PROTECTION AGAINST EXTERIOR FIRE EXPOSURE

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1.0 SCOPE

This data sheet provides guidelines for evaluating fire exposure from adjacent buildings or yard storage, and recommendations for protecting property from such exposures. It also provides loss protection guidelines for buildings over highways with respect to the hazards created by vehicles.

This data sheet does not address all the exposure hazards from ignitable liquids, fire in certain outdoor equipment, detonations, explosions, or contamination. Table 1 provides a list of the applicable data sheets for those and other hazards.

Table 1. Hazards Not Covered by This Data Sheet

Hazard	*Applicable Data Sheet*
Fire in high-rise buildings	1-3, *High-Rise Buildings*
	1-22, *Maximum Foreseeable Loss*
Fire in cooling towers	1-6, *Cooling Towers*
Fire in yard storage tanks	1-57, *Plastics in Construction*
	7-88, *Ignitable Liquid Storage Tanks*
Transformers	5-4, *Transformers*
Ignitable liquid storage buildings that are unsprinklered	7-29, *Ignitable Liquid Storage in Portable Containers*
Ignitable liquid yard storage pads or detached, sprinklered ignitable liquid storage buildings	7-29, *Ignitable Liquid Storage in Portable Containers*
Ignitable liquid transmission pipelines	7-32, *Ignitable Liquid Operations*
Vapor cloud explosions	7-42, *Evaluating Vapor Cloud Explosions Using a Flame Acceleration Method*
Liquefied petroleum gas	7-55, *Liquefied Petroleum Gas (LPG) in Stationary Installations*
Ignitable liquid storage tanks	7-88, *Ignitable Liquid Storage Tanks*
Baled waste paper	8-22, *Baled Waste Paper*
Idle pallet storage	8-24, *Idle Pallet Storage*
Storage of wood chips	8-27, *Storage of Wood Chips*
Pulpwood and outdoor log storage	8-28, *Pulpwood and Outdoor Log Storage*
Forested areas or underbrush	9-19, *Wildland Fire*
Another tenant within the same building	Refer to the applicable occupancy- or hazard-specific data sheet.

This data sheet is applicable to fire exposures on adjacent property and to situations where the fire exposure and exposed building are on the same property. In the former case, it is recognized that controlling the exposure may be outside the influence of the owner of the exposed building. In the latter case, providing adequate and reliable automatic sprinklers in the exposing building eliminates the hazard. Where adequate and reliable protection is provided, this data sheet assumes that protection is not impaired.

1.1 Changes

October 2016. Interim revision. Clarifications were made to recommendation 3.3.1.2.

2.0 LOSS PREVENTION RECOMMENDATIONS

Exposures that were protected in accordance with the recommendations in the previous edition of this data sheet do not need to be re-evaluated.

The guidance in this data sheet is intended to prevent physical loss and damage from a fire exposure to property under normal conditions. It does not address potential loss or damage from any other hazard. It also does not preclude damage from very large fires under adverse conditions such as a maximum foreseeable loss (MFL) fire on-site or on an adjacent property. Refer to Data Sheet 1-22, *Maximum Foreseeable Loss*, for guidance in those cases.

Recommended separation distances assume normal fire service response.

2.1 FM Approved Equipment

Use FM Approved products when available for the intended service. When FM Approved products are not available, use products that have a proven reliability in the operating environment and process conditions under which they will be used.

2.2 Fire Exposure from Buildings

2.2.1 Provide adequate and reliable sprinkler protection in exposed buildings when needed based on construction and occupancy (see Data Sheet 3-26, *Fire Protection Water Demand For Nonstorage Sprinklered Properties*, Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*, or other applicable data sheets).

2.2.2 When exposing buildings are protected by automatic sprinklers and/or a special protection system, and it can be established that the protection is adequate and reliable, there is no fire exposure.

2.2.3 When exposing buildings are of noncombustible or fire-resistive construction and are vacant or contain only noncombustible contents, there is no fire exposure.

2.2.4 If the exposing wall and roof of the exposing building are categorized as Stable Fire-Resistive (SFR) (see Section 3.1.1 and Appendix A) and there are no unprotected wall or roof openings (such as windows or skylights), there is no fire exposure.

2.2.5 Use Table 2 to determine the minimum safe separation distance (S_M) from an exposing building when the exposed wall is fire-rated. Table 2 assumes a fire duration at least as long as the exposed wall fire rating. If the expected fire duration is less than the fire rating, only structural separation and minimum clearance for thermal expansion are needed for building-to-building spacing.

Table 2. Minimum Safe Separation Distance (S_M) for Fire-Rated Exposed Walls

Exposed Wall Fire Rating (hours)[1]	*Exposing Building Fire Hazard Category (see Table 9)*			
	HC-1/HC-2 (see DS 3-26)	Storage Occupancy (Exposure Height, H)		
		≤ 30 ft (≤ 9.0 m)	31-45 ft (9.1-13.5 m)	> 45 ft (>13.5 m)
<1	Categorize the exposed wall as either combustible or noncombustible (see Table 10)			
1	10 ft (3 m)	30 ft (9 m)	40 ft (12 m)	50 ft (15 m)
2	5 ft (1.5 m)	20 ft (6 m)	30 ft (9 m)	35 ft (10.5 m)
3	5 ft (1.5 m)			
≥ 4	None[2]			

[1]The exposed wall rating applies to the wall as a unit and includes windows, openings, and penetrations.
[2] Only structural separation and minimum clearance for thermal expansion are needed for building-to-building spacing.

2.2.6 For buildings exposing non-fire-rated walls determine S_M using Equation 1 and Figure 1 for combustible exposed walls or Figure 2 for noncombustible exposed walls. Use section 3.1.2 to determine the fire hazard category. Use Sections 3.1.3 and 3.1.4 to determine the exposure length (L). L need not exceed 500 ft (150 m). Use Section 3.1.5 to determine the Unprotected Opening Adjustment Factor (U) and Section 3.1.6 to determine the Exposure Angle Adjustment Factor (M).

$S_M = S_B \times U \times M$ (Equation 1)

Where:

S_M = minimum safe separation distance.
S_B = base separation distance per figures.
U = unprotected opening adjustment factor for openings in the exposing wall (see Figure 21).
M = exposure angle adjustment factor (see Figure 23).

2.2.7 When S_M is not available, provide either passive or active protection.

2.2.8 When using passive protection, provide the necessary protection using a listed assembly or a generic construction per Data Sheet 1-21, *Fire Resistance of Building Assemblies.*

2.2.9 When using active protection, provide active protection for the exposed building as described in Section 2.4, and a minimum separation of 5 ft (1.5 m) for firefighting access.

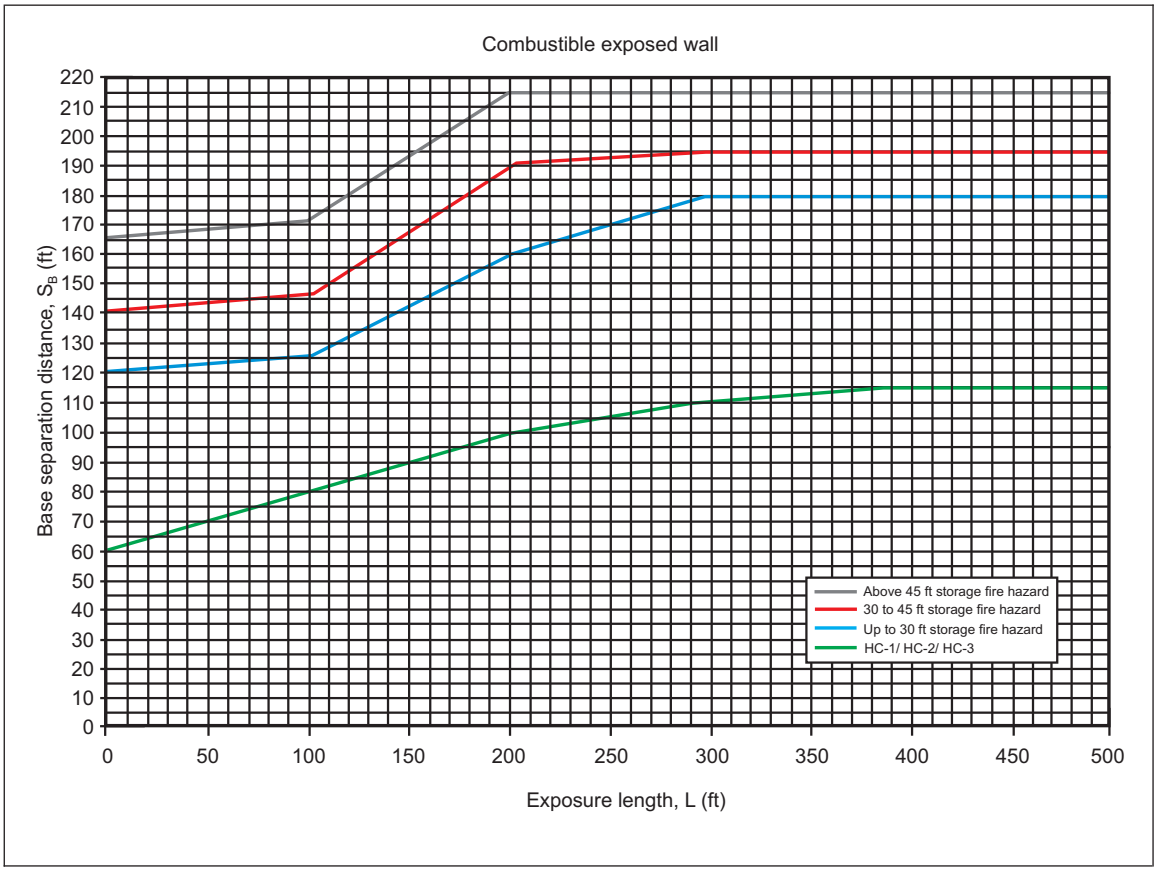

Fig.1a. Base separation distance (S_B) for a combustible exposed wall (ft)

2.2.10 Where the exposure and actual separation distance (D) are such that a fire-rated exposed wall is needed, provide walls and protect door openings and wall penetrations.

2.2.11 Where the exposure and actual separation distance (D) are such that a fire-rated exposed wall is needed, protect windows using one of the following methods:

A. 1-hour rating needed—do one of the following:

1. Replace windows and frames with a listed window assembly of equivalent fire rating.

2. Protect windows with minimum ¾-hr automatic closing shutters.

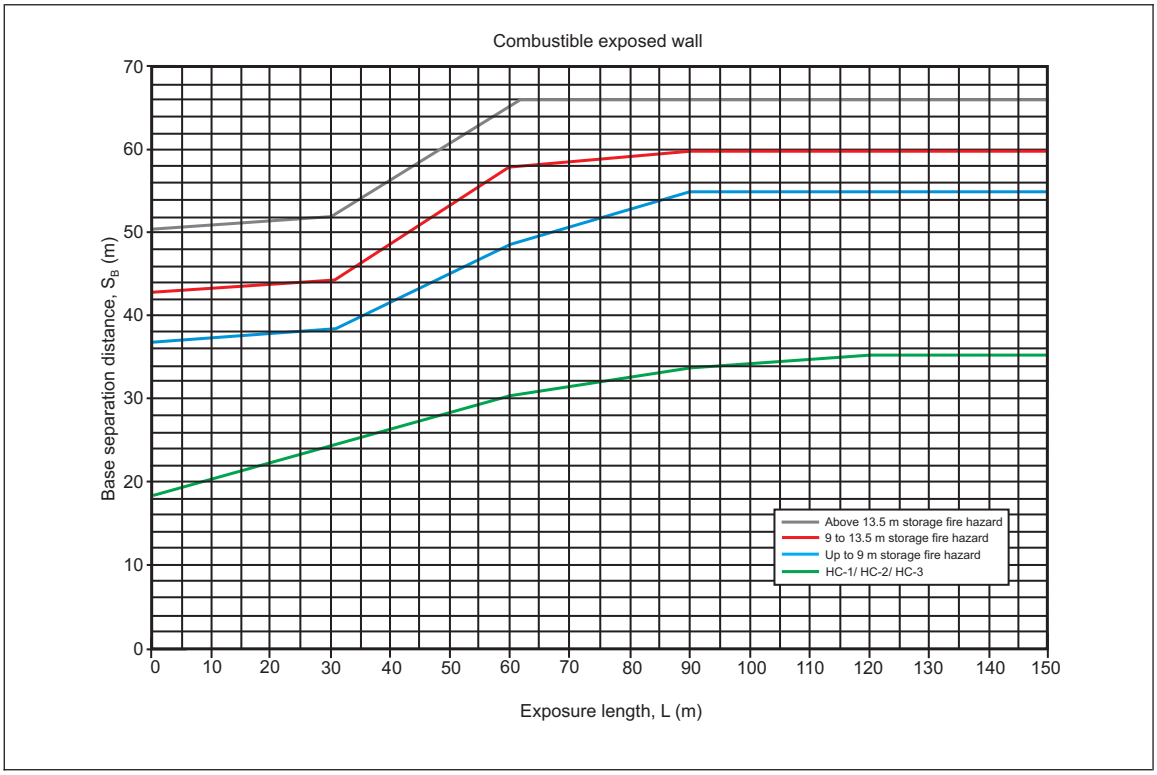

Fig.1b. Base separation distance (S_B) for a combustible exposed wall (m)

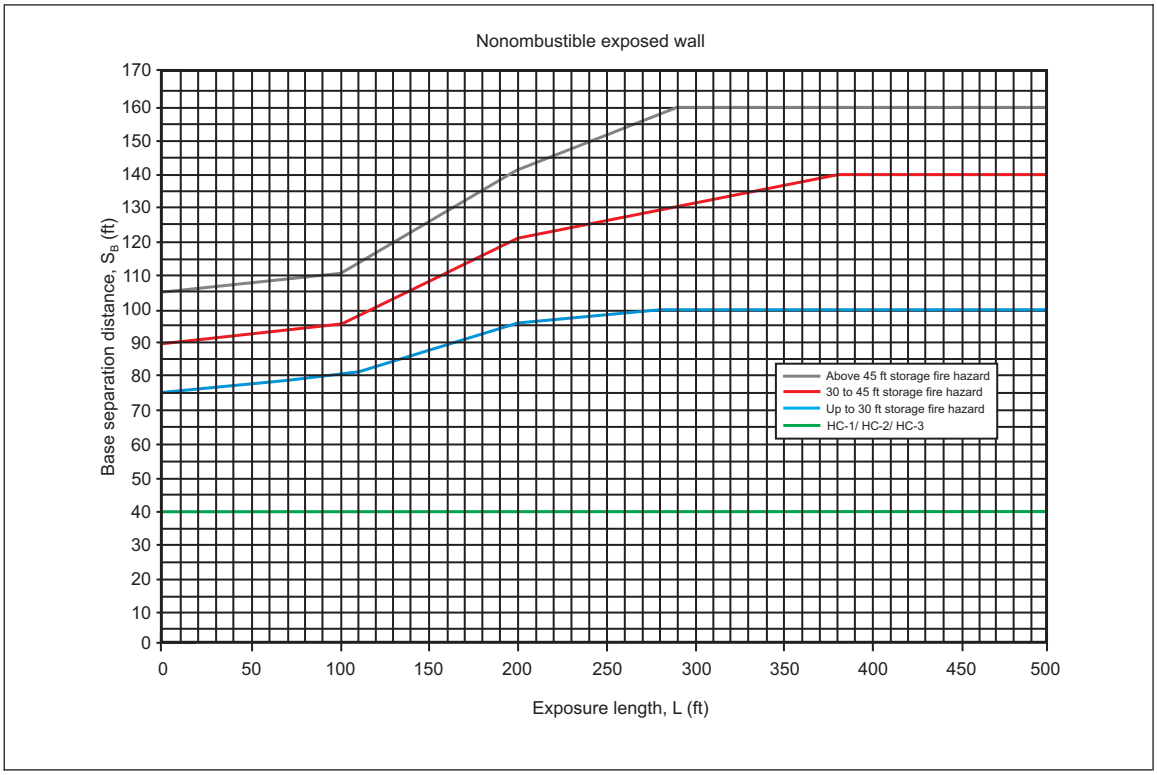

Fig. 2a. Base separation distance (S_B) for a noncombustible exposed wall (ft)

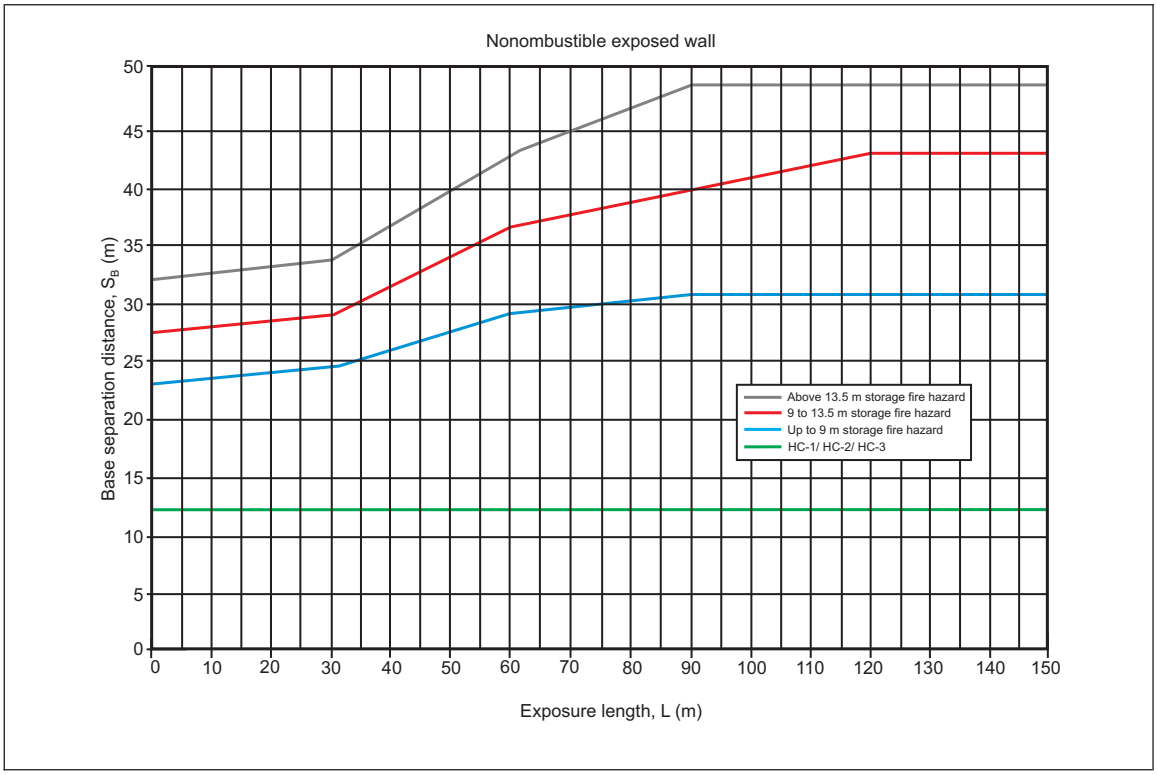

Fig. 2b. Base separation distance (S_B) for a noncombustible exposed wall (m)

3. Provide noncombustible frames and glazing that is listed, minimum ¾-hour fire rated glass, glass block or wired glass. Ensure the dimensions of the windows do not exceed the dimensions and area limitations of the listing or applicable building code. Keep combustibles away from the inside of the exposed windows a distance at least equal to the largest dimension of the window.

B. More than 1-hour rating needed—do one of the following:

1. Replace windows and frames with a listed window assembly of equivalent fire rating.

2. Replace windows and frames with a wall assembly of equivalent fire rating.

3. Protect windows with fire-rated automatic closing shutters with the appropriate rating for the wall.

4. If D ≥ 5 ft (1.5 m), provide listed fire-rated glass (such as ceramic glass, glass block, or wired glass that has passed a hose stream test [see Data Sheet 1-21]), and window sprinklers (see Section 2.4).

2.2.12 Where the exposure and actual separation distance (D) are such that a noncombustible exposed wall is needed, protect door openings on the exposed wall with doors that are:

A. normally closed, self-closing or automatic closing;

B. provided with a latch;

C. noncombustible or minimum ¾-hour fire-rated;

D. blank or have vision panels made of fire-rated, wired, or tempered glass.

2.2.13 Where the exposure and actual separation distance (D) are such that a noncombustible exposed wall is needed, protect windows using one of the following methods:

A. Provide protection according to 2.2.11; or

B. Provide noncombustible window frames and glazing that is:

1. tempered glass;

2. double-paned annealed glass;

3. heat-strengthened glass;

4. wired glass;

5. glass block; or

6. listed fire-rated glass.

2.2.14 For all occupancies with ignitable liquids, evaluate whether the ignitable liquid can compromise the minimum safe separation distance by flowing into the area. Provide containment or drainage if needed (see Data Sheets 7-83, *Drainage Systems for Ignitable Liquids*, and 7-88, *Ignitable Liquid Storage Tanks*).

2.2.15 If the exposed wall is asphalt shingle over wood or asphalt-coated metal (ACM), increase by 25% the S_M determined (using Equation 1) for combustible exposed walls.

2.2.16 Do not store combustible materials within the minimum safe separation space. When combustibles are stored within a space between buildings, provide adequate space between the yard storage and any exposed buildings per Section 2.3. Do not store fuel or chemicals near the interior face of an exposed wall.

2.2.17 Provide a Class A roof cover (per American Society for Testing and Materials [ASTM] test standard E108) on combustible, exposed roofs in the following areas:

A. Within 150 ft (46 m) of an exposing building with a wood roof, walls, or floors, or combustible yard storage.

B. Where the occupancy below the roof is susceptible to water, smoke, or other nonthermal damage.

2.2.18 When the roof of the exposed building is lower than the exposing building, protect combustible, exposed roof coverings within 50 ft (15 m) of the exposure as follows:

A. Surface built-up roofs with a minimum 4 psf (0.19 kN/m^2) of pea gravel or slag embedded in a flood coat of asphalt.

B. Protect single-ply membrane assemblies with large stone ballast or concrete paver blocks in accordance with Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*.

