If the width of the obstruction is more than 10 ft (3.0 m), treat the underside of the obstruction as a ceiling and install ceiling-level sprinklers for this area in accordance with the recommendations in Sections 2.1.3.2.1 through 2.1.3.2.4.

In both cases listed above, unless recommended otherwise by the relevant occupancy-specific data sheet, feed the additional sprinklers installed under the obstruction on a maximum linear spacing of 13 ft (3.9 m) and a maximum area spacing of 130 ft^2 (12 m^2) using the same branchline piping installed at ceiling level.

The additional sprinklers installed under the obstruction as outlined above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

2.1.3.2.5.2 Obstruction to Inner Core Discharge Pattern of Pendent and Upright Nonstorage Sprinklers

In addition to the recommendations in Sections 2.1.3.2.1 through 2.1.3.2.4 and Section 2.1.3.2.5.1, install sprinklers that match those at ceiling level under any individual object (see Appendix A, *Glossary of Terms*, for definition of “individual object”) that is at least 5 ft (1.5 m) above floor level and is 4 ft (1.2 m) wide or more in its least horizontal dimension, in one of the following ways:

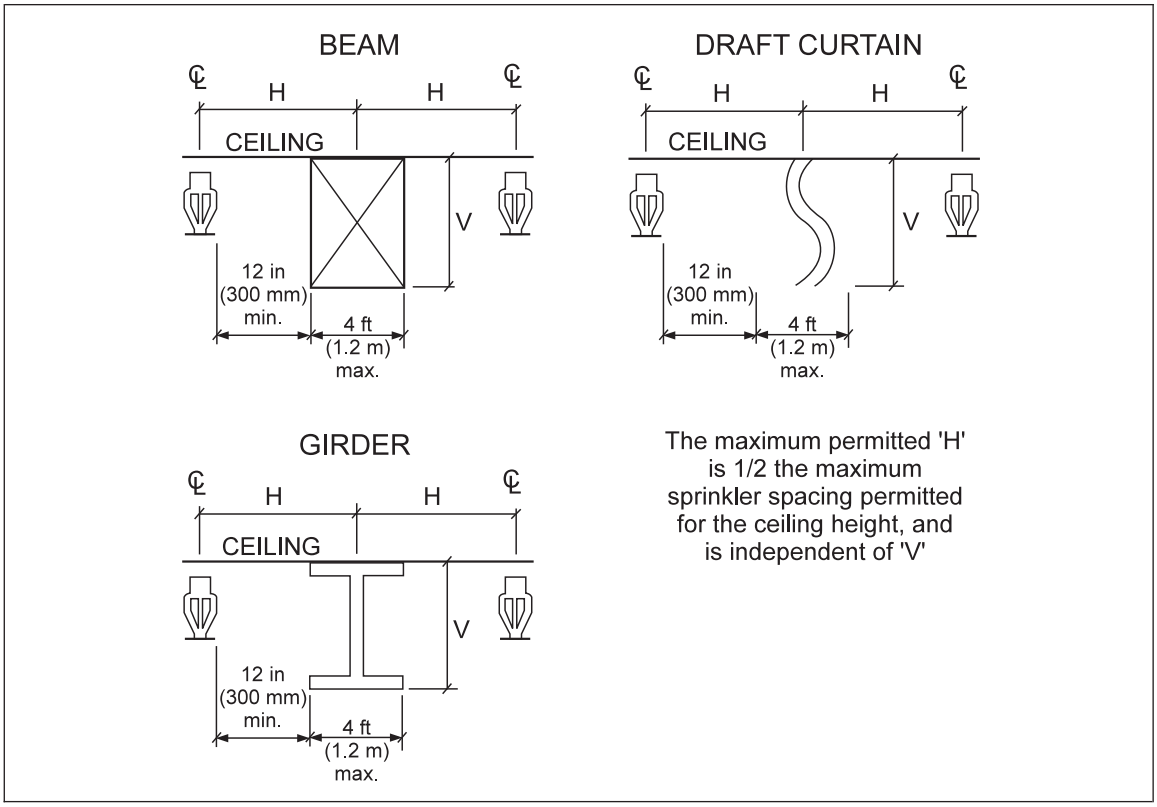

Fig. 10. Additional sprinklers installed to mitigate obstructed umbrella discharge pattern caused by solid objects at ceiling level

(a) For flat, continuous, solid objects that are between 4 ft (1.2 m) and 10 ft (3.0 m) wide, install a single line of ceiling-level sprinklers centered under the object on a linear spacing not exceeding the maximum recommended for the sprinkler being used. See Figure 11 for a diagram of this arrangement.

(b) For flat, continuous, solid objects over 10 ft (3.0 m) wide, treat the underside of the object as a ceiling and install ceiling-level sprinklers for this area in accordance with the recommendations in Sections 2.1.3.2.1 through 2.1.3.2.4.

(c) For non-flat, non-continuous, or non-solid type objects, install a flat, continuous, solid barrier under the object that equals the width of the object, and install sprinklers as recommended in options (a) or (b), depending on the width of the object. See Figure 12 for a diagram of this arrangement.

(d) As an alternative to option (c), install quick-response ceiling-level sprinklers under the object on a maximum 4 ft (1.2 m) linear spacing and a maximum 16 ft^2 (1.5 m^2) area spacing. See Figure 13 for a diagram of this arrangement.

Option (d) negates the need for a flat, continuous, solid barrier under the obstructing object.

For options (a) through (d), unless recommended otherwise by the relevant occupancy-specific data sheet, feed the additional sprinklers installed under the obstruction on a maximum linear spacing of 13 ft (3.9 m) and a maximum area spacing of 130 ft^2 (12 m^2) using the same branchline piping installed at ceiling level.

The additional sprinklers installed under the obstruction as outlined above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

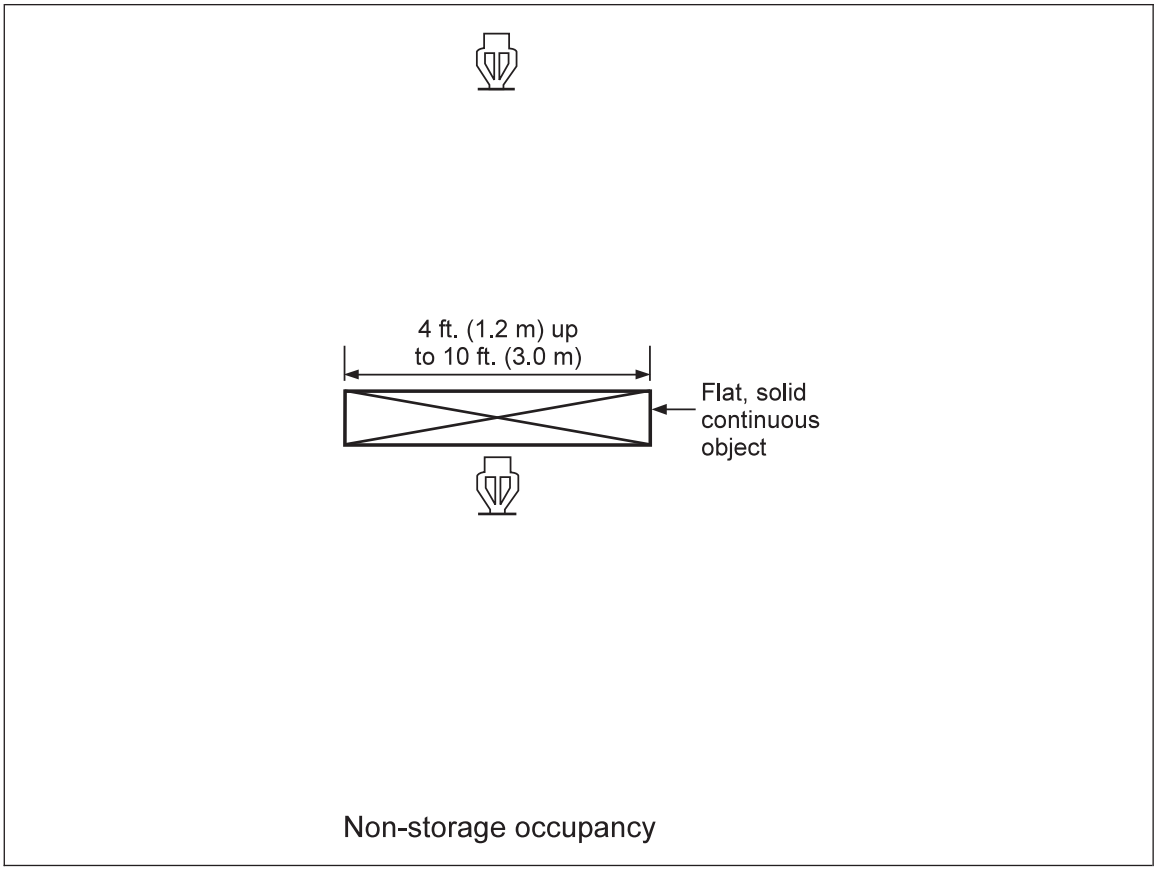

Fig. 11. Additional sprinklers installed below flat, continuous, solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide

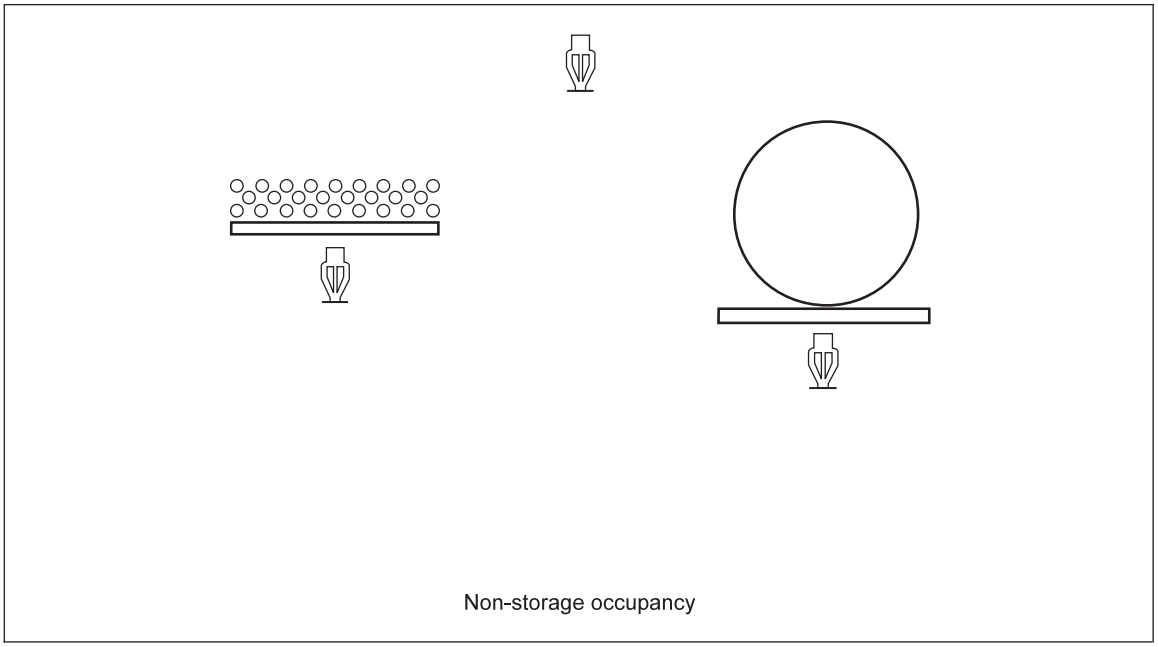

Fig. 12. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide with flat, continuous, solid barrier provided

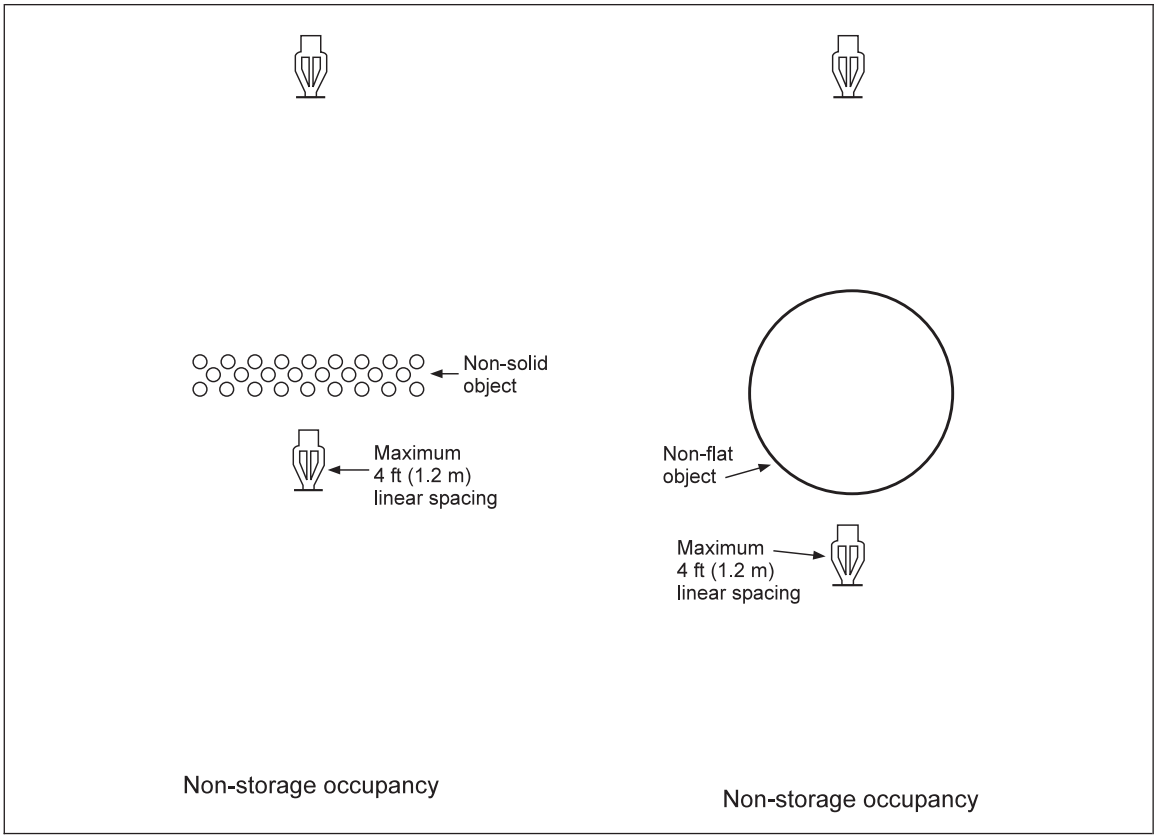

Fig. 13. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide without a flat, continuous, solid barrier provided

2.1.3.3 Sidewall Nonstorage Sprinklers

2.1.3.3.1 General

Unless recommended otherwise in the relevant occupancy-specific data sheet, install sidewall Nonstorage sprinklers along a wall, lintel, or similar structural object, and near the peak of a flat solid ceiling.

Install sidewall Nonstorage sprinklers only under flat, smooth ceiling construction. Install the sprinklers so their deflectors are parallel to the ceiling.

2.1.3.3.2 Linear and Area Spacing of Sidewall Nonstorage Sprinklers

Install sidewall Nonstorage sprinklers under unobstructed ceiling construction in accordance with the minimum and maximum linear and area spacing recommendations listed in Tables 8 or 9, unless indicated otherwise in the relevant occupancy-specific data sheet.

Table 8. Spacing of Ceiling-Level Sidewall Nonstorage Sprinklers for Hazard Category No. 1

Ceiling Height, ft (m)	*Ceiling/Wall Type*	*K-Factor*	*Response*	*Linear Spacing*				*Area Spacing*	
				Along the Wall		Away From the Wall			
				Min, ft (m)	Max, ft (m)	Min., ft (m)	Max, ft (m)	Min, ft^2 (m^2)	Max, ft^2 (m^2)
Up to 35 (10.5)	Flat, Smooth, Unobstructed Ceiling w/Noncombustible Finish	5.6 (80)	Quick or Standard	6 (1.8)	14 (4.2)	6 (1.8)	14 (4.2)	70 (6.5)	196 (18.0)
		5.6EC (80EC)	Quick	10 (3.0)	16 (4.8)	10 (3.0)	20 (6.0)	100 (9.3)	320 (30.0)
		8.0EC (115EC)	Quick	10 (3.0)	16 (4.8)	10 (3.0)	24 (7.2)	100 (9.3)	384 (35.5)
		14.0EC (200EC)	Quick	8 (2.4)	14 (4.2)	8 (2.4)	12.5 (3.8)	64 (6.0)	175 (16.0)
	Flat, Smooth, Unobstructed Ceiling w/Combustible Finish	5.6 (80)	Quick or Standard	6 (1.8)	14 (4.2)	6 (1.8)	12 (3.6)	70 (6.5)	120 (11.0)
		5.6EC (80EC)	Quick	10 (3.0)	16 (4.8)	10 (3.0)	20 (6.0)	100 (9.3)	320 (30.0)
		8.0EC (115EC)	Quick	10 (3.0)	16 (4.8)	10 (3.0)	24 (7.2)	100 (9.3)	384 (35.5)
		14.0EC (200EC)	Quick	8 (2.4)	14 (4.2)	8 (2.4)	12.5 (3.8)	64 (6.0)	175 (16.0)

Table 9. Spacing of Ceiling-Level Sidewall Nonstorage Sprinklers for Hazard Category No. 2

Ceiling Height, ft (m)	*Ceiling/Wall Type*	*K-Factor*	*Response*	*Linear Spacing*				*Area Spacing*	
				Along the Wall		Away From the Wall			
				Min, ft (m)	Max, ft (m)	Min., ft (m)	Max, ft (m)	Min, ft^2 (m^2)	Max, ft^2 (m^2)
Up to 32 (9.6)	Flat, Smooth, Unobstructed Ceiling	14.0EC (200EC)	Quick	8 (2.4)	14 (4.2)	8 (2.4)	12.5 (3.8)	64 (6.0)	175 (16.0)
Up to 35 (10.5)	Flat, Smooth, Unobstructed Ceiling w/Noncombustible Finish	5.6 (80)	Quick or Standard	6 (1.8)	10 (3.0)	6 (1.8)	10 (3.0)	70 (6.5)	100 (9.3)
	Flat, Smooth, Unobstructed Ceiling w/Combustible Finish	5.6 (80)	Quick or Standard	6 (1.8)	10 (3.0)	6 (1.8)	10 (3.0)	70 (6.5)	80 (7.5)

2.1.3.3.3 Horizontal Distance from Walls to Sidewall Nonstorage Sprinklers

2.1.3.3.3.1 Horizontal Distance from Mounting Walls to Sidewall Nonstorage Sprinklers

Unless recommended otherwise in the relevant occupancy-specific data sheet or the *Approval Guide,* install the centerline of the thermal sensing element of sidewall Nonstorage sprinklers no more than 6 in. (150 mm) horizontally from the wall on which the sprinkler is being mounted.

Exception: Install the centerline of the thermal sensing element of an extended-coverage sidewall Non-Storage sprinkler between ¾ in. (20 mm) and 1-½ in. (40 mm) horizontally from the mounting wall.

2.1.3.3.3.2 Horizontal Distance from End Walls to Sidewall Nonstorage Sprinklers

Unless recommended otherwise in the relevant occupancy-specific data sheet or the *Approval Guide,* install the centerline of the thermal sensing element of sidewall Nonstorage sprinklers no closer than 4 in. (100 mm)

and no farther away than 50% of the sprinkler's maximum recommended linear spacing (as given in the relevant occupancy-specific data sheet) from any wall that forms an angle other than 180° with the mounting wall.

2.1.3.3.4 Vertical Distance from the Ceiling to Sidewall Nonstorage Sprinklers

Unless recommended otherwise in the relevant occupancy-specific data sheet or the *Approval Guide*, install the centerline of the thermal sensing element of sidewall Nonstorage sprinklers below a ceiling as follows:

Minimum vertical distance: 4 in. (100 mm)
Maximum vertical distance:

- Vertical sidewall: 6 in. (150 mm)
- Horizontal sidewall: 12 in. (300 mm) under combustible ceiling, or 18 in. (450 mm) under noncombustible ceiling

(See Section 2.1.3.2.4 for a description of how the vertical distance from the ceiling to the sprinkler is measured.)

Sidewall Nonstorage sprinklers may be installed along non-continuous vertical walls, such as lintels and soffits, provided the following criteria are met:

(a) The non-continuous wall is tight to the ceiling above, and

(b) The wall extends vertically downward a minimum of 2 in. (50 mm) beyond the centerline of the sprinkler's thermal sensing element, and

(c) The recommendations for deflector arrangement are met.

Install Nonstorage sprinklers under combustible shielded areas when a non-continuous vertical wall creates such an area more than 8 in. (200 mm) deep below the sidewall Nonstorage sprinkler. See Figure 14 for a diagram of this arrangement.

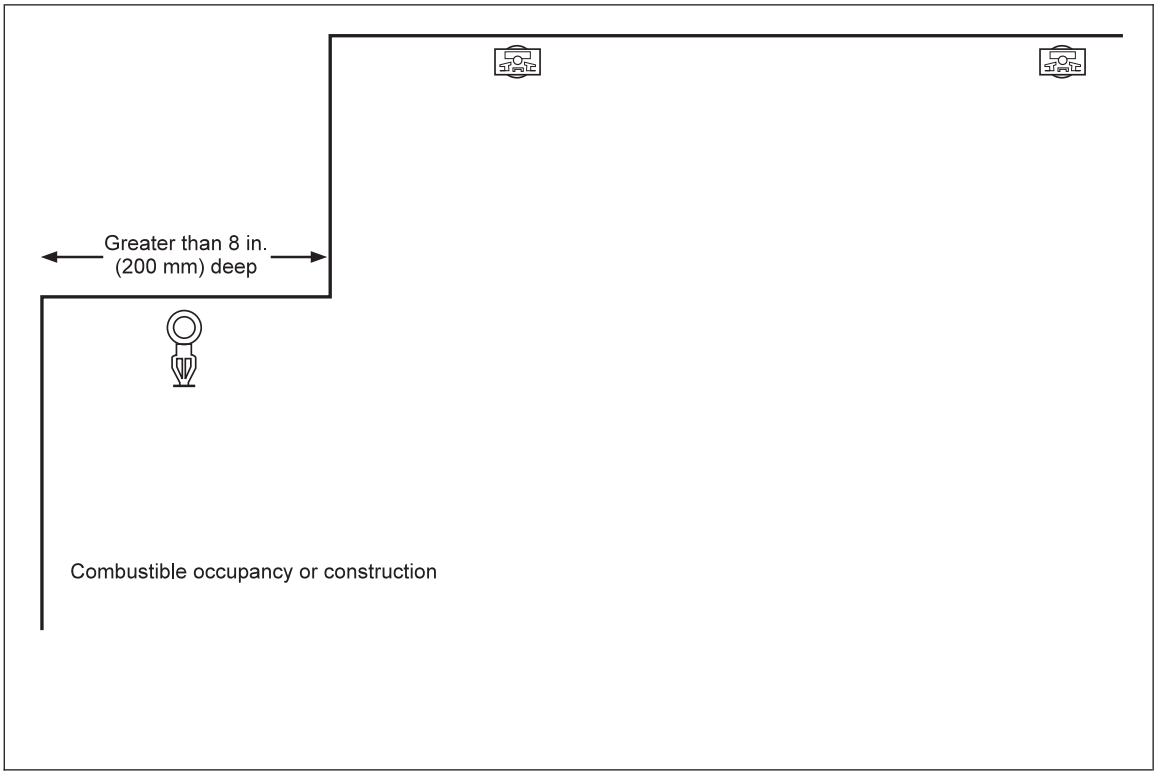

Fig. 14. Nonstorage sprinklers under combustible shielded areas more than 8 in. (200 mm) deep

2.1.3.3.5 Obstructions to Discharge Pattern of Sidewall Nonstorage Sprinklers

Install sidewall Nonstorage sprinklers in accordance with Sections 2.1.3.3.5.1 and 2.1.3.3.5.2 to ensure the water discharged from sprinklers is not significantly obstructed.

2.1.3.3.5.1 Obstructions to Umbrella Discharge Pattern of Sidewall Nonstorage Sprinklers

2.1.3.3.5.1.1 Obstruction to Umbrella Discharge Pattern of Sidewall Nonstorage Sprinklers Away from the Mounting Wall

In addition to the recommendations in Sections 2.1.3.3.1 through 2.1.3.3.4, install sidewall Nonstorage sprinklers in accordance with Figures 15 and 16, as well as Tables 10 and 11 to avoid obstruction to the sprinkler's umbrella pattern away from the mounting wall caused by an object located at or near ceiling level.

For sidewall Nonstorage sprinklers on standard spacing, locate objects within 4 ft (1.2 m) horizontally from the sprinkler at or above the horizontal plane of the sprinkler's deflector. This does not apply to the pipe the sprinkler is connected to.

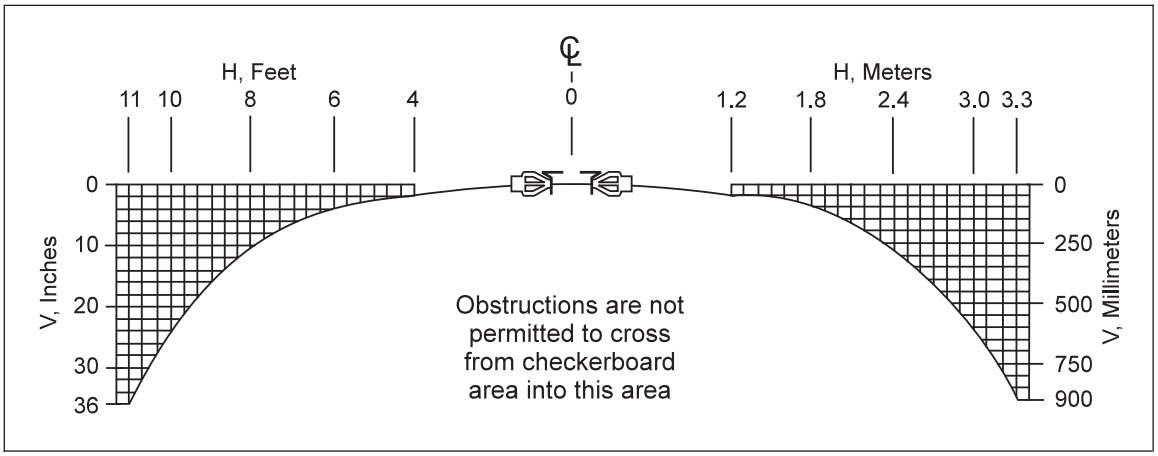

Fig. 15. Obstruction area to umbrella pattern away from the mounting wall of sidewall Nonstorage sprinklers (not extended-coverage)

Table 10. Minimum Horizontal Distance of Ceiling Objects From the Mounting Wall of Sidewall Nonstorage Sprinklers (not Extended-Coverage) to Avoid Obstructing Umbrella Pattern

Maximum Vertical Distance of Ceiling Object Located Below Sprinkler Deflector; in. (mm)	*Minimum Horizontal Distance From Sprinkler to Avoid Obstructing Umbrella Pattern; ft (m)*
2 (50)	4 (1.20)
3 (75)	6 (1.80)
9 (225)	7.5 (2.25)
15 (375)	9 (2.70)
30 (750)	10.5 (3.15)
36 (900)	11 (3.3)

For extended-coverage sidewall Nonstorage sprinklers, locate objects within 8 ft (2.4 m) horizontally from the sprinkler at or above the horizontal plane of the sprinkler's deflector. This does not apply to the pipe the sprinkler is connected to.

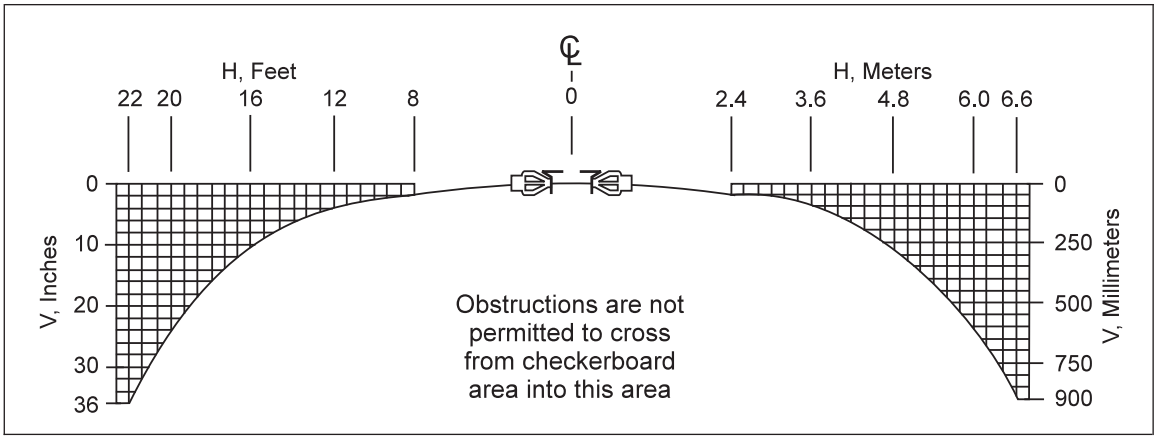

Fig. 16. Obstruction area to umbrella pattern away from the mounting wall of extended-coverage sidewall Nonstorage sprinkler

Table 11. Minimum Horizontal Distance of Ceiling Objects From the Mounting Wall of Extended-Coverage Sidewall Nonstorage Sprinklers to Avoid Obstructing Umbrella Pattern

Maximum Vertical Distance of Ceiling Object Located Below Sprinkler Deflector; in. (mm)	*Minimum Horizontal Distance From Sprinkler to Avoid Obstructing Umbrella Pattern; ft (m)*
1 (25)	8 (2.4)
2 (50)	10 (3.0)
3 (75)	12 (3.6)
4 (100)	13 (3.9)
6 (150)	14 (4.2)
10 (250)	16 (4.8)
18 (450)	18 (5.4)
36 (900)	22 (6.6)

Any object at or near ceiling level that is located entirely within the checkerboard pattern shown in Figures 15 or 16 is not considered an obstruction to the sprinkler's umbrella pattern.

An object located at or near ceiling level that extends downward into the area located below the checkerboard pattern in Figures 15 and 16 considered an obstruction to the sprinkler's umbrella pattern except under the following conditions:

(a) The object located at or near ceiling level is considered at least 70% open.

(b) The object located at or near ceiling level is no wider than 3 in. (75 mm) in its least dimension and is separated from other objects by a minimum of 12 in. (300 mm).

Mitigate obstructions by using either of the two following methods:

(a) Relocate the obstructed sprinkler or the ceiling object so it complies with the horizontal and vertical distances demonstrated in Figures 15 or 16, while at the same time meeting the installation recommendations in Sections 2.1.3.3.1 through 2.1.3.3.4.

(b) Install additional sprinklers on the opposite side of the obstruction at a horizontal distance that does not exceed 50% of the maximum recommended linear spacing of the sprinkler that is installed. See Figure 17 for a diagram of this arrangement.

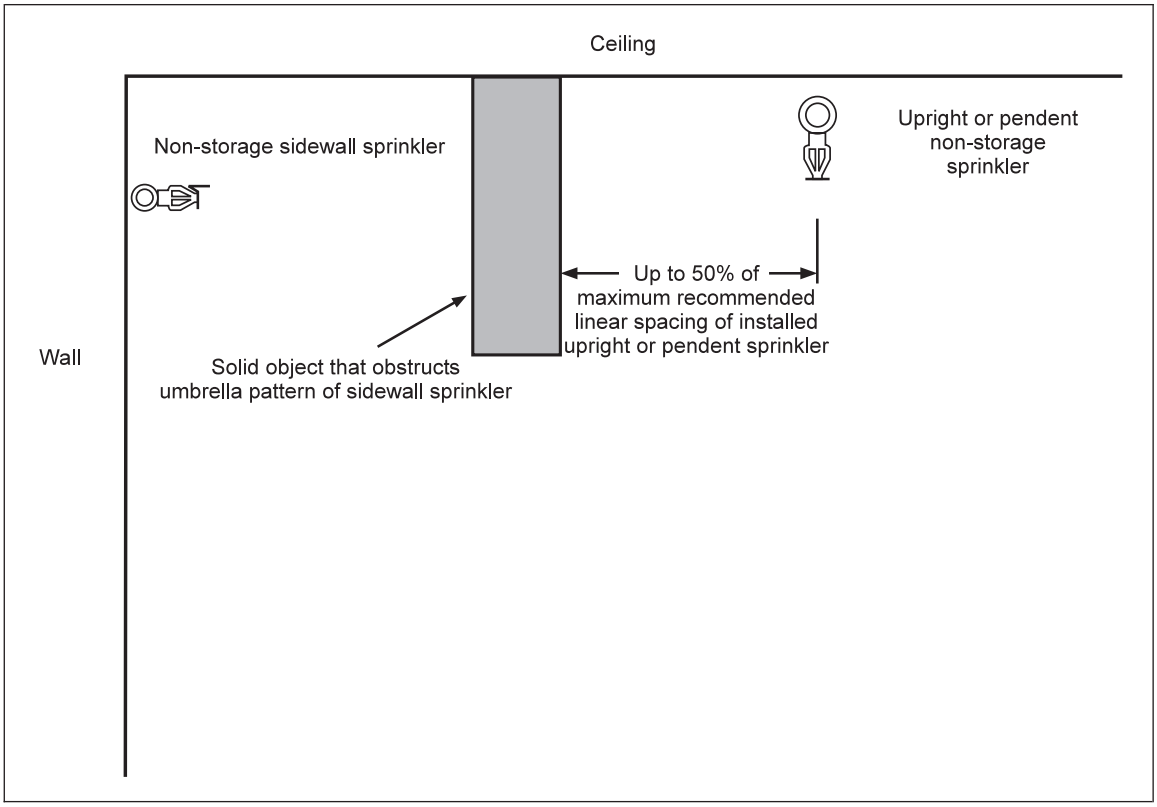

Fig. 17. Additional sprinklers installed to account for obstructed umbrella discharge pattern away from the wall caused by solid objects at ceiling level

If the width of the obstruction is more than 12 in. (300 mm) but less than 10 ft (3.0 m), install a single line of Nonstorage sprinklers centered under the obstruction on a linear spacing not exceeding the maximum recommended for the sprinkler being used.

If the width of the obstruction is greater than 10 ft (3.0 m), treat the underside of the obstruction as a ceiling and install Nonstorage sprinklers for this area in accordance with the recommendations in Sections 2.1.3.3.1 through 2.1.3.3.4.

In both cases listed above, unless recommended otherwise by the relevant occupancy-specific data sheet, feed the additional sprinklers installed under the obstruction on a maximum linear spacing of 13 ft (3.9 m) and a maximum area spacing of 130 ft^2 (12 m^2) using the same branchline piping installed at ceiling level.

The additional sprinklers installed under the obstruction as outlined above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

2.1.3.3.5.1.2 Obstruction to Umbrella Discharge Pattern of Sidewall Nonstorage Sprinklers Along the Mounting Wall

In addition to the recommendations in Sections 2.1.3.3.1 through 2.1.3.3.4, install sidewall Nonstorage sprinklers in accordance with Figures 18 and 19 as well as Tables 12 and 13 to avoid obstructing the sprinkler's umbrella pattern along the mounting wall.

For sidewall Nonstorage sprinklers on standard spacing, locate objects within 6 in. (150 mm) horizontally of a sprinkler at or above the horizontal plane of the sprinkler's deflector. This does not apply to the pipe the sprinkler is connected to.

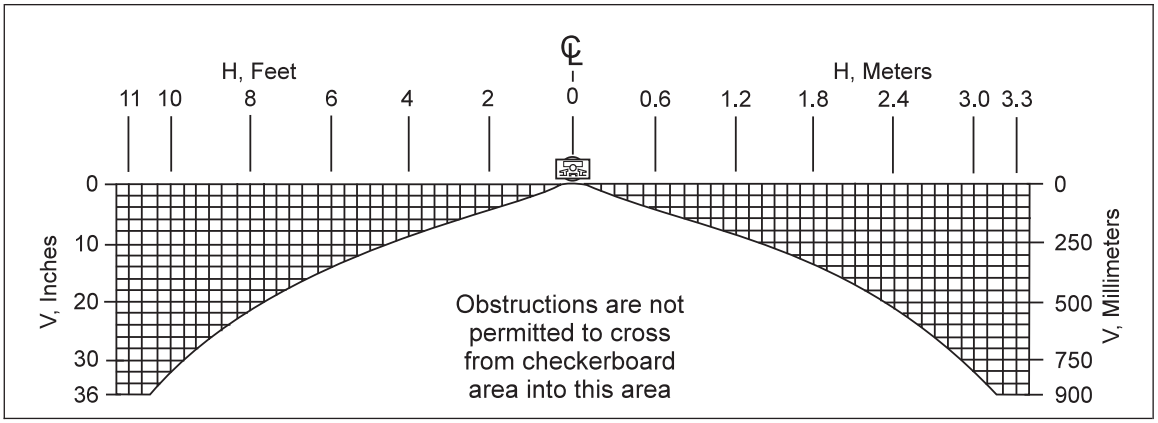

Fig. 18. Obstruction area to umbrella pattern along the mounting wall of sidewall Nonstorage sprinklers on standard spacing

Table 12. Minimum Horizontal Distance of Ceiling Objects Along the Mounting Wall of Sidewall Nonstorage Sprinklers (not Extended-Coverage) to Avoid Obstructing Umbrella Pattern

Maximum Vertical Distance of Ceiling Object Located Below Sprinkler Deflector; in. (mm)	*Minimum Horizontal Distance From Sprinkler to Avoid Obstructing Umbrella Pattern; ft (m)*
1 (25)	0.5 (0.15)
2 (50)	1 (0.30)
3 (75)	1.5 (0.45)
6 (150)	2.5 (0.75)
9 (225)	4 (1.20)
15 (375)	6.5 (1.95)
24 (600)	8.5 (25.5)
36 (900)	10.5 (31.5)

For extended-coverage sidewall Nonstorage sprinklers, locate objects within 18 in. (450 mm) horizontally of the sprinkler at or above the horizontal plane of the sprinkler's deflector. This does not apply to the pipe the sprinkler is connected to.

