MAXIMUM FORESEEABLE LOSS LIMITING FACTORS

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1.0 SCOPE

This data sheet provides design criteria and guidelines for maximum foreseeable loss (MFL) limiting factors and the protection of openings in MFL limiting factors.

For general guidance and information related to the maximum foreseeable loss (MFL) concept see Data Sheet 1-22, *Maximum Foreseeable Loss*.

1.1 Changes

April 2025. Interim revision. Minor changes made to clarify guidance related to space separation analysis to be consistent with revised guidance in FM Property Loss Prevention Data Sheet 1-20, *Exterior Fire Exposures*.

2.0 LOSS PREVENTION RECOMMENDATIONS

The need for MFL limiting factors is usually determined by the values exposed in a single fire. Limiting factors may be walls, space separation, lack of continuity of combustibles, fire response, or a combination of these.

2.1 Introduction or Construction

2.1.1 Use FM Approved equipment, materials, and services whenever they are applicable. For a list of products and services that are FM Approved, see the *Approval Guide* and/or Roof*Nav*, online resources of FM Approvals.

2.1.2 FM Approvals does not Approve concrete masonry units (CMU), fire wall assemblies, floor/ceiling assemblies, beam, joist, truss, or column fire-rated assemblies (i.e., fireproofing). FM Approvals does test and list fire-rated assemblies that have been tested to ASTM E119. These assemblies are listed in the *Approval Guide* under Specification Tested, Building Materials, ASTM E119. Other generic and proprietary assemblies listed by other testing agencies, trade groups, or associations are acceptable provided internationally recognized test standards are used. For more information, refer to Data Sheet 1-21, *Fire Resistance of Building Assemblies*.

2.2 MFL Fire Walls

The purpose of an MFL wall is to confine an uncontrolled fire to the side of fire origin. The wall must be designed for stability as well as fire resistance. Other factors that must be considered in the design are protection of openings, exterior walls, parapets, penetrations, and roof details. The system design must prevent fire spread through, under, over, or around the MFL firewall.

An MFL fire wall must have insulating qualities so temperatures on the unexposed face of the wall will not ignite combustibles. The recommended fire rating of the wall is determined by the expected severity and duration of the fire. MFL firewalls normally need a 4-hour fire-resistance rating.

2.2.1 Fire Resistance of Wall Construction

2.2.1.1 Design MFL fire walls for 4-hour (F240, EI240) fire resistance, unless otherwise specified. Use durable and impact resistant materials such as masonry, brick, and concrete.

2.2.1.2 When using proprietary assemblies or materials, use only those products listed by a recognized testing laboratory that provide the needed fire resistance.

2.2.1.3 Do not use the following for MFL walls:

A. Walls constructed of gypsum wallboard on studs or a cementitious coating on lath on studs

B. Exterior insulation and finishing systems (EIFS) as part of an MFL wall or as part of end walls or angular exposure walls

C. Wall assemblies that contain foam plastic insulation

D. Spray-applied fire protection coatings that use an expanded plastic aggregate.

E. Walls constructed with mass engineered timber.

2.2.1.4 Use only those autoclaved aerated concrete (AAC) wall assemblies that have passed a documented fire test that includes a hose stream test. Provide the same wall joints as those in the fire-tested assembly, or use a listed joint system with a proper fire endurance rating.

2.2.1.5 Construct lintels used in openings in MFL fire walls of reinforced concrete, reinforced concrete masonry, or concrete-encased steel. Design the lintel to have a fire-resistance rating equivalent to the rating of the wall. Do not leave the bottom steel flange of steel members exposed.

2.2.1.6 When the fire rating of concrete masonry construction relies on grouted cores, ensure cores are grouted for the full height of the wall. Use low-lift grouting techniques (grout in a maximum of 5 ft [1.5 m] lifts) to prevent grout voids in the lower cores. Do not use loose fill material because it may spill out if the wall is later damaged.

Exception: When mechanical vibration is used, grouting lifts may be increased to 10 ft (3 m).

2.2.2 Stability and Strength

2.2.2.1 Design MFL fire walls as **non-loadbearing** only. Walls should not support any gravity load other than their own weight. Special precautions must be taken regarding the detailing of wall penetrations for structural elements to ensure MFL fire walls do not unintentionally provide vertical support to adjacent structures. Refer to Section 2.2.6.6 for additional information on penetrating pipes, conduit, etc.

2.2.2.2 MFL fire walls can be used as shear walls as part of the lateral-force-resisting system of the building provided the walls are properly designed and constructed to adequately resist the design loads. Where MFL fire walls are not intended to act as part of the lateral-force-resisting system of the building, take special precautions with connection detailing and deflection compatibility between the walls and the adjacent building framing to ensure MFL fire walls are not stressed or damaged by lateral forces.

2.2.2.3 If any significant modifications are intended to be made to an existing MFL fire wall, or to an existing wall intended to be accepted as an MFL fire wall, retain a registered civil or structural engineer to provide an evaluation and to ensure the wall will function as required. Significant modifications could include changes to the strength, stiffness, stability, mass, durability, and connections associated with the wall.

2.2.2.4 Do not use unreinforced masonry or unreinforced concrete walls or portions of walls as MFL walls.

2.2.2.5 When using tilt-up or precast concrete construction, provide joint integrity and prevent differential movement between panels by using a shiplap joint, tongue-and-groove joint, or other positive mechanical means. Ensure all joints have the same fire resistance rating as the wall. (Refer to Figure 1.)

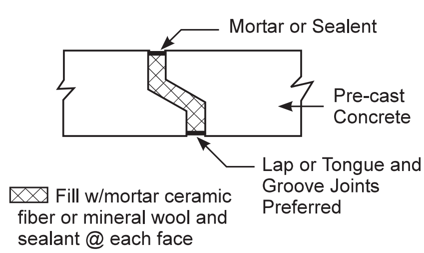


Fig. 1. Typical joint detail in precast concrete (courtesy of the National Concrete Masonry Association)

2.2.2.6 Provide adequate clearances between MFL fire walls and steel framing, and between adjacent MFL fire walls to prevent damage from horizontal thermal expansion of the steel during a fire. For buildings located in FM earthquake zones 50-year through 500-year, adjust clearances as necessary to prevent pounding during seismic events.

Use one of the following methods:

A. Provide minimum adequate clearance (see Table 1) between the wall and the steel framing (see Figure 2) on each side of the wall or between the two walls of a double wall system (see Figure 3).

B. Provide a maximum of ¾ in. (19 mm) clearance between the wall and the structural framework for walls up to 40 ft (12.2 m) high if the steel is aligned horizontally and vertically on both sides of the wall (see Figure 4). For walls higher than 40 ft (12 m), this maximum space may be increased ¼ in. (6 mm) for each additional 10 ft (3.0 m) of wall height. Install a bond beam in the first full course below the bottom of the primary steel for the full length of the wall.

Where the adjacent primary steel is parallel to the MFL fire wall, grout all cores above the bond beam to the top of the wall; however, in FM earthquake zones 50-year through 500-year, grout the cores above the bond beam along the full length of the wall, but only to the first course above the top of the primary steel.

Where the adjacent primary steel is perpendicular to the MFL fire wall, grout cores above the bond beam to the top of the wall, but only to 16 in. (0.4 m) on each side of the columns.

In all cases, grout reinforced cores the full height of the wall, and continue vertical reinforcement for the full height of the wall (i.e., ensure vertical reinforcing is not interrupted at bond beams).

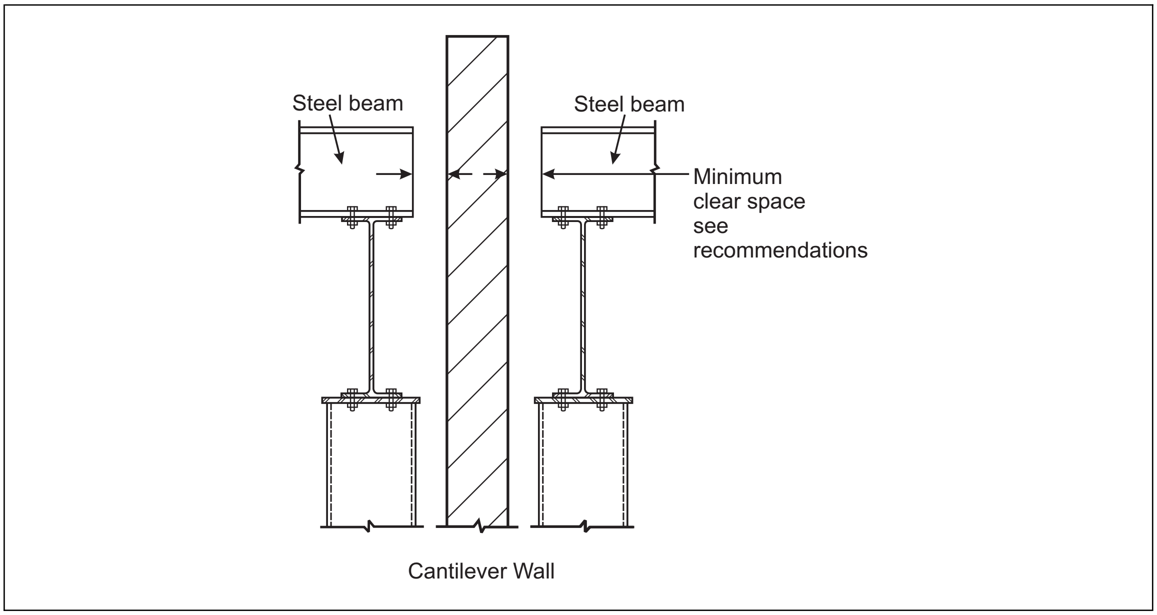


Fig. 2. Minimum clearance between MFL fire wall and aligned steel framing

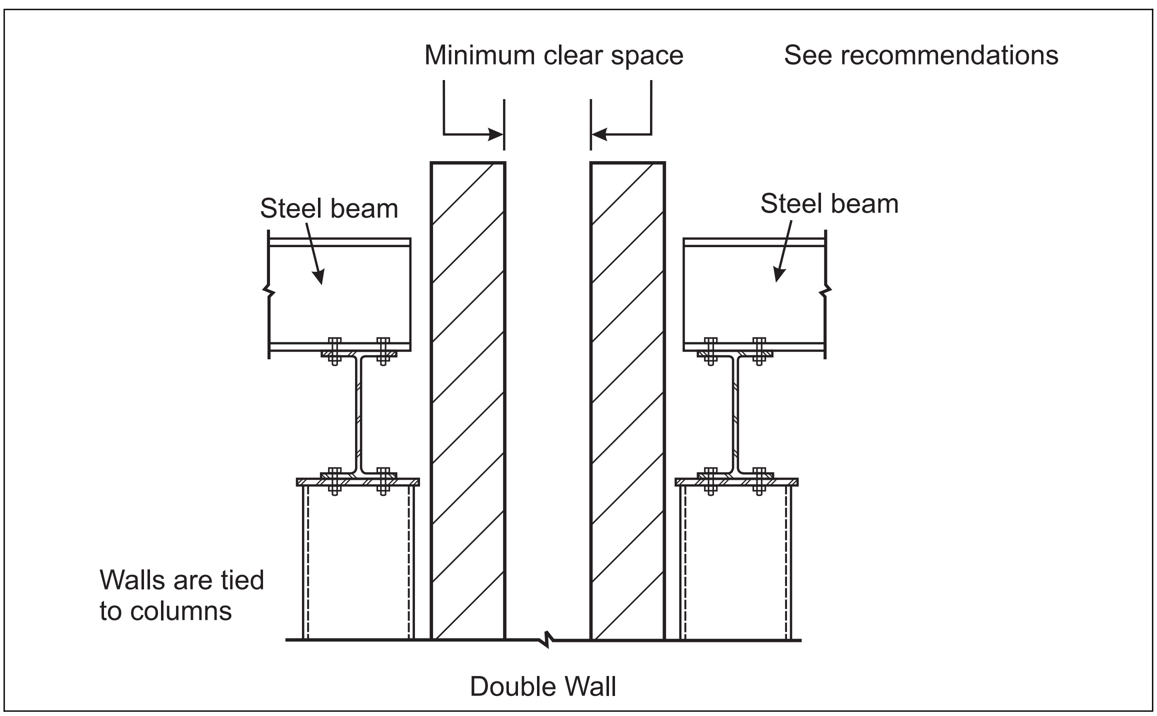


Fig. 3. Minimum clearance between Double MFL wall and aligned steel framing

Table 1. Minimum Clearance Between Structural Steel and MFL Fire Wall or between the two walls of a double wall system

Length of Bay Perpendicular to the Fire Wall		*Minimum Clearance Between Wall and Steel*	
ft	m	in.	mm
20	6.0	2½	65
25	7.5	3¼	80
30	9.0	3¾	95
35	10.5	4½	115
40	12.2	5	125
45	13.5	5¾	145
50	15.0	6¼	160
55	16.5	7	175
60 or longer	18.0	7½	190

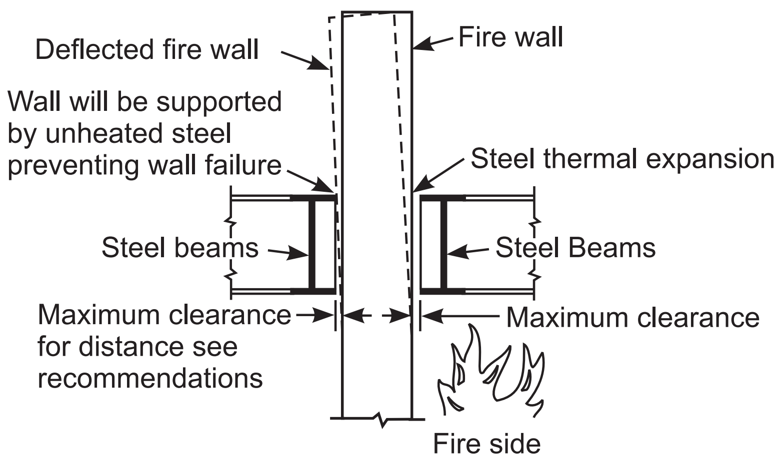


Fig. 4. Maximum clearance for support of a cantilever MFL fire wall under fire conditions (note: this condition applies only when steel is aligned horizontally and vertically)

2.2.2.7 Design and construct MFL fire walls to provide adequate strength, stiffness, stability, and durability.

A. Design wall panels to adequately resist a minimum uniform lateral pressure of 5 psf (0.24 kN/m^2) for allowable stress design (ASD) or working stress design (WSD) (using a load factor of 1.0); use a load factor of 1.6 for load and resistance factor design (LRFD) methodology (1.6 x 5 psf = 8 psf [0.38 kN/m^2]). This usually is accomplished easily in all walls except the cantilever type.

For buildings located in hurricane-prone regions (see definition in FM Data Sheet 1-28), ensure wall panels can adequately resist design wind pressures derived from the basic wind speed per Data Sheet 1-28, *Wind Design*. Examine both enclosed and partially enclosed conditions if applicable. Do not, under any circumstances, use uniform wind pressures less than 5 psf (0.24 kN/m^2) for ASD design or 8 psf (0.38 kN/m^2) for LRFD design.

B. Apply the lateral pressure, which is perpendicular to the wall face, on the side of the wall that produces the more severe demand. This minimum lateral load typically will not be adequate for walls exposed directly to wind (i.e., fire walls used as temporary exterior walls or walls subjected to interior wind force due to partially enclosed buildings) or in FM earthquake zones 50-year through 500-year.

Where MFL fire walls are subjected directly to wind forces (e.g., a fire wall used as a temporary exterior wall), the wall must be designed to adequately resist these forces (see Data Sheet 1-28, *Wind Design*).

2.2.2.8 For locations in active seismic areas (see Data sheet 1-2, *Earthquakes*), ensure MFL fire walls are designed by an engineer familiar with earthquake design and registered to practice structural design in the jurisdiction in which the project is located, and refer to Appendix C, Design of MFL Fire Walls in FM Earthquake Zones.

2.2.2.9 Detail masonry and reinforced concrete MFL fire walls per Appendix D, Structural Design Details, Detailing Guidelines, and Quality Assurance for MFL Fire Wall Construction.

2.2.2.10 Locate any occupancy presenting an explosion hazard, BLEVE, pressure vessel (PV) rupture or runaway reaction a minimum of 125 ft (38 m) from MFL fire walls.

2.2.2.11 Due to the complexity of rack-supported structures, double MFL fire walls are preferred for interior subdivision in this type of construction. Other types may be used but generally will cost much more.

2.2.2.12 Arrange storage racks perpendicular to the fire wall so they pose less of an impact exposure in case of rack collapse during an MFL fire.

2.2.2.13 Do not allow bridging and bracing for joists or trusses to be continuous through an MFL fire wall.

2.2.2.14 Retain a registered civil or structural engineer with experience in geotechnical engineering who is familiar with local geological conditions to provide the foundation design. Foundations require careful design to provide adequate bearing support and resistance to overturning, particularly for cantilever walls.

2.2.3 Control of Cracking

2.2.3.1 Locate expansion joints for masonry MFL fire walls so they are spaced a maximum of 200 ft (61 m) on center and in line with those of the building frame. Firestop the joints with a listed joint system with equal or greater-hourly rating as the wall.

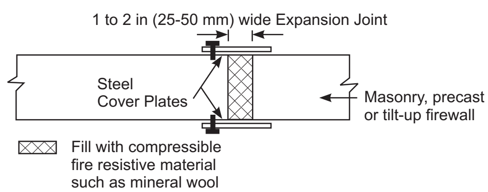


Fig. 5. Expansion joint (courtesy of the National Concrete Masonry Association)

2.2.3.2 Provide control joints at intervals not exceeding 50 ft (15 m) in concrete masonry MFL walls to prevent irregular cracking due to initial shrinkage. Any of the types shown in Figures 6 and 7 are applicable. Use an elastomeric firestop sealant for caulking all joints.

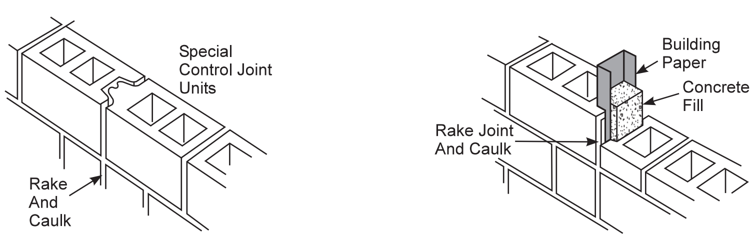


Fig. 6. Typical control joints in concrete masonry (reinforcing not shown) (courtesy of the National Concrete Masonry Association)

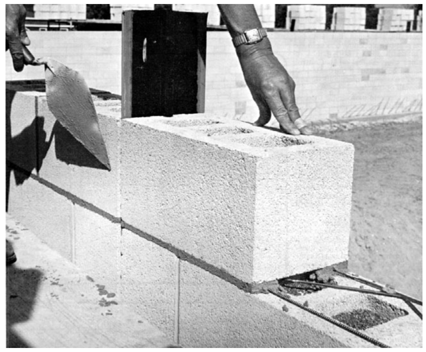


Fig. 7. Horizontal joint reinforcing and control joint in concrete block wall construction (courtesy of the National Concrete Masonry Association)

2.2.3.3 Detail bond beam reinforcement as follows:

A. Expansion joints: If structural continuity is required, provide taped (18 in. [0.46 m] on each side) or smooth dowel laps. Otherwise, interrupt bond beam reinforcing, but provide 180 degree hooks to vertical rebar. Provide at least two grouted and reinforced cores on each side of the joint (see Figures 9 and 10).

Smooth steel dowel laps at expansion joints (as opposed to typical deformed steel rebar) are intended to allow for unrestrained deflection parallel to the dowel while still providing resistance perpendicular to the axis of the dowel (i.e., a one-way slip connection).

B. Control joints: Extend bond beam reinforcing uninterrupted through control joints. Provide at least one grouted and reinforced core on each side of the joint (see Figure 8).

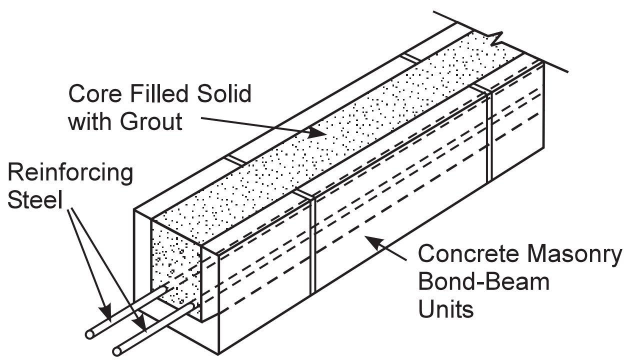


Fig. 8. Typical concrete masonry bond beam (courtesy of the National Concrete Masonry Association)

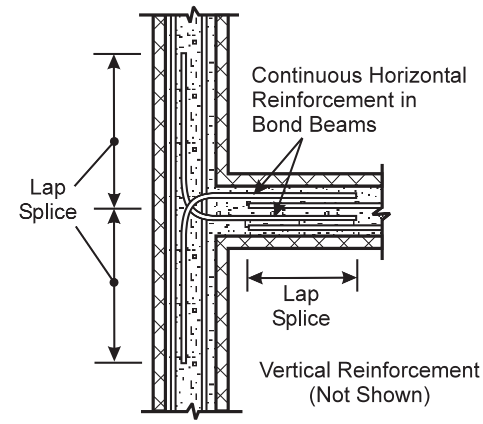


Fig. 9. Bond beam reinforcing at intersecting concrete masonry walls

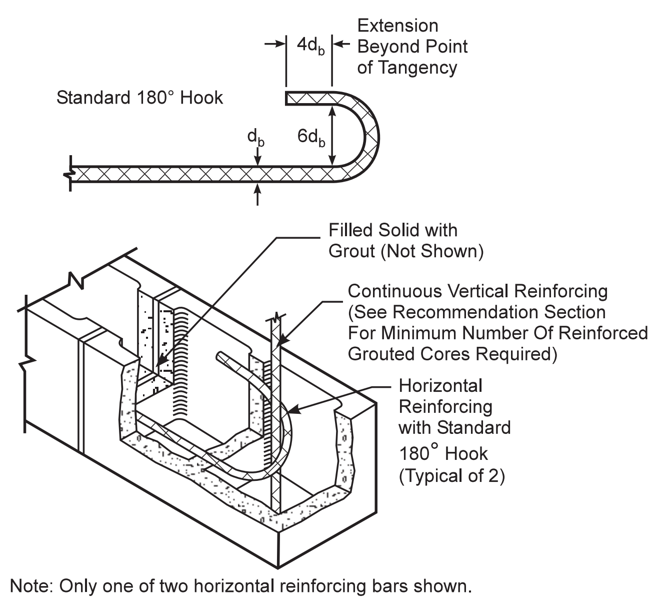


Fig. 10. Bond beam reinforcing termination detail for concrete masonry walls in FM earthquake zones

2.2.3.4 Provide minimum shrinkage and temperature reinforcement per the applicable building code (e.g., ACI 318).

2.2.3.5 Provide minimum concrete protection for reinforcement per the applicable building code (e.g., ACI 318) or for the required fire resistance, whichever is greater. Refer to Data Sheet 1-21.

2.2.4 Parapets, Roof Protection, and Elevation Differences

2.2.4.1 Except where noted otherwise, provide MFL fire walls with parapets at least 30 in. (800 mm) high (see Figure 11) constructed of material having fire resistance equal to the wall. Measure the 30 in. (800 mm) dimension from the top surface of the protected roof to the top of the parapet. Design the wall assembly to withstand the appropriate wind loads applied to the parapet (see Data Sheet 1-28, *Wind Design*).

Exception: For reinforced concrete frame buildings with concrete roof deck and gravel surfacing as in section 2.2.4.4 below, a parapet may be omitted.

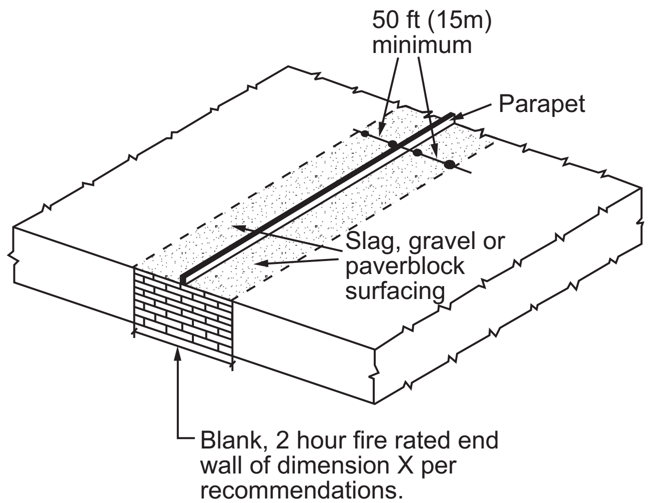


Fig. 11. An MFL fire wall divides a one-story facility

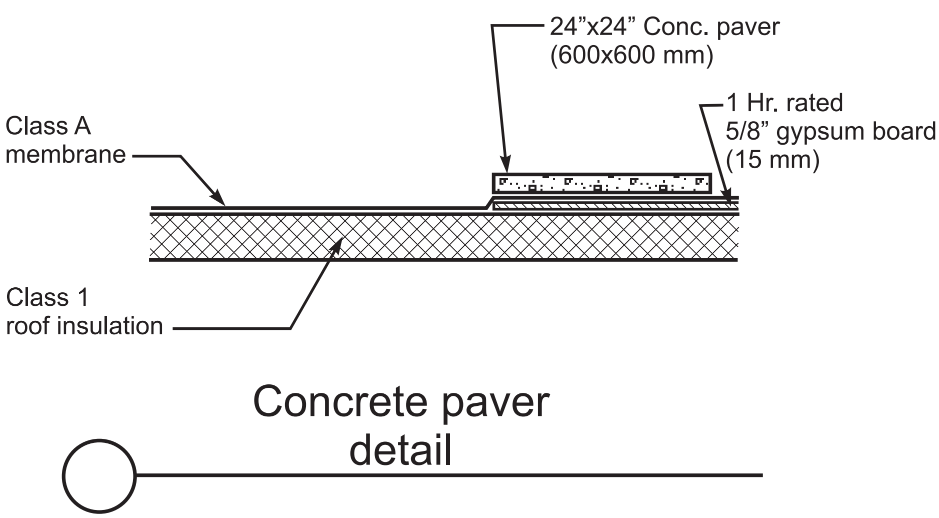


Fig. 12. Single-ply membrane roof at an MFL fire wall

2.2.4.2 If steel deck roofs are used, provide FM Approved Class 1 assemblies.

2.2.4.3 Provide FM Approved roof decks and above-deck assemblies including roof cover assemblies that have an FM Approved Class A rating (per ASTM E108) on the entire roof of buildings separated by MFL fire walls. (See Data Sheet 1-28R/29R, *Roof Systems*.)

2.2.4.4 Protect the top surface of roof assemblies as follows:

A. Surface built-up roofs for at least 50 ft (15 m) on both sides of the MFL fire wall with pea gravel or slag embedded in a flood coat of asphalt (see Figure 11). Use a gravel application rate of at least 4 psf (0.19 kN/m^2).

B. For single-ply membrane assemblies, use an assembly that has a Class A rating (for the specific maximum slope and assembly in question). In addition, protect the top surface with one of the following:

1. Paver blocks or large gravel ballast (ASTM No. 3 stone) for at least 50 ft (15 m) on both sides of the MFL wall (ASTM No. 4 stone is acceptable if the membrane is fully adhered or mechanically attached and doesn’t require ballast for wind uplift). Apply the gravel at a rate of 10 to 12 psf (0.48 to 0.57 kN/m^2). If 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. Rigid thermal barrier of equal fire resistance as a single layer of 5/8 in. Type X gypsum board directly beneath the membrane for the first 50 ft (15 m) on each side of the fire wall parapet. The thermal barrier should be moisture resistant such as glass fiber faced gypsum board and fastened to the deck per RoofNav. In addition, provide a single line of concrete paver blocks (2 x 2 ft [600 x 600 mm]) at the termination of the thermal barrier 50 ft (15 m) away from the parapet (see Figure 12).

C. On metal panel roof systems (e.g., lap seam or standing seam) install a layer of ceramic fiber, mineral wool or glass fiber batt insulation between the bottom of the roof panels and the top of the purlin flange for at least 50 ft (15 m) on each side of the MFL wall. Ensure the batt is a minimum of 1 in. (25 mm) thick ceramic fiber or mineral wool, or 2 in. (50 mm) thick glass fiber.

D. For roof drains do one of the following:

1. Omit any roof drains within 50 ft (15 m) on both sides of the MFL fire wall.

2. Within 50 ft (15 m) on both sides of the MFL fire wall, provide noncombustible drain covers and steel or cast iron drain pipe for at least the first 3 ft (1 m). Design roof drains so that gravel, slag, ballast, and pavers can be held back as needed for proper drainage as long as it does not exceed 3 ft (1 m).

2.2.4.5 Do not use fire-retardant coatings or paints as an alternative to 2.2.4.4.

2.2.4.6 Do not use spray-applied polyurethane foam roof cover systems within 50 ft (15 m) of an MFL fire wall.

2.2.4.7 Where a higher building or higher portion of a building adjoins a lower building at an MFL fire wall, ensure the exterior wall above the roof of the lower building is blank and has a 3-hour fire resistance, depending on the occupancy and construction of the exposing building (see Figures 13 and 14). Ensure the lower building has a 30 in. (0.76 m) high parapet. A parapet may be omitted on the higher building if there is at least a 15 to 50 ft (4.5 to 15 m) elevation difference, depending on the severity of the exposure. When the parapet is omitted, ensure the exterior wall construction extends up to the gravel stop. Gravel surfacing (or paver blocks) is still recommended for 50 ft (15 m) on the higher roof and at least 50 ft (15 m) on the lower roof to protect against flying brands.

Construct the upper section of the wall of fire-rated insulated metal panel or precast concrete panel to reduce the probability of damage to the lower roof from falling concrete masonry units. However, to provide penetration resistance from falling upper wall material if masonry units are used, design the roof of the lower building for minimum 100 psf (4.8 kN/m^2) construction for a length equal to the height of the elevation difference or one bay, whichever is less.

The assembly can be arranged in either of the two following ways:

A. Separate the high bay and low bay with a double MFL fire wall, each wall tied to its respective framework (see Figure 13).

B. Construct a cantilevered, 4-hour fire wall from the foundation to the top of the parapet level for the lower roof. Ensure the upper wall section is 2 or 3-hour fire rated and tied to the framework of the higher building. Ensure the upper wall section is not connected to or does not extend over the face of the lower wall section. Fill the space between the upper and lower wall sections with a fire-resistive material (see Figure 14).