C. Do not use polyurethane foam roof cover systems that are spray-applied to roofs.

D. Protect metal panel roofs (e.g., lap seam or standing seam roofs) by installing a layer of ceramic fiber or mineral wool or glass fiber batt insulation between the bottom of the roof panels and the top of the purlins. Use batt with a minimum of 1 in. (25.4 mm) thick ceramic fiber or mineral wool, or 2 in. (50.8 mm) thick glass fiber.

E. If gravel, slag, pavers, ballast, or insulation is to be added to an existing roof during re-roofing, have a registered civil or structural engineer analyze the roof to verify it can support the additional load.

2.2.19 When the minimum safe separation distance (S_M) is less than 50 ft (15 m), protect combustible, exposed roof coverings within 50 ft (15 m) of the exposure in accordance with Section 2.2.18.

2.2.20 When the exposed wall is longer than the exposure (L), provide protection beyond the end(s) of the exposing building in accordance with Section 3.2.5.

2.2.21 When the exposed wall is shorter than the exposure (L), provide protection for the side walls of the exposed building in accordance with Section 3.2.6.

2.2.22 When the exposed wall is higher than the exposure (H), and the actual separation distance (D) is less than the minimum safe separation distance (S_M), provide protection for the higher portions of the exposed wall in accordance with Section 3.2.7.

2.2.23 When a fire exposure exists, protect the exposed building contents from nonthermal damage as follows:

A. Locate outside air intakes at least a distance S_M from the exposure, or

B. Locate outside air intakes as close to grade-level as practical and provide automatic closing leakage rated dampers.

2.2.24 When a fire exposure exists, conduct pre-fire planning with the fire service.

2.2.25 Prior to demolition of an exposing building, follow the precautions in Data Sheet 1-0, *Safeguards During Construction, Alteration and Demolition*. The most likely time for a major exposure fire to occur is during the demolition of an exposing building.

2.3 Fire Exposure from Yard Storage

2.3.1 Refer to Table 3 for a list of data sheets and the types of yard storage they cover. Use this document to supplement those data sheets or to determine the exposure protection needed for yard storage that is not covered by any other data sheet.

Table 3. Yard Storage Covered in Other Data Sheets

Type of Yard Storage	*Applicable Data Sheet*
Cooling towers	1-6, *Cooling Towers*
Transformers	5-4, *Transformers*
Bunker and outdoor storage of explosives	7-28N, *Explosive Materials*
Ignitable liquid drums, IBC, cylinders, etc.	7-29, *Ignitable Liquid Storage in Portable Containers*
Ignitable liquid yard storage pads or detached, sprinklered ignitable liquid storage buildings	7-29, *Ignitable Liquid Storage in Portable Containers*
Ignitable liquid transmission pipelines	7-32, *Ignitable Liquid Operations*
Vapor Cloud Explosions	7-42, *Evaluating Vapor Cloud Explosions Using a Flame Acceleration Method*
Oxygen storage tanks	7-52, *Oxygen*
Liquefied petroleum gas	7-55, *Liquefied Petroleum Gas (LPG) in Stationary Installations*
Steel, aluminum, iron	7-85, *Metals and Alloys*
Ignitable liquid storage tanks	7-88, *Ignitable Liquid Storage Tanks*
Coal and charcoal storage	8-10, *Coal and Charcoal Storage*
Idle pallet storage	8-24, *Idle Pallet Storage*
Storage of wood chips	8-27, *Storage of Wood Chips*
Pulpwood and outdoor log storage	8-28, *Pulpwood and Outdoor Log Storage*
Forested areas or underbrush	9-19, *Wildland Fire*

2.3.2 Provide adequate and reliable sprinkler protection in exposed buildings when needed based on construction and occupancy (see DS 3-26, DS 8-9, or other applicable data sheet).

2.3.3 When the yard storage is protected by automatic sprinklers or a special protection system, and it can be established that the protection is adequate and reliable, there is no fire exposure.

2.3.4 When there is a fire exposure, relocate yard storage to provide the minimum safe separation distance (S_M).

2.3.5 When there is a fire exposure and the minimum safe separation distance (S_M) is not available to relocate yard storage, provide passive or active protection (see Section 2.4 or the applicable data sheet).

2.3.6 When using passive protection, provide the necessary protection using a listed assembly or a generic construction per Data Sheet 1-21, *Fire Resistance of Building Assemblies*.

2.3.7 When using active protection, provide active protection for the exposed building in accordance with Section 2.4 and a minimum separation of 5 ft (1.5 m) for firefighting access.

2.3.8 Use Table 4 to determine the minimum safe separation distance (S_M) when the exposed wall is fire-rated. Table 4 assumes a fire duration at least as long as the exposed wall fire rating. If the expected fire duration is less than the fire rating, no separation is needed.

Table 4. Minimum Safe Separation Distance (S_M) between Yard Storage and Fire-Rated Exposed Walls

Exposed Wall Fire Rating (hours)[1]	*Yard Storage Fire Hazard Category (see Table 13)*			
	Low Hazard Yard Storage	Ordinary Hazard Yard Storage Exposure Height, H ft (m)		
		≤30 (≤ 9)	31-45 (9-13)	>45 (>13.5)
<1	Categorize the exposed wall as either combustible or noncombustible (see Table 10)			
1	10 ft (3 m)	30 (9 m)	40 ft (12 m)	50 ft (15 m)
2	5 ft (1.5 m)	20 ft (6 m)	30 ft (9 m)	35 ft (10.5 m)
3	5 ft (1.5 m)			
≥ 4	None			

[1]The exposed wall rating applies to the wall as a unit and includes windows, openings, and penetrations.

2.3.9 For yard storage exposing combustible and noncombustible walls, determine S_M using Equation 1 and Figure 3 for combustible exposed walls or Figure 4 for noncombustible exposed walls (interpolation between curves in Figures 3 and 4 is acceptable). Use Section 3.3.1 and Table 13 to determine the fire hazard category. Use L equal to the length of the exposing yard storage up to the maximum length in Figures 3 or 4. Use Figure 23 to determine M and Figure 29 to determine U.

2.3.10 For the exterior protection of exposed building roofs see Sections 2.2.17 through 2.2.19.

2.3.11 Provide at least 30 ft (10 m) horizontally between combustible yard storage and building air intakes or exhaust vents.

2.3.12 Limit combustible yard storage height to the greater of the minimum safe separation distance (S_M) or the lowest exposed wall height.

2.3.13 When the exposed wall is longer than the yard storage exposure (L), provide protection beyond the end(s) of the exposure in accordance with Section 3.2.5.

2.3.14 When the exposed wall is shorter than the yard storage exposure (L), provide protection for the side walls of the exposed building in accordance with Section 3.2.6.

2.3.15 When the exposed wall is higher than the yard storage exposure (H), and the actual separation distance (D) is less than the minimum safe separation distance (S_M), provide protection for the higher portions of the exposed wall in accordance with Section 3.2.7.

2.3.16 Provide yard hydrants when combustible materials are stored outside (see Data Sheet 3-10, *Installation and Maintenance of Private Fire Service Mains and their Appurtenances)*. Locate hydrants just outside the ends of spaces between buildings and at intervals not exceeding 300 ft (90 m).

2.3.17 Maintain unpaved yards so that the height of grass and weeds does not exceed 4 in. (100 mm). Keep the yard free from all combustible trash.

2.3.18 Locate dumpsters (rubbish skips) at least 30 ft (9 m) from exposed buildings, unless the exposed walls are blank (no unprotected openings) and minimum 1-hr fire rated, in which case no separation is needed.

2.3.19 Treat loaded trailers stored in the yard as an exposing building, taking into consideration the contents and construction of the trailer.

2.3.20 Provide metal chain link fencing around the yard, with an adjacent aisle space between it and yard storage to prevent direct access by vandals. (See Data Sheet 9-17, *Protection Against Arson and Other Incendiary Fires.*)

2.4 Active Exposure Protection

2.4.1 Provide a water supply capable of simultaneously supplying the total demand of systems along an exposure up to a maximum length of 400 ft (122 m). Where systems of open sprinklers are used, provide a supply capable of simultaneously flowing all sprinklers that would operate as part of all systems that could be actuated within any 400 ft (122 m) length.

2.4.2 Provide a water supply capable of providing a minimum duration of 60 minutes.

2.4.3 Provide an independent control valve for each system.

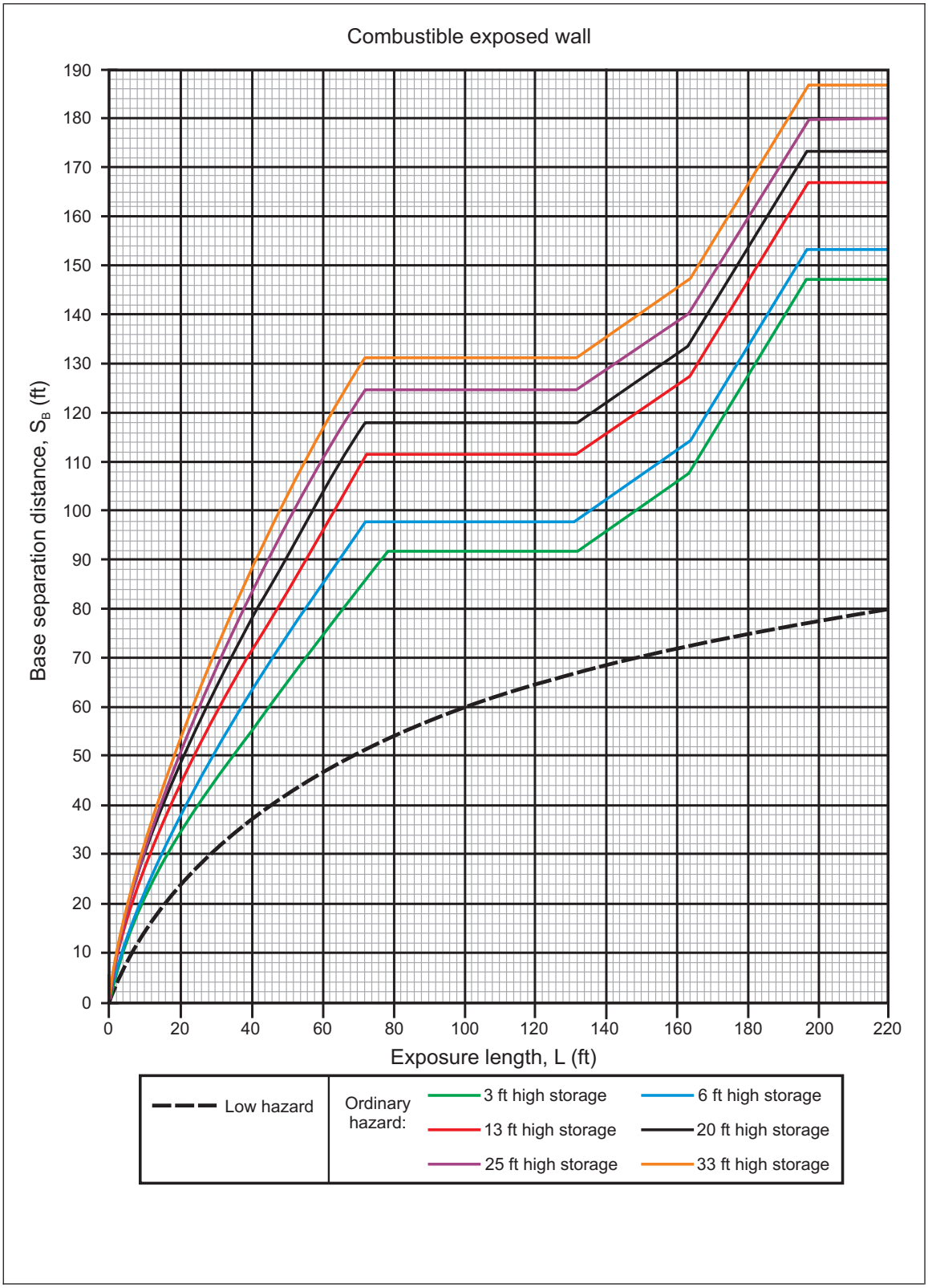

Fig. 3a. Base separation distance (S_B) for yard storage exposing a combustible exposed wall (ft)

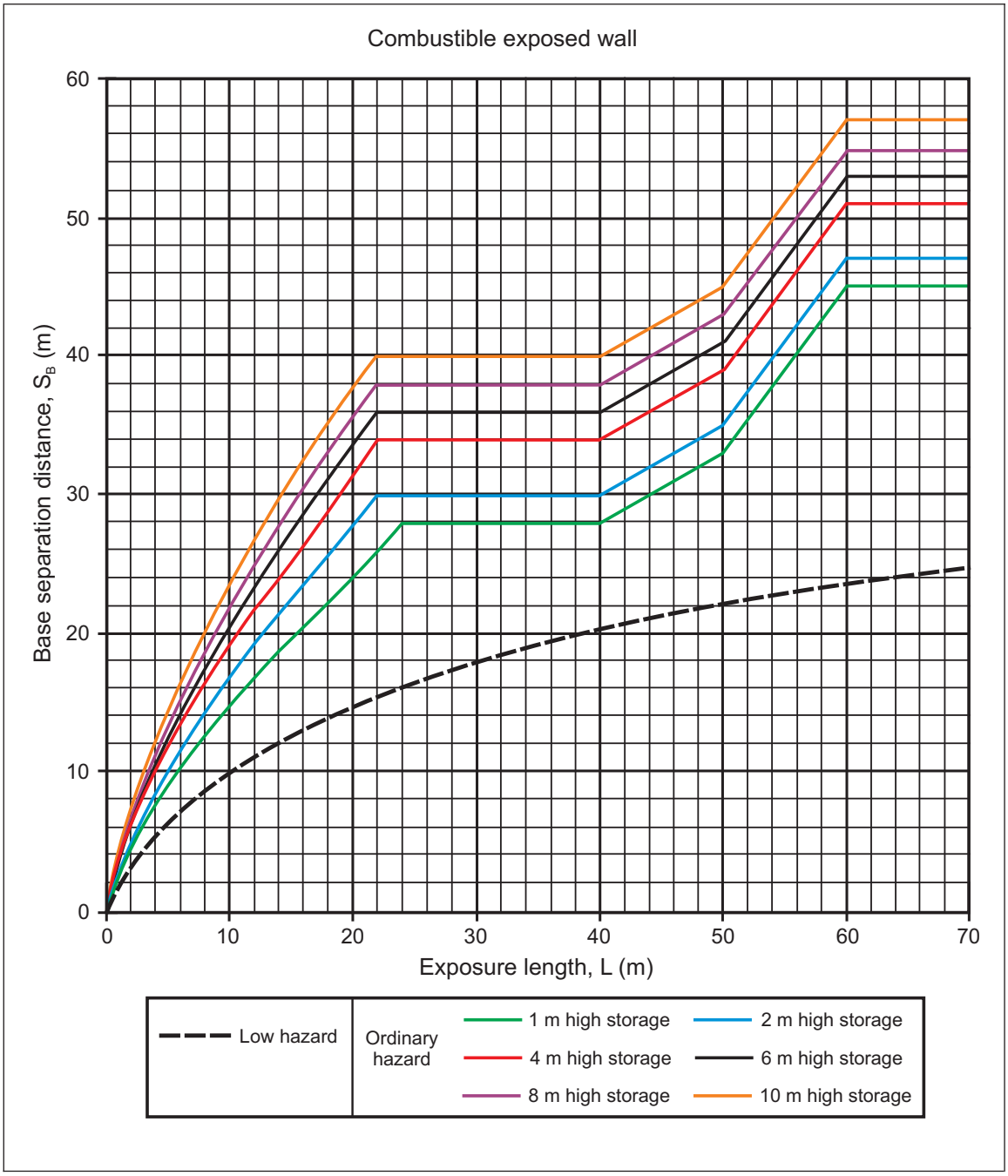

Fig. 3b. Base separation distance (S_B) for yard storage exposing a combustible exposed wall (m)

2.4.4 Use only open or automatic-type sprinklers and water-spray nozzles.

2.4.5 In areas subject to freezing, use dry or antifreeze systems.

2.4.6 Control systems of open sprinklers or water-spray nozzles using fire detection devices designed for the specific application.

2.4.7 Provide a separate drain valve for each system. Install the drain valve on the system side of each control valve, except where a top-fed, open system is arranged to facilitate drainage.

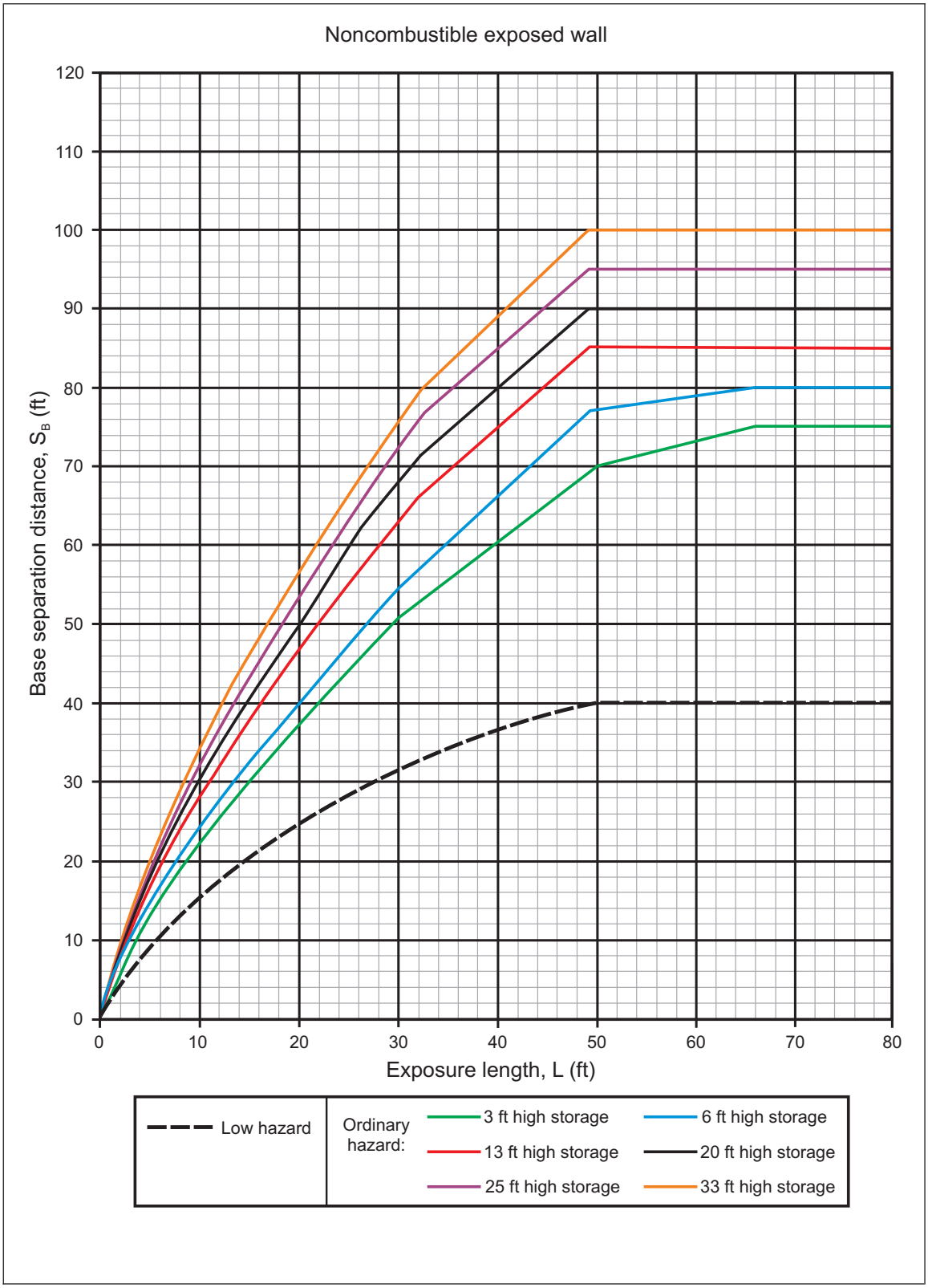

Fig. 4a. Base separation distance (S_B) for yard storage exposing a noncombustible exposed wall (ft)

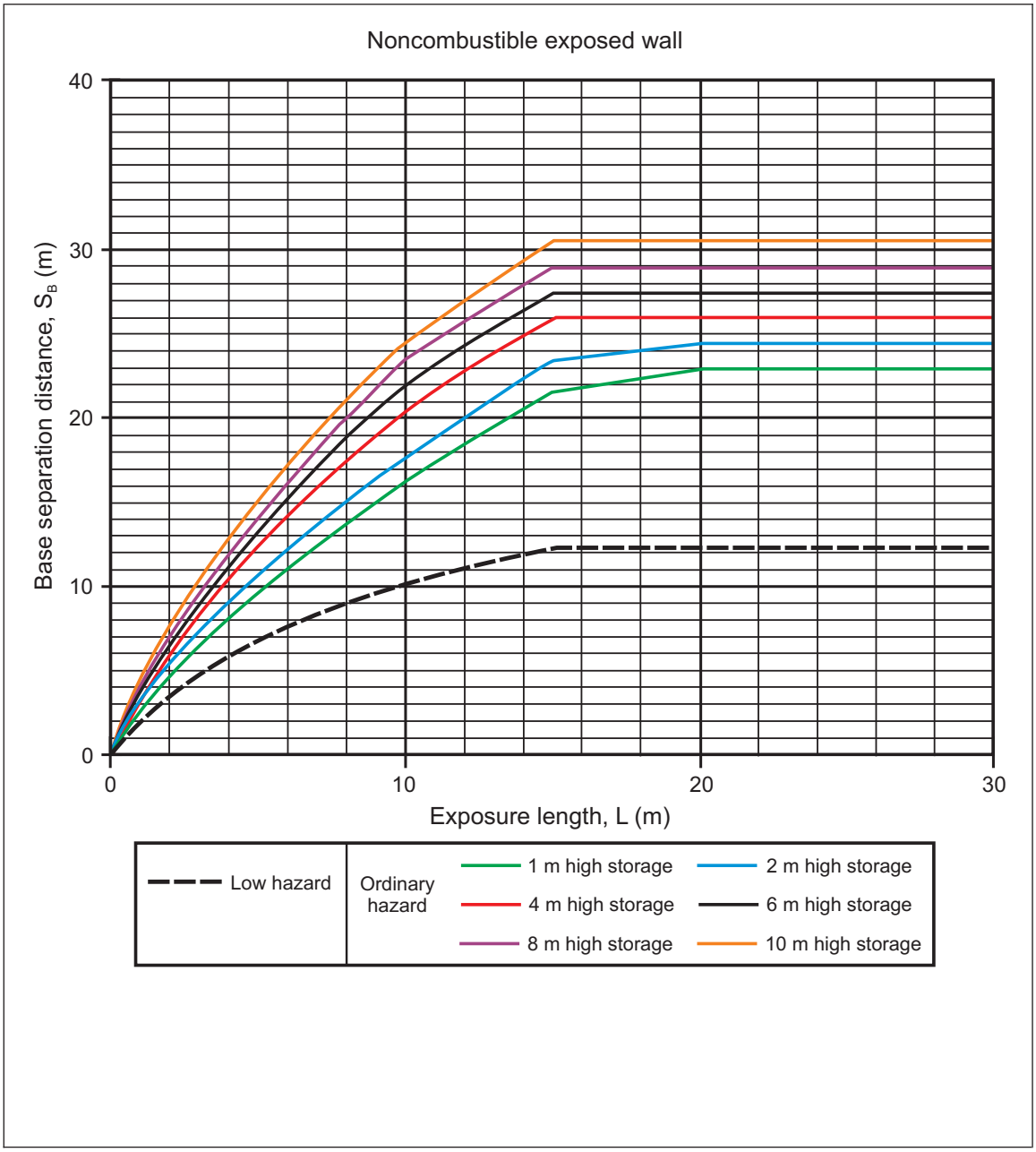

Fig. 4b. Base separation distance (S_B) for yard storage exposing a noncombustible exposed wall (m)

2.4.8 Where exposure protection is installed on two adjacent sides of a building, protecting against two separate and distinct exposures, with separate control valves for each side, design the system(s) using one of the following methods:

A. Provide a single system interconnected by an intermediate pipe and provided with check valves located so that one sprinkler or water-spray nozzle around the corner from the exposed system will operate. Provide a separate drain valve for the intermediate pipe between the two check valves (see Figure 5).