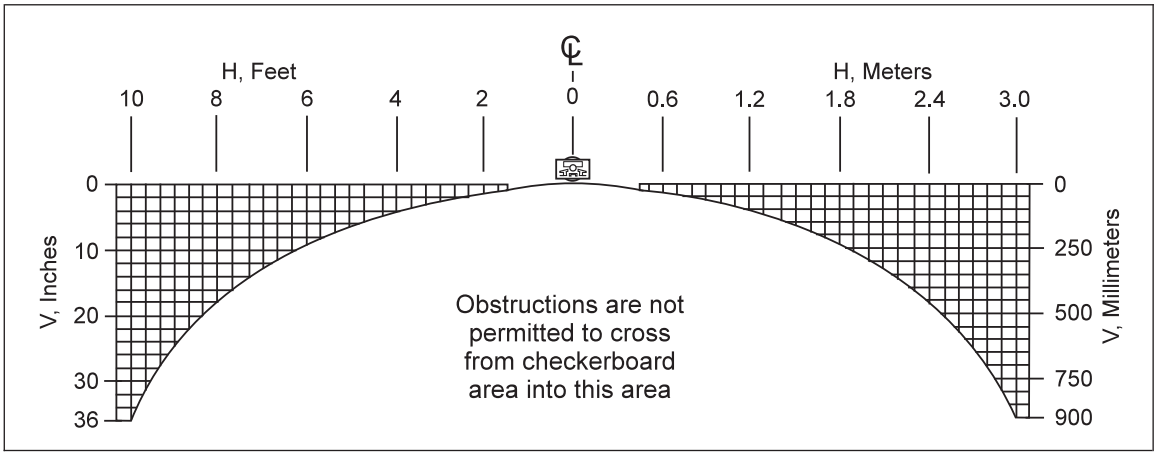

Fig. 19. Obstruction area to umbrella pattern along the mounting wall of extended-coverage sidewall Nonstorage sprinklers

Table 13. Minimum Horizontal Distance of Ceiling Objects Along the Mounting Wall of Extended-Coverage Sidewall Nonstorage Sprinklers to Avoid Obstructing Umbrella Pattern

Maximum Vertical Distance of Ceiling Object Located Below Sprinkler Deflector; in. (mm)	*Minimum Horizontal Distance From Sprinkler to Avoid Obstructing Umbrella Pattern; ft (m)*
1 (25)	1.5 (0.45)
3 (75)	3.0 (0.90)
5 (125)	4.5 (1.35)
9 (225)	6.0 (1.80)
15 (375)	7.5 (2.25)
25 (625)	9.0 (2.70)
36 (900)	10.0 (3.00)

An object at or near ceiling level located entirely within the checkerboard pattern shown in Figures 18 or 19 is not considered an obstruction to the sprinkler's umbrella pattern.

An object located at or near ceiling level that extends downward into the area located below the checkerboard pattern in Figures 18 and 19 is considered an obstruction to the sprinkler's umbrella pattern, except under the following conditions:

(a) The object located at or near ceiling level is at least 70% open.

(b) The object located at or near ceiling level is no wider than 3 in. (75 mm) in its least dimension and is separated from other objects by a minimum of 12 in. (300 mm).

Mitigate obstructions by using either of the two following methods:

(a) Relocate the obstructed sprinkler or the ceiling object so it complies with the horizontal and vertical distances demonstrated in Figures 18 or 19, while at the same time meeting the installation recommendations in Sections 2.1.3.3.1 through 2.1.3.3.4.

(b) Install sidewall Nonstorage sprinklers on both sides of the object at equal horizontal distances, minimum 12 in. (300 mm), as demonstrated in Figure 20.

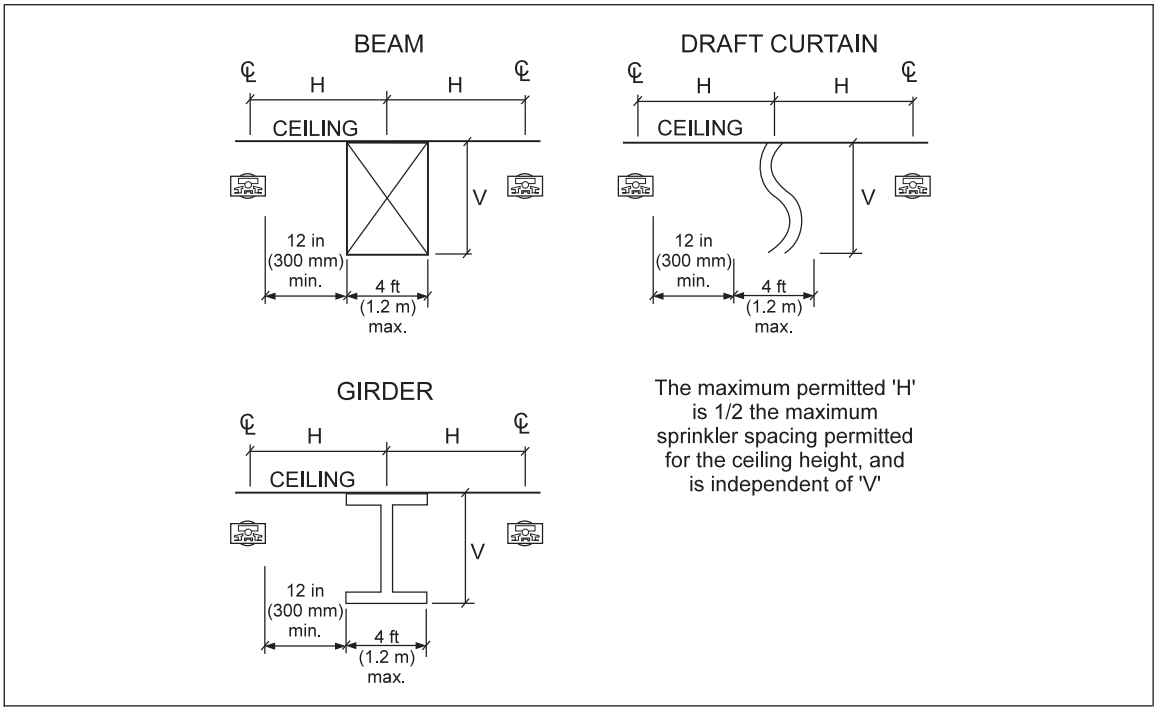

Fig. 20. Positioning of sidewall Nonstorage Sprinklers to account for obstructed umbrella discharge pattern along the mounting wall caused by solid objects at ceiling level

If the width of the obstruction is more than 12 in. (300 mm) but less than 10 ft (3.0 m), install a single line of Nonstorage sprinklers centered under the obstruction on a linear spacing not exceeding the maximum recommended for the sprinkler being used.

If the width of the obstruction is greater than 10 ft (3.0 m), treat the underside of the obstruction as a ceiling and install Nonstorage sprinklers for this area in accordance with the recommendations in Sections 2.1.3.3.1 through 2.1.3.3.4.

In both cases listed above, unless recommended otherwise by the relevant occupancy-specific data sheet, feed the additional sprinklers installed under the obstruction on a maximum linear spacing of 13 ft (3.9 m) and a maximum area spacing of 130 ft^2 (12 m^2) using the same branchline piping installed at ceiling level.

The additional sprinklers installed under the obstruction as outlined above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

2.1.3.3.5.2 Obstruction to Inner Core Discharge Pattern of Sidewall Nonstorage Sprinklers

In addition to the recommendations in Sections 2.1.3.3.1 through 2.1.3.3.4 and 2.1.3.3.5.1, install Non-Storage sprinklers having the same K-factor, nominal temperature rating, and nominal RTI values as the sidewall Nonstorage sprinklers under any individual object (see Appendix A, *Glossary of Terms*, for definition) that is at least 5 ft (1.5 m) above floor level and is 4 ft (1.2 m) wide or more in its least horizontal dimension using one of the following methods:

(a) For flat, continuous, solid objects that are between 4 ft (1.2 m) and 10 ft (3.0 m) wide, install a single line of Nonstorage sprinklers centered under the object on a linear spacing not exceeding the maximum recommended for the sprinkler being used. See Figure 21 for a diagram of this arrangement.

(b) For flat, continuous, solid objects over 10 ft (3.0 m) wide, treat the underside of the object as a ceiling and install Nonstorage sprinklers for this area in accordance with the recommendations in Sections 2.1.3.2.1 through 2.1.3.2.4.

(c) For non-flat, non-continuous, or non-solid type objects, install a flat, continuous, solid barrier under the object that equals the width of the object, and install sprinklers as outlined in options (a) or (b), depending on the width of the object. See Figure 22 for a diagram of this arrangement.

(d) As an alternative to option (c), install quick-response Nonstorage sprinklers under the object on a maximum 4 ft (1.2 m) linear spacing and a maximum 16 ft^2 (1.5 m^2) area spacing. See Figure 23 for a diagram of this arrangement.

Option (d) negates the need for a flat, continuous, solid barrier installed under the obstructing object.

For options (a) through (d), unless recommended otherwise by the relevant occupancy-specific data sheet, feed the additional sprinklers installed under the obstruction on a maximum linear spacing of 13 ft (3.9 m) and a maximum area spacing of 130 ft^2 (12 m^2) using the same branchline piping installed at ceiling level.

The additional sprinklers installed under the obstruction as outlined above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

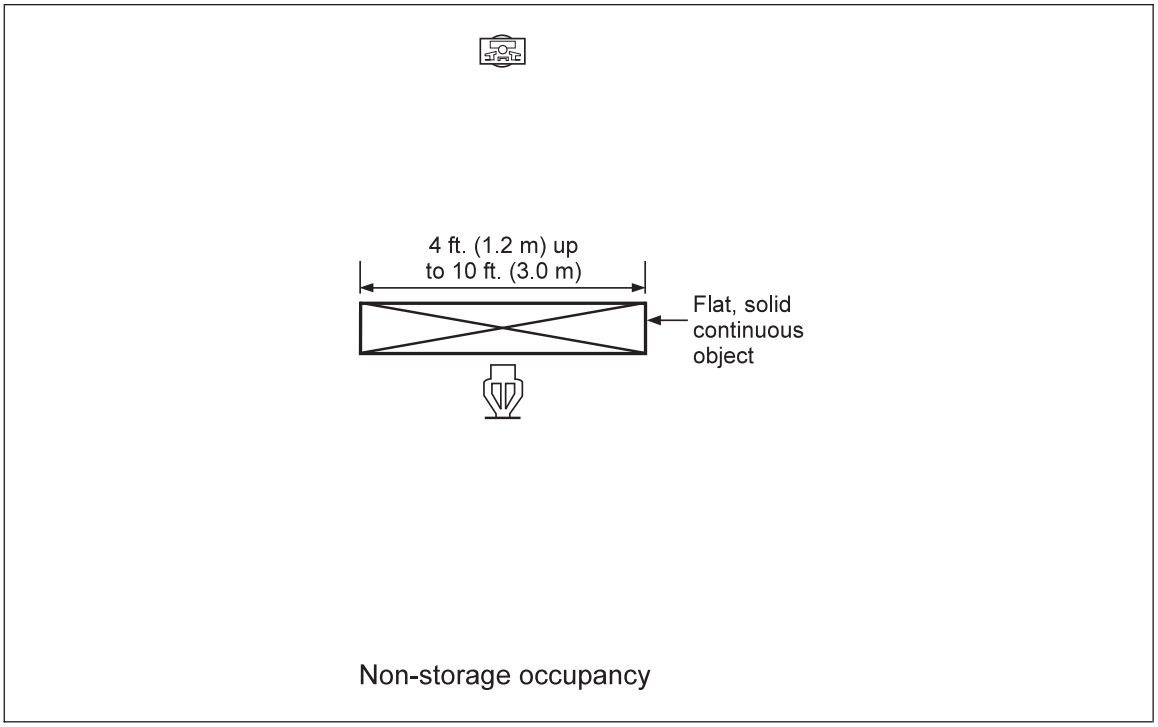

Fig. 21. Additional sprinklers installed below flat, continuous, solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide

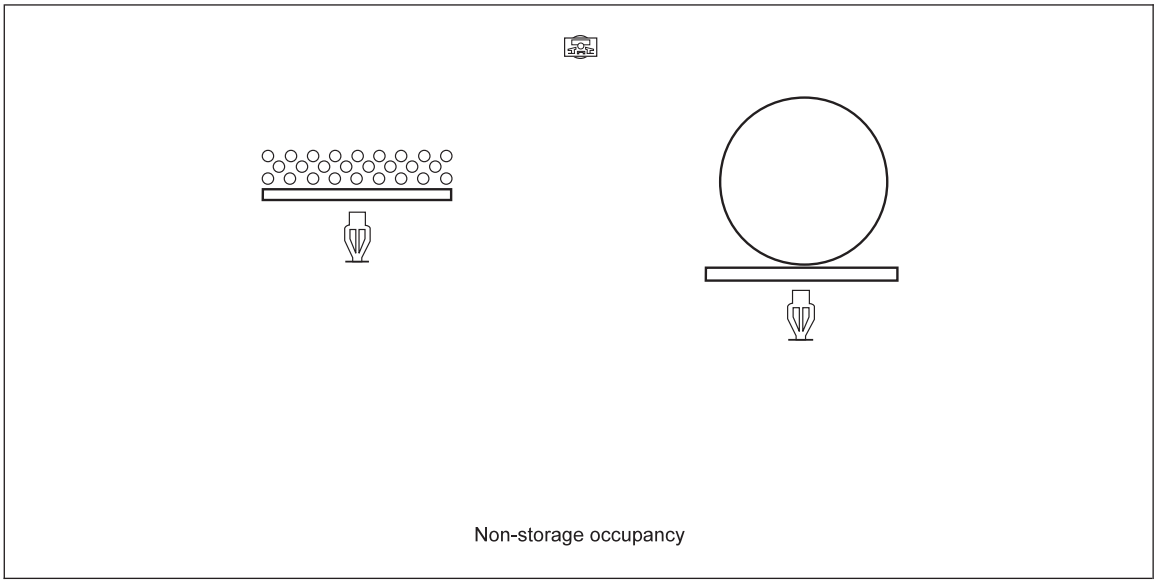

Fig. 22. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide with flat, continuous, solid barrier provided

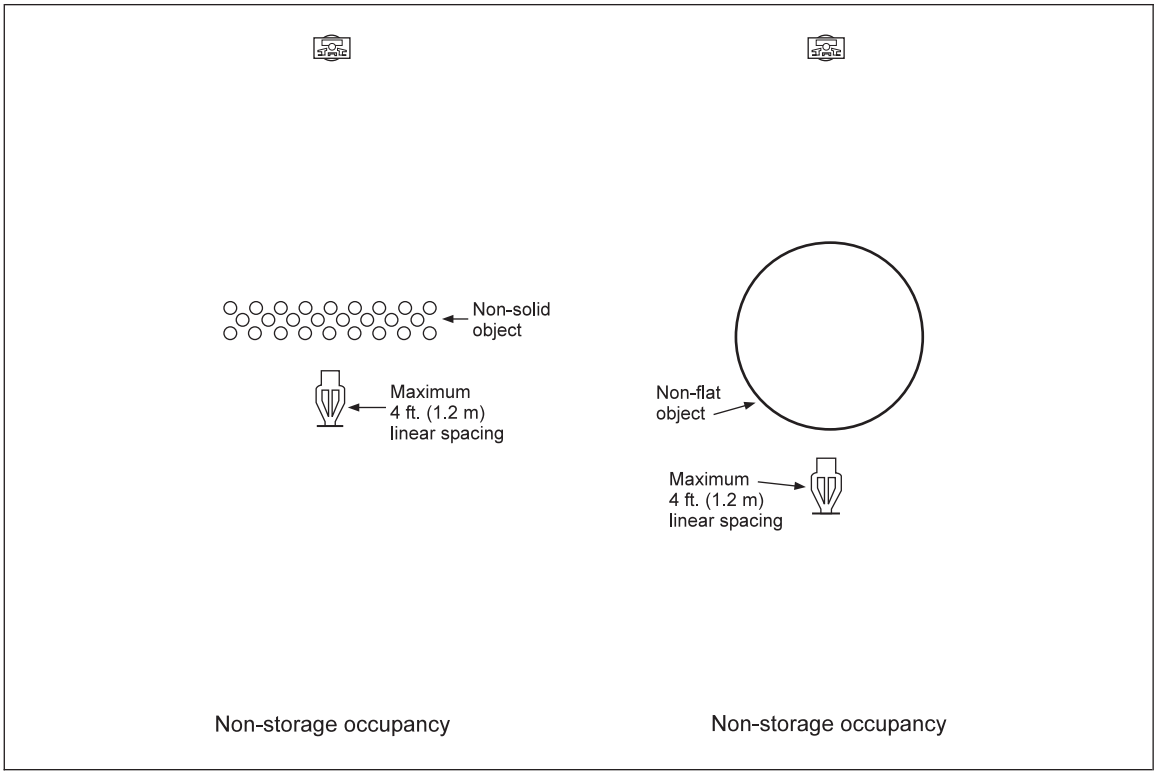

Fig. 23. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions between 4 ft (1.2 m) and 10 ft (3.0 m) wide without a flat, continuous, solid barrier provided

2.2 Storage Sprinklers

2.2.1 Construction and Location

2.2.1.1 General

The two main factors affecting sprinkler system performance are (a) prompt sprinkler operation, and (b) sufficient, unobstructed sprinkler discharge to the fire area. A facility's construction features have a major impact on both of these critical factors.

Ceiling construction has a significant effect on the performance of a sprinkler system. Of particular importance is whether the ceiling construction is "obstructed" or "unobstructed" (see Appendix A: Glossary of Terms for definitions). Recommendations for installing sprinklers under these two types of ceilings can be found in Section 2.2.3.4.1 for unobstructed construction and Section 2.2.3.4.2 for obstructed construction.

2.2.1.2 Wall or Ceiling Construction Consisting of Plastic Materials

When the interior walls and/or ceiling of a facility contain plastic building materials, see Data Sheet 1-57, *Plastics in Construction*, for sprinkler system design requirements and additional installation recommendations.

2.2.1.3 Exposed Structural Steel

See the relevant occupancy-specific data sheet to determine if protection beyond that offered by the sprinkler system is required for exposed structural steel.

2.2.1.4 Open-Grid Ceilings, Mezzanines or Walkways (Open Grids)

Avoid the installation of open grids because they can obstruct ceiling-level sprinkler discharge. As an alternative, make the mezzanine or walkway solid and protect it in accordance with Section 2.2.1.5.

If open grids cannot be avoided, provide sprinkler protection per the following recommendations.

2.2.1.4.1 Ceiling-Level Sprinklers Above Open Grids

Design ceiling-level sprinklers as recommended in the relevant occupancy-specific data sheet. If the occupancy-specific data sheet does not address open grids, design the system as though no open grid was present.

2.2.1.4.2 Sprinklers Under Open Grids

Unless recommended otherwise in a relevant occupancy-specific data sheet or in Section 2.2.1.4.3 of this data sheet, install sprinkler protection under open grids using 160°F (70°C) nominally rated quick-response sprinklers having the same:

- K-factor,
- orientation, and
- area spacingas the sprinklers installed at ceiling level.

Install Storage sprinklers under open grids on a maximum linear spacing of 8 ft (2.4 m) and a maximum area spacing of 64 ft^2 (6 m^2), using the same branchline piping installed at ceiling level.

Sprinklers installed under open grids as outlined above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

2.2.1.4.3 Exception for Sprinklers Under Open Grids

Storage sprinklers are not required under an open grid when the following conditions are met:

Exception 1:

- The open grid is a minimum of 70% open, and
- The open grid is a maximum of ¼ in. (6 mm) deep, and
- The open grid is at least 3 ft (0.9 m) vertically below the deflector of the ceiling-level sprinklers, and
- It is not possible for materials to fall onto the top of the open grid and obstruct sprinkler discharge during a fire, and
- There is only one open grid ceiling between the solid ceiling and the floor, and
- The ceiling sprinkler system can protect the occupancy in the absence of the open grid.

2.2.1.5 Solid Mezzanines and Walkways

2.2.1.5.1 Solid Mezzanines

Install quick-response sprinklers under solid mezzanines that have combustible construction and/or a combustible occupancy located below them.

Exception: Standard-response sprinklers can be installed under a solid mezzanine when:

(a) Standard-response sprinklers are installed at ceiling level and can protect the occupancy located under the mezzanine, or

(b) A draft curtain is provided around the perimeter of the mezzanine in accordance with Data Sheet 1-10

Install a draft curtain around the perimeter of the solid mezzanine in accordance with Data Sheet 1-10.

Exception: A draft curtain is not required around the perimeter of a solid mezzanine when:

(a) The ceiling sprinkler protection can protect the occupancy located under the solid mezzanine, or

(b) The ceiling-level and mezzanine-level sprinklers are of the same nominal RTI value and the occupancy under the mezzanine is located completely within the sprinklers at the edge of the mezzanine, or

(c) The sprinklers located under the solid mezzanine are quick-response and the sprinklers located at ceiling level are standard-response.

Unless recommended otherwise in a relevant occupancy-specific data sheet, base the design of the mezzanine-level sprinkler protection on the height of the mezzanine and the occupancy located underneath it.

2.2.1.5.2 Solid Walkways

Install quick-response sprinklers under solid walkways that have combustible construction and/or a combustible occupancy located below them. In addition, install quick-response sprinklers under solid walkways located between storage racks or similar structures.

For solid walkways up to 4 ft (1.2 m) wide, install a single line of quick-response sprinklers down the center of the walkway on maximum 10 ft (3.0 m) linear spacing.

For solid walkways over 4 ft (1.2 m) wide, install a line of quick-response sprinklers within 12 in. (300 mm) horizontally of the perimeter of the walkway on maximum 10 ft (3.0 m) linear spacing and 100 ft^2 (9.0 m^2) area spacing.

Treat the walkway sprinklers as in-rack sprinklers and design in accordance with the relevant occupancy-specific data sheet based on the commodity hazard located either under or adjacent to the solid walkway.

2.2.1.6 Ceiling Slope

Unless recommended otherwise by the relevant occupancy-specific data sheet, Storage sprinklers are acceptable under sloped ceilings as indicated in Table 14.

Table 14. Storage Sprinklers Under Sloped Ceilings

Nominal RTI Rating of Sprinkler	*In-Rack Sprinklers Provided?*	*Acceptable Ceiling Slope*
Quick-Response	Yes or No	Up to 10°
Standard-Response	No	Up to 10°
	Yes	Up to 20°

For ceiling slopes that exceed the maximum indicated in Table 14, do one of the following:

- Install a flat, continuous false ceiling (see Appendix A for definition) over the affected area and for 20 ft (6.0 m) beyond in all directions. Design the false ceiling in accordance with Data Sheet 1-12, *Ceilings and Concealed Spaces*, and ensure it can withstand a minimum uplift pressure of 3 lb/ft^2 (14.4 kg/m^2). Provide sprinkler protection beneath the false ceiling based on the recommendations in the relevant occupancy-specific data sheet, or
- If the affected occupancy is rack storage, protect the storage racks based on the presence of excessive clearance as outlined in Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*.

For ceilings with a slope greater than 5°, locate sprinklers within 3 ft (0.9 m) of a ceiling's peak, measured horizontally along the slope of the ceiling.

For ceiling slopes that exceed the maximum allowed, install a flat, continuous false ceiling (see Appendix A for definition) over the affected area and for 20 ft (6.0 m) beyond in all directions. Design the false ceiling in accordance with Data Sheet 1-12, *Ceilings and Concealed Spaces*, and ensure it can withstand a minimum uplift pressure of 3 lb/ft^2 (14.4 kg/m^2). Provide sprinkler protection beneath the false ceiling designed in accordance with the relevant occupancy-specific data sheet.

For ceilings with a slope greater than 5°, locate sprinklers within 3 ft (0.9 m) of a ceiling's peak, measured horizontally along the slope of the ceiling.

2.2.1.7 Heat and/or Smoke Vents and Other Exhaust Openings at Ceiling Level

2.2.1.7.1 Heat and/or Smoke Vents

Do not install automatic smoke and heat vents in facilities equipped with sprinkler protection; manual heat and smoke vents, however, are acceptable. If local codes require the installation of automatic smoke and heat vents, do one of the following:

(a) Install vents that are FM Approved for occupancies protected by quick-response Storage sprinklers.

(b) Install FM Approved vents equipped with a standard-response 360°F (182°C) nominal thermal activating device.

(c) Install quick-response sprinklers directly under the vent opening on a maximum 4 ft (1.2 m) linear and 16 ft^2 (1.5 m^2) area spacing. Position the centerline of the sprinkler's thermal element in accordance with the guidelines outlined in Section 2.2.3.4. Ensure these sprinklers have, at a minimum, the same K-factor and orientation as the adjacent ceiling-level sprinklers and are fed by sprinkler piping no smaller than the ceiling level branchlines. Sprinklers located under the ceiling vent and installed as outlined above do not need to be added to the hydraulic design of the ceiling sprinkler system. See Figure 24a for a diagram of this arrangement.

Do not install drop-out-type heat vents over storage areas. If local codes require the installation of drop-out-type heat vents over storage areas, install vents that are FM Approved for occupancies protected by quick-response Storage sprinklers.

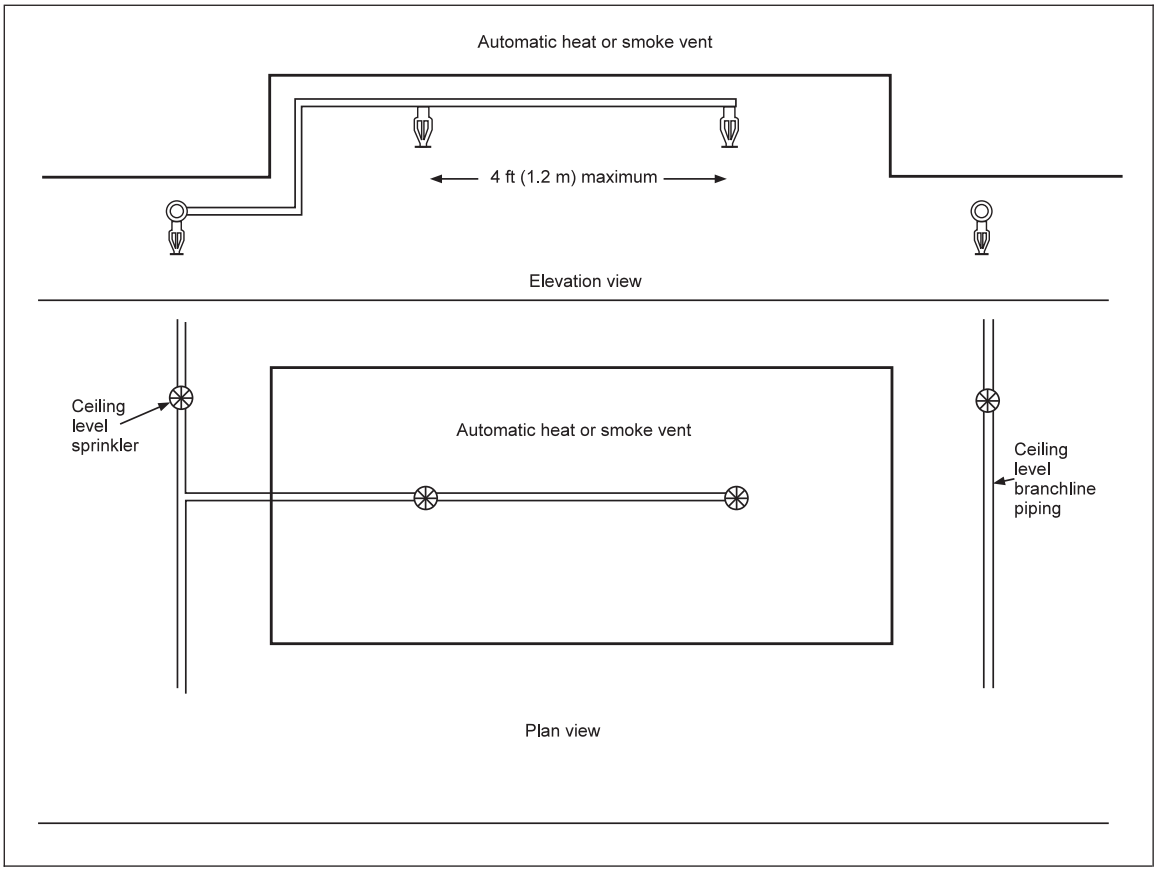

Fig. 24a. Quick-Response sprinklers installed under automatic smoke and heat vents

2.2.1.7.2 Exhaust Openings at Ceiling Level

Arrange openings at ceiling level, such as exhaust and ridge vents, to close automatically upon early fire detection (prior to first sprinkler operation). If this is not possible, do one of the following:

(a) Install a false ceiling (see Appendix A for definition) under the ceiling opening. Ensure the false ceiling is, at a minimum, the same size as the ceiling opening, and install sprinklers below the false ceiling using the same branchline pipe size and sprinkler spacing installed at ceiling level. Design the false ceiling in accordance with Data Sheet 1-12, *Ceilings and Concealed Spaces*, and ensure it can withstand a minimum uplift pressure of 3 lb/ft^2 (14.4 kg/m^2). Sprinklers located under the false ceiling and installed as outlined

above do not need to be added to the hydraulic design of the ceiling sprinkler system.

(b) Install quick-response sprinklers directly under the ceiling opening on a maximum 4 ft (1.2 m) linear and 16 ft^2 (1.5 m^2) area spacing. Ensure these sprinklers have, at a minimum, the same K-factor and orientation as the adjacent ceiling-level sprinklers, and are fed by sprinkler piping no smaller than the ceiling-level branchlines. Sprinklers located under the ceiling opening and installed as outlined above do not need to be added to the hydraulic design of the ceiling sprinkler system. See Figure 24b for a diagram of this arrangement.

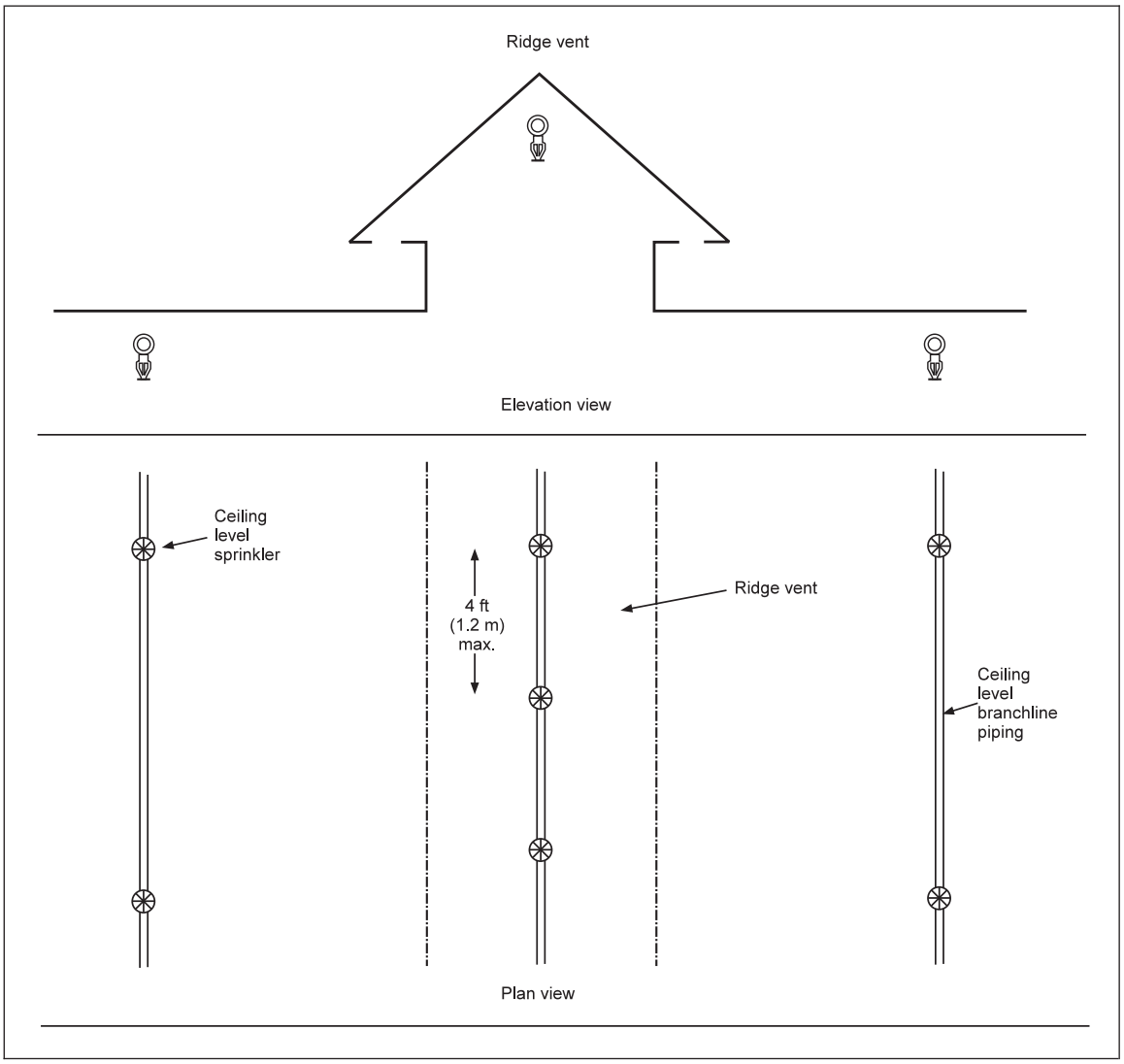

Fig. 24b. Quick-Response sprinklers installed under ceiling-level exhaust devices

2.2.1.8 Airflow Velocities at Ceiling-Level Sprinklers

Arrange air-handling equipment (and similar devices that discharge air into a protected area) so the multidirectional airflow velocity at any ceiling-level Storage sprinkler does not exceed 5 ft/s (1.5 m/s).

If it is not possible to avoid airflow velocities in excess of 5 ft/s (1.5 m/s) at ceiling-level Storage sprinklers, chose one of the following two options:

(a) False Ceiling Under an Air Vent

If the airflow velocity is due to a ceiling-level air-discharge vent, install a false ceiling (see Appendix A for definition) under the vent and install Storage sprinklers below the false ceiling using the same branchline pipe size and sprinkler spacing installed at ceiling level. Locate and size the false ceiling so the air velocity at the sprinklers adjacent to the false ceiling does not exceed 5 ft/s (1.5 m/s). Design the false ceiling in accordance with Data Sheet 1-12, *Ceilings and Concealed Spaces*, and ensure it can withstand a minimum uplift pressure of 3 lb/ft^2 (14.4 kg/m^2). Sprinklers located under the false ceiling do not need to be added to the hydraulic design of the ceiling sprinkler system.

(b) Heat/Flame Detection

Install either FM Approved flame detection at ceiling level, or line-type heat detection within storage racks. Arrange either type of detection system to automatically shut down the flow of air upon detector actuation.

For flame detection, arrange the detection to monitor the area located within a 10 ft (3.0 m) radius from all affected sprinklers.

For line-type detection, install the detection at the top of the storage rack structure and within all transverse flue spaces that are within a 10 ft (3.0 m) radius of any affected sprinkler. The nominal temperature rating of the line-type detection should be as low as permissible based on ambient temperature conditions.

2.2.1.9 Draft Curtains

Do not install draft curtains in buildings protected by sprinklers unless they are specifically used to (a) separate areas protected by quick-response Storage sprinklers from areas protected by standard-response Non-Storage or Storage sprinklers, or (b) recommended by other sections of this data sheet, or (c) recommended by the relevant occupancy-specific data sheet.

If draft curtains are recommended, install the draft curtain in accordance with Data Sheet 1-10. Solid beams, girders, or other structural features that meet the criteria outlined in Data Sheet 1-10 can be considered the equivalent of a draft curtain. Extend the draft curtain at least 2 ft (0.6 m) below the ceiling, and position the sprinklers horizontally from the draft curtain based on the installation guidelines for obstructed construction as outlined in Section 2.2.3.1.

2.2.2 Occupancy

2.2.2.1 Clearance Below Sprinklers

Maintain a minimum 3 ft (0.9 m) clearance between the deflector of a sprinkler and any combustibles located below it.

2.2.2.2 Conveyors

Provide sprinkler protection under belt-type or other solid-type conveyor systems having combustible construction and/or a combustible occupancy below them as follows:

2.2.2.2.1 Belt or Similar Solid-Type Conveyors

Treat belt-type and similar solid-type conveyor systems the same as a solid walkway and provide sprinkler protection in accordance with Section 2.2.1.5.2.

2.2.2.2.2 Roller and Similar Open-Type Conveyors

Sprinklers are not required below conveyor systems that are a minimum of 70% open, or below roller-type conveyors that are at least 50% open. If these conditions cannot be met, treat conveyors as open-grid ceilings and adhere to the recommendations in Section 2.2.1.4.

2.2.2.2.3 Automatic Shutdown of Conveyor Systems

Arrange conveyor systems to automatically shut down in the event of sprinkler water discharge. See Data Sheet 7-11, *Conveyors*, for other guidelines regarding the presence of conveyor systems in buildings equipped with sprinkler protection.

2.2.2.3 Aisle Storage

Maintain aisles located between storage racks free of combustibles.

2.2.3 Protection

2.2.3.1 General

2.2.3.1.1 Where Sprinklers Are Needed

Install sprinkler protection wherever there is combustible construction or a combustible occupancy. Refer to any relevant occupancy-specific data sheets to determine if exceptions to this recommendation exist.

See Data Sheet 1-12, *Ceilings and Combustible Spaces*, for recommendations related to installing sprinklers within combustible ceilings or concealed spaces.

Install sprinkler protection under any fixed object more than 4 ft (1.2 m) wide in its least horizontal dimension and beneath which combustible construction or a combustible occupancy is located.

Provide exposure protection when exterior hazards, such as large oil-filled transformers, exterior loading docks, and yard storage, are located in close proximity to a building that either has or requires sprinkler protection. See Data Sheet 1-20, *Protection Against Exterior Fire Exposure*, for additional guidelines.

Do not use fixed special protection extinguishing systems as an alternative to sprinklers unless recommended by the relevant occupancy-specific data sheet.

2.2.3.1.2 Sprinkler Applications

The recommendations in this section address the installation of Storage sprinklers (see Appendix A, Glossary of Terms, for the definition of a Storage sprinkler). The goal of these recommendations is to ensure prompt actuation of sprinklers and a sufficient flow of unobstructed water to the fire.