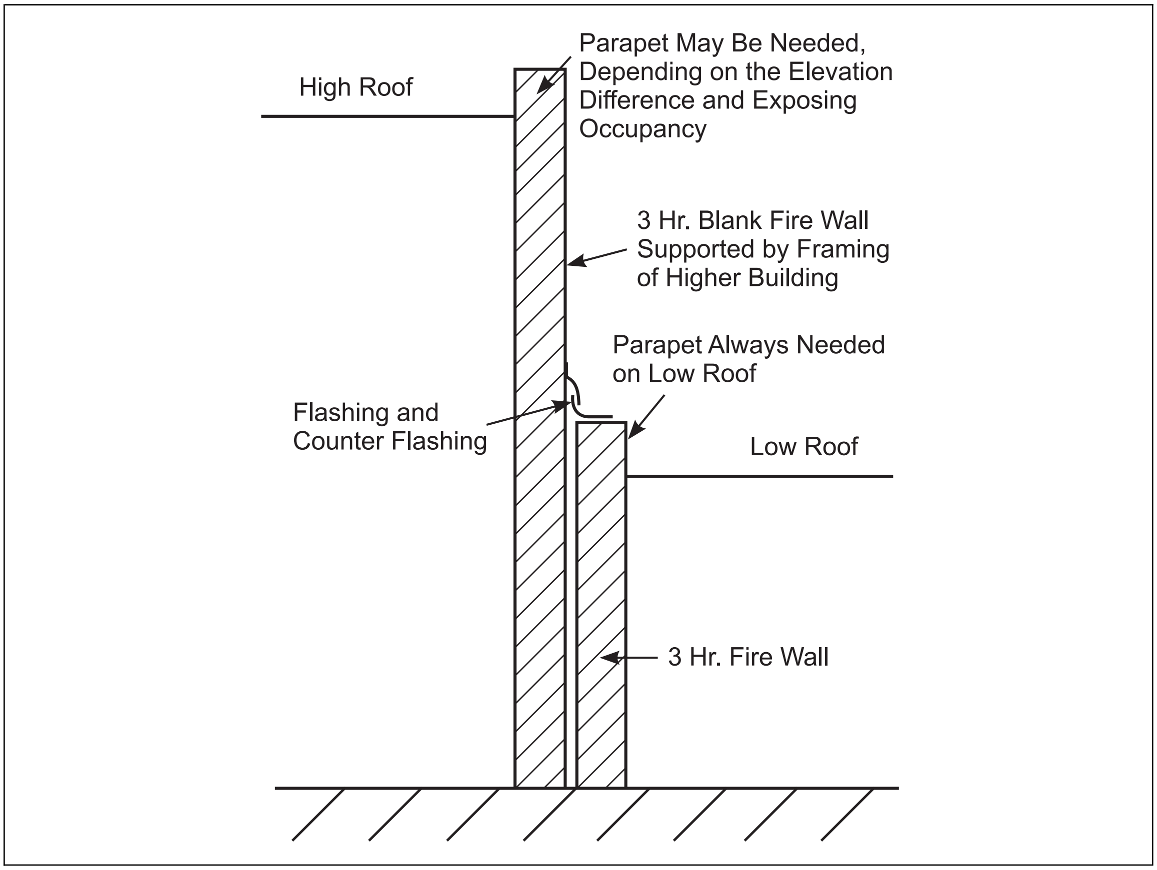


Fig. 13. MFL wall arrangement at elevation difference (double wall)

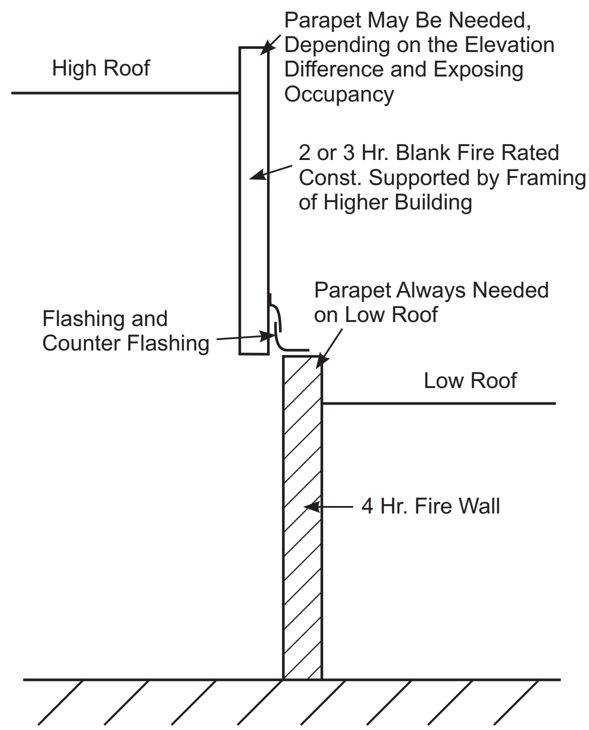


Fig. 14. MFL wall arrangement at elevation difference (cantilever wall)

2.2.4.8 Monitors, penthouses, cooling towers, and other structures, combustible or noncombustible, mounted on roofs can present special problems and require individual attention. Evaluate the space separation requirements for such structures or equipment using the methodology and guidelines in Section 2.3. Locate such structures at least far enough from fire walls, or construct them of sufficiently fire-resistant material, to prevent ignition.

Unusually high roof structures (over 20 ft [6 m] high) may require a greater separation distance. When this is not practical, construct fire partitions on the exposed side of the roof projection.

2.2.4.9 Locate heat and smoke vents, skylights, roof hatches, and roof penetrations for air-handling equipment at least 50 ft (15 m) from the MFL fire walls.

2.2.5 End Walls and Angle Exposure

2.2.5.1 Base the length and arrangement of end walls (exterior walls that are perpendicular to the MFL fire wall on each side) on the height of the building exposing the fire wall and in accordance with Figures 15 and 16 and Table 2. Use blank construction, with a minimum 2-hour fire-rating. Roof scuppers in end walls or angular exposure walls are acceptable provided the criteria in Section 2.2.4.4 is met.

An alternative end-wall arrangement is to extend the fire wall itself beyond the exterior walls of the building a distance equal to 1/2 X. (See Figure 17 and Table 2.) Be aware that this type of wall extension may be difficult and expensive to accomplish, since it must be designed for wind load.

Table 2. Length of End Wall Protection[1]

Height of exposing area, ft (m)	*X, Length of end wall protection, ft (m)*
Up to 40 (12.2)	6 (1.8)
41 to 70 (21.3)	10 (3.1)
71 (21.6) and over	14 (4.3)

[1] Protection must consist of blank, 2-hour fire-rated construction.

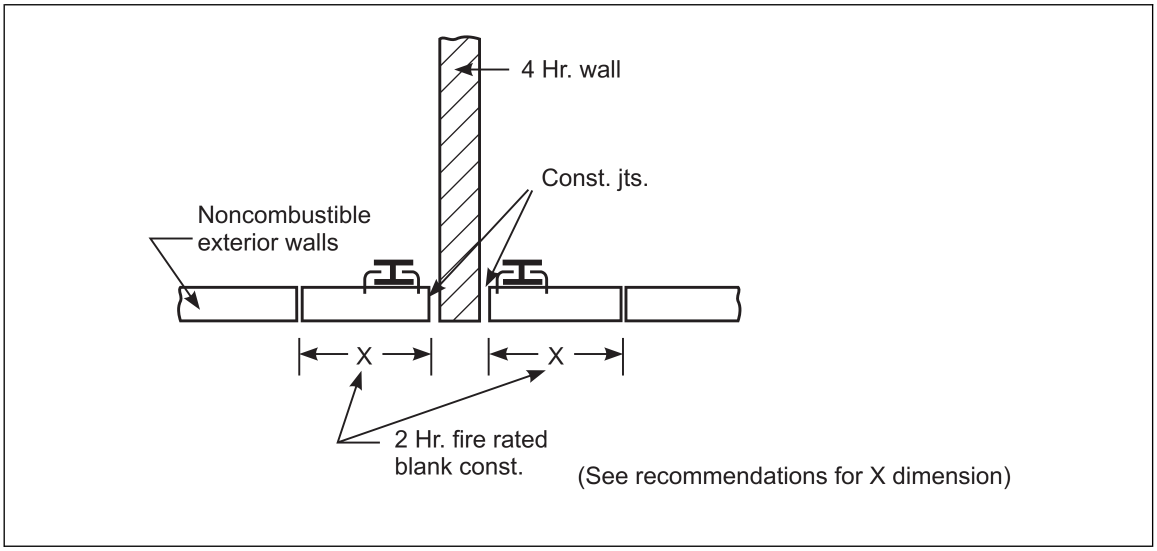


Fig. 15. End wall exposure protection; end walls tied to steel framing

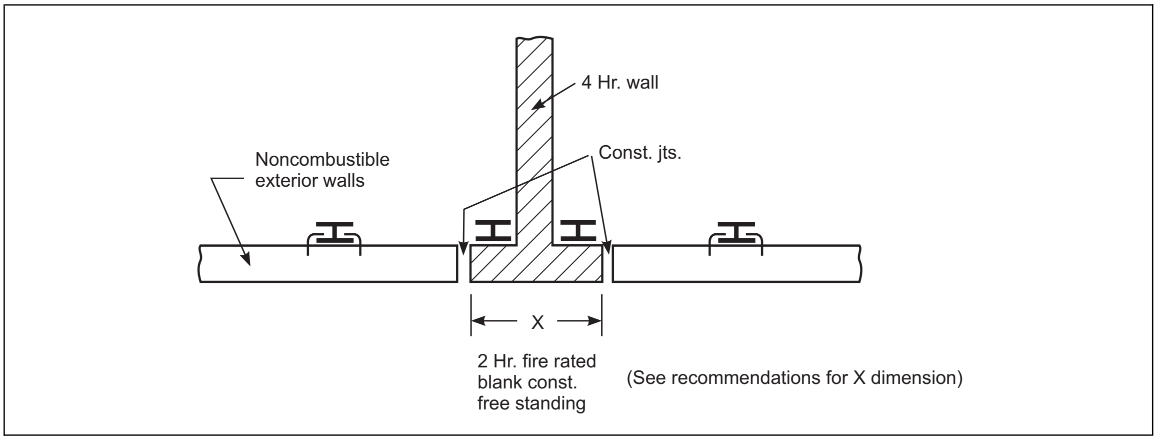


Fig. 16. End wall exposure protection; end walls not tied to steel framing

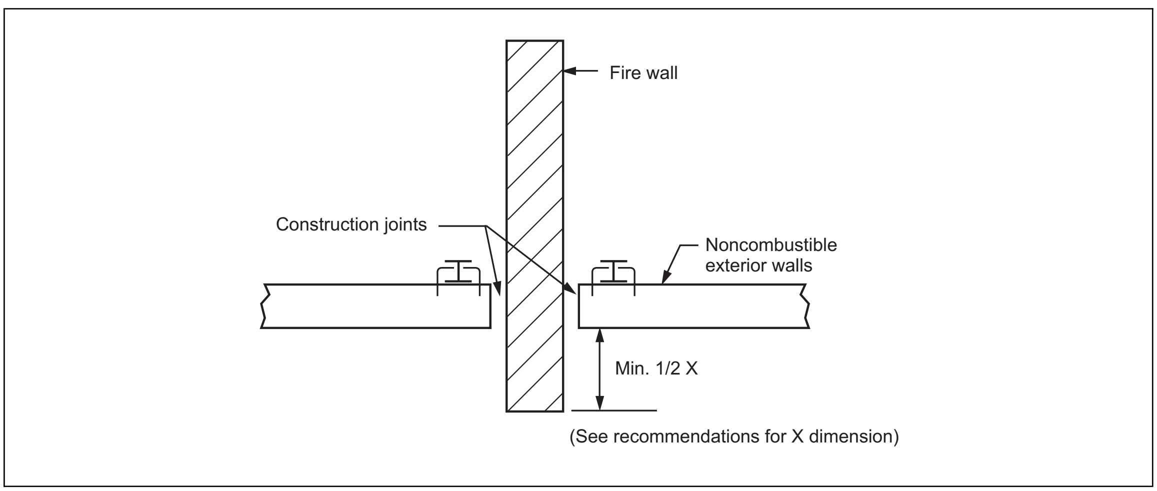


Fig. 17. Alternative end wall protection

2.2.5.2 Protect angle exposure at the end of an MFL fire wall (or section of it) by constructing both exterior walls of blank, 3-hour rated construction (Figure 18). The length of protection (Y) is 20 ft (6 m) if the exposing building has HC1/HC2 occupancy; 30 ft (9 m) if the exposing building has HC3 occupancy, and 35 ft (11 m) if the exposing building has combustible storage. In addition, construction of each wall and eave must be noncombustible up to a point of 60 ft (18 m), 75 ft (23 m), or 100 ft (30 m) away from the junction (of the MFL wall and the exterior walls) for HC1/HC2, HC3, or combustible storage exposures, respectively. Use wired glass, glass block, or special windows that have passed a ¾-hour fire test for windows beyond the 3-hour rated portion.

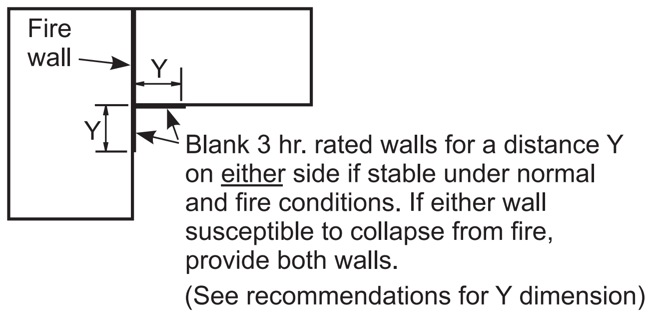


Fig. 18. Angular wall exposure protection

2.2.5.3 Provide a minimum 12 in. (300 mm) parapet atop end walls and angular exposure walls. Ensure the parapet is at least as tall as the gravel stop.

2.2.5.4 For at least 20 ft (6 m) on each side of the end walls, ensure there are:

- no unprotected openings (truck docks, windows, personnel doors, ventilation openings, etc.).
- no combustible equipment.
- no combustible yard storage.

Determine the MFL space separation from the exterior walls based on the exposed construction beyond the end walls, and severity of the exposure (e.g., yard storage or trailers) using Section 2.3 for MFL space separation.

Provide barriers when necessary to prevent temporary vehicle parking, combustible equipment, or yard storage being placed within 20 ft (6 m) of the end walls.

2.2.5.5 Locate railroad sidings at the end of the building that is parallel to the MFL fire wall. Alternatively, if the railroad siding runs perpendicular to the MFL fire wall on the outside of the building, do not use combustible construction or exterior wall openings for at least 50 ft (15 m) on each side of the MFL wall.

2.2.5.6 Protect roof elevation differences perpendicular to fire walls as angle exposure (see Figure 19 and Section 2.2.5.2).

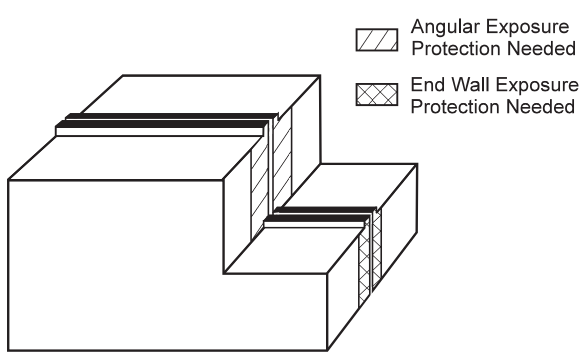


Fig. 19. Exterior wall protection

2.2.5.7 Locate fire-resistive end/angular exposure wall protection on the exterior surface. Do not place siding materials that are combustible or of limited combustibility over them.

2.2.6 MFL Wall Penetrations

2.2.6.1 Do not penetrate MFL fire walls.

2.2.6.2 Minimize the number of unavoidable penetrations and arrange them as recommended below.

A. Position all penetrations (regardless of size) to pass through the wall as close as practical to, but no more than 3 ft (1.0 m) above, the finished ground floor level.

B. For steel pipes, provide a center-to-center spacing of at least three times the largest pipe diameter.

Exception: The structural aspects of this recommendation do not apply to panel walls in reinforced concrete buildings, provided the frames on both sides of the wall are reinforced concrete. However, FM Approved firestop systems still need to be used to seal around penetrations.

C. Provide 4-hour-rated firestop assemblies for all cables with combustible insulation.

2.2.6.3 Firestop all penetrations and joints with an FM Approved firestop system installed by an FM Approved firestop contractor.

2.2.6.4 Feed automatic sprinkler systems on either side of an MFL fire wall independently (Figure 20).

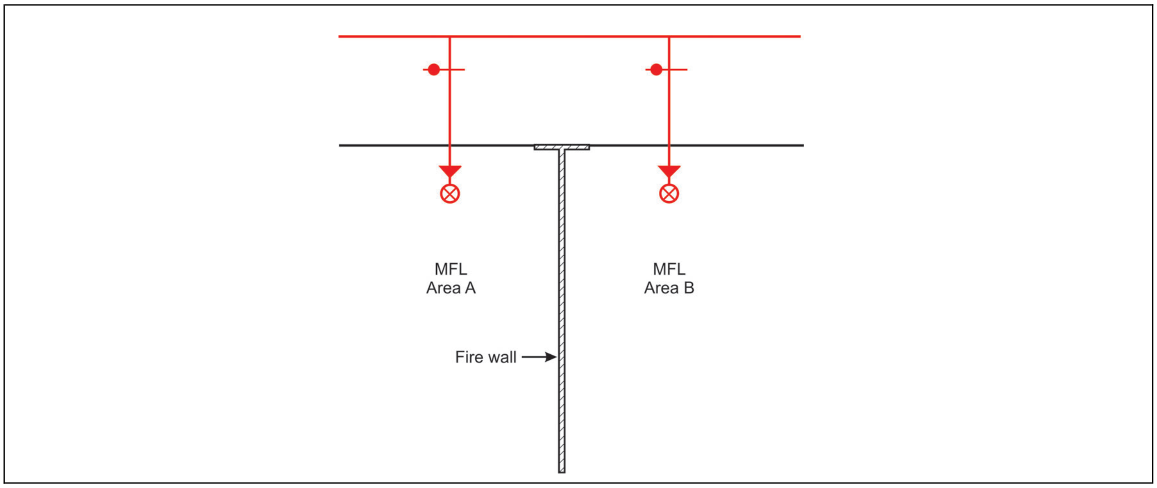


Fig. 20. Independent feeds for automatic sprinkler systems on each side of an MFL fire wall

2.2.6.5 Arrange heating, ventilating, and air conditioning ducts penetrating MFL fire walls with a slip joint (see Figure 21) located on each side of the wall as near to the face of the wall as practical. Provide 3-hour rated fire doors or dampers in the section of duct that penetrates the wall and securely fasten it to the wall at the opening. Provide two dampers for a double wall (one damper in each wall) with a slip joint between the walls. Install access panels nearby. For more information, see Sections 2.5.10 and 3.4.5.

Building code requirements may not allow the use of dampers in ducts conveying hazardous materials or used for smoke removal. In such cases, reroute the duct to avoid penetration of the fire wall.

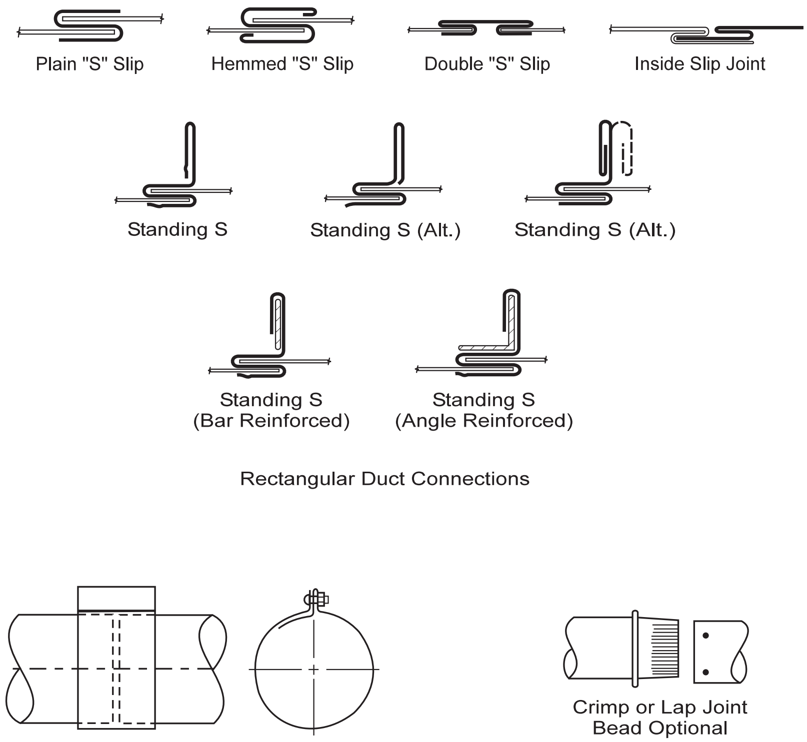


Fig. 21. Breakaway connections; slip joints (courtesy of the Sheet Metal and Air Conditioning Contractor's National Association, Inc. [SMACNA].)

2.2.6.6 Do not laterally brace or support piping, conduit, cables, ducts, or connected electrical control panels on MFL walls. When any of these services must penetrate the wall, ensure the service is attached to and supported from the building columns and not the MFL wall.

Exception: This does not apply to double MFL fire walls or MFL panel walls in reinforced concrete buildings.

2.2.6.7 Do not penetrate an MFL wall with piping that conveys combustible gas or ignitable liquid. Provide separate supplies to each side of the wall.

2.2.6.8 Allow only noncombustible pipe to pass through any MFL fire wall.

2.2.6.9 Allow only noncombustible conduit or ducts to pass through any MFL fire wall

2.2.7 Cantilever Walls

Cantilever walls are entirely self-supporting without any connections to adjacent framing.

2.2.7.1 Design cantilever walls for the lateral loads specified in Section 2.2.2.7 to ensure stability under MFL fire conditions (see Figures 22 and 23). Ensure there are no connections between the wall and the building frame on either side.

2.2.7.2 Design the flashing on each side of a cantilever wall to release easily from the wall in order to prevent a potential damaging load on the wall (see Figure 24).

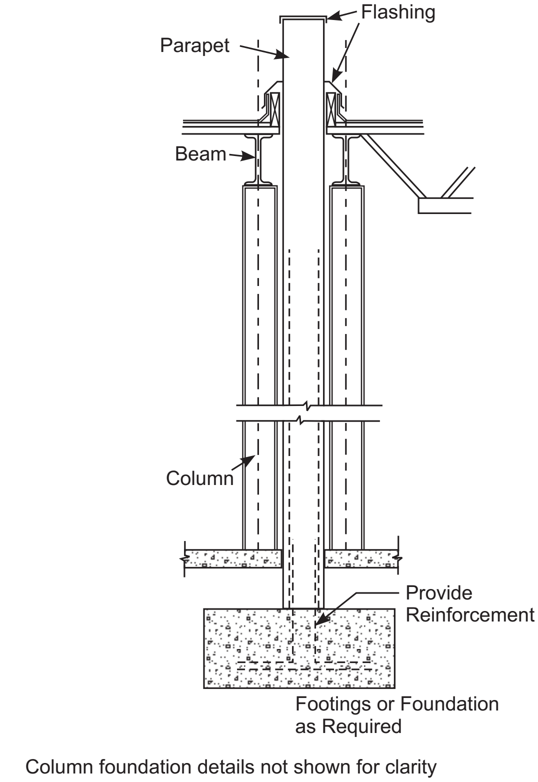


Fig. 22. Cantilever wall: typical at expansion joints or at joints between buildings

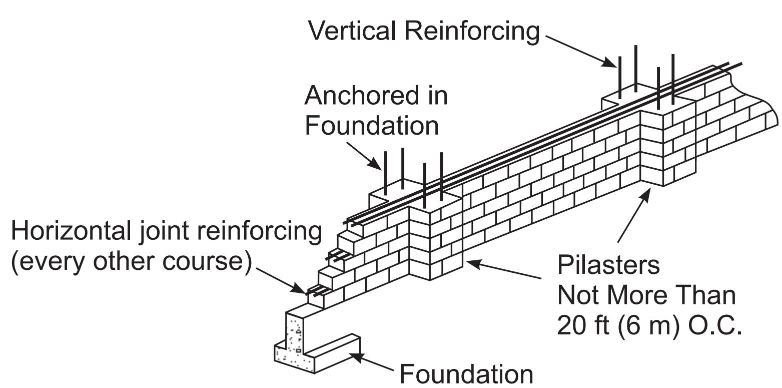


Fig. 23. Cantilever wall: reinforced masonry

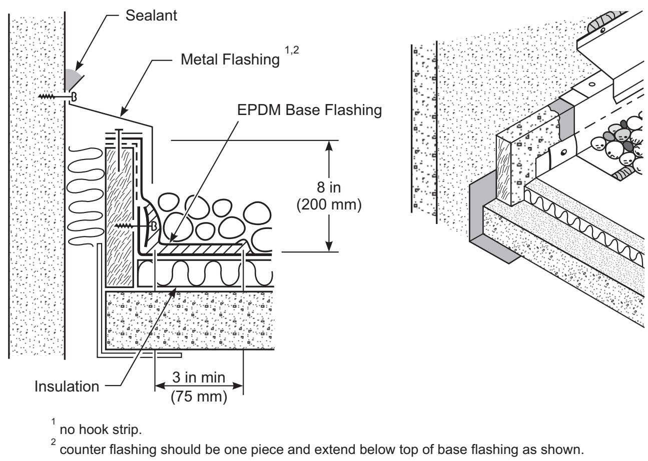


Fig. 24. Cantilever wall: flashing detail

2.2.7.3 Anchor cantilever walls to their foundations to properly resist overturning moments and base shears. Permanent soil overburden and concrete floor slab may be used to resist overturning moment when needed.

2.2.7.4 If tilt-up or precast concrete construction is used in a cantilever wall design, pay particular attention to the connections to the foundation, structural slabs, or pilasters. If connections are added external to the wall panels to allow the wall to adequately resist the overturning moment, fireproof these connections with a durable material to obtain the same fire resistance rating as the wall.

2.2.7.5 Cantilever fire walls used as temporary exterior walls (until future construction occurs) will be subjected directly to wind loads, and therefore must be properly designed and temporarily connected to the building frame until the additional building is constructed. Ensure all connections to the wall are completely removed or cut when the new construction has been completed.

An alternative to temporarily affixing the wall to the building frame is to design the wall as a cantilever wall to adequately resist the full lateral loads; note that foundations would also need to be designed to support the forces on a cantilever wall. This method could be costly due to the larger design loads on both the wall and the foundation.

2.2.7.6 Do not use cantilever walls in active seismic areas (FM 50-year through 500-year earthquake zones as defined in Data sheet 1-2, *Earthquakes*). If they must be used, specifically design them to resist anticipated seismic conditions (see Appendix C).

2.2.8 Tied Walls

Tied walls are laterally supported by the steel building frames on each side, which are tied together through the wall. The frames must be of sufficient strength so the force of collapsing steel on the fire-exposed side is resisted by the steel framing on the cold side.

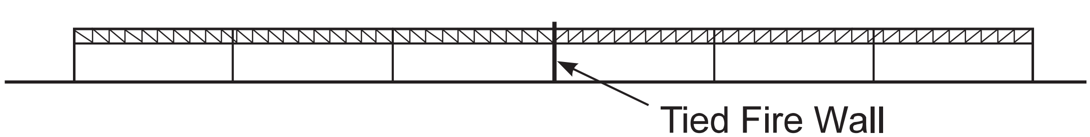


Fig. 25. Tied wall: At the center of a continuous steel frame. The horizontal force from collapsing steel on the fire side must be resisted by the lateral strength of steel on the other side.

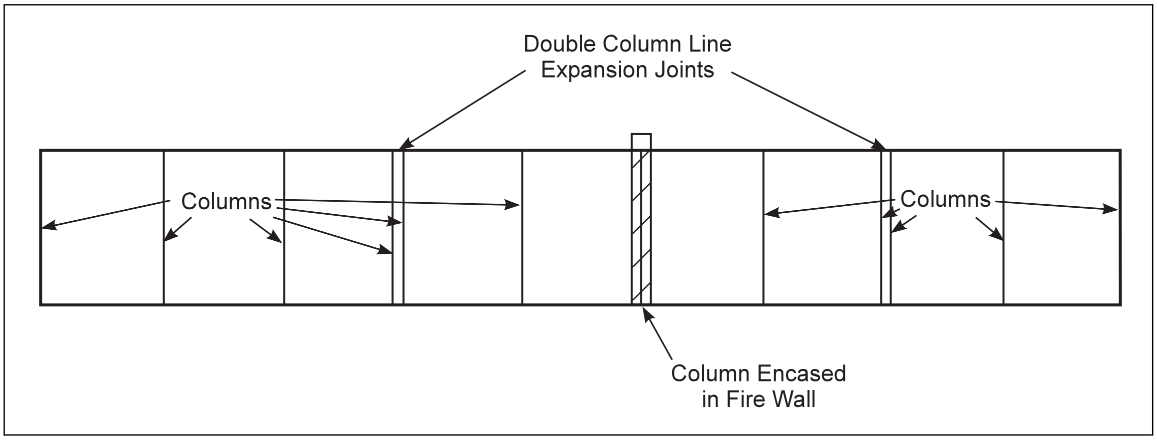


Fig. 26. Tied wall: Steel framing is not continuous throughout the building

2.2.8.1 Design tied walls for the lateral loads specified in Section 2.2.2.7 to ensure stability under MFL fire conditions.

2.2.8.2 A tied wall (see Figures 27, 28, and 29) must follow a single or double column line to take advantage of the vertical strength of the column and to minimize lateral and torsional forces on the wall.

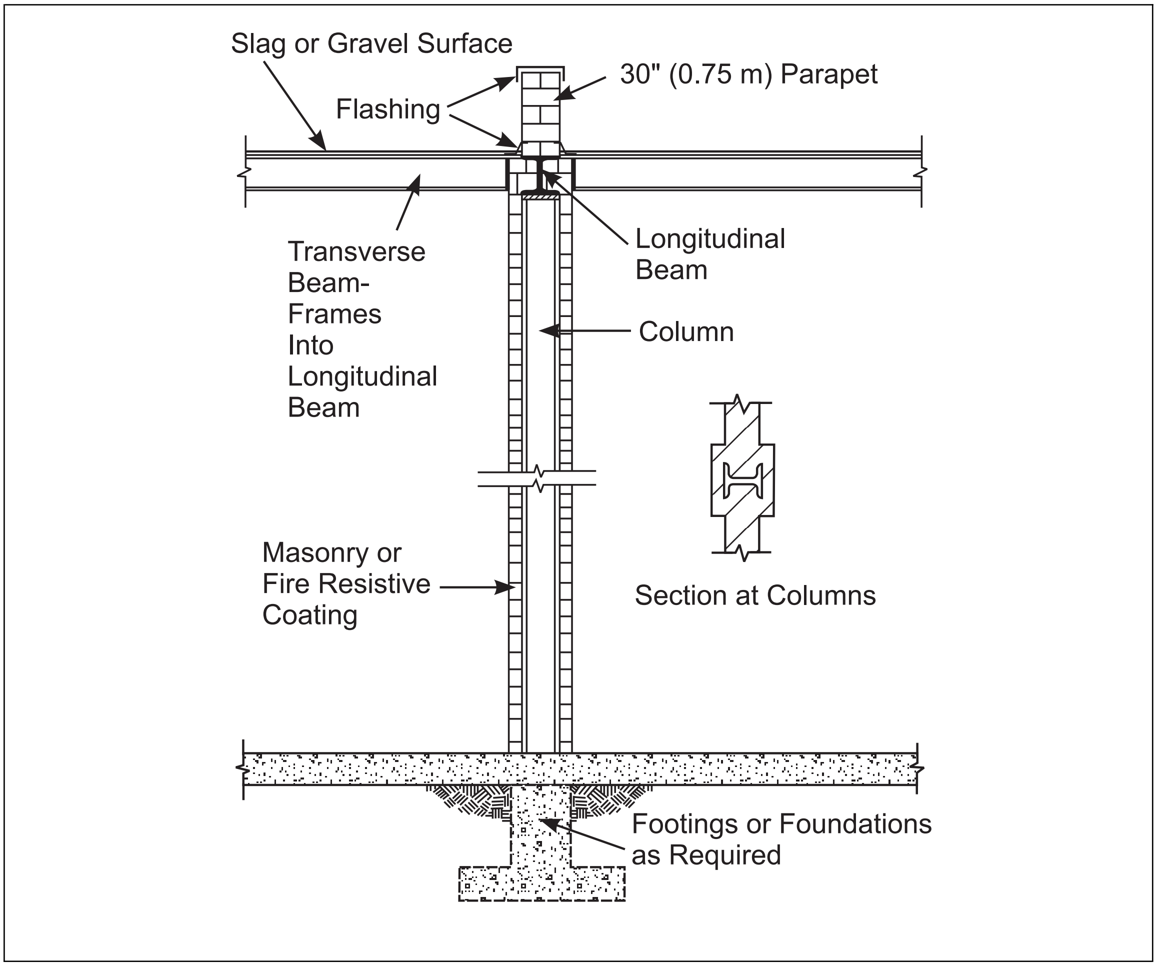


Fig. 27. Tied wall: Typical at single column line with continuous primary steel perpendicular to fire wall

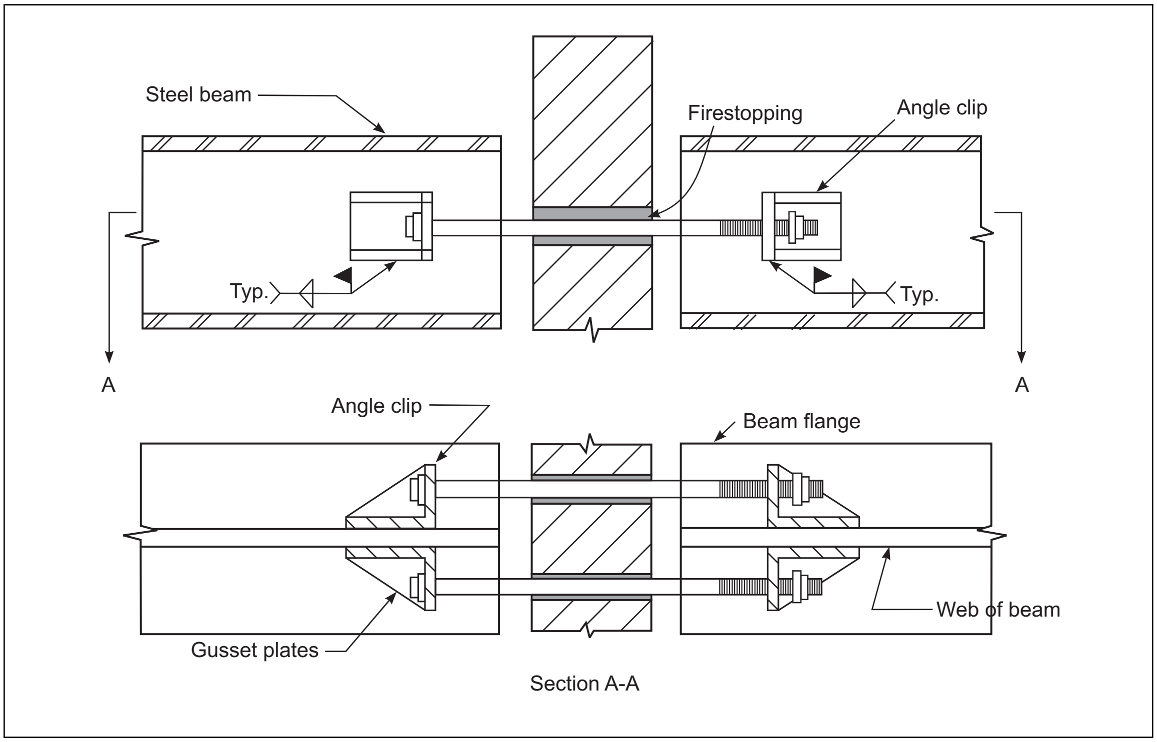


Fig. 28. Tied wall: Conventional through-wall tie, shown with primary steel perpendicular to wall. Note: Columns are needed, but not illustrated here.