B. Provide two separate systems with an additional sprinkler or nozzle on each system located around the corner (see Figure 6).

2.4.9 Where one exposure affects two sides of the exposed building, provide a single system rather than a separate system for each side.

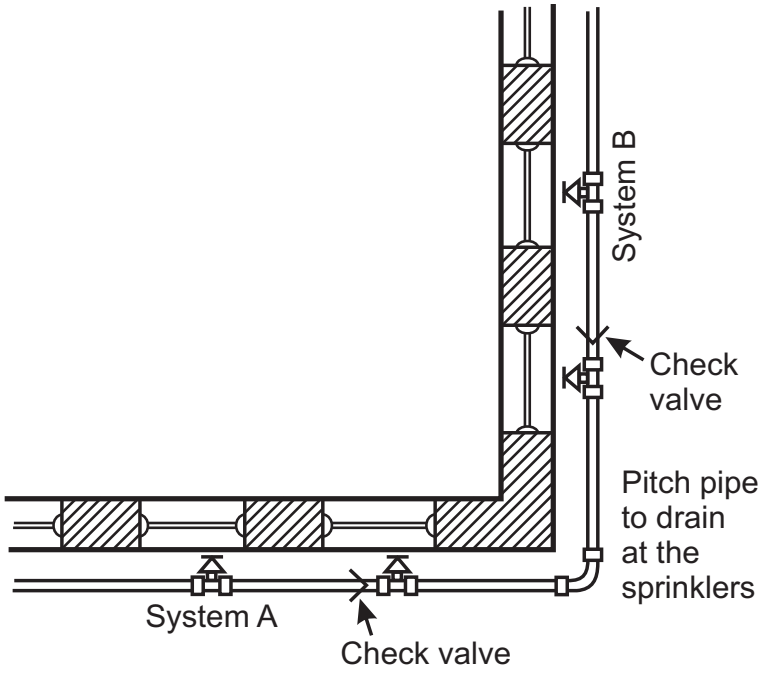

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Fig. 5. Exposure protection system with check valves

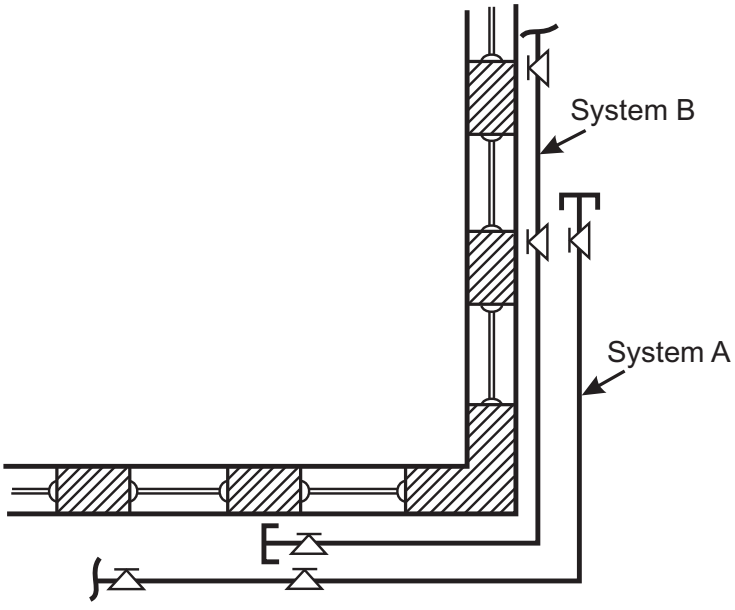

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Fig. 6. Separate exposure protection systems

2.4.10 Provide corrosion-resistant pipe and fittings for systems installed on the exterior of a building or structure.

2.4.11 Provide a strainer in the riser or feed main that supplies sprinklers or nozzles having nominal K-factors smaller than K2.8 (40).

2.4.12 Provide a pressure gauge immediately below the control valve of each system.

2.4.13 Window sprinklers or water-spray protection are alternatives to upgrading the type of glazing in exposed walls, except where a fire rating of 2 or more hours is needed. In such cases, do one of the following:

A. Remove the windows and block up the openings.

B. Provide 2-hour or 3-hour rated fire doors/shutters to protect the windows.

C. Provide 2-hour or 3-hour rated and listed window assemblies.

2.4.14 Use no more than half of the flow from nondirectional sprinklers in determining the minimum average application rate over the protected surface.

2.4.15 A single line of sprinklers is acceptable to protect a maximum of 15 ft (4.5 m) of wall and 13 ft (4 m) of window height where architectural features are sufficiently flush to allow the sprinkler discharge to run down.

2.4.16 Where window sills or similar features result in recesses or projections exceeding 1 in. (25 mm) in depth, provide separate sprinklers for each window on each level, regardless of whether protection is being provided for windows or complete walls.

2.4.17 Design and install systems protecting windows with open water-spray nozzles as follows:

A. Use open water-spray nozzles that are acceptable for exterior applications.

B. Locate at least one row of nozzles at the top of the windows.

C. Do not exceed a spacing of 8 ft (2.4 m) between nozzles unless they are specifically listed for a greater distance.

D. Design the system based on the fire hazard category from the exposing building (see Table 5). Provide no less than 4 gal/min/ft (50 L/min/m) of window width.

E. Where the water supply feeds other fire protection systems (ceiling sprinklers, hose streams, etc.), provide a supply capable of furnishing the total demand for such systems, as well as the window system demand, for a minimum of 60 minutes.

F. Design the system to be activated by combination rate-of-rise, fixed-temperature (nominal 135°F, 57°C) detectors. Locate detectors above the window at roof level, at least 6 in. (150 mm) from the wall and a maximum of 10 ft (3 m) on center parallel to the windows.

G. Where window heights exceed 13 ft (4 m), provide additional level(s) of nozzles. Space the levels to cover an approximately equal vertical surface area. Provide separate piping and valving for window systems as recommended for in-rack sprinklers in Data Sheet 2-0, *Installation of Sprinkler Systems.*

H. Arrange the system for automatic operation and delivery of water to the most remote nozzle at the design pressure within 60 seconds of detector activation.

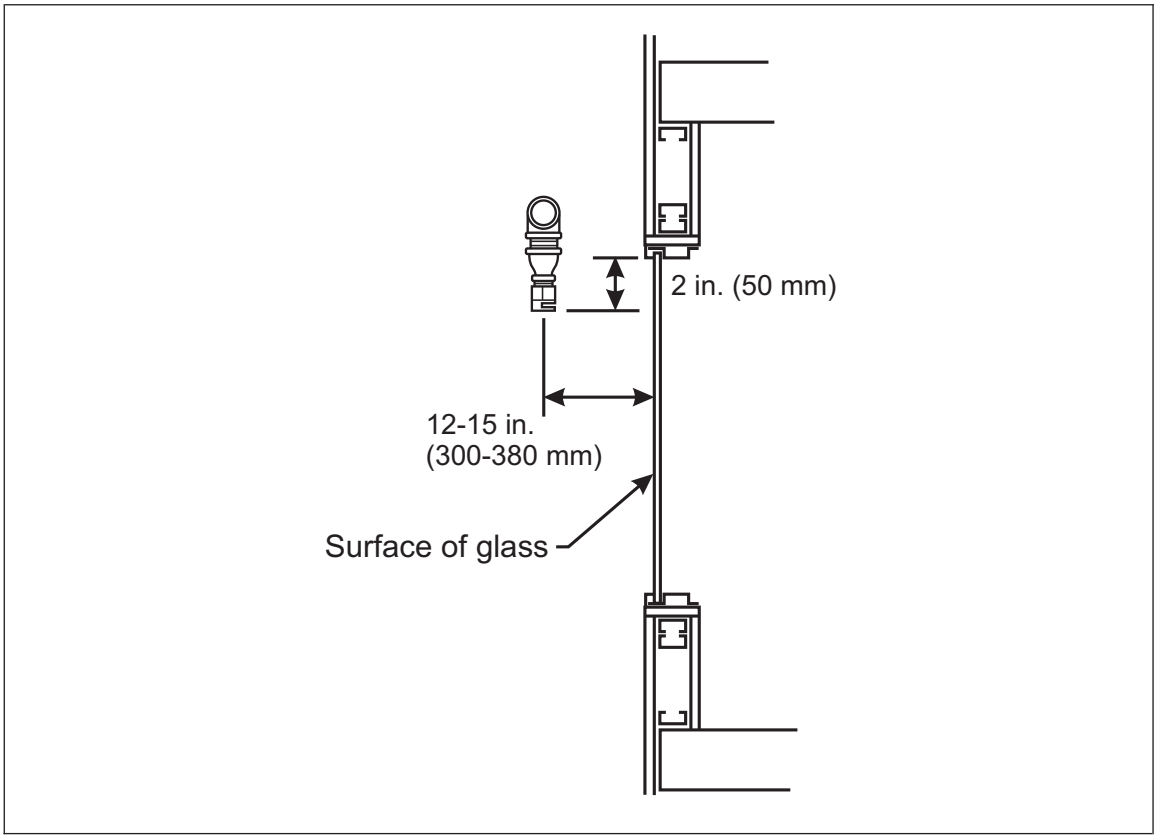

Fig. 7. Typical window sprinkler

Table 5. Exposure Protection Wall and Window Water-Spray Systems

Fire Hazard Category	*Level of Wall or Window Nozzles*[1]	*Minimum K-factor, English (Metric)*	*Minimum Flow Rate, gpm (L/min)*
HC-1/HC-2 (see DS 3-26), Low Hazard Yard Storage	Top 2 levels	2.8 (40)	7.4 (28)
	Next lower 2 levels	1.9 (27)	5.0 (19)
	All levels below	1.4 (20)	3.7 (14)
Storage up to 30 ft (9.0 m)	Top 2 levels	5.6 (80)	14.8 (56)
	Next lower 2 levels	4.2 (60)	11.1 (42)
	All levels below	2.8 (40)	7.4 (28)
Storage above 30 ft (9.0 m)	Top 2 levels	11.2 (161)	29.6 (112)
	Next lower 2 levels	8.0 (115)	21.2 (80)
	All levels below	5.6 (80)	14.8 (56)

[1]A level is defined as a single horizontal branch line across the wall or window being protected.

2.4.18 Design and install systems protecting windows with closed-type water-spray nozzles as follows:

A. Use control-mode, quick-response, pendant sprinklers that are acceptable for exterior applications.

B. Space the nozzles so as not to exceed 8 ft (2.4 m) unless they are specifically listed for a greater distance.

C. Locate at least one row of sprinklers at the top of the windows, but at least 6 in. (150 mm) below any overhanging eave.

D. Design the system based on the fire hazard category from the exposing building (see Table 5). Provide no less than 4 gal/min/ft (50 L/min/m) of window width.

E. Where the water supply feeds other fire protection systems (ceiling sprinklers, hose streams, etc.), provide a supply capable of furnishing the total demand for such systems, as well as the window system demand, for a minimum of 60 minutes.

F. Where window heights exceed 13 ft (4 m), provide additional level(s) of window sprinklers with water shields to prevent pre-wetting of the sprinklers below. Space the levels of window sprinklers to cover an approximately equal vertical surface area. Provide separate piping and valving for window sprinklers as recommended for in-rack sprinklers in Data Sheet 2-0, *Installation of Sprinkler Systems.*

G. Arrange the system for automatic operation.

2.4.19 Design and install systems protecting exposed walls with open-type water-spray nozzles as follows:

A. Use open sprinklers or open water-spray nozzles that are acceptable for exterior applications.

B. Space the sprinklers 6 to 10 ft (1.8 to 3 m) on center.

C. Design the system based on the fire hazard category from the exposing building (see Table 5 or Table 6).

D. Where the water supply feeds other fire protection systems (ceiling sprinklers, hose streams, etc.), provide a supply capable of furnishing the total demand for such systems, as well as the exposure system demand, for a minimum of 60 minutes.

E. Design the system to be activated by combination rate-of-rise, fixed-temperature (nominal 135°F, 57°C) detectors. Locate detectors at roof level, at least 6 in. (150 mm) from the wall and a maximum of 10 ft (3 m) on center.

F. Arrange the system for automatic operation. Design the system to deliver water to the most remote head at the design pressure within 60 seconds of detector activation.

Table 6. Wall and Cornice Exposure Protection with Open Water-Spray Nozzles

Fire Hazard Category	*Open Water-Spray Nozzles Minimum K-factor, English (Metric)*	*Application Rate, gpm/ft (Lpm/m)*
HC-1/HC-2, Low Hazard Yard Storage	2.8 (40)	0.75 (9.3)
Storage up to 30 ft (9.0 m)	5.6 (80)	1.50 (18.6)
Storage above 30 ft (9.0 m)	11.2 (161)	3.00 (37.2)

2.4.20 Design and install closed-type exposure sprinklers for the protection of exposed walls as follows:

A. Use control-mode sprinklers that are acceptable for exterior applications.

B. Space the sprinklers 6 to 10 ft (1.8 to 3 m) on center.

C. Design the system based on the fire hazard category of the exposing building (see Table 5 or Table 6).

D. Where the water supply feeds other fire protection systems (ceiling sprinklers, hose streams, etc.), provide a supply capable of furnishing the total demand for such systems, as well as the exposure system demand, for a minimum of 60 minutes.

E. Arrange the system for automatic operation.

2.4.21 Where exposed walls need to be noncombustible or 1-hr fire-rated, glaze windows with listed fire-rated glass; tempered glass; laminated glass; min. ¼ in. (6 mm) thick wired glass; or glass blocks. Install glazing in fire-rated window frames that allow for glass expansion and are equipped with gasketing.

2.4.22 For wall protection systems, locate sprinklers 6 in. to 12 in. (150 mm to 300 mm) from the wall surface and the top level within 6 in. (150 mm) of the top of the wall.

2.4.23 For protection of windows and similar openings, position window sprinklers or water-spray nozzles within 2 in. (50 mm) of the top of the window and in accordance with Table 7.

Table 7. Position of Window Water-Spray Nozzles

Width of Window, ft (m)	*K-Factor, English (Metric)*	*Distance from Window, in (mm)*
≤3 (≤0.9)	2.8 (40)	7 (180)
>3-4 (>0.9-1.2)	2.8 (40)	8 (200)
>4-5 (>1.2-1.5)	2.8 (40)	9 (230)
	5.6 (80)	12 (300)
>5-7 (>1.5-2.1)	11.2 (160)	12 (300)
	Two 2.8 (40)	7 (180)
>7-9.5 (>2.1-2.9)	14.0 (200)	12 (300)
	Two 2.8 (40)	9 (230)
>9.5-12 (>2.9-3.6)	Two 5.6 (80)	12 (300)

2.4.24 Where active exposure protection is needed to protect combustible cornices exceeding 12 in. (300 mm) in depth, use open water-spray nozzles. Install nozzles in each bay formed by cornice features and space them up to a maximum distance of 10 ft (3 m) apart, with deflectors 8 in. (200 mm) below the underside of the cornice (see Figure 8). Use Table 6 to determine the minimum application rate per unit length of combustible cornice and the minimum K-factor. Provide at least 7 psi (0.5 bar) at the most remote nozzle.

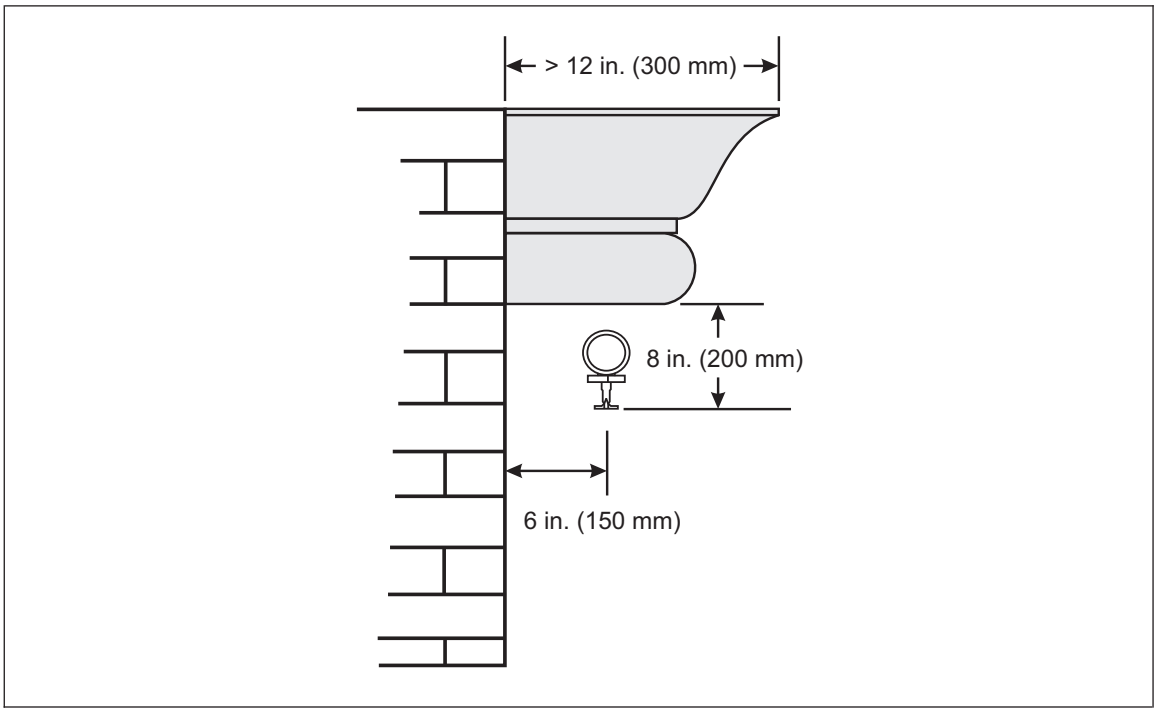

Fig. 8. Cornice sprinkler below combustible cornice

2.4.25 Open sprinklers or open water-spray nozzles (upright, pendent, or sidewall) may be used for roof protection when installed in accordance with hazard category HC-2 (see DS 3-26) protection areas and discharge criteria, with deflectors aligned parallel to the slope and positioned a minimum 18 in. (460 mm) above the roof surface.

2.4.26 Upright sprinklers may be used as roof ridge sprinklers with their deflectors horizontal and minimum 6 in. (150 mm) above the ridge, with their maximum spacing and protection areas determined in the plan view rather than along the slope (see Figure 9).