For sprinklers to perform properly during a fire, the appropriate sprinkler must be chosen for the fire hazard. In addition, proper installation is required to allow the sprinkler to operate in a timely fashion and deliver an adequate amount of unobstructed water to the fire.

When choosing a sprinkler for the protection of a given fire hazard, see the relevant occupancy-specific data sheet to determine the following:

(a) The types of sprinklers that can be installed.

(b) The sprinkler's recommended nominal temperature rating. If the ambient temperature exceeds 100°F, see Table 15 for the recommended nominal temperature rating of a sprinkler based on the maximum expected ambient temperature at sprinkler level.

(c) The sprinkler's recommended K-factor, RTI, and orientation. See Table 16 for nominal K-factor values of FM Approved Storage sprinklers.

(d) The sprinkler's recommended minimum and maximum linear horizontal spacing, as well as the minimum and maximum area spacing. Note that the linear distance between sprinklers is measured along the slope of the ceiling, not on the viewpoint from floor level.

Table 15. Nominal Temperature Ratings of Sprinklers Based on Maximum Ambient Temperature at Sprinkler Level

Maximum Ambient Temperature at Sprinkler Level, °F (°C)	*Nominal Temperature Rating of Sprinkler, °F (°C)*	*Temperature Classification of Sprinkler*	*Color of Sprinkler Glass Bulb*
100 (38)	135 (55)	Ordinary	Orange
100 (38)	160 (70)	Ordinary	Red
150 (66)	175 (80)	Ordinary	Yellow
150 (66)	212 (100)	Intermediate	Green
225 (107)	280 (140)	High	Blue
300 (149)	350 (175)	Extra High	Mauve
375 (191)	425 (220)	Very Extra High	Black
475 (246)	525 (275)	Ultra High	Black
625 (329)	650 (345)	Ultra High	Black

In several countries, the arm frames of the sprinkler are provided with a color coding to represent the temperature classification of the sprinkler. Check the local country code to determine the temperature classification for the sprinkler based on the sprinkler's arm-frame color.

Table 16. Nominal K-factor Values of FM Approved Storage Sprinklers

Nominal K-factor Values, gpm/(psi)$^{0.5}$ (L/min/[bar]$^{0.5}$)	*K-factor Range Values, gpm/(psi)$^{0.5}$*	*K-factor Range Values, L/min/[bar]$^{0.5}$*	*Nominal Pipe Thread Size, in. (mm)*
5.6 (80)	5.3 – 5.8	76 – 84	½ or ¾ (15 or 20)
8.0 (115)	7.4 – 8.2	107 – 118	½ or ¾ (15 or 20)
11.2 (160)	11.0 – 11.5	159 – 166	½ or ¾ (15 or 20)*
14.0 (200)	13.5 – 14.5	195 – 209	¾ (20)
16.8 (240)	16.0 – 17.6	231 – 254	¾ (20)
19.6 (280)	18.6 – 20.6	269 – 297	1 (25)
22.4 (320)	21.3 – 23.5	307 – 339	1 (25)
25.2 (360)	23.9 – 26.5	344 – 382	1 (25)

* The use of K11.2 (K160) sprinklers having nominal ½ in. (15 mm) npt threaded connections is acceptable only when they are being considered as a retrofit option for the replacement of existing K8.0 (K115) or smaller sprinklers.

Install upright Storage sprinklers so their frame arms are parallel to the branchline.

Install Storage sprinklers so their deflector is parallel to the floor.

Exception: The deflector of the sprinkler can be installed parallel to the ceiling if the ceiling slope is 5° or less.

2.2.3.1.3 Mixing of Different Types of Sprinklers

Do not mix the following types of sprinklers on the same sprinkler system protecting the same hazard area unless otherwise recommended in the relevant occupancy-specific data sheet:

(a) Storage, Nonstorage, and Special Protection sprinklers

(b) Sprinklers having different K-factors

(c) Sprinklers having different orientation

(d) Sprinklers having different nominal temperature ratings

(e) Sprinklers having different nominal RTI values

(f) Sprinklers having different linear and/or area spacing requirements (e.g., extended-coverage and non-extended-coverage sprinklers)

Exception No. 1: Install individual sprinklers having a higher temperature rating as needed based on ambient temperature conditions (such as near unit heater outlets). Ensure the higher-temperature sprinklers are of the same make, model, type, K-Factor, RTI, and orientation as the lower-temperature sprinklers.

Exception No. 2: An upright sprinkler may be substituted for an obstructed pendent sprinkler provided it has the same K-factor, nominal temperature rating, nominal RTI, and recommended sprinkler spacing as the pendent sprinkler and is compatible for the occupancy hazard.

Exception No. 3: Sprinklers installed under lower ceilings are not considered "on the same system." See recommendations in Section 2.2.1.4 if the lower ceiling is open-grid, or Section 2.2.1.5 if the lower ceiling is solid.

Exception No. 4: When two different occupancy hazards are adjacent to each other and are not separated by a wall or draft curtain, extend the design of the sprinkler system protecting the higher-hazard occupancy a minimum of 20 ft (6.0 m) in all directions beyond the perimeter of the higher-hazard occupancy area.

2.2.3.1.4 Return Bends for Sprinklers

Provide individual return bends for all K11.2 (K160) or smaller pendent sprinklers that are supplied from a raw water source, mill pond, or from open-top reservoirs. Also provide return bends on vertical pipe drops

supplying in-rack sprinklers from these types of water sources. The size of the return bend can be either the same size of the branchline that feeds the return bend or one pipe diameter size smaller, but not less than 1 in. (25 mm).

Exception No. 1: Return bends are not necessary on sprinkler systems equipped with an FM Approved strainer.

Exception No. 2: Return bends are not necessary for deluge systems.

Exception No. 3: Return bends are not necessary where dry pendent sprinklers are used.

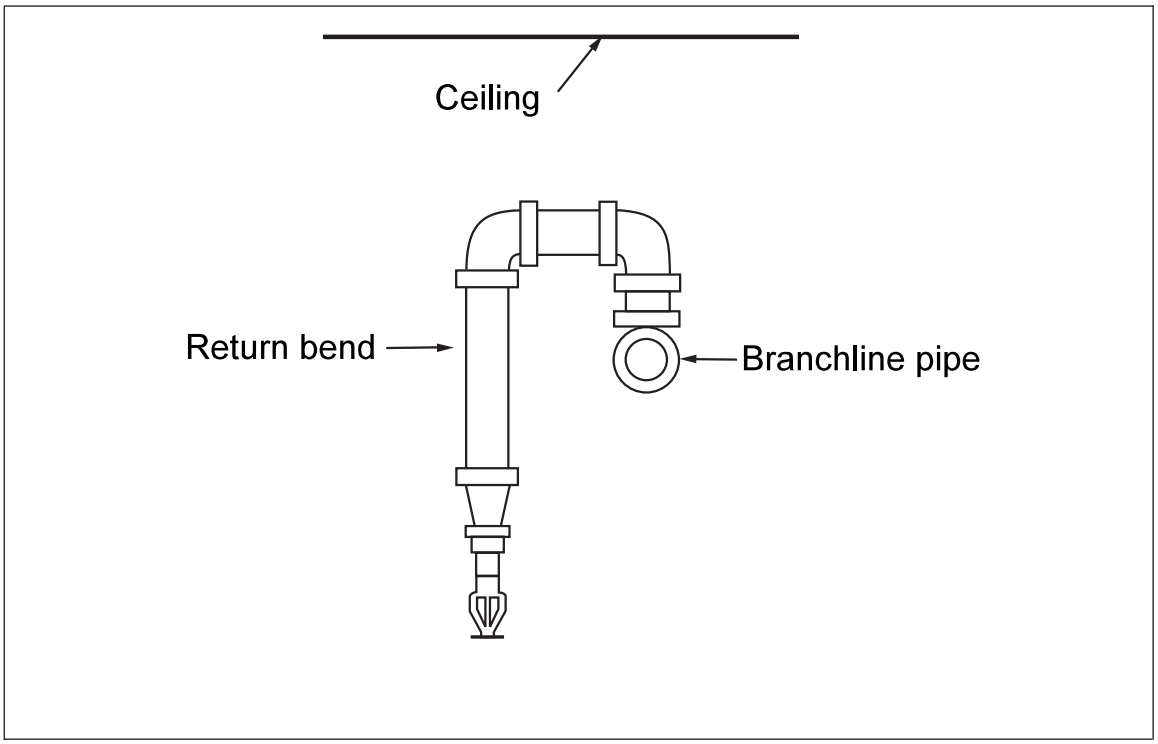

Fig. 25. Return bends for Storage sprinklers

2.2.3.1.5 Protection of Sprinklers from Damage

Provide protection for sprinklers that are subject to mechanical damage. Ensure the protection does not degrade the performance of the sprinkler.

2.2.3.1.6 Spare Sprinklers

Maintain a supply of spare sprinklers on site for each type of sprinkler installed, as well as any equipment required for installing them. Base the minimum number of spare sprinklers required of each type on their largest demand area.

Example: A facility has two types of sprinklers; a Nonstorage sprinkler for the manufacturing area, and a Storage sprinkler for the warehouse area. The largest sprinkler system demand area for the manufacturing area is 25 sprinklers, and for the warehouse area it is 15 sprinklers. Therefore, the minimum number of spare sprinklers is 25 Nonstorage sprinklers and 15 Storage sprinklers.

2.2.3.2 Linear and Area Spacing of Storage Sprinklers

Install Storage sprinklers under unobstructed ceiling construction in accordance with the minimum and maximum linear and area spacing recommendations listed in Table 17, unless indicated otherwise in the relevant occupancy-specific data sheet.

Table 17. Spacing of Ceiling-Level Storage Sprinklers

Ceiling Height, ft (m)	*Sprinkler K-Factor*	*Sprinkler Orientation*	*Sprinkler Response*	*Sprinkler Linear Spacing, ft (m)*		*Sprinkler Area Spacing, ft^2 (m^2)*	
				Min.	Max.	Min.	Max.
Up to 30 (9.0)	11.2 (160)	Pendent or Upright	Quick or Standard	8 (2.4)	12 (3.6)	80 (7.5)	100 (9.0)
	14.0 (200), 16.8 (240), 19.6 (280), 22.4 (320) or 25.2 (360)	Pendent	Quick or Standard	8 (2.4)	12 (3.6)	64 (6.0)	100 (9.0)
		Upright	Quick	8 (2.4)	12 (3.6)	64 (6.0)	100 (9.0)
			Standard	8 (2.4)	12 (3.6)	80 (7.5)	100 (9.0)
	25.2EC (360EC)	Pendent or Upright	Quick	10 (3.0)	14 (4.2)	100 (9.0)	196 (18.0)
Over 30 (9.0)	11.2 (160)	Pendent or Upright	Quick or Standard	8 (2.4)	10 (3.0)	80 (7.5)	100 (9.0)
	14.0 (200), 16.8 (240), 19.6 (280), 22.4 (320), or 25.2 (360)	Pendent or Upright	Quick	8 (2.4)	10 (3.0)	64 (6.0)	100 (9.0)
			Standard	8 (2.4)	10 (3.0)	80 (7.5)	100 (9.0)
	*25.2EC (360EC)	Pendent or Upright	Quick	10 (3.0)	12 (3.6)	100 (9.0)	144 (13.4)

*If the K25.2EC (360EC) sprinkler is supplemented with in-rack sprinklers in accordance with this data sheet, then the maximum linear spacing can be increased to 14 ft (4.2 m) and the maximum area spacing can be increased to 196 ft^2 (18.0 m^2)

Install Storage sprinklers under obstructed ceiling construction in accordance with the minimum and maximum linear and area spacing recommendations listed in Table 17 as well as the recommendations in Section 2.2.3.4.2, unless indicated in the relevant occupancy-specific data sheet.

Exception: When sprinklers are provided in every channel bay formed by obstructed construction, the minimum linear and area spacing recommendations listed in Table 17 do not apply to the sprinklers located in adjacent channel bays. See Figure 26 for a diagram of this arrangement.

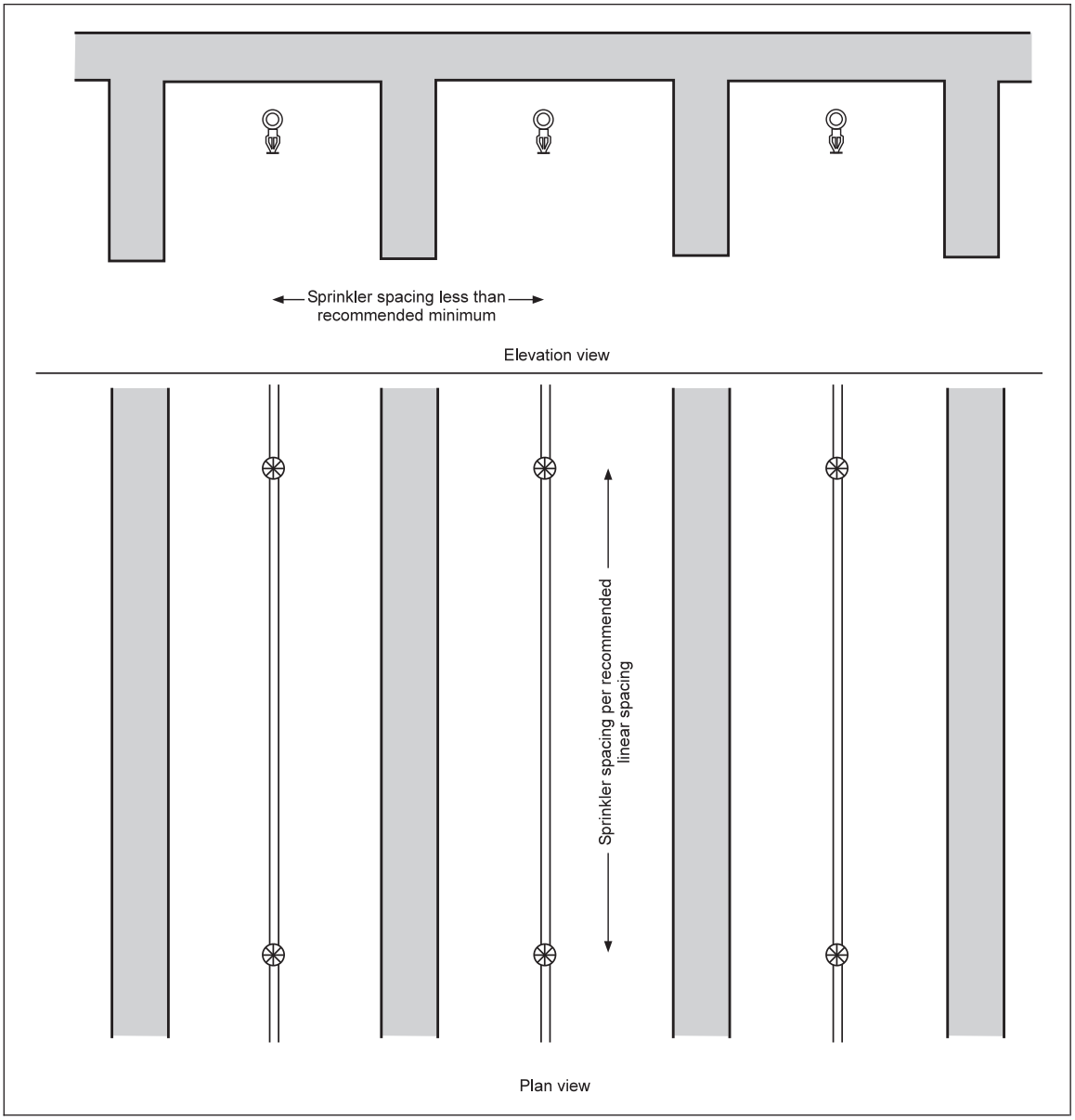

Fig. 26. Spacing of sprinklers when installed in every bay channel formed by solid structural members

The maximum linear spacing of a Storage sprinkler, as well as its maximum area spacing, can be increased by 1 ft (0.3 m) and 15 ft^2 (1.4 m^2) respectively in order to avoid obstructing sprinkler discharge as recommended in Section 2.2.3.5.

Note that the extension in Storage sprinkler spacing outlined above applies only to:

- a maximum of two adjacent sprinklers on the same branchline, or
- a maximum of two adjacent branchlines.

See Figure 27 for a diagram of this arrangement.

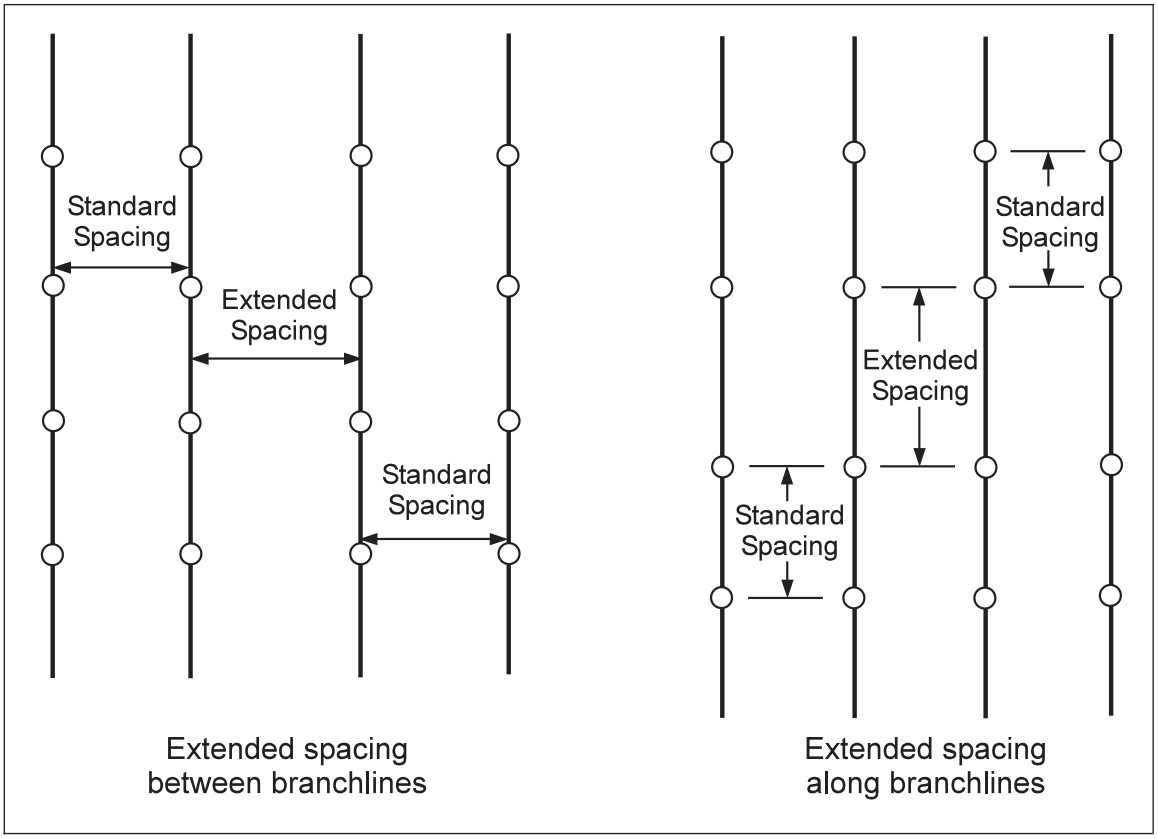

Fig. 27. Maximum increase in linear and area spacing to avoid obstructing sprinkler discharge

2.2.3.3 Horizontal Distance from Walls to Storage Sprinklers

Install Storage sprinklers horizontally from walls, measured perpendicular to the wall, as follows:

Minimum horizontal distance: 4 in. (100 mm)

Maximum horizontal distance unless recommended otherwise in the relevant occupancy-specific data sheet or the *Approval Guide*:

(a) Wall angle greater than 90°: 50% of the recommended maximum linear spacing of the sprinkler as outlined in the relevant occupancy-specific data sheet.

(b) Wall angle equal to or less than 90°: 70% of the recommended maximum linear spacing of the sprinkler as outlined in the relevant occupancy-specific data sheet.

See Figure 28 for a representation of the wall angles outlined above.

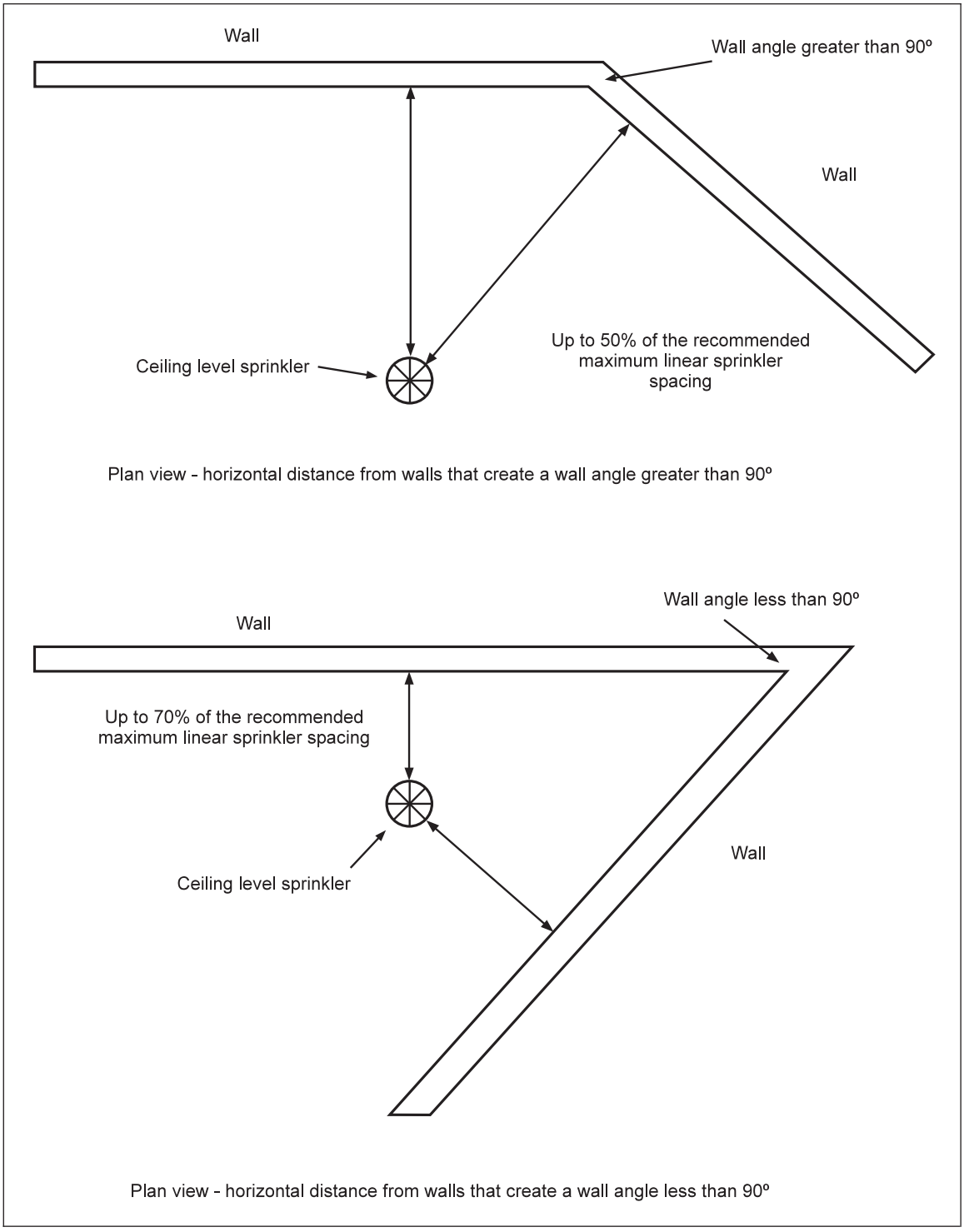

Fig. 28. Horizontal distance from walls to Storage sprinklers

2.2.3.4 Vertical Distance from the Ceiling to Storage Sprinklers

Vertical distance is measured perpendicular to the floor, between the centerline of the sprinkler's thermal element to the uppermost portion of the underside of the ceiling. This vertical distance can be measured to the underside of the lowermost portion of the ceiling when this section of the ceiling is flat, smooth, and at least 3 in. (75 mm) wide in its least dimension, as well as at least twice as wide as the vertical distance between the uppermost and lowermost ceilings. In addition, the horizontal gap between lowermost ceiling sections (i.e., the width of the flute area) cannot be more than 3 in. (75 mm) wide.

Install Storage sprinklers under ceilings in accordance with the recommendations in Section 2.2.3.4.1 for unobstructed ceiling construction, and Section 2.2.3.4.2 for obstructed ceiling construction. If the ceiling slope exceeds 10°, ensure sprinklers are within a 3 ft (0.9 m) vertical plane of the peak of the ceiling, in addition to the following guidelines.

See the relevant occupancy-specific data sheet or the *Approval Guide* to ensure the construction type (obstructed or unobstructed) is compatible with the sprinkler.

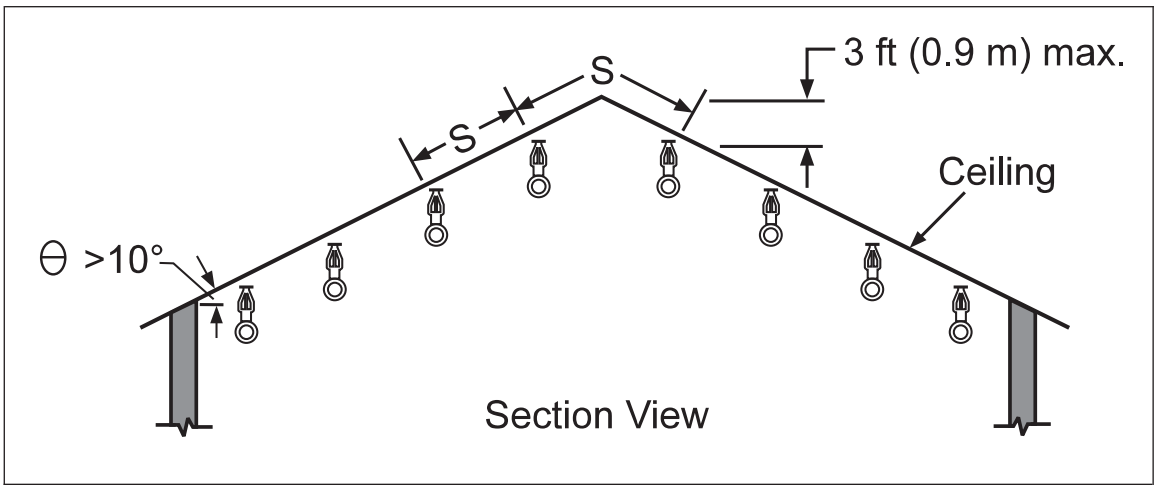

Fig. 29. Location of storage sprinklers if ceiling slope exceeds 10°

2.2.3.4.1 Unobstructed Ceiling Construction

Unless recommended otherwise by the relevant occupancy-specific data sheet, install Storage sprinklers under unobstructed ceiling construction so the centerline of the sprinkler's thermal sensing element is positioned vertically as follows:

Minimum vertical distance below ceiling:

- Smooth ceiling: 2 in. (50 mm)
- Non-smooth ceiling: 4 in. (100 mm)

Maximum vertical distance below ceiling:

- Standard-response sprinklers or extended-coverage sprinklers: 12 in. (300 mm)
- Quick-response sprinkler less than or equal to K16.8 (K240): 13 in. (330 mm)
- Quick-response sprinkler greater than or equal to K22.4 (K320): 17 in. (425 mm)

Ensure the location of the sprinkler deflector meets the recommendations for obstructions to the umbrella pattern outlined in Section 2.2.3.5.1.

Exception to minimum vertical distance: The recommended minimum vertical distances does not apply when installing FM Approved flush, recessed, or concealed Storage sprinklers that are acceptable for the hazard being protected.

2.2.3.4.2 Obstructed Ceiling Construction

Install Storage sprinklers in every channel bay formed by obstructed ceiling construction. Ensure the location of the sprinkler deflector adheres to the recommendations in Section 2.2.3.5.1, and position the centerline of the sprinkler's thermal sensing element vertically as follows:

Minimum vertical distance below ceiling:

- Smooth ceiling: 2 in. (50 mm)
- Non-smooth ceiling: 4 in. (100 mm)

Exception: The minimum vertical distance does not apply when installing FM Approved flush, recessed, or concealed Storage sprinklers that are appropriate for the hazard being protected.

Maximum vertical distance below ceiling:

- Standard-response sprinklers or extended-coverage sprinklers: 12 in. (300 mm)
- Quick-response sprinklers less than or equal to K16.8 (K240): 13 in. (330 mm)
- Quick-response sprinklers greater than or equal to K22.4 (K320): 17 in. (425 mm)

Exception for quick-response or standard-response Storage sprinklers: Quick-response storage sprinklers are not necessary in every channel bay formed by obstructed ceiling construction and can have a maximum spacing of 100 ft^2 (9 m^2) when the following criteria are met:

(a) Combustible and noncombustible solid structural members extend up to a maximum of 12 in. (300 mm) from the underside of the ceiling, and

(b) The sprinklers are located below the bottom of the structural members.

See Figure 30 for a diagram of this arrangement.

Exception for standard-response Storage sprinklers: Standard-response Storage sprinklers are not necessary in every channel bay formed by obstructed ceiling construction and can have a maximum spacing of 100 ft^2 (9 m^2) when the following criteria are met:

(a) Combustible and noncombustible solid structural members extend more than 12 in. (300 mm) from the underside of the ceiling, form channel bays not exceeding 300 ft^2 (28 m^2) in area, and are horizontally separated by less than 3 ft (0.9 m) on center, or

(b) Combustible solid structural members extend from more than 12 in. (300 mm) up to 21 in. (525 mm) from the underside of the ceiling and form channel bays not exceeding 300 ft^2 (28 m^2) in area, or

(c) Noncombustible solid structural members extend from more than 12 in. (300 mm) up to 21 in. (525 mm) from the underside of the ceiling and form channel bays not exceeding 300 ft^2 (28 m^2) in area, or

(d) Noncombustible solid structural members form channel bays that exceed 300 ft^2 (28 m^2) in area, but have horizontal separation between 3 ft (0.9 m) and 7.5 ft (2.3 m) on center.

For Exception (a), vertically install the centerline of the sprinkler's thermal sensing element from 1 in. (25 mm) to a maximum of 6 in. (150 mm) below the underside of the solid structural member.

For Exception (b), vertically install the centerline of the sprinkler's thermal sensing element a maximum of 1 in. (25 mm) directly below the underside of the solid structural member.

For Exceptions (c) and (d), vertically install the centerline of the sprinkler's thermal sensing element a maximum of 22 in. (550 mm) below the underside of the ceiling as well as on a horizontal plane from 1 in. (25 mm) to a maximum of 6 in. (150 mm) below the bottom of the solid structural member. See Figure 30 for a diagram of this arrangement.

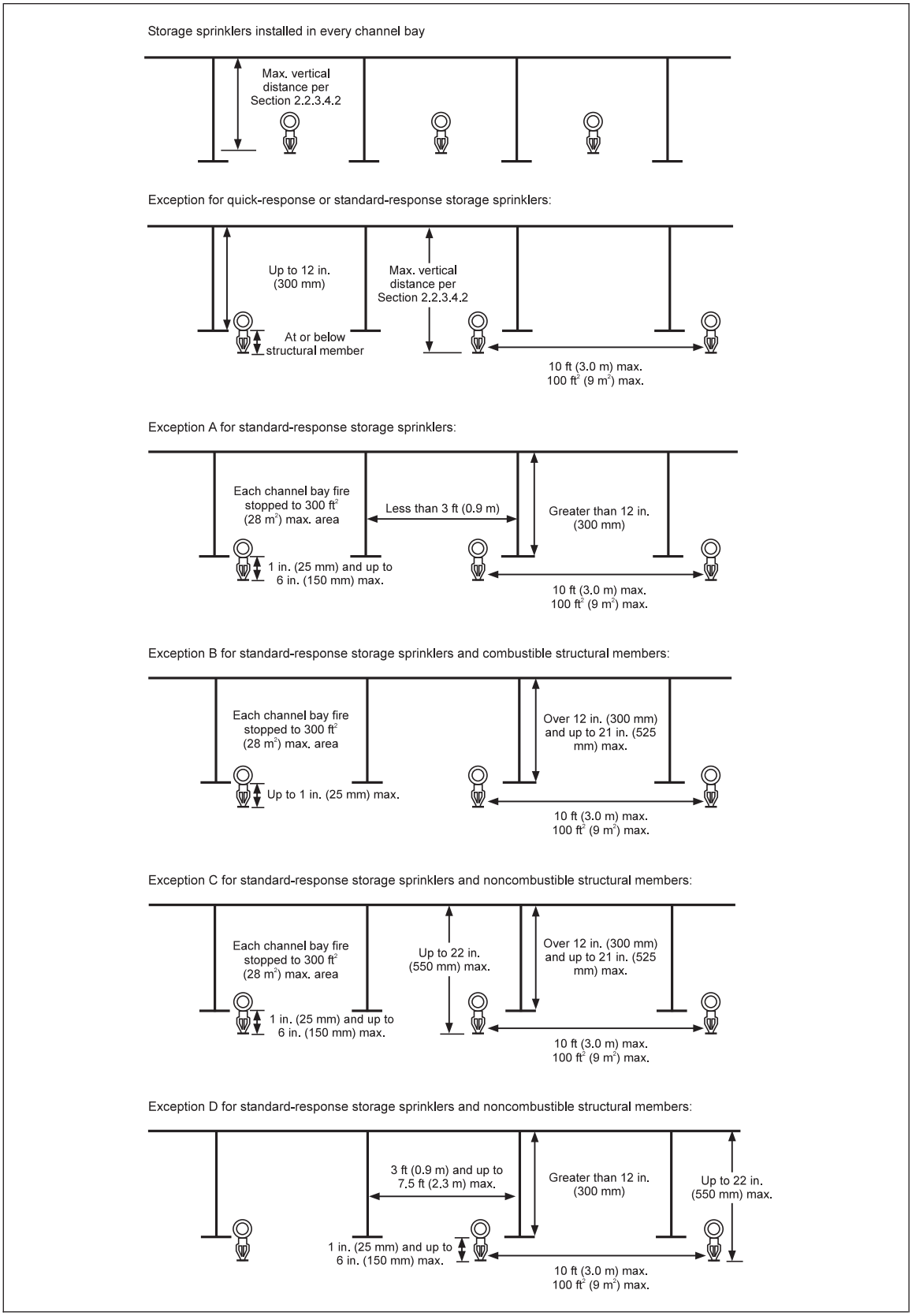

Fig. 30. Location of Storage Sprinklers Under Obstructed Ceiling Construction

2.2.3.5 Obstruction to Discharge Pattern of Storage Sprinklers

Install Storage sprinklers in accordance with Sections 2.2.3.5.1 and 2.2.3.5.2 to ensure the water discharged from sprinklers is not significantly obstructed.

2.2.3.5.1 Obstruction to Umbrella Discharge Pattern of Ceiling-Level Storage Sprinklers

In addition to the recommendations in Sections 2.2.3.1 through 2.2.3.4, install pendent and upright Storage sprinklers on standard spacing in accordance with Figure 31 and Table 18 to avoid obstructing the sprinkler's umbrella pattern. Locate objects less than 12 in. (300 mm) horizontally from the sprinkler above the horizontal plane of the sprinkler's deflector.

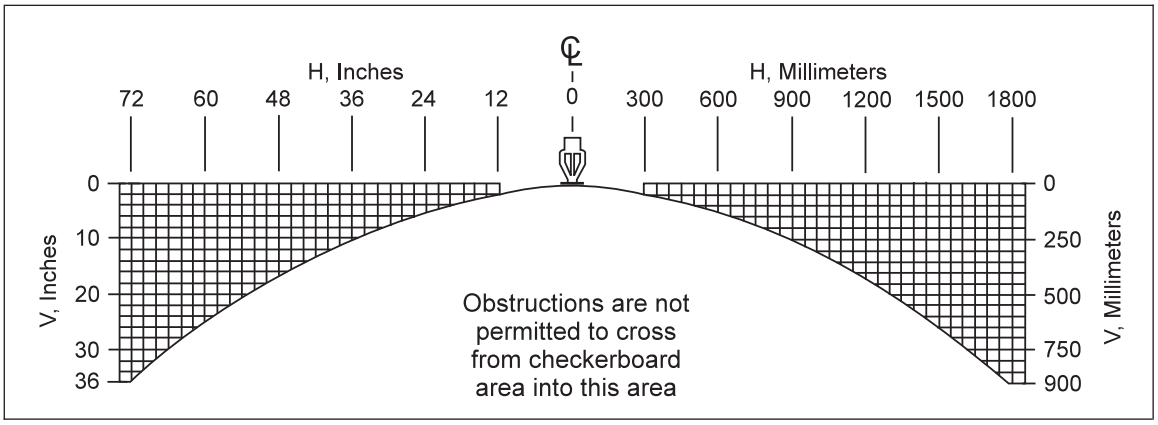

Fig. 31. Obstruction Area to Umbrella Pattern of Ceiling-Level Storage Sprinklers on Standard Spacing

Table 18. Minimum Horizontal Distance of Ceiling Objects to Avoid Obstructing Umbrella Patterns of Storage Sprinklers (not Extended-Coverage)

Maximum Vertical Distance of Ceiling Object Located Below Sprinkler Deflector; in. (mm)	*Minimum Horizontal Distance From Sprinkler to Avoid Obstructing Umbrella Pattern; in. (mm)*
2 (50)	12 (300)
4 (100)	20 (500)
6 (150)	28 (700)
8 (200)	32 (800)
12 (300)	40 (1000)
20 (500)	52 (1300)
36 (900)	72 (1800)

In addition to the recommendations in Sections 2.2.3.1 through 2.2.3.4, install pendent and upright extended-coverage Storage sprinklers in accordance with Figure 32 and Table 19. Locate Objects less than 18 in. (450 mm) horizontally from the sprinkler above the horizontal plane of the sprinkler's deflector.