2.2.8.3 Fireproof the steel columns and roof framing in the plane of the wall to have fire resistance equal to the wall. For situations in which the wall is constructed between columns on a double-column line, the columns and beams or trusses parallel to the wall immediately on each side must have fire resistance equal to the wall to prevent the steel from buckling and fracturing the wall. Use concrete, masonry, or durable fire-resistant coatings to provide fire resistance for the steel.

2.2.8.4 Ensure the building framing on each side of a tied MFL fire wall is at the same elevation and in line horizontally.

2.2.8.5 Locate a tied fire wall near the center of the building frame (see Figures 25 and 26) so the building frame on each side of the fire wall will provide roughly the same lateral resistance. Consider breaks in continuity of the building frame (e.g., double-column expansion joints) when locating a tied fire wall.

2.2.8.6 The lateral resistance of the frames on either side of the wall must be sufficient to resist the horizontal component of the force resulting from the collapsing frame on the opposite side. This is critical if the building frames on both sides of the wall are not of equivalent strength (see Figure 30). Consider a collapse of the frame and the horizontal force on each side since the fire may occur on either side. The horizontal force may be computed by using the following catenary cable formula:

$H = WL^2/8S$

Where:

H = Horizontal force, lb (kg).

W = Tributary dead load of the roof per unit length of truss or beam, lb/ft (N/m).*

L = Truss or beam span, ft (m).

S = Sag, ft (m) that may be assumed as:

0.09L for solid-web steel beams
0.07L for open-web steel trusses
0.06L for open-web wood trusses

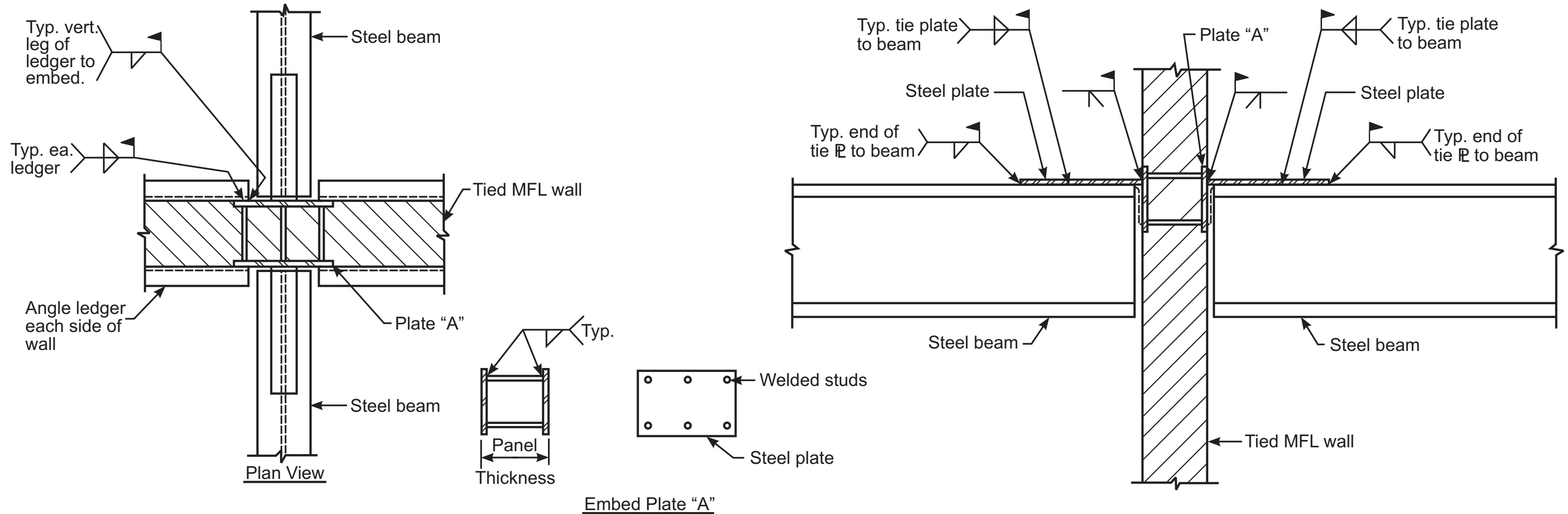


Fig. 29. Tied wall: Tilt-up wall, diaphragm roof with embed plate through-wall tie, shown with primary steel perpendicular to wall. Note: Columns are not shown.

*Note: Under certain conditions, W must also include environmental loads. Include the weight of rainwater when roofs are capable of ponding water. In locations where snow could accumulate on the roof for a significant period of time during the year (locations with 20 psf [0.96 kN/m^2] or greater ground snow load as determined using Data Sheet 1-54, *Roof Loads for New Construction*), add 25% of that ground snow load to the dead load to determine W. If both of the above conditions exist, use the higher figure.

Assume the horizontal force, H, is applied at two adjacent column lines simultaneously. Use a worst-case scenario in deciding where to apply these design forces.

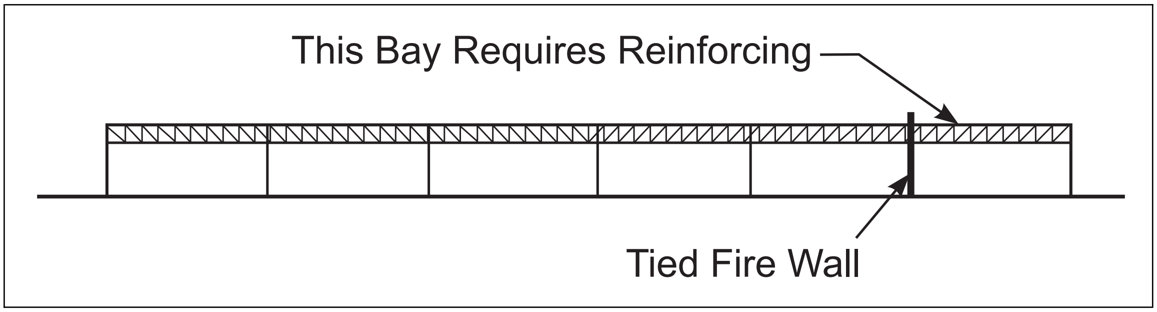


Fig. 30. Tied wall: Off center of continuous steel framing

2.2.8.7 At roof level, the expected horizontal force must be transmitted through the wall with continuous framing (for single-column line tied walls) or through-wall ties (for double-column line tied walls). Note: Do not use masonry anchors from the wall to the respective framework on each side as they will not provide adequate reliability.

2.2.8.8 For walls constructed between columns on a double-column line, design the strength of ties based on the horizontal force, H, calculated using the formula in section 2.2.8.6. For design purposes, use an allowable tensile stress of **not more than 0.3F_y** and an allowable shear stress of 0.2F_y for steel tie rods and connection assemblies.

2.2.8.8.1 Use equal pairs of tie rods per column to reduce torsion (see Figure 28) when primary roof framing is perpendicular to the wall. The ties must connect the roof framing members on each side of the wall over the columns. When the primary roof framing is parallel to the wall it may be necessary to install ties at a more frequent interval than every column line (see Figure 31); in this case, the tie rods and wall penetrations must be designed and detailed to ensure vertical deflections of the roof framing due to gravity loads will not transfer load to the tie rods or fire wall. Nuts for through-wall ties must be backed off slightly (up to ¾ in. [19 mm] for walls up to 40 ft [12 m] high and an additional ¼ in. [6 mm] for every additional 10 ft [3.0 m] of wall height) to allow for normal building movement.

2.2.8.8.2 Where tie rod penetrations will be core-drilled, locate the penetrations such that vertical and horizontal reinforcing is avoided. Where tie rod openings are to be blocked out, ensure the horizontal and vertical wall reinforcing runs continuously through the openings. In all cases, properly pack the fire wall penetrations with a flexible fire-proofing material, such as mineral wool, to ensure the fire resistance of the wall is not compromised. Install an integral steel cover plate or escutcheon plate at all penetrations to hold the fire-proofing material in place.

2.2.8.8.3 While through-wall connections are needed to make framework continuous across the wall, it is also essential to provide flexible concrete or masonry anchors (see Figure 33) at approximately 2 to 4 ft (0.6 to 1.2 m) on center to brace the wall laterally. Allow enough slip in the anchors to compensate for the slip (as noted above) in the through-wall ties; this is to prevent the collapsing frame from pulling on the wall before the frame on the non-fire side provides the needed resistance. The maximum space is 3/4 in. (19 mm) for walls up to 40 ft (12.2 m) high and an additional 1/4 in. (6 mm) for every additional 10 ft (3.0 m) of wall height.

2.2.8.9 In the case of single-column-line tied MFL walls (see Figure 27), the framing on the unexposed side of the wall will resist steel expansion on the fire side. However, the connection of the wall to the columns must allow some flexibility, as the building frame on the unexposed side will deflect laterally due to the pull from the sagging steel on the fire side. Use flexible masonry anchors (see Figure 33) or concrete blocks that loosely key into the reentrant space of the column to provide the needed flexibility. If sprayed-on fireproofing is used, spray the entire column before constructing the wall.

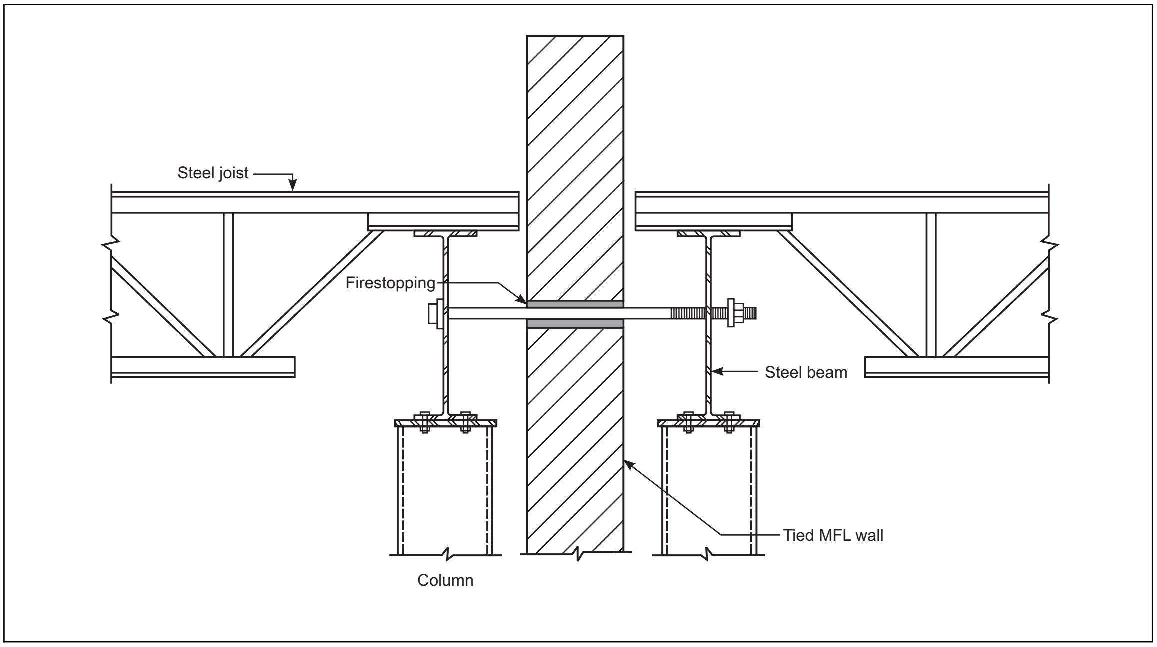


Fig. 31. Tied wall: Conventional through-wall tie, shown with primary steel parallel to fire wall

2.2.9 One-Way Walls

One-way walls are laterally supported by framing members on one side only. There should be no rigid connections or attachments to the opposing side of the wall.

2.2.9.1 Design one-way walls for the lateral loads specified in Section 2.2.2.7 to ensure stability under MFL fire conditions.

2.2.9.2 Connect one-way walls only to the frame of the area to be protected.

2.2.10 Double Walls

Double fire walls consist of a set of two one-way walls, with no connections between the walls.

2.2.10.1 Design double MFL walls for the lateral loads specified in Section 2.2.2.7 to ensure stability under MFL fire conditions.

2.2.10.2 Connect each wall only to its respective building frame (see Figures 34 and 35).

2.2.10.3 Ensure each of the two wall elements has a 3-hour (F180, EI180) fire resistance rating.

2.2.10.4 If masonry walls are not sufficiently separated to prevent bonding, install a layer of building paper or other suitable bond breaker between the walls.

2.2.10.5 Anchor each wall to its respective steel framework at roof level and at columns if necessary.

2.2.10.6 Allow no connections between the two walls other than easily separated roof flashing. Pay particular attention to details at openings in the walls and at the roof flashing between the walls (see Figure 36).

2.2.11 Panel Walls In Reinforced Concrete Buildings

Panel walls in reinforced concrete buildings are tied to the concrete columns and/or floor and roof framing.

2.2.11.1 Design panel walls for the lateral loads specified in Section 2.2.2.7 to ensure stability under MFL fire conditions.

2.2.11.2 Provide a minimum 4-hour (F240, EI240) fire resistant rating for both the wall panels and the reinforced concrete frame.

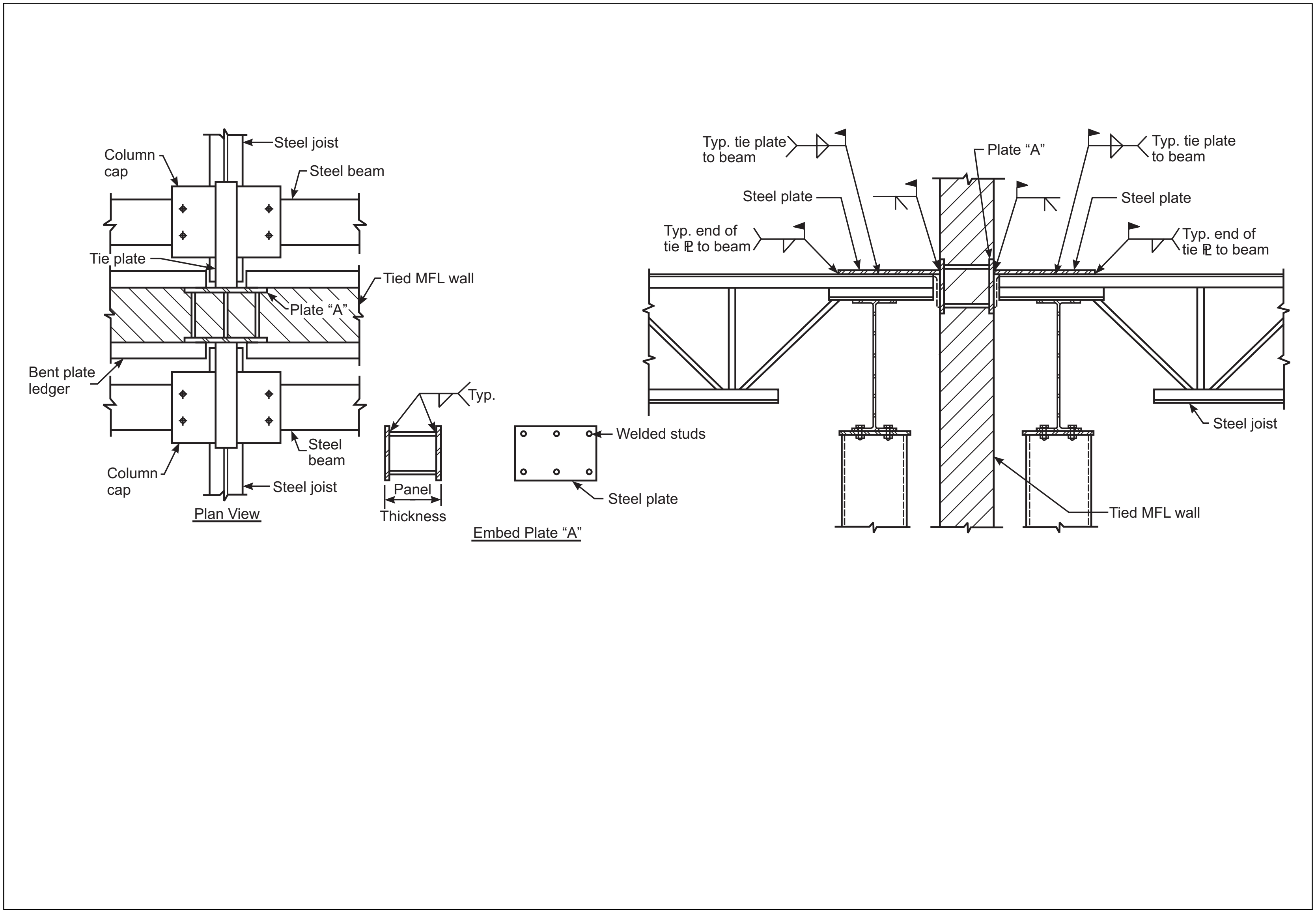


Fig. 32. Tied wall: Tilt-up wall, diaphragm roof with embed plate through-wall tie, shown with primary steel parallel to fire wall

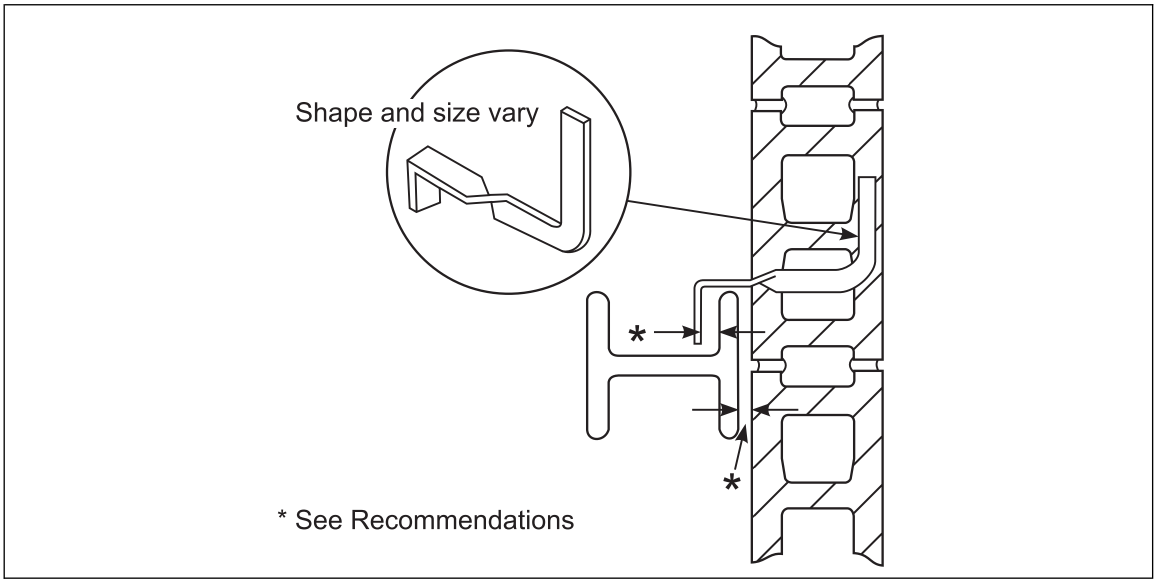


Fig. 33. Tied wall: Flexible masonry anchors (courtesy of the National Concrete Masonry Association)

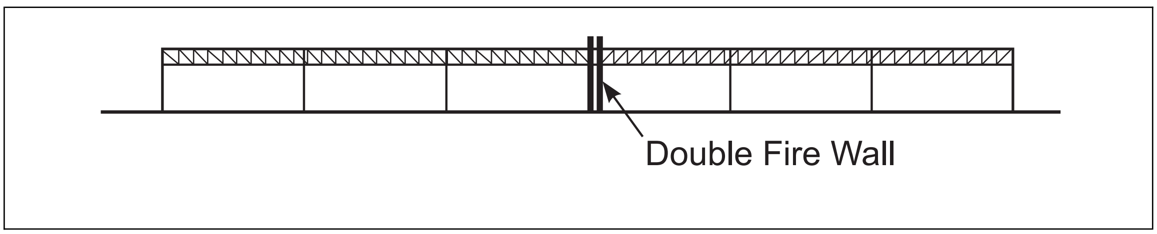


Fig. 34. Double wall

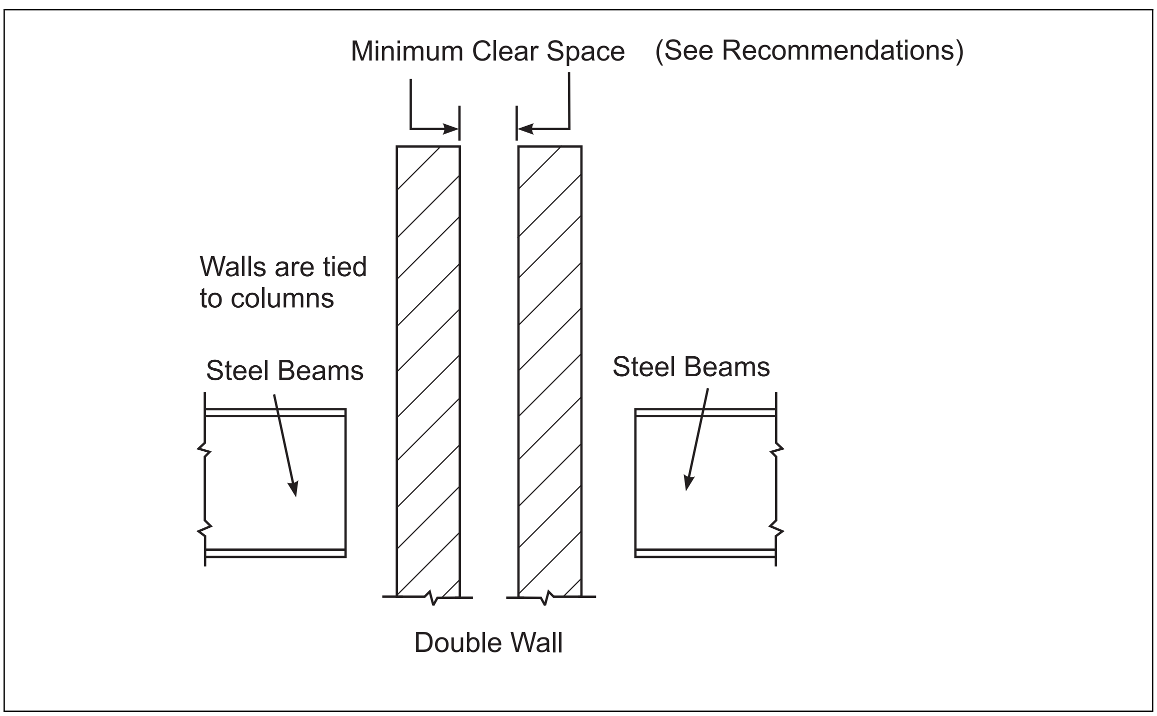


Fig. 35. Double wall: typical, used at expansion joints or joints between buildings

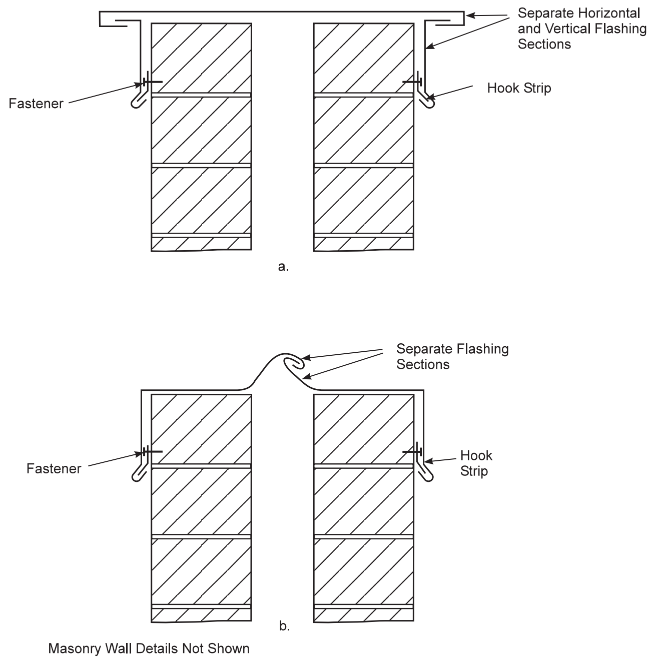


Fig. 36. Double wall: Examples of roof flashing details

2.2.11.3 If the panel wall is tied to a 4-hour fire-rated reinforced concrete building (including floor and roof decks and all structural framing) on one side, but the building on the other side is of different construction (such as steel), do the following:

A. Make structural connections of the panel wall only to the adequately fire-rated building frame. Do not make connections to the building frame on the opposite side if it could collapse in an uncontrolled fire.

B. Follow the recommendations in Section 2.2.5.

C. Follow all recommendations in Section 2.2.6; however, note the exceptions for panel walls in Sections 2.2.6.2 and 2.2.6.5.

2.2.11.4 If tilt-up or precast concrete construction is used, pay particular attention to the connections at foundations, structural slabs and decks, and pilasters. Fireproof all connections as necessary to obtain the same fire resistance as the rating of the wall.

2.3 MFL Space Separation

The MFL space separation is the clear distance needed to prevent a fire from propagating across an open space from one building to another (or to/from combustible yard storage). The analysis must include the fire severity, the susceptibility of the exposed construction, heat transfer via convection and radiation, the effect of wind and the potential for burning brands.

2.3.1 Methodology and Base Separation Distances

2.3.1.1 The minimum space separation distance (S_M, min) is:

A. 10 ft (3.0 m) for any situation except for exposed walls with a fire-rating ≥3-hours (F180, EI180) (see Table 3).

B. 125 ft (38 m) from any occupancy presenting an explosion hazard, BLEVE, PV rupture or run-away reaction.

2.3.1.2 Calculate the MFL space separation distance (S_M) as follows:

$S_M = S_B \times U \times M$

Where:

S_M = MFL separation distance.
S_B = Base separation distance from Table 3 or Figures 37-39.
U = Unprotected opening adjustment factor (see 2.3.3.1 and 2.3.3.2).
M = Exposure angle adjustment factor (see 2.3.6).

2.3.1.3 The information needed to use Figures 37 through 39 is the exposed wall category (see Section 2.3.2), classification of exposing wall construction (see Section 2.3.3), exposing fire hazard category (see Section 2.3.4, and exposing wall length (see Section 2.3.5).

Table 3. Base Separation Distance for Fire-Rated Exposed Walls

Fire Rating (hours)	*Exposing Occupancy Fire Hazard*				
	HC-1 HC-2 HC-3	Storage Occupancy			Ignitable Liquids
		<30 ft (<9 m)	30-45 ft (9-14 m)	≥45 ft (≥14 m)	
<1	Categorize the exposed wall as either combustible or noncombustible				
1	15 ft (4.5 m)	40 ft (12 m)	50 ft (15 m)	60 ft (18 m)	40 ft (12 m)
2	10 ft (3 m)	30 ft (9 m)	40 ft (12 m)	50 ft (15 m)	25 ft (8 m)
3	5 ft (1.5 m)				
≥4	None[1]				

[1]Only structural separation and minimum clearance for thermal expansion (see Table 1) are required.