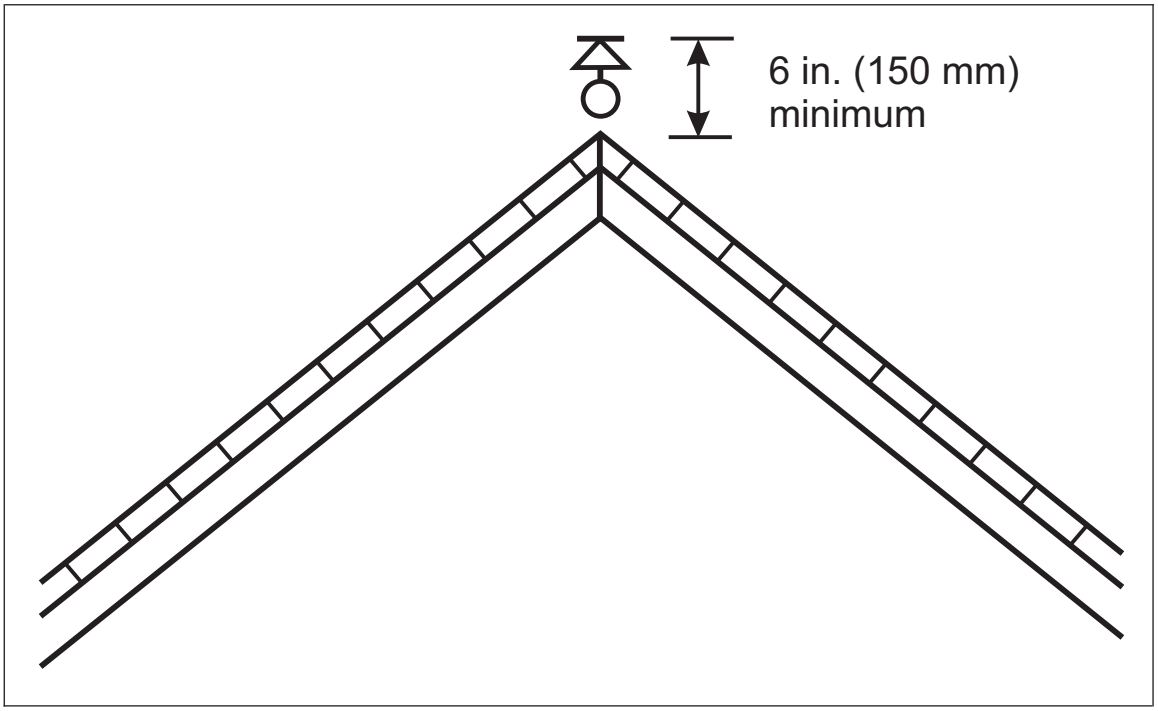

Fig. 9. Roof ridge sprinkler above combustible roof

2.5 Buildings Over Highways

2.5.1 Construction and Location

2.5.1.1 Provide a minimum fire-resistance rating of 4 hours for floors, beams, and columns of buildings over highways that are exposed to the space below. Refer to Data Sheet 1-1, *Firesafe Building Construction* and Materials, and Data Sheet 1-21, *Fire Resistance of Building Assemblies.*

2.5.1.2 Provide exposure protection against fires at the entrances or exits of the space under a building using the more practical of the following recommendations:

A. Do not penetrate the fire-resistive floor slabs of buildings over highways (as specified by 2.5.1.1 or 2.5.2.1) that extend 50 ft (15 m) beyond the building line (se Figure 10).

Or

B. Provide blank, 2-hour rated building walls facing the highway for 20 ft (6 m) above the top of the building slab, or at least one story, whichever is higher. Provide equal-height blank, 2-hour rated walls for at least 20 ft (6 m) for walls parallel to the highway (see Figure 11).

2.5.1.3 Provide the following for new construction located over a highway:

A. Install a complete drainage system for the highway space under the building. Provide sumps with automatic pumps where necessary. Design the drainage system with protected collection areas of sufficient volume to contain the largest expected spill of hazardous material.

B. For roadways under buildings in excess of 200 ft (60 m) long, provide an emergency exhaust ventilation system designed for the removal of smoke and other toxic fumes. Design the system to prevent or minimize adverse effects on the buildings and their occupants from fire products (such as heat, smoke, and toxic gases) with a minimum of ten air changes per hour.

2.5.1.4 Where possible, provide walkways, elevated 6 in. (150 mm) and about 4 ft (1.2 m) wide, on both sides of the roadway to facilitate manual firefighting.

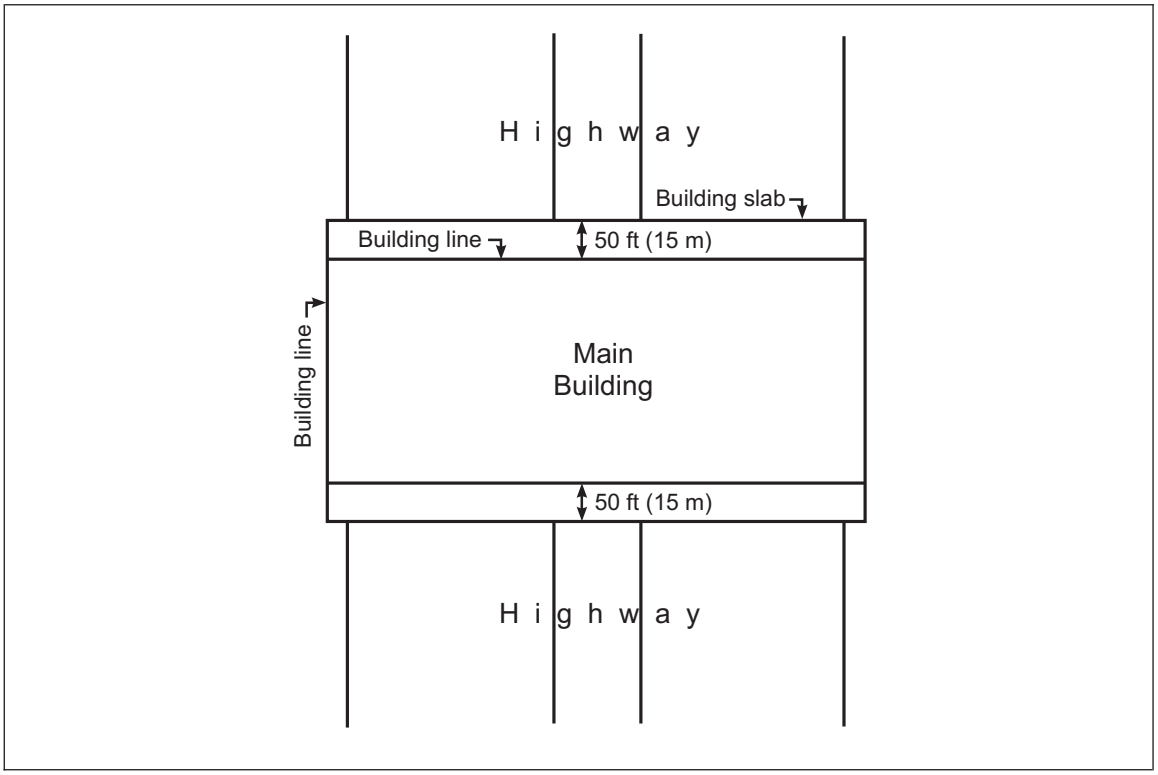

Fig. 10. Building slab extending 50 ft (15 m) beyond the building line (plan view)

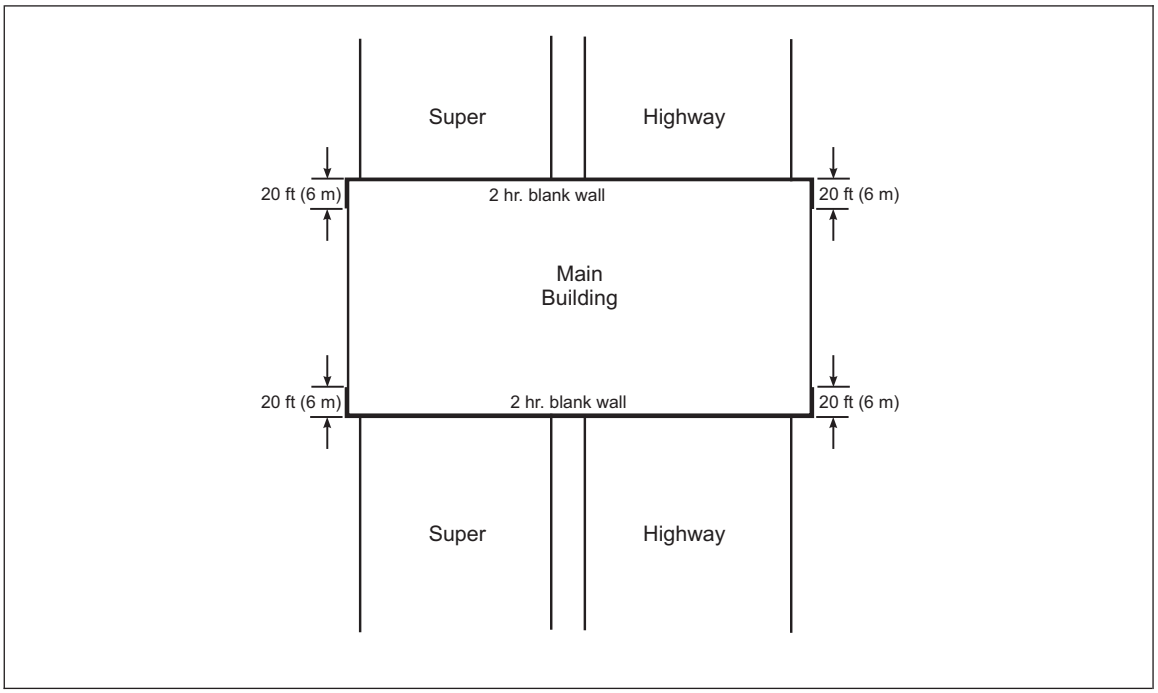

Fig. 11. Fire-resistive walls of building over highway (plan view)

2.5.2 Protection

2.5.2.1 As an alternative to Recommendation 2.1.1, provide the exposed floors, beams, and columns of the building with a minimum fire resistance of at least 2 hours, and protect the space under the building with automatic sprinklers in accordance with Data Sheet 3-26, *Fire Protection Water Demand for Nonstorage Sprinklered Properties.* Either dry or preaction systems are suitable in cold climates.

2.5.2.2 Provide readily accessible hydrants immediately outside the space under the building entrances and exits. For buildings that extend over the roadway by 200 ft (60 m) or more, provide wall hydrants spaced every 150 ft (45 m) in accordance with Data Sheet 4-4N, *Standpipe and Hose Systems*.

Fig. 12. The Crown Plaza® Boston Newton hotel, built over the Massachusetts Turnpike in Newton, MA

2.5.2.3 Provide manually activated emergency alarms that transmit to a constantly attended location, preferably the local fire service.

2.5.3 Human Element

2.5.3.1 Provide an emergency preplanning traffic control system that reduces the risk of the involvement of additional vehicles in an accident below the building, slows traffic during inclement weather conditions, and assists in fire service vehicle access.

2.5.3.2 Dangerous cargo, as defined by the U.S. Department of Transportation (or international equivalent), should be prohibited from passing under buildings over highways.

3.0 EXPOSURE FIRES

An exposure fire, for the purposes of this document, is a fire in an adjacent building or yard storage that results in ignition of or damage to a building. The adjacent building (i.e., exposing building) may be owned and in the care and custody of the exposed building's owner, owned but in the control of others, or not owned and having no relation to the owner of the exposed building. It may be on the owner's property or it may not be. These same conditions also apply to exposing yard storage.

Fig. 13. The Crown Plaza® Boston Newton hotel

In many large exposure fires, the origin of the fire has been on neighboring or adjoining properties. Buildings also have been damaged by exposure fires starting in yard storage, such as lumber, roll paper, tires, plastics, etc., or in separate, unsprinklered structures. Automatic sprinklers and manual firefighting usually control the fire and keep it from spreading throughout the exposed building, although heat, water, and smoke damage may be considerable.

It is necessary to consider fire exposure protection from a fire in adjacent buildings or yard storage when:

A. Separation distances are close enough that a hazard to the exposed building is judged to exist, and

B. An exposing property is unsprinklered, or has sprinkler protection that is inadequate or is not considered reliable.

Once a fire exposure hazard is judged to exist, guidelines in this data sheet can be used to determine if separation distances between the exposing and exposed buildings are safe for the degree of protection afforded by the construction and sprinklers in the exposed building, or if protection for the exposed building is needed.

Protection may be active, in which case a fire protection system (e.g., outside sprinklers) actively protects the exposed building during a fire; or passive, in which the exposed building is protected by noncombustible or fire-resistive construction, materials, or coatings, alone or in conjunction with some amount of open space.

Protection needed for an exposed building depends on the size and intensity of the exposure fire, the horizontal distance from the fire, and the position of the exposed portion in relation to the fire. The growth of a building fire will depend on: (a) the nature and quantity of combustibles in the building construction and occupancy; (b) the amount of ventilation air; and (c) external factors such as wind velocity, promptness of

detection, manual response, and available water supplies. In the vast majority of cases, it is reasonable to assume there will be sufficient ventilation air to feed the fire.

When evaluating the magnitude of the exposure fire, the type of construction, area, percentage of wall openings, occupancy, and adequacy and reliability of the fire protection system(s) of the exposure must be considered.

When evaluating the susceptibility to fire of the exposed building, consider the type of exposed wall, protection of openings, and combustibility of the exposed roof. Generally, the main concern is the exposure to radiant heat; however, there will be situations where the susceptibility to flowing ignitable liquids or the intake of smoke are of equal concern.

Recommended separations are based on estimated portions of the exposing flame height that are not obscured by smoke. While the fire hazard categories are based on the height of the exposure, the minimum safe separation distance (S_M) is determined taking into consideration the calculated total flame height.

Figures 1 through 4 combine construction, occupancy, and flame height to evaluate various degrees of fire exposure and assume that conditions are favorable for a free-burning fire.

3.1 Exposing Building

3.1.1 Exposing Building Wall Categories

Categorize the exposing wall using Table 8. For additional details and definitions of exposing wall categories, see Appendix A.

Table 8. Exposing Building Wall Categories

Exposing Wall Category	*Description*
COMBUSTIBLE (C)	All metal-faced panels with thermoplastic insulation
	Aluminum panels without insulation[1]
	Any wall with exposed combustible materials
	Asphalt-coated metal (ACM)
	Asphalt shingled wood sheathing
	Cementitious panels on wood frame
	Cementitious shingles on wood frame
	EIFS[2]
	Non-Approved metal-faced panels with plastic insulation
	Other assemblies on unprotected wood frame
	Rigid plastic panels (FRP, PVC)
	Wood (painted, stained or unfinished)
NONCOMBUSTIBLE (NC)	Aluminum-faced panels with noncombustible insulation on steel or reinforced concrete frame
	Any tempered glass panels in noncombustible frames on a steel or reinforced concrete building frame
	Any unrated glass block
	Any unrated precast, cast-in-place, or tilt-up concrete panels (solid, hollow, or insulated) on steel or reinforced concrete frame
	Cementitious panels with noncombustible insulation on steel or reinforced concrete frame
	Cementitious panels without insulation on steel or reinforced concrete frame
	Cementitious shingles on steel or reinforced concrete frame
	Cementitious shingles over noncombustible sheathing on steel or reinforced concrete frame
	Cementitious stucco
	EIFS with class 1 insulation over gypsum board sheathing
	EIFS with noncombustible insulation over gypsum board sheathing
	FM Approved aluminum-faced class 1 panels with thermoset insulation on steel or reinforced concrete frame
	FM Approved steel-faced class 1 panels on steel or reinforced concrete frame
	FM Approved steel-faced class 1 panels with thermoset insulation on steel or reinforced concrete frame
	FM Approved steel-faced noncombustible panels on steel or reinforced concrete frame
	Metal lath and plaster
	Steel-faced panels with noncombustible insulation on steel or reinforced concrete frame
	Steel-faced panels without insulation on steel or reinforced concrete frame
STABLE FIRE RESISTIVE (SFR)	The wall and structural frame of the exposing building are fire resistive, and given the combustible loading of its occupancy, are expected to remain in place throughout the duration of the fire.

The categories of construction materials used for Table 8 are not based on the combustibility of the material alone. Consideration is also given to the ease of ignition, and the potential for burn-through or melting as it relates to an exposing building radiating heat.

If the exposing building is fire-resistive such that the floor and/or roof deck, the framing, and the exposing exterior wall (must be blank) are at least adequate for the expected exposure fire duration (so as to contain the exposure fire), no separation is needed for the exposed building.

Exposing walls are categorized as Combustible (C), Noncombustible (NC), or Stable Fire Resistive (SFR). If a wall is fire resistive but tied to unprotected steel framing, for example, it may partially collapse as the steel fails early in a fire and is therefore not considered stable. Treat such an assembly as NC.

The category of Noncombustible covers exposing materials that have some fire resistance or a high melting temperature that will not burn through. Consideration is given to the fact that some breakage or opening of panel joints may occur during the fire. The category of Combustible covers exposing materials that may burn through with a significant fire exposure, or may melt at fire temperatures, eventually allowing the exposed wall to feel the full effect of radiation. Masonry walls may be brick, concrete block, or stone. Noncombustible

(NC) walls have less fire resistance and are curtain walls constructed of panels such as protected metal, corrugated iron, or cementitious panels on steel frame. Combustible walls may consist of wood or rigid plastic building materials. Wood walls with an exterior veneer of stucco, brick, masonry, etc., are considered to be combustible (see Table 8) when considered as the exposing building (fire exposure from its interior), but are considered to be fire resistive as the exposed building (when exposed from the exterior).

3.1.2 Exposing Building Occupancy

Categorize the exposing building's occupancy using Table 9. For a description of storage commodities, see Data Sheet 8-1, *Commodity Classification*.

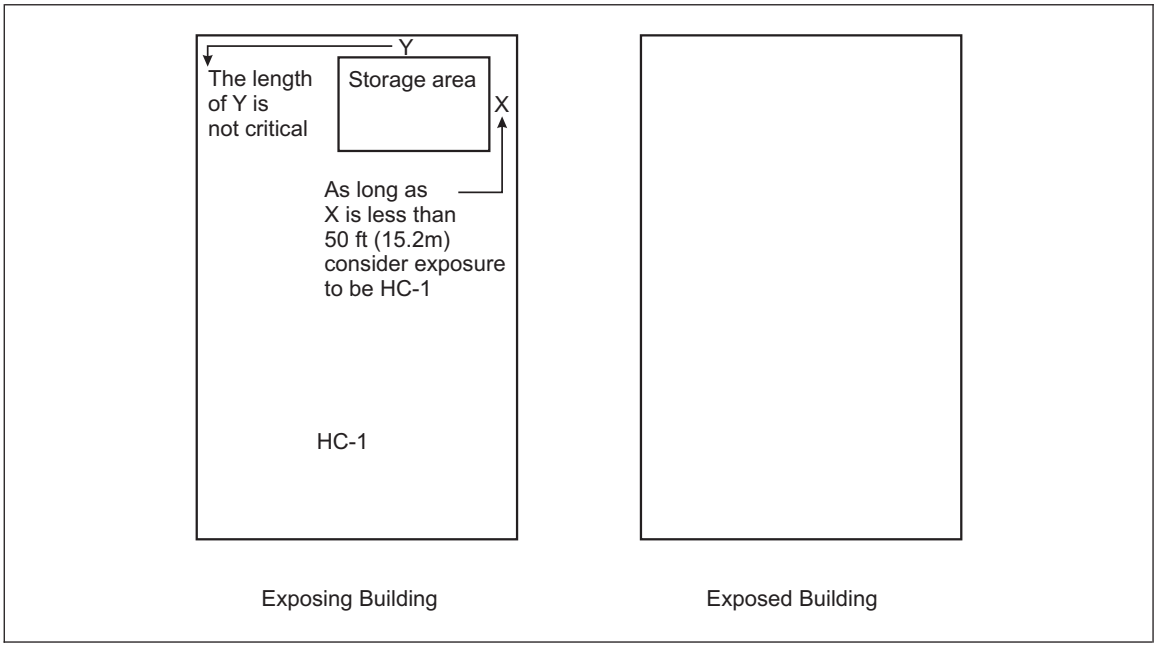

Fig. 14. Small storage area

Table 9. Exposing Building Fire Hazard Categories

Fire Hazard Category	*Description*
HC-1/HC-2 (see DS 3-26)	This category includes manufacturing, office, hotel, and similar occupancies where there are no significant storage areas over 50 ft (15 m) in length as measured parallel to the exposed wall; see Figure 45. In-process storage of Class 1, 2, or 3 commodities, up to 6 ft (1.8 m) is not considered storage. Do not use this category for multistory combustible construction. See the storage categories below. Do not use this category for multistory buildings with unprotected openings between floors and combustible interior finish material (walls and ceiling). If both of those are present, treat the building as a storage occupancy up to 30 ft (9 m) high. In an office occupancy an example would be wood paneling on the walls and a woodfiber suspended ceiling. In a manufacturing occupancy an example would be non-FM Approved foam plastic insulated metal panel walls and a Class 2 steel deck roof.
HC-3 (see DS 3-26)	HC-3 occupancies must be evaluated on a case-by-case basis and could fall into either the HC-1/HC-2 category or the storage up to 30 ft (9 m) category.
Storage occupancies up to 30 ft (9 m) high	This category includes storage of any commodity up to 30 ft (9 m) in height. It also includes multistory combustible construction buildings up to 30 ft (9 m) tall. Storage of noncombustible goods in noncombustible packaging can be considered HC-1/HC-2 hazard category..
Storage occupancies greater than 30 ft (9 m) up to 45 ft (14 m) high	This category includes storage of any commodity over 30 ft (9 m) up to 45 ft (14 m) in height. It also includes multistory combustible construction buildings up to 45 ft (14 m) tall. Storage of noncombustible goods in noncombustible packaging can be considered HC-1/HC-2 hazard category.
Storage occupancies over 45 ft (14 m) high	This category includes storage of any commodity above 45 ft (14 m) in height. It also includes multistory combustible construction buildings above 45 ft (14 m) tall. Storage of noncombustible goods in noncombustible packaging can be considered HC-1/HC-2 hazard category.

3.1.2.1 Categorize production areas using ignitable liquids (i.e., not storage) with isolated systems with less than 500 gal (1900 L) capacity per reservoir as HC-1/HC-2 fire hazard.

3.1.2.2 Categorize production areas using ignitable liquids (i.e., not storage) in closed systems containing more than 500 gal (1900 L) as fire hazard category storage up to 30 ft (9.0 m) high.