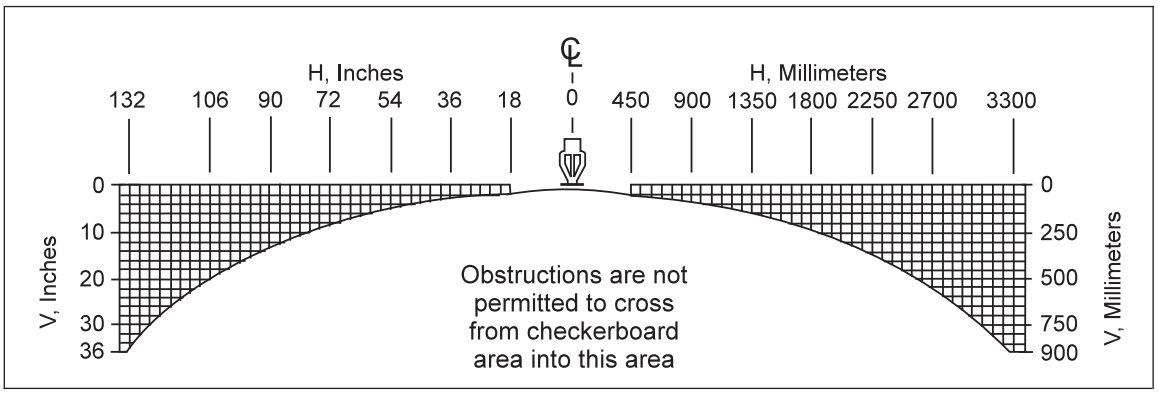

Fig. 32. Obstruction Area to Umbrella Pattern of Ceiling-Level Extended-Coverage Storage Sprinkler

Table 19. Minimum Horizontal Distance of Ceiling Objects to Avoid Obstructing Umbrella Patterns of Extended-Coverage Storage Sprinklers

Maximum Vertical Distance of Ceiling Object Located Below Sprinkler Deflector; in. (mm)	*Minimum Horizontal Distance From Sprinkler to Avoid Obstructing Umbrella Pattern; in. (mm)*
2 (50)	18 (450)
4 (100)	48 (1200)
6 (150)	60 (1500)
8 (200)	72 (1800)
12 (300)	84 (2100)
20 (500)	108 (2700)
36 (900)	132 (3300)

An object located at or near ceiling level that is entirely within the checkerboard pattern shown in Figures 31 or 32 is not considered an obstruction to the sprinkler's umbrella pattern.

Any object located at or near ceiling level that extends downward into the area below the checkerboard pattern in Figures 31 and 32 is considered an obstruction to the sprinkler's umbrella pattern, except under the following conditions:

(a) The object located at or near ceiling level is a structure member or similar that is at least 70% open, or

(b) The object located at or near ceiling level is no wider than 3 in. (75 mm) in its least dimension and is separated from other objects by a minimum of 12 in. (300 mm).

Account for obstructions by using either of the two following methods:

(a) Relocate the obstructed sprinkler so it complies with the horizontal and vertical distances recommended in Figure 31 or 32, while still meeting the installation guidelines in Sections 2.2.3.1 through 2.2.3.4.

(b) Install sprinklers on both sides of the obstruction as follows (see Figure 33 for a diagram of this arrangement):

- At equal horizontal distances from the obstruction, and
- A minimum of 12 in. (300 mm) horizontally from the edge of the obstruction

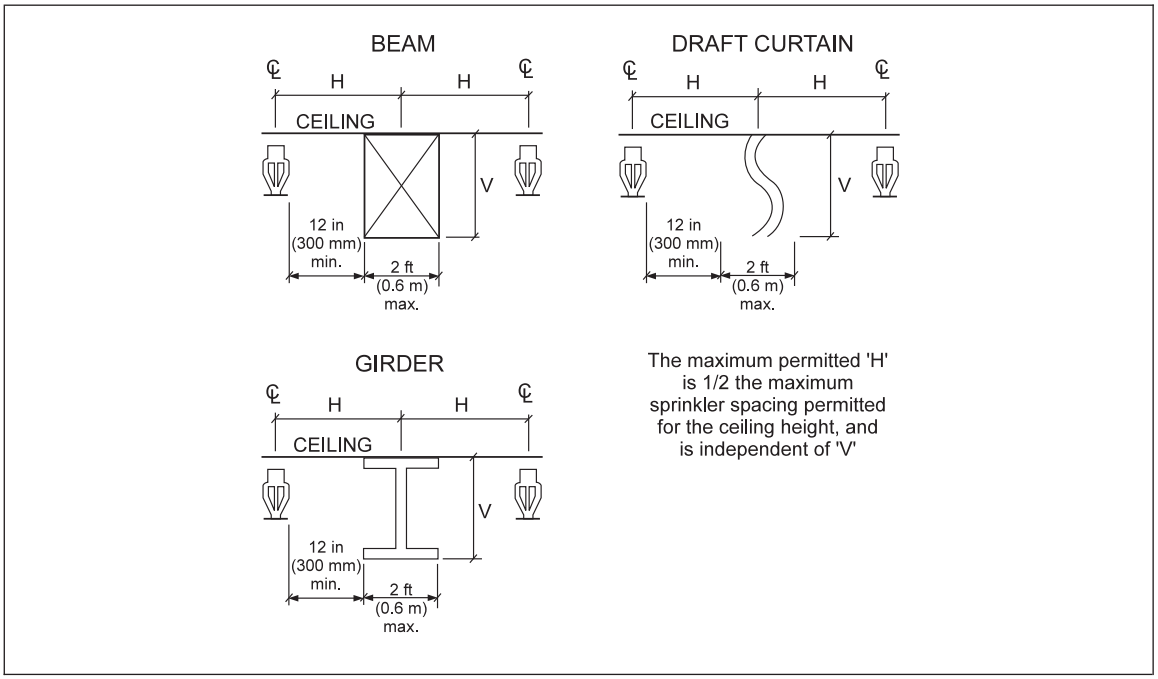

Fig. 33. Installing Additional Sprinklers to Account for Obstructed Umbrella Discharge Pattern Caused by Solid Objects at Ceiling Level

If the width of the obstruction is from more than 24 in. (600 mm) to 4 ft (1.2 m), install a single line of ceiling-level sprinklers centered under the obstruction on a maximum linear spacing of 4 ft (1.2 m) fed by the same branchline pipe size used at ceiling-level.

If the width of the obstruction is from more than 4 ft (1.2 m) to 10 ft (3.0 m), install ceiling-level sprinklers under the obstruction on a maximum linear spacing of 4 ft (1.2 m) and area spacing of 16 ft^2 (1.5 m^2) fed by the same branchline pipe size used at ceiling-level.

If the width of the obstruction is greater than 10 ft (3.0 m), treat the underside of the obstruction as a ceiling and install ceiling-level sprinklers for this area fed by the same branchline pipe size used at ceiling-level and in accordance with the recommendations in Sections 2.2.3.1 through 2.2.3.4.

In all three cases above, maintain a minimum 3 ft (0.9 m) vertical distance between the sprinkler deflector and the top of storage.

The additional sprinklers installed under the obstruction as recommended above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

2.2.3.5.2 Obstruction to Inner Core Discharge Pattern of Ceiling-Level Storage Sprinklers

In addition to the recommendations in Sections 2.2.3.1 through 2.2.3.4 and Section 2.2.3.5.1, install Storage sprinklers as recommended in Table 20 and Figures 34 through 38 to avoid the sprinkler's inner core distribution pattern being obstructed by individual objects located below the sprinklers (see Appendix A, *Glossary of Terms*, for definition of individual object).

Table 20. Installation Guidelines to Avoid Obstructions to Inner Core Distribution Pattern of Storage Sprinklers

Width of Object in Least Dimension, in. (mm)	*Horizontal Distance from Nearest Edge of Object to Sprinkler Deflector, in. (mm)*	*Minimum Vertical Distance from Nearest Edge of Object Below Sprinkler to Sprinkler Deflector, in. (mm)*
Up to 0.75 (20)[a]	Up to 12 (300)	4 (100)
	12 (300) or more	0 (0)
Over 0.75 (20) and up to 1.25 (32)[a]	Up to 12 (300)	16 (400)
	12 (300) or more	0 (0)
Over 1.25 (32) and up to 2 (50)[a]	Up to 12 (300)	24 (600)
	12 (300) or more	0 (0)
Over 2 (50) and up to 12 (300)[a]	Up to 12 (300)	Object must be below the top of storage and not blocking any flue spaces
	12 (300) or more	Object must be at least 18 in. (450 mm) above any flue space that is parallel and directly under the object
Over 12 (300) and up to 24 (600)[b]	Up to 24 (600)	Object must be below the top of storage and not blocking any flue spaces
	24 (600) or more	Object must be at least 36 in. (900 mm) above any flue space that is parallel and directly under the object
Over 24 (600)	Sprinklers needed under object per Section 2.2.3.5.2.1	Sprinklers needed under object per Section 2.2.3.5.2.1

[a] Upright Storage sprinklers can tolerate individual objects up to 4 in. (100 mm) wide located directly below them at any vertical distance.
[b] If the object is up to 24 in. (600 mm) wide in its maximum dimension, the object must be located a minimum 12 in. (300 mm) horizontally from the nearest sprinkler.

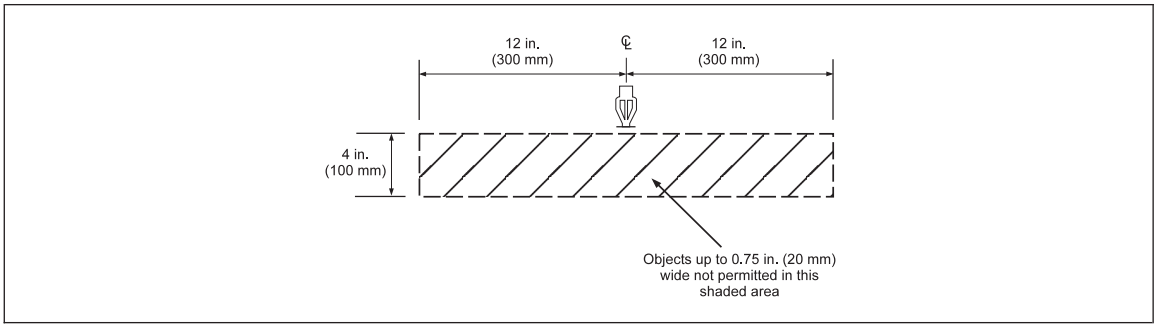

Fig. 34. Obstruction area to inner core discharge pattern of pendent Storage sprinklers for objects up to 0.75 in. (20 mm) wide

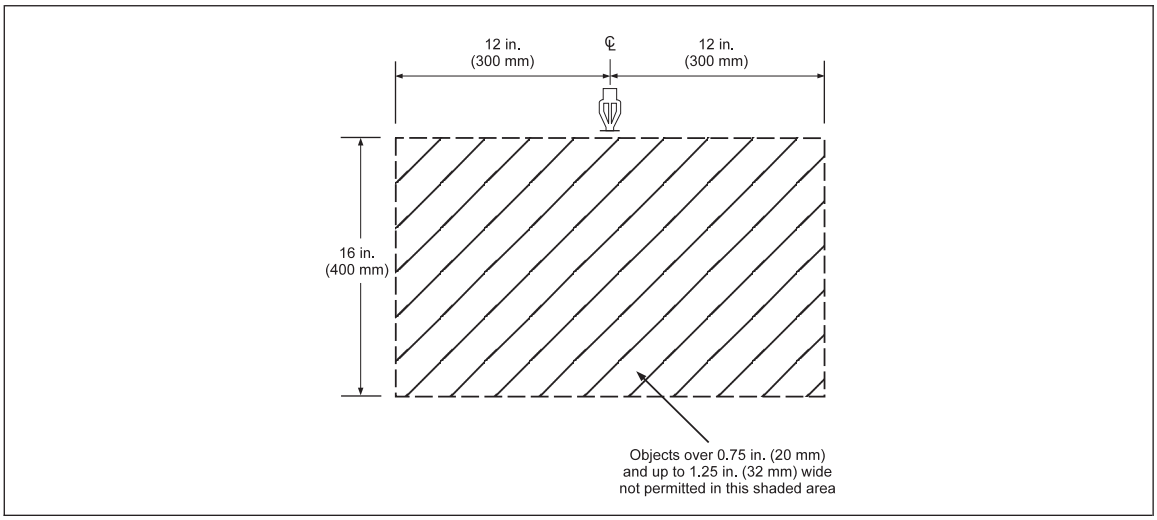

Fig. 35. Obstruction area to inner core discharge pattern of pendent Storage sprinklers for objects over 0.75 in. (20 mm) and up to 1.25 in. (32 mm) wide

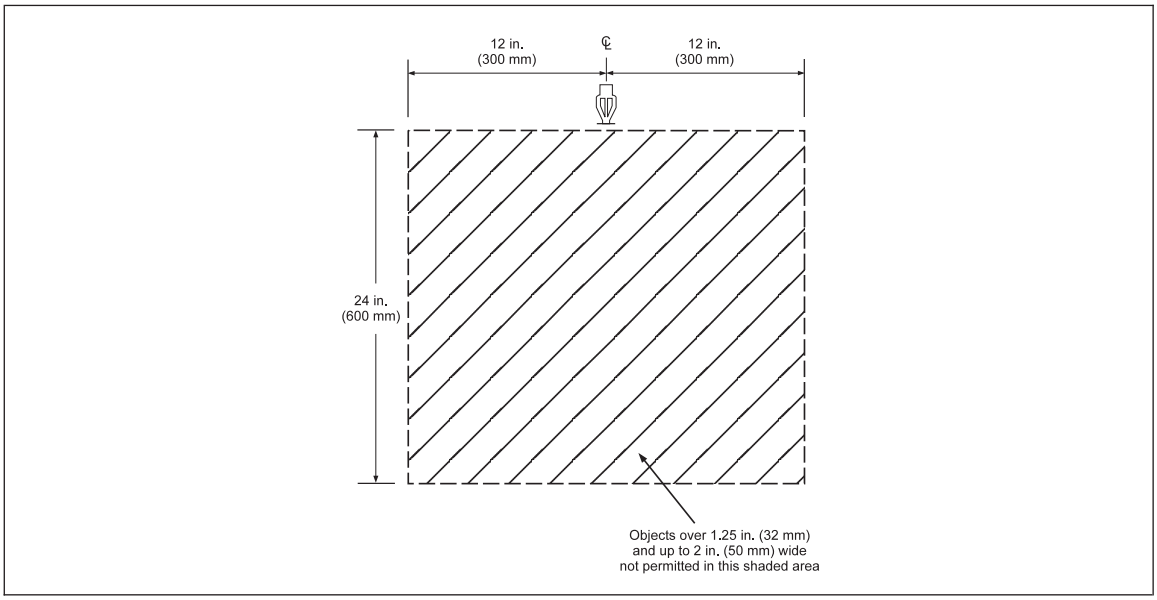

Fig. 36. Obstruction area to inner core discharge pattern of pendent Storage sprinklers for objects over 1.25 in. (32 mm) and up to 2 in. (50 mm) wide

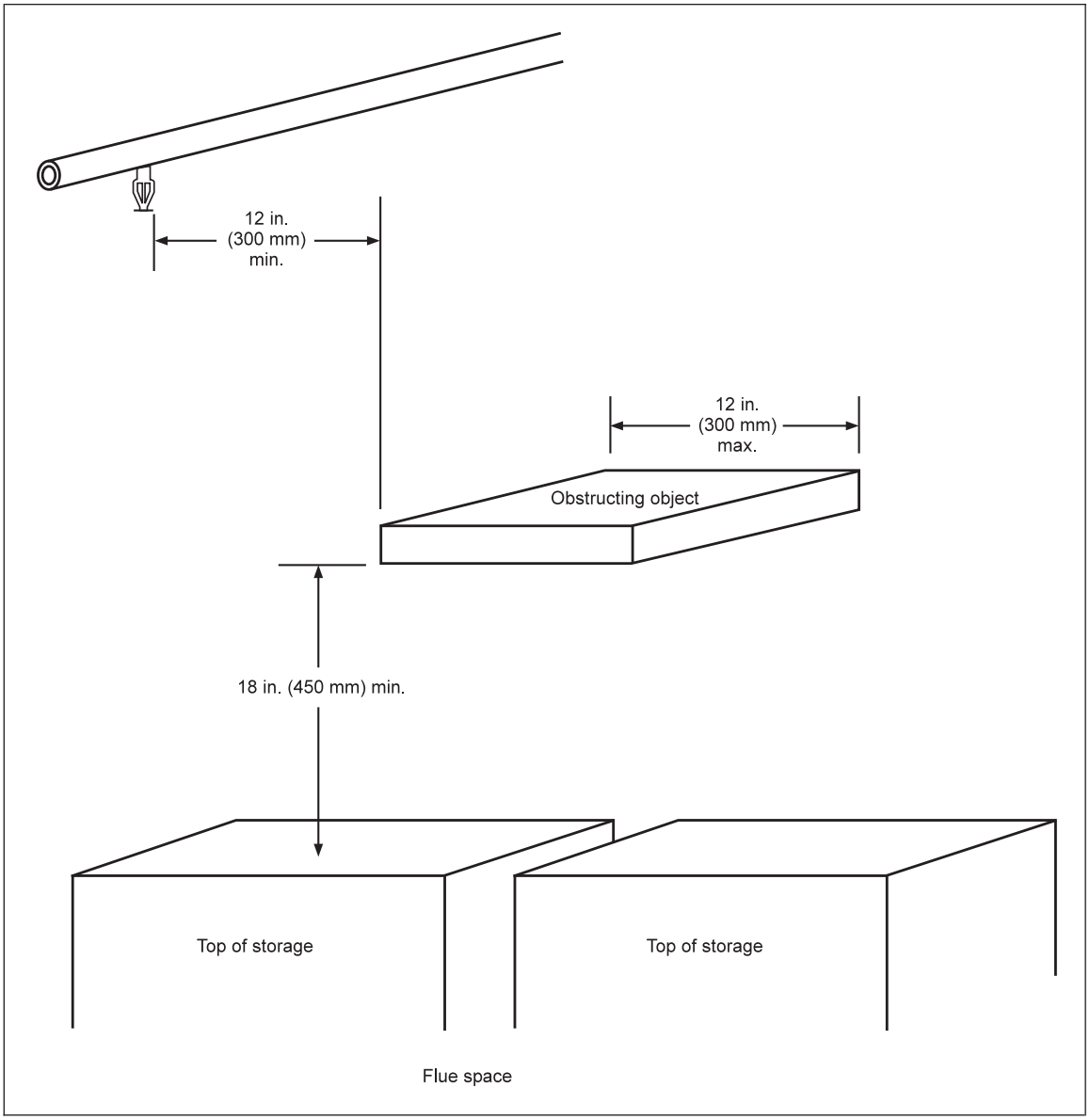

Fig. 37. Obstruction area to inner core discharge pattern of pendent Storage sprinklers for objects over 2 in. (50 mm) and up to 12 in. (300 mm) wide

An upright Storage sprinkler can be used as a replacement for an obstructed pendent sprinkler, provided all of the following criteria are met:

- The upright Storage sprinkler has the same K-factor, nominal temperature rating, nominal RTI, and recommended spacing as the obstructed pendent Storage sprinkler, and
- The upright Storage sprinkler is appropriate for the occupancy hazard, and
- The upright Storage sprinkler is not considered obstructed (see Note 1 of Table 20)

2.2.3.5.2.1 Additional Sprinklers for Objects Wider than 24 in. (600 mm) in Least Dimension that Obstruct a Sprinkler's Inner Core Distribution Pattern

For objects wider than 24 in. (600 mm) that obstruct a sprinkler's inner core distribution pattern, install sprinklers in one of the following ways:

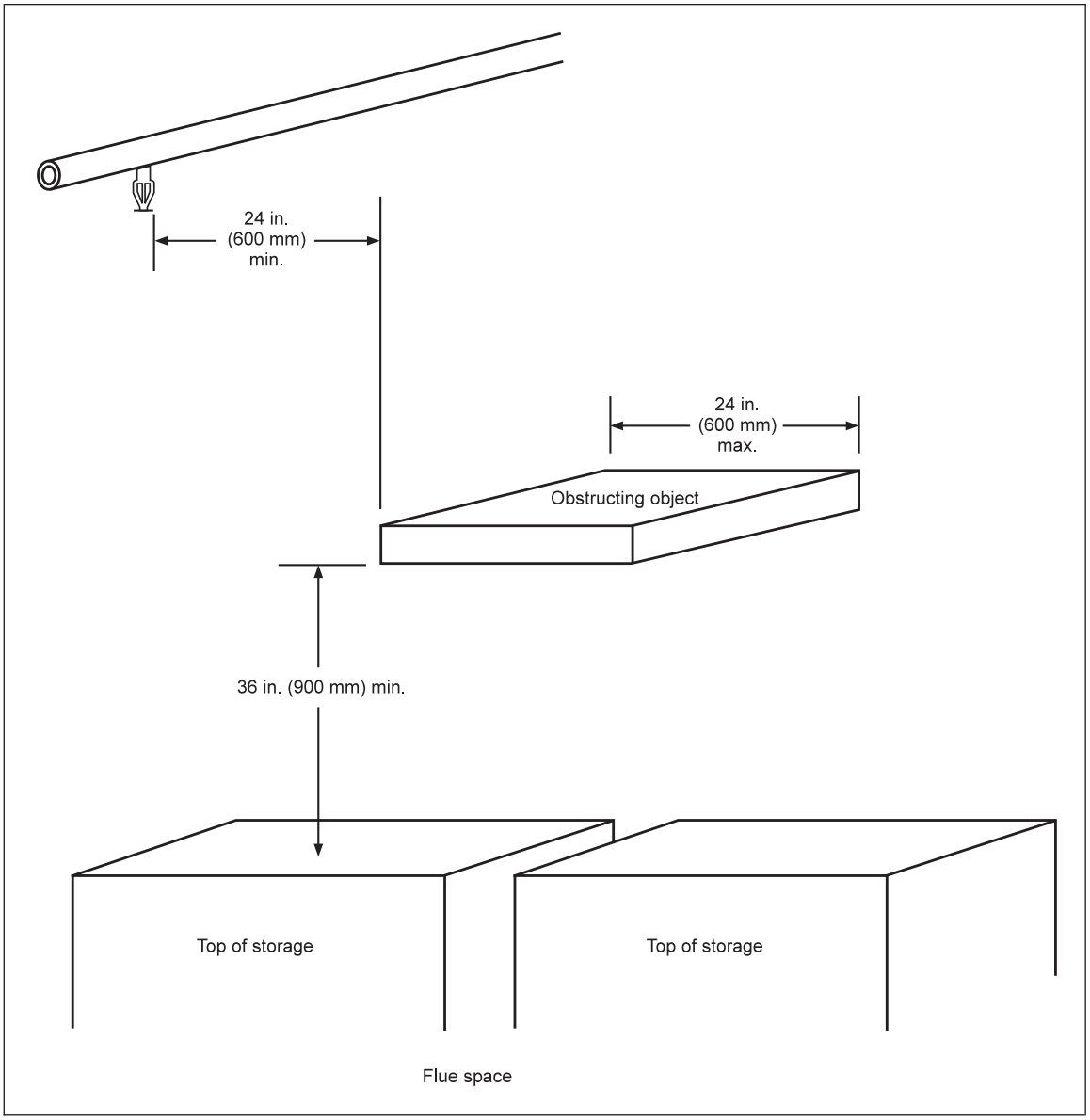

Fig. 38. Obstruction area to inner core discharge pattern of pendent Storage sprinklers for objects over 12 in. (300 mm) and up to 24 in. (600 mm) wide

(a) For flat, continuous, solid objects up to 4 ft (1.2 m) wide, install a single line of ceiling-level sprinklers centered under the object on a maximum linear spacing of 8 ft (2.4 m) fed by the same branchline pipe size used at ceiling-level. See Figure 39 for a diagram of this arrangement.

(b) For flat, continuous, solid objects from 4 ft (1.2 m) wide to 10 ft (3.0 m) wide, install ceiling-level sprinklers under the object on a maximum linear spacing of 8 ft (2.4 m) and area spacing of 64 ft^2 (6.0 m^2) fed by the same branchline pipe size used at ceiling-level. Maintain a minimum 3 ft (0.9 m) vertical distance between the sprinkler deflector and the top of storage. See Figure 39 for a diagram of this arrangement.

(c) For flat, continuous, solid objects over 10 ft (3.0 m) wide, treat the underside of the object as a ceiling and install ceiling-level sprinklers for this area fed by the same branchline pipe size used at ceiling-level and in accordance with the recommendations in Sections 2.2.3.1 through 2.2.3.4. Maintain a minimum 3 ft (0.9 m) vertical distance between the sprinkler deflector and the top of storage.

(d) For non-flat, non-continuous, or non-solid objects, install a flat, continuous, solid barrier of equal width under the object and install sprinklers as recommended in options (a), (b), or (c) depending on the width of the object. See Figure 40 for a diagram of this arrangement.

(e) As an alternative to option (d), install quick-response ceiling-level sprinklers under the object on a maximum 4 ft (1.2 m) linear spacing and a maximum 16 ft^2 (1.5 m^2) area spacing fed by the same branchline pipe size used at ceiling-level. Maintain a minimum 3 ft (0.9 m) vertical distance between the sprinkler deflector and the top of storage. See Figure 41 for a diagram of this arrangement.

(f) As an alternative to options (a) through (e) when protecting rack storage, install ceiling-level sprinklers at the top of the storage rack at all flue space intersections (face and longitudinal) that are affected in a Plan View by the obstructing object; feed these sprinklers using the same branchline pipe size used at ceiling-level. Limit the height of storage above these sprinklers to 5 ft (1.5 m) maximum. See Figure 42 for a diagram of this arrangement.

Options (e) and (f) negate the need for a flat, continuous, solid barrier under the obstructing object. Option (f) can also be implemented when a minimum 3 ft (0.9 m) clearance cannot be maintained between the deflectors of the additional sprinklers and the top of storage.

For options (a) through (e), maintain a minimum 3 ft (0.9 m) vertical distance between the deflector of the additional sprinklers and the top of storage. This is not required for option (f) because the additional sprinklers are installed as in-rack sprinklers.

For options (a) through (f), the additional sprinklers installed under the obstruction as recommended above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

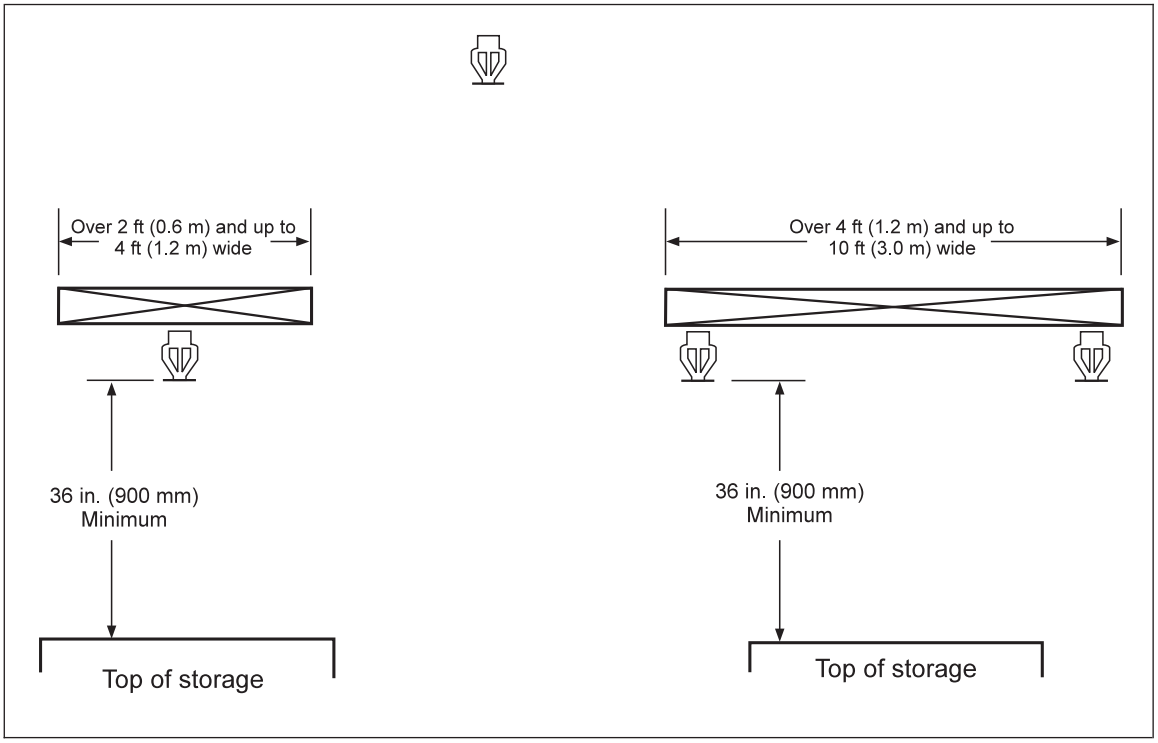

Fig. 39. Additional sprinklers installed below flat, continuous, solid obstructions from over 2 ft (0.6 m) wide to 10 ft (3.0 m) wide

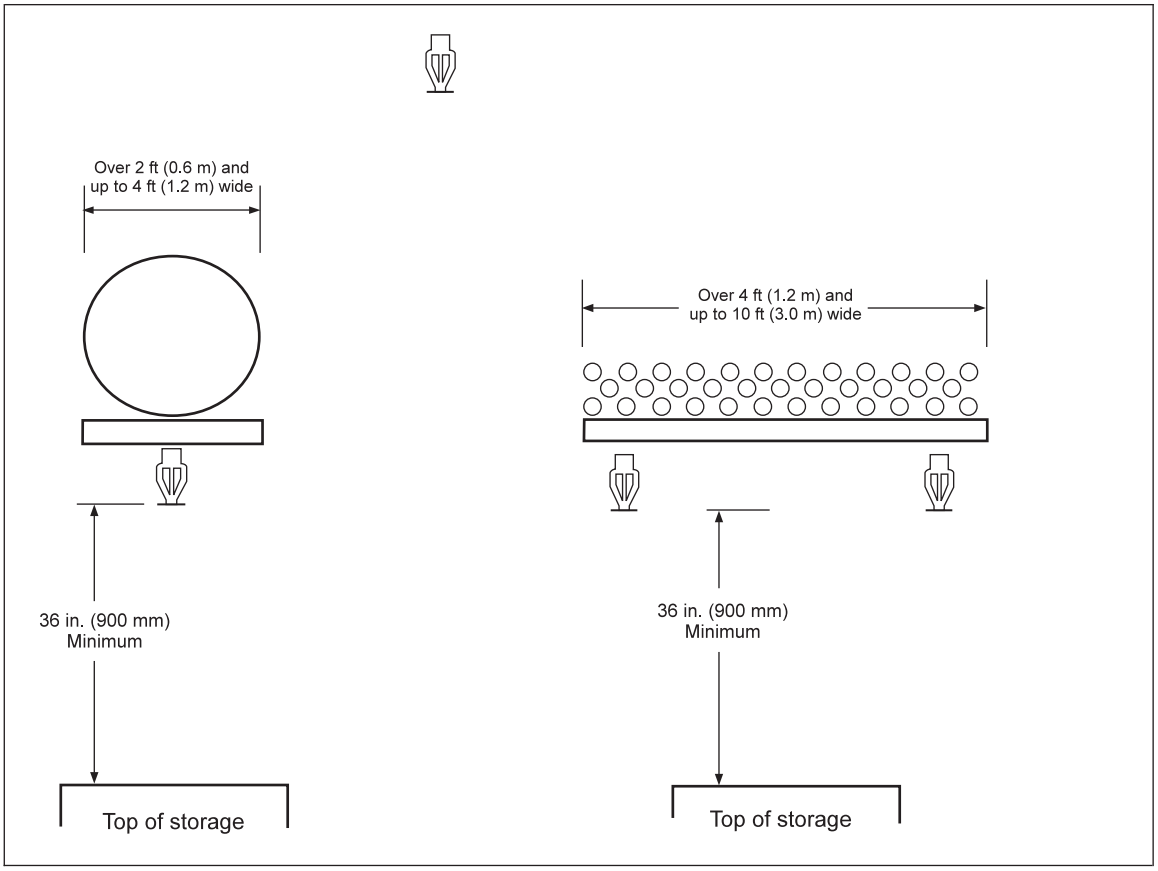

Fig. 40. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions more than 2 ft (0.6 m) wide up to 10 ft (3.0 m) wide

2.2.3.5.3 Obstruction to In-Rack Storage Sprinklers

Locate all in-rack sprinklers within the rack storage array. Position the in-rack sprinklers so they are not directly behind rack uprights, and are no more than 3 in. (75 mm) horizontally away from the transverse flue space intersection they are intended to protect.

Position the in-rack sprinkler's deflector so it is at or just below the bottom of the rack's horizontal support member at each tier level under full load condition where in-rack sprinklers are recommended. When in-rack sprinklers are not provided at every transverse flue space intersection, ensure a minimum 6 in. (150 mm) clearance is provided between the deflector of the in-rack sprinkler and the top of storage.

Arrange sprinkler piping and the in-rack sprinklers to avoid mechanical damage, but ensure proper distribution from the in-rack sprinkler can be achieved. Prior to installing the in-rack sprinklers, check the proposed in-rack sprinkler locations to ensure both adequate protection against mechanical damage and proper sprinkler discharge.

2.3 Special Protection Sprinklers

2.3.1 Construction and Location

See the occupancy-specific data sheet for construction and location guidelines regarding Special Protection sprinklers.

2.3.2 Occupancy

See the occupancy-specific data sheet for occupancy guidelines regarding Special Protection sprinklers.

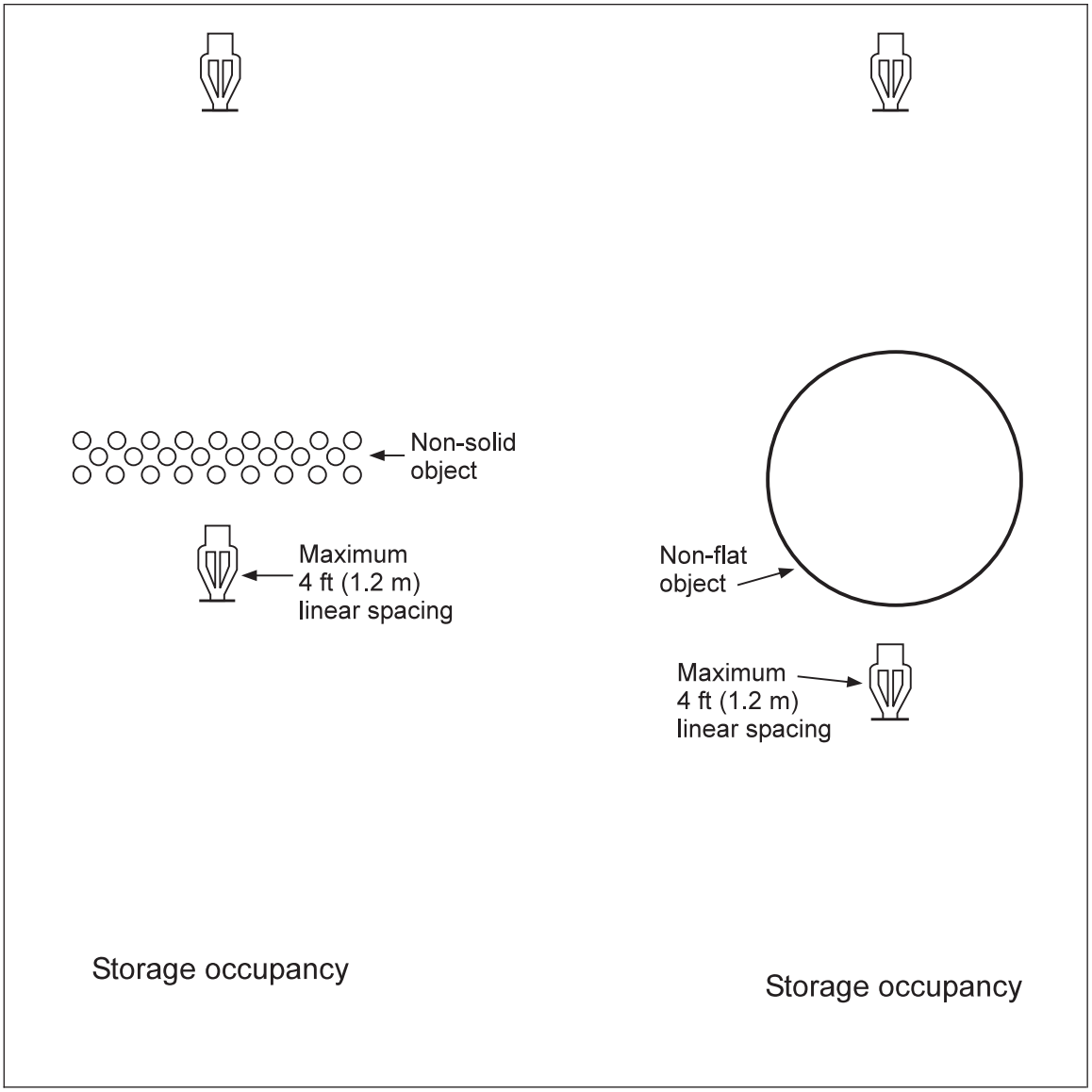

Fig. 41. Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions over 2 ft (0.6 m) and up to 10 ft (3.0 m) wide without a flat, continuous, solid barrier provided

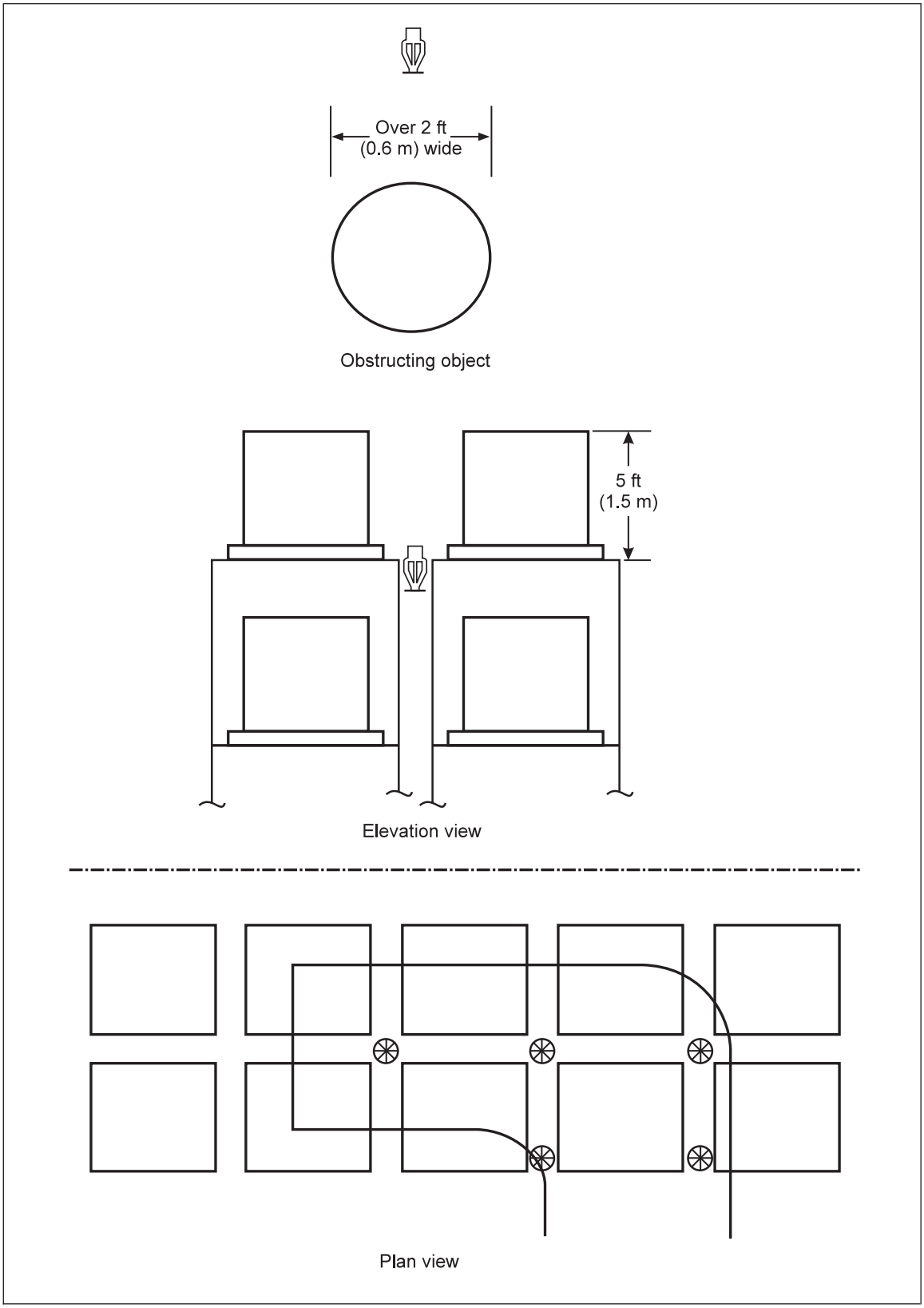

Fig. 42. Additional sprinklers installed within storage racks to account for obstructions to the inner core distribution pattern of a sprinkler

2.3.3 Protection

Special protection sprinklers are sprinklers used for the protection of special non-room types of environments, such as anechoic chambers, combustible concealed spaces, internal ductwork, cooling towers, oil-filled transformers, exterior exposed walls, as well as windows and cornices.