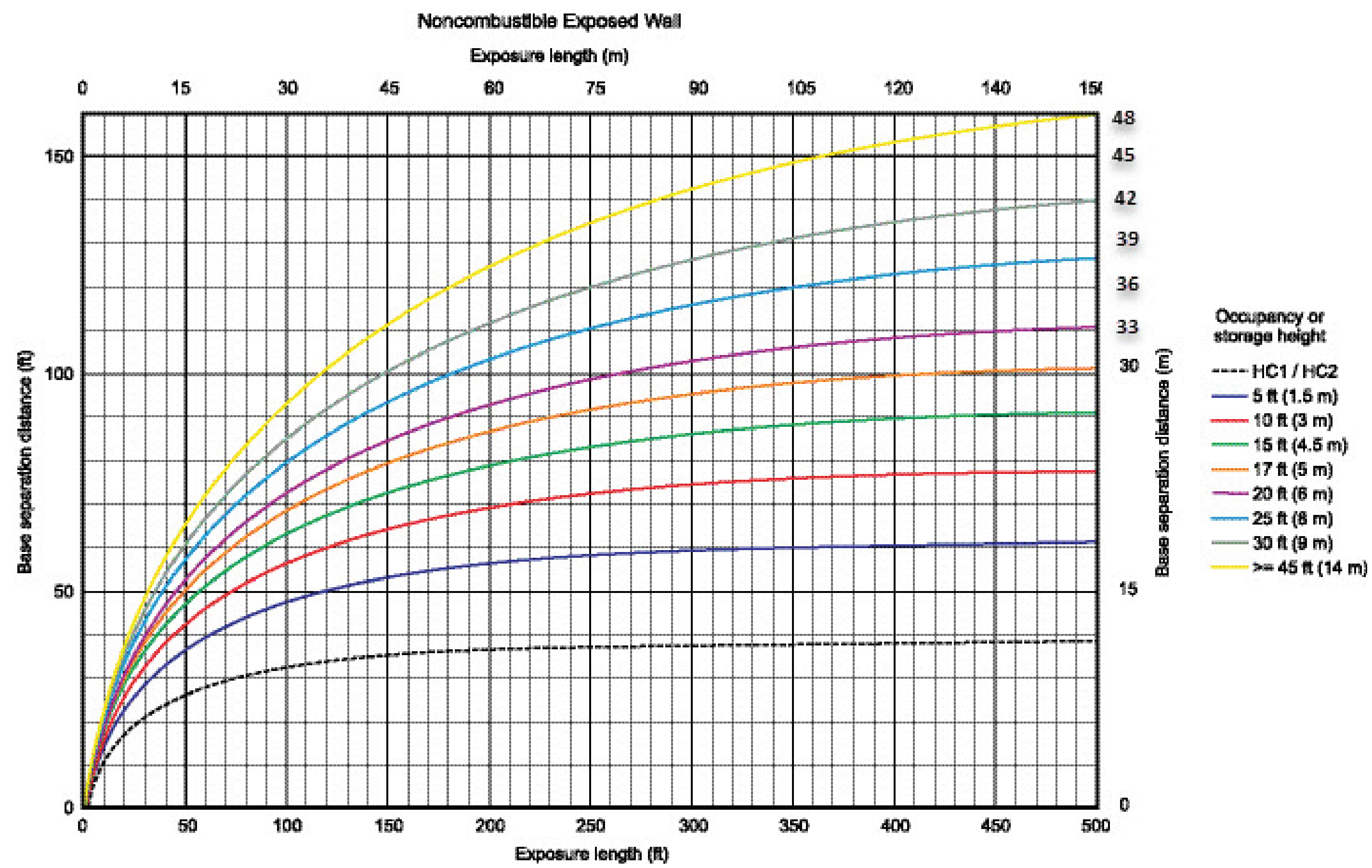


Fig. 37. Base separation distance for exposed noncombustible walls

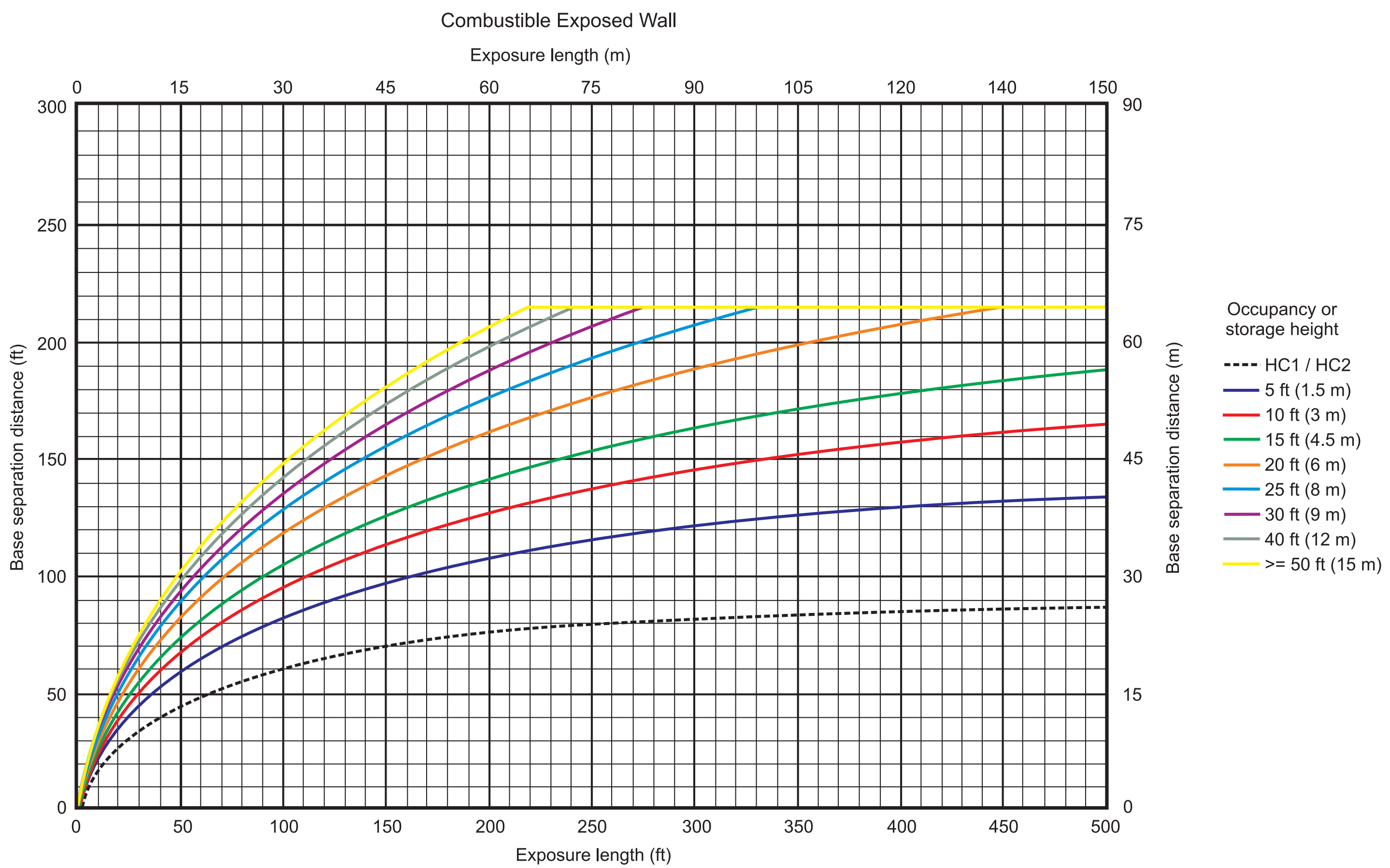


Fig. 38. Base separation distance for exposed combustible walls

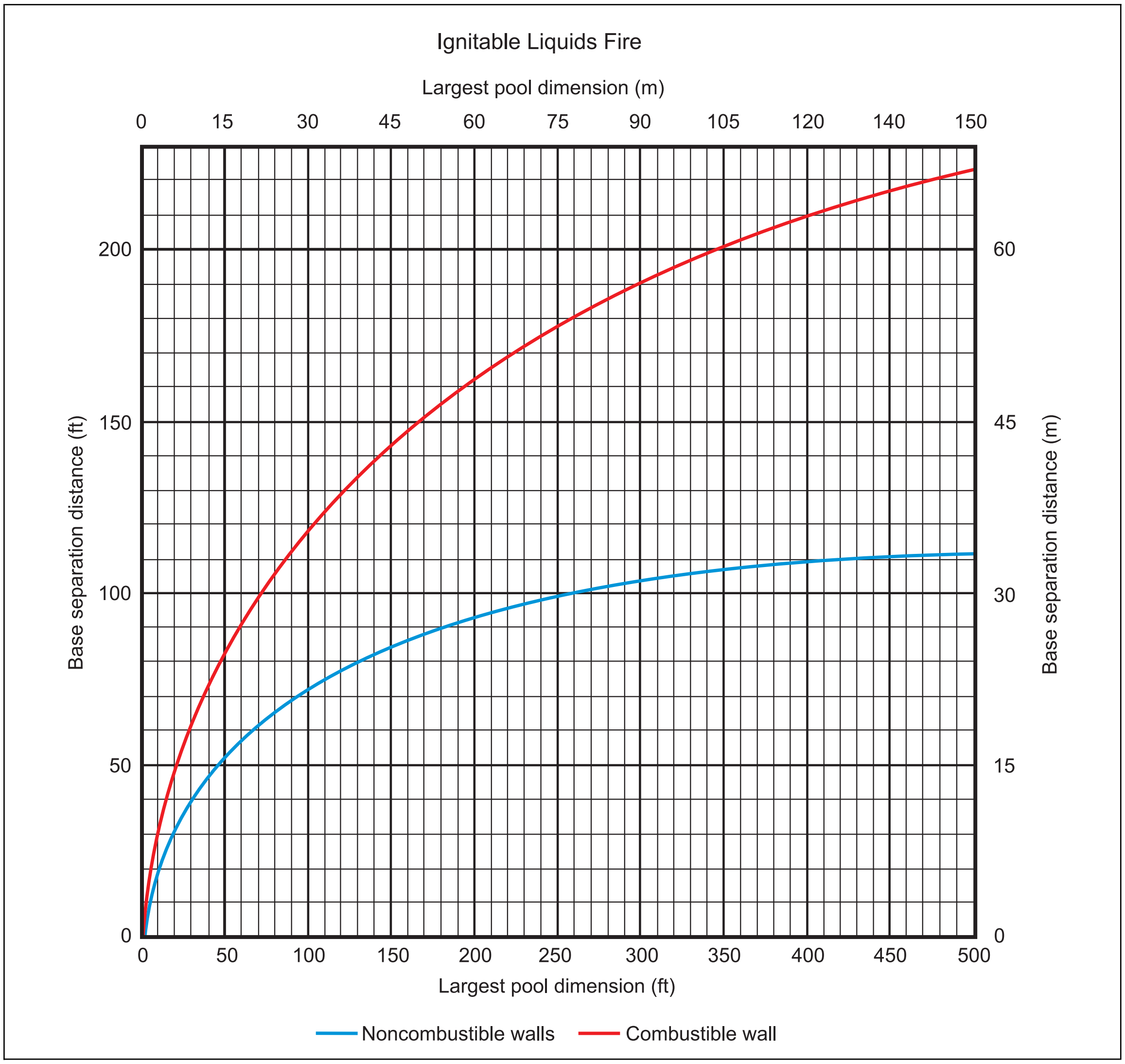


Fig. 39. Base separation distance for ignitable liquids

2.3.2 Exposed Wall Category

2.3.2.1 Classify fire-resistance-rated walls as either 1, 2, 3, ≥4 hours (60, 120, 180, ≥240 minutes). Classify walls with a rating less than 1 hour (60 minutes) as noncombustible.

2.3.2.2 Classify non-fire-resistance-rated walls as either combustible or noncombustible. (See Appendix A for definitions of combustible and noncombustible.)

2.3.2.3 Classify exterior insulation and finish systems (EIFS) as follows:

A. EIFS with noncombustible or Class 1 insulation over gypsum board sheathing should be treated as noncombustible exposed wall construction.

B. Any other EIFS should be treated as combustible exposed wall construction.

C. For EIFS with noncombustible insulation (glass fiber, mineral wool, perlite, etc.), the EIFS is considered equivalent to a noncombustible wall: Classify the wall as noncombustible.

2.3.2.4 Windows

A. Classify the wall as combustible if windows (of any material) are operable.

B. Classify the wall as noncombustible, if windows have noncombustible window frames and glazing that is one of the following:

- tempered glass
- laminated glass
- double-paned annealed glass
- heat-strengthened glass
- min. ¼ inch (6 mm) wired glass
- glass block
- listed fire-rated glass

C. Classify the wall as 1-hour fire rated, if one of the following conditions is met:

1. Windows and frames are part of a listed window assembly of equivalent fire rating.

2. Windows and frames are protected with minimum ¾-hour fire-rated automatic closing shutters.

3. Window frames are noncombustible and glazing is of 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 combustible material away from the inside of the exposed windows a distance at least equal to the largest dimension of the window.

D. Classify the wall as more than 1-hour fire rated, if one of the following conditions is met:

1. Windows and frames are part of a listed window assembly of the needed fire rating for the wall.

2. Windows and frames are removed and replaced with a wall assembly of the needed fire rating for the wall.

3. Windows and frames are protected with fire-rated automatic closing shutters with needed fire rating for the wall.

2.3.3 Classification of Exposing Wall Construction

Exposing walls are classified as either stable fire-resistive walls (SFR) or non-stable fire-resistive walls (Non-SFR).

2.3.3.1 SFR Exposing Walls

2.3.3.1.1 If the wall and structural frame of the exposing building is fire resistive (i.e., the wall is expected to remain in place throughout the duration of the MFL fire), the base space separation can be reduced (see Section 2.3.3.1.2).

2.3.3.1.2 Credit can be given to those portions of exposing SFR walls that will remain in place for the duration of the fire and block the radiant heat from reaching the target. 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 SFR wall.

A. Determine the total amount of unprotected openings in the SFR exposing wall as a percentage of the total 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.

B. For exposing walls categorized as SFR, use the unprotected opening adjustment factor (U) from Figure 40 corresponding with the number of stories and percentage of unprotected openings in the exposing wall.

C. For exposing walls categorized as SFR and the roof as SFR, then the only radiation will be from the unprotected openings. Do not use Figure 40; U will equal the actual percentage of the wall area that is unprotected openings.

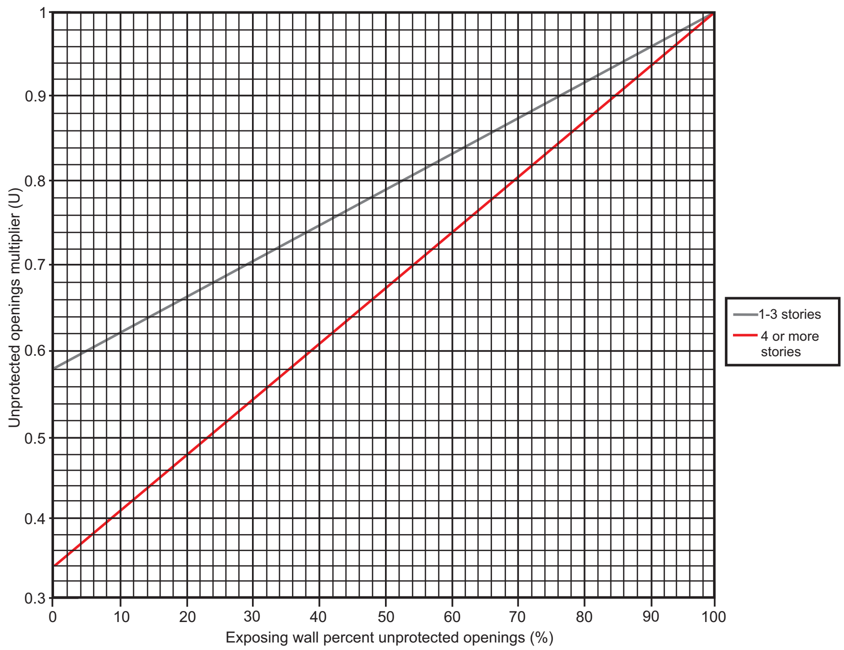


Fig. 40. Exposing wall adjustment factor for unprotected openings in an SFR wall

2.3.3.2 Non-SFR Exposing Walls

Walls laterally supported by a steel frame without fire-proofing or by a combustible frame can be expected to be damaged or collapse when exposed to an uncontrolled fire. Figures 37-39 are based on a flame front unobstructed by the exposing building wall (i.e., collapse of the exposing wall or a wall with 100% openings). For all Non-SFR walls, U = 1.0.

2.3.4 Exposing Fire Hazard Categories

2.3.4.1 Determine the exposing fire hazard categories per Table 4.

Table 4. Exposing Fire Hazard Categories

Fire Hazard Category	*Description*
HC-1/HC-2(see Data Sheet 3-26, *Fire Protection Water Demand for Nonstorage Sprinklered Properties*)	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 41). In-process storage of Class 1, 2, or 3 commodities, up to 6 ft (1.8 m) is not considered storage.
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 a storage category.
Storage occupancies	This category includes storage of any commodity based on the storage height. Storage of noncombustible goods in noncombustible packaging can be considered HC-1 hazard category.
Ignitable liquids	See Sections 2.3.4.3 and 2.3.4.4.
Multistory combustible construction	Use a Storage occupancy up to the eave height of the building.

2.3.4.2 Classify production areas with in-process storage with an exposing dimension ≤50 ft (15 m) as HC-1/HC-2 hazard category (see Figure 41).

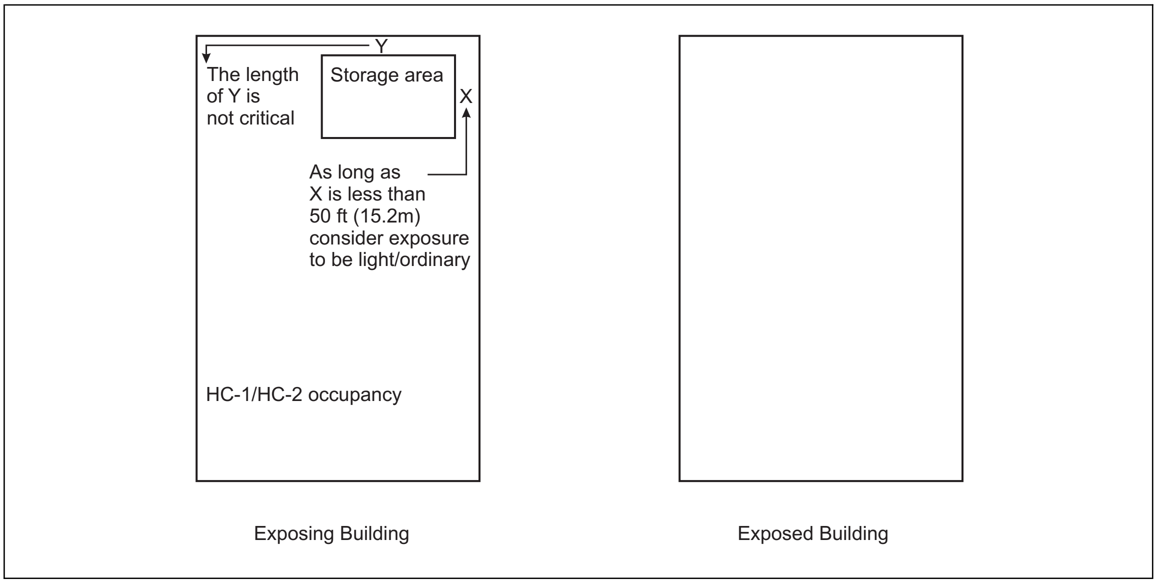


Fig. 41. Small storage areas in HC-1/HC-2 hazard buildings

2.3.4.3 Classify production areas with isolated systems of ignitable liquids of less than 500 gal (2,000 L) capacity per reservoir as HC-1/HC-2 hazard category.

2.3.4.4 Evaluate ignitable liquid exposures of 500 gal (2,000 L) or more using Table 3 or Figure 39 based on the maximum foreseeable pool dimension.

2.3.4.5 The required separation is from the exposed wall to the edge of the pool fire.

2.3.4.6 For all occupancies with ignitable liquids, evaluate whether or not ignitable liquids can compromise the space by flowing into the area. Provide containment if needed.

2.3.5 Exposing Wall Length (L)

2.3.5.1 Unless adjusted in accordance with Section 2.3.5.2, the length (L) is the actual length of the exposure up to a maximum of 500 ft (150 m).

2.3.5.2 When the exposure overlaps or is off-set from the exposed building, use Figures 42-46 to determine the exposure length (L).

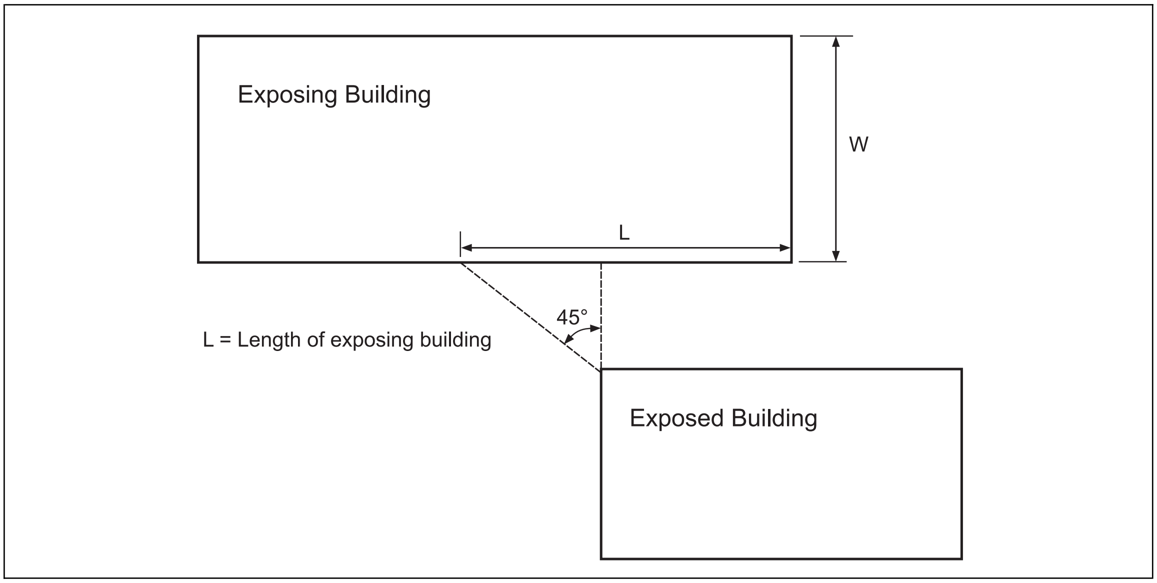


Fig. 42. Length of exposing wall for overlapping buildings

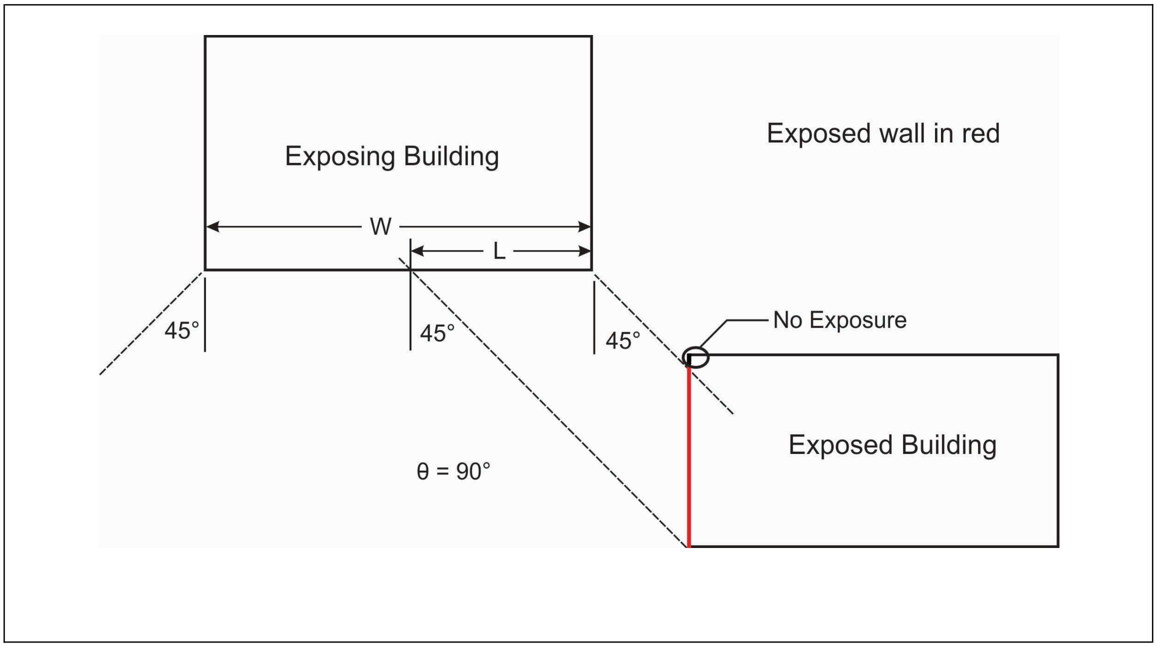


Fig. 43. Offset buildings: longer exposing wall exposing shorter exposed wall

2.3.6 Exposure Angle Adjustment

2.3.6.1 When the exposed buildings are at an angle to one another, use Figures 47-49 to determine the exposure angle adjustment factor (M).

2.3.7 Yard Storage, Conveyors, Pipes and Passageways

2.3.7.1 Remove combustible yard storage that can negate a space separation. If yard storage cannot be avoided, maintain adequate space between yard storage and the exposed building considering the yard storage as an exposing building.

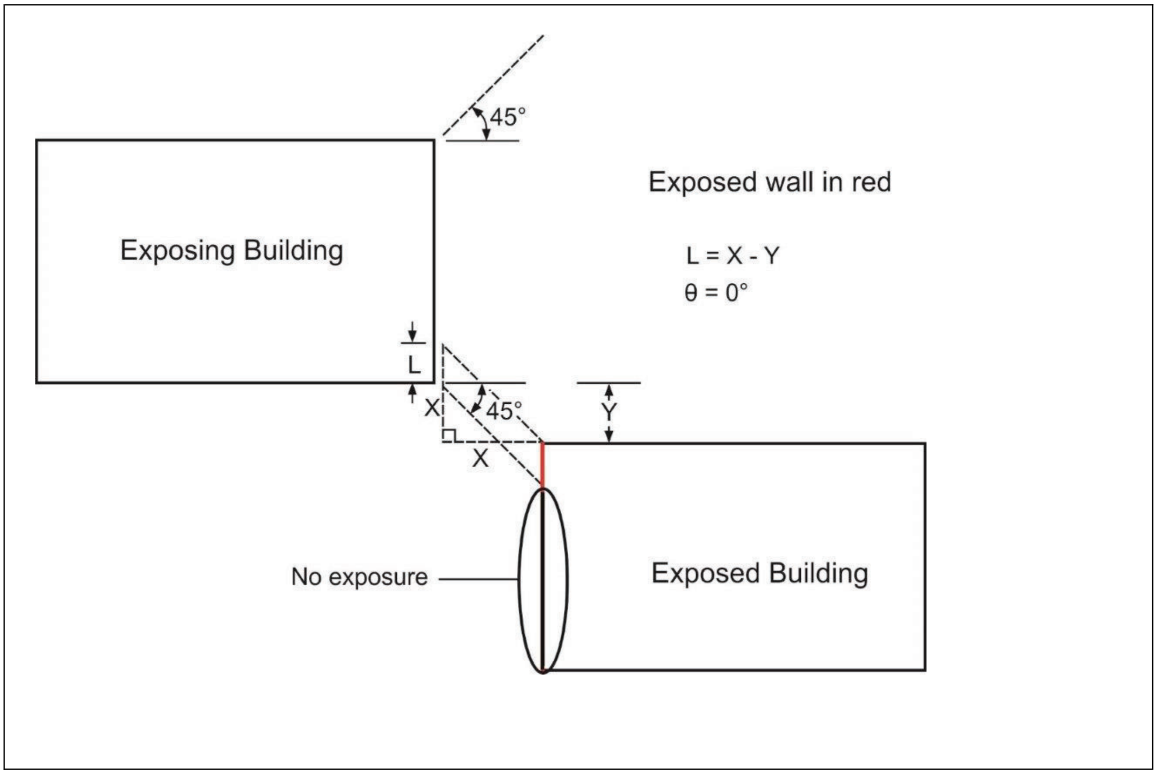


Fig. 44. Offset buildings: shorter exposing wall exposing shorter exposed wall

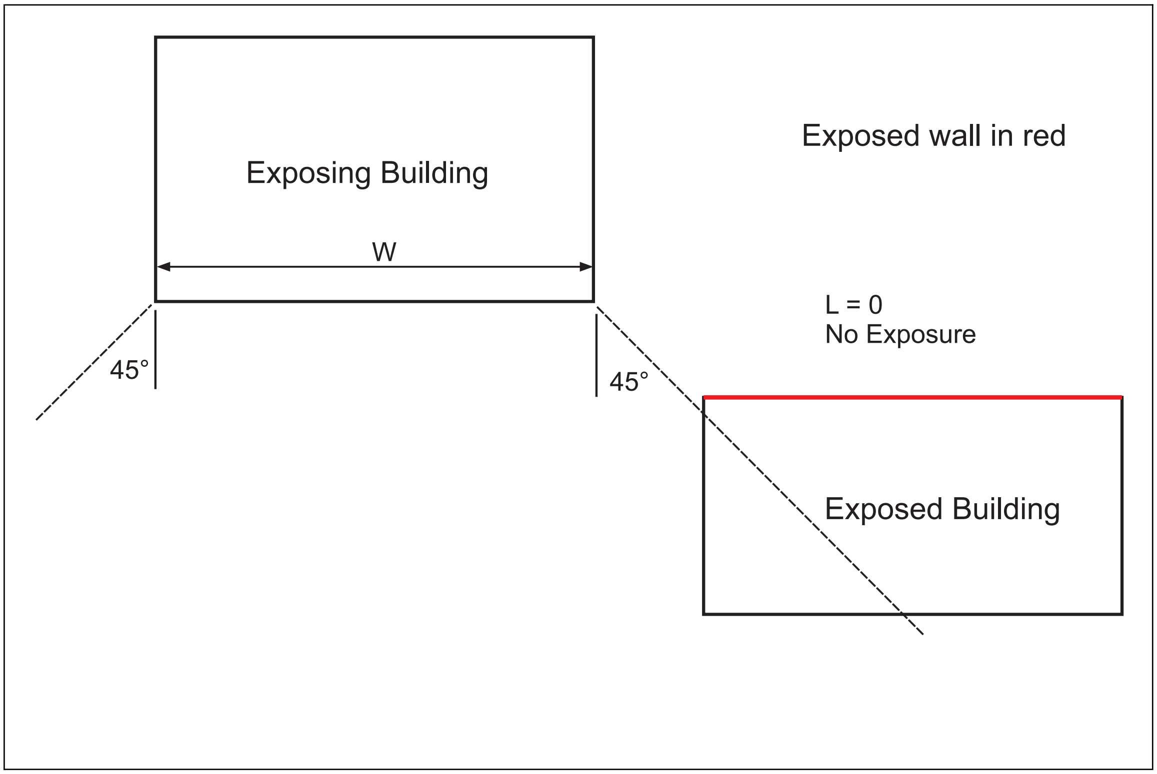


Fig. 45. Offset buildings: longer exposing wall exposing longer exposed wall

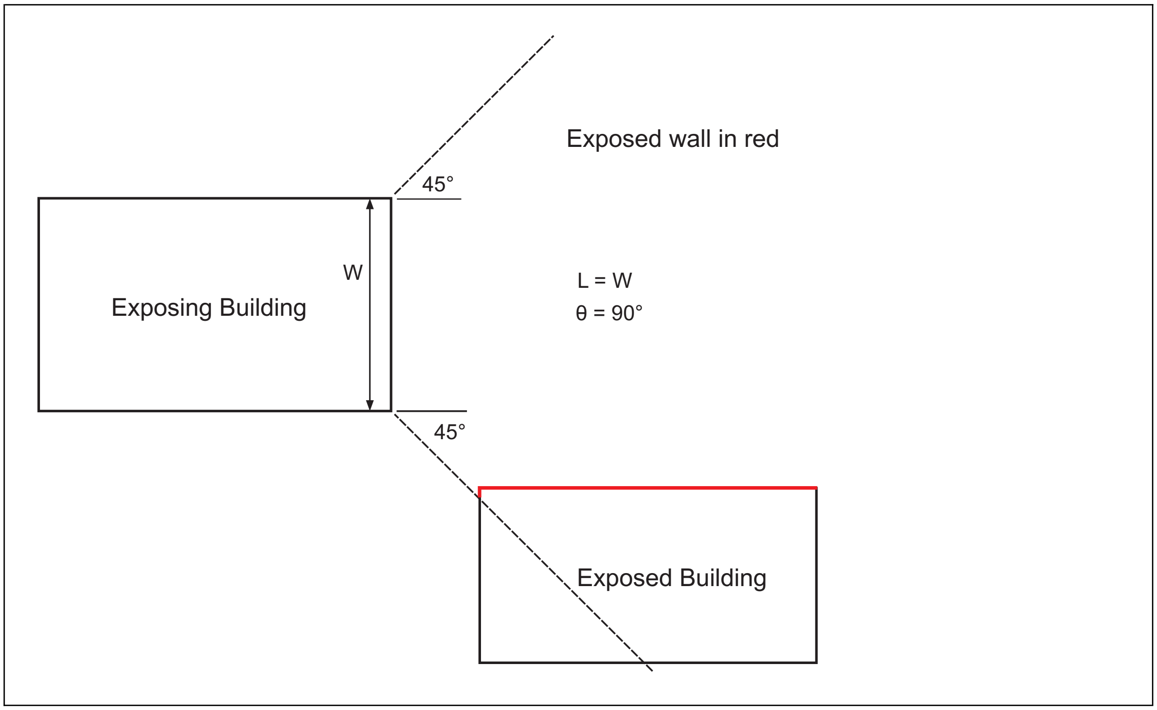


Fig. 46. Offset buildings: shorter exposing wall exposing longer exposed wall

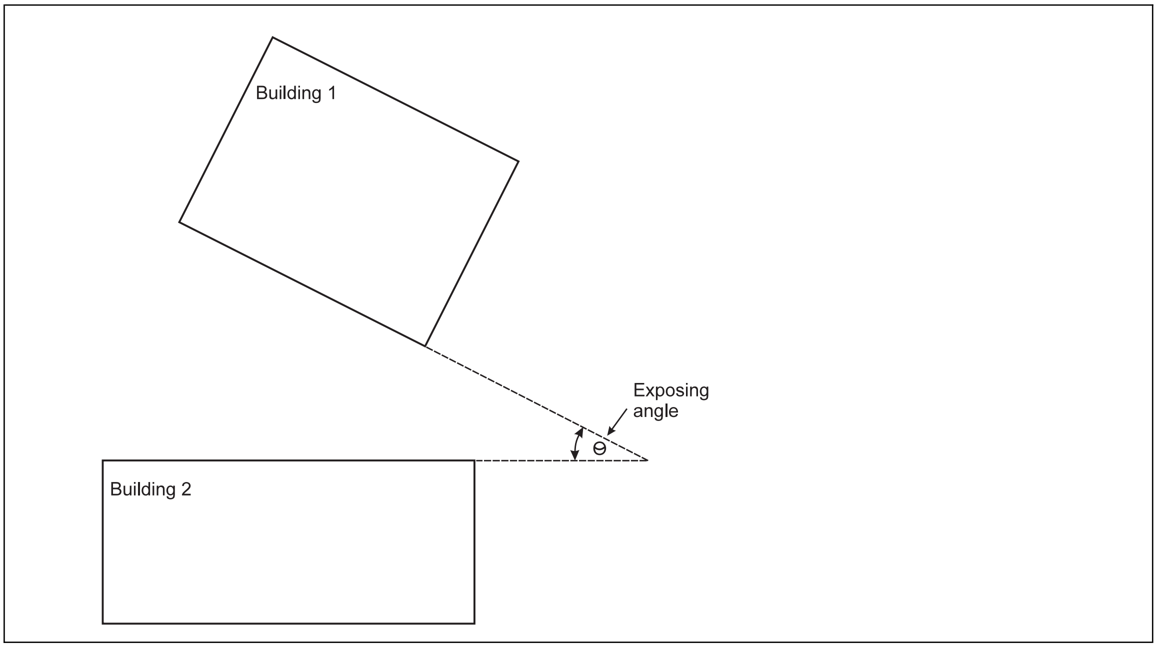


Fig. 47. Exposed buildings at angles

2.3.7.2 Provide protection for conveyors, pipes, bridges, tunnels, and other connector links that could damage or otherwise compromise the protective wall of an exposed building. Bridges must be independently supported with fireproofed supports to prevent the protecting wall of the exposed building from collapsing.