3.1.2.3 For exposing buildings with HC-1/HC-2 occupancies and combustible interior finishes, categorize the occupancy as storage up to the height of the ceiling. In multistory buildings with unprotected openings between floors and combustible interior finish material, categorize the occupancy as storage with a height equal to the total height of all interconnected floors. This applies to buildings that have combustible ceilings, combustible interior walls, or wood floors.

3.1.2.4 For exposing buildings that have combustible construction (exterior walls, interior finishes, ceilings, wood floors, boards on joist construction, etc.), categorize the occupancy as storage up to the height of the building regardless of the actual building occupancy.

3.1.2.5 Evaluate the storage of ignitable liquids (inside or yard storage) using Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers.*

3.1.2.6 Evaluate ignitable liquid tanks, loading/unloading areas, and pipe racks in spaces using Data Sheets 7-43, *Process Safety*, and 7-88, *Ignitable Liquid Storage Tanks.*

3.1.3 Exposure Length (L)

The exposure length is typically assumed to be the length of the exposing wall of the exposing building. L need not exceed 500 ft (150 m).

The fire hazard categories are determined from the nature of the construction and occupancy in the exposing building. An additional factor, however, is the length of the potential flame front. When two buildings are exposed by a rectangular building, the building exposed by the longer wall will experience the greater radiant heat, provided all other aspects of the fire exposure are the same.

Where the exposing building is considerably longer than the exposed building, L may be considered as the lesser of four times the actual separation distance (4D) or the actual length of the exposing building.

When this method is used for proposed installations, it may involve several iterations if the originally proposed space is inadequate. In each successive iteration the effective length L must be increased in proportion to the separation distance until the proposed space is adequate. A simpler approach is to use the entire length of the exposing building for L, which may yield a minimum safe separation distance (S_M) greater than actually needed.

If adequate horizontal or vertical fire cutoffs exist in the exposing building, they may be used to reduce L.

3.1.4 Adjustments to Exposure Length (L)

3.1.4.1 When the exposing building is offset from or overlaps the exposed building, it is appropriate to adjust L to account for a reduction in radiant heat incident on the exposed wall. The radiant heat emitted from the flames of a burning building decreases not only as the distance increases but also as the angle of the exposure deviates from parallel. To simplify the analysis, assume the exposure envelope is defined as an area directly parallel to the exposure, plus the area created by a 45° angle from a perpendicular line at both ends of the exposure (see Figure 15).

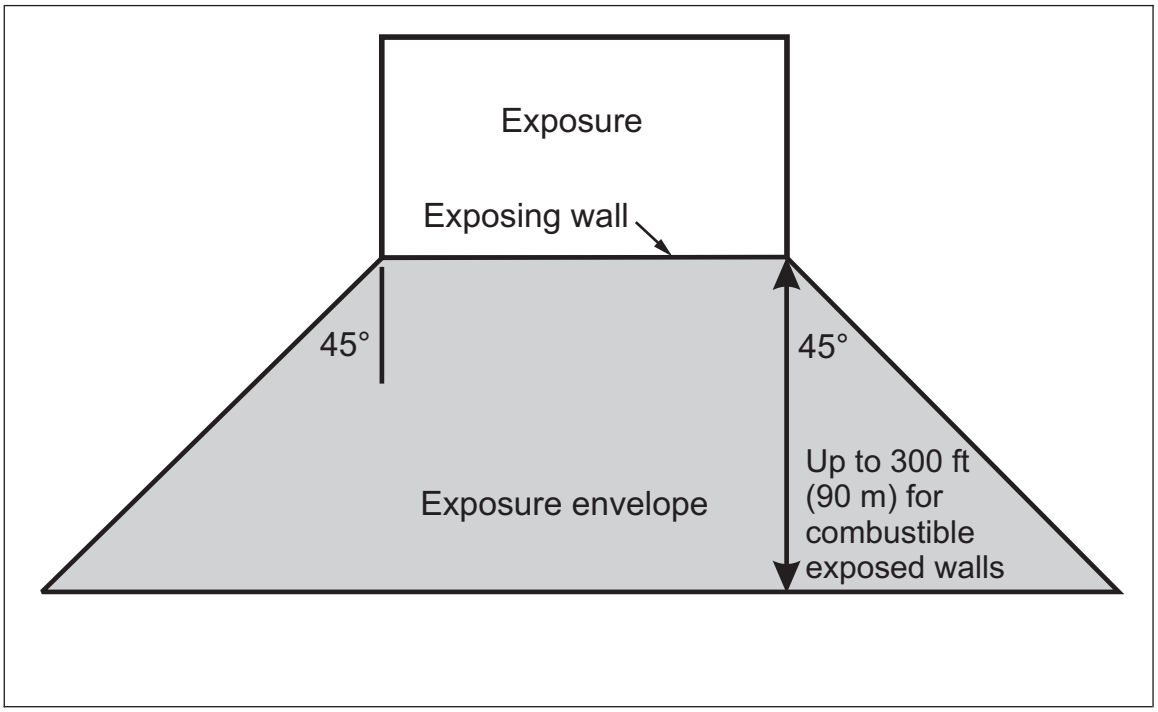

Fig. 15. Exposure envelope

3.1.4.2 Adjust the exposing length (L) and area exposed based on the exposure envelope defined in Section 3.1.4.1 and Figures 16 through 20.

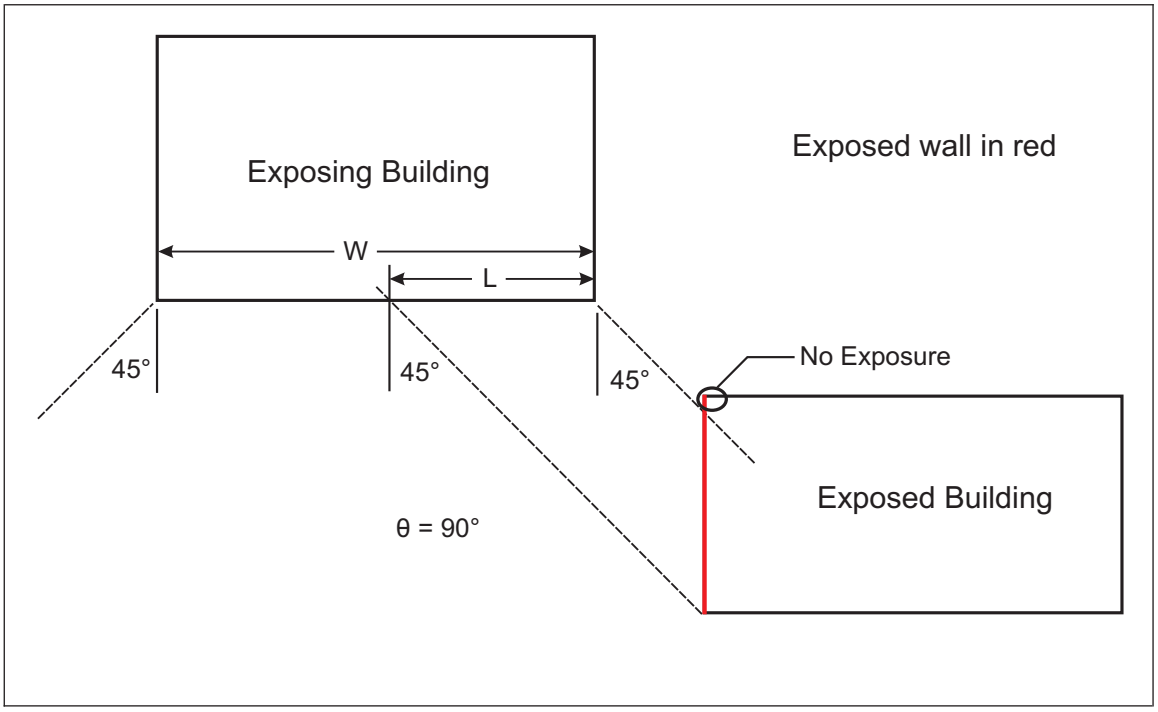

Fig. 16. Offset buildings: longer exposing wall exposing shorter exposed wall

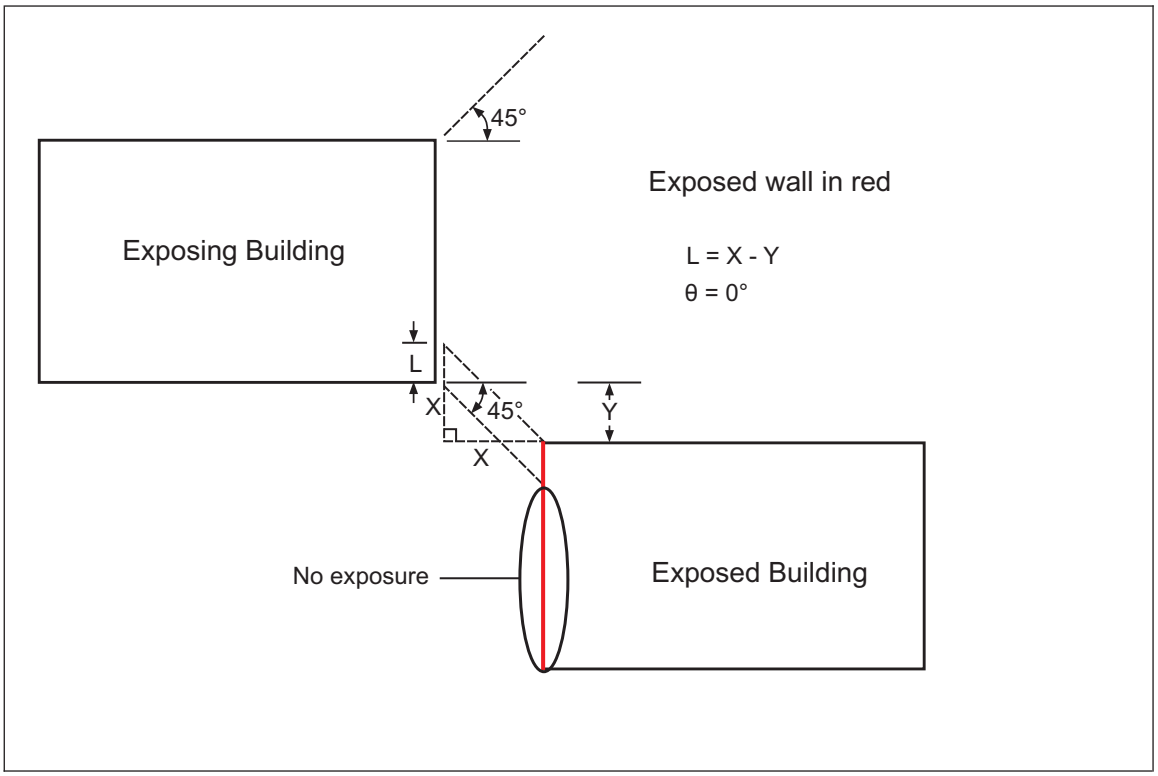

Fig. 17. Offset buildings: shorter exposing wall exposing shorter exposed wall

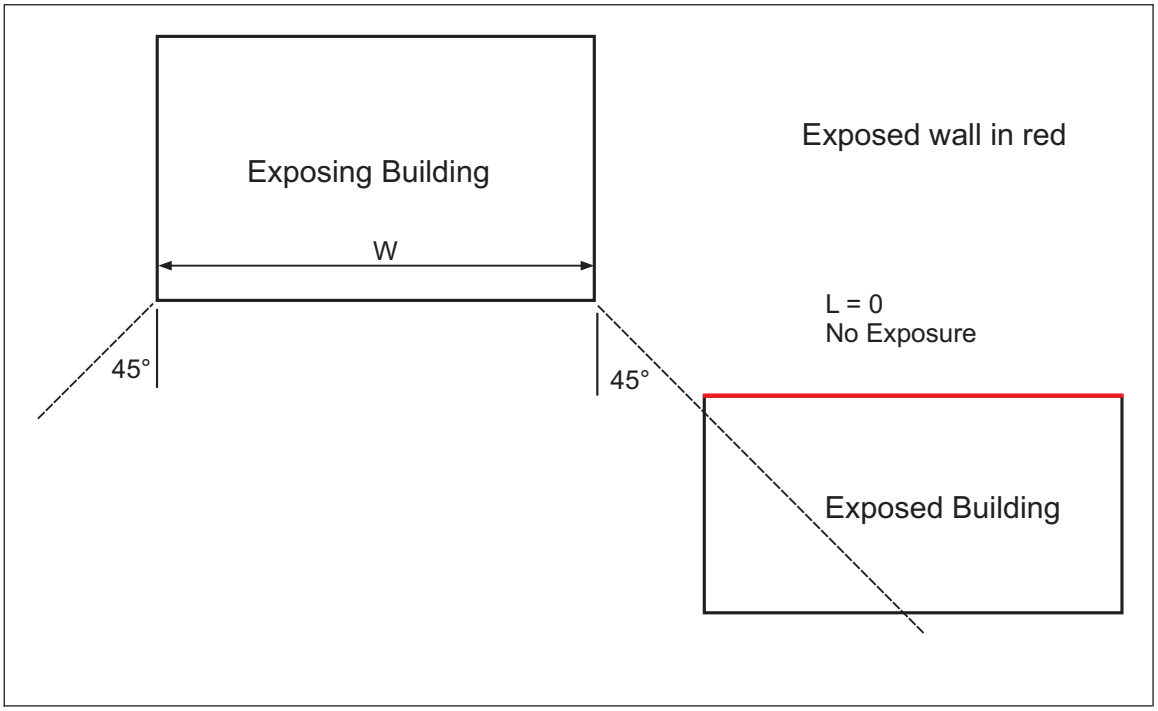

Fig. 18. Offset buildings: longer exposing wall exposing longer exposed wall

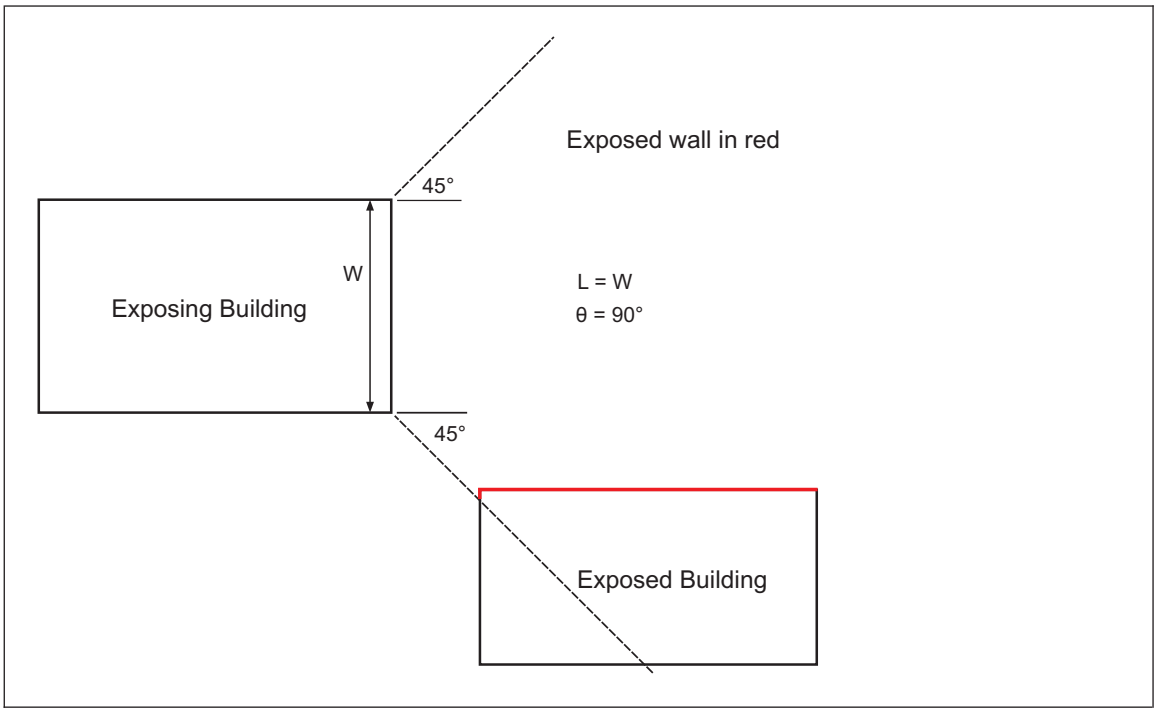

Fig. 19. Offset buildings: shorter exposing wall exposing longer exposed wall

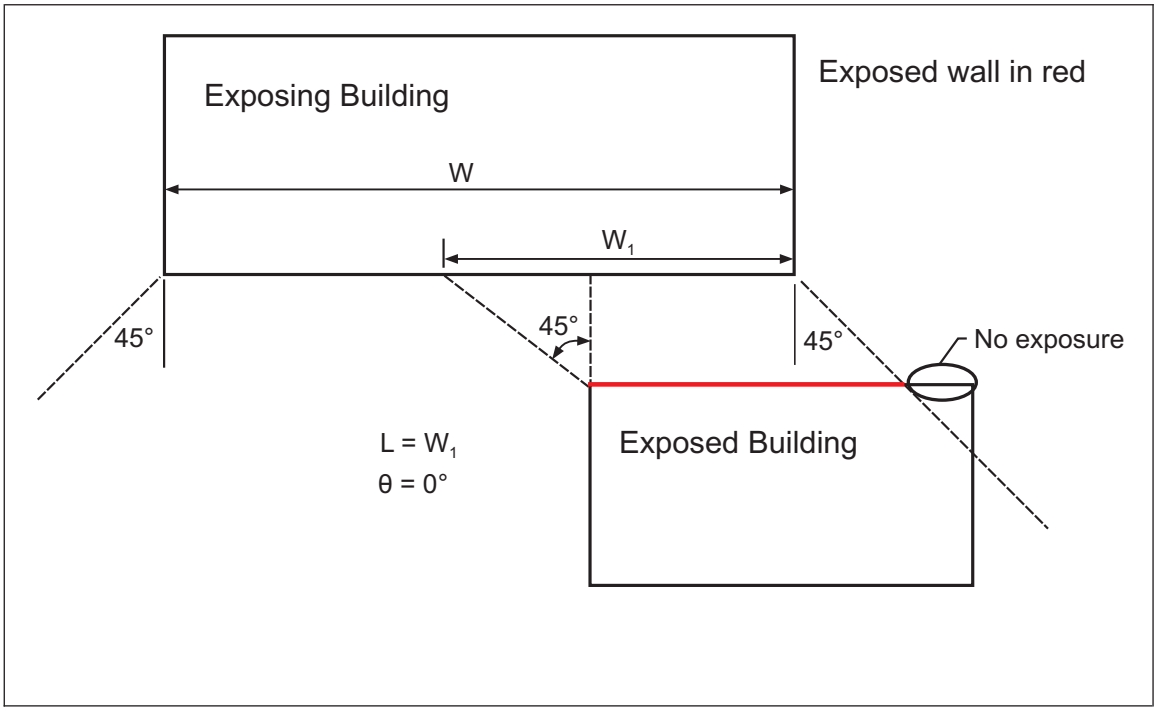

Fig. 20. Overlapping buildings

3.1.5 Unprotected Opening Adjustment Factor (U)

Figures 1 through 4 are based on a flame front unobstructed by the exposing building wall (i.e., a wall with 100% openings) or obstructing objects. This is a valid and typical assumption for large fires under adverse conditions, such as an MFL fire. However, under normal conditions, credit can be given to those portions of exposing NC and SFR walls that will remain in place at the early stages of the fire and block the radiant heat from reaching the exposed wall. In such cases, the radiant heat experienced by the exposed wall will be limited to the visible flame coming from unprotected openings and flames above the roof.

3.1.5.1 Determine the total amount of unprotected openings in the exposing wall as a percentage of the total exposing wall area. Include door openings if the door is not automatic closing or normally closed and the door construction has a lesser fire rating than the wall.

A. If the exposing wall is categorized as NC or SFR per Table 8, use the unprotected opening adjustment factor (U) from Figure 21 corresponding with the number of stories and percentage of unprotected openings in the exposing wall.

B. If the exposing wall is categorized as C per Table 8, use an unprotected opening adjustment factor (U) of 1.0.

3.1.6 Exposure Angle Adjustment Factor (M)

Determine the exposure angle (Θ) and exposure angle adjustment factor (M) for use in Equation 1 using Figures 22 and 23.