Determine the type of system (e.g., wet or dry) to be installed per Section 2.4.

Determine the installation requirements for the sprinkler system's piping, connection, and support per Section 2.5.

Determine the installation guidelines for the sprinklers being used per the relevant occupancy-specific data sheet.

Use sprinkler system accessories that are in accordance with Section 2.6.

2.4 Sprinkler System Types

2.4.1 General

2.4.1.1 Selection of Sprinkler System

The selection of a particular type of sprinkler system is determined in large part by the expected ambient temperatures in the area to be protected. The type of system used may also be determined by the potential exposure of water damage to the protected area.

A wet-pipe sprinkler system usually is preferred, due to its ability to discharge water immediately onto a fire upon the first sprinkler operation, as well the system's reliance on fewer mechanisms to function properly (i.e., higher reliability).

See the relevant occupancy-specific data sheet for the type(s) of sprinkler system recommended for installation.

See Appendix A for the definition of each type of sprinkler system listed in this section.

2.4.1.2 New Components for Sprinkler Systems

Use only new, FM Approved sprinkler system components. Ensure the components are compatible with each other and their application is in accordance with their listing in the *Approval Guide*. Components include, but are not limited to, the following:

- Sprinklers and sprinkler escutcheons (see Sections 2.1.3 for Nonstorage sprinklers, 2.2.3 for Storage sprinklers and 2.3.3 for Special Protection sprinklers)
- Sprinkler system valves (alarm check, dry-pipe, etc.) (see Section 2.4)
- Sprinkler system valve accessories (accelerators, etc.) (see Section 2.4.3)
- Sprinkler system piping (see Section 2.5.2)
- Sprinkler system pipe connections (see Section 2.5.3)
- Sprinkler system piping supports / hanging and bracing (see Section 2.5.4)
- Sprinkler system control valves (see Section 2.6.2)
- Sprinkler system check valves (see Section 2.6.3)
- Sprinkler system waterflow alarms (see Section 2.6.4)
- Sprinkler system inspectors test connections (see Section 2.6.5)
- Sprinkler system pressure gauges (see Section 2.6.6)
- Sprinkler system fire service connections (see Section 2.6.7)
- Sprinkler system drain valves (see Section 2.6.8)
- Sprinkler system relief valves (see Section 2.6.9)

2.4.1.3 Compatibility of Sprinkler System Components With Environment

Ensure the materials chosen for the sprinkler system are compatible with the environment they will be protecting. See the *Approval Guide* for sprinkler system components that can be used in atypical environments, such as corrosive, low- or high-temperature environments.

2.4.1.4 Design of Sprinkler Systems

For sprinkler system design guidance, refer to the relevant occupancy-specific data sheet.

Post the sprinkler system's design criteria on a rigid placard installed at the system valve. At a minimum, include the following information:

- Name of the area protected by the sprinkler system
- Classification of the occupancy hazard
- Sprinkler's SIN
- Nominal temperature rating of the sprinklers
- Maximum area spacing of the sprinklers
- Number of sprinklers in the design
- Minimum sprinkler design pressure
- Flow and pressure required at the base of the riser
- Hose stream allowance
- Name of installing contractor

For antifreeze solution systems, see Section 2.4.7.3 for additional required information.

2.4.1.5 Hydraulic Calculation of Sprinkler Systems

See Data Sheet 3-0, *Hydraulics of Fire Protection Systems*.

2.4.1.6 Sprinkler System Maximum Area of Coverage

The maximum area of coverage for a sprinkler system is limited only by (1) the hydraulic requirements of the sprinkler system's design and (2) the waterflow alarm requirements outlined in Section 2.6.4.

Note: If the local authority having jurisdiction (AHJ) limits a sprinkler system's area of coverage based on a local code, follow the local code.

2.4.1.7 Arranging Sprinkler Systems for Flushing

Arrange all sprinkler systems for flushing by providing removable fittings (i.e., flushing connections; see Appendix A for definition) at the end of all cross mains. The diameter of the flushing connection can be minimum 1.25 in. (32 mm) up to a maximum of 2 in. (50 mm).

Arrange all branchlines on grid-type sprinkler systems to facilitate flushing by having one end of each branchline be detachable by means of a simple union or flexible joint (see Figure 43). Other arrangements that accomplish this goal, such as the installation of FM Approved branchline testers, are acceptable.

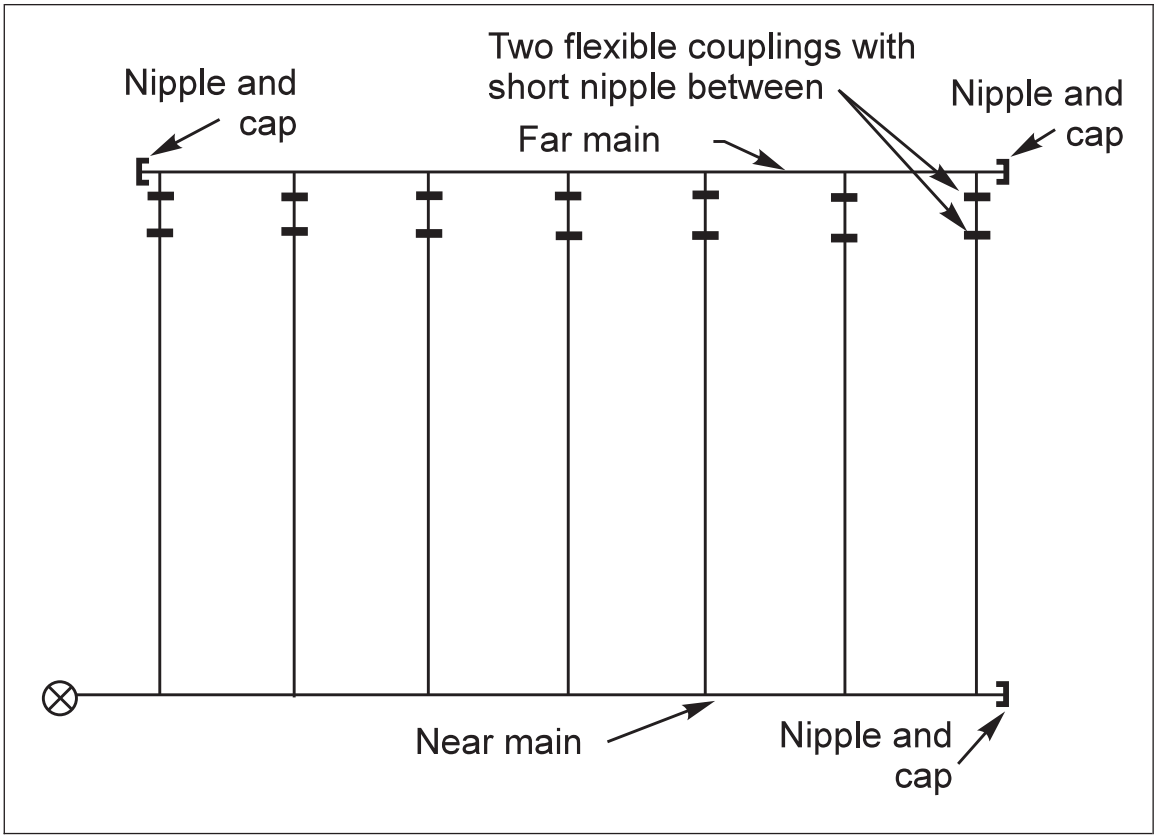

Fig. 43. Provision for flushing grid-type sprinkler systems

2.4.1.8 Protection of Sprinkler System from Mechanical and/or Freeze Damage

Ensure all parts of a sprinkler system are protected against potential freeze-up. See Data Sheet 9-18, *Protection Against Freeze-Ups*, for recommendations.

Regardless of the sprinkler system type, ensure the automatic system valve (alarm check, dry-pipe, etc.) servicing the sprinkler system is protected against mechanical damage as well as exposure to potential freezing conditions. If the automatic system valve can potentially be exposed to freezing conditions, do the following:

(a) Locate the system valve in a noncombustible enclosure near the area it protects, and

(b) Provide the enclosure with adequate lighting as well as a fixed-in-place reliable heat source that will prevent any water in the sprinkler system from freezing (see Data Sheet 9-18, *Prevention of Freeze-Ups*), and

(c) Size the enclosure to allow for easy access to all components of the system valve servicing the sprinkler system.

2.4.1.9 Additives and Chemicals for Sprinkler Systems

Unless recommended otherwise in this data sheet or a relevant occupancy-specific data sheet, do not use any fluid in an automatic sprinkler system other than water or an antifreeze solution as described in Section 2.4.7. Do not use additives and/or chemicals intended to improve the performance of the sprinkler system unless they are FM Approved specifically for such purposes.

2.4.1.10 Water Supplies for Sprinkler Systems

Provide each sprinkler system with at least one reliable water supply capable of meeting the total flow and pressure demand (ceiling, in-rack, and hose stream), as well as duration for the occupancy hazard the sprinkler system is designed to protect. See the appropriate 3-series data sheet for the type of water supply to be provided. Arrange the water supply in accordance with Data Sheet 3-10, *Installation/Maintenance of Private Service Mains and Their Appurtenances*.

Note that the water supply for domestic use can tap off the water supply for a sprinkler system, provided the feed connection for the domestic supply is upstream of the waterflow alarm and fire service connection on the sprinkler system riser.

2.4.2 Wet-Pipe Sprinkler Systems

Wet-pipe sprinkler systems are recommended only in areas where the ambient temperature can maintain the sprinkler water at or above 40°F (4°C) and at or below 200°F (95°C) at all times.

2.4.3 Dry-Pipe Sprinkler Systems

2.4.3.1 Recommended Ambient Temperature Conditions

Dry-pipe sprinkler systems are acceptable when the ambient temperature of the protected area can drop below 40°F (4°C) or rise above 200°F (95°C). Use a refrigerated-area sprinkler system instead of a dry-pipe system if the ambient temperature of the protected area is maintained below 20°F (-7°C) at all times.

Ensure the components of the sprinkler system are compatible with the expected ambient temperatures.

2.4.3.2 Dry-Pipe Valve in Combination With Other System or Check Valves

Do not install other system valves (such as preaction or deluge valves) or check valves in the waterway downstream of the dry-pipe valve.

2.4.3.3 Excessive Water Accumulation Above the Dry-Pipe Valve Clapper

Provide an automatic high-water level signaling device or an automatic drain device for any dry-pipe valve where an unacceptable level of water can accumulate above the clapper, such as with a low-differential dry-pipe valve.

2.4.3.4 Sprinklers for Dry-Pipe Sprinkler Systems

Install only upright or dry-type sprinklers (dry-pendent, dry-upright, or dry-sidewall sprinklers) on a dry-pipe sprinkler system.

See the relevant occupancy-specific data sheet for additional recommendations.

2.4.3.5 Sprinkler Piping Arrangement of Dry-Pipe Sprinkler Systems

Arrange the sprinkler piping of a dry-pipe sprinkler system as follows:

- To provide single-path flow within all parts of the sprinkler system, and
- To meet the maximum recommended water delivery time once the first sprinkler has operated, and
- To meet the recommendations in Section 2.4.1.6.

Exception: The feedmain or crossmain of a dry-pipe sprinkler system protecting a nonstorage occupancy can be looped, as opposed to single-path flow, but must still meet the other two criteria listed above.

See the relevant occupancy-specific data sheet for the maximum recommended water delivery time.

2.4.3.6 Accelerators for Dry-Pipe Sprinkler Systems

When installing an accelerator on a dry-pipe sprinkler system, ensure the *Approval Guide* indicates the accelerator is compatible for the particular dry-pipe valve being used.

Follow the manufacturer's installation guidelines for the specific accelerator being installed. Ensure the following conditions are met:

(a) Locate the connection of the accelerator to the riser above the point at which water (priming water and back drainage) is expected when the dry-pipe valve and the accelerator are set.

Exception: This connection arrangement is not required when the design features of the chosen accelerator prevent submergence of the restriction orifice as well as other operating parts of the accelerator.

(b) Install an indicating control valve and an FM Approved anti-flooding device between the riser and the accelerator.

Exception: An anti-flooding device is not required when using FM Approved accelerators with built-in anti-flooding devices.

(c) Install a check valve between the accelerator and the intermediate chamber of the dry-pipe valve. An indicating valve may be installed in place of the check valve if the accelerator requires pressure feedback.

Exception: This does not apply to (a) FM Approved accelerators with built-in anti-flooding devices, or (b) FM Approved accelerators that are not expected to flood.

2.4.3.7 Gas Supply for Dry-Pipe Sprinkler Systems

The gas used for maintaining internal pressure within the dry-pipe sprinkler system can be dry air, an inert gas, or a gas that is FM Approved specifically for this application. Ensure the gas used in the dry-pipe sprinkler system is compatible with all sprinkler system components.

Arrange the gas supply so it is available at all times for the dry-pipe sprinkler system in accordance with the dry-pipe valve manufacturer's specifications.

Ensure the gas supply maintained on site is reliable (see Appendix A for definition of reliable gas supply), and is capable of filling the dry-pipe automatic system up to the minimum required system maintenance pressure within 30 minutes, but is also arranged to:

- Allow the dry-pipe sprinkler system to meet the maximum recommended water delivery time outlined in Section 2.4.3.5, and
- Not exceed the maximum recommended gas pressure maintained in the sprinkler system.

Install a check valve on the connection between the gas supply and the dry-pipe sprinkler system.

Install a relief valve between the gas supply and the sprinkler system arranged to relieve at 5 psi (0.3 bar) above the maximum recommended gas pressure maintained within the sprinkler system.

2.4.4 Preaction Sprinkler Systems

2.4.4.1 General

Preaction sprinkler systems may be arranged as follows:

(a) Non-interlock sprinkler systems, or

(b) Single-interlock sprinkler systems, or

(c) Double-interlock sprinkler systems

When used to protect areas that are subject to freezing, install all double-interlock sprinkler systems in accordance with the recommendations for refrigerated-area sprinkler systems (see Section 2.4.6).

Use a preaction valve, solenoid valve, and automatic-release panel combination that is FM Approved as a compatible automatic sprinkler system. Ensure its application, along with the chosen detection system, is in accordance with the listing outlined in the *Approval Guide*.

2.4.4.2 Recommended Ambient Temperature Conditions

Preaction sprinkler systems are acceptable when the ambient temperature of the protected area is not maintained below 20°F (-7°C) at all times. Use a refrigerated-area sprinkler system instead of a preaction system, however, if the ambient temperature of the protected area is maintained below 20°F (-7°C) at all times.

Ensure the components of the sprinkler system are compatible with the expected ambient temperatures.

2.4.4.3 Automatic and Manual Release of Preaction Sprinkler Systems

See Data Sheet 5-48, *Automatic Fire Detection*, for recommended arrangements of detectors and control panels used to activate a preaction valve.

Arrange preaction systems to be activated both automatically and manually. Provide a readily accessible means for the preaction valve to be manually activated during a fire.

2.4.4.4 Preaction Valve in Combination With Other System or Check Valves

Unless recommended otherwise by a relevant occupancy-specific data sheet, do not install other system valves, such as dry-pipe valves or deluge valves, or check valves in the waterway downstream of the preaction valve.

2.4.4.5 Excessive Water Accumulation Above the Preaction Valve

Provide an automatic high-water level signaling device or an automatic drain device for any preaction valve where an unacceptable level of water can accumulate above the releasing mechanism and prevent the flow of water through the valve.

2.4.4.6 Sprinklers for Preaction Sprinkler Systems

Install only upright or dry-type (e.g., dry pendent, dry-upright, or dry-sidewall sprinklers) on a preaction sprinkler system.

Exception: Pendent sprinklers can be installed on a preaction sprinkler system if the protected area is not subject to freezing and the inside of the piping is protected against corrosion.

2.4.4.7 Sprinkler Piping Arrangement of Preaction Sprinkler Systems

Arrange the sprinkler piping of a single-interlock preaction sprinkler system as follows:

- To provide single-path flow within all parts of the sprinkler system, and
- To meet the recommendations in Section 2.4.1.6.

Exception: The feedmain or crossmain of a single-interlock preaction sprinkler system protecting a nonstorage occupancy can be looped as opposed to single-path flow, but must still meet the recommendations in Section 2.4.1.6.

Arrange the sprinkler piping of a non-interlock or double-interlock preaction sprinkler system as follows:

- To provide single-path flow within all parts of the sprinkler system, and
- To meet the maximum recommended water delivery time once the first sprinkler has operated, and
- To meet the recommendations in Section 2.4.1.6.

Exception: The feedmain or crossmain of a non-interlock or double-interlock preaction sprinkler system protecting a nonstorage occupancy can be looped as opposed to single-path flow, but must still meet the other two criteria listed above.

See the relevant occupancy-specific data sheet for the maximum recommended water delivery time.

2.4.4.8 Gas Supply for Preaction Sprinkler Systems

Provide the gas supply for a preaction sprinkler system in accordance with the recommendations in Section 2.4.3.7 for dry-pipe sprinkler systems.

2.4.5 Deluge Sprinkler Systems

2.4.5.1 General Information

When activated electronically, use a deluge valve, solenoid valve, and automatic-release panel combination FM Approved as a compatible automatic sprinkler system. Ensure its application, along with the chosen detection system, is in accordance with its listing in the *Approval Guide*.

Apply all of the recommendations in Section 2.4.4 related to preaction sprinkler systems to deluge sprinkler systems except as follows:

(a) Section 2.4.4.1: This section only applies to preaction sprinkler systems.

(b) Section 2.4.4.2: There are no ambient temperature restrictions for the use of deluge sprinkler systems. However, ensure the deluge sprinkler system components are compatible for the environment they will be installed in.

(c) Section 2.4.4.6: Use FM Approved sprinklers that have had the fusible element and the orifice cap removed and are recommended for the hazard being protected, or FM Approved open water-spray nozzles that are recommended for the hazard being protected.

(d) Section 2.4.4.7: The sprinkler piping of a deluge system does not have to be arranged for single-path flow.

(e) Section 2.4.4.8: A gas supply is not required for the deluge sprinkler system.

2.4.5.2 Sprinkler Piping Arrangement of Deluge Sprinkler Systems

Ensure the arrangement of the deluge sprinkler system piping can meet both:

- the maximum allowable water delivery time for the chosen system design pressure, and
- the guidelines outlined in Section 2.4.1.6.

See the relevant occupancy-specific data sheet to determine the maximum water delivery time based on the design pressure chosen.

2.4.6 Refrigerated-Area Sprinkler Systems

Use a refrigerated-area sprinkler system if the ambient temperature of the protected area is maintained below 20°F (-7°C) at all times. See Data Sheet 8-29, *Refrigerated Storage,* for other installation guidelines regarding refrigerated-area sprinkler systems.

2.4.7 Antifreeze Solution Sprinkler Systems

2.4.7.1 Recommended Ambient Temperature Conditions

A 30% solution propylene glycol antifreeze system is acceptable if the ambient temperature of the protected area is maintained at or above 25°F (-4°C), as well as at or below 200°F (95°C) at all times.

Use either a dry-pipe or preaction sprinkler system if the ambient temperature of the protected area can drop below 25°F (-4°C) or can rise above 200°F (95°C). Use a refrigerated-area sprinkler system if the ambient temperature of the protected area is maintained below 20°F (-7°C) at all times.

Exception 1: An antifreeze solution sprinkler system may be installed for ambient temperatures below 25°F (-4°C) when the antifreeze solution is specifically FM Approved for 10 degrees F (6 degrees C) below the expected lowest ambient temperature condition and the relevant occupancy-specific data sheet allows the use of an antifreeze solution system. Base the required concentration of the antifreeze solution on a temperature that is 10 degrees F (6 degrees C) lower than the lowest expected ambient temperature in the protected area.

Exception 2: An antifreeze solution sprinkler system, as outlined in Table 21, can be used if the ambient temperature of the protected area can drop below 25°F (-4°C), as long as size of the protected area does not exceed 2,000 ft^2 (185 m^2).

Ensure the components of the sprinkler system are compatible with the antifreeze solution, as well as the expected ambient temperatures.

2.4.7.2 Compatibility of Antifreeze Solution and Sprinkler System Components

Use FM Approved sprinkler system components that are compatible with the antifreeze solution at the expected ambient temperature range of the occupancy hazard being protected.

2.4.7.3 Documentation of Antifreeze Solution Sprinkler Systems

Install a placard on the antifreeze solution sprinkler system that lists the type, percent concentration, and volume of antifreeze solution required for the sprinkler system. Also include the lowest ambient temperature the antifreeze solution was designed for.

2.4.7.4 Sprinkler Piping Arrangement of Antifreeze Solution Sprinkler Systems

If the antifreeze solution sprinkler system is fed from a potable water supply, arrange the supply piping, backflow preventer, and expansion chamber in accordance with Figure 44.

Size the expansion chamber to account for 1.5 times the maximum expected thermal expansion of the antifreeze solution for the anticipated maximum and minimum ambient temperatures. Ensure the expansion chamber is compatible with the antifreeze solution.

If the antifreeze solution sprinkler system is fed from a non-potable water supply, do one of the following:

(a) Arrange the supply piping and valves in accordance with Figure 44, or

(b) Arrange the supply piping and valves in accordance with Figure 44, but replace the indicated backflow preventer with a check valve equipped with a 1⁄32 in. (0.8 mm) hole in the clapper. The expansion tank is optional with this arrangement.

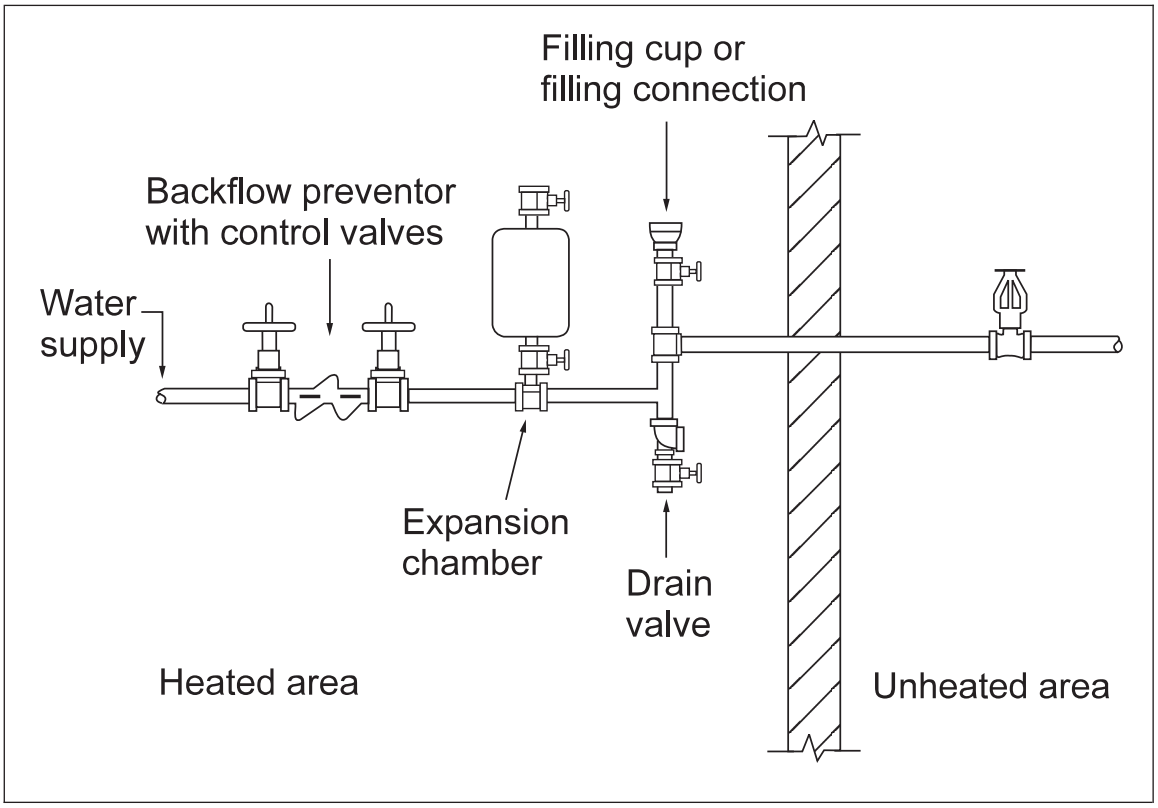

Fig. 44. Antifreeze solution sprinkler system piping arrangements connected to a potable water supply

2.4.7.5 Antifreeze Solution

Where applicable, use an FM Approved antifreeze solution compatible for the occupancy hazard being protected. If an FM Approved antifreeze solution is not available, use an antifreeze solution listed in Table 21 based on the concentration for the maximum lowest expected ambient temperature in the protected area.

Pre-mix the antifreeze solution and validate its concentration percentage before introducing it into the sprinkler system.

For any antifreeze solution that will be connected to a potable water supply, use only those antifreeze solutions that are acceptable to the authority having jurisdiction.

Table 21. Recommended Concentration Levels for Antifreeze Solutions in Water for Ambient Temperature Conditions per Section 2.4.7.5

Solution Material	*Concentration Percentage (by Volume in Water)*[1]	*Maximum Lowest Ambient Temperature of the Protected Area, °F (°C)*
Diethylene Glycol	50	-3 (-19)
	55	-17 (-27)
	60	-32 (-36)
Ethylene Glycol	39	0 (-18)
	44	-10 (-23)
	49	-20 (-29)
	53	-30 (-34)
Glycerine (C.P. or U.S.P. 96.5)[2]	50	-5 (-21)
	60	-12 (-24)
	70	-30 (-34)
Propylene Glycol	30	25 (-4)
	40	4 (-16)
	50	-16 (-27)
	60	-50 (-46)

[1] See Data Sheet 2-81, *Fire Safety Inspections and Sprinkler System Maintenance*, for specific gravity measurements.
[2] C.P. = chemically pure; U.S.P. = United States Pharmacopoeia

2.4.8 Exposure-Protection Sprinkler System

Follow the recommendations for dry-pipe sprinkler systems in Section 2.4.3 for an exposure-protection sprinkler system that uses either closed-type sprinklers or automatic water-spray-type nozzles, and where the system is activated in the same manner as a dry-pipe sprinkler system.

Follow the recommendations for preaction sprinkler systems in Section 2.4.4 for an exposure-protection sprinkler system that uses either closed-type sprinklers or automatic water-spray-type nozzles, and where the system is activated in the same manner as a preaction sprinkler system.

Follow the recommendations for deluge sprinkler systems in Section 2.4.5 for an exposure-protection sprinkler system that uses either open-type sprinklers or open water-spray-type nozzles.

Check the *Approval Guide* to ensure the sprinklers chosen for the exposure-protection sprinkler system are FM Approved for the hazard they are intended to protect.

2.5 Sprinkler Piping: Connection, Hanging, and Bracing

2.5.1 General

For a sprinkler system to perform properly during a fire, the network of piping that delivers water from its source to the open sprinklers must be capable of withstanding both the internal pressure acting upon it and high external temperatures. In addition, the piping network must be properly supported and able to maintain its structural integrity during an earthquake. It must also be installed so it does not interfere with the sprinkler's water discharge.

The following sections provide installation guidance for the type of piping used in the sprinkler system, its method of connection, and its method of support.

This section does not provide guidance on the installation of below-ground piping used for feeding water supplies to a sprinkler system; see Data Sheet 3-10, *Installation/Maintenance of Private Service Mains and Their Appurtenances*, for installation guidelines for this type of piping system.

2.5.2 Sprinkler System Piping

2.5.2.1 General

Use only new sprinkler system piping.

When using flexible metallic pipe, ensure it is FM Approved and compatible with the hazard it is intended to protect. Follow the manufacturer's guidelines for installing the pipe and refer to their guidelines for analysis of the anticipated friction loss through the length of pipe installed.

When using non-metallic pipe, ensure it is FM Approved and compatible with the hazard it is intended to protect. Check the manufacturer's installation guidelines to ensure the compatibility of the non-metallic sprinkler pipe with all other sprinkler system components. See Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*, for restrictions involving non-metallic sprinkler pipe in areas subject to earthquakes.

When using CPVC pipe, ensure it is FM Approved and meets all other guidelines above for non-metallic pipe. Use it only for the following:

- Any occupancy hazard protected by Nonstorage sprinklers when the pipe is shielded from the fire area by a non-removable barrier having a fire rating equal to or greater than 1 hour, or
- Any occupancy hazard protected by quick-response Nonstorage sprinklers when the pipe is not shielded from the fire area, but all of the following conditions are met:
    - The pipe can be protected by a sprinkler design that is based on a flow application rate equal to 0.10 gpm/ft^2 (4 mm/min), and
    - The pipe is installed on a wet-pipe sprinkler system, and
    - Any CPVC vertical risers are protected by a quick-response ceiling-level Nonstorage sprinkler located no more than 1 ft (0.3 m) horizontally from the vertical riser pipe.

For rigid metallic pipe, ensure it meets the minimum wall thickness indicated in Table 22. Use FM Approved piping when the wall thickness of the rigid metallic pipe will be less than that shown in Table 22.

Table 22. Minimum Wall Thickness of Rigid Metallic Sprinkler Piping

Nominal Pipe Diameter, in. (mm)	*Minimum Wall Thickness of Non-FM Approved Sprinkler Pipe, in. (mm)*
1 (25)	0.100 (2.60)
1¼ (32)	0.100 (2.60)
1½ (40)	0.100 (2.60)
2 (50)	0.100 (2.60)
2½ (65)	0.115 (2.90)
3 (80)	0.115 (2.90)
3½ (90)	0.115 (2.90)
4 (100)	0.115 (2.90)
5 (125)	0.130 (3.30)
6 (150)	0.130 (3.30)
8 (200)	0.180 (4.50)
10 (250)	0.180 (4.50)
12 (300)	0.180 (4.50)

Ensure the pipe's application is in accordance with its listing in the *Approval Guide*, the relevant occupancy-specific data sheet, and any specific jurisdictional requirements.

Ensure the sprinkler system piping is compatible with the environment it will be protecting, including the highest expected internal pressure. Sprinkler system piping that is to be installed in atypical environments, such as corrosive, low-temperature or high-temperature environments, needs special consideration. See the *Approval Guide* for sprinkler system piping that can be used where the expected internal pressure will exceed 175 psi (12.1 bar). See Data Sheet 2-1, *Prevention and Control of Internal Corrosion in Automatic Sprinkler Systems*, for recommendations on how to prevent internal corrosion in sprinkler system piping.

Ensure the ends of all sprinkler system pipes are smooth and free of any burrs or fins.

To help reduce the potential for accelerated internal pipe corrosion of longitudinally-welded black steel pipe, install such pipe with the weld line rotated at least 45° in relationship to the floor (for reference, the weld line points at the floor at 0°).

2.5.2.2 Bending Steel Pipe for Sprinkler Systems

Bending sprinkler system piping is permissible for any steel pipe having a minimum wall thickness of 0.109 in. (2.8 mm), provided the pipe remains round and the minimum radius of a bend is 12 pipe diameters, regardless of pipe size. See Table 23 for an exception to this recommendation.

Table 23. Steel Pipe That Does Not Require Minimum 12-Pipe Diameter Minimum Radius Bend

Nominal Pipe Diameter, in. (mm)	*Nominal Wall Thickness, in. (mm)*	*Minimum Radius Bend, Pipe Diameters*
1 (25)	0.125 (3.2)	6
1¼ (32)	0.140 (3.6)	6
1½ (40)	0.140 (3.6)	6
2 (50)	0.155 (4.0)	6
2½ (65)	0.195 (5.0)	5
3 (80)	0.220 (5.6)	5
3½ (90)	0.220 (5.6)	5
4 (100)	0.235 (6.0)	5
5 (125)	0.250 (6.3)	5
6 (150)	0.280 (7.1)	5
8 (200)	0.315 (8.0)	5
10 (250)	0.345 (8.8)	5
12 (300)	0.405 (10.3)	5

2.5.2.3 Minimum Pipe Sizes for Sprinkler Systems

Except for FM Approved flexible metal pipe used to connect an automatic sprinkler to a branchline, the minimum pipe size for sprinkler system piping (i.e., piping whose purpose is to transport water to a sprinkler) is 1 in. (25 mm).

The minimum nominal pipe diameter for any sprinkler pipe equipped with a vane-type waterflow alarm is 2 in. (50 mm).

Regardless of the sprinkler pipe size chosen, ensure it is hydraulically proven to be capable of meeting the minimum design requirements outlined in the relevant occupancy-specific data sheet.

2.5.2.4 Pitch of Dry-Type Sprinkler System Piping

Arrange dry-type (i.e., dry-pipe, preaction, etc.,) sprinkler system piping to drain back to the system's main 2 in. (50 mm) riser drain. For any part of a sprinkler system that cannot drain back to the system's main 2 in. (50 mm) drain, provide auxiliary drains (or equivalent) that will drain the sprinkler system water to a safe area.

Arrange the sprinkler system piping to be pitched ½ in. per 10 ft (4 mm/m) for all branchlines, and ¼ in. per 10 ft (2 mm/m) for all other sprinkler piping.

2.5.2.5 Protection of Sprinkler System Piping

See Data Sheet 7-14, *Protection for Flammable Liquid/Flammable Gas Processing Equipment*, for installation guidelines for sprinkler system piping in areas subject to potential explosion hazards.

Do not hang anything, including conduit, cable trays, air piping, speakers, and signs, from sprinkler system piping.

Use internally galvanized, stainless steel, or similar corrosion-resistant pipe in all new dry-pipe, preaction, refrigerated-area, deluge, and exposure-protection sprinkler systems. Do not use galvanized pipe in areas where the ambient temperature could exceed 130°F (54°C) unless the pipe is specifically FM Approved for use in such conditions.

Exception: Black steel pipe can be used in dry-pipe sprinkler systems equipped with closed-type sprinklers if the piping system is filled with an inert gas.

2.5.3 Sprinkler System Pipe Connections

2.5.3.1 General

For sprinkler systems that will be installed in 50-year through 500-year earthquake zones (as defined by FM Global Data Sheet 1-2, *Earthquakes)*, install the pipe connections in accordance with Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*.

2.5.3.2 Pipe Connections

Use only new FM Approved sprinkler system pipe connections (couplings, fittings, welded, and threaded joints) and ensure their application is in accordance with their listing in the *Approval Guide as well as* the manufacturer's product installation guidelines, the relevant occupancy-specific data sheet, and any jurisdictional requirements.

Ensure the sprinkler system pipe connections are compatible with the environment in which they will be used. Pipe connections that will be installed in atypical environments, such as those that are corrosive or in which very low or very high temperatures exist, need special consideration. Also, see the *Approval Guide* for piping and connections that can be used in sprinkler systems where the expected internal pressure will exceed 175 psi (12.1 bar). Use FM Approved one-piece reducing fittings when connecting two sprinkler system pipes of different size.

Do not allow sprinkler system pipe connections to extend into the flow path of the sprinkler system piping as this will reduce the diameter of the sprinkler pipe and restrict water flow.

2.5.3.3 Threaded Pipe Connections

Do not thread pipe with a wall thickness less than 0.133 in. (3.4 mm).

Ensure the threads of the sprinkler system piping are cut in accordance with local codes and are compatible to the threads of the sprinkler system pipe connection.