2.3.7.3 Ensure construction of all conveyors, bridges, tunnels or other passageways is noncombustible (i.e., no Class 2 steel deck roofs).

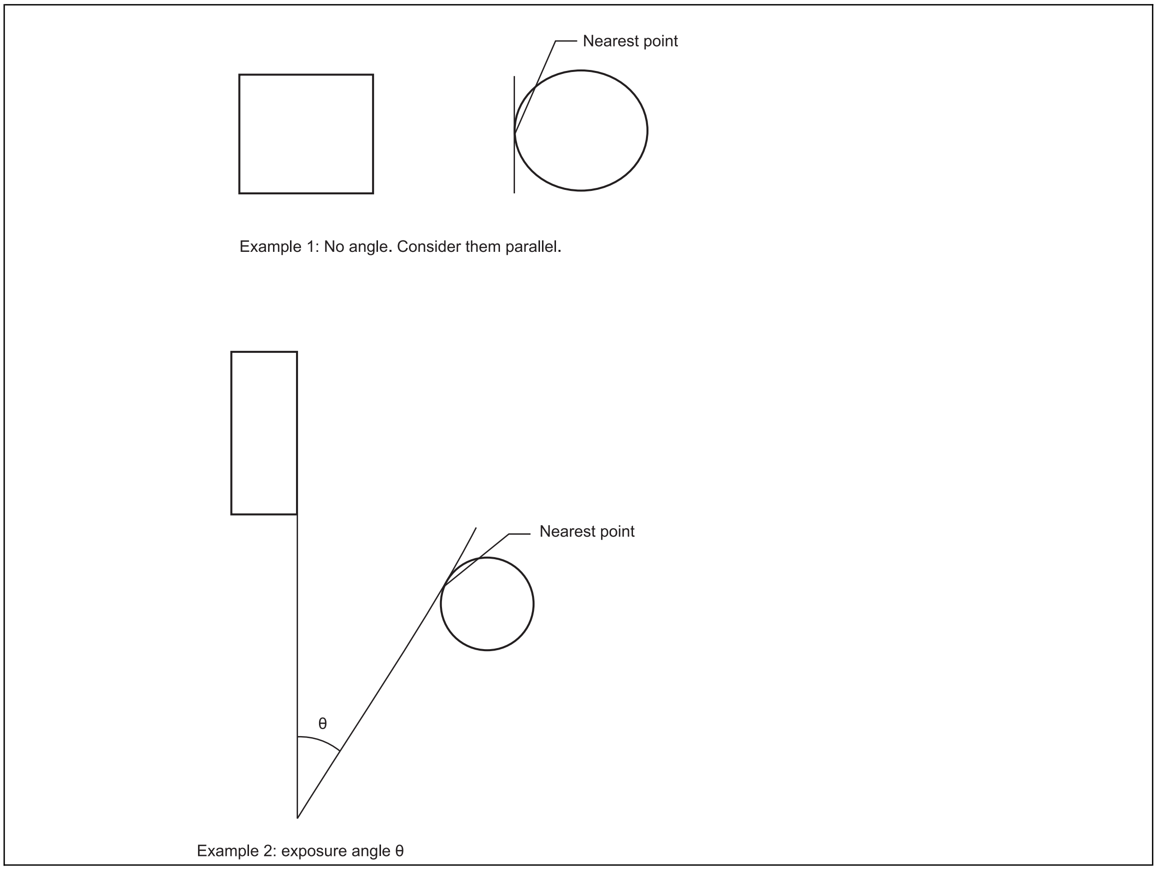


Fig. 48. Angle to circular buildings

2.3.7.4 Provide fire doors at each end of tunnels, passes, connector links, etc., with a minimum fire resistance equal to the needed fire resistance of the walls in accordance with Table 3, but not less than 1-hour.

2.3.8 Separation to Exposed Side Walls

2.3.8.1 When the exposing wall is longer than the exposed wall, analysis of separation to side walls may be needed (see Sections 2.3.8.2 to 2.3.8.4).

2.3.8.2 If the space is adequate per this data sheet, then no side wall protection is needed, as long as the construction of the side wall is the same as the exposed wall.

2.3.8.3 If the space is inadequate, analyze the exposure to the side wall using the proper exposure angle adjustment, M (see Section 2.3.6).

2.3.8.4 The length of the protection needed for the side wall is equal to the space needed using the proper adjustment factor, M, minus the actual space separation provided. See DS 1-20 for more details.

2.3.9 Vegetation

2.3.9.1 Vegetation in temperate climates without significant undergrowth does not contribute to fire spread if the space separation is otherwise acceptable. Each case must be evaluated on its own merits and it is possible that there are exceptions.

2.3.9.2 In non-temperate or non-tropical climates, such as deserts and other hot, arid locales, trees and undergrowth can contribute to fire spread. Use Data Sheet 9-19, *Wildland Fire*, to identify geographic areas in which vegetation should be considered a possible contributing factor in MFL scenarios.

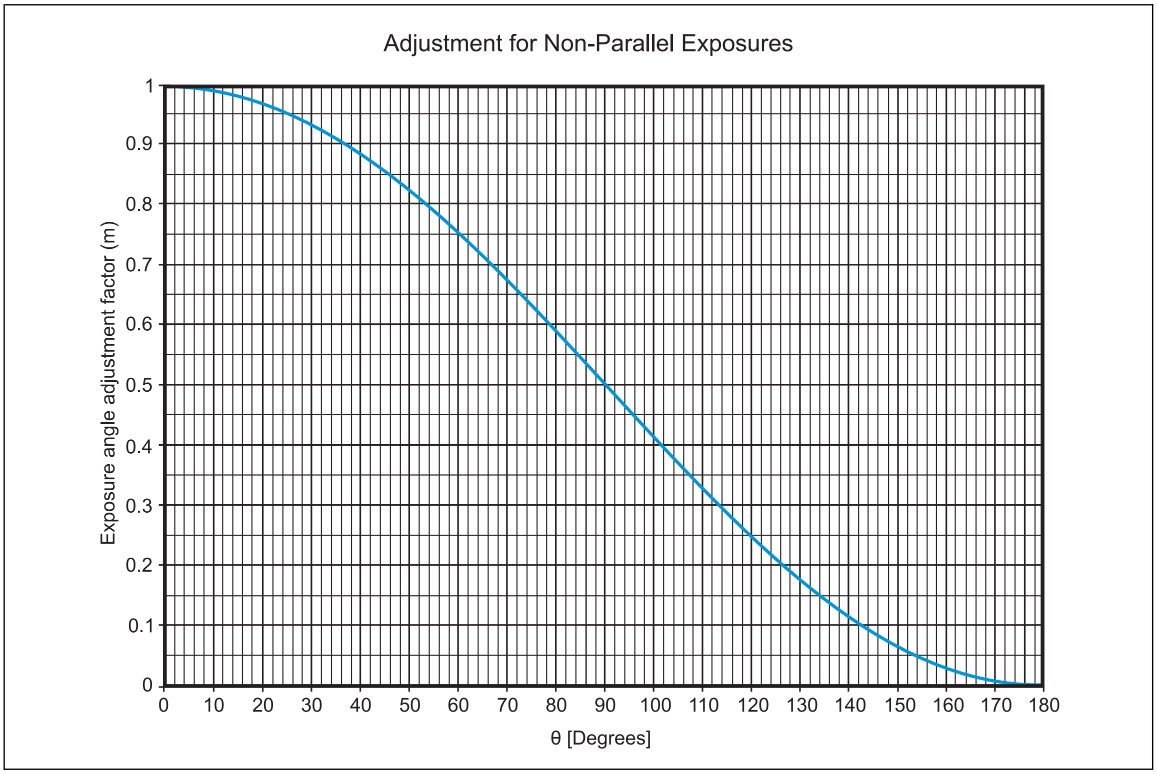


Fig. 49. Angular exposure adjustment factor (M)

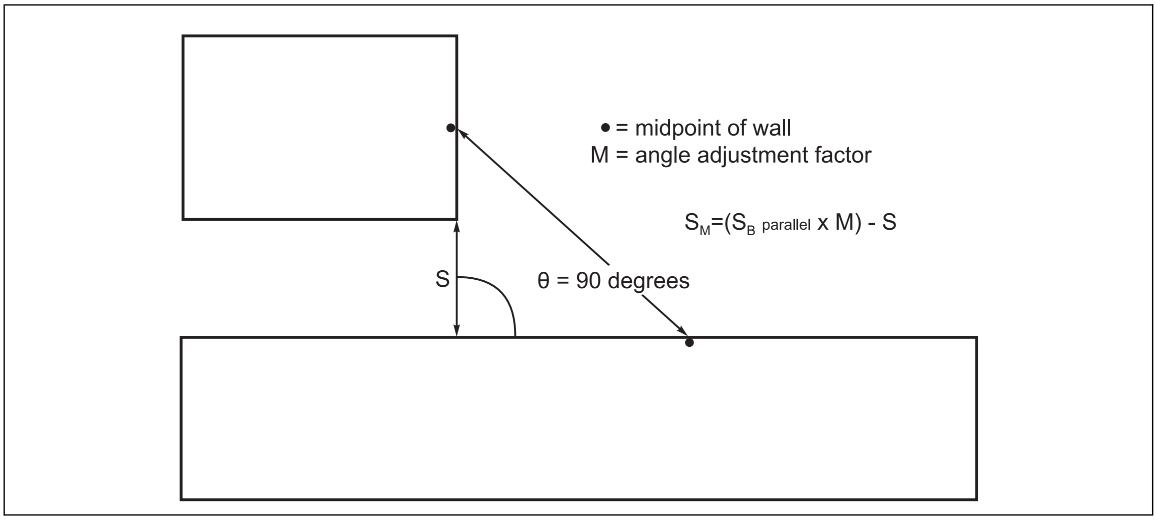


Fig. 50. Longer exposing wall

2.3.9.3 Typical urban and suburban areas of eastern North America receive sufficient rainfall or supplemental watering that this type of foliage would not be expected to contribute to the MFL scenario. However, a large tree canopy that spans the entire space and comes in contact with combustible roof surfaces or eaves would result in a space being unacceptable.

2.3.10 Motor Vehicle Parking

2.3.10.1 Grade-Level Open Parking Lots

Private vehicle parking (passenger cars) in an open lot generally will not spread a fire across an open space.

Commercial vehicles (trucks, buses, tractor trailers) with or without trailers (loaded or unloaded) can spread fire across an open space. They have the potential for a significant increase in combustible loading due to the larger plastic body panels and amount of on-board fuel. Each case must be evaluated on its own merits.

2.3.10.2 Parking Garages

Private and/or commercial vehicle parking can spread a fire across any type of parking garage: open-sided above-ground, enclosed above-ground, or underground.

2.3.11 Ignitable Liquid and Flammable Gas Loading and Unloading Stations

2.3.11.1 Ignitable Liquids Stations

The MFL space separation analysis must consider all the foreseeable hazards associated with these facilities. Consider the following scenarios:

- The fire occurs when a tanker truck is parked at the station in the space.
- The spill of a tanker's entire contents and a subsequent fire.
- The spill of a tanker's entire contents into an existing fire.
- Failure of piping and pumping systems and then a subsequent fire.
- Failure of piping and pumping systems at the station that feeds an existing fire.

2.3.11.2 Flammable Gas Stations

The MFL space separation analysis must consider all the foreseeable hazards associated with these facilities. Consider the following scenarios:

- A vapor cloud fire
- A vapor cloud explosion

Also refer to Data Sheet 7-42, *Vapor Cloud Explosions*.

2.3.12 Rail Lines and Sidings

The MFL space separation analysis must consider all the foreseeable hazards associated with these facilities. Consider the following scenarios:

- The fire occurs when the siding or rail line is occupied by open cars carrying a combustible material.
- The fire occurs when the siding or rail line is occupied by any one of the typical types of rail car (boxcar, refrigerated boxcar, flatcar, tanker, container carrier, gondola, hopper, center partition car, auto transporter).
- If ignitable liquids are normally delivered to the site via rail, consider that the fire occurs when a tanker car is parked in the space.
- The spill of a tanker's entire contents and a subsequent fire.
- The spill of a tanker's entire contents into an existing fire.

2.4 MFL Control of Exterior Vertical Fire Spread

2.4.1 Mechanical Floors

2.4.1.1 A mechanical floor can serve as an exterior vertical fire spread limiting factor and stop vertical fire spread if designed per 2.4.1.2 and 2.4.1.3.

2.4.1.2 A 2-hour fire-resistance rated floor stops the interior vertical fire spread while the mechanical floor stops the exterior vertical fire spread.

2.4.1.3 To stop vertical fire spread at a mechanical floor ensure all of the following:

- There are no interconnected floors directly below the mechanical floor.
- There are no combustible interior finishes on walls and ceilings within the mechanical floor.
- The existing floor height exceeds the minimum floor height B_r (see Sections 2.4.1.4 and 2.4.1.5).

2.4.1.4 Determine the minimum floor height B_r as follows:

$B_r = 4.78h - S_1 - 2(S_1 + S_2)$

Where:

B_r = required minimum height of the mechanical floor (ft, m).
h = window height (ft, m) on the floors above and below the mechanical floor.
S_1 = height of the lower spandrel (ft, m).
S_2 = height of the upper spandrel (ft, m).

Note: Floor height is equal to $S_1 + S_2 + h$ (see Figure 51).

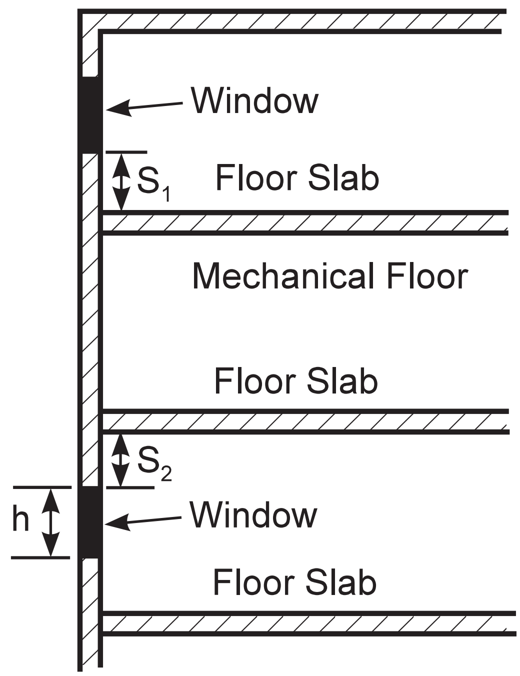


Fig. 51. Window and spandrel heights

2.4.1.5 Example: A 30-story, reinforced concrete frame high-rise building has no interconnected floors, has 12 ft (3.7 m) high stories, with 5.8 ft (1.8 m) high windows, and spandrels centered on the floor slabs. It has a 20 ft (8 m) high, 17th story mechanical floor with no windows and negligible combustibles. What is the minimum required height for an acceptable mechanical floor break?

Solution:

English Units:

h = 5.8 ft S_1 = 3.1 ft S_2 = 3.1 ft
B_r = 4.78 (5.8) - 3.1 - 2 (3.1 + 3.1)
B_r = 27.7 - 3.1 - 12.4
B_r = 12.2 ft

The mechanical floor is 20 ft tall, so this is an acceptable fire break.

SI Units:

h = 1.8 m S_1 = 0.95 m S_2 = 0.95 m
B_r = 4.78 (1.8) - 0.95 - 2 (0.95 + 0.95)
B_r = 8.6 - 0.95 - 3.8 B_r = 3.85 m

The mechanical floor is 6.1 m tall, so this is an acceptable fire break.

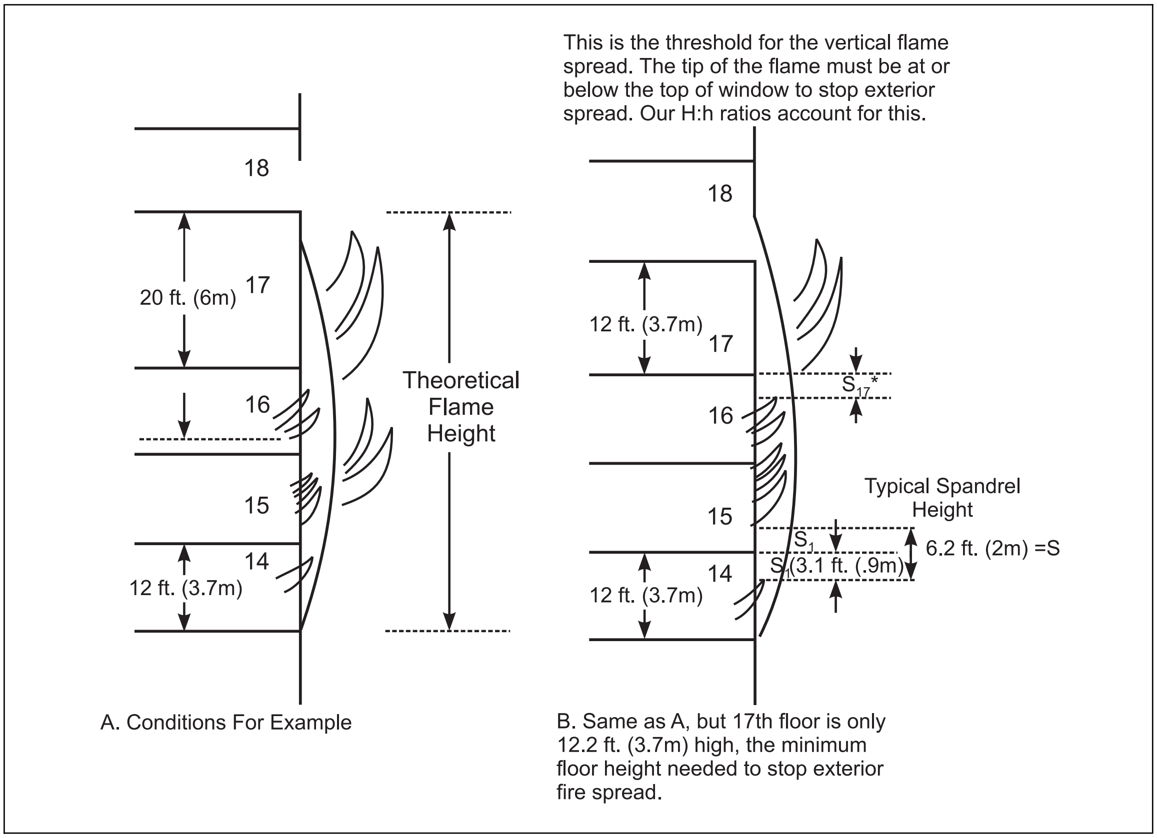


Fig. 52. Mechanical floor fire break and theoretical flame height

* The bottom section of spandrel S_{17} may be deeper than on other floors to accommodate deeper beams supporting the mechanical floor. If S_{17} is deeper, we can consider the mechanical floor fire break to be higher by that distance; for example, if S_{17} = 5 ft, the effective height of the 17th story fire break could be considered 12.2 + (5 - 3.1) = 14.1 ft.

2.4.2 Setbacks

A high-rise may have one or more abrupt reductions in floor area. Consider the reduction deep enough to stop exterior fire spread if its depth is equal to or greater than the height needed for a mechanical floor break and it extends around the entire building perimeter. In the previous example, the required mechanical floor height was a minimum of 12 ft (3.7 m). A setback that goes completely around the building that is greater than 12 ft (3.7 m) would be sufficient to stop vertical exterior fire spread. All other criteria per 2.4.1 must also be provided.

2.4.3 Balconies

2.4.3.1 Noncombustible balconies of adequate size can deflect flames and stop upward exterior fire spread. To qualify as an adequate vertical fire break, the balcony must overlap the openings on the lower floor by at least 4 ft (1.2 m), both outward and to the sides.

2.4.3.2 Ensure all other windows on the same floor without balconies meet the following criteria:

A. One window vertically per floor (see Figure 53):

1. Fixed or permanently closed windows: Ensure the distance between any floor and the bottom of the window on the next story above that floor (H) is at least 2.8 times the window height (h).

$H \geq 2.8\ h$

2. Operable windows: Ensure the distance between any floor and the bottom of the window on the next story above that floor (H) is at least 3.8 times the window height (h).

$H \geq 3.8\ h$

B. More than one window vertically per floor (see Figure 54):

1. Fixed or permanently closed windows: Ensure the distance (H’) between any floor and the top of the lower window on the floor above is at least 3.8 times the sum of the window heights (h_{TOTAL}).

$H' \geq 3.8\ h_{TOTAL}$

2. Operable windows: Ensure the distance (H’) between any floor and the top of the lower window on the floor above is at least 4.8 times the sum of the window heights (h_{TOTAL}).

$h_{TOTAL} = h_1 + h_2 + ...h_n$

$H' \geq 4.8\ h_{TOTAL}$

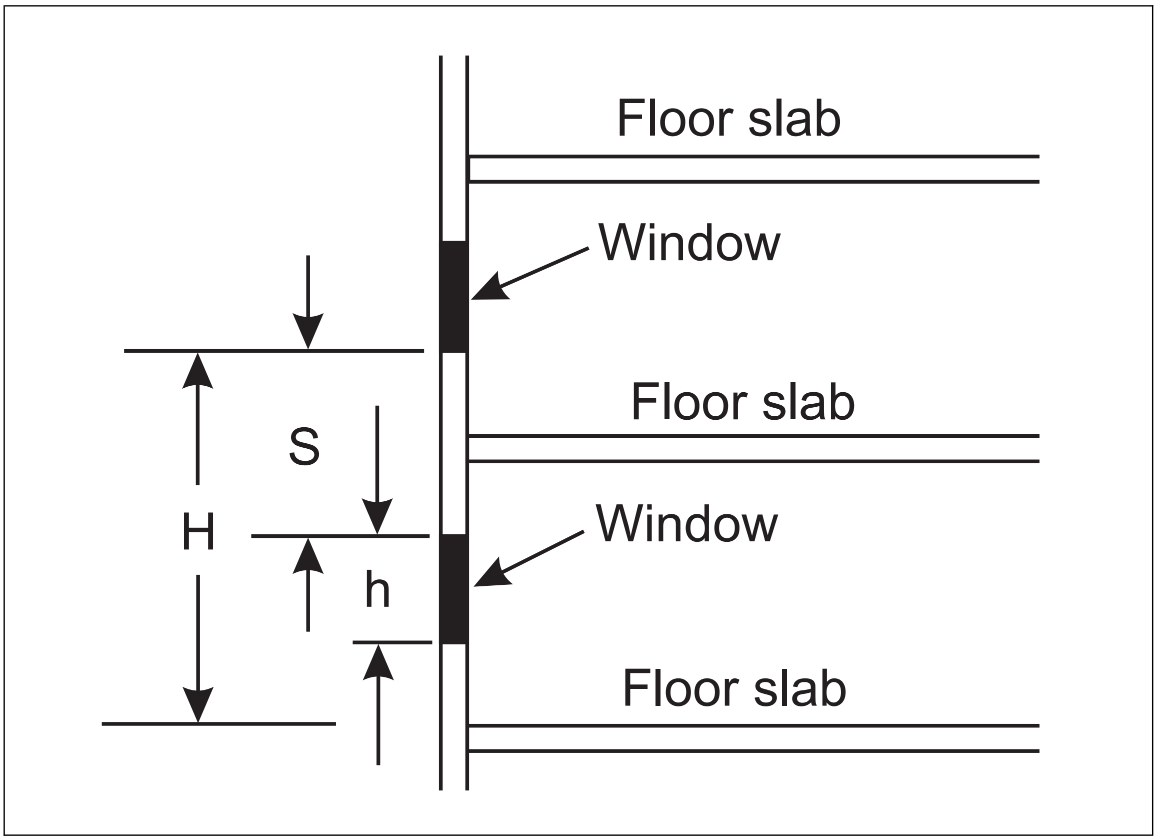


Fig. 53. Typical exterior window arrangement

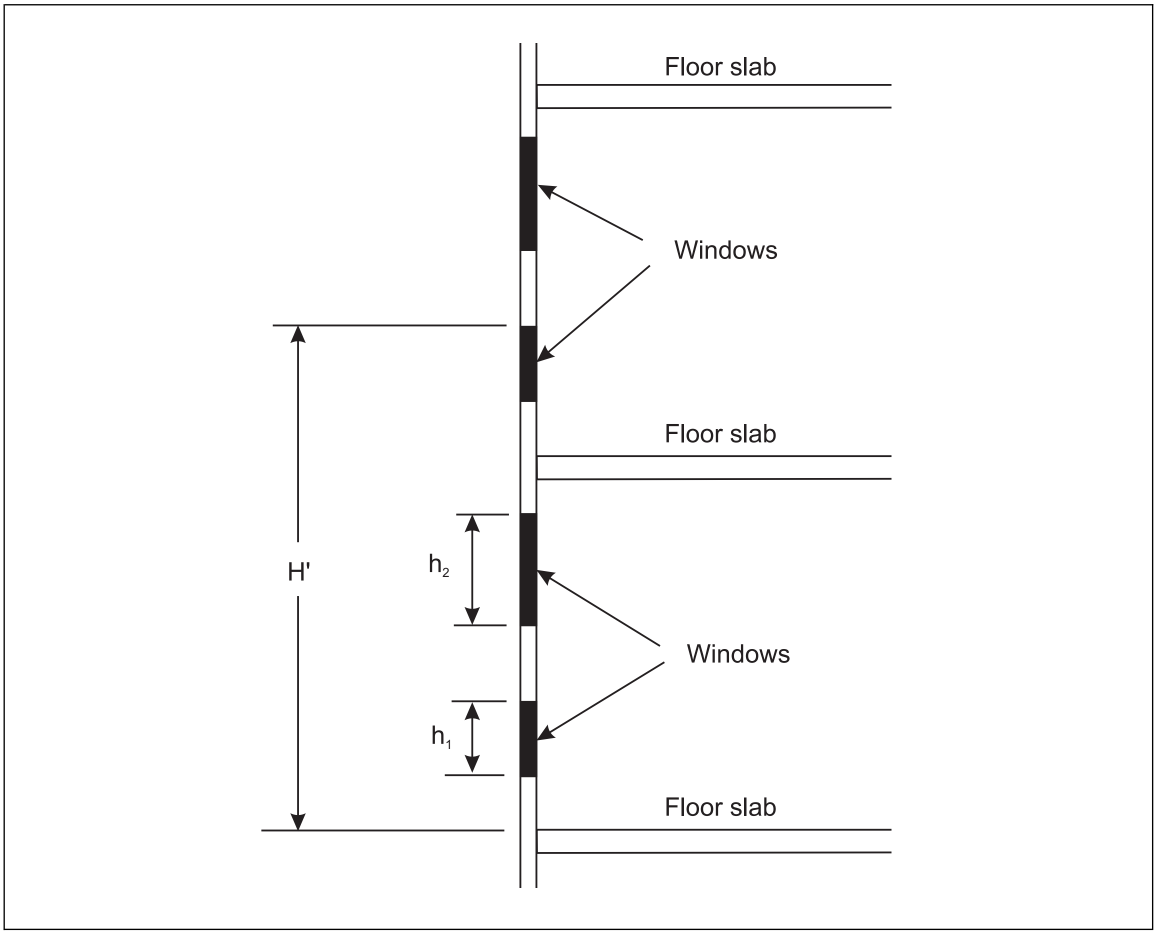


Fig. 54. More than one window per floor

2.4.4 Podium Floors

Floor-ceiling assemblies can be used as limiting factors in multistory construction. Typically, a large retail or casino floor is separated from a hotel tower by a reinforced concrete podium floor supported by a reinforced concrete frame. Due to the many variables involved, a complete list of criteria cannot be provided.

The following are general guidelines:

- the floor-ceiling assembly must be 4-hour rated.
- the structural frame supporting the podium must be 4-hour rated.
- All penetrations must be adequately fire stopped.
- All openings must be protected with minimum 3-hour rated fire doors. Elevator shafts, vent shafts and utility shafts must be minimum 2-hour. rated assemblies.
- Elevator doors must be at least 2-hour rated. Enclosed elevator lobbies must be at least 2-hour rated.
- External fire spread must be prevented by either extending the podium a minimum of 40 ft from the base of the tower on all sides, or by providing mechanical floor breaks, setbacks, or balconies as described above.
- The tower exterior cladding must be noncombustible.

2.5 Protection of Openings in MFL Limiting Factors

2.5.1 General

2.5.1.1 Openings are defined as personnel, vehicle, and material-handling-system openings. For maximum reliability, minimize the number of openings in MFL limiting factors. When they are necessary, keep them as small as practical.

2.5.1.2 Refer to Appendix E for general requirements on the protection of openings.

2.5.1.3 For guidelines on the protection of penetrations (pipes, cables, etc.), see Section 2.2.6.

2.5.1.4 Refer to Section 2.5.2 for additional requirements for protection of openings in MFL limiting factors.

2.5.1.5 Except where single fire doors are acceptable), provide opening protection on each side of the opening.

2.5.2 Detection and Actuation Devices

2.5.2.1 Do not use sprinkler water flow as the sole means of initiating fire door closure.

2.5.2.2 Locate detectors per DS 5-48, *Automatic Fire Detection*.

2.5.2.3 When temperature-based detectors are used, locate or arrange the detectors so automatic sprinkler activation will not pre-wet the detector and delay detection.

2.5.3 Water Spray

2.5.3.1 Do not use water spray or water curtains for opening protection in MFL limiting factors.

2.5.4 Occupancy Specific Protection

2.5.4.1 Locate and arrange storage of small, pressurized containers of aerosol products so that, in a fire, rocketing cans cannot pass through protected openings. For other details of protection, see Data Sheet 7-31, *Storage of Aerosol Products*.

2.5.4.2 When fire doors protect occupancies highly sensitive to smoke damage, do the following:

A. Arrange fire doors to close automatically by actuation of smoke detectors. Ensure the smoke detector is suitable for the environment.

B. In the case of conveyor openings, make arrangements to shut down the feed conveyor and allow conveyed material to clear the opening before the door is allowed to close. This can be accomplished by using cross-zoned detectors on each side of the wall. Have the first signal initiate feed conveyor shutdown. Receipt of a second signal must initiate door closure. Provide a 15 ft (4.5 m) space between the detectors on respective sides of the fire wall to allow sufficient time delay for the feed conveyor to be shut down and the opening to be cleared.

C. An alternative to cross-zoning is to provide a single smoke detector on each side of the wall that upon actuation will shut down the feed conveyor and activate a time delay switch, which will allow delayed door closure. The time delay must be adequate to allow clearing of the opening, but generally must only be a few seconds. In either case, connect the door holder to a back-up power supply using an uninterruptible power supply (UPS) system. This will prevent premature door closure during a power failure.

D. Equip doors with listed 3-hour rated fire door gasket material (that will not restrict door closure). Protect the bottom of swinging personnel doors with either an automatic door bottom or listed 3-hour rated fire door gasket material.

E. Ensure openings protected by horizontal sliding doors are equipped with continuous front, rear, and top binders, and have listed fire door gasket material at their bottom edges to reduce smoke passage.

F. Ensure fire dampers used to protect openings for air-handling systems have a Class 0, I, or II leakage classification (see Section 3.4.5).

2.5.5 Fire Doors

2.5.5.1 Provide fire doors that are FM Approved and labeled and have a minimum 3-hour fire rating. Do not use glazing material in fire doors in MFL fire walls.

2.5.5.2 Ensure architectural drawings and specifications call for the use of FM Approved fire doors and do not use the phrase “or equal.” When selecting new fire doors in MFL fire walls used to separate warehousing areas, take into consideration the temperature-rise rating of the door. (See Appendix E, Section E.2.8.)

2.5.5.3 Except where explicitly directed otherwise in this document, provide automatic closing fire doors on both sides of the opening for all MFL fire walls. In the case of a double wall, provide one door on each wall.

2.5.5.4 Provide an area clear of any combustibles on both sides of the opening as follows (see Figure 55):

- Provide a clear space perpendicular to the wall of at least the maximum dimension (height or width) of the opening, but not less than 6 ft (1.8 m).
- Provide a clear space of 2 ft (0.6 m) on both sides of the opening.