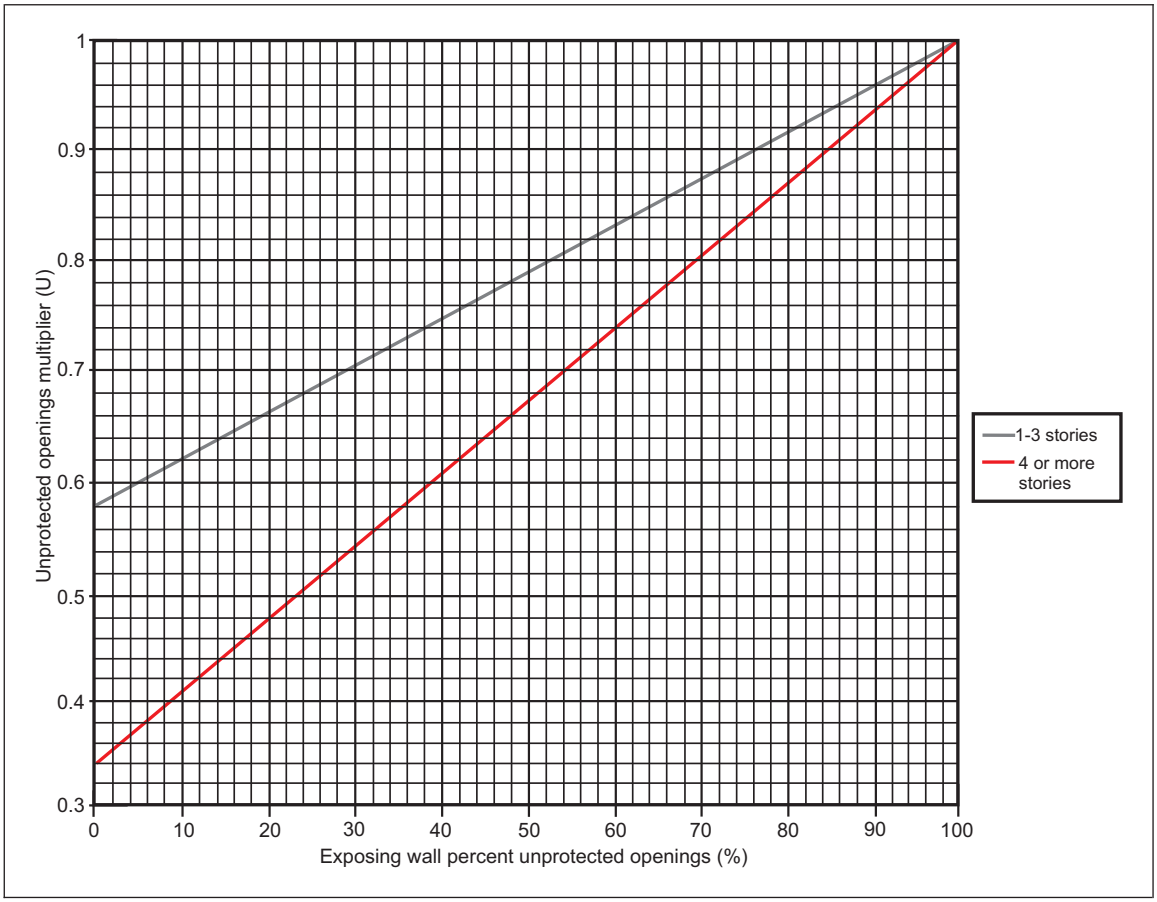

Fig. 21. Exposing building adjustment factor for unprotected openings (U) in the exposing wall

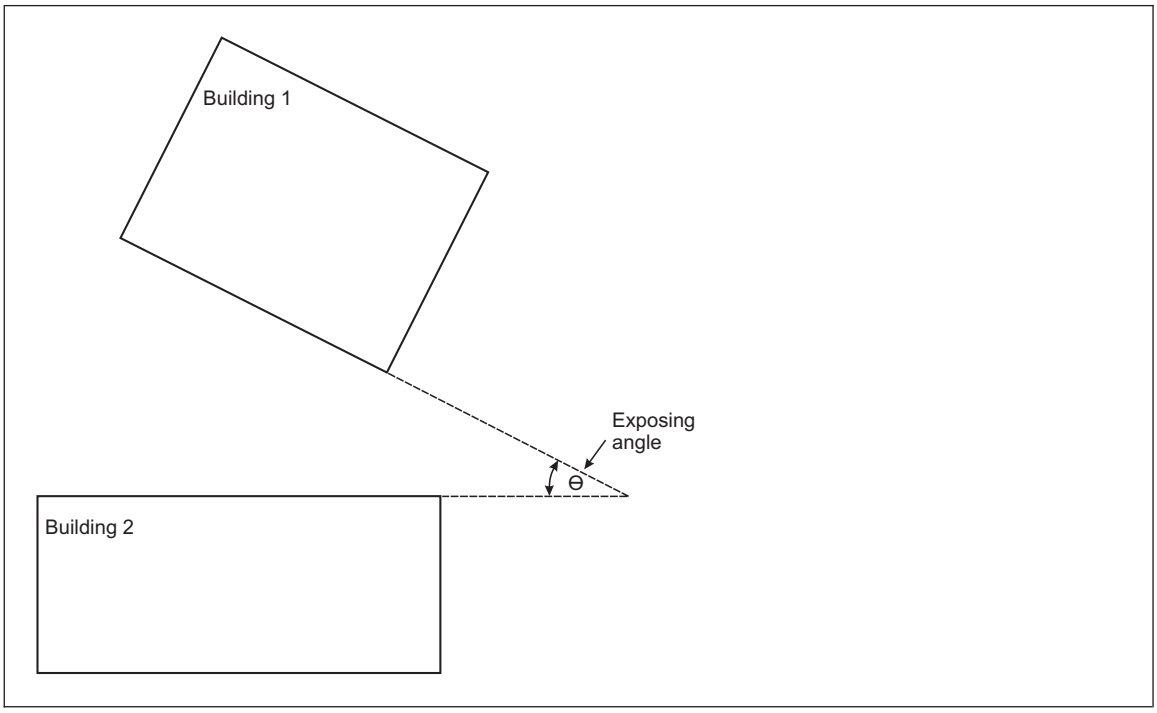

Fig. 22. Exposure angle (Θ)

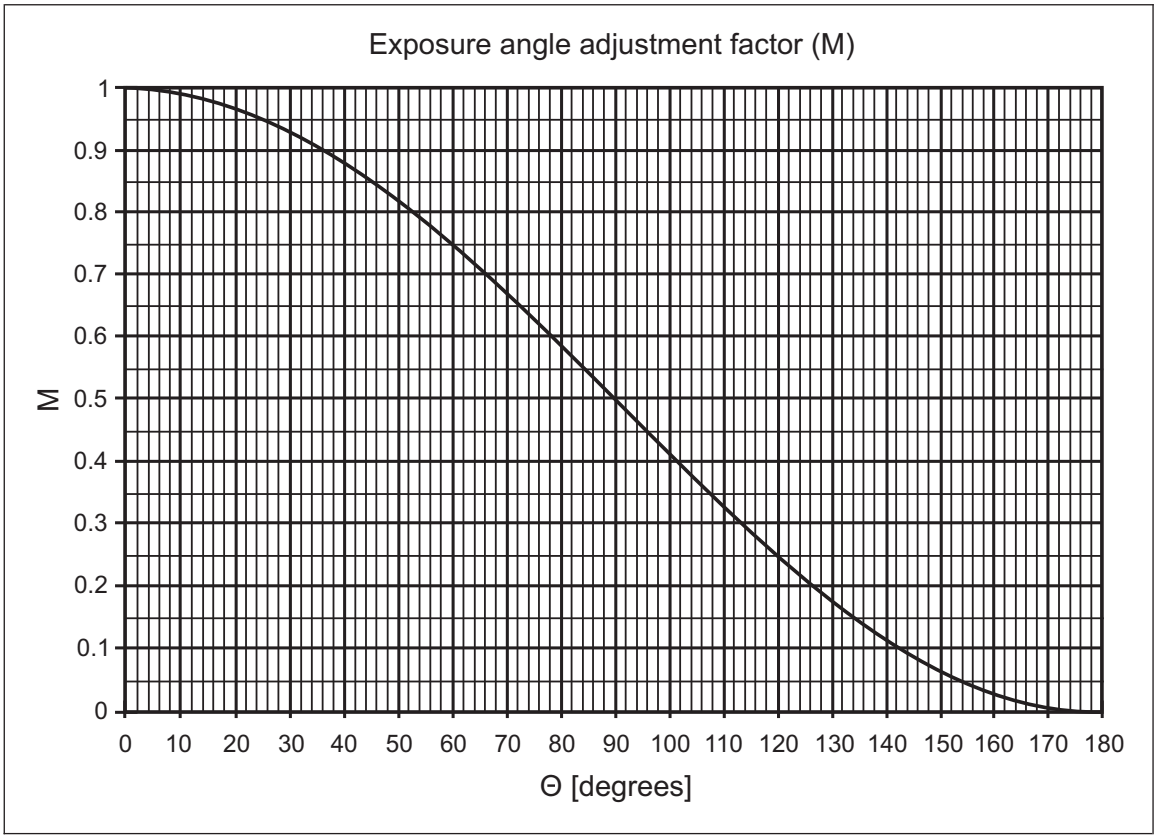

Fig. 23. Exposure angle adjustment factor (M)

The base separation distances determined from Figures 1 and 2 are for cases where the exposed and exposing walls are parallel or nearly parallel. When situated that way the exposed wall receives the most radiation. When heat radiation falls on a wall at an angle $\theta > 0$ with the exposing wall, the reduced intensity of radiation may be taken into account. This is done by use of the exposure angle adjustment factor (M) from Figure 23.

Example No. 1:

The exposing building is unsprinklered and is 20 ft (6.0 m) high. The exposing wall is 100 ft (30.5 m) long. It is operated 1 shift, 5 days per week and has no fire detection or watch service. The exposing occupancy is 15 ft (4.5 m) high rack storage of Class 3 commodities. The exposing walls and roof are of wood construction. The proposed exposed wall will be parallel to the exposing building and is to be of painted wood construction and the exposed roof is to be gravel surfaced. What is the minimum safe separation distance (S_M)?

Solution: The exposed and exposing walls are combustible per Tables 10 and 12. The exposing occupancy is storage up to 30 ft (9.0 m) per Table 9. The length of the exposure, L, is 100 ft (30.5 m) and there are no adjustments.

From Figure 1, S_B = 125 ft (38 m).
U = 1.0 because the exposing wall is combustible.
M = 1.0 because the buildings are parallel and $\Theta = 0°$.
$S_M = S_B \times U \times M$ = 125 ft (38 m)

Example No. 2:

Based on Figure 24, determine the distance out from the exposing wall to the points where protection can be reduced.

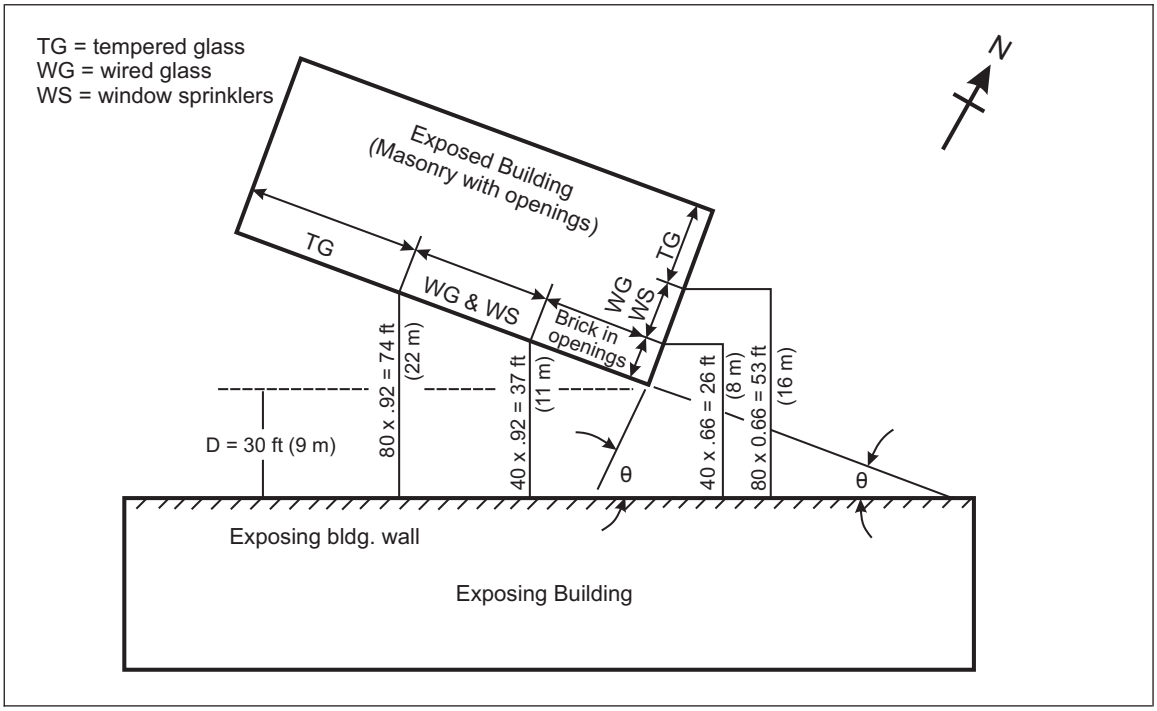

Fig. 24. Protection for exposed building when walls are at an angle (Θ) with exposing building

Solution:

The actual separation (D) at the nearest point is 30 ft (9.0 m). The exposure is 100 ft (30.5 m) long racks of automobile parts in cardboard boxes 30 ft (9.0 m) high. The masonry walls of the exposed building are 2-hr fire-rated and have tempered glass windows. Θ is 15° for the longer south exposed wall and 60° for the shorter east exposed wall. Per Table 2, S_M = 30 ft (9.0 m) for a 2-hr, parallel exposed wall. The D is adequate for the 2-hr wall; however, the need for a 2-hr wall requires some of the windows to be removed and the opening filled with masonry.

Use the angle Θ and an exposed 1-hr wall to determine how far out from the nearest point of the exposing wall fire-rated glass and window sprinklers can be accepted. Do the same for a noncombustible wall to determine where the existing tempered glass would be acceptable.

From Table 2, S_M = 40 ft (12.2 m) for a 1-hr, parallel exposed wall. A 1-hr wall can have fire-rated windows protected by window sprinklers.

From Figure 2, L = 100 ft (30.5 m), S_B = 80 ft (24 m) for a noncombustible, parallel exposed wall. A noncombustible wall can have the existing tempered glass windows.

From Figure 23, M = 0.98 for the longer south wall at 15° and 0.75 for the shorter east wall at 60°.

Exposed Wall	*1-hr with fire rated windows with window sprinklers required*	*NC with tempered glass windows required*
South wall	40 ft x 0.98 = 39 ft (12.2 m x 0.98 = 12 m)	80 ft x 0.98 = 78 ft (24.4 m x 0.98 = 24 m)
East wall	40 ft x 0.75 = 30 ft (12.2 m x 0.75 = 9 m)	80 ft x 0.75 = 60 ft (24.4 m x 0.75 = 18 m)

3.1.7 Ventilation

The base separation distances in Figures 1 and 2 are based on well-ventilated fires in the exposing buildings with adequate air supply to support the fire growth. Openings or spaces in the building wall are necessary to admit combustion air, while openings in the roof (vents, skylights, etc.) will discharge hot gases and allow entry of additional air to aid in fire development. There is normally enough air within a building to feed a fire in the early stages. Typically, openings are present or will develop in the early stages of a fire (windows or skylights break, heat and smoke vents open, combustible construction burns, steel panels buckle, aluminum panels melt, etc.). Consequently it is safe to assume there will be adequate ventilation for an exposure fire in the vast majority of cases.

3.1.8 Wind

When the exposed building walls are combustible, it is assumed wind will carry a spark or ember to the exposed wall. Therefore, the minimum separation distances for combustible walls are based on the critical heat flux for piloted-ignition of wood and not the autoignition heat flux.

3.1.9 Effect of Fire Service

The exposure categories are based on full flame front at the exposure fire; however, long exposures to combustible materials could still cause ignition. It is assumed the fire service and site conditions are adequate for the fire conditions, and that only a brief delay between ignition and fire service response will be experienced.

3.2 Exposed Buildings

3.2.1 Unsprinklered Exposed Buildings

When not in need of sprinklers, the separation distances determined by this standard still apply.

3.2.2 Exposed Building Wall Categories

Exposed walls are categorized as either C, NC, or FR. Category SFR is not applicable because a fire-rated exposed wall is assumed to be stable. Categorize the exposed wall construction using Table 10 and Appendix A.

Table 10. Exposed Building Wall Categories

Exposed Wall Category	*Description*
COMBUSTIBLE[1] (C)	All metal-faced panels with thermoplastic insulation
	Aluminum panels without insulation[3]
	Any wall with exposed combustible materials
	Any wall with windows that can be opened
	Asphalt Coated Metal (ACM)
	Asphalt shingled wood sheathing
	Cementitious panels on wood frame
	Cementitious shingles on wood frame
	EIFS[4]
	Non-Approved metal-faced panels with plastic insulation
	Other assemblies on unprotected wood frame
	Rigid plastic panels (FRP, PVC)
	Wood (painted, stained or unfinished)
NONCOMBUSTIBLE[2] (NC)	Aluminum-faced panels with noncombustible insulation on steel or reinforced concrete frame
	Any tempered glass panels in noncombustible frames on a steel or reinforced concrete building frame
	Any unrated glass block
	Any unrated precast, cast-in-place or tilt-up concrete panels (solid, hollow or insulated) on steel or reinforced concrete frame
	Cementitious panels with noncombustible insulation on steel or reinforced concrete frame
	Cementitious panels without insulation on steel or reinforced concrete frame
	Cementitious shingles on steel or reinforced concrete frame
	Cementitious shingles over noncombustible sheathing on steel or reinforced concrete frame
	Cementitious stucco
	EIFS with class 1 insulation over gypsum board sheathing
	EIFS with noncombustible insulation over gypsum board sheathing
	FM Approved aluminum-faced class 1 panels with thermoset insulation on steel or reinforced concrete frame
	FM Approved steel-faced class 1 panels on steel or reinforced concrete frame
	FM Approved steel-faced class 1 panels with thermoset insulation on steel or reinforced concrete frame
	FM Approved steel-faced noncombustible panels on steel or reinforced concrete frame
	Metal lath and plaster
	Steel-faced panels with noncombustible insulation on steel or reinforced concrete frame
	Steel-faced panels without insulation on steel or reinforced concrete frame
FIRE-RATED (FR)	A wall meeting the required fire rating per Data Sheet 1-21. Openings are protected with fire-rated doors or shutters. Windows without fire-rated shutters will have a fire rating equal to the wall.

[1] Combustible exposed walls include any wall with overhanging wood eaves and any wall with single-pane, annealed (not tempered) glass windows.
[2] Noncombustible exposed walls can have no overhanging wood eaves and any windows must be one of the following types: listed fire-rated glass; tempered glass; laminated glass; min. ¼ in. (6 mm) thick wired glass; or glass blocks.

If a combustible canopy or overhanging eave exists on the exposed building, base the separation distance between the exposing building and the outer edge of the canopy or overhang on a combustible exposed wall, regardless of the type of wall construction. Alternatively, separation that is adequate for the wall construction is acceptable provided the combustible canopy or overhang is sheathed with a material having fire resistance at least equal to that of the wall.

The presence of cementitious shingles over exposed wood walls lessens the needed space separation, while the presence of asphalt shingles over exposed wood walls increases the space separation needed.

If the exposed wall is combustible, S_M need not exceed 300 ft (90 m).

If the exposed wall is NC or FR, S_M need not exceed 200 ft (60 m).

3.2.3 Protection of Openings in the Exposed Building

A. Combustible Walls (C). Exposed walls that have a combustible exterior surface are as vulnerable to fire exposure as ordinary doors and windows. Installing fire doors and fire-rated glass windows would serve little purpose. Therefore, when the separation distance is adequate for C exposed walls, unprotected openings with ordinary doors and windows are adequate. In fact, unprotected openings without a door or window would also be adequate.

B. Noncombustible Walls (NC). NC walls have no fire resistance in terms of a fire endurance rating determined by testing or calculation; however, the lack of combustibility can be said to provide a level of fire resistance in preventing fire spread when exposed to radiant heat. Therefore, openings in exposed NC walls need only be protected with normally closed doors and windows of noncombustible construction. Where separation distances are adequate for NC walls, self-closing or automatic closing noncombustible or fire endurance rated doors that are blank or have fire-rated or tempered glass vision panels are adequate.

When outside automatic sprinklers are not provided, windows should be constructed with listed fire-rated glass, min. ¼ in. (6 mm) thick wired glass, or glass blocks.

C. Fire-Rated Walls (FR). When space separation is minimal, such that fire resistive exterior wall construction is needed, window openings usually need to be blocked in with material that has an equivalent fire endurance rating to that of the exposed wall, except as noted in Sections 2.2.7 and 2.2.8.

3.2.4 Protection of the Exposed Roof When Lower Than the Exposing Building

When the roof of the exposed building is below the top of the exposing building, the exposed roof may receive sufficient radiant heat to be ignited. A burning brand, large enough to cause pilot ignition, may also fall on the roof. For built-up roof coverings (BUR), placing a minimum of 4 lb/ft^2 (20 kg/m^2) of pea gravel on the roof in a flood coat of coal tar or asphalt is recommended. For single-ply membranes, large stone ballast or paver blocks may be used. (See Data Sheet 1-29.) It would only be necessary to provide this protection within 50 ft (15 m) of the exposure; however, provide a Class A rating for the remaining portion of the roof for the distance defined in Section 2.2.15.

3.2.5 Protection Beyond the Ends of the Exposing Building

When the exposed building is longer than the exposing one, protection beyond the ends of the exposing building is needed. The distances X2, X3, and X4 are based on the angle Φ, measured from a line perpendicular to the adjacent walls at the corner of the exposing wall (see Figure 25). As Φ increases, the level of protection needed is reduced. Protection for the wall area marked X2 in Figure 25 should be the same protection as that required for X1. No additional protection is needed when Φ exceeds 45°. For more specific details, see Tables 11 and 12.

Levels of exposed wall passive protection are ranked from greatest fire resistance to least fire resistance in Table 11.

Table 11. Levels of Passive Protection, P

Level	*Passive Fire Rating, P*
1	4 hour or more fire rated
2	3 hour fire rated
3	2 hour fire rated
4	1 hour fire rated
5	Noncombustible*
6	Combustible*

*See Appendix A and Table 10.

For example, Noncombustible is one level lower in fire resistance than a 1-hour fire-rating.

Openings should be protected in accordance with Sections 2.0 and 3.2.3 for the respective level of passive wall protection.