Apply joint compound, tape, or similar thread-sealing material to the male threads of all threaded connections.

2.5.3.4 Grooved Pipe Connections

Both rolled-grooved and cut-grooved pipe connections are acceptable for sprinkler pipe having a wall thickness of 0.133 in. (3.4 mm) or greater. Do not use cut-grooved pipe connections when sprinkler pipe wall thickness is less than 0.133 in. (3.4 mm). For sprinkler pipe that has a wall thickness less than 0.133 in. (3.4 mm), use FM Approved couplings that are specifically compatible with the chosen sprinkler pipe.

Ensure the groove dimensions of the sprinkler pipe meet the requirements of the grooved pipe-coupling manufacturer.

Unless indicated otherwise by the sprinkler pipe's listing in the *Approval Guide*, roll groove all sprinkler pipe prior to its being galvanized.

2.5.3.5 Plain-End Pipe Connections

Use FM Approved sprinkler pipe that is specifically compatible with FM Approved plain-end or similar pipe connections when the wall thickness of the sprinkler pipe is less than 0.133 in. (3.4 mm).

Ensure the correct torque has been applied to the plain-end connection's fasteners per the manufacturer's installation guidelines.

2.5.3.6 Welded Pipe Connections

Use FM Approved welded pipe connections and welded formations.

Ensure welding methods and qualifications for joining sprinkler system piping comply with the minimum requirements of the latest version of ANSI/AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, or equivalent method.

A fitting is not required where pipe ends are butt-welded in accordance with acceptable welding methods.

Ensure all hot work operations associated with the welding of sprinkler pipe on site are carried out in accordance with the recommendations in Data Sheet 10-3, *Hot Work Management*.

Ensure the welding environment does not adversely affect the quality of the welding.

Ensure the holes cut into sprinkler piping for fitting outlets are the same size diameter as the fitting and are free of burrs or fins.

Document that all coupons or discs cut from sprinkler piping have been removed from within the sprinkler system piping prior to placing the system in service.

2.5.4 Sprinkler System Piping Support

2.5.4.1 General

For sprinkler systems that will be installed in 50-year through 500-year earthquake zones (as defined by FM Global Data Sheet 1-2, *Earthquakes)*, install the pipe support and bracing in accordance Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems,* in addition to the recommendations below.

2.5.4.2 Pipe Supports

Use new FM Approved sprinkler system pipe supports (hangers, fasteners, etc.) and ensure their application is compatible with their listing in the *Approval Guide* as well as the manufacturer's product installation guidelines, the relevant occupancy-specific data sheet, and any jurisdictional requirements.

Ensure the pipe support assembly is compatible with the environment in which it will be installed. Pipe support assemblies that will be installed in atypical environments, such as those that are corrosive or in which very low or very high temperatures exist, need special consideration.

Ensure all auxiliary components, such as rods and angle steel, that supplement the attachment of pipe hangers and fasteners listed in the *Approval Guide* are of ferrous material and are compatible with the environment in which they will be installed.

2.5.4.3 Pipe Hanger Minimum Load Support Calculations

Ensure the building structure can support the added minimum load. When pipe hangers are attached to a non-building structure, ensure the non-building structure design takes into account the load imposed by the sprinkler system piping.

Obtain calculations that verify (a) the supporting structural member is capable of carrying the load, and (b) the piping support is attached to the structural member in accordance with the recommendations in this section.

2.5.4.3.1 Pipe Hanger Minimum Load

For the pipe hanger assembly (struts, rods, brackets, straps, etc.) and the supporting structural member (e.g., purlins, joists, beams, or slabs), base the support on a minimum design point load of two (2) times the tributary weight of the water-filled sprinkler system piping, using a safety factor of not less than 1.0 for yield strength, or 1.25 for ultimate strength; however, ensure the design point load is not less than 375 lb (170 kg).

2.5.4.3.2 Pipe Hanger Fastener Connection and Fastener Minimum Load

For pipe hanger connections and fasteners (welds, screws, bolts, etc.), use a minimum design point load of five (5) times the tributary weight of the water-filled sprinkler system piping, using a safety factor of not less than 1.0 based on the ultimate strength of the connection or fastener component; however, ensure the design point load is not less than 750 lb (340 kg).

2.5.4.3.3 Powder-Actuated and Chemical/Resin Anchors Minimum Load

For chemical/resin anchors or powder-actuated fastener systems (PAFS) where the fastener component is subjected to direct tension from the supported gravity loads, use a minimum point load of ten (10) times the tributary weight of the water-filled sprinkler system piping, using a safety factor of not less than 1.0 based on the ultimate strength of the connection or fastener component.

2.5.4.4 Attaching Pipe Hanger Assemblies

Ensure the pipe hanger fastener or anchor is compatible with the material to which it is attached (including wood) and is installed in accordance with its listing in the *Approval Guide* as well as the manufacturers' installation instructions. See additional guidance below when installing pipe hangers into steel decking, steel purlins, or concrete.

2.5.4.4.1 Attaching Pipe Hanger Assemblies to Steel Decking

Do not attach pipe hangers directly to roof decking.

Exception:

Pipe hangers supporting branchline pipe only in sizes up to and including 3 in. (75 mm) can be attached to steel decking provided all of the following conditions are met:

(1) The distance between building structural supports is more than the maximum allowable distance between piping supports for branchlines; and

(2) The pipe hanger fasteners are listed in the *Approval Guide* as compatible for steel decking; and

(3) The pipe hanger fasteners are installed in accordance with the manufacturer's installation guidelines; and

(4) The structural design of the steel decking can account for the dead, live, and collateral loads of any items attached to it, as well as the required minimum load of the sprinkler system piping.

2.5.4.4.2 Attaching Pipe Hanger Assemblies to Steel Purlins

Attach pipe hanger fasteners to C-shaped or Z-shaped steel secondary roof members (purlins) in accordance with the building manufacturer's specifications, and ensure the building structure can adequately support the added minimum load of the sprinkler system piping (based on the effective section properties of the members). If the building manufacturer is not known or is no longer available for advice, use the following guidelines:

- Z-Shaped Purlins: Attach pipe hanger fasteners to the midpoint of the vertical web. As an alternative, pipe hanger fastener can be attached to the bottom flange of the Z-shaped purlin at a point as close to the vertical web as possible, but at a distance from the vertical web no further than ½ of the flange width. Do not, under any circumstances, use the purlin flange stiffener as the point of attachment, or allow the pipe hanger assembly to come into contact with the flange stiffener.
- C-Shaped Purlins: Attach pipe hanger fasteners to the midpoint of the vertical web. Do not, under any circumstances, use the purlin flange stiffener as the point of attachment, or allow the pipe hanger assembly to come into contact with the flange stiffener.

See Figure 45 for additional guidance.

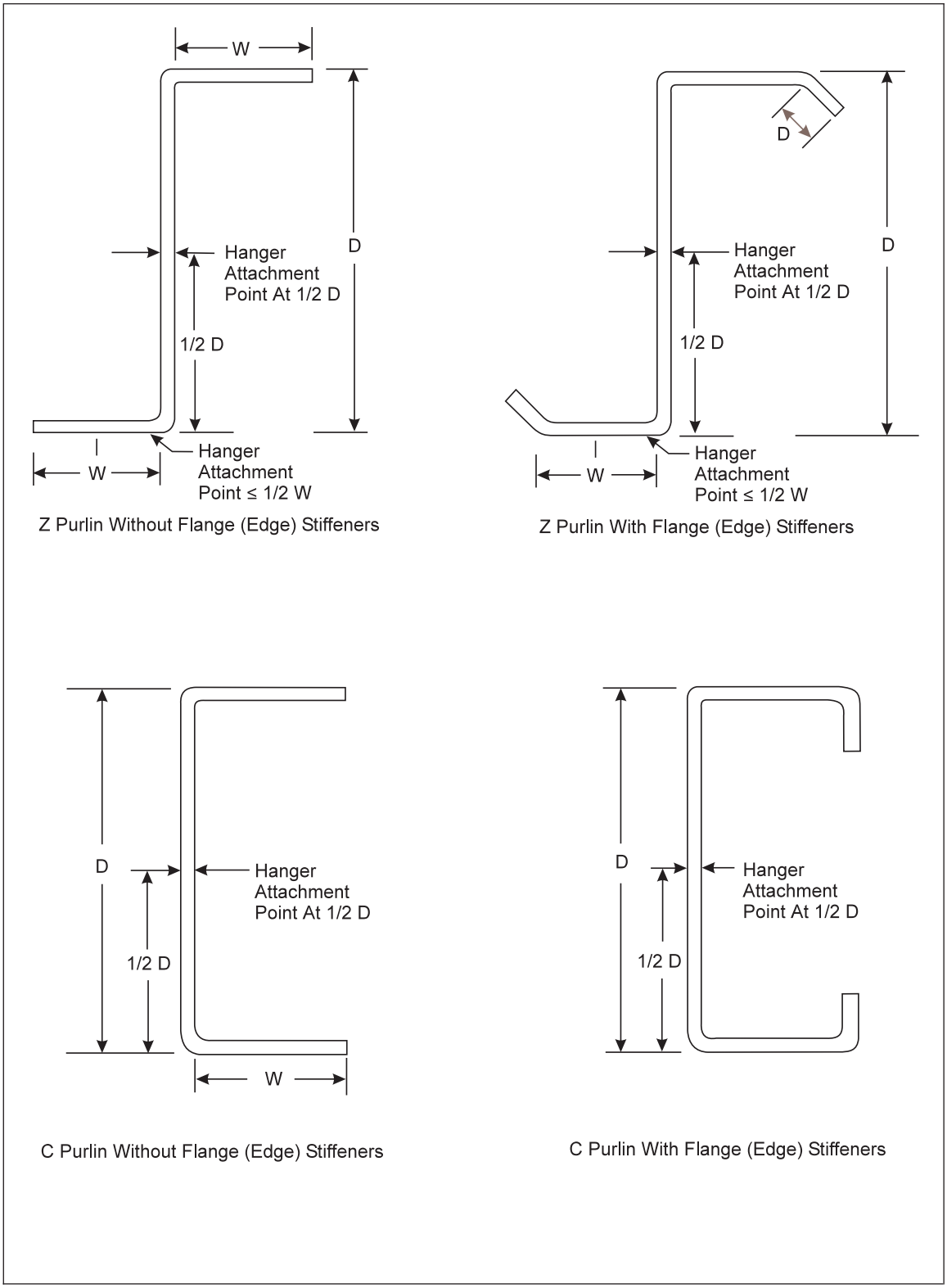

Fig. 45. Attachment locations for hangers with C-shaped or Z-shaped purlins

2.5.4.4.3 Attaching Pipe Hanger Assemblies to Concrete

Attach pipe hangers to structural concrete using inserts, expansion anchors, or fasteners FM Approved for use in concrete and installed in accordance with the manufacturer's guidelines as well as the recommendations in this section. Ensure the piping supports can support the minimum load of the sprinkler system piping per Section 2.5.4.4.

For all concrete fasteners, ensure the fastener installation will not damage concrete reinforcement, such as steel reinforcing bars (rebar) for cast-in-place or pre-cast concrete, high-strength steel strand in precast/prestressed concrete, or high-strength steel tendon (bonded or unbonded) in post-tension concrete.

Do not install concrete fasteners into hollow concrete block (masonry) construction.

If a powder-actuated fastener system (PAFS) is used, ensure the powder-actuated tool and the explosive-driven fastener are FM Approved and compatible with the material into which the fastener is being driven.

In FM Global earthquake zones less than or equal to 500 years, do not use powder-actuated fastener systems for sprinkler pipe supports or bracing. See Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*, for additional guidance.

For structural concrete members, install FM Approved undercut-type fasteners in either a vertical or horizontal orientation. Install all other concrete fasteners in a horizontal position only, unless they meet the criteria in Section 2.5.4.4.3.1.

2.5.4.4.3.1 Field Testing of Concrete Fasteners

To ensure fasteners can meet the minimum loads recommended in Section 2.5.4.4.3, conduct a load-supporting field test on at least 3 representative pipe hangers per ceiling when:

(a) Post-installed concrete fasteners (other than under-cut fasteners) are installed in the vertical orientation and are used to support piping larger than 3 in. (80 mm), or

(b) Any type of fastener, regardless of its orientation, is installed into light-weight structural or similar type concrete.

Base the load for the field tests on two (2) times the tributary weight of the water-filled sprinkler system piping.

2.5.4.5 Location and Spacing of Pipe Hangers

2.5.4.5.1 Maximum Distance Between Pipe Hangers

Use Table 24 below to determine the maximum allowable distance between pipe hangers for all sprinkler system piping installed horizontally. Have all sections of sprinkler piping over 6 ft (1.8 m) in length supported by at least one pipe hanger.

Install all pipe hangers a minimum distance of 1 ft (0.3 m) horizontally from all upright sprinklers.

Table 24. Maximum Distance Between Pipe Hangers

Piping Material	*Maximum Horizontal Distance Between Pipe Hangers, ft (m)*								
	Nominal Pipe Diameter, in. (mm)								
	1 (25)	1-¼ (32)	1-½ (40)	2 (50)	2-½ (65)	3 (80)	3-½ (90)	4 (100)	> 4 (> 100)
Steel Pipe[1]	12 (3.6)	12 (3.6)	15 (4.5)	15 (4.5)	15 (4.5)	15 (4.5)	15 (4.5)	15 (4.5)	15 (4.5)
CPVC[2]	6 (1.8)	6-½ (1.95)	7 (2.1)	8 (2.4)	9 (2.7)	10 (3.0)	N/A	N/A	N/A

[1] For sprinkler pipe having a nominal pipe diameter greater than 4 in. (100 mm) the maximum distance between hangers in the table above can be extended by up to 5 ft (1.5 m) provided (a) there are a minimum of 2 hangers per pipe section, and (b) the minimum supporting load per hanger was calculated in accordance with Section 2.5.4.3.

[2] Space FM Approved CPVC sprinkler system piping and its accompanying piping support in accordance with their listing in the *Approval Guide*.

See the *Approval Guide* for the required location and spacing of pipe hangers for FM Approved non-rigid sprinkler piping (i.e., flexible sprinkler hose).

2.5.4.5.2 Additional Piping Support

2.5.4.5.2.1 Additional Support for Sprinklers

Provide additional piping support for any vertical piping 4 ft (1.2 m) long or more to which a sprinkler is directly attached.

Provide additional piping support to restrict the rotation of wall-mounted sidewall sprinklers.

Provide additional piping support to restrict upward movement for all return bends, armovers, and similar piping arrangements—regardless of the horizontal length—when the sprinkler system piping is connected via grooved couplings. For all other acceptable means of pipe connection, provide piping support that restricts upward movement for all return bends, armovers, and similar piping arrangements that are more than 2 ft (0.6 m) horizontally in length.

2.5.4.5.2.2 Additional Support for Branchlines

In addition to the recommendations in Table 24, provide sprinkler system piping support on the branchline and within 1 ft (0.3 m) horizontally of the main if the piping support for the main is located more than 6 ft (1.8 m) horizontally from the branchline connection to the main.

In addition to the recommendations in Table 24, provide sprinkler system pipe support that restricts upward movement within 1 to 3 ft (0.3 to 0.9 m) horizontally from the last sprinkler on a single-path branchline piping system.

In addition to the recommendations in Table 24, provide sprinkler system piping support within 1 ft (0.3 m) horizontally of the sprinkler piping connection at each section of branchline pipe where there is a horizontal change in the direction of flow.

2.5.4.5.2.3 Additional Support for Mains

The maximum distance between pipe supports for crossmains, nearmains, and farmains may be increased by 5 ft (1.5 m) over that indicated in Table 24 provided all branchlines located between the main's piping supports are equipped with a piping support that is (a) within 6 ft (1.8 m) of the connection to the main, or (b) within one-half the distance indicated in Table 24, whichever is the lesser value.

In addition to the recommendations in Table 24, provide pipe support on the main within 3 ft (0.9 m) horizontally from the last branchline to restrict upward movement.

Provide a pipe support that restricts upward movement on any horizontal section of pipe within 2 ft (0.6 m) of where it connects to a vertical section of pipe.

2.5.4.5.2.4 Support for Vertical Piping

Provide at least one pipe support every 12 ft (3.6 m) vertically. Use a piping support that is specifically manufactured for vertically running pipe, and install it in accordance with the recommendations in this section as well as the manufacturer's installation guidelines. Any sprinkler system piping used to feed an individual sprinkler that extends vertically downward less than 12 ft (3.6 m) does not require additional piping support.

2.6 Sprinkler System Components

2.6.1 General

Install sprinkler system components that are FM Approved, and ensure their application is consistent with their listing in the *Approval Guide,* as well as the manufacturer's installation instructions, the relevant occupancy-specific data sheet, and any specific jurisdictional requirements. Sprinkler system components include, but are not limited to, the following:

- Sprinklers
- System valves
- Piping (See Section 2.5.2)
- Pipe connections
- Hanging and bracing pipe supports
- Control valves

- Check valves
- Waterflow alarms
- Pressure gauges
- Fire service connections
- Drain valves
- Relief valves

Ensure the sprinkler system components and their accessories are compatible with the environment in which they will be installed, including the highest expected internal pressure. Sprinkler system components that are to be installed in atypical environments, such as corrosive, low-temperature or high-temperature environments, need special consideration. See Data Sheet 2-1, *Prevention and Control of Internal Corrosion in Automatic Sprinkler Systems*, for recommendations on how to prevent internal corrosion in sprinkler system piping.

Maintain, test and inspect all sprinkler system components in accordance with Data Sheet 2-81, *Fire Safety Inspections and Sprinkler System Maintenance*.

2.6.2 Control Valves

Install all valves that control waterflow to a sprinkler system so they are readily accessible and operable during a fire, as well as for any testing, inspection and maintenance requirements.

Equip each sprinkler system with at least one control valve.

Install valves that control waterflow to a sprinkler system in the following order of preference:

(1) Locate control valves outdoors a minimum of 40 ft (12.0 m) from the building or area they serve.

(2) Locate control valves outdoors less than 40 ft (12.0 m) from the building or area they serve.

(3) Use wall post indicator valves.

(4) If control valves must be located within the area they provide protection to, install them in a room with minimum 1-hour fire-rated construction and ensure the room is directly accessible via an exterior door.

If the occupancy hazard requires damage-limiting construction, ensure all outside control valves are located behind a pressure-resistant exterior wall, and all internal control valves are located within an enclosure equipped with pressure-resistant walls.

Provide a means of identifying the area of the facility affected by each control valve.

2.6.3 Check Valves

See Data Sheet 3-3, *Cross Connections*, when backflow prevention devices are required by the authority having jurisdiction.

Install at least one check valve for each sprinkler system. Providing an alarm check valve, dry-pipe valve, preaction valve or deluge valve will meet the intent of this recommendation.

FM Approved check valves can be installed in either the vertical or horizontal position as specified in their *Approval Guide* listing.

Check valves can be used on a riser equipped with a dry, deluge, preaction, or refrigerated-area sprinkler valve unless specifically recommended against in the relevant occupancy-specific data sheet. However, do not install a check valve downstream of the riser (i.e., on a feedmain, crossmain, etc.) in these types of systems unless specifically recommended in the relevant occupancy-specific data sheet.

2.6.4 Waterflow Alarms

Provide a new FM Approved alarm device that activates upon waterflow within the sprinkler system. Provide each sprinkler system with its own alarm device and arrange it to alarm locally for any sprinkler system that has an area of protection of 2,000 ft^2 (185 m^2) or larger.

In addition to installing the waterflow alarm device in accordance with the manufacturer's installation guidelines, ensure the alarm device is installed in accordance with its *Approval Guide* listing, as well as the recommendations in Data Sheet 9-1, *Supervision of Property*, and Data Sheet 5-40, *Fire Alarm Systems*.

Arrange sprinkler system alarm devices to initiate an alarm signal no more than 60 seconds after the activation of a sprinkler.

Ensure the alarm device is compatible with the type of sprinkler system it is being installed on.

2.6.5 Inspector's and By-Pass Test Connections

Install an Inspector's Test Connection downstream of each sprinkler system that is equipped with a waterflow alarm device.

Exception No. 1: An Inspector's Test Connection is not necessary for deluge systems.

Install each Inspector's Test Connection so it is readily accessible for testing purposes and arrange its discharge to a safe location that is capable of handling the maximum anticipated water discharge.

Equip the Inspector's Test Connection with an orifice outlet equal to the smallest orifice of any sprinkler installed on the sprinkler system to which the Inspector's Test Connection is attached.

Connect the Inspector's Test Connection to the sprinkler system using piping that is of nominal minimum 1 in. (25 mm) diameter, but no larger than the smallest system branchline pipe.

Provide each Inspector's Test Connection with an identification tag that indicates the system being tested.

For dry-pipe, preaction, and refrigerated-area sprinkler systems, install a by-pass test connection at the sprinkler system riser that will allow testing of the system alarm device independent of the Inspector's Test Connection.

2.6.6 Pressure Gauges

Install new FM Approved pressure gauges as recommended in this section, and ensure they are rated for at least twice the expected static pressure at the spot of their installation.

Install all sprinkler system pressure gauges so they are readily accessible for visual inspection as well as for any testing and maintenance requirements.

Install pressure gauges at the following locations:

(1) On the upstream and downstream sides of any alarm check valve, dry-pipe valve, preaction valve, and refrigerated-area valve.

(2) On the upstream and downstream sides of any check valve that is installed on a sprinkler riser in the absence of an alarm check valve, dry-pipe valve, preaction valve, or refrigerated-area valve.

(3) On the upstream side of any sprinkler system's automatic system valve that feeds open sprinklers.

(4) On the air supply that feeds dry-pipe, preaction, and refrigerated-area sprinkler systems.

(5) On the air receiver and air pump supply if they have been provided on dry-pipe sprinkler systems.

(6) At any accelerators on dry-pipe or preaction sprinkler systems arranged to indicate the air pressure at the accelerator.

Provide a pressure gauge connection near the most remote sprinkler located on either a deluge or exposure-protection sprinkler system.

2.6.7 Fire Service Connections

Provide a fire service connection for each sprinkler system and install it along an external wall (or equivalent) near the sprinkler system it is intended to supply.

Exception: A fire service connection may be omitted from a sprinkler system at the discretion of the authority having jurisdiction.

Where permitted by the authority having jurisdiction, a single fire service connection may be connected to the underground yard main downstream of any fire pumps and arranged to supply all the sprinkler systems

fed from the yard mains. See Data Sheet 3-10, *Installation/Maintenance of Private Service Mains and Their Appurtenances*, for the arrangement of fire service connections installed on yard mains.

Ensure the fire service connection is equipped with fittings and internal connections that are compatible with those of the local fire service.

Base the size of the fire service connection on the same size as the largest sprinkler system riser it is intended to supply.

Provide an identification placard at all fire service connections that identifies the sprinkler system the fire service connection supplies.

When connecting the fire service connection directly to a sprinkler system, attach the fire service connection on the downstream side of the sprinkler system's main check valve, alarm check, preaction valve, deluge valve, or refrigerated-area valve.

Exception: The fire service connection may be attached to a sprinkler system manifold that is equipped with a check valve, provided the attachment is downstream of the check valve.

When connecting the fire service connection directly to a dry-pipe sprinkler system, install a check valve on the sprinkler system riser upstream of the dry-pipe valve and attach the fire service connection to the riser between the dry-pipe valve and the check valve.

2.6.8 Drain Valves

Provide each sprinkler system with a new minimum 2 in. (50 mm) drain valve at the sprinkler system riser.

Install each drain valve so it is readily accessible for operation, testing, and maintenance purposes.

Arrange the drain valve to discharge to a safe location that is capable of handling the maximum anticipated water discharge with the drain valve fully open.

Provide each sprinkler system drain valve with an identification tag that indicates the function of the valve.

2.6.9 Pressure Relief Valves

Where the ambient temperature at the sprinkler piping can exceed 120°F (50°C), provide each gridded wet-pipe sprinkler system with a pressure relief valve not less than 1/4 in. (6 mm) in size, or an equivalent pressure relief device, set to operate at minimum pressure of 10 psi (0.7 bar) below the rated pressure of the sprinkler system piping. Arrange the pressure relief valve to discharge to a safe location (typically into the main drain line).

2.6.10 Pressure Reducing Valves

Use alternative methods to reduce the number of or completely eliminate the need for pressure reducing valves in the sprinkler system.

See Data Sheet 3-11, *Pressure Reducing Valves for Fire Protection Services*, when a pressure reducing valve is required.

2.7 Plan Review of Sprinkler Systems

2.7.1 General

Design the sprinkler system in accordance with the relevant occupancy-specific data sheet and perform the hydraulic calculation analysis of the sprinkler system in accordance with Data Sheet 3-0, *Hydraulics of Fire Protection Systems*.

Submit one set of working drawings, sprinkler system hydraulic calculations, specifications, and any other required documentation as described in Sections 2.7.2 through 2.7.5 to a designated representative of FM Global for review and acceptance prior to the start of any sprinkler system installation.

Submit any revised working drawings, sprinkler system hydraulic calculations, specifications, and any other required documentation to a designated representative of FM Global for review and acceptance prior to the start of any sprinkler system installation.

Provide a complete set of final working drawings, sprinkler system hydraulic analysis, specifications, and any required documentation to the building owner and/or customer for their files.

2.7.2 Working Drawings

Provide the following information on the working drawings submitted for review and acceptance:

- A scaled site plan showing:
    - The water supply that is available for the property. Include any information regarding a fire pump house, fire pump, water supply tank, etc., if they are part of the on-site water supply system.
    - All underground water supply mains and the control valves provided for them.
    - All fire hydrants and the control valves for them.
    - Any fire service pumper connections.
    - All other similar related fire protection equipment (such as check valves, etc.).
    - The building in which sprinkler protection is being installed.
    - Any building within 100 ft (30 m) of the subject building.
    - A direction arrow.
    - All elevation differences between the effective point of the water supply test and the sprinkler system's base of riser.

- A scaled plan view sprinkler system drawing for each building being provided with sprinkler protection. For each drawing, show:
    - All of the nodes used in the hydraulic analysis.
    - The design the sprinkler system is based on.
    - The flow and pressure required for the sprinkler system, as well as the point of reference that the flow and pressure have been calculated to.
    - The sprinkler SIN, K-factor, and nominal temperature rating for each sprinkler shown on the drawing.
    - Any and all components of the sprinkler system that are listed in Section 2.4.1.2; ensure they are adequately labeled.
    - Any piping and outlets for inside hose stations and/or wall hydrants.
    - The linear spacing of the sprinklers.
    - Horizontal distances of sprinklers from walls.
    - The location of any heat / smoke vents or power exhaust vents in relationship to the location of all sprinklers.
    - The location of any areas where the ambient temperature of the occupancy is expected to be less than 40°F (4°C) or more than 130°F (54°C).

- Scaled sectional view sprinkler system drawings for each building being provided with sprinkler protection. For each drawing show:
    - Vertical distances of sprinklers from ceilings.
    - That all obstruction recommendations in Section 2.1.3.2.5 for Nonstorage sprinklers, Section 2.1.3.3.5 for Nonstorage Sidewall sprinklers and Section 2.2.3.5 for Storage sprinklers are being met.

A scaled sectional view can be omitted if detailed information regarding obstructions to sprinklers and vertical distances between the ceiling and the sprinklers is provided on the plan view.

2.7.3 Sprinkler System Hydraulic Analysis

Unless recommended otherwise by the relevant occupancy-specific data sheet, prove via hydraulic analysis, as recommended in Data Sheet 3-0, *Hydraulics of Fire Protection Systems*, the proposed sprinkler system can provide the required design and duration specified in the relevant occupancy-specific data sheet.

See Section 2.7.5 for additional required documentation regarding sprinkler system hydraulic analysis.

2.7.4 Specifications

Submit specifications for the following:

- Specifications regarding any combustible construction for each area being provided with sprinkler protection as well as any areas being provided with heat / smoke vents and/or any open-grid ceilings, mezzanines or walkways.
- Specifications regarding the occupancy for each area being provided with sprinkler protection. For storage occupancies, see form FM999C, *FM Global Contractor's Hydraulic Analysis Certificate for Automatic Sprinkler Systems*.
- Provide details regarding the occupancy of any area where the area's ambient temperature is expected to be less than 40°F (4°C) or more than 130°F (54°C).
- Indicate the Year Zone designation of the area if it is in a 50-year through 500-year earthquake zone as defined in FM Global Data Sheet 1-2, *Earthquakes*, and indicate the provisions being taken to account for earthquake protection.
- Detailed specifications on the water supply that will feed the sprinkler system. This includes, but is not limited to, information on the pump house, fire pump, and water storage tank, if they are part of the water supply. Use flow test data for any existing water supply that is no more than 12 months old. Water supplies that will include a new fire pump must include a copy of the pump's characteristic curve and follow the recommendations in Data Sheet 3-7, *Fire Protection Pumps*. If a water storage tank will be installed, specifications must be included to demonstrate its overall capacity, as well as its meeting the recommendations in Data Sheet 3-2, *Water Tanks for Fire Protection*.
- Detailed specifications for each component of the sprinkler system, including, but not limited to, the following:
    - Sprinklers
    - Sprinkler system automatic system valve
    - Sprinkler system piping
    - Sprinkler system pipe connections
    - Sprinkler system pipe support assemblies
    - Sprinkler system control valves and pressure regulating valves
    - Sprinkler system check valves and backflow preventers
    - Sprinkler system alarms
    - Sprinkler system pressure gauges
    - Sprinkler system fire service connections
    - Sprinkler system drain valves
    - Sprinkler system relief valves
    - Sprinkler system quick opening devices
- Detailed specifications of the gas supply for any dry-pipe, preaction, or refrigerated-area sprinkler systems.
- Detailed specifications on the antifreeze solution used in an antifreeze solution sprinkler system, and the expected lowest ambient temperature of the area being protected.

- Detailed specifications on the actuating components of a dry-pipe (if used), preaction, or refrigerated-area sprinkler system, as well as their sequence of operation.
- Detailed specifications on any interlocks being provided for the sprinkler system, and their method of actuation.
- Detailed specifications on the location that will be monitoring the alarms provided for the sprinkler system.

2.7.5 Required Documentation

Submit the following documentation for review and acceptance:

- The *FM Global Contractor's Material and Test Certificate for Automatic Sprinkler Systems* form (FM85A) with all sections preceding the Automatic Sprinkler System Tests section completed by the installing contractor. See Appendix C for a copy of this form.
- Completed *FM Global Contractor's Hydraulic Analysis Certificate for Automatic Sprinkler Systems* form (FM999C). See Appendix C for a copy of this form.
- Documentation showing that the expected water delivery time for any dry-pipe, refrigerated-area, or "dry-type" preaction sprinkler system can meet the maximum time allowance.
- On receipt of FM Global's plan review correspondence, provide a revised submittal or written response to FM Global. The response should document how FM Global's plan review recommendations will be addressed.

2.7.6 Arranging for FM Global Field Acceptance

Contact the local FM Global field servicing office to arrange field acceptance visits. The FM Global field servicing office will determine the scope of field examination and testing FM Global needs to witness. This depends on a number of factors, such as type of installation, hazard protected, size of the installation, and earthquake zone.

2.8 Sprinkler System Acceptance Tests

An acceptance test must be conducted by the installing contractor on every new sprinkler system prior to placing it into service. The acceptance test will consist of, but not be limited to, the following items:

- Ensure all working drawings and specifications for the sprinkler system, as recommended in Section 2.7, have been submitted, reviewed, and found acceptable to FM Global.
- Verify any outstanding recommendations listed on FM Global plan review correspondence have been addressed to the satisfaction of FM Global.
- Ensure the sprinkler system has been installed per the reviewed and accepted working drawings. Ensure any deviations from the working drawings have been listed and are considered acceptable to FM Global.
- Confirm that all required fields of the *FM Global Contractor's Material and Test Certificate for Automatic Sprinkler Systems* form (FM85A) have been completed by the installing contractor and that a copy of the form has been left with a designated representative of FM Global. See Appendix C for a copy of this form.
- Confirm that all required fields of the *FM Global Contractor's Hydraulic Analysis Certificate for Automatic Sprinkler Systems* form (FM999C) have been completed by the installing contractor and that a copy of the form has been left with a designated representative of FM Global. See Appendix C for a copy of this form.
- Prove via a trip test that all dry-pipe, refrigerated-area, and "dry-type" preaction sprinkler systems can reach the required full-system operating pressure at the most remote sprinkler within the maximum allotted timeframe (see test procedure below).
- Prove via a full-flow test that the actual water supply available to the sprinkler system is equal to or greater than the available water supply indicated on the submitted and accepted working drawings.
- Verify via physical testing that all sprinkler system control valves are in the fully open position. Ensure any tamper alarms provided for the sprinkler system control valves function properly during the physical testing of the control valves. See Data Sheet 2-81, *Fire Safety Inspections and Sprinkler System Maintenance*, for guidelines specific to physical testing of control valves.

- Ensure any alarms provided for the sprinkler system are received at the alarm control panel, as well as at the alarm monitoring station, if one is provided. If local alarms are provided, ensure they function properly.
- Verify proper function of all actuation systems, associated detection devices, and any interlocked equipment required for adequate sprinkler system operation.
- Confirm that any interlocks that are activated by the operation of a sprinkler system function properly during testing of the sprinkler system.
- Verify that all equipment identification tags have been provided where needed.
- Ensure a cabinet for spare sprinklers has been provided for each sprinkler system as recommended in Section 2.1.3.1.7 for Nonstorage sprinklers and 2.2.3.1.6 for Storage sprinklers.

Once the acceptance test has been completed and proper documentation has been provided to the designated FM Global representative, verify that all aspects of the sprinkler system, including all alarms and interlocks, have been placed in service.

2.8.1 Test Procedure for Preaction, Deluge, and Refrigerated-Area Sprinkler Systems

1. Trip test the sprinkler system by activating a heat-responsive actuating device. If heat detectors are used, test the system by applying heat to a heat detector in each detection zone. If wet or dry pilot sprinklers are used, test the system by fusing a sprinkler or by opening the pilot line test connection at the end of the pilot line system.

Ensure the system control valve is in the wide-open position and that all water supplies, including fire pumps, are in service. This will test the integrity of the system (piping, fittings, hangers, valve clapper, etc.).

During this test, also check for proper operation of supervisory equipment, waterflow alarms, and interlocking controls for starting fire pumps, stopping conveyors, shutting down air-handling systems, etc.

In special cases, such as with anechoic chambers, where values may be high and there is a concern with possible damage during full-flow acceptance tests (see Data Sheet 1-53, *Anechoic Chambers)*, or with freezers where water may freeze, make every effort to complete acceptance testing prior to introducing any high-value contents or before bringing the freezer temperature down to the operating level.

2. After a successful full-flow trip test, make additional trip tests to ensure proper operation of each circuit of heat-responsive devices and manual trip stations, both local and remote. These tests can be made with the system control valve throttled. After successful completion of trip tests, make sure the system piping is properly drained and leave the system in service.

2.9 Operation and Maintenance

See Data Sheet 2-81, *Fire Safety Inspections and Sprinkler System Maintenance*, for guidelines on the operation and maintenance guidelines for sprinklers and/or sprinkler systems.

2.10 Ignition Source Control

Ensure all hot work operations associated with the installation of a sprinkler system are safeguarded as recommended in Data Sheet 10-3, *Hot Work Management*.

3.0 SUPPORT FOR RECOMMENDATIONS

The fire protection recommendations in this data sheet are based on testing, loss experience, and engineering judgment. Not every situation has been tested, nor has every potential solution been identified. Carefully consider all the variables involved when exploring options different from those covered in this data sheet.

The recommendations in this data sheet are aimed at ensuring the following:

(1) Sprinklers will operate in a timely fashion.

(2) Sprinklers will have an unobstructed water discharge pattern.

(3) Sprinkler system components will function in a reliable manner.

The recommendations in this data sheet must be combined with the design parameters in the relevant occupancy-specific data sheets to ensure the sprinkler system will provide a sufficient volume of water to control or suppress a fire.

3.1 Loss History

Automatic sprinklers have been commercially available for well over 100 years. The loss history of facilities equipped with sprinkler systems is excellent when they have been installed in accordance with the recommendations in this data sheet.

The majority of large fire losses at industrial facilities is primarily due to lack of sprinkler protection. Over the last ten years (1998-2008), the average fire loss at locations where sprinkler systems were needed but not installed was US$3.4 million, whereas the average fire loss at a location equipped with a properly installed and designed sprinkler system was approximately US$600,000; a ratio of roughly 6 to 1.

FM Global loss history over the past twenty years indicates that approximately 25% of the time, the operation of a single sprinkler will control or suppress a fire if the sprinkler system has been properly designed and installed. This percentage increases to approximately 50% of the time with the operation of three or fewer sprinklers, and 75% of the time with the operation of nine or fewer sprinklers. There are other publicly available sources that indicate even better results.

The maximum number of sprinklers that operate during a fire will typically do so well before the local fire service can reach the fire and begin attacking it. Providing sprinkler protection in accordance with this data sheet can mean the difference between the local fire service arriving to find a relatively small fire and one that is uncontrolled.

Table 25 shows the major causes of fire over the past ten years (1998-2008) at FM Global client facilities equipped with sprinkler protection:

Table 25. Loss Experience: Causes of Fire by Frequency (1998-2008)

Cause of Fire	*Percentage of Fire Losses by Frequency*
Arson, incendiarism	34
Electrical problems	15
Smoking	7
Hot work	6
Spontaneous ignition, chemical reaction	4
Hot surfaces	4
Miscellaneous sparks	2
Other	28

The results indicated in this table are based on fires in storage occupancies. In manufacturing occupancies, the numbers are different, with the majority of fires attributable to electrical problems and hot surfaces (friction).

The majority of fires at locations equipped with sprinkler protection are primarily due to either incorrect sprinkler design for the occupancy hazard or inadequate maintenance of the sprinkler system.

3.1.1 Loss Examples

3.1.1.1 Hot Work at Facility with Sprinklers in the Process of Being Installed

A fire caused by contractor welding damaged a chicken-processing plant. Sprinklers were being installed in the area but had not yet been placed into service. The fire involved wall insulation consisting of polystyrene board covered with fiberglass-reinforced plastic. The fire spread to polyurethane insulation, which had been sprayed onto a lap-seam steel-on-steel roof, resulting in about 28,000 ft^2 (2,600 m^2) of roof collapse. Fire spread to a maintenance shop, motor control centers, and corrugated box storage areas. Equipment in the collapsed area was severely damaged. Contractors were welding within 4 in. (100 mm) of the combustible insulation. The plant's hot work permit system was not followed. A fire watch was not posted, and fire extinguishers were not present.