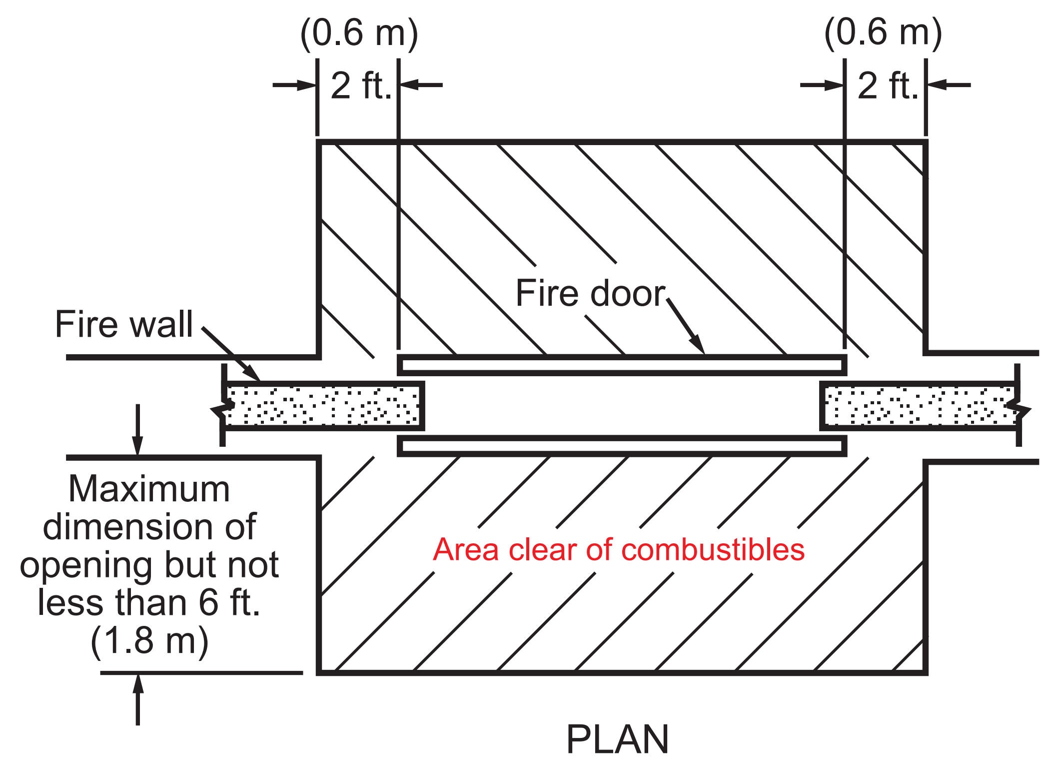


Fig. 55. Clearance area at fire doors

2.5.5.5 To help prevent mechanical damage to fire doors, resulting in their failure to operate, provide the following at any existing installation with a history of vehicular damage:

A. Guard rails (such as highway guard rails) installed in front of the entire length of horizontal sliding fire doors (in the open position) to prevent storage from being placed against it, as well as damage from impact.

B. Guard posts (such as concrete-filled steel pipe) rigidly secured to the floor or foundation installed in front of all guides or tracks for rolling steel and vertical sliding fire doors used to protect personnel-operated vehicle openings.

C. A heavy steel horizontal guard installed in front of the hood of a rolling steel door. Ensure the guard is vertically supported directly off the floor with posts. An alternative is to use surface-mounted doors with at least 2 ft (0.6 m) of clear space between the top of the opening and the bottom of the door hood.

2.5.5.6 Use aircraft cable (see Figure 56) for connecting fusible links and weights (counterweights, hold-open weights, etc.) to automatic closing mechanisms. Ordinary cable may take a permanent set, and chain can kink or hang up on other components. Avoid sharp changes in direction (>90°) unless pulleys are used.

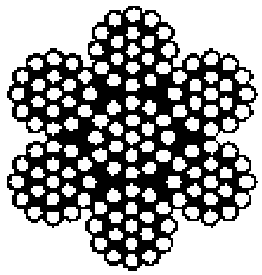


Fig. 56. Aircraft cable (7 × 19).

2.5.5.7 If needed, arrange and interconnect trip assemblies for fire doors in accordance with Figure 57.

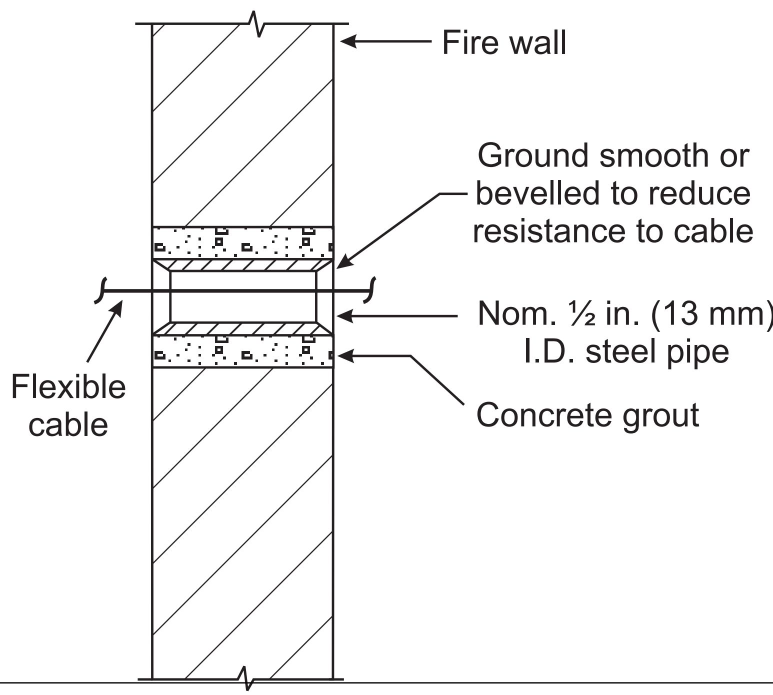


Fig. 57. Interconnection of trip assemblies through fire wall

2.5.5.8 Provide adequate clearance for vertical guides on rolling steel and vertical sliding fire doors. This clearance allows for the expansion of the steel guides and prevents buckling at elevated fire temperatures. Attach the vertical guides with bolts located in slotted holes to allow for expansion. Do not attach the guides by welds unless specifically FM Approved and listed that way in the *Approval Guide*.

2.5.6 Single Swinging Personnel Fire Doors

2.5.6.1 Where personnel doors (up to a maximum size of 4 by 8 ft [1.2 x 2.4 m]) swinging in the direction of the exit route are required for egress by the governing codes, use a single minimum 3-hour-rated fire door. Provide the door with a positive latch and door closer. Ensure the door is normally closed.

2.5.6.2 If a double MFL fire wall is used and a narrow, reinforced concrete, self-supporting frame is provided, use one normally closed, self-closing fire door supported by the frame.

2.5.6.3 If double egress doors (a pair of side-by-side doors swinging in opposite directions) are required by the local code, do the following:

A. If the MFL wall is a single fire wall, use one set of doors if the doors are self-closing.

B. If the MFL wall is a double fire wall, provide two sets of doors, with one set at each end of a 4-hour fire-rated, reinforced concrete vestibule designed for a 100 psf (4.8 kN/m^2) ceiling load.

2.5.6.4 If local codes require personnel doors in a double MFL wall to open in the same direction, use a 4-hour fire-rated, reinforced concrete vestibule designed for a 100 psf (4.8 kN/m^2) ceiling load with a single set of minimum 3-hour rated fire doors.

2.5.6.5 If side-by-side exit (egress) doors are required by local authorities to open in opposite directions, use separate doors latching into a fixed (non-removable) mullion or are equipped with an astragal that conforms to NFPA 80, *Fire Doors and Windows* (see Figure 58). Provide a device to coordinate door closure.

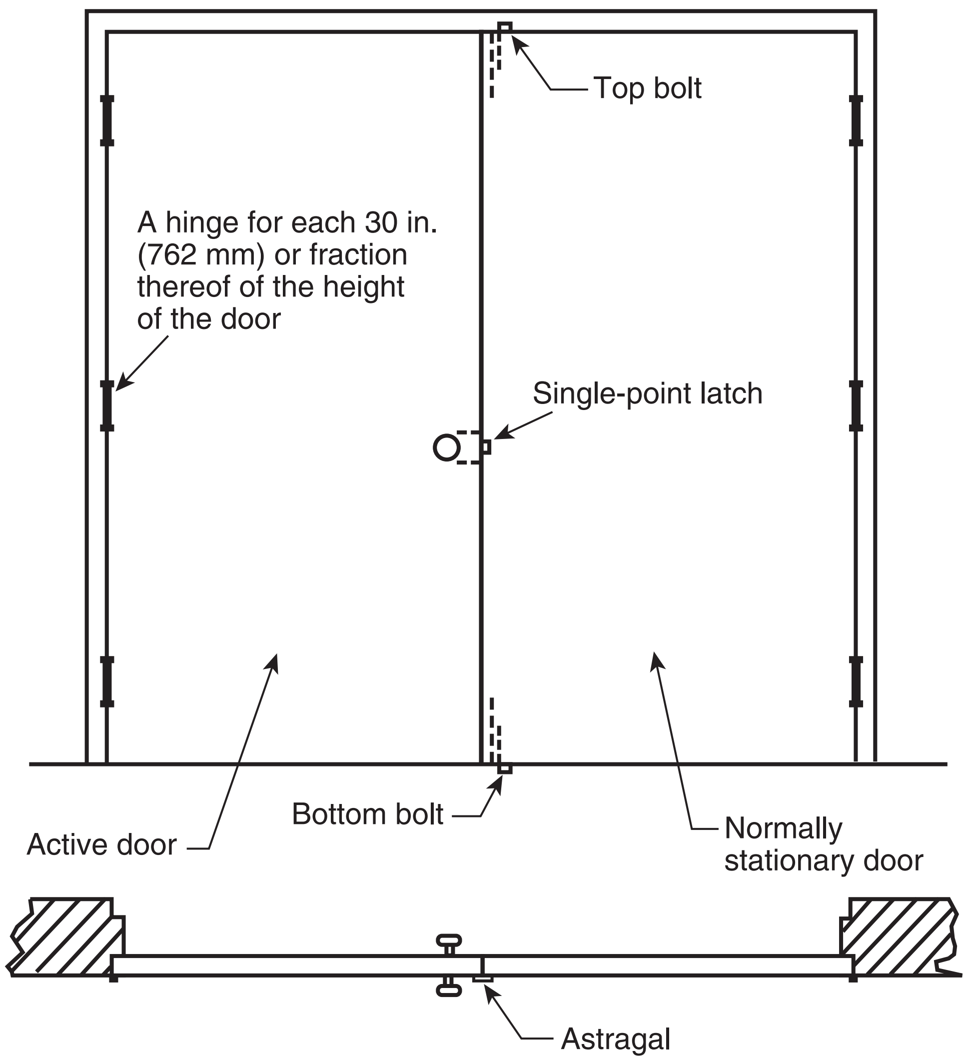


Fig. 58. Doors swinging in pairs-flush mounted (reprinted with permission from NFPA 80, Fire Doors and Windows)

2.5.6.6 If local codes require personnel doors in a double MFL wall to open in the same direction, use a 4-hour fire-rated, reinforced concrete vestibule designed for a 100 psf (4.8 kN/m^2) ceiling load with a single set of minimum 3-hour rated fire doors.

2.5.7 Fire Doors in Double Walls

2.5.7.1 Ensure openings in double MFL fire walls that require two doors use a reinforced concrete, self-supporting frame that passes through (but is not structurally connected to) both walls. Ensure the fire doors on either side of the opening (surface mounted) or in the opening are supported by the frame (see Figures 59 through 62).

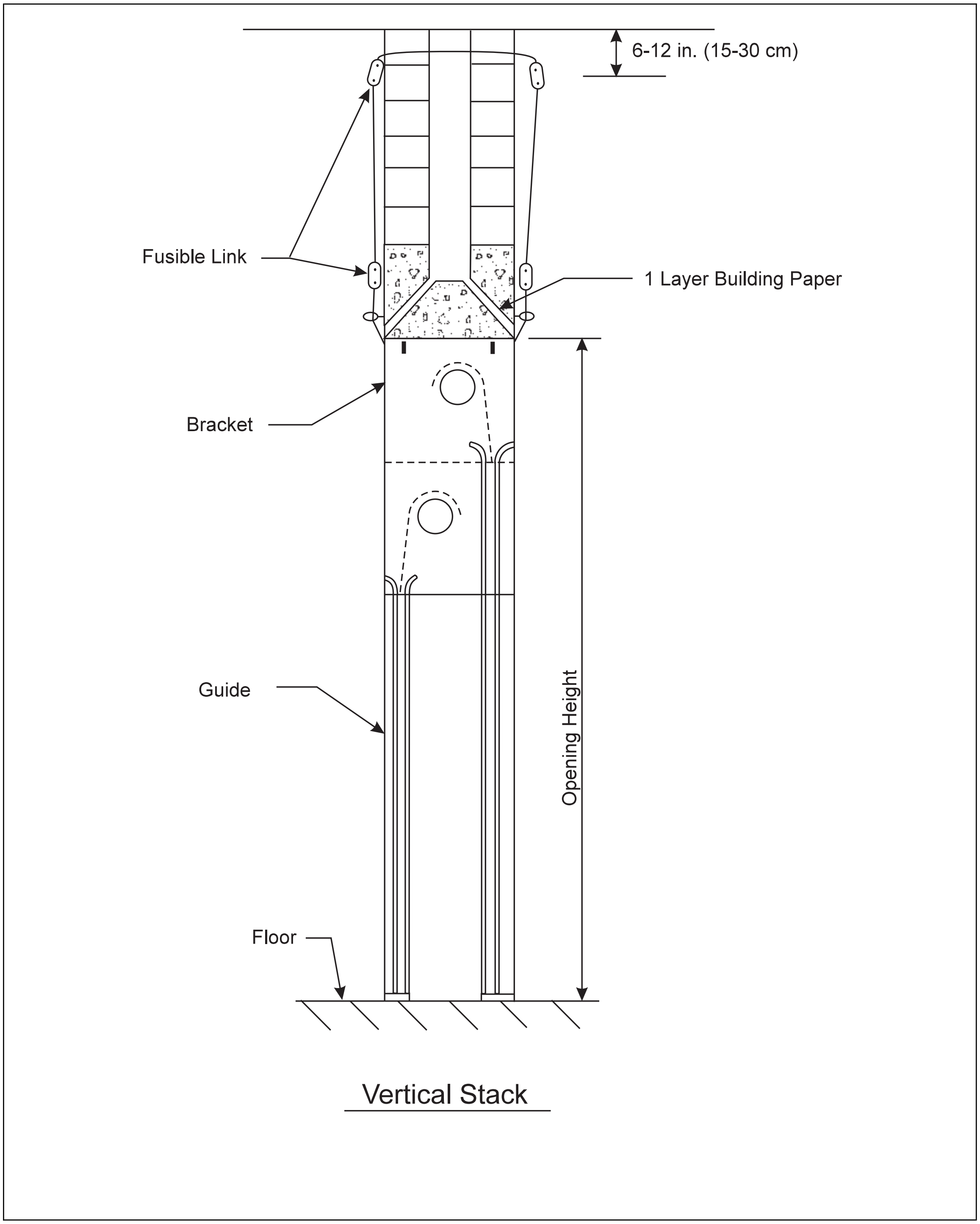


Fig. 59. Rolling steel fire doors in double MFL wall using reinforced concrete frame (stacked)

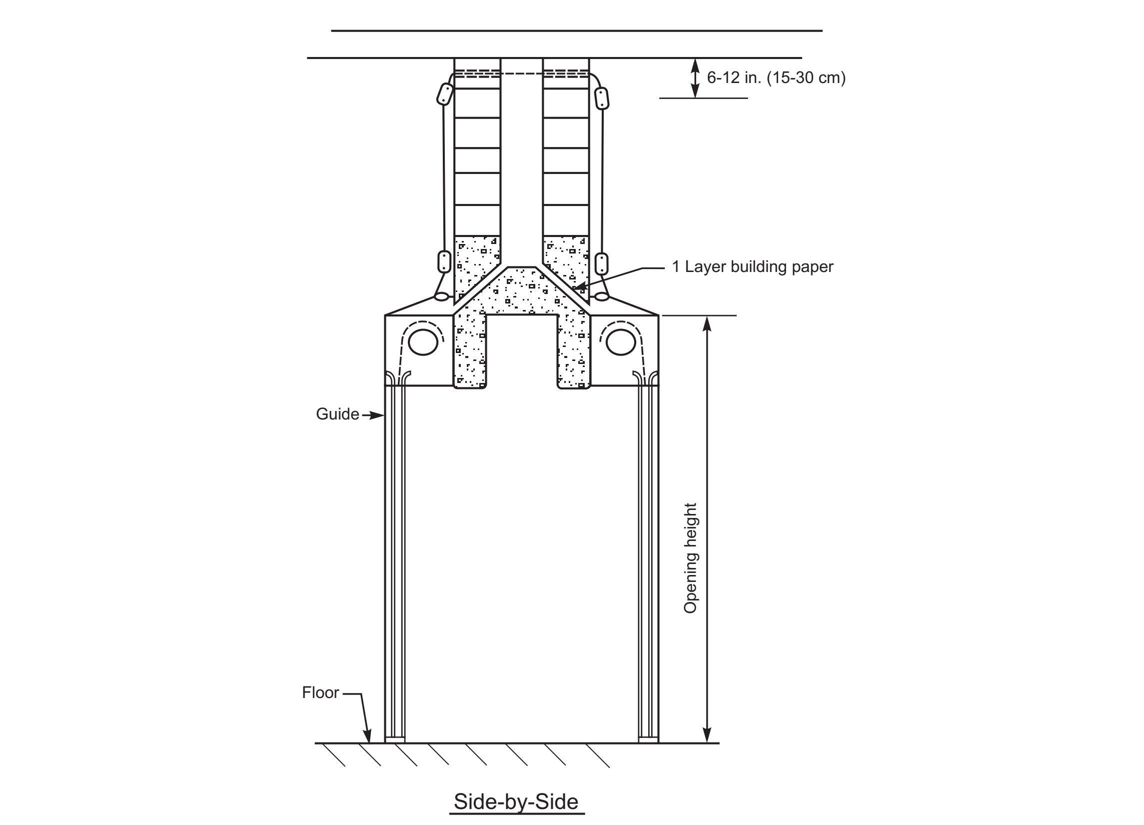


Fig. 60. Rolling steel fire doors in double MFL wall using reinforced concrete frame (side-by side)

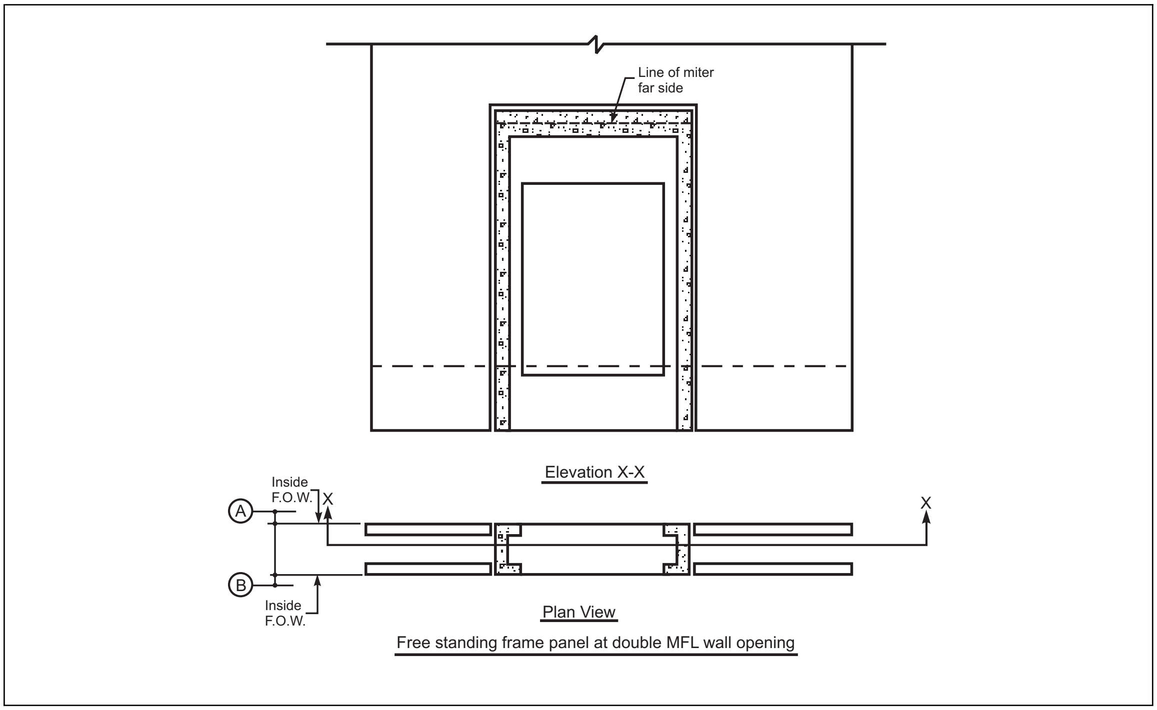


Fig. 61. Rolling steel fire doors in double MFL wall using reinforced concrete frame (section details)

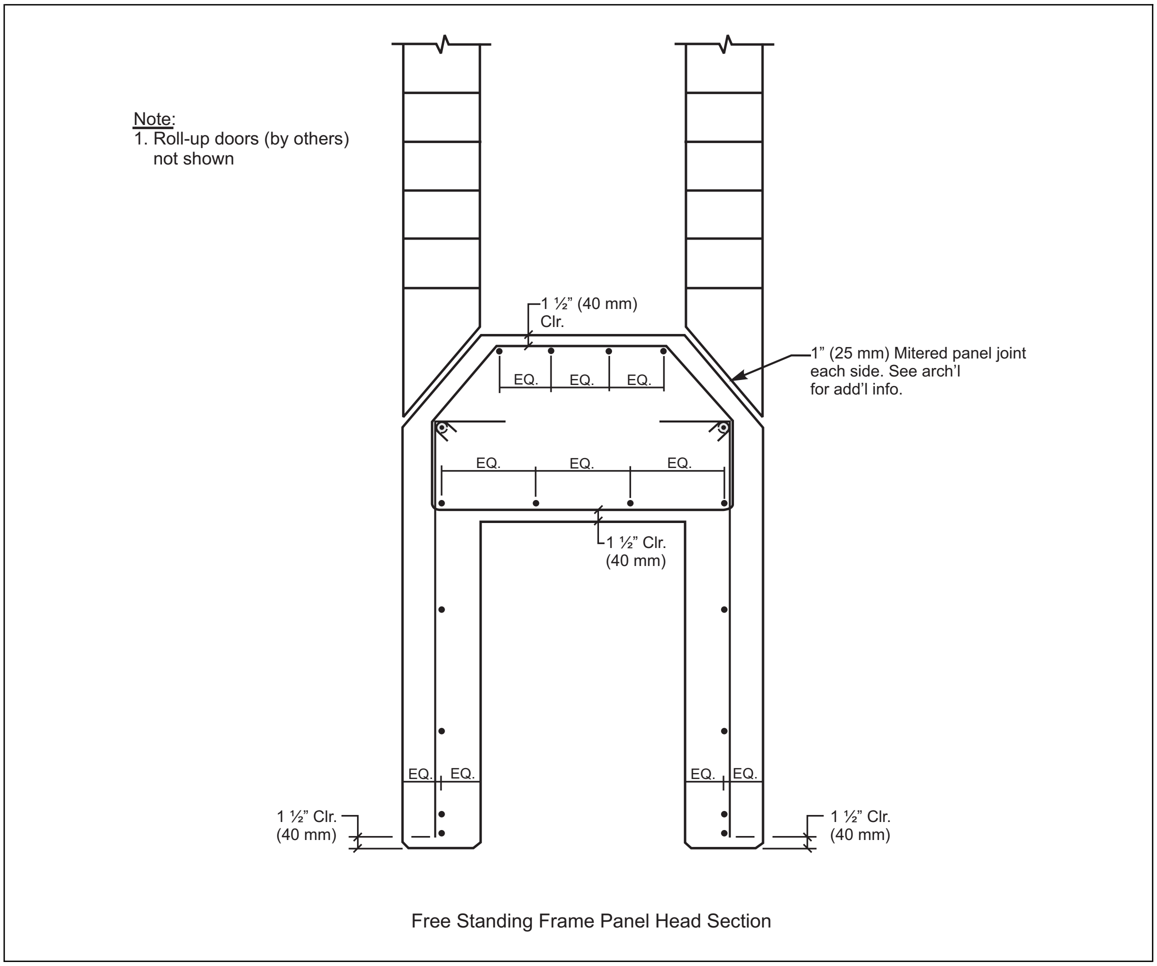


Fig. 62. Rolling steel fire doors in double MFL wall using reinforced concrete frame (plan details)

2.5.8 Fire Doors in FM Earthquake Zones

2.5.8.1 Anchor fire doors and fire door frames to masonry or concrete walls at locations in FM 50-year through 500-year earthquake zones.

2.5.8.2 Where toppling of equipment or stock positioned close to fire doors may interfere with complete closure of the doors, properly anchor or relocate equipment and stock away from doors.

2.5.9 Material Handling Systems

2.5.9.1 All Material Handling Systems Except Automatic Guided Vehicle Systems (AGVS)

The following recommendations apply to all material handling systems, with the exception of automatic guided vehicle systems (AGVS). For AGVS recommendations, see Section 2.5.9.2.

2.5.9.1.1 Ensure the design of the material handling system allows for complete closure of the opening upon automatic release of the fire door. (See Section 3.4.1.) Ensure the design is as simple and reliable as possible.

2.5.9.1.2 Design material handling systems to provide a clear distance perpendicular to the opening equal to the maximum dimension (height or width) of the opening. Maintain a clear space of 2 ft (0.6 m) in the direction parallel to the wall (See Figure 55 and Section 2.5.9.15).

Exception: When the fire door has a temperature rise rating or insulation rating (I) for the unexposed face of 325°F (180°C) or less, this recommendation does not apply.

2.5.9.1.3 Ensure combustible conveyor belts are not continuous through the fire wall. Ensure the system has a discontinuity of combustibles, as well as an opening that will allow for complete closure of the fire door.

2.5.9.1.4 Arrange detectors to do the following in the order shown:

A. Stop the feed conveyor or otherwise initiate the mechanism that clears the path of the fire door.

B. Provide an adequate time delay to clear the opening.

C. Activate the fire door closing mechanism.

2.5.9.1.5 Design the material-handling system and its support structure so its collapse will not damage, or put any significant loading or stress on, the fire wall. Ensure conveyor sections on either side of the fire wall are supported by the floor or roof, and not by the fire wall. The short section within the plane of the fire wall (between fire doors) may be supported directly by the fire wall (only one of the fire walls in the case of a double fire wall). Where the supports for the sections on either side of the fire wall may be exposed to lift truck traffic, provide guards to prevent movement of these sections into the fire door path.

2.5.9.1.6 Protect chain or rail conveyors with door packs (see Figure 63 and Section 3.4.3).

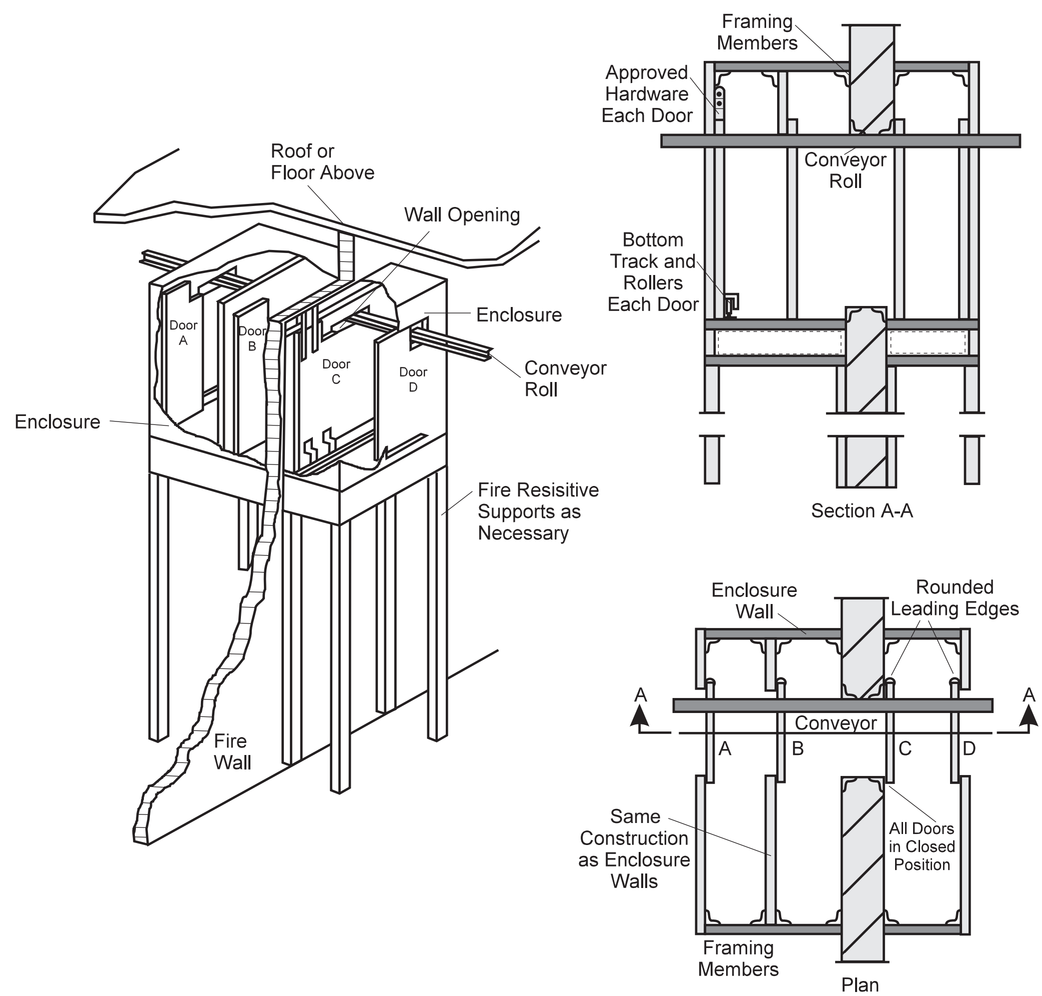


Fig. 63. Door-pack installation (reprinted with permission from NFPA 80, Fire Doors and Windows)

2.5.9.1.7 Ensure the enclosure and baffles in the door pack are constructed of at least 4-hour fire-rated material. If the door pack enclosure is above floor level, ensure its supporting structure has a fire-resistance rating equivalent to that of the wall. Ensure fire doors are rated for at least 3 hours (F180, EI180).

2.5.9.1.8 Ensure “Go” and “Return” passes for chain or rail conveyors do not penetrate the same wall opening or use the same door pack enclosure.

2.5.9.1.9 Use the following formula to determine the minimum number of 3-hour fire-rated doors in door packs for chain or rail conveyors (see Section 3.4.3 for an example):

$N = S_h/(S_c - T_d)$

Where:

N = number of doors.
S_h = horizontal spacing between hangers, in. (mm).
S_c = clear space between stock, in. (mm).
T_d = thickness of the door, in. (mm).

2.5.9.1.10 Ensure the door spacings for door packs in chain and rail conveyors are even and meet the following criteria:

$S_d = S_c - T_d$
$S_d = (L_s + Td)/(N-1)$

Where:

S_d = center-to-center spacing of doors, in. (mm).
L_s = length of stock perpendicular to wall, in. (mm).

2.5.9.1.11 When it is not practical to provide door packs, arrange the chain or rail conveyor system so all fire wall openings can be cleared at the same time. Provide double, minimum 3-hour-rated fire doors at each opening along with photo eyes that will allow the openings to be cleared before the material handling system is shut down for any reason. Provide a backup power supply to prevent conveyed material from stopping in the path of fire doors due to power failure.

2.5.9.1.12 Do not penetrate MFL fire walls with pneumatic conveyors carrying combustible material.

2.5.9.1.13 Protect pneumatic conveyors carrying noncombustible material with two 3-hour fire-rated dampers located in the fire wall. (Provide at least one in each wall in the case of a double wall.) Arrange the dampers for automatic closure by activation of detectors rated at 165°F or less but no lower than 50°F above ambient temperature (74°C or less but no lower than 28°C above ambient temperature) located on each side of the wall (Figure 64).

2.5.9.1.14 Provide slip joints in the pneumatic conveyor on both sides of the wall (see Figure 65). If a double fire wall is used, provide a slip joint between the two walls.