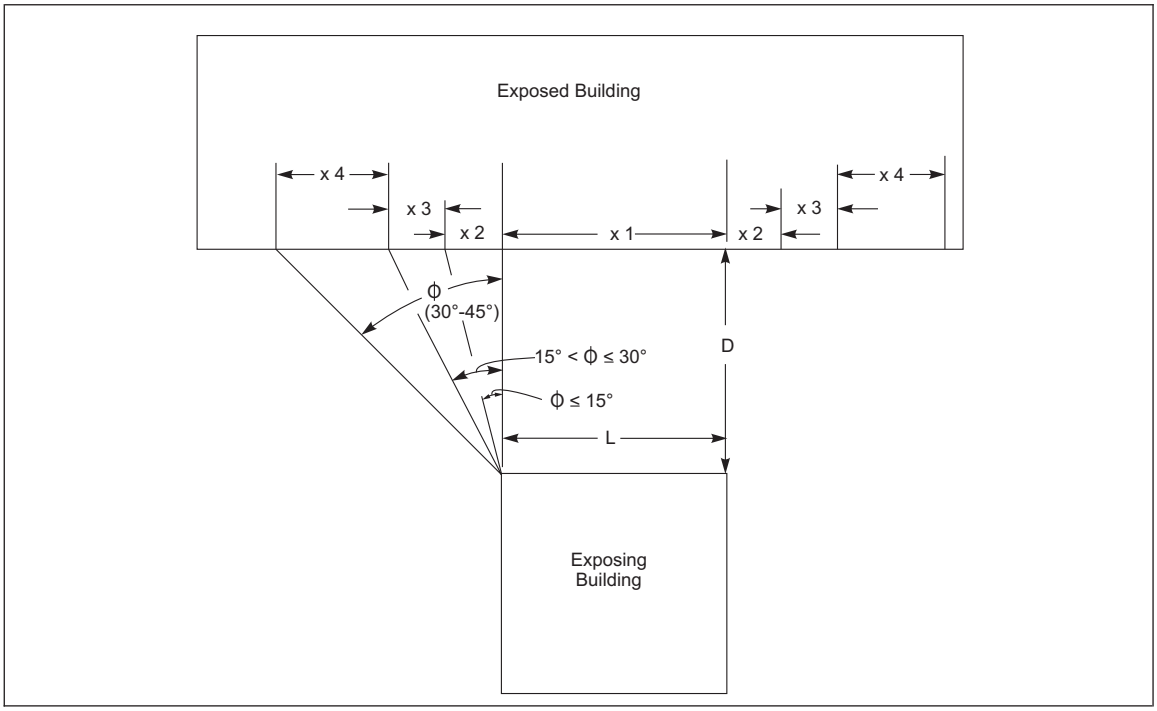

Fig. 25. Exposed building walls longer than exposing walls

Table 12. Protection for Longer Exposed Walls

Location of exposed wall with respect to exposing wall	Φ = 0°	*0°*< Φ ≤ 15°	*15°* <Φ ≤ 30°	*30°*< Φ ≤45°
Designation on Figure 21	X1	X2	X3	X4
Distance protection is needed	L	0.25S	0.25S	0.5S
Level of protection	P	P	P-1	P-2

S_B = Separation distance needed per figures and tables

P = Exposed wall category needed per Table 2 or Figures 1 and 2

P-1 = One level of passive protection less than P using Table 11

P-2 = Two levels of passive protection less than P using Table 11

L = Length of the exposing building

D = Actual separation distance

Φ = end wall angle

If D > S_B for the type of exposed wall construction provided, the distances (X2, X3, or X4) that need passive or active protection for openings is based on S_B rather than D. If S_B is less than 40 ft (12.2 m) provide a level of protection P, P-1 and P-2, of at least 10 ft (3.0 m), 10 ft (3.0 m), and 20 ft (6.0 m), respectively, for X2, X3, and X4.

3.2.6 Protection of the Side Walls of the Exposed Building

3.2.6.1 When the exposed building is shorter than the exposing one, protection beyond the ends of the exposing building may be needed. When the separation between buildings is adequate for the type of construction available, no additional protection is needed for the exposed wall or adjacent sidewalls (exterior walls perpendicular to the exposed wall, see Figure 26). When separation is inadequate for the exposed

construction and passive protection or outside sprinklers are recommended for the exposed wall, protection will also be needed for some portion of the side walls of the exposed building. In such cases:

A. Determine the minimum safe separation distance (S_M) needed for that construction.

B. Multiply that figure by 0.5. The result is the distance out from the face of the exposing building that protection is needed for the exposed side walls.

C. Subtract from this the actual separation distance (D) to arrive at (X), the length of the side wall that needs protection (Figure 26) (including the protection of openings) as outlined in Section 2.0.

If $D \geq 0.5S_M$, no side wall protection is needed.

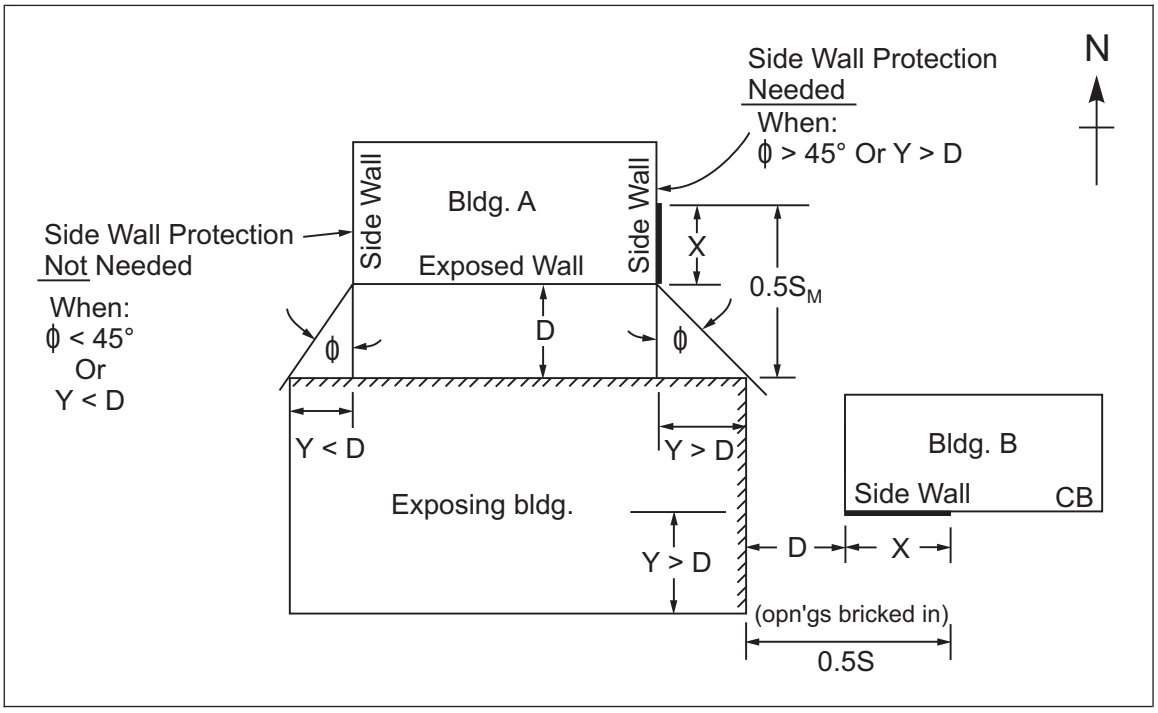

Fig. 26. Protection for side walls of exposed building

3.2.6.2 When the exposed building side walls have adequate fire resistance for the separation distance, but have openings, the openings may need to be filled in with material of sufficient fire resistance (or comparably protected) for some distance along the side wall. To determine this distance:

A. Determine the minimum safe separation distance (S_M).

B. Multiply that figure by 0.5. The result is the distance out from the face of the exposing building to where filling in or other protection of the openings in the exposed side wall is needed.

C. Subtract D from this to determine X (see Figure 26). $X = 0.5S_M - D$.

3.2.6.3 The same procedure can be used to determine where fire-resistant glass is needed (see Section 3.2.3). Determine S_M for a combustible exposed wall. Multiply 0.5 times S_M. Subtract D from the result to get the length of side wall where fire-resistant glass is needed (beyond this length, plain glass windows are acceptable).

Example No. 3:

See Figure 26. Building A is wood; separation is inadequate. Significant exposure exists for the south part of the east side wall for a distance X. Recommend outside sprinklers for the exposed wall and for a distance X on the east side wall.

Building B is masonry with openings. Separation will be adequate if openings are bricked in along the exposed west wall and for the distance X along the south side wall.

S_M = The minimum safe separation distance

D = Actual separation provided

X = length of side wall needing protection

$X = 0.5S_M - D$

3.2.7 Protection of Walls Above a Lower Exposing Building

When the height of the exposed building does not exceed the height of the exposing building, use Table 2 or Figures 1 and 2 to determine the separation distance (S_B) or needed protection for the entire exposed wall. When the height of the exposed building exceeds the height of the exposing building (Figure 27), and the actual separation distance (D) between buildings is less than the minimum safe separation distance (S_M), provide protection for the portion of the exposed wall that is above the height of the exposing wall as outlined in Figures 28a and 28b. Base the type of protection needed on the severity of the exposure (Section 3.1.2) and the actual horizontal separation distance (D) between buildings.

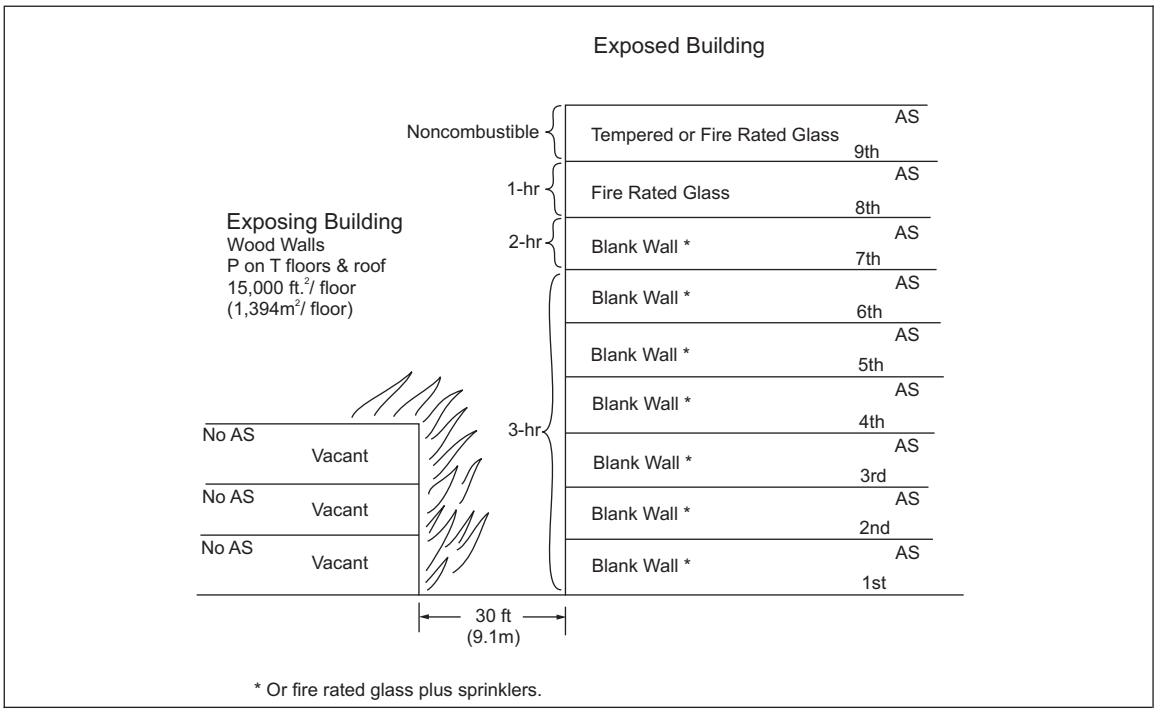

Fig. 27. Protection for exposed buildings higher than the exposing building

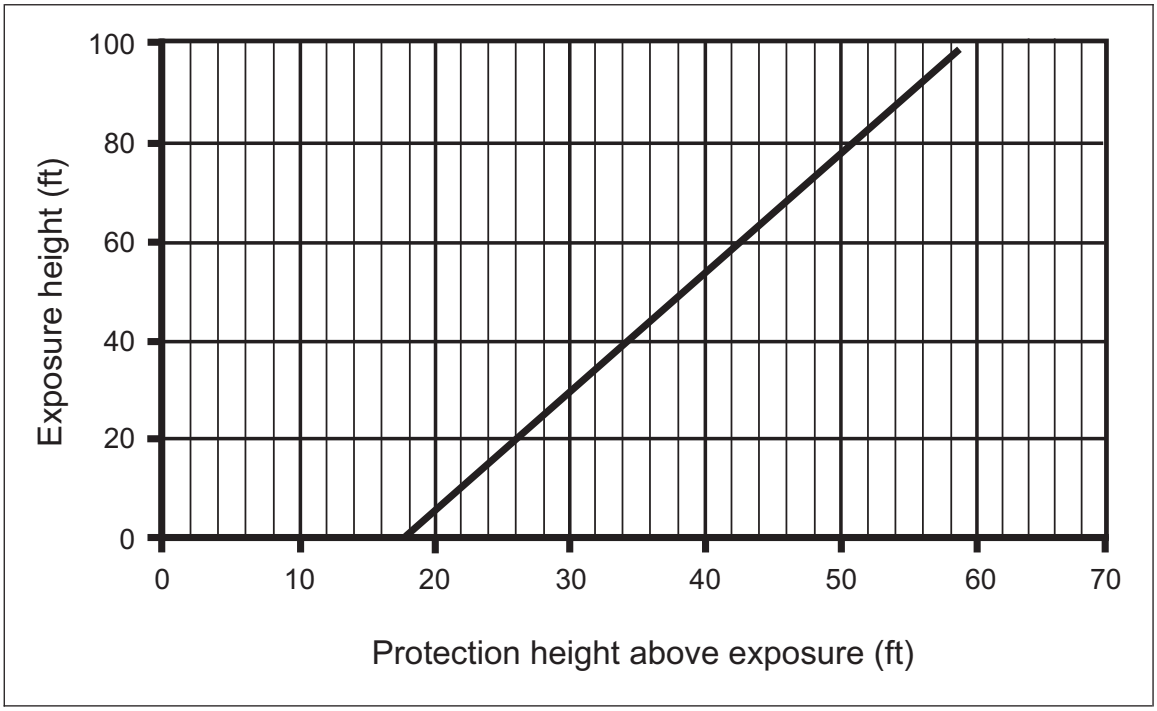

Fig. 28a. Protection of walls above the exposure (English units).

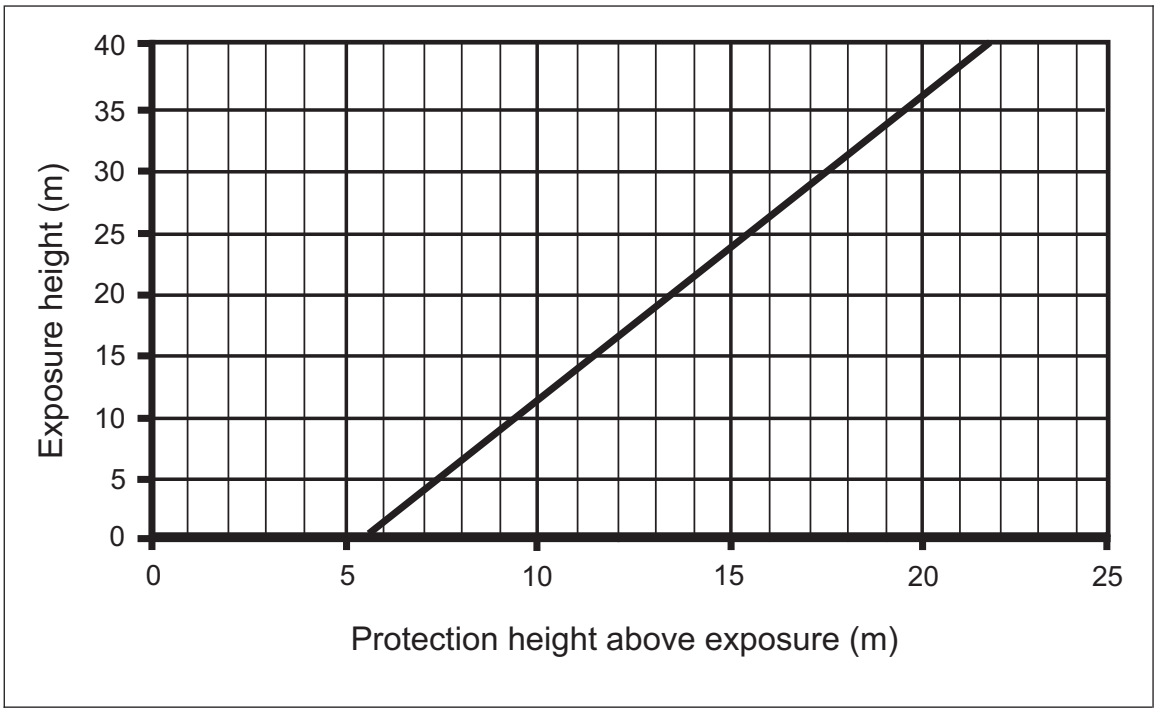

Fig. 28b. Protection of walls above the exposure (SI units).

When there is considerable height difference between a significant exposure and the higher exposed building, the level of protection of openings may be decreased one level for each story height above the distance of needed protection according to Figure 28a or 28b. As in Example No. 4 below, windows on floors one through seven need to be bricked in (or have sprinklers and fire rated glass), those on the eighth floor should have fire rated glass, those on the ninth floor should be tempered, wired glass or fire rated.

Example No. 4:

In Figure 27, a nine-story sprinklered building with 12 in. (300 mm) thick brick exterior walls and plain glass windows is exposed by a three-story unsprinklered building. The actual separation distance (D) is 30 ft (9.1 m).

The exposing building is a vacant plank-on-timber warehouse having wood walls and an area of 15,000 ft^2 (1,400 m^2) per floor. The length of the exposing wall is 112 ft (34 m). The story height in both buildings is 15 ft (4.6 m). What protection is required for the openings in the exposed building?

Solution:

Because the exposing building is multistory with wood walls and plank-on-timber floors, treat the occupancy as storage regardless of the actual occupancy. Since the exposing building has three 15 ft (4.5 m) stories, the occupancy is considered as storage up to 45 ft (13.5 m). The length (L) of the exposing wall is 112 ft (34 m). The fire resistance of the exposed brick wall is in excess of 3 hours (see Data Sheet 1-21); however, the minimum safe separation distance (S_M) needs to be adequate for a combustible exposed wall due to the plain glass windows. If the windows were removed and the openings filled with 3-hr rated construction, then according to Table 2 the minimum safe separation distance (S_M) = 5 ft (1.5 m).

The respective minimum safe separation distances (S_M) are 5 ft (1.5 m) for a 3-hour wall and 175 ft (53 m) for a combustible wall. The provided separation distance of 30 ft (9.0 m) is adequate for the brick walls, but not the plain glass. According to Figure 28a, the height above the exposure needing protection is at least 36 ft (11 m). Consequently, since the story heights are 15 ft (4.5 m), protection comparable to a 3-hr wall is needed for the first six floors; three up to the top of the exposing wall and three above it. The seventh and eighth floors should have protection comparable to a 2-hr (blank wall or fire rated glass plus sprinklers) and 1 hr (fire-rated glass) exposed wall, respectively. The ninth floor should have tempered or fire-rated glass to provide protection comparable to a noncombustible wall.

3.3 Exposing Yard Storage

3.3.1 Exposing Yard Storage Fire Hazard Categories

3.3.1.1 Categorize the exposing yard storage using Table 13. For additional details and definitions of exposing yard storage, see Appendix A.

Table 13. Exposing Yard Storage Fire Hazard

Fire Hazard Category	*Description*
Low Hazard Yard Storage	Yard storage of Class 1 and 2 commodities. Yard storage of noncombustible goods in noncombustible packaging. Yard storage of vehicles, construction and farm equipment. Palletized storage of Class 3 commodities no more than one tier or 6 ft (1.8 m) high. Baled waste paper. Roll paper on-side storage.
Ordinary Hazard Yard Storage	Yard storage of Class 3 and 4 commodities. Yard storage of plastic commodities. Yard storage of rubber tires. Roll paper on-end storage.
High Hazard Yard Storage[1]	Yard storage of ignitable liquids, flammable gases and explosives.

[1]Covered in other data sheets.

3.3.1.2 Evaluate ignitable liquid tanks, loading/unloading areas, and pipe racks in spaces using Data Sheets 7-43, *Process Safety*, and 7-88, *Ignitable Liquid Storage Tanks.*

Where spacing between tanks and exposed buildings is inadequate (not in accordance with Data Sheet 7-88) provide one of the following:

A. Increase the level of passive protection (per Table 11) to meet the spacing requirements of Data Sheet 7-88 (also refer to sections 2.3.5 and 2.3.6).

Example: Spacing is inadequate for the combustible exposed building wall. Replace or cover the combustible construction with noncombustible construction or provide a higher level of passive protection.

B. Provide automatic deluge water spray protection for the ignitable liquids tanks in accordance with Data Sheet 7-88.

3.3.2 Buildings Exposed by Yard Storage

When not in need of sprinklers, the separation distances determined by this standard still apply.

Exposed walls are categorized as either C, NC, or FR. Categorize the exposed wall construction using Table 10 and Appendix A.

If the exposed wall is combustible, S_M need not exceed 200 ft (60 m).

If the exposed wall is NC or FR, S_M need not exceed 100 ft (30 m).

Levels of exposed wall passive protection are ranked from greatest fire resistance to least fire resistance in Table 11.

3.3.3 Yard Storage Exposure Length (L)

The exposure length (L) is typically assumed to be the length of the exposing yard storage; L need not exceed 200 ft (60 m).

The fire hazard categories are determined from the nature of the storage. An additional factor, however, is the length of the potential flame front. When two buildings are exposed by yard storage, the building exposed by the longer dimension of the storage array will experience the greater radiant heat, provided all other aspects of the fire exposure are the same.

Where the yard storage array is considerably longer than the exposed building, L may be considered the lesser of either (a) four times the actual separation distance (4D,) or (b) the actual length of the storage.