3.1.1.2 Arson at a Facility with Newly Installed Sprinklers but Not Yet Connected to Water Supply

A fire took place at a fiber optic cable manufacturing plant where arson was deemed the most likely cause. The fire occurred in a roughly 7,500 ft^2 (700 m^2) building section where raw materials (mainly plastic pellets) were being stored on racks to a height of 13 ft (3.9 m). The roof and walls of this building section consisted of plastic insulated sandwich panels. Sprinkler protection had been installed in this area but was not yet in service because work was not yet completed on the fire pump. During the fire both the roof and walls of this section of building collapsed. Production equipment and in-process product in an adjoining section were damaged. Smoke damage was also extensive in adjoining buildings. Smoke damage was extensive because of doors left open between adjoining buildings. Although fire detection was prompt, due to the operation of burglary and smoke alarms, response by the paid fire department was delayed by over 20 minutes.

3.1.1.3 Fire Loss at High-Rise Facility Equipped with Sprinklers but Not in Fire Area

A fire took place at a large complex that included 2,900 hotel rooms, a gambling casino, convention hall and shopping areas. Arson by an employee was determined to be the cause of fire origin.

The employee set fire to four separate areas of the complex. In one area the fire originated on the eighth floor of one of three 30 story wings. The absence of sprinklers in this area allowed the fire to spread from the drapes in an elevator lobby through large broken windows to the 28th floor where it was halted by concrete floors extending at least 5 ft (1.5 m) beyond concrete curtain walls. Severe fire damage occurred to carpeting, vinyl wall coverings and wooden guest room doors on all affected floors. The interiors of at least seven guest rooms were burned after departing guests left doors open. Smoke damage was extensive in all hallways and about 50% of the rooms in the wing where the fire occurred. Part of another wing also experienced smoke damage.

Of the other remaining three affected areas, one fire was started in a uniform storage room that was equipped with sprinkler protection. The fire opened one sprinkler which controlled the fire. The fires in the other two areas self-extinguished due to the limited combustibles that were present.

The entire complex had to be shut down for about three weeks whereas the hotel wing where the fire started, including about 900 damaged rooms, had to be shut down for much longer.

4.0 REFERENCES

4.1 FM Global

Approval Guide, a publication of FM Approvals
Data Sheet 1-2, *Earthquakes*
Data Sheet 1-10, *Interaction of Sprinklers, Smoke and Heat Vents, and Draft Curtains*
Data Sheet 1-12, *Ceilings and Concealed Spaces*
Data Sheet 1-20, *Protection Against Exterior Fire Exposure*
Data Sheet 1-57, *Plastics in Construction*
Data Sheet 2-1, *Prevention and Control of Internal Corrosion in Automatic Sprinkler Systems*
Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*
Data Sheet 2-81, *Fire Safety Inspections and Sprinkler System Maintenance*
Data Sheet 3-0, *Hydraulics of Fire Protection Systems*
Data Sheet 3-2, *Water Tanks for Fire Protection*
Data Sheet 3-3, *Cross Connections*
Data Sheet 3-7, *Fire Protection Pumps*
Data Sheet 3-10, *Installation/Maintenance of Private Service Mains and Their Appurtenances*
Data Sheet 3-11, *Pressure Reducing Valves for Fire Protection Services*
Data Sheet 5-40, *Fire Alarm Systems*
Data Sheet 5-48, *Automatic Fire Detection*
Data Sheet 7-11, *Conveyors*
Data Sheet 7-14, *Protection for Flammable Liquid / Flammable Gas Processing Equipment*
Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*
Data Sheet 8-29, *Refrigerated Storage*
Data Sheet 9-1, *Supervision of Property*
Data Sheet 9-18, *Protection Against Freeze-Ups*
Data Sheet 10-3, *Hot Work Management*

4.2 Other

4.2.1 American Society of Mechanical Engineers

ASME Boiler and Pressure Vessel Code, Section IX, *Welding and Brazing Qualifications*

4.2.2 American Welding Society (AWS)

AWS B2.1, *Specification for Welding Procedure and Performance Qualification*
AWS D10.9, *Specification for Qualification of Welding Procedures and Welders for Piping and Tubing*

APPENDIX A GLOSSARY OF TERMS

Accelerator: A quick-opening device, typically installed on the dry-pipe valve of a dry-pipe system, that is used to reduce the time it takes a water control valve (such as a dry-pipe valve) to open. It works by reducing the pressure differential across the clapper of the water control valve.

Acceptance Test: A test conducted on the sprinkler system, or a specific portion of the sprinkler system, to ensure that it will function to the satisfaction of the authority having jurisdiction.

Actuating Component: Any component of a sprinkler system that is used to actuate the system's automatic water control valve. An example would be an accelerator for a dry-pipe valve.

Alarm Check Valve: A check valve, typically installed on the riser of a sprinkler system, which is specifically designed to allow a means of alarm notification when waterflows through it.

Anti-Flooding Device: A component of an accelerator that prevents the introduction of water or foreign matter from entering the accelerator.

Antifreeze Solution Sprinkler System: A sprinkler system in which the media within the sprinkler system consists of a combined antifreeze and water solution.

Approval Guide: A publication of FM Approvals that provides a guide to equipment, materials and services FM Approved for property conservation.

Area Spacing: The portion of the protected area that is protected by an individual sprinkler. It is calculated using the following equation:

$$\text{Area Spacing} = (S) \times (L),\ ft^2\ (m^2)$$

Where:
S - The linear distance from one sprinkler to the nearest sprinkler installed on the same branchline

L - The linear distance from one sprinkler to the nearest sprinkler installed on an adjacent branchline

Arm-Over: A combination of piping and fittings (typically elbows) that connects the branchline to a sprinkler that is positioned horizontally away from the branchline.

Authority Having Jurisdiction (AHJ): The person, or persons, responsible for enforcing the guidelines provided in this data sheet. For FM Global purposes, the AHJ is the appointed Field Engineering representative from the applicable Operations Center.

Automatic Sprinkler: A piece of fire protection equipment through which water is automatically discharged with the intent of either controlling or suppressing a fire. A sprinkler typically consists of four main components: the sprinkler frame, the orifice cap, the thermal sensing element and the deflector. Note that the orifice cap and the thermal sensing element components are provided on closed-type sprinklers but are removed from open-type or deluge-type sprinklers.

Automatic Sprinkler Deflector: The component of a sprinkler that redirects the water discharged through the orifice towards the protected area.

Automatic Sprinkler Frame: The component of a sprinkler that is connected to the sprinkler piping and contains the sprinkler orifice.

Automatic Sprinkler Frame Arm: The component of a sprinkler frame that is used to connect the sprinkler deflector to the sprinkler a given distance away from the sprinkler orifice.

Automatic Sprinkler Orifice: A component of a sprinkler located on the sprinkler frame through which water is discharged.

Automatic Sprinkler System: An integrated network of above-ground piping to which sprinklers are attached. As a minimum each sprinkler system is provided with at least one system control valve, system pressure gauge, system drain valve and a means of initiating alarm notification in the event of water movement through the system's piping network. A sprinkler system is considered to provide "Adequate" protection when it is connected to a reliable automatic water supply that can provide the flow, pressure and duration requirements for all occupancy hazards protected by the sprinkler system as required by the FM Global occupancy-specific data sheet.

Automatic Sprinkler System Hydraulic Calculations: A set of calculations that indicates the flow and pressure required at a given reference point on the sprinkler system (Base-of-Riser) in order to satisfy the required design of the sprinkler system.

Automatic Sprinkler Temperature Rating: The temperature at which the thermal sensing element of the sprinkler operates. See Table 1 for the nominal temperature ratings of Nonstorage sprinklers or Table 15 for the nominal temperature ratings of Storage sprinklers.

Automatic Sprinkler Thermal Sensing Element: It is the component of a sprinkler that, when subjected to the influence of heat, weakens to the point where pressure acting on the orifice cap will cause it to dislodge, thus allowing water to flow from the sprinkler.

Automatic System Valve: Automatic system valves hold back water from entering a preaction, deluge or similar type sprinkler system until the valves are automatically released by a system of electrical, pneumatic, or hydraulic signaling and releasing devices. These valves are usually single or multiple clapper valves, with the clappers held on their seats by a series of latches and levers or by differential water pressure.

Back Drainage: Water that can collect above the seat of a water control valve subsequent to the closure of the sprinkler system's main drain valve.

Bar Joist Chord: Also known as the flange of a bar joist, it is the top and bottom parts of a bar joist that support the web of the joist. It typically consists of two angle irons installed back-to-back.

Base of Riser: A reference point on a sprinkler system at which the hydraulic analysis of the sprinkler system demand as well as the water supply available for the sprinkler system is analyzed. This reference point is typically at floor level just prior to the sprinkler system's control valve.

Belt-Type Conveyor: A conveying system that uses typically a solid rubber belt to move products from one area of a facility to another area. These types of conveying systems can be an obstruction to sprinkler discharge depending on how wide the belt is. See Section 2.1.2.2 for Nonstorage sprinklers or Section 2.2.2.2 for Storage sprinklers for additional information.

Blocked Flue Space: A minimum 3 in. (75 mm) net wide flue space that is either (a) reduced in size to a net width less than 3 in. (75 mm) vertically above the bottom load, or (b) has an obstructing object located less than 36 in. (900 mm) vertically above the top of the flue space. A blocked flue space can allow for unacceptable fire growth below it to take place by promoting horizontal fire spread as well as preventing sprinkler discharge from reaching the vertical surfaces of the burning commodity.

Boards-on-Joists: Construction that consists of wooden ceiling or floor decking that is supported by closely spaced wooden joists (typically nominal 2 in. x 4 in. or larger joists).

Branchline: The piping network of a sprinkler system that provides water to a sprinkler or sprinkler assembly.

Bridging: A structural building member, typically steel angle iron, which is attached perpendicular to the bottom chords of bar joists in order to provide increased lateral resistance to wind forces acting on the roof.

Burrs or Fins: Protrusions, also referred to as "rough edges", from a sprinkler pipe that need to be removed before the pipe is connected to another piece of the sprinkler system.

Butt-Welded: A connection process by which the ends of two pieces of sprinkler pipe are joined together by an acceptable welding means without the pipe ends overlapping.

By-Pass Test Connection: An assembly consisting of pipe, a check valve (when necessary) and a manually operated 90° turn valve that is connected to the supply side of the sprinkler system's system valve (i.e., alarm

check, dry-pipe, preaction or deluge valve) and arranged to activate a waterflow device that is connected to the sprinkler system's system valve. Its purpose is to allow testing of the sprinkler system's waterflow alarm without having to flow water past the system valve.

Ceiling Slope: The measured angle created by the rise in ceiling height relative to the floor. Ceiling slope in this data sheet is measured in degrees. The following is a conversion into length-based units:

Table 26. Ceiling Slope Conversions

Slope in Nominal Degrees (°)	*Slope in Inches (in.) per Foot*	*Slope as a Percentage*
5	1	5
10	2	10
20	4	22
45	8.5	50

Channel Bay: The space created by the primary and secondary structural ceiling members.

Check Valve: A valve with an inherent design characteristic that permits flow of water in one direction and prevents waterflow in the opposite direction under cyclic pressure conditions.

Chemical/Resin Anchor: A means of installing load supporting anchors into concrete using epoxies or similar chemicals.

Class 1 Construction: Wall and ceiling construction that consists of materials that contribute limited quantities of fuel when exposed to fire, but in the form they will be installed will not propagate a fire. This includes FM Approved Class 1 wall, ceiling or roofing assemblies including fire retardant treated lumber. Non-plastic ceiling tiles that have a flame spread index (FSI) less than or equal to 25, based on testing per ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, may be considered limited combustible for sprinkler protection purposes.

Collateral Load: Dead loads created by the weight of objects hung from the underside of a roof or ceiling, such as piping, ductwork, equipment, etc.

Combustible Construction: Wall and/or ceiling construction that cannot be classified as either noncombustible construction or limited-combustible construction, and could result in a self-propagating fire. Such construction warrants the provision of sprinkler protection.

Combustible Occupancy: An occupancy that contains sufficient combustible materials within to allow horizontal spread throughout a given area in the absence of sprinkler protection; or an occupancy that contains a sufficient concentration of combustibles that could cause significant damage to the building structure or flashover in the absence of sprinklers.

Combustible Solid Structural Members: Ceiling structural members that are void of openings but do not comply with ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*.

Concealed Automatic Sprinkler: A sprinkler that is installed under a flat, smooth ceiling, and the entire body of the sprinkler, including the operating mechanisms, is above a concealing plate, the margin of which is nearly flush to the ceiling surface.

Concrete Tee Construction: Ceiling or floor construction consisting of pretensioned concrete in the form of the letter T. See the example below of a double-tee concrete slab.

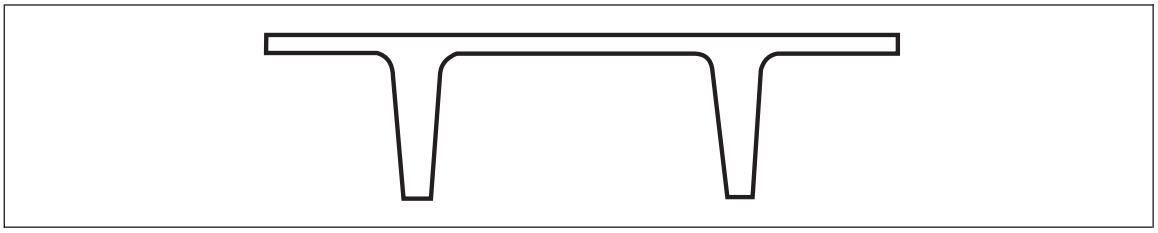

Fig. 46. Double-Tee Concrete Slab

Control Valve: A manually operated fire service valve, typically of the gate or butterfly type, which controls the water supply to a sprinkler system.

Conventional Automatic Sprinkler: A sprinkler that has components similar to a standard-spray sprinkler, except that its deflector is designed to discharge 40% or more of its water in an upward trajectory.

Corrosive Environment: An environment that would cause corrosive damage to metallic components of a sprinkler system.

Coupling: A coupling is a fitting that is used to join two or more sprinkler system components together.

Coupon: The cut-out (disc) portion of a sprinkler pipe that is removed (typically from a welded sprinkler system) for the purpose of creating an outlet in the pipe.

CPVC Pipe: The term CPVC is short for Chlorinated Poly Vinyl Chloride and is a plastic material that is used to produce a type of plastic sprinkler pipe.

Crossmain: The piping network of a tree-type sprinkler system that provides water to the branchlines.

C-Shaped Steel Secondary Roof Member (Purlin): A thin, usually 0.058 to 0.120 in. (1.5 to 3.0 mm) thick, solid web, cold-formed steel secondary member (directly supports deck) that is formed in the shape of the letter C. It usually varies in depth from 8 to 11.5 in. (200 to 290 mm), but may range from 6.5 to 14.5 in. (165 to 368 mm). See FM Global Data Sheet 1-31, *Metal Roof Systems*, for further details.

Damage-Limiting Construction: A type of construction that consists of both pressure-resistant and pressure-relieving ceiling and/or walls that allows the internal pressure building-up from a deflagration type of explosion to release safely to a designated external area. See FM Global Data Sheet 1-44, *Damage-Limiting Construction*, for further details.

Darcy-Weisbach Method: A method of calculating friction loss within a sprinkler system that is based on a given internal pipe diameter, the average velocity of the liquid moving through the pipe, the material make-up of the pipe as well as the viscosity of the liquid moving through the pipe. Although it can be used for any sprinkler system hydraulic analysis, it should be used for any sprinkler system that is not water-based or any sprinkler system where the waterflow velocity exceeds 30 ft/s (9.0 m/s).

Data Sheet: Engineering guidelines for a given subject matter that are written to help reduce the chance of property loss due to fire, natural hazards and failure of electrical or mechanical equipment, and incorporate loss experience, research results, input from consensus standards committees, equipment manufacturers and others.

Dead Load: Loads consisting of the weights of all materials of construction, building finishes, and fixed service equipment. In the case of green roof systems, the entire roof assembly (including growth media, roofing materials, and captured water) is considered dead load.

Deluge Sprinkler System: A sprinkler system that is located downstream of a deluge valve and is equipped with open-type sprinklers (i.e., sprinklers where the thermal sensing element and the orifice cap have been removed).

Deluge Valve: An automatic water control valve, typically installed on a sprinkler system riser, specifically designed to hold back water from passing through it until certain conditions have been met. It is typically connected to an automatic detection system that, once activated, opens the valve and allows water to flow through it. It is connected upstream of a deluge sprinkler system.

Demand Area: The expected area of sprinkler operation, based on the commodity hazard being protected, used for hydraulic design purposes.

Double-Interlock Preaction System: A sprinkler system that is located downstream of a preaction valve and is equipped with closed-type sprinklers. The preaction valve is arranged to open only once both a sprinkler has operated as well as the activation of a detection system that is supervising the area being protected by the preaction sprinkler system. Most double-interlock sprinkler systems have either electric or pneumatic means of accomplishing these two activating conditions.

Draft Curtain: Also referred to as a curtain board, a draft curtain is a solid continuous material that is installed perpendicular to a ceiling with the intent of preventing the flow of hot gases from a fire from traveling horizontally beyond the curtain. Draft curtain are typically not recommended for buildings equipped with

sprinkler protection except where specifically required in either this standard or an occupancy-specific data sheet. Install draft curtains, when required, in accordance with Data Sheet 1-10.

Drain Valve: A manually operated valve and pipe assembly, typically 2 in. (50 mm) in size and located on the sprinkler system riser, which is used for the purpose of draining water out of the sprinkler system and verification of waterflow at the riser.

Drop Nipple: The piece of pipe that connects the branchline to a sprinkler located directly below the branchline.

Dry Inert Gas Supply: The gaseous medium provided into a dry-pipe, preaction or similar sprinkler system. It needs to be void of substances, such as water, which could interact with the inner walls of the sprinkler piping leading to either corrosion of the sprinkler piping and/or potential build-up of solids, such as ice or rust, which could cause blockage of waterflow to sprinklers during a fire condition. For sprinkler systems provided with air, either:

(1) Use an FM Approved air supply package, or

(2) Use a regenerative air dryer that can dehumidify the air to a pressure dew point that is 20 degrees F (11 degrees C) lower than the nominal ambient temperature of the area protected by the sprinkler system.

Dry-Pendent Automatic Sprinkler: A dry-type sprinkler where the sprinkler attached to the extension nipple is of the pendent orientation. These types of sprinklers are typically used to protect areas subject to freezing and are connected to water-filled sprinkler piping located above the protected area in an area provided with sufficient heat. They are also sometimes used on dry type sprinkler systems where the installed sprinkler must be of the pendent orientation.

Dry-Pipe Sprinkler System: A sprinkler system that is located downstream of a dry-pipe valve. It is filled with a pressurized gaseous medium (typically air or an inert gas such as nitrogen) for the purpose of maintaining the dry-pipe valve closed. Upon sprinkler actuation, the pressure within the sprinkler system begins to drop until the pressure becomes too low to keep the dry-pipe valve closed. At this time the dry-pipe valve opens (trips) allowing water to fill the sprinkler system and discharge through any sprinklers that have been actuated. A dry-pipe sprinkler system is typically used in areas where the presence of water within the sprinkler system is not suitable.

Dry-Pipe Valve: An automatic water control valve, typically installed on the riser of a sprinkler system, which is specifically designed to use a pressurized gaseous medium (typically air or an inert gas such as nitrogen) to hold back water on the upstream side of the valve. The valve remains closed until the gas pressure on the downstream side of the valve drops, such as by sprinkler operation, to a value too low to hold back the pressure of the water, thus opening the valve and allowing water to flow into and fill up the dry-pipe sprinkler system. Similar to an alarm check valve, it is designed to be equipped with a means of alarm notification in the event waterflows through it, but it is also equipped with a means of measuring the gas pressure within the sprinkler system and provide an alarm in the event of low pressure condition.

Dry-Sidewall Automatic Sprinkler: A dry-type sprinkler where the sprinkler attached to the extension nipple is of the sidewall orientation.

Dry-Type Automatic Sprinkler: A sprinkler assembly that consists of a sprinkler and an extension nipple to which the sprinkler has been permanently connected to. The extension nipple is equipped with a closure at the inlet end that prevents water from entering the nipple until the sprinkler operates.

Dry-Upright Automatic Sprinkler: A dry-type sprinkler where the sprinkler attached to the extension nipple is of the upright orientation. These types of sprinklers are typically used to protect areas subject to freezing and are connected to water-filled sprinkler piping located below the protected area in an area provided with sufficient heat.

Earthquake Zone Designation: FM Global Earthquake Zones are based on the 50-year, 100-year, 250-year, 500-year, and >500-year earthquake ground shaking recurrence intervals. See Section C.7.3 of FM Global Data Sheet 1-2, *Earthquakes*, for clarification of these designations as well as the earthquake map that applies to a given geographical area.

Effective Point of Water Supply Test: This is a reference point within the water supply's piping network at which the results of a water supply test are applicable. This reference point is determined by starting at the pressure gauge where the static and residual pressure readings are taken during the water supply test. During the test there is no flowing water at this gauge. The next step is to travel a path from the pressure gauge back upstream through the piping network towards the source for the water supply. The Effective Point

is the point in the water supply piping network where flowing water from the test meets non-flowing water that supplies pressure to the pressure gauge used for reading both the static and residual pressures during the test. If there is any elevation difference between the pressure gauge and the Effective Point, it must then be accounted for in both the static and residual pressures obtained during the test.

Equivalent Length: A measurement used in hydraulic calculations to represent the pressure loss through a sprinkler system fitting. The length indicated represents a section of pipe that would have the same friction loss through it that occurs through the fitting.

Expansion Anchor: A hanger that is inserted into a self-drilled or predrilled hole in concrete and then "set", usually by tightening of a bolt, setting of a cam or semi-soft member, or forced expansion over a hardened steel plug.

Explosive-Driven Fastener: Fasteners that are used in either the vertical or horizontal plane to attach sprinkler pipe hanger rods to structural steel or concrete. The fasteners are imbedded into the supporting structure under high-pressure via a powder-actuated tool.

Exposure-Protection Sprinkler System: A sprinkler system that is specifically designed to protect a building or an object from a fire that originates remotely from the building or object being protected.

Extended Coverage Automatic Sprinkler: A sprinkler where the area of coverage exceeds that given for a standard sprinkler based on the occupancy being protected.

False Ceiling: A solid continuous sub-ceiling that is installed in accordance with Data Sheet 1-12, *Ceilings and Concealed Spaces,* and aligned parallel to floor level at a given vertical distance below the primary ceiling or roof. Sprinkler protection is installed under the false ceiling and designed in accordance with the occupancy-specific data sheet. The purpose of a false ceiling with sprinklers installed below it is to typically address hazards that can negatively affect sprinkler performance such as excessive clearance, excessive airflow velocities, excessive ceiling slope or loss of the heat plume through exhaust openings at ceiling level. Design the false ceiling to withstand a minimum fire plume uplift velocity pressure of 3 lb/ft^2 (14.4 kg/m^2). Suitable ceiling materials include minimum ⅜ in. (10 mm) plywood or gypsum board as well as corrugated or sheet steel. If the false ceiling is made of ordinary plywood or other combustible construction, sprinkler protection may also be needed above the false ceiling (see DS 1-12). If the false ceiling is hung from the existing roof framework, ensure the roof can withstand the additional dead load.

Far Main: The piping network of a grid-type sprinkler system that is connected to the branchlines on the side opposite from the near main.

Feedmain: The piping network of a sprinkler system that connects the sprinkler system riser to the main(s) that feeds the branchlines.

Ferrous Material: A material that consists mainly of iron.

Fire Control: A condition in which equilibrium has been achieved between burning commodity and sprinkler system discharge such that ceiling level temperatures do not increase and horizontal fire spread has been eliminated.

Fire Service Connection: A device, consisting of at least one outlet and a check valve, which connects to the sprinkler system and provides a means for the local fire service to pump water into the sprinkler system from a public hydrant or other available water supply.

Fire Extinguishment: A condition defined by which the temperature of all surfaces of a burning commodity has been lowered below the commodity's fire point.

Fire Suppression: The conditions for fire control have been met; however fire on the vertical surfaces of burning commodities has been extinguished.

Fitting: A sprinkler system piping-related product that is manufactured to standardized dimensions. These dimensions may exist in Industry Standards or be based on those of manufacturers that have been accepted by the market as the "norm".

Flame Detection: Detection that is sensitive to infrared, visible, or ultraviolet radiation produced by a fire, or to specific ranges of radiation that are modulated at characteristic flame flicker frequencies. Flame detectors are essentially line-of-sight devices, and are usually designed to respond to a fire within the detector's cone of vision in approximately one second or less. Typical flame detectors include infrared, ultraviolet,

photoelectric and flame-flicker. See Data Sheet 5-48, *Automatic Fire Detection*, for more information regarding these types of detectors and the type of fire hazard they are appropriate for.

Flat Continuous Solid Barrier: A smooth false ceiling void of any openings that is installed parallel to the floor and spans the entire area under which supplemental sprinklers are required. It is typically installed under non-flat objects that are considered obstructions to ceiling-level sprinklers.

Flat Smooth Ceiling Construction: A ceiling construction that is void of undulations, indentations or projections and is installed parallel to the floor.

Flue Space: A vertical space located between two adjacent commodities that are being maintained in a storage arrangement.

Flush Automatic Sprinkler: A sprinkler in which essentially all of the body, with the exception of the thermal sensing element, is mounted above the lower plane of a ceiling.

Flushing: The practice of flowing water or pneumatically blowing through a fire protection piping system for the purpose of removing obstructions.

Flushing Connection: A pipe extension on the end of a crossmain that consists of either a threaded capped nipple (see figure below) or an FM Approved mechanical groove coupling with a blank flange provided inside the coupling. The diameter of the flushing connection can be minimum 1.25 in. (32 mm) up to a maximum of 2 in. (50 mm).

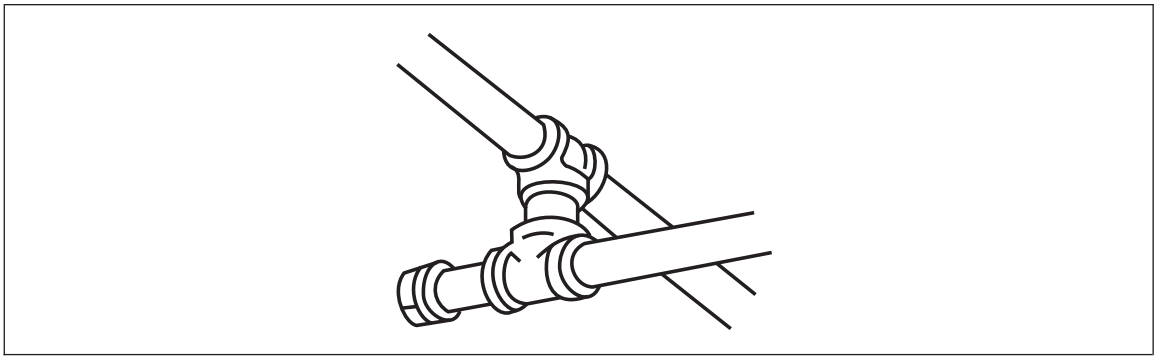

Fig. 47. Flushing connection with a threaded end cap

FM Approved: A product that has been tested to and meets the requirements of a specific Approval Standard and has been listed in the *Approval Guide*, a publication of FM Approvals.

Grid-Type Sprinkler System: A sprinkler system in which the network of branchlines are connected to at least two mains (typically a nearmain and a farmain) thus allowing waterflow to any operating sprinklers within the grid to be from at least two directions.

Grouped Object (obstruction): Two or more adjacent objects are considered a grouped object for obstruction purposes when the horizontal distance between them is less than 3 times the object's least dimension. Under these conditions the width of the object, for obstruction evaluation purposes, is considered the width of both objects' least dimensions plus the horizontal distance between them. An example of a grouped object would be a 3-in. (75-mm) wide service pipe that is located 8 in. (200 mm) away from another 3-in. (75-mm) wide service pipe. Collectively, they represent a 14-in. (350-mm) wide object for obstruction analysis purposes.

Grooved Pipe: A piece of sprinkler piping in which at least one of the ends of the pipe has been fabricated with an acceptable standardized groove (cut or rolled) to allow the pipe to be connected to another sprinkler piping via a grooved coupling or fitting.

Hanging and Bracing Pipe Support: A mechanical assembly consisting of a fastener, an intermediate connecting component (threaded steel rod or similar), and a hanger used for the purpose of supporting sprinkler piping from a building structure.

Hazen-Williams Method: A method of calculating friction loss within a sprinkler system that is based on a given waterflow rate, internal pipe diameter, and internal pipe roughness coefficient. It can be used for the

calculation of friction loss through a water based sprinkler system having waterflow velocities not exceeding 30 ft/s (9.0 m/s). See FM Global Data Sheet 3-0, *Hydraulics of Fire Protection Systems*, for more information on this hydraulic calculation method.

Heat and/or Smoke Vent: A device installed at ceiling level that is designed to allow heat and/or smoke from a fire condition to vent through it. Such devices can be arranged for either manual or automatic operation. Such devices arranged in automatic operation mode are not recommended for buildings equipped with sprinkler protection.

Highest Hazard Commodity: For commodities maintained in a storage arrangement, the commodity that is expected to release the highest amount of heat within a fixed timeframe. FM Global recommends that a sprinkler system be capable of protecting a storage arrangement based on the commodity that is considered the highest hazard.

High-Temperature Environment: An environment where the ambient temperature is expected to rise above 200°F (95°C).

Horizontal Sidewall Automatic Sprinkler: A sidewall-type sprinkler where the sprinkler deflector is located in a horizontal plane relative to the protected area.

Indicating Control Valve: A manually operated valve, installed within a sprinkler system, that when shut prevents the flow of water downstream of it. The valve is equipped with a visual means of determining whether the valve is open or closed.

Individual Object (Obstruction): An object can be considered an individual object for obstruction purposes when the horizontal distance between it and the nearest object is more than 3 times the objects least dimension. Otherwise the width of the object, for obstruction evaluation purposes, would be based on the width of both objects least dimensions plus the horizontal distance between them. An example of an individual object would be a 3 in. (75 mm) wide service pipe that is located at least 9 in. (225 mm) horizontally away from any other object.

Inner Core Discharge Pattern: The portion of the water discharge from a sprinkler that is directed nearly straight downwards from the sprinkler deflector. The area of the inner core is generally based on a 2 ft radius from the center of the sprinkler deflector. This typically applies to pendent sprinklers since very little water from an upright sprinkler is directed into the inner core pattern area.

In-Rack Automatic Sprinkler: A sprinkler that is installed within a storage rack. Such sprinklers are also referred to as rack storage sprinklers as well as intermediate level sprinklers.

Insert: A fastener that is driven vertically into a concrete structural member in order to provide anchorage for a supporting pipe hanger.

Inspector's Test Connection: A device consisting of a manual control valve, a section of sprinkler piping (allowing discharge to a safe location), and a smooth bore corrosion-resistant orifice (no larger than the smallest orifice of any sprinkler installed on the sprinkler system to which the Inspector's Test Connection serves). It is used to test the waterflow alarm mechanism provided for the sprinkler system. It is typically installed at the hydraulically remote end of a sprinkler system.

Interlocks: The arrangement of normal operating functions, such as room air flow or conveyor-belt operation, to be either interrupted or altered in the event of a sprinkler system's alarm condition.

Intermediate Chamber: The space formed within a dry-pipe valve between the air and water clappers, or between the two seat rings in a single clapper design. This chamber is vented to atmosphere through an automatic drain valve when the valve is in its normally shut or "set" position. This chamber allows any water or air leakage by the clapper(s) to be detected. When the dry-pipe valve operates or "trips", water enters this chamber, the automatic drain valve shuts and water flows to the alarms associated with the dry-pipe system as well as into the sprinkler system piping.

Internally Galvanized: Sprinkler pipe that has been coated internally with a layer of zinc for the purpose of preventing the oxidation of the pipe.

K-factor: Also known as the discharge coefficient, it is a numerical value representing the orifice size of the sprinkler in combination with the expected flow through the sprinkler orifice at a given pressure value. It is calculated using the following equation:

$$K = \frac{Q}{\sqrt{P}}$$

Where: Q is the flow through the sprinkler orifice in gpm (Lpm).
P is the pressure at the sprinkler orifice in psi (bar).
The units for K are gpm/psi$^{0.5}$ (Lpm/bar$^{0.5}$).

See Table 2 for K-factor values of Nonstorage sprinklers that are currently FM Approved or Table 16 for K-factor values of Storage sprinklers that are currently FM Approved.

Light-Weight Concrete: Concrete that has a unit weight less than 115 lb/ft^3 (1,840 kg/m^3).

Limited-Combustible Construction: Wall and ceiling construction that consists of materials that contribute limited quantities of fuel when exposed to fire, but in the form they will be installed will not propagate a fire. This includes FM Approved Class 1 wall, ceiling or roofing assemblies including fire retardant treated lumber. Non-plastic ceiling tiles that have a flame spread index (FSI) less than or equal to 25, based on testing per ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, may be considered limited combustible for sprinkler protection purposes.

Linear Spacing: The horizontal distance between sprinklers as measured relative to the protected area.

Line-Type Detection: Detection that is continuous along a given path. See Data Sheet 5-48, *Automatic Fire Detection*, for more information regarding these types of detectors and the type of fire hazard they are appropriate for.

Live Load: Variable loads produced by the use and occupancy during the life of the structure. Live loads on a roof include those loads produced by people, moveable maintenance materials and equipment, and other moveable object such as planters.

Load-Supporting Test: A test conducted on the supporting systems of sprinkler piping to ensure they have been properly installed and can support the anticipated load of the liquid-filled pipe.

Longitudinal Flue Spaces: A vertical space, located between materials maintained in a storage arrangement, which is parallel to the loading aisle. Such flue spaces are typically found in storage racks. A longitudinal flue space must be at least a net 3 in. (75 mm) wide the entire vertical height above the bottom load in order to establish the boundary of a separate shelf area when storage is maintained within storage racks.

Low-Temperature Environment: An environment where the ambient temperature is expected to drop below 40°F (4°C).

Most Remote Sprinkler: The sprinkler on a sprinkler system that would have the least amount of pressure available to it in the event all sprinklers were discharging water simultaneously.

Near Main: The piping network of a grid-type sprinkler system that is connected to the feedmain and provides water to the branchlines.

Node: A point provided on a sprinkler system working drawing for hydraulic calculation purposes. It is provided to represent any sprinkler that is expected to operate during a fire, a change in internal pipe diameter, a change in pipe roughness, a change in the flow rate, or a point needed for reference (the base of the riser).

Noncombustible Construction: Wall and ceiling construction that consists of materials that do not contribute significant quantities of fuel when exposed to fire. This includes an FM Approved Class 1, Noncombustible Core Metal Panel or Class 1 Insulated Steel Deck Roof Assembly with noncombustible insulation. Any material or assembly that passes ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, such as concrete, brick, glass-faced or unfaced gypsum panels, can also be categorized as noncombustible. While paper-faced gypsum marginally fails ASTM E136, it can be treated as noncombustible for sprinkler protection purposes.

Noncombustible Solid Structural Members: Ceiling structural members that are void of openings and comply with ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*.

Non-Interlock Preaction System: A sprinkler system that is located downstream of a preaction valve and is equipped with closed-type sprinklers. The preaction valve is arranged to open upon either the operation of a sprinkler or the actuation of a detection system that is supervising the area being protected by the preaction sprinkler system.

Non-Potable Water Supply: A water supply that is not safe for human consumption as described by the public health authority having jurisdiction.

Non-Smooth Ceiling Construction: A ceiling construction that is not void of undulations, indentations or projections.

Nonstorage Automatic Sprinkler: A sprinkler that has been categorized by FM Global as acceptable for protecting nonstorage-type occupancies and/or any other low to moderate heat-release type fires as permitted in an occupancy-specific data sheet.

Nonstorage Type Occupancy: An occupancy consisting of combustible or noncombustible materials that are not maintained in a storage arrangement.

Obstructed Ceiling Construction: A ceiling structural assembly that prevents the flow of hot gases from spreading out under the ceiling uniformly from the point of fire origin to the nearest four sprinklers. This would apply to ceiling structural assemblies that do not meet the definition of unobstructed ceiling construction.

Occupancy-Specific Data Sheet: A data sheet that addresses a specific occupancy hazard. The FM Global data sheets are categorized into one of fifteen series that generally have the following subject matter:

Series 1 Data Sheets – Construction Guidelines
Series 2 Data Sheets – Sprinkler and Sprinkler System Installation Guidelines
Series 3 Data Sheets – Water Supply Guidelines and Design Guidelines of most nonstorage type occupancies
Series 4 Data Sheets – Guidelines for Protection Systems other than Sprinklers
Series 5 Data Sheets – Electrical Guidelines
Series 6 Data Sheets – Boilers and Industrial Heating Equipment Guidelines
Series 7 Data Sheets – Guidelines for Occupancies that are considered Special Hazards
Series 8 Data Sheets – Storage Protection Guidelines
Series 9 Data Sheets – Property Protection Guidelines and Miscellaneous Information
Series 10 Data Sheets – Human Factor Guidelines
Series 11 Data Sheets – Systems Instrumentation and Control Guidelines
Series 12 Data Sheets – Pressure Vessel Guidelines
Series 13 Data Sheets – Mechanical Guidelines
Series 15 Data Sheets – Welding Guidelines
Series 17 Data Sheets – Miscellaneous Boiler and Machinery Guidelines

Old-Style Automatic Sprinkler: A sprinkler that was manufactured prior to 1953. These sprinklers were designed to discharge 40% to 60% of their water upwards in an effort to extinguish any fire that might be at ceiling level.

One-Piece Reducing Fitting: A fitting that connects two pipes of different diameter.

Open-Grid Ceiling: A ceiling that consists of uniform openings which constitute at least 70 percent of the ceiling area.