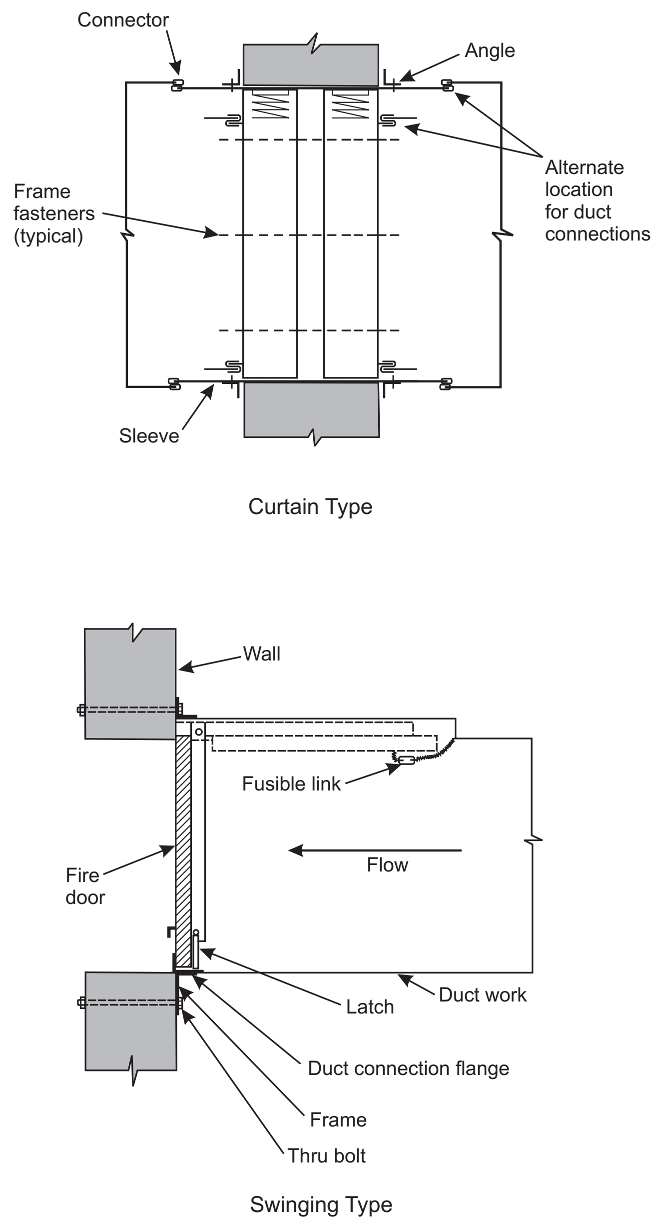


Fig. 64. Fire dampers (courtesy of the Sheet Metal and Air Conditioning Contractor's National Association, Inc. [SMACNA])

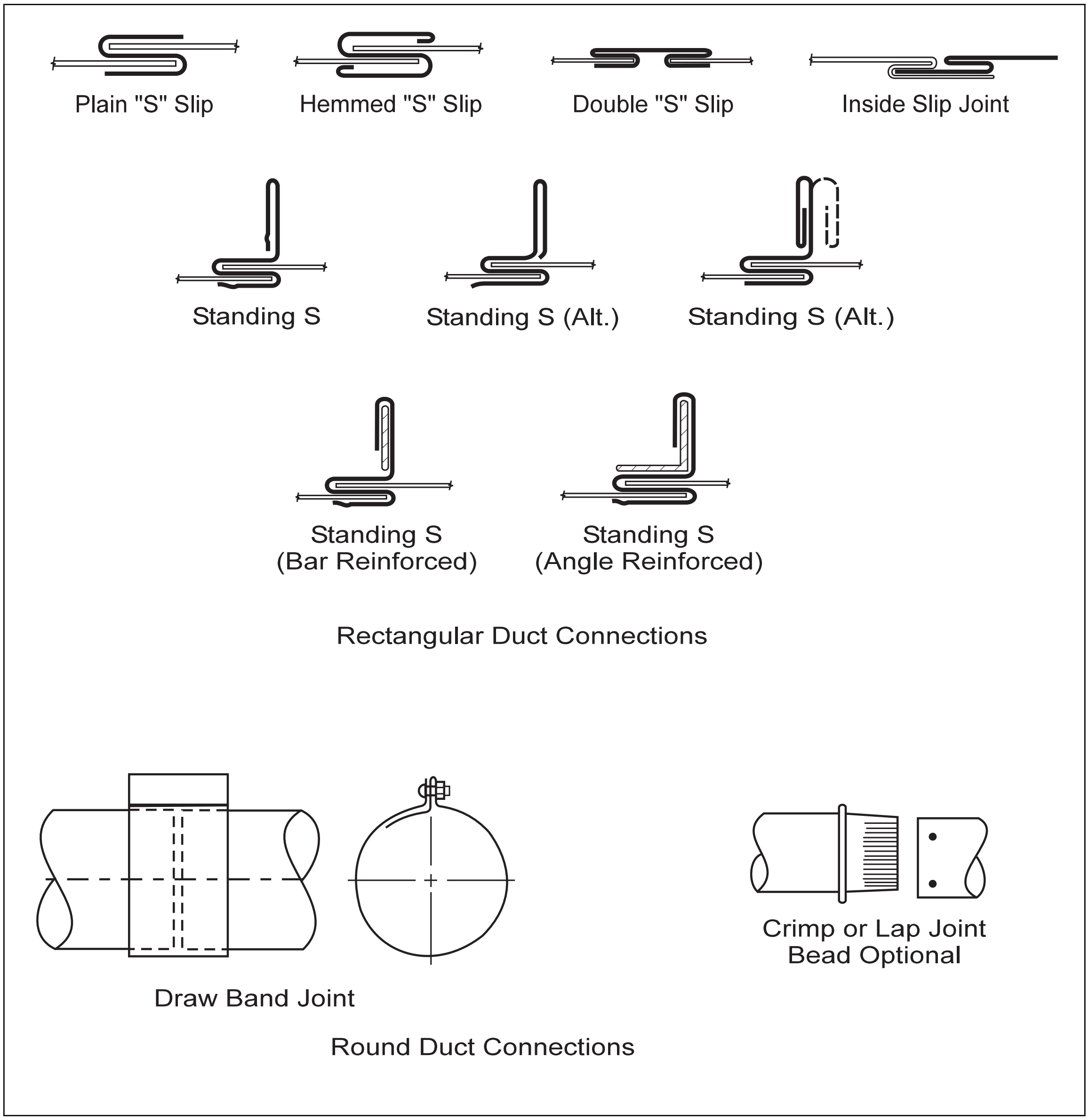


Fig. 65. Breakaway connections (slip joints) (courtesy of the Sheet Metal and Air Conditioning Contractor's National Association, Inc. [SMACNA])

2.5.9.1.15 Roller and Belt Conveyors with Inclined Gravity Sections

2.5.9.1.15.1 Regardless of the power supply arrangement, provide a photo-eye on the take-away side of the opening to prevent back-up of goods near the door. Arrange it to shut down the feed conveyor before goods can back up within a distance equal to the maximum opening dimension (see Figures 66-68).

Exception: When the fire doors have a temperature rise rating or insulation rating (I) for the unexposed face of 325°F (180°C) or less, the distance equal to the maximum dimension of opening is not needed.

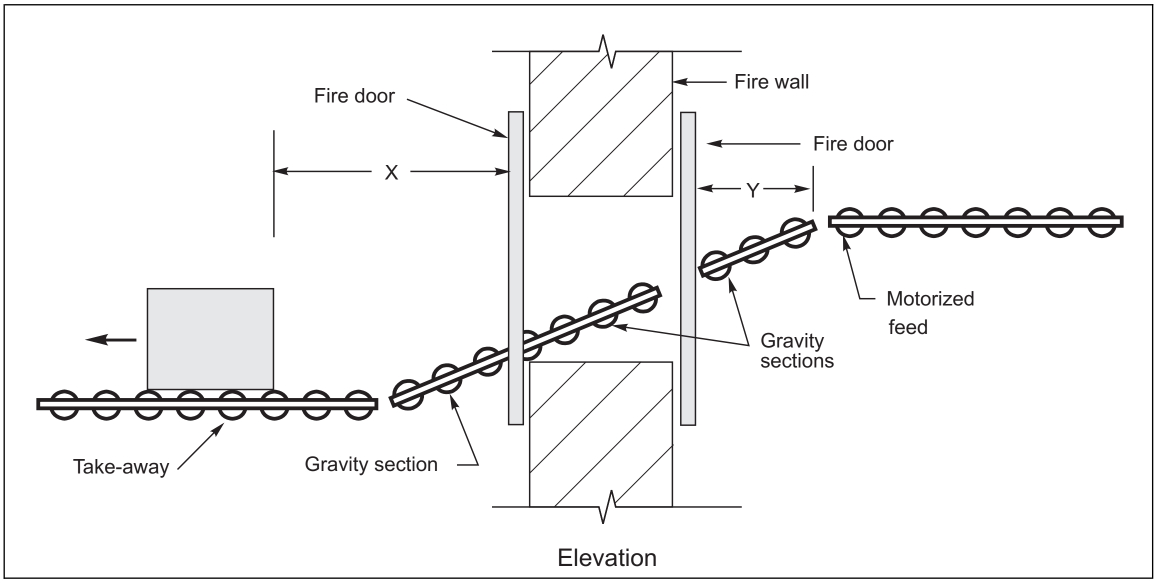


Fig. 66. Roller conveyor protection.

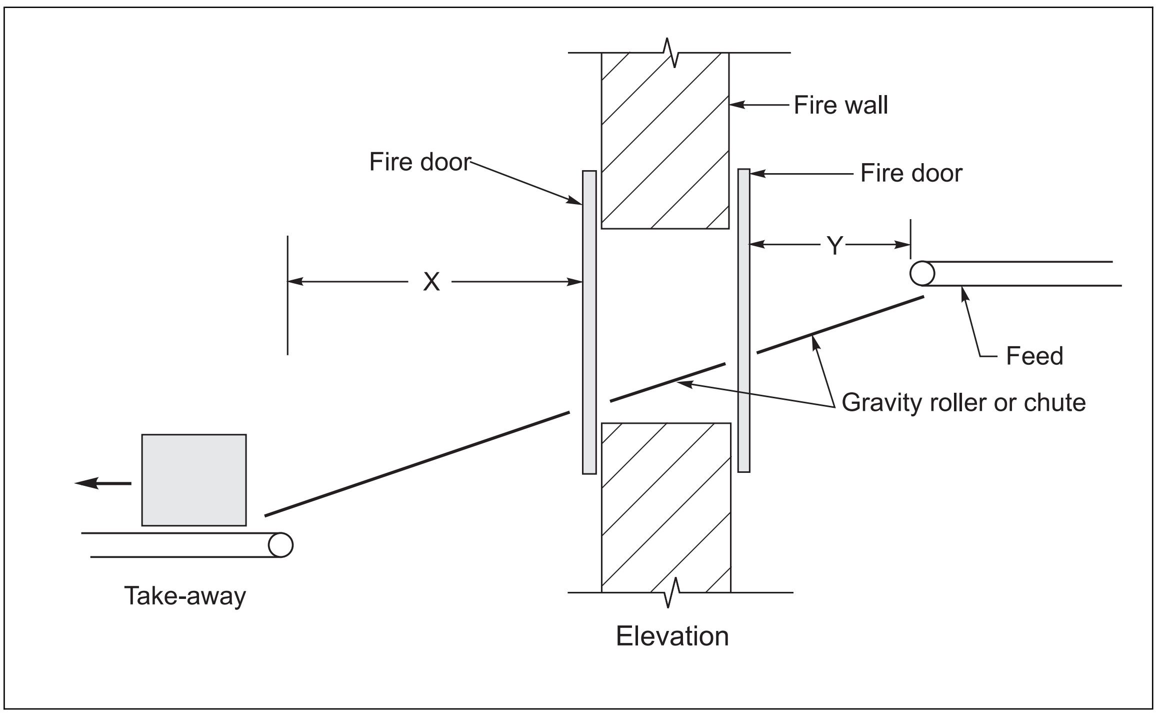


Fig. 67. Belt conveyor protection.

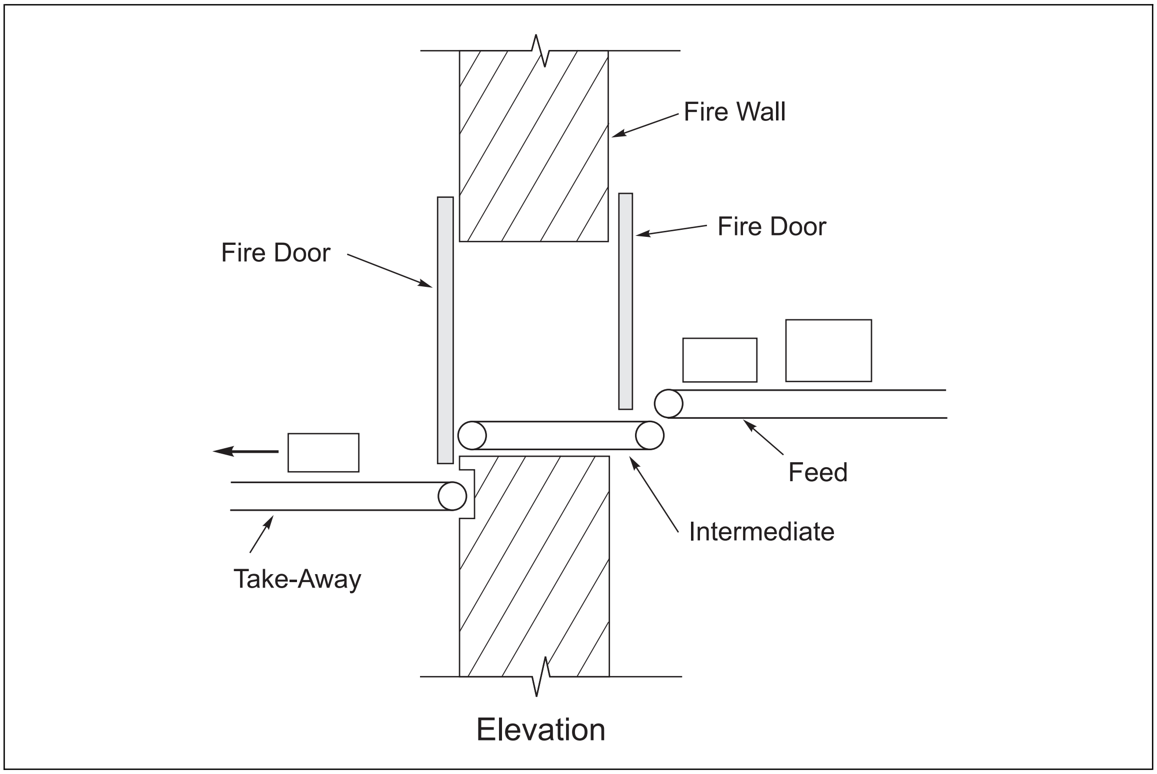


Fig. 68. Conveyor penetration without incline

2.5.9.2 Automatic Guided Vehicle Systems (AGVS)

2.5.9.2.1 Test the AGVS interlocks at least semiannually.

2.5.9.2.2 Instruct AGVS operators as follows:

A. Investigate and correct all vehicle alarm conditions immediately after discovery.

B. Take vehicles with low batteries out of service and recharge them.

C. If the emergency bumper is actuated, remove any remaining obstacles, restart the vehicle and continue its route.

D. In the event of a control system malfunction, shut the system down (after all vehicles are stopped at the next zone station); investigate AGV passages through fire walls and remove vehicles from the path of fire doors immediately.

2.5.10 Air-Handling Systems

2.5.10.1 Provide slip joints in the ductwork on both sides of the wall. If a double fire wall is used, provide a slip joint between the two walls.

2.5.10.2 Provide openings for ductwork with two 3-hour rated fire dampers located in the plane of the fire wall. (Provide at least one in each wall in the case of a double wall.) Arrange the dampers for automatic closure by activation of 135°F or 165°F, or 50°F above ambient temperature (57°C or 74°C, or 28°C above ambient temperature) rated detectors located on each side of the wall.

2.5.10.3 Ensure duct coverings (insulation) do not extend through the wall. Ensure coverings do not conceal or interfere with the use of any service opening.

2.5.10.4 Interrupt duct linings at fire dampers so as not to interfere with automatic closure.

2.5.10.5 Provide a service opening adjacent to each fire damper and fire detection device (e.g., smoke detector, fusible link). Ensure the opening is large enough to permit testing and resetting of the damper.

2.5.11 Operation and Maintenance

2.5.11.1 Test fire doors per Appendix E semiannually, using a method that constitutes a simulation of an actual fire.

2.5.11.2 Close fire doors during idle periods.

2.5.11.3 Instruct facility personnel in the importance of keeping openings clear of stock and equipment.

2.5.11.4 Post signs instructing employees to keep fire wall openings clear and to report all damage to fire doors or hardware immediately.

2.5.11.5 Keep doors clean and painted (except as noted in 2.5.11.6 and 2.5.11.7), particularly when subject to deterioration from corrosion. Examine metal-clad fire doors periodically for evidence of deterioration of wood cores. Keep flame baffles and binders clean and free.

2.5.11.6 Do not apply paint to the slats of rolling steel fire doors or to the operating components (moving parts) of any type of fire door.

2.5.11.7 Do not paint over labels on fire doors, frames, or operators.

2.5.11.8 Keep door tracks clean at all times.

2.5.11.9 Fill in all openings no longer required with concrete or masonry of a fire-resistance rating equivalent to that of the fire wall. Remove steel jambs or cover them with fire-resistant material.

2.5.12 Use of Other Codes and Standards

2.5.12.1 Products tested and listed by internationally recognized testing laboratories can be used when FM Approvals does not list that category of product or material or where FM Approved products are not available.

2.6 Multiple Water Supplies

2.6.1 The concept of multiple water supplies for automatic sprinkler protection may be used to limit the MFL area. Consult with your FM loss prevention engineer for details before applying this concept.

2.6.2 Ensure each water supply provides adequate flow and duration for the automatic sprinkler protection supplied (refer to other Data Sheets).

2.6.3 Ensure the water supplies are independent and not subject to a common, local impairment such as a broken underground main (on or off the subject property).

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Application of MFL Limiting Factors

Larger properties generally are subdivided into fire areas to limit the spread of fire. Horizontal fire spread is limited by space separations between buildings, or by MFL fire walls. In multi-story buildings, vertical spread from one story to another is limited by floor construction, exterior wall construction, mechanical floors, setbacks, balconies, and by enclosures around stairways, elevator shafts, and other openings.

The need for MFL limiting factors is usually determined by the values exposed in a single fire. Limiting factors may be walls, space separation, lack of continuity of combustibles, fire response or a combination of these. If an MFL fire wall is used, the wall must be designed for stability as well as fire resistance, and must confine an uncontrolled fire to the side of origin. In addition to stability and fire resistance, other factors that must be considered in the design are protection of openings, exterior walls, parapets, penetrations, and roof details. The system design must prevent fire spread through, under, over, or around the MFL fire wall.

The placement of MFL fire walls takes into consideration property damage and loss of production. MFL fire walls are used to subdivide production and to separate manufacturing lines from storage.

Considering MFL fire walls in the design of new construction is imperative. When MFL subdivision is indicated, consideration must be given to providing separate electrical, mechanical, and plumbing systems on each side of the wall to help eliminate the need for penetrations through the wall. Consideration at the planning stage also may help in limiting the number and size of openings in the wall as well as in ensuring that loading docks, roof penetrations, and roof-mounted structures are at an adequate distance from the fire wall.

3.2 MFL Fire Walls

3.2.1 Fire Resistance of Wall Construction

An MFL fire wall must have insulating qualities so temperatures on the unexposed face of the wall will not ignite combustibles. The recommended fire rating of the wall is determined by the expected severity and duration of the fire. MFL fire walls normally need a 4-hour fire-resistance rating.

Walls constructed of gypsum wallboard on studs or a cementitious coating on lath on studs are not considered durable enough to be acceptable as MFL walls. It is expected that both types of construction would be damaged during roof framing collapse, either by glancing blows from falling objects or from stress at penetrations. Damage to gypsum wallboard in earthquakes is also common. In addition, unprotected gypsum board may erode when subjected to hose streams that exceed (in flow, pressure, and duration) those used in fire-resistance tests.

Do not use any type of EIFS as part of an MFL wall, end wall, or angular exposure wall. EIFS is not considered adequately durable or impact resistant. Even EIFS with a noncombustible insulation or as an architectural feature over a durable, impact-resistant, and fire-rated wall should not be used because the finish and base coats can be combustible.

Do not use wall assemblies that contain foam plastic insulation (e.g., precast or tilt-up concrete panels). Such assemblies, even those that have passed fire resistance testing for 4 hours, are subject to failure due to the liquification or vaporization of the plastic insulation.

Do not use spray-applied fire protection coatings that use an expanded plastic aggregate. Spots where the spray-applied coating is missing or is thinner than the tested minimum thickness are more critical when using a plastic aggregate in place of a noncombustible aggregate such as perlite or vermiculite.

See Data Sheet 1-21, *Fire Resistance of Building Assemblies*, for methods of providing fire resistance.

3.2.2 Stability and Strength

Stability is an essential property of an MFL fire wall because it must remain standing during a fire, even if the building frame on one side collapses.

Several different types of MFL fire walls exist. Each type achieves stability in a different way. Consequently, combining the stability aspects of two different types of MFL fire walls may result in a lack of stability under fire conditions. Unless otherwise noted, general recommendations for integrity apply to all types of MFL fire walls.

Strength is necessary so the wall will be able to resist glancing blows from falling materials, force and thermal shock of fire hose streams, thermal stresses from the fire, and forces from collapsing portions of floors and/or roofs adjacent to the wall.

Many modern industrial buildings depend on structural steel frames for stability. A wall that obtains its lateral support from a steel frame can be destroyed by collapse of part of the frame in an uncontrolled fire. As unprotected steel trusses, girders, or beams approach and exceed temperatures of 1000°F (538°C), they initially expand and then lose some of their strength, twisting and sagging. Large horizontal forces can develop toward the wall as the steel expands, and then away from the wall as the steel fails. Design considerations must be made to prevent damage as a result of these forces, which may crush the wall or deflect it laterally to the extent that its structural integrity is destroyed.

3.2.2.1 Clearance Between MFL Fire Walls and Steel Framing

The information in Table 1 is based on the thermal expansion of steel heated to an average temperature of 825°F (441°C) over two bays.

Clearance = (0.0000065 in/in.°F) x (825°F) x (2) x (span ft) x (12 in./ft)

The assumption is that the greatest expansion will occur given the following:

A. The MFL fire will be large enough that more than one bay will be affected before collapse.

B. Three or more bays could be affected, but a third or fourth bay is less likely to contribute to the expansion because of additional joints and minute differences in alignment that will absorb the additional expansion in buckling.

C. An average steel temperature (not gas temperature) of 825°F (441°C) was used based on the assumption that by the time the average steel temperature is reached, some portion of the two bays will have exceeded 1,000°F (538°C) and that portion will have started to sag and thus will no longer add to the expansion.

Therefore, although one bay length is used in the table, this length is actually doubled when calculating the minimum clearance.

For tall frame structures it is recommended that the structural system be evaluated on a case-by-case basis because of the high variability that these systems can exhibit depending on the dimensions, boundary conditions, element size, etc.

Reinforced concrete frame buildings have some degree of fire resistance and will remain structurally sound until heat penetrates the concrete cover over the reinforcing steel and weakens the steel. For the amount of cover necessary, or a given fire-resistance rating of a reinforced concrete member, see Data Sheet 1-21, *Fire Resistance of Building Assemblies*.

3.2.2.2 MFL Walls in FM Earthquake Zones

The potential for a fire during or after an earthquake increases due to the damage caused by the ground movement. The likelihood that automatic fire protection systems will be damaged or completely out of service also increases as a result of the earthquake. Therefore, passive fire protection, such as fire-resistant construction and fire walls, becomes increasingly important in active seismic zones. The maximum foreseeable loss philosophy dictates that MFL fire walls must remain stable during and after an earthquake in order to perform their purpose of subdividing properties into separate fire areas. To accomplish this, the wall must be designed for seismic loads as well as stability under fire conditions.

The recommendations in Appendix C were developed to ensure reasonable stability during an earthquake. The design criteria are based on SEI/ASCE 7, *Minimum Design Loads for Buildings and Other Structures*. The SEI/ASCE 7 criteria are incorporated in building codes such as the International Building Code.

Meeting earthquake design requirements may eliminate one or more of the options for achieving stability that would otherwise be allowed in non-earthquake areas. For example, preventing damage to a fire wall from steel expansion during a fire by aligning the steel members on both sides of the wall and providing essentially no clearance is not an option in active seismic areas if it will allow pounding during an earthquake.

Because MFL fire walls must be the most reliable method of preventing horizontal fire spread, they are equated with an essential facility. Essential facilities are those structures that must remain functional subsequent to an earthquake. Therefore, an importance factor (IE) of 1.5 is used for MFL fire walls.

The earthquake accelerations given in Appendix C are only intended to be used when other appropriate earthquake acceleration parameters are not available. These accelerations were chosen to provide a degree of reasonableness given the combination of factors relating to both probability and severity.

Specifying a minimum reinforcing ratio is a method of ensuring a minimum level of strength and crack control for the wall.

Example 1: Calculation of Reinforcing Ratios for a Masonry Wall

Given:

- 8 in. nominal (7.625 in. [195 mm] actual) masonry wall
- 10 ft (3.0 m) in height
- No. 9 (W1.7) horizontal joint reinforcing (two 0.148 in. [3.7 mm] diameter steel wires) at 16 in. (400 mm) on center
- One bond beam reinforced with two #4 bars (1/2 in. [13 mm] diameter)
- Vertical reinforcing #5 (0.625 in. [16 mm] diameter) spaced at 24 in. (600 mm) on center

Steel area calculations:

- #4 bars steel area = 0.20 in^2
- #5 bars steel area = 0.31 in^2
- No. 9 wires (2) steel area = 2 x 0.0172 in^2 = 0.0344 in^2

Calculate ratios:

- Gross horizontal area = 10 ft x 12 in./ft x 7.625 in. = 915 in^2
- Minimum horizontal steel area = 0.0007 x 915 in^2 = 0.64 in^2
- Check horizontal steel area = (2)(0.20 in^2) + (7)(0.0344 in^2) = 0.641 in^2 > 0.64 in^2
- Gross vertical area = 12 in./ft x 7.625 in. = 91.5 in^2/ft
- Minimum vertical steel area = 0.0007 x 91.5 in^2/ft = 0.064 in^2/ft
- Check vertical steel area = (0.31 in^2/24 in.)(12 in./ft) = 0.155 in^2/ft > 0.064 in^2/ft
- Check total steel area = (0.641 in^2/15 in^2) + (0.155 in^2/91.5 in^2) = 0.0007 + 0.0017 = 0.0024 > 0.002
- Therefore, the wall reinforcing meets the prescribed minimum values.

3.2.2.3 Explosion Hazards

Examples of occupancies that present an explosion hazard:

- Any ignitable liquid process that has an explosion hazard as defined in FM Data Sheet 7-32, *Ignitable Liquid Operations*
- BLEVE potential (refer to multiple 7-series data sheets)
- Improperly protected dust-handling equipment
- An occupancy with a dust room explosion hazard
- Equipment with a PV rupture potential

Walls designed to be MFL fire walls do not have sufficient strength to act as explosion-resistant walls. Occupancies that are not considered a potential explosion hazard with sprinklers in service (such as ignitable liquid storage rooms) may be an explosion hazard if protection is impaired. Occupancies with a potential explosion hazard (with or without sprinklers in service) should be located in rooms remote from MFL fire walls.

As a guideline, a space of 125 ft (38.1 m) is suggested. Such rooms that are not remote from MFL fire walls should be designed according to Data Sheet 1-44, *Damage Limiting Construction*. Where such a room must be adjacent to an MFL fire wall, the pressure-resistant wall must be a separate wall on the hazard side of the MFL fire wall. The pressure-resistant wall should be far enough away from the MFL wall so it would not deflect into the fire wall. It is not recommended that a common wall section of the MFL fire wall be reinforced to act as a pressure-resistant wall. Even an effective pressure-resistant wall may be compromised during an explosion. If ignitable liquids with flashpoints below 100°F (38°C) are used or handled in areas near MFL fire walls, refer to the appropriate 7-series data sheet for safeguards.

3.2.3 Cantilever Fire Walls

Cantilever MFL fire walls (see Figures 22 and 23) are entirely self-supporting without any ties to adjacent framing. They are usually constructed of reinforced concrete masonry, brick, or reinforced concrete. Such walls are erected at an expansion joint in the framing, but are not fastened to the building frame on either side.

Horizontal forces in cantilever walls are induced by fire. The horizontal forces may be caused by the pull of roof flashing as the burning portion of the building collapses, by irregularities of construction, or by warping of the wall under fire exposure.

For stability against horizontal forces, the wall must rely on its own strength as a cantilever. Such lateral strength may be obtained by providing vertical reinforcing bars in the wall, or reinforced pilasters. Unreinforced pilasters or pilasters constructed on only one side of the wall usually do not adequately strengthen the wall. Cantilever walls over 30 ft (9 m) high become expensive to stabilize.

Use of tilt-up concrete panels for cantilever (and other types) of fire walls has become increasingly popular in recent years. Some key requirements during design and review are the following:

- Stabilize the wall as a cantilever using footing, floor slab, soil, etc., to resist the required overturning moment.
- Pay attention to joint details between panels to ensure they are adequately sealed and no relative panel movement occurs.
- If precast panels are used, ensure they do not contain foam plastic or other combustible material in the cores.

Steel framing on the fire side of the wall will expand and may cause failure of the wall, particularly when steel on each side does not line up horizontally and vertically (see Figure 69). Clearance between the wall and steel framing (Table 1) on both sides is needed to allow steel framing on the fire side to reach the point of maximum expansion without exerting force on the fire wall (see Figure 4).

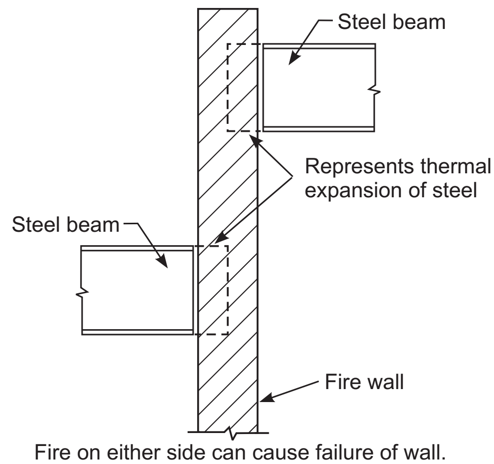


Fig. 69. Steel not lined up vertically

3.2.4 Tied Fire Walls

Tied MFL fire walls (see Figures 27, 28, and 31) are fastened to (and usually encase) members of the steel building frame. To remain stable, the pull of the collapsing steel on the fire side of the wall must be resisted by the strength of the unheated steel framing on the other side.

Because the fire can occur on either side of the wall, the wall must be located at the center of strength of the building frame. The center of strength is the plane within the building frame in which the steel framing on either side has equal resistance. In small structures, the center of strength generally is in the middle of the building frame (see Figure 25). The center of strength may lie between two double-column expansion joints (see Figure 26) in large buildings. Single column line expansion joints do not break the continuity of the building frame.

Fire exposure can cause bowing of the wall. This movement of the wall out of its normal vertical plane could allow normal gravity loads (live and dead roof loads) to overstress the wall. Also, the sagging of the steel on the collapsing side will result in lateral and twisting forces at the top of the wall, which could collapse or otherwise damage the wall.

3.2.5 One-Way Fire Walls

A wall that is tied to a steel building frame on one side and is entirely independent of the frame on the other side is a one-way fire wall. Generally, this type of wall is only effective if an uncontrolled fire starts on the side of the wall that is not providing structural stability for the wall.

One-way walls also may reduce the MFL when used in combination with MFL fire walls. As an example (see Figure 70), a building could be separated into three areas by an MFL fire wall (A) and a one-way wall (B) tied to the steel frame of areas 1 and 3. Fire originating in area 1 could involve two of the areas (1 and 2) but would be prevented from entering the third area (3) by the one-way wall.

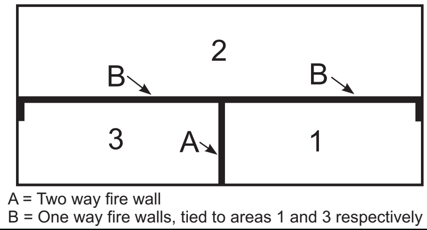


Fig. 70. One-way fire walls

Two distant one-way walls in parallel and supported by separate framework can be built at double-column line expansion joints. As an example (see Figure 71), one-way fire walls (B) could be tied to the steel framework of Areas 1 and 3 respectively. A single fire would not involve more than two areas. Usually a 4-hour fire rating is needed.