3.3.4 Adjustments to Yard Storage Exposure Length (L)

3.3.4.1 When the yard storage is offset from or overlaps the exposed building, it is appropriate to adjust L to account for a reduction if radiant heat incident on the exposed wall. The radiant heat emitted from the flames decreases not only as the distance increases but also as the angle of the exposure deviates from a parallel arrangement. To simplify the analysis, assume the exposure envelope is defined as an area directly parallel to the exposure plus the area created by a 45° angle from a perpendicular line at both ends of the exposure (see Figure 15).

3.3.4.2 Adjust the exposing length (L) and area exposed based on the exposure envelope defined in 3.1.4.1 and Figures 16 through 20.

3.3.5 Yard Storage Obstructed View Adjustment Factor (U)

Figures 3 and 4 are based on a flame front with radiation unobstructed to the exposed wall. If there are noncombustible items between the yard storage and the exposed wall, the radiant heat experienced by the exposed wall will be limited to the portion of the flame front visible at the target wall. Therefore, it is acceptable to adjust the base separation distance (S_B) by the applicable obstructed view multiplier, U.

3.3.5.1 Determine the total amount of obstructed view as a percentage of the exposing yard storage area defined by L x H. Use the obstructed view multiplier, U from Figure 29 corresponding with the height of the exposing yard storage and percentage of obstructed view.

3.3.6 Yard Storage Exposure Angle (Θ) *Adjustment Factor (M)*

Determine the exposure angle (Θ) and exposure angle adjustment factor (M) for use in Equation 1 using Figure 23.

3.3.7 Wind

The basic separation distances (S_B) given in Figures 3 and 4 are based on a critical wind speed that results in the greatest incident radiation at the target exposed wall. This critical wind speed accounts for a wind-tilted flame toward the target, lessening the distance to the target. It also accounts for the shortening of the flame height associated with a tilted flame. The critical winds speeds are on the order of 4 to 18 mph (2 to 8 m/s).

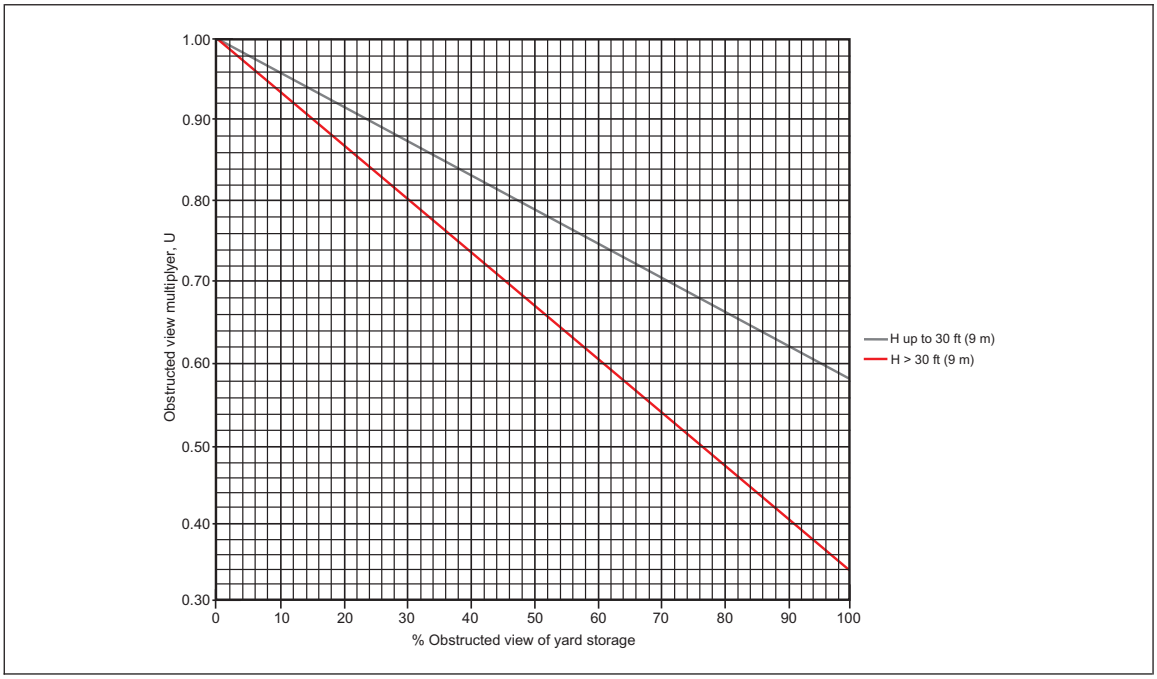

Fig. 29. Exposing yard storage adjustment factor (U) for obstructed view to the exposed wall

3.3.8 Effect of Fire Service

The basic separation distances (S_B) given in Figures 3 and 4 are based on an incident radiant heat flux that will result in piloted ignition or wall failure in 15 minutes. It is assumed that the fire service and site conditions are such that only a brief delay between fire ignition and fire service response will be experienced. Where response time is expected to be significantly longer, separation distances need to be adjusted accordingly or additional protection (passive or active) provided.

3.3.9 Openings in Buildings Exposed by Yard Storage

Protect openings in accordance with Sections 2.2 through 2.4 and Section 3.2.3 for the appropriate level of active or passive wall protection.

3.3.10 Buildings Exposed by Shorter Yard Storage

When the exposure length (L) is shorter than the exposed building, the exposed building may need protection beyond the ends of the yard storage (see Section 3.2.4).

3.3.11 Protection of Side Walls of Buildings Exposed by Yard Storage

When the exposed building is shorter than the exposure length (L), protection of the side walls of the exposed building may be needed (see Section 3.2.5).

3.3.12 Protection of the Exposed Roof When Lower Than Yard Storage

When the roof of the exposed building is below the top of the yard storage, the exposed roof may receive sufficient radiation to be ignited. Even when radiation levels are not sufficient to ignite a combustible roof surface, a burning brand large enough to ignite the roof cover may fall on the roof. For combustible roof covers, pea gravel, stone ballast, or concrete pavers adequately protect the roof from both radiant heat and burning brands. An ASTM E108 Class A rating alone is not adequate to prevent fire spread to the roof due to the impact of the additional radiation from the yard storage fire.

Caution must be exercised when adding additional weight and potential wind-blown missiles to the roof. Consult a structural engineer about the additional roof load and adhere to recommendations in Data Sheets 1-28 and 1-29 regarding the application of gravel or ballast.

For the exterior protection of exposed building roofs see Sections 2.2.17 through 2.2.19.

3.3.13 Protection of Walls Above Lower Yard Storage

When the height of the exposed building exceeds the height of the yard storage and $D < S_M$ provide protection for the portion of the exposed wall that is above the height of the storage as outlined in Figures 28a and 28b. Base the type of protection needed on the severity of the exposure (Section 3.3.1) and the actual horizontal separation distance (D) between buildings.

3.4 Yard Housekeeping

Unpaved yards with grass, weeds, and bushes are hazardous, especially to buildings with combustible walls. Piles of combustibles, stored either in the yard or on nearby property, add to the hazard. Combustible yard storage may be vulnerable both to incendiarism and to fire spread from adjoining properties. These hazards may be reduced by yard paving, metal fencing, and maintaining an aisle space along the fence.

3.5 Exposure Sprinklers and Water-Spray Nozzles

Exposure sprinklers and water-spray nozzles used for exterior exposure protection need to be corrosion resistant to remain reliable after exposure to harsh weather. They do not have to be special protection sprinklers designed for corrosive environments such as acid fumes, but they do need to be able to withstand typical weathering that an indoor sprinkler does not. Sprinklers and nozzles made from stainless steel or coated with Teflon or lead are acceptable for exterior applications. Wax-coated sprinklers or nozzles do not provide the same level of durability and should not be used for exposure protection.

3.6 Buildings Over Highways

Buildings that span highways in and around metropolitan areas are becoming more common. Potential fire emergencies range from fires in passenger vehicles to major accidents involving loaded trucks carrying ignitable liquids or other hazardous cargoes. Heavy traffic and adverse weather conditions may contribute to the seriousness of an accident by involving approaching vehicles and obstructing fire service access.

The structural members supporting a building over a highway could be subjected to very high temperatures during a ignitable liquid fire or explosion, even if of short duration. Damage to these members could have a serious effect on the building. Most fires of these types substantially exceed the ASTM Standard Time-Temperature Curve during the early stages and could drop below the curve after two or three hours. The structural elements that support the building may also be subjected to physical damage caused by the impact of motor vehicle accidents.

Ignitable liquid and flammable vapor can flow by gravity or via drainage systems and spread fire well beyond the area of the original emergency. During a fire, smoke can also spread in all directions as a result of density and pressure differentials, thus impeding efficient manual firefighting. Consequently, a drainage system and emergency ventilation are needed in the space under the building to help firefighting and control the spread of the fire.

Many highway spaces under buildings are not equipped with manual firefighting equipment, such as hydrants and fire extinguishers. This equipment is especially needed when the space is not protected with sprinklers.

Limited access to highways under buildings and backed-up traffic frequently hinder public fire service response. Problems are further complicated by the lack of adequate communication facilities for reporting emergency conditions and for warning approaching vehicle operators of fire, hazardous conditions, or visibility limitations.

Traffic management is a continuous problem from the time the emergency occurs until it has been brought under control. Diverting or slowing traffic is essential to minimize the hazard of multiple collisions.

Openings in buildings over highways can be exposed to vehicle fires or explosions occurring at the entrance or exit of the space under the building. Protection against such occurrences is needed.

While building developments over highways sometimes pose complex fire protection problems, few of these problems are new or unique. The comparative rarity of this type of situation may cause adequate fire protection to be overlooked or only superficially considered. The fire protection guidelines in this data sheet should be considered for this type of development.

4.0 REFERENCES

4.1 FM Global

Data Sheet 1-0, *Safeguards During Construction, Alteration and Demolition*
Data Sheet 1-1, *Firesafe Building Construction and Materials*
Data Sheet 1-3, *High-Rise Buildings*
Data Sheet 1-6, *Cooling Towers*
Data Sheet 1-21, *Fire Resistance of Building Assemblies*
Data Sheet 1-22, *Maximum Foreseeable Loss*
Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*
Data Sheet 1-57, *Plastics in Construction*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 3-10, *Installation and Maintenance of Private Fire Service Mains and their Appurtenances*
Data Sheet 3-26, *Fire Protection Water Demand For Nonstorage Sprinklered Properties*
Data Sheet 4-4N, *Standpipe and Hose Systems*
Data Sheet 5-4, *Transformers*
Data Sheet 7-28N, *Explosive Materials*
Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers*
Data Sheet 7-32, *Ignitable Liquid Operations*
Data Sheet 7-52, *Oxygen*
Data Sheet 7-55, *Liquefied Petroleum Gas (LPG) in Stationary Installations*
Data Sheet 7-85, *Metals and Alloys*
Data Sheet 7-88, *Ignitable Liquid Storage Tanks*
Data Sheet 8-1, *Commodity Classification*
Data Sheet 8-3, *Rubber Tire Storage*
Data Sheet 8-7, *Baled Fiber Storage*
Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*
Data Sheet 8-10, *Coal and Charcoal Storage*
Data Sheet 8-21, *Roll Paper Storage*
Data Sheet 8-22, *Storage of Baled Waste Paper*
Data Sheet 8-24, *Idle Pallet Storage*
Data Sheet 8-27, *Storage of Wood Chips*
Data Sheet 8-28, *Pulpwood and Outdoor Log Storage*
Data Sheet 9-1, *Supervision of Property*
Data Sheet 9-17, *Protection Against Arson and Other Incendiary Fires*
Data Sheet 9-19, *Wildland Fire*

4.2 Others

ASTM International. ASTM E108-11, *Standard Test Methods for Fire Tests of Roof Coverings.*

Mowrer, F. W. *Window Breakage Induced by Exterior Fires*. NIST-GCR-98-751. National Institute of Standards and Technology (NIST).

National Fire Protection Association (NFPA). *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*. NFPA 80A, 2012 Edition.

National Fire Protection Association (NFPA). *Standard for the Installation of Sprinkler Systems*. NFPA 13, 2010 Edition.

APPENDIX A GLOSSARY OF TERMS

Actual Separation Distance (D): The existing or proposed separation distance between adjacent buildings or between yard storage and a building.

Approval Guide: An on-line resource of FM Approvals listing FM Approved products and services.

Base Separation Distance (S_B): The distance determined from figures and tables based on the exposed wall construction and the exposing fire hazard. The base separation distance assumes the exposure and exposed wall are parallel and the exposure has 100% unprotected openings.

Class 1: FM Approved wall/ceiling panel assemblies that don't create a need for automatic sprinklers and would be acceptable in a combustible occupancy protected by automatic sprinklers as defined by FM Global Property Loss Prevention Data Sheets. FM Approved wall/ceiling panels include, but are not limited to, metal or plastic single skin panels and bare or painted metal facers with polyisocyanurate, polyurethane, mineral wool, and aluminum honeycomb cores.

Combustible (C): Includes painted or unpainted wood, rigid plastic building materials that are not FM Approved, and Class 2 insulated steel decks.

Concrete Block on Exposed (From the Exterior Side) Steel Frame: When any portion of the steel framing is on the exterior side of concrete block, expansion of the steel frame under heat exposure may open up the mortar joints. This tends to weaken the wall and permit the passage of heat and flame to the unexposed side. Some credit, however, can be given to this type of wall to act as a fire barrier under reduced exposure.

If an exterior grade fire-resistant coating (such as an intumescent mastic) is applied to the exterior side of the exposed steel to provide a comparable rating to that of the wall, that rating may be used to determine the separation. Otherwise, using the separation distances for noncombustible construction will provide a very conservative estimate of the needed separation.

Exposure Angle Adjustment Factor (M): An adjustment factor that accounts for the reduced radiation experienced by an exposed wall that is not parallel with the exposing wall.

Exposure Envelope: The area where a potential exposure exists, defined as an area directly parallel to the exposure plus the area created by a 45° angle from a perpendicular line at both ends of the exposure.

Exterior Insulation and Finish System (EIFS): EIFS often uses expanded or extruded polystyrene insulation (EPS). The exterior coating for the EPS is a thin (about 1/8 in.; 3 mm) layer of proprietary plaster-like material that may be only 50% cement and 50% polymers. It offers considerably less thermal resistance than stucco (lath and plaster), which is typically 1/2 in. to 3/4 in. thick (13 mm to 19 mm).

Fire Rated (FR): An assembly that has passed an internationally recognized fire endurance test (e.g., ASTM E119) or is rated based on calculation or convention. For more information, see Data Sheet 1-21, *Fire Resistance of Building Assemblies*.

Fire-Rated Glass: Glass such as wired glass, glass block, or ceramic glass that has passed a minimum 3/4 hour fire endurance test and hose stream test.

Fire Resistive: For more information, including specific hourly fire ratings, refer to Data Sheet 1-21. This category includes concrete (tilt-up, precast, poured-in-place), concrete block, brick (but not quarter brick which is only about 1/2 in. [13 mm] thick when used as a veneer in EIFS systems), metal sandwich panels with a gypsum board core, and plaster/stucco (not EIFS). Well-maintained concrete or masonry walls without openings usually need little or no separation or protection against fire exposure.

FM Approved: References to ″FM Approved″ in this data sheet mean the product or service has satisfied the criteria for Approval by FM Approvals. Refer to the Approval Guide for a complete listing of products and services that are FM Approved.

HC-1/HC-2 hazard occupancy: See Data Sheet 3-26, *Fire Protection Water Demand for Nonstorage Sprinklered Properties*.

High Hazard Yard Storage: Yard storage of ignitable liquids, flammable gases and explosives.

Listed: Listed by a reputable testing laboratory according to a widely recognized testing standard adopted by model building codes.

Low Hazard Yard Storage: Storage of Class 1 and 2 commodities. Storage of noncombustible goods in noncombustible packaging. Storage of vehicles, construction and farm equipment.

Maximum Foreseeable Loss (MFL): The largest loss to result from an event, as calculated from an understanding of the overall hazard and associated business impact. This event assumes active protection systems or safety devices are impaired, with the exception of specifically FM Approved and tested MFL fire doors. The event can be related to fire, explosion, equipment failure, or other scenario, with the exception of natural hazards. MFL limiting factors are physical barriers or conditions that limit the spread of fire or contain explosive forces and control the amount of damage from the event.

Noncombustible (NC): Noncombustible walls usually consist of panels over steel framing. Panels may be painted or galvanized steel, corrugated iron, or corrugated cementitious panels supported on a steel frame. The panels are light in weight, and unless protected or adequately separated, they may buckle and open at their joints, or crack under fire exposure. Since heat will easily conduct through thin steel and ignite combustible insulation, insulations acceptable for use in this category include glass fiber, mineral wool, and expanded glass. For other types of insulation, see Class 1 or combustible categories. Noncombustible panels also include protected metal panels and fiber-reinforced cement panels FM Approved and listed in the *Approval Guide* under Exterior Roofing and Siding.

Obstructed View Adjustment Factor (U): An adjustment factor to account for the reduced radiation from yard storage when noncombustible objects are between the storage and the exposed wall.

Ordinary Hazard Yard Storage: Storage of Class 3 and 4 commodities. Storage of plastic commodities. Storage of rubber tires.

Minimum Safe Separation Distance (S_M): The distance recommended per this document to prevent ignition of a building or its contents due to an exposure fire in an adjacent building or yard storage.

Stable Fire Resistive (SFR): SFR walls are constructed of materials having a fire resistance rating at least adequate for the exposing occupancy. The category SFR only applies to exposing walls and not to exposed walls. The exposing wall must be constructed so that it will not collapse in an uncontrolled fire. This includes freestanding fire walls. It does not include fire walls that are laterally supported by structural framework that does not have adequate fire resistance.

Storage Occupancies: Storage of any commodity, ignitable liquids, plastics, roll paper, rubber tires, and any material judged to have a comparable or higher hazard. When palletized storage of Class 3 commodities are no more than one tier or 6 ft (1.8 m) high, the hazard may be reduced to HC-1/HC-2.

Unprotected Opening: Openings in walls that have no fire-resistance ratings and are not protected by sprinklers, spray nozzles, open heads, window sprinklers, water curtains, open water-spray nozzles, deluge systems, pre-action systems, special protection systems, fire doors, fire shutters, fire dampers, or fire stop systems. The opening can be a window, door, ventilation opening, opening around a penetration or any other unobstructed opening in the wall with a width greater than ¾ in. (19 mm).

Unprotected Opening Adjustment Factor (U): An adjustment factor to account for radiation from unprotected openings in noncombustible, fire resistive, and stable fire-resistive exposing walls.

A.1 Nomenclature

C = combustible wall (exposing or exposed).
D = actual perpendicular separation distance between exposing and exposed walls.
FR = fire rated exposed wall.
H = exposure height, or yard storage height..
L = exposure length.
M = exposure angle adjustment factor.
NC = noncombustible wall (exposing or exposed).
O = offset distance between parallel exposing and exposed walls.
P = passive fire rating needed per Table 2 and 4 or Figures 1, 2, 3 or 4 (also see Table 11).
P-1 = one level of passive protection less than P.
P-2 = two levels of passive protection less than P.
S_B = the base separation distance needed per figures and tables.
S_{100} = the needed safe separation distance for 100% unprotected openings.
S_N = the needed safe separation distance for N% unprotected openings.
S_M = the minimum safe separation distance.
SFR = stable fire resistive exposing wall.
TG = tempered glass.
U = unprotected opening adjustment factor/obstructed view adjustment factor.
WG = wired glass.
WS = window sprinklers.
X = length of side wall needing protection (0.5S-D).
Y = side wall exposure length.
Θ = exposure angle.
Φ = end wall and side wall angle.

APPENDIX B DOCUMENT REVISION HISTORY

October 2016. Interim revision. Clarifications were made to recommendation 3.3.1.2.

July 2016. Interim revision. Clarification was made to recommendation 3.3.1.2.

July 2014. Interim revision. This document was revised to improve and simplify the way minimum safe separation distances (S_M) are determined. Additional changes include the following:

- Minimum safe separation distances exposing fire-rated construction (Tables 2 and 4) were revised. S_M was significantly reduced.
- Yard storage Figures 3 and 4 were revised to provide better agreement with Figures 1 and 2 and MFL separation distances in Data Sheet 1-22, *Maximum Foreseeable Loss.* S_M was reduced.
- Tables 1 and 3 were updated to reflect changes in other data sheets.
- Fire protection guidance for buildings over highways was added, and Data Sheet 1-16, *Fire Protection For Buildings Over Highways*, was made obsolete.
- The terminology for occupancy hazard categories was updated to agree with Data Sheet 3-26, *Fire Protection Water Demand for Nonstorage Sprinklered Properties.* The term “Light/ordinary” has been replaced with ″HC-1/HC-2″ for building occupancies. ″Low,″ ″ordinary″, and ″high″ are used for yard storage.

April 2014. Replaced the terms ″light hazard″ occupancy with ″Hazard Category 1 (HC-1)″ occupancy, and the term ″ordinary hazard″ occupancy with ″Hazard Category 2 (HC-2)″ occupancy to be consistent with Data Sheet 3-26, *Fire Protection Water Demand for Nonstorage Sprinklered Properties.*

October 2012. This document was revised to improve and simplify the way minimum safe separation distance (S_M) are determined. Additional changes include the following:

- Window and exposure sprinkler design criteria were added.
- Exposed and exposing wall categories were changed; former Categories A, B, C, and D no longer apply.
- The methodology for determining building exposure safe separation distances was changed in its entirety; former Tables 1a, 1b, 1c, and 2 are no longer used.
- The methodology for determining yard storage safe separation distances was changed in its entirety; former Equations 1 and 2 are no longer used.
- This data sheet now covers all yard storage exposures except those listed in Tables 1 and 3.
- Editorial changes were made.

January 2007. Minor editorial changes were made.

September 2006. Minor editorial changes were made.

January 2006. Minor editorial changes were made.

May 2003. This revision of the document has been reorganized to provide a consistent format.

In September 1999, the March 1979 version was completely revised.