Orientation: A description of a sprinkler's deflector relative to the protected area. Terms describing the orientation of a sprinkler include pendent, sidewall or upright.

Orifice Cap: A component of a closed-type sprinkler that is placed over the sprinkler orifice and prevents water from discharging through it until the thermal sensing element of the sprinkler has been activated.

Pendent Automatic Sprinkler: A sprinkler where the water discharge from the sprinkler orifice is directed vertically downward towards the deflector which in turn directs the water downwards toward the protected area. The sprinkler is designed to have the deflector oriented vertically below the pipe to which the sprinkler is connected.

Pipe Hanger: A pipe support component that attaches to the sprinkler pipe.

Pipe Hanger Fastener: A pipe support component, such as an anchor, expansion shield, concrete insert, explosive-driven fastener or a threaded head screw, installed in the vertical position that provides anchorage into the building structure.

Pipe Roughness (C Factor): The measure of resistance the internal walls of a pipe offer to the flow of liquid through the pipe. The value is used in friction loss calculations as part of the hydraulic calculations of a sprinkler system.

Pitch: The measured angle created by the rise in sprinkler pipe relative to the floor.

Plain-End Pipe: A piece of sprinkler piping in which at least one of the ends of the pipe has not been fabricated. The connection of this type of pipe to another piece of sprinkler pipe is via a fitting specifically design for plain-end type pipe.

Point Load: A single load value that represents the total weight transferred to the building structure at the point of connection.

Potable Water Supply: A water supply that is safe for human consumption as described by the public health authority having jurisdiction.

Powder-Actuated Tool: A special device that is used to imbed explosive-driven fasteners into either structural steel or concrete.

Powder-Actuated Fastener Systems (PAFS): A fastening system consisting of a tool, powder cartridge, and fastener. The tool drives the fastener into the point of attachment using the explosive cartridge.

Preaction Sprinkler System: A sprinkler system that is located downstream of a preaction valve and is equipped with closed-type sprinklers (i.e., sprinklers equipped with a thermal sensing element and an orifice cap).

Preaction Valve: An automatic water control valve, typically installed on a sprinkler system riser, specifically designed to hold back water from passing through it until certain conditions have been met, such as activation of a detection system supervising the area protected by the preaction sprinkler system or by pressure drop downstream of the valve. It is connected upstream of a preaction sprinkler system.

Pressure Gauge: A device installed on a sprinkler system that measures the pressure of the water, or other media within the sprinkler system, acting on the internal walls of the sprinkler piping.

Pressure Reducing Valve: An automatic device that is installed within a sprinkler system and is used to control the water pressure within the sprinkler system downstream of it to a pre-set acceptable level. They may currently be either direct acting, which are operated automatically by inner hydraulic controls, or pilot-operated diaphragm type globe valves.

Pressure Relief Valve: An automatic operating valve that will react rapidly to pressure build-up within a sprinkler system and relieve the pressure to atmosphere. The goal of the device is to maintain the internal pressure of a sprinkler system at or below a pre-set value, typically 175 psi (12.1 bar).

Pressure-Resistant Wall: A wall that has been specifically designed and built to resist deformation due to an expected internal pressure build-up during a deflagration type of explosion. It is installed in combination with a pressure-relieving type of wall or ceiling to help ensure serious damage is not experienced to the room area of explosion origin.

Priming Water: Water that is applied over the top of the internal clapper of an automatic system valve (i.e., dry-pipe valve, preaction valve, etc.) to help keep any rubber or similar components from drying out and causing possible failure of the valve.

Quick-Opening Device: An automatic device installed either on an automatic water control valve or within a sprinkler system whose purpose is to decrease the sprinkler system's trip time (and possibly the water travel time as well).

Quick-Response Automatic Sprinkler: A sprinkler that when submitted to a Plunge Tunnel Test has a resulting Response Time Index (RTI) value that is typically equal to or less than 90 $(ft \bullet s)^{0.5}$ (50 $[m \bullet s]^{0.5}$) and a Conductivity factor that is equal to or less than 1.81 $(ft/s)^{0.5}$ (1.0 $[m/s]^{0.5}$). See FM Global Approval Standard 2000 for further details.

Recessed Automatic Sprinkler: A sprinkler in which part or most of the body of the sprinkler, other than the part that is connected to the sprinkler piping, is mounted within a recessed housing with the plane of the orifice above the plane of the ceiling, or behind the plane of the wall on which the sprinkler is mounted.

Refrigerated-Area Sprinkler System: A sprinkler system that is located downstream of a preaction valve and is equipped with closed-type sprinklers. The preaction valve is arranged to open only once both a sprinkler has operated as well as the activation of a heat-type detection system that is supervising the area being protected by the preaction sprinkler system. This type of system is in freezers with extremely low temperatures. See Data Sheet 8-29, *Refrigerated Storage*, for additional information.

Reliable Automatic Water Supply: A water source for a sprinkler system, and any connected manual extinguishing systems, that is installed and maintained in accordance with FM Global Data Sheet 3-10, *Installation and Maintenance of Private Fire Service Mains and their Appurtenances.* The water source must always be able to maintain an adequate volume of water for fire protection purposes. In addition, the integrated piping network that connects the water source to the sprinkler system must be arranged to allow for water delivery to a sprinkler system at all times.

Reliable Gas Supply: A gas supply used for filling a dry-pipe or preaction sprinkler system that is available at all times. If the air supply is reliant on electrical power, to be considered reliable, the power supply must be fed by either a secondary supply independent of the facility' primary electrical supply or from an emergency generator adequately sized to properly maintained the facility's fire protection requirements.

Reliable Heat Source: A heat source for a sprinkler system that is installed and maintained such that it can provide a sufficient heat output in order to prevent the freezing of any portion of a sprinkler system at all times (even during power outages).

Response Time Index (RTI): A numerical value that represents the sprinkler's sensitivity to heat and is used to predict the response of a sprinkler in fire environments defined in terms of gas temperature and velocity versus time. It is represented in the following equation:

$$RTI = \tau \times (u)^{0.5}$$

where:

τ is time constant of the heat responsive element, and

u is the gas velocity

Sprinklers having a RTI value of 90 $(ft \bullet s)^{0.5}$ (50 $[m \bullet s]^{0.5}$) or less are considered to be quick-response type sprinklers. Sprinklers having a RTI value of 145 $(ft \bullet s)^{0.5}$ (80 $[m \bullet s]^{0.5}$) or more are considered to be standard-response type sprinklers. Sprinklers having a RTI value between those values indicated for quick-response and standard-response sprinklers are called special-response type sprinklers.

Restriction Orifice: An orifice separating two air pressure chambers within an accelerator. The orifice is large enough to allow slowly developing air pressure differentials between the two chambers to equalize, however it is too small to allow such an equilibrium state when the air pressure differential between the two chambers is developed relatively fast, such as in the event of a sprinkler actuation. The subsequent imbalance in pressure between the two air chambers is what causes the accelerator to activate.

Return Bend: A combination of piping and fittings (typically elbows) that connect the top of a branchline to a sprinkler or another pipe that feeds sprinklers. They are typically used in sprinkler systems that are fed from raw water type sources to help avoid the accumulation of sediment in any drop nipples.

Riser Nipple: A vertical piece of pipe that connects a main to a branchline.

Roller-Type Conveyor: A conveying system that uses a cylindrically-shaped roller over which a product is moved from one area of a facility to another area. These types of conveying systems can be an obstruction to sprinkler discharge depending on how far apart horizontally the rollers are positioned. See Section 2.1.2.2 for Nonstorage sprinklers or Section 2.2.2.2 for Storage sprinklers for additional information.

Schedule Pipe: A rating assigned to a sprinkler pipe based on its wall thickness.

Section Properties of the Members: The properties of a secondary roof member (i.e., purlin) defined by its Cross-Sectional Area (A), Moment of Inertia (I), Section Modulus (S) and its Radius of Gyration (r). Base the actual purlin load carrying capacity on *effective* section properties, which account for local buckling in the cross-section of the purlin.

Shield Anchor: A two-part fastener consisting of an expansion shield that is inserted into a predrilled hole and a lag bolt.

Sidewall Automatic Sprinkler: A sprinkler intended for installation near a wall and ceiling interface and designed to discharge water horizontally outward and onto adjacent walls as well as the protected area.

Single-Path Flow: Waterflow through a section of sprinkler piping that is in one direction only.

Single-Interlock Preaction System: A sprinkler system that is located downstream of a preaction valve and is equipped with closed-type sprinklers. The preaction valve is arranged to open upon the actuation of a detection system that is supervising the area being protected by the preaction sprinkler system.

Solid Ceiling: A ceiling that is void of any openings and does not allow the flow of hot gases from a fire to travel vertically through the ceiling.

Solid-Type Conveyor: A conveying system that uses a solid moving platform to move products from one area of a facility to another area. These types of conveying systems can be an obstruction to sprinkler discharge depending on how wide the solid moving platform is. See Section 2.1.2.2 for Nonstorage sprinklers or Section 2.2.2.2 for additional information.

Spare Automatic Sprinklers: Sprinklers that are maintained on site within a clearly marked dedicated cabinet or box for the purpose of allowing prompt replacement of any existing sprinkler that has either operated or has been damaged.

Special Protection Automatic Sprinkler: A sprinkler that is designed for a hazard not associated with storage or typical room hazard occupancies. Examples would be sprinklers that are intended to protect the inside of ductwork and cooling towers as well as sprinklers that are intended to be used on exposure-protection sprinkler systems.

Special-Response Automatic Sprinkler: A sprinkler that when submitted to a Plunge Tunnel Test has a resulting Response Time Index (RTI) value that is greater than 90 (ft•s) $^{0.5}$ (50 [m•s] $^{0.5}$) and less than 145 (ft•s) $^{0.5}$ (80 [m•s] $^{0.5}$). FM Approval Standards 2000 and 2008 do not currently recognize this type of sprinkler response rating.

Specifications: A listing of the specific equipment and/or components that is to be installed in a sprinkler system. It could also be detailed information regarding the construction and/or occupancy of the area to be protected by sprinklers in order to validate the compatibility and effectiveness of the sprinkler system based on the details provided.

Sprig: The piece of pipe that connects the branchline to a sprinkler located directly above the branchline.

Sprinkler Nozzle: A piece of fire protection equipment through which water is automatically discharged with the intent of either controlling or suppressing a fire. A sprinkler nozzle is similar to a sprinkler; however it typically is void of an orifice cap, a thermal sensing element and a deflector. Instead it discharges water at a high velocity in a cone shape with a spray pattern that is void of air pockets.

Sprinkler System Components: The various materials and products that constitute a sprinkler system. They include but are not limited to sprinklers, sprinkler piping, automatic water control valves, check valves and pressure gauges.

Sprinkler System Piping: The combination of sprinkler pipe, couplings and fittings that together allow water to be fed from the base ofthe sprinkler system's riser to the sprinklers that are installed on the sprinkler system.

Sprinkler System Pipe Connections: The means by which two pieces of sprinkler pipe are connected. Connections can consist of couplings, fittings, flanges or by an acceptable welding process.

Sprinkler System Riser: It is the vertical piping network of a sprinkler system that connects the sprinkler system's water supply (typically the underground water supply piping network) to the sprinkler system's feedmain. It is equipped with the sprinkler system's waterflow alarm device as well as a pressure gauge and a drain valve. Other auxiliary equipment typically provided on the sprinkler system riser includes a relief valve and the attachment point of the fire service connection.

Sprinkler System's System Valve: It is the automatic valve provided on the sprinkler system riser to which the waterflow alarm device, pressure gauge(s) and drain valve are connected (i.e., alarm check valve on a wet sprinkler system; dry-pipe valve on a dry sprinkler system; etc.).

Standard-Response Automatic Sprinkler: A sprinkler that when submitted to a Plunge Tunnel Test has a resulting Response Time Index (RTI) value that is typically equal to or greater than 145 (ft•s) $^{0.5}$ (80 [m•s] $^{0.5}$) but not exceeding 635 (ft•s) $^{0.5}$ (350 [m•s] $^{0.5}$) and a Conductivity factor that is equal to or less than 3.62 (ft/s)$^{0.5}$ (2.0 [m/s]$^{0.5}$). See FM Global Approval Standard 2000 for further details.

Standard-Spray Automatic Sprinkler: A sprinkler with a deflector designed to discharge nearly all its water down toward the protected area. This type of sprinkler has been common since 1953.

Storage Arrangements: The manner in which a stored commodity is maintained. Typical storage arrangements include solid-piled, palletized, shelf, bin-box, movable shelving units, fixed storage racks and portable racks.

Storage Automatic Sprinkler: A sprinkler that has been categorized by FM Global as acceptable for protecting storage-type occupancies and/or any other high heat-release type fires as permitted in an occupancy-specific data sheet.

Storage-Type Occupancy: An occupancy consisting of combustible or noncombustible materials that are maintained in a storage arrangement covering a minimum area of 200 ft^2 (18.5 m^2) and have a minimum height of 5 ft (1.5 m) for commodity hazards that are plastic or worse (flammable liquids, flammable gasses, roll paper, rubber tires, etc.) in content, or have a minimum height of 10 ft (3.0 m) for commodity hazards that are cellulosic or less hazardous in content.

Strainer: A device that is installed within a sprinkler system to help prevent the flow of foreign debris, such as grit, stones, leaves, etc., beyond it. It is typically required in sprinkler systems equipped with small K-factor sprinklers.

Structural Concrete: Concrete that has a unit weight equal to or greater than 115 lb/ft^3 (1,840 kg/m^3).

Tamper Alarm: A device that is installed on a manually operated sprinkler system control valve which will provide an alarm condition if the valve stem is not located in the proper location (i.e., fully open or fully closed).

Threaded Pipe: A piece of sprinkler piping in which at least one of the ends of the pipe has been fabricated with an acceptable standardized thread style to allow the pipe to be connected to another sprinkler piping via a threaded fitting.

Transverse Flue Spaces: A vertical space, located between materials maintained in a storage arrangement, which is perpendicular to the loading aisle. Such flue spaces are typically found in storage racks. A transverse flue space must be at least a net 3 in. (75 mm) wide the entire vertical height above the bottom load in order to be given credit for defining a shelf area when storage is maintained within storage racks.

Trip Test: A test involving a sprinkler system equipped with an automatic system valve to ensure that (a) the valve functions properly, (b) that the minimum required system pressure is achieved within the permissible timeframe, (c) that all detection and components used for activating the automatic system valve operate properly, and (d) that all interlocks provided on the sprinkler system operate as expected. See Data Sheet 2-81, *Fire Safety Inspections and Sprinkler System Maintenance*, for additional information regarding procedures and documentation needed as part of a trip test.

Trip Time: The time interval, measured in seconds, between the following two events:

(1) The point in time when the most hydraulically remote sprinkler on a dry-pipe, preaction, or similar type of sprinkler system equipped with an automatic system valve opens.

(2) The point in time when the automatic system valve for the sprinkler system opens, allowing water to enter the sprinkler system.

Ultimate Strength: The load value at which a material will fail.

Umbrella Discharge Pattern: The portion of the water discharge from a sprinkler that extends outward from the deflector of a sprinkler, typically in a parabolic shape.

Undercut Fastener: A concrete fastener that utilizes a single-piece bolt and expansion sleeve that is inserted into a predrilled inverted cone-shaped hole.

Unobstructed Ceiling Construction: A ceiling structural assembly that allows the flow of hot gases to spread out under the ceiling uniformly from the point of fire origin to the nearest four sprinklers in a timely fashion. Ceiling structural assemblies that meet this definition include:

- ceiling systems that have construction materials that do not protrude downward from the ceiling more than 4 in. (100 mm), or
- ceiling systems that have construction materials that protrude downward from the ceiling more than 4 in. (100 mm) but their cross-sectional area is 70% or more open, or
- ceiling systems that have construction materials that protrude downward from the ceiling more than 4 in. (100 mm) and are less than 70% open in their cross-sectional area, but the volume created by the ceiling structural assembly does not exceed 100 ft^3 (2.8 m^3), or
- the horizontal distance between the construction material protrusions exceeds the maximum allowable spacing for the sprinkler being installed.

Ceiling assembly systems that do not meet the guidelines outlined above for unobstructed ceiling construction would be classified as obstructed ceiling construction.

Upright Automatic Sprinkler: A sprinkler where the water discharge from the sprinkler orifice is directed vertically upward towards the deflector which in turn redirects the water downwards toward the protected area. The sprinkler is designed to have the deflector oriented vertically above the pipe to which the sprinkler is connected.

Vertical Distance: Vertical distance is measured perpendicular to the floor, between the centerline of the sprinkler's thermal element to the uppermost portion of the underside of the ceiling. This vertical distance can be measured to the underside of the lowermost portion of the ceiling when this section of the ceiling is flat, smooth, and at least 3 in. (75 mm) wide in its least dimension, as well as at least twice as wide as the vertical distance between the uppermost and lowermost ceilings. In addition, the horizontal gap between lowermost ceiling sections (i.e., the width of the flute area) cannot be more than 3 in. (75 mm) wide.

Vertical Sidewall Automatic Sprinkler: A sidewall-type sprinkler where the sprinkler deflector is located in a vertical plane relative to the protected area.

Walkway: For the purpose of this data sheet, walkways are typically located between storage structures for material-handling purposes and are not utilized for storage. They may, however have conveyor systems passing over them upon which combustible material is placed. If walkways have combustibles maintained on them other than those found on conveyors, protect them using the guidelines for mezzanines.

Wall Post Indicator Valve: A manually operated fire service gate valve which controls the water supply to a sprinkler system. Manual access is provided to the valve by positioning the control handle on the opposite side of a nearby wall or barrier. The valve is equipped with target indicator, visible through an opening in the post, which is provided to show whether the valve is open or shut.

Wall-Mounted Sidewall Automatic Sprinkler: A sidewall-type sprinkler that is connected to sprinkler piping that is located along as well as supported by a wall of the protected area. Special care is needed for such sprinklers to ensure they do not rotate upon sprinkler actuation.

Water Delivery Time: The time interval, measured in seconds, of both the trip time and the water travel time of a sprinkler system. It can also be defined as the time interval, in seconds, between the following two events:

(1) The point in time when the most hydraulically remote sprinkler on a dry-pipe, preaction, or similar type of sprinkler system equipped with an automatic system valve opens.

(2) The point in time when pressure at the most remote sprinkler reaches or surpasses the design pressure for the sprinkler system.

Waterflow Alarm: A device that is installed on a sprinkler system and arranged to provide an alarm when one or more sprinklers operate.

Water Travel Time: The time interval, measured in seconds, between the following two events:

(1) The point in time when the water control valve for the sprinkler system opens, allowing water to enter the sprinkler system.

(2) The point in time when pressure at the most remote sprinkler reaches or surpasses the design pressure for the sprinkler system.

Wet-Pipe Sprinkler System: The portion of a sprinkler system that is located downstream of the base of a sprinkler system riser and is filled with water.

Wind Bracing: See the definition for Bridging.

Working Drawings: Sprinkler drawings that are developed and utilized by a contractor for the purpose of installing a sprinkler system.

Yard Main: The network of underground piping, located within the property lines of the protected facility, which supplies water to the sprinkler system.

Yield Strength: The load value at which a material begins to deform plastically (i.e., does not return to its original shape when the load is removed).

Z-Shaped Steel Secondary Roof Member (Purlin): A thin, usually 0.058 to 0.120 in. (1.5 to 3.0 mm) thick, solid web, cold-formed steel secondary member (directly supports deck) that is formed in the shape of the

letter Z. It usually varies in depth from 8 to 11.5 in. (200 to 290 mm), but may range from 6.5 to 14.5 in. (165 to 368 mm). See FM Global Data Sheet 1-31, *Metal Roof Systems*, for further details.

APPENDIX B DOCUMENT REVISION HISTORY

January 2014. Correction was made to Table 24, Maximum Distance Between Pipe Hangers.

April 2011. Further clarification was made to the guidelines for a sprinkler system's area limitation (Section 2.4.1.6, Sprinkler System Maximum Area of Coverage).

January 2011. Modifications were made to the following: Tables 3, 4, 5 and 17, and Sections 2.4.1.6, 2.4.3.7 and 2.5.2.4.

March 2010. This is the first publication of this document.

Advanced Copy. January 2010. This is the first publication of this document. However, changes have been made to the following subject areas previously covered in Data Sheets 2-2, 2-7, or 2-8N, which this document supersedes:

- Sprinklers located under open-grid mezzanines and walkways (see Sections 2.1.1.4 for Nonstorage sprinklers or 2.2.1.4 for Storage sprinklers)
- Acceptable ceiling slopes in the presence of various ceiling-level sprinklers (see Sections 2.1.1.6 for Nonstorage sprinklers or 2.2.1.6 for Storage sprinklers)
- Heat and/or smoke vents, as well as other exhaust openings at ceiling level (see Sections 2.1.1.7 for Nonstorage sprinklers or 2.2.1.7 for Storage sprinklers)
- The maximum recommended area of coverage for each sprinkler system (see Section 2.4.1.6)
- The requirements for dry-pipe sprinkler systems (see Section 2.4.3)
- The requirements for antifreeze solution sprinkler systems (see Section 2.4.7)
- The number of spare sprinklers recommended for each sprinkler system (see Sections 2.1.3.1.7 for Nonstorage sprinklers and 2.2.3.1.6 for Storage sprinklers)
- The allowable linear and area spacing of ceiling-level sprinklers (see Sections 2.1.3.2.2 for Nonstorage sprinklers, 2.1.3.3.2 for sidewall Nonstorage sprinklers or 2.2.3.2 for Storage sprinklers)
- The guidelines for objects that obstruct sprinklers (ceiling and in-rack) protecting storage occupancies (see Section 2.2.3.5)
- The guidelines for the support of sprinkler piping, including field testing of concrete fasteners (see Section 2.5.4)In addition, the following changes have been made:
- This data sheet contains no references to local codes.
- Sprinklers are no longer required to be added to hydraulic calculations when installed to mitigate obstructed ceiling sprinklers.
- The terms "Control Mode Density Area (CMDA)," "Control Mode Specific Application (CMSA)," and "Suppression Mode" are no longer used to describe sprinklers.
- The terms "Storage," "Nonstorage," and "Special Protection" are now used to describe sprinklers (see Appendix A, Glossary of Terms, for definitions).
- The definition of an "individual object" (for obstruction purposes) has been modified: the horizontal distance between the potential obstruction and the nearest object has been changed from more than 6 times to more than 3 times the object's least dimension.

APPENDIX C FORMS

FM Global Forms FM85A and FM999C are provided on the following pages.

FM Global Contractor's Material & Test Certificate for Automatic Sprinkler Systems

Additional printed copies of this form are available to clients from:
Customer Services, FM Global, 1151 Boston Providence Turnpike, P.O. Box 9102, Norwood, MA 02062

Procedure: Upon completion of work, inspection and tests shall be made by the contractor's representative and witnessed by an owner's representative. All defects shall be corrected and system left in service before contractor's personnel finally leave the job.

A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners and contractor. It is understood the owner's representatives signature in no way prejudices any claim against the contractor for faulty material, poor workmanship or failure to comply with approving authority's requirements or local ordinances.

Contractor Information	Date:
Contractor Company Name:	
Contractor Company Address:	

FM Global Client Information	FM Global Index No.:	FM Global Account No.:
FM Global Client Building Owner or Tenant (Y/N)?	Building Name or No.:	
FM Global Client Name:		
FM Global Client Address:		
Description of Occupancy Being Protected:		

Automatic Sprinkler System Components and Materials

Automatic Sprinklers:

Manufacturer	Model / Trade Name	K-Factor	Temperature Rating	SIN	Year of Manufacture	Quantity

Automatic Sprinkler Pipe:

Manufacturer	Model / Trade Name	Product Description	Schedule	Connection Type	Max. Working Pressure

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Automatic Sprinkler System Components and Materials (cont.)

Automatic Sprinkler Pipe Connection:

Manufacturer	Model / Trade Name	Product Description	Pipe Ends	Max. Working Pressure

Automatic Sprinkler Pipe Hangers:

Manufacturer	Model / Trade Name	Product Description	Hanger Rod Size	Component Description	Nominal Pipe Size

Automatic Sprinkler System Alarm-Check, Dry-Pipe or Automatic-Release Type Valves:

Type	Manufacturer	Model	Serial Number	Quantity

If Automatic-Release Type Valve:

Is the detection electronic, hydraulic and/or pneumatic?
Is the interlock arrangement single, double or non-interlock?
Is the air pressure in the system piping supervised?
Is the Automatic-Release Valve arranged for manual operation?

Detection for Automatic-Release Type Valves:

Type	Manufacturer	Model	Protected Area	Linear Spacing	Area Spacing	Quantity

If the Detection for Automatic-Release Type Valve is electric:

Is the circuitry supervised in accordance with Data Sheet 5-40?
What is make and model of Automatic Release Control Panel?
What is make and model of Solenoid Release Valve?

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Automatic Sprinkler System Components and Materials (cont.)

Automatic Sprinkler System Control or Pressure-Reducing Type Valves:

Type	Manufacturer	Model	Serial Number	Quantity

Automatic Sprinkler System Check or Backflow Preventer Type Valves:

Type	Manufacturer	Model	Serial Number	Quantity

Automatic Sprinkler System – Miscellaneous Components:

Component	Manufacturer	Model	Quantity
Waterflow Alarm			
Quick Opening Device			
Pressure Gauge			
Fire Department Connection			
Relief Valve			
Test Connection			
Drain Valve			

Automatic Sprinkler System – Other Components:

Component	Manufacturer	Model	Quantity

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Automatic Sprinkler System Tests

Hydrostatic Tests: Hydrostatic tests shall be conducted at not less than 200 psi (13.8 bar) or 50 psi (3.5 bar) above any static pressure in excess of 150 psi (10.3 bar) for 2 hours. Hydrostatically test any anti-freeze solution sprinkler systems equipped with pendent sprinklers with the anti-freeze solution being used. Differential dry-pipe valves clappers shall be left open during the test to prevent damage. Modify the automatic sprinkler as needed to ensure there is no pressure drop over the 2 hour timeframe.

The sprinkler piping for all wet-pipe automatic sprinkler systems as well as anti-freeze solution automatic sprinkler systems equipped with pendent sprinklers have been hydrostatically tested at _____ psi for _____ hours with _____ psi drop.

Pneumatic Tests: Pneumatic tests shall be conducted at not less than 40 psi (2.8 bar) air pressure. Ensure pressure tanks are arranged for their normal water level and air pressure conditions. Modify the automatic sprinkler system as needed to ensure there is no more than a 1.5 psi (0.1 bar) pressure drop over a 24 hour timeframe.

The sprinkler piping for all dry-pipe and similar automatic sprinkler systems have been pneumatically tested at _____ psi for _____ hours with _____ psi drop.

Waterflow Alarm Tests: Tests shall be conducted on all automatic sprinkler system alarm devices to ensure that an alarm signal is activated no more than 60 seconds after initiating waterflow through the Inspector's Test Connection or similar device.

A total of _____ waterflow alarm devices were tested. A total of _____ waterflow alarm devices activated an alarm signal in more than 60 seconds.

Dry Pipe System or Automatic-Release Type System Testing:

System No./Name	Water Pressure Below Valve	System Air Pressure	Min. Pressure Req. at Sprinkler	Required Water Delivery Time	Time to Achieve Minimum Required Sprinkler Pressure: Without Q.O.D.	With Q.O.D.

If Automatic-Release Type Valve:

Was valve operated manually as well as automatically?

If Detection is electronic, were all detection units tested?

Pressure-Reducing Valve Testing:

Location	Make	Model	Setting	Static Pressure		Residual Pressure		Flow Rate
				Inlet	Outlet	Inlet	Outlet	

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Automatic Sprinkler System Tests (cont.)		
Blank Testing Gaskets:		
Number Used	**Location**	**Number Removed**

Welded Pipe Connections:	**Yes or No?**
Do you certify as the sprinkler contractor that the welding procedures used for the connection of sprinkler piping materials complied with the minimum requirements of AWS B2.1, ASME Section IX *Welding and Brazing Qualifications*, or other applicable qualification standards as required by the AHJ?	
Do you certify that all welding procedures used for the connection of sprinkler piping materials was conducted by welders or welding operators qualified in accordance with the minimum requirements of AWS B2.1, ASME Section IX *Welding and Brazing Qualifications*, or other applicable qualification standards as required by the AHJ?	
Do you certify that the welding was carried out in compliance with a documented quality control procedure to ensure that all discs and field-cut pipe coupons were retrieved from the sprinkler system piping, that openings in piping are smooth, that slag and other welding residue were removed, and that internal diameters of piping were not penetrated?	

Drain Tests:			
System Name/No.	**Static Pressure**	**Residual Pressure**	**Static Pressure Afterwards**

Underground Mains:	
All underground mains and lead-in connections to automatic sprinkler system risers shall be flushed before connection is made to automatic sprinkler system piping.	
Was this verified on Form FM85B?	If No, what form was used?
What contractor flushed the underground mains and lead-ins?	

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Automatic Sprinkler System Tests (cont.)	
Instruction Materials:	**Yes or No?**
Has the person in charge of the fire equipment been instructed as to the location of all the automatic sprinkler system control valves and the care and maintenance of this new equipment?	
Have copies of the appropriate instructions and care of maintenance charts been left on the premises?	
If the answer to either of these questions is "No", explain:	
Date Sprinkler System Left in Service With All Control Valves Open:	
Signatures:	
The Property Owner or their authorized agent:	
Signature and Title	**Date**
The Sprinkler Contractor:	
Signature and Title	**Date**
Additional Explanations, Comments and/or Notes:	

FM Global's Contractor's Hydraulic Analysis Certificate for Automatic Sprinkler Systems

Contractor Information	Drawing No.:	Date:
Contractor Company Name:		
Contractor Company Address:		
Hydraulic Analysis Conducted By:		

FM Global Client Information	FM Global Index No.:	FM Global Account No.:
FM Global Client Building Owner or Tenant (Y/N)?	Building Name or No.:	
FM Global Client Name:		
FM Global Client Address:		
Description of Occupancy Being Protected:		

Protection Required: Ceiling Sprinkler System Design			
FM Global Data Sheet Used:	Table/Figure Used:		Demand Area Shape Factor:
Ceiling Sprinkler System Design Requirements:			
Hose Demand:	Table/Figure Used:	Duration:	Table/Figure Used:
Steel Protection Required per Data Sheet:	Overhead Steel (Y/N)?		Steel Columns (Y/N)?
Ceiling Sprinkler System Flow and Pressure Required at BOR:			
If Not at BOR, Describe Location:			

Ceiling Sprinkler System Information			
Ceiling Sprinkler System Name and/or Number:			
Sprinkler System Type:	System Volume:		Schedule of Pipe:
Sprinkler Manufacturer:	Sprinkler Model:		Sprinkler SIN:
Sprinkler Type: Storage ☐	Non-Storage ☐		Special Protection ☐
Sprinkler RTI: Standard-Response ☐	Quick-Response ☐		Sprinkler Temperature Rating:
Sprinkler K-Factor:	Sprinkler On-Line Spacing:		Sprinkler Between-Line Spacing:
Sprinkler Orientation: Pendent ☐	Upright ☐		Other ☐
If Other, Describe:			

FM Global's Contractor's Hydraulic Analysis Certificate for Automatic Sprinkler Systems

Protection Required: In-Rack Sprinkler System Design		
FM Global Data Sheet Used:	Table/Figure Used:	Demand Area Shape Factor:
In-Rack Sprinkler System Design Requirements:		
Flow and Pressure Required at BOR or POC:		
If at POC, Describe Location:		

In-Rack Sprinkler System Information			
In-Rack Sprinkler System Name and/or Number:			
Sprinkler System Type:	System Volume:	Schedule of Pipe:	
Sprinkler Manufacturer:	Sprinkler Model:	Sprinkler SIN:	
Sprinkler Type: Storage ☐	Non-Storage ☐	Special Protection ☐	
Sprinkler RTI: Standard-Response ☐	Quick-Response ☐	Sprinkler Temperature Rating:	
Sprinkler K-Factor:	Sprinkler On-Line Spacing:	Sprinkler Between-Line Spacing:	
Sprinkler Orientation: Pendent ☐	Upright ☐	Other ☐	
If Other, Describe:			

Storage Arrangement Information			
Commodity Hazard Description:			
Cartoned (Y/N)?	Encapsulated (Y/N)?	Open-Top Combustible Container (Y/N)?	
Storage Height:		Ceiling Height:	
Storage Arrangement:			
If Rack Storage:	Rack Bay Width:	Rack Bay Depth:	Rack Bay Height:
Aisle Width:	Solid Shelves (Y/N)? ☐	If Yes, Shelf Area:	
Additional Storage Information:			

Protection Available
Flow and Pressure Available to Ceiling System at BOR (or Other) After Hose Deduction:
Density or Pressure / Demand Area to Ceiling System at BOR (or Other) After Hose Deduction:
Flow and Pressure Available to In-Rack System at BOR (or Other) After Hose Deduction:
Flow or Pressure / Demand Area to In-Rack System at BOR (or Other) After Hose Deduction:
Duration Available:

FM999C ENGINEERING

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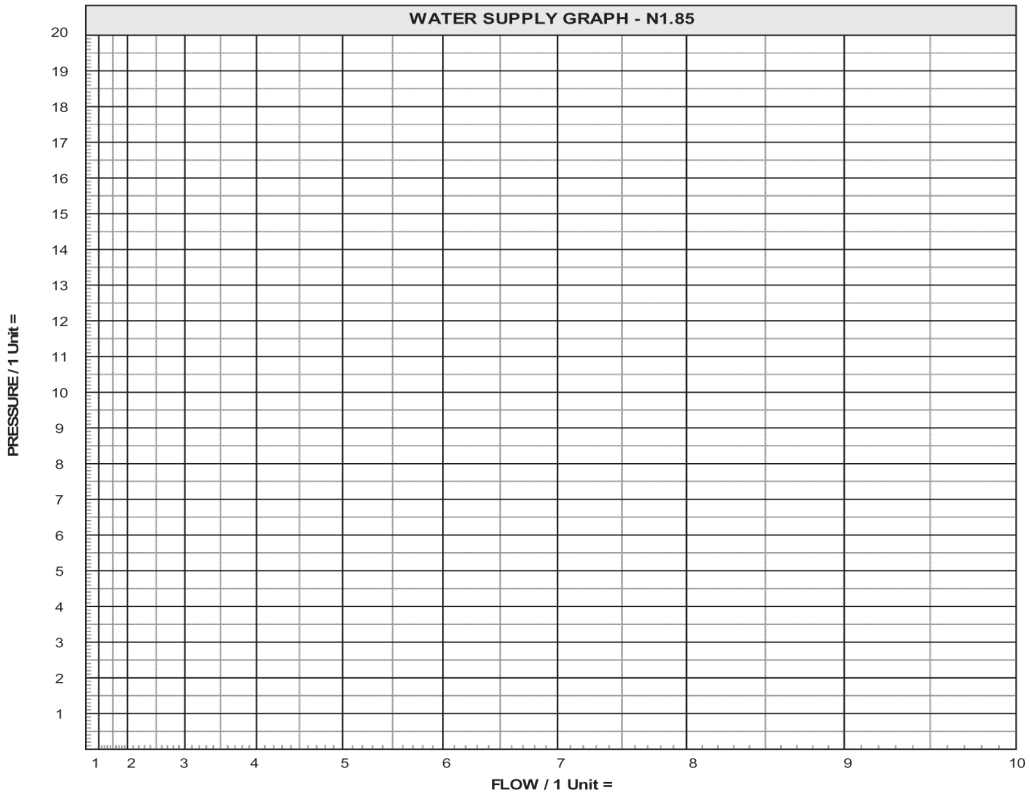
Water Supplies Available						
Name of Source 1:		Type of Source:		Location of Source 1:		
Date of Test:		Effective Point of Test:				
Static/Churn:	Flow 1:	Residual 1:	Flow 2:	Residual 2:	Flow 3:	Residual 3:
Name of Source 2:		Type of Source:		Location of Source 2:		
Date of Test:		Effective Point of Test:				
Static/Churn:	Flow 1:	Residual 1:	Flow 2:	Residual 2:	Flow 3:	Residual 3:



FM Global's Contractor's Hydraulic Analysis Certificate for Automatic Sprinkler Systems

Information to Include on the Water Supply Graph:

(1) Ceiling System Demand Area Curve: This is a curve representing the flow and pressure required for the ceiling sprinkler system that has been analyzed. Plot this curve using the following two points:

(a) The required flow and pressure for the automatic sprinkler system's design, and
(b) The required pressure due to elevation with no flow taking place

Provide an indication on this curve that represents the flow and pressure for the required design.

(2) In-Rack System Demand Area Curve (if applicable): This is a curve representing the flow and pressure required for the in-rack sprinkler system that has been analyzed. Plot this curve using the following two points:

(a) The required flow and pressure for the automatic sprinkler system's design, and
(b) The required pressure due to elevation with no flow taking place

Provide an indication on this curve that represents the flow and pressure for the required design.

(3) Combined Ceiling and In-Rack System Demand Area Curve (if applicable): This is a curve representing the flow and pressure required for both the ceiling and in-rack sprinkler systems, which have been analyzed, simultaneously. Plot this curve in two separate segments as follows:

(a) The first segment consists initially of only the In-Rack Sprinkler Demand Area Curve between zero flow and the flow that reaches the elevation pressure for the Ceiling System Demand Area Curve.
(b) The second segment consists of the combined flow between both the Ceiling System Demand Area Curve and the In-Rack System Demand Area Curve at any given pressure point.

Provide an indication on this curve that represents the flow and pressure for the required combined design.

(4) Water Supply Curve Without Hose Stream Deduction: This is a curve that represents the water supply available at the termination point of the hydraulic calculations for the automatic sprinkler system. For FM Global, this should be the base of the riser (BOR).

(5) Water Supply Curve With Hose Stream Deduction: This is a curve that represents the water supply available at the termination point of the hydraulic calculations for the automatic sprinkler system after a required allotment of flow for hose stream usage has been deducted from the supply. For FM Global, the termination point for the hydraulic calculations should be the base of the riser (BOR). This curve is drawn by subtracting the required hose stream allowance, indicated in the FM Global occupancy-specific data sheet, from the water supply indicated in Item 4 above.

For examples on how to draw these curves, reference FM Global Data Sheet 3-0, *Hydraulics of Fire Protection Systems*.

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