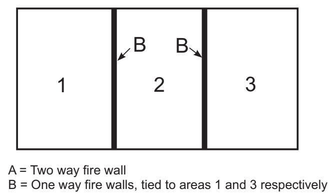


Fig. 71. Two one-way fire walls tied to areas 1 and 3 respectively

3.2.6 Double Fire Walls

A double MFL fire wall (Figures 34 and 35) consists of two one-way walls back to back. It is most adaptable where an addition to a facility necessitates an MFL fire wall between an existing structure and a new building.

The existing wall, which is secured to the building frame, is altered to provide the proper fire resistance if necessary. Another fire wall is then constructed adjacent to the existing one and secured to the new building frame. With an uncontrolled fire on either side of this double wall, one building frame will collapse, pulling the wall on that side with it. The other wall, being supported by steel on the protected side, will remain in place to stop the fire spread.

3.2.7 Panel Walls in Reinforced Concrete Buildings

This type of MFL fire wall consists of wall panels (usually 4-hour rated) tied to the columns and/or floor(s) and roof framing of a reinforced concrete building (columns, floor, and roof supports) of equal fire resistance.

Because the building to which the wall is tied will be stable throughout the duration of the fire, no special considerations need be made regarding stability. The span between, and connection to, columns and/ or floor(s) and roof framing should be adequate to resist the loads specified in Section 2.2.2.7.

If construction on both sides of the wall is 4-hour fire-rated reinforced concrete, the roof or floor framing would not sag onto pipe penetrations through the wall and then collapse.

Consequently, the structural aspects of recommendations 2.2.6.2(A) and 2.2.6.5, need not apply to this situation. However, penetrations must still be sealed with FM Approved fire stop systems.

3.2.8 Control of Cracking

MFL fire walls must have expansion joints in line with those of the building frame to prevent cracking. The width of these joints is determined by normal building temperature change.

Control joints also must be provided in masonry walls to accommodate initial shrinkage in the wall. These normally are narrower than expansion joints and usually are spaced one per bay.

3.2.9 Parapets and Roof Protection

MFL fire walls have no value if an uncontrolled fire can sweep over them and spread to the protected area via the roof. Parapets are needed to help prevent this.

Parapets must be high enough to protect adjacent combustible monitors, penthouses, cooling towers, and saw tooth roofs from direct ignition by heat or flames passing over the wall.

Resistance of the parapet to wind or earthquake loads also must be considered. Extremely high parapets are impractical to construct; consequently the design of the buildings must allow for roof structures to be as remote as possible from the MFL fire wall.

Burning embers and heat radiating over a parapet of reasonable height necessitate surface protection for the roof covering, and space separation between equipment or structures mounted on or penetrating the roof (see Figure 11).

Fire-retardant coatings or paints may increase the fire performance of roof membranes; however, their durability and fire performance is not as good as a gravel surface. The coatings are also likely to wear off, so they are not considered reliable enough for use with MFL walls.

3.2.10 End Walls and Angle Exposure

The building walls at each end of an MFL fire wall must be designed to prevent fire from sweeping around the MFL fire wall (see Figures 15, 16 and 17).

There is also danger of fire spread from the exterior walls of two buildings or sections of a building that form an angle at or near the end of the MFL fire wall (see Figure 18). Flames or heat can penetrate openings in walls across this intersection and start fires around the MFL fire wall. The degree of protection needed depends upon the expected durability of the exterior walls during an uncontrolled fire, and on the hazards of the occupancies and construction.

3.2.11 Penetrations: Pipes, Conduit, Cables, and Ducts

Pipes, conduit, cables, and ducts must not penetrate MFL fire walls because they could destroy the structural integrity and the resistance of the wall. If pipe, duct, conduit, or cable penetrations of MFL fire walls are necessary, they must be kept to a minimum and the precautions recommended in Section 2.2.6 must be taken to maintain the integrity of the wall.

Recommendations 2.2.6.2(A) and 2.2.6.5 do not apply to panel MFL fire walls in reinforced concrete frame buildings, except that penetrations must still be sealed with FM Approved fire stop systems.

Although automatic sprinklers are not depended upon to limit an MFL loss, feeding the sprinkler systems on each side of the wall separately will reduce the chance of both systems being out of service.

3.3 MFL Space Separation

3.3.1 General Space Separation Information

MFL subdivision may be provided by adequate space separation between buildings. The area must remain clear of combustible material.

Space separation is one aspect of MFL subdivision where judgment is extremely important. Many factors need to be considered in determining how much separation is needed. These factors include the height and severity of the exposure hazard, the floor area, type of building construction, and length of the exposing wall of the exposing structure, in addition to the construction of the walls and roof of the exposed building.

In evaluating space separation, items to consider include the following:

- Building height
- Slope of land between buildings
- Vehicle parking between buildings
- Clear space
- Yard storage
- Vegetation

3.3.2 Categorizing Exposed Construction in MFL Space Separations

In evaluating space separation, the construction features on each side of the separation must be considered individually because, under MFL conditions, the MFL exposure could occur from either side.

When categorizing the exposed wall construction you must consider not only the combustibility and susceptibility of the wall itself but also any openings, penetrations and anything attached to the wall. The assigned wall category must be driven by the least fire resistant element. For example, a concrete masonry wall consisting of 1-hour fire-rated concrete masonry units, type S mortar has several single-pane, annealed glass windows. The least fire resistant element of the wall is the windows. The wall must be categorized as combustible because when exposed to enough radiation, the single-pane, annealed glass windows will break and expose ordinary combustibles inside the building to radiation and possibly burning brands.

When categorizing exposed walls, consider the fire resistance of the following elements:

- Wall external surface
- Wall insulation
- Penetrations (pipe, cable, utilities, etc.)
- Windows (type of glazing and number of panes)
- Doors (fire-rated, unrated, noncombustible and combustible)
- Roof eaves (wood eaves and soffits)
- Exposed roof surfaces (gravel surfaced, unprotected, ASTM E108 ratings, mineral surfaced cap sheets, etc.)
- HVAC openings

Tempered glass is also called safety glass. It is treated with a special heating and cooling process to increase its resistance to stress. This treatment also changes the way the glass breaks, making it better for use where safety is a concern, such as in doors and car windows. International codes specify that all safety glass be marked by etching, embossing, or ceramic firing so the label cannot be removed or destroyed.

- Examine the thickness of the glass. Tempered glass is up to five times thicker than standard glass.
- Check for optical distortion. Tempered glass gives a distortion to reflected images as opposed to any other glass. This happens as it is made through extreme heat and cold temperatures.
- Look for roller marks. These will be small whitish-colored streaks on the tempered glass that occurred when it was made.
- Inspect each corner of the glass to see whether it has an etched logo. This may be covered by a frame. The logo may contain wording indicating that it is tempered glass, along with the manufacturer’s identifying information.
- Look along the surface of the glass with light reflecting off it. Tempered glass may have a very slight wavy surface, caused by the rollers used to move it through a horizontal surface. If this is not apparent, the glass may have marks on one edge where tongs held it when moving through the furnace.
- Put on polarized glasses and look at the glass at an angle. A vague checkered pattern is visible at the right angle on tempered glass, which is a result of the tempering process.

Operable windows can obviously be open and thus provide no resistance to convection, radiation or burning brands.

The hazard with windows is that they break and fall out when exposed to significant heat. (While the windows are in place, much of the radiation is reflected or absorbed and does not transmit through the glass.)

3.3.3 Space Separation Analysis Methodology

There are several basic assumptions built into the methodology of analyzing MFL space separation in this document. The first is that the burning building’s exposing wall is either (a) stable, fire resistant, and will remain standing for the duration of the fire, or (b) likely to collapse early in the fire. In the case of the former, the wall will shield some of the radiation allowing only that fraction coming through the openings and from flames above the roof to reach the exposed wall. In the latter case, there is no shielding of the radiation by the exposing building wall and thus the exposed building is subject to 100% of the expected radiation from the fire.

The second assumption is that adequate space separation for exposed wall constructions is based on maintaining a heat flux below the critical heat flux (CHF) for the exposed wall construction.

The third assumption is that the radiant flux on the surface of the exposed wall is generated by the visible portion of the wind-tilted flames above the commodity and from the visible portion of the flames on the commodity itself, to a vertical target.

And the fourth assumption is that the length of the burning array is typically the length of the exposing building but no longer than 500 ft (150 m).

3.3.4 MFL Space Separation Analysis Example

Example: Two 1-story buildings, each 20 ft (6 m) high, are separated by a distance of 35 ft (10.7 m). The exterior walls facing each other across the space separation each have 2-hour fire resistance and parapets. The length of each wall is 80 ft (24 m). Neither wall has any window openings and all door openings are provided with Class D fire doors. The roof of each building is Class 1 steel deck on exposed steel framing. Occupancy in each building is storage. Is the space separation adequate for MFL subdivision?

Solution: From Table 3 for 2-hour fire-rated construction and storage occupancy up to 30 ft (9.1 m), a separation of 30 ft (9 m) is needed; 35 ft (10.5 m) is available, so the separation is adequate.

3.3.5 Pipe Racks in Spaces

Pipe racks over streets and loading stations in streets can result in the failure of a space separation. The event can start in the street between units. In Figure 72, note the storage of totes downhill of the loading station and the lack of drainage or dikes. In Figure 73, note the dikes on both sides of street.

Fig. 72. Pipe rack across a space

Fig. 73. Pipe rack across a space

In Figure 74, a propane fire impinged on the pipe rack support on the left. The pipe rack sagged. Fireproofed steel stayed intact.

In Figure 75, the pipe rack failure did not spread the fire across the space from right to left.

Fig. 74. Failed pipe rack

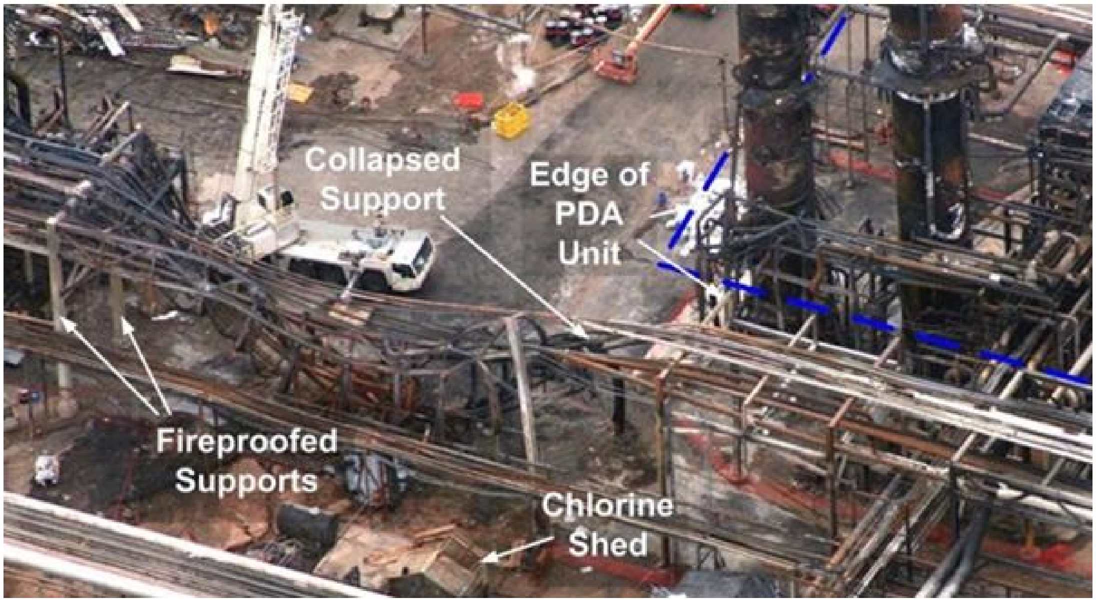


Fig. 75. Failed pipe rack

3.4 Openings in MFL Fire Walls

Openings present a severe threat to the integrity of an MFL fire wall and need the best protection available. The fewer openings in an MFL fire wall, the greater its reliability.

Keep combustibles far enough away from fire doors to prevent their ignition. Unless specifically labeled as a temperature-rise rated door, the door offers virtually no resistance to the passage of heat.

Springs for rolling steel fire doors are under extreme tension. Have only properly trained and qualified personnel test, reset, repair, or adjust these doors.

Protection of material-handling system openings in MFL fire walls is usually a challenge requiring ingenuity and careful design.

3.4.1 Material-Handling Systems

The intent of the recommendations in Section 2.5.9 are to ensure that neither the material-handling system nor the material being conveyed will prevent the fire doors from complete automatic closure and that a clear space is provided on either side of the opening. Other arrangements that meet this intent with the same degree of reliability are acceptable.

Protecting openings for material-handling systems in MFL fire walls is a challenge requiring ingenuity and careful design. Conveyors present a problem because of the variety of arrangements and the variation in shapes and sizes of the material being conveyed.

The most desirable solution is to arrange material flow so material-handling systems need not pass through an MFL fire wall. When this is not possible, the openings in the wall must be protected with an arrangement of automatic closing fire doors. Since the design of MFL subdivision assumes sprinkler protection will be out of service, the use of water spray protection in lieu of fire doors and the use of water flow for initiation of fire door closure is not recommended.

For any material handling system passing through an opening in an MFL fire wall, the fire door assembly with its related hardware and controls must be arranged so the doors will close under fire conditions despite the materials on the conveyor. Controls are needed so that, in the event of fire, the opening is cleared and then the doors automatically operate, completely closing the opening. With chain, rail, or tow conveyors, the conveyor must be de-energized immediately, and then at least one door will find a clear path between the material on the conveyor. With roller or belt conveyors, the feed conveyor is stopped immediately and the downstream conveyor continues to operate (at least briefly) until the opening is cleared, after which the door closes (see Figures 66, 67, and 68).

When multiple fixed temperature or rate-of-rise detectors are used to provide a fire-dependent time delay between the clearing of the opening and closure of the door, the detectors need to have different temperature ratings and be located no more than a few inches apart.

The detector that initiates fire door closure should be rated at least 100°F (38°C) above the temperature rating of the detector used to clear the opening and/or stop the feed conveyor.

The detectors should be closely spaced and located near the top of the opening and at ceiling level on each side of the fire wall.

Unless a gravity section (see Figures 66 and 67) is provided through the MFL fire wall, conveyor protection may not work if the power fails. Systems not using a gravity section (see Figure 68) are consequently less reliable unless a standby power supply, UPS, or mechanical system is provided. In either case, the door closer must function by gravity or by mechanical means, not by electric motor.

3.4.2 Automatic Guided Vehicle Systems

Automatic guided vehicle systems (AGVS) consist of electric-powered, driverless vehicles that can be programmed to follow various paths and load and unload at different stations. There are two types of guidance systems for the automatic guided vehicles (AGV), both consisting of a sensing unit and steering mechanism. An electromagnetic system follows a signal sent through a guide wire located below the surface of the desired path. An optical system uses a guide path that contrasts in color with the floor.

AGVs can be controlled in any of the following ways:

A. By controls located on the vehicle

B. By programming panels located at various fixed stations throughout the system

C. By a single central control station

The central control station (CCS) is the most elaborate of the three control methods. The CCS can be programmed to question the vehicles on a regular basis and obtain information such as the identity and location of the vehicle and the status of its route. It can also monitor vehicle alarm conditions such as loss of guide signal, loss of blocking signal, low battery, and emergency bumper actuation.

An AGV may come equipped with the following safety features:

- Warning lights
- Intersection warning horns
- Emergency bumpers
- Brakes
- Wheel bells
- Emergency stop buttons
- Fire door safety interlocks
- Ramp controls
- Door controls
- Low battery indicators

In an emergency stop, the vehicle will stop with maximum deceleration. The emergency bumper projects in front of the vehicle. When it comes in contact with a person or an object, the vehicle will stop immediately. Loss of guidance signal or manual actuation of an on-board emergency button can also cause an emergency stop of the vehicle. The vehicle must then be manually restarted. AGVS can be programmed for automatic door control, which allows it to open and close power-operated doors.

3.4.3 Chain or Rail Conveyors

A door pack (see Figure 63) consists of a set of fire doors spaced in relation to the stock on the conveyor so that at least one door will always be able to close fully no matter when the conveyor stops. A door pack requires uniform fixed spacing and length of stock. Its use is impractical if the length of stock (perpendicular to the fire wall/partition) exceeds a maximum of about 2¼ times the clear distance between the stock. Take this into consideration when designing chain conveyors and give ample spacing between main hangers. If the conveyor chain is shortened or lengthened, ensure this is done without reducing the distance between hangers. Conveyors with adjacent “go” and “return” passes can be arranged similarly, but ensure there is a noncombustible dividing partition between conveyors as the stock will usually be in a different position relative to the doors at the two openings.

Example: The following is an example using the formula for determining the minimum number of door packs.

Given:

S_h = 65 in. (1650 mm)
L_s = 45 in. (1140 mm)
T_d = 3 in. (75 mm)

Question 1. Is a door pack practical?

$S_c = S_h - L_s = 65-45 = 20$ in.
($S_c = S_h - L_s = 1651-1143 = 508$ mm) $L_s = 45$ in. $\leq (2.25)(S_c) = 45$ in.
($L_s = 1143$ mm $\leq (2.25)(S_c) = 1143$ mm).

Answer 1. Yes, a door pack is practical.

Question 2. How many doors are needed?

N = 65/(203) = 3.8.
(N = 1651/(50876) = 3.8).

Answer 2. Four doors are needed.

Question 3. What is the center-to-center spacing of the doors?

$S_d \leq S_c - T_d = 203 = 17$ in.
($S_d \leq S_c - T_d = 508-76 = 430$ mm).

$S_d \geq (L_s + T_d)/(N-1) = (45 + 3)/(4-1) = 16$ in.
($S_d \geq (L_s + T_d)/(N-1) = (1143 + 76)/(4-1) = 400$ mm.

Answer 3. Use S_d = 16.5 in. (420 mm).

3.4.4 Tow Conveyors

If the clip-on points of tow conveyors are far enough apart to give a clear space between carts greater than the length of the cart, a fire-resistive vestibule abutting the wall with fire doors at each end is adequate.

Ensure the walls and roof of the vestibule are equal in fire resistance to the fire wall, and that the roof is constructed of reinforced concrete to protect against damage from collapsing roof members.

$D_c > L_v + 2\ T_d$
$D_D > L_c$

Where:

D_c = clear distance between carts, ft (m).
L_v = length of the vestibule, ft (m).
T_d = door thickness, ft (m).
D_D = clear distance between doors, ft (m).
L_c = length of the carts, ft (m).

This assumes doors are mounted on the face of the vestibule.

Example: The distance between clip-on points is 12 ft (3.7 m); carts are 4 ft (1.2 m) long; the space between carts is 8 ft (2.4 m); the vestibule is 6 ft (1.8 m) long; and the doors are 0.25 ft (0.1 m) thick and mounted on the faces of the vestibule.

The same principles apply as for door packs, but conditions are usually much simpler.

L_c = 4 ft (1.2 m)
D_c = 12 ft-4 ft = 8 ft (3.7 m-1.2 m = 2.5 m)
L_v = 6 ft (1.8 m)D_D
T_d = 0.25 ft (0.1 m)
D_c = 8 ft > 6 ft + 2 (0.25 ft) = 6.5 ft, (meets criteria)
(2.5 m > 1.8 m + 2 (0.1 m) = 2.0 m, meets criteria)
D_D = 6 ft > 4 ft (1.8 m 1.2 m, meets criteria)

3.4.5 Air Handling Systems

Penetration of MFL walls and fire walls with ductwork must be avoided. When they are necessary, they must be treated like other openings. The recommendations for slip joints on either side of the wall, and for dampers in the plane of the wall, are intended to prevent a collapse on the fire side from reducing the effectiveness of the fire dampers.

Fire dampers are tested in much the same way as fire doors. The assembly is subjected to an exposure conforming with the standard time-temperature curve for the specified time. Immediately after the fire exposure, the assembly is subjected to a hose stream test whose duration and water pressure depend on the size of the assembly and the length of the exposure. Like fire doors, the pass/fail criteria is based on the passage of flames and restrictions on the size of openings created by the exposure. Fire dampers generally do not have any significant insulating value or ability to prevent the passage of smoke.

Listed leakage rated dampers used to control the passage of smoke (smoke dampers) are also available. These dampers do not necessarily have a fire endurance rating. They are classified according to the rate of smoke leakage through the damper under specified pressure differentials (see Table 5).

Table 5. Damper Leakage Classification

	$ft^3/min/ft^2$ ($m^3/s/m^2$)			
Class	1 in. H_2O (0.249 kPa)	4 in. H_2O (0.995 kPa)	8 in. H_2O (1.99 kPa)	12 in. H_2O (2.99 kPa)
0	0	0	0	0
I	4 (0.0204)	8 (0.0408)	11 (0.0561)	14 (0.0714)
II	10 (0.0510)	20 (0.1020)	28 (0.1429)	35 (0.1786)
III	40 (0.2041)	80 (0.4082)	112 (0.5714)	140 (0.7143)
IV	60 (0.3061)	120 (0.6122)	168 (0.8571)	210 (1.0714)

3.4.6 Openings in MFL Fire Walls in FM Earthquake Zones

Performance of fire doors after an earthquake can be affected in two ways. The first is the attachment of the door/frame to the wall. The seismically induced movement of the wall could result in the door/frame becoming dislodged from the wall, or movement of the frame or guides so they are no longer plumb or square. Secondly, the functional operation of the door itself could be affected by the seismic shaking.

To reduce the risk of detachment from, or movement of, the wall affecting the fire door, it is recommended that MFL fire walls be designed for seismic loads, and that they be limited to reinforced masonry or reinforced concrete construction. The use of lighter construction (e.g., gypsum on metal studs) and unreinforced masonry is more likely to result in the door/frame being detached from the wall or the opening/frame being no longer plumb and square.

3.5 Multiple Water Supplies

The concept of multiple water supplies is based on the premise that the maximum foreseeable fire event consists of impairment of a single water supply or all the automatic sprinklers it supplies. If there are multiple supplies the MFL area may be limited.

3.5.1 Independency and Common Impairment

The water supplies must not be connected in any way that would reduce the reliability and effectiveness of both supplies. Three examples are:

A. Direct physical connection: A direct connection via above or belowground piping could result in the depletion of both supplies. In the case of fire protection tanks, a piping failure could empty both tanks. An aboveground pipe failure could lead to failure of one supply and overtaxing of the second supply.

B. Electric fire pumps with a common power supply: A common power supply could be two electric fire pumps relying on the same transformer on the property. The failure of that transformer would disable both pumps and water supplies.

C. Multiple connections to the same public supply: A common impairment in this case could be a local main break on the public supply. If the break can not be quickly isolated, multiple connections could be impaired.

4.0 REFERENCES

4.1 FM

Data Sheet 1-2, *Earthquakes*
Data Sheet 1-3, *High-Rise Buildings*
Data Sheet 1-20, *Protection Against Exterior Fire Exposure*
Data Sheet 1-21, *Fire Resistance of Building Assemblies*
Data Sheet 1-28, *Wind Design*
Data Sheet 1-28R/1-29R, *Roof Systems*
Data Sheet 1-44, *Damage-Limiting Construction*
Data Sheet 1-54, *Roof Loads for New Construction*
Data Sheet 3-26, *Fire Protection Water Demand for Non-Storage Sprinklered Properties*
Data Sheet 7-4, *Paper Machines and Pulp Dryers*
Data Sheet 7-32, *Ignitable Liquid Operations*
Data Sheet 7-42, *Vapor Cloud Explosions*
Data Sheet 7-43, *Loss Prevention in Chemical Plants*
Data Sheet 7-54, *Natural Gas and Gas Piping*
Data Sheet 7-88, *Outdoor Ignitable Liquid Storage Tanks*

4.2 Other

American Concrete Institute (ACI). *Building Code Requirements for Structural Concrete*. ACI 318, latest edition.

American Society of Civil Engineers (ASCE). *Minimum Design Loads for Buildings and Other Structures*. ASCE/SEI-7, latest edition.

ASTM International. *Standard Specification for Loadbearing Concrete Masonry Units*. ASTM C90, latest edition.

ASTM International. *Standard Specification for Steel Wire, Plain, for Concrete Reinforcement*. ASTM A82, latest edition.

ASTM International. *Standard Specification for Stainless Steel Wire*. ASTM A580, latest edition.

ASTM International. *Standard Specification for Grout for Masonry*. ASTM C476, latest edition.

British Standard BS 476:20:1987. *Method of Determination of Fire Resistance of Elements of Construction (Thermal Exposure and Performance Criteria)*.

EN 13501-2, *Fire classification of construction products and building elements, Part 2: Classification using data from fire resistance tests, excluding ventilation services*.

German Standard DIN 4102, *Fire Behavior of Building Materials and Building Components*.

International Code Council (ICC). *International Building Code*. Latest edition.

National Fire Protection Association (NFPA). *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*. NFPA 13E, latest edition.

National Fire Protection Association (NFPA). *Standard on Industrial Fire Brigades*. NFPA 600, latest edition.

National Fire Protection Association (NFPA). *Recommended Practice for Pre-Incident Planning*. NFPA 1620, latest edition.

National Fire Protection Association (NFPA). *National Electrical Code*. NFPA 70, latest edition.

National Fire Protection Association (NFPA). *Fire Doors and Windows*. NFPA 80, latest edition.

National Fire Protection Association (NFPA). *Fire Walls and Fire Barrier Walls*. NFPA 221, latest edition.

APPENDIX A GLOSSARY OF TERMS

Access door: A door assembly, for installation in fire resistancerated walls or for installation in ceilings of fire resistance- rated floorceiling or roof-ceiling assemblies, that is used to provide access to shafts, chases, attics, spaces above ceilings, or other concealed spaces.

Active leaf: The first operating door of a pair, which is usually the door in which a lock is installed.

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

Allowable stress design (ASD): A method of designing structural members so computed stresses produced by normal gravity design loads (i.e., the weight of the building and usual occupancy live loads) do not exceed allowable stresses that are typically below the elastic limit of the material (e.g., in steel these are typically well below the yield point). Normal allowable stresses are commonly increased by a factor (often a one-third increase) when design includes extreme environmental loads, such as earthquakes. Also called “working stress design” or “elastic design.”

Ambient: For the purposes of this standard, the temperature of the room in which the test is being conducted.

Anchor: A device for attaching frames to the surrounding structure.

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

Approved inspector: Personnel trained in conducting and evaluating tests and inspections; employed by an independent inspection/ testing agency hired by the owner, or by the design professional in responsible charge acting as the owner’s agent; approved by the building official.

Automatic fire detector: A device designed to detect the presence of a fire signature and to initiate action. For the purpose of this standard, automatic fire detectors are classified as follows: Automatic Fire Extinguishing or Suppression System Operation Detector, Fire-Gas Detector, Heat Detector, Other Fire Detectors, Radiant Energy-Sensing Fire Detector, and Smoke Detector.

Automatic flush bolts: A mortised bolt installed near the top or bottom of the inactive leaf of a pair of doors that holds the inactive leaf in a closed position until the active leaf is opened.

Automatic louver: An opening in a door with a series of slats or blades to allow passage of air and designed to close automatically in the event of fire.

Automatic-closing device: A device that causes the door or window to close when activated by a fusible link or detector.Automaticclosing door:A door that normally is open but that closes when the automatic-closing device is activated.

Automatic-closing door: A door that normally is open but that closes when the automatic-closing device is activated.

Barrel: A cylindrical horizontal member at the head of the opening that supports the door curtain of a rolling steel door and contains the counterbalance springs.

Base separation distance (SB): 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.

Batten: A horizontal pipe, tube, or other structural shape in a pocket of or attached to a fire safety curtain.

Binders: Pieces of hardware used to hold a sliding door to the wall, preventing lateral movement of the door from the wall.

Biparting: A vertically sliding door in which half of the door moves up and half of the door moves down in order to open, or a horizontal sliding door in which one door moves to the right and one moves to the left in order to open.

Blank construction: Walls and roofs without any openings such as windows, skylights, doors or hatches.

Bottom bar (rolling steel door): A reinforcing member at the lower edge of the door curtain assembly.

Brail fire safety curtain: A fire safety curtain that folds up and stores in the space above a proscenium opening.

Breakaway connection: A joint connecting a fire damper sleeve and attached ductwork that will allow collapse of the ductwork during a fire without disturbing the integrity of the fire damper.

Bumper (fire safety curtain): A filled fabric pocket below the bottom batten or frame member of a fire safety curtain designed to press against the floor.

Bumpers: Stops to limit the closing or opening movement of a sliding door.Ceiling radiation damper: A listed device installed in a ceiling membrane of a fire resistance-rated floor-ceiling or roof-ceiling assembly to automatically limit the radiative heat transfer through an air inlet/outlet opening. [5000, 2015]

Center latch: A latch used to hold the two halves of a centerparting or biparting fire door together, which is usually two pieces surfaceapplied to doors and interlocked in the closed position.

Center parting: See Biparting.

Chafing strip: A metal strip applied to the back surface of a sliding door to protect the door surface from damage from the wall.

Channel frame: A frame that consists of head and jamb members of structural steel channels, either shop assembled or field assembled, to be used with masonry walls.

Class 1: Class 1 includes FM Approved plastic panels and plastic building panels. FM Approved foam insulated wall/ceiling constructions that use a polyurethane or polyisocyanurate foam core and steel or aluminum-faced panels are considered Class 1. FM Approved insulated steel deck roof assemblies are also considered Class 1.

Classified: Products or materials of a specific group category that are constructed, inspected, tested, and subsequently reinspected in accordance with an established set of requirements.

Closed position (rolling steel fire door): A position of the door curtain with the underside of the bottom bar, including a compressible seal or sensing edge, if provided, in contact with the sill along the entire width of the opening.

Closing device: A means of closing a door from the partially or fully opened position.

Combination fire/smoke damper: A device that meets both the fire damper and smoke damper requirements.

Combustible (C): Class 2 materials and assemblies and any material or assembly with a critical heat flux for piloted ignition ≤ 12 Kw/m^2.

Combustible exposed walls: : Any material or assembly with a critical heat flux for piloted ignition ≤ 12 kW/m^2. For a list of walls considered combustible, see the following table:

Table A-1. Combustible Walls

Any wall with exposed combustible materials such as wood eaves
Any wall with windows that can be opened
Any wall with windows that are single-pane annealed glass
EIFS that does not meet the criteria to be considered noncombustible walls
Asphalt Coated Metal (ACM)
Rigid plastic panels (FRP, PVC)
Aluminum panels w/o insulation[1]
Non-Approved metal-faced panels w/plastic insulation
Cementitious panels on wood frame
Cementitious shingles on wood frame
Painted or unpainted wood of all species
Other assemblies on unprotected wood frame
Asphalt shingled wood sheathing

Note 1. Aluminum panels must be considered combustible due to low-melting temperature.

Composite doors: Doors having a noncombustible core with untreated wood veneers or facings of plastic or metal. Single-sliding, bi-parting, and single or double-swinging arrangements are available.

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.

Concrete lintel: A precast concrete horizontal member spanning and carrying the load above an opening.

Continuous glazing molding: A continuous molding used to hold glass or glazing in a window.

Continuous inspection and verification: Full-time observation of the work being performed by an approved inspector:

Coordinator: A device used on pairs of swinging doors that prevents the active leaf from closing before the inactive leaf closes.

Corbel: In architecture a corbel is a structural member jutting from a wall designed to carry a specified load or bearing.

Counterbalancing: A method by which the hanging weight of the door is balanced by helical torsion springs or weights.

Cover plate: A plate to cover the joint between the sections of multiple panel doors, usually applied to the front and back of the vertical or horizontal slide door.

Critical heat flux (CHF): The heat energy per unit area required to cause damage (noncombustible materials) or ignition of a combustible material.

Crush plates: Bearing plates provided where doors are mounted on concrete masonry wall units with hollow cells to accommodate through-wall bolts to prevent crushing of the hollow concrete masonry unit.

Curtain (rolling steel fire door): Interlocking curtain slats assembled together.

Curtain slats: Formed sheet steel members that, when interlocked together, form the rolling steel door curtain.

Detector: See “Automatic fire detector.”

Detectors: Devices such as fusible links, heat detectors (fixed temperature and/or rate-of-rise), and smoke detectors.

Diaphragm, horizontal: The wood sheathing, concrete slab or fill, or metal deck at a roof or floor capable of transferring earthquake forces to vertical lateral force-resisting elements (e.g., shear walls, braced frames, or moment frames).

Door closer (swinging): A labeled device that, where applied to a door and frame, causes an open door to close by mechanical force. The closing speed can be regulated by this device.

Door holder/release device: A labeled, fail-safe device, controlled by a detection device, used on an automatic closing door to release the door at the time of fire.

Door protection plate: Protective material applied to the face of a door and generally made of approximately 0.05 in. (1 mm) thick brass, bronze, aluminum, or stainless steel or 1⁄8 in. (3 mm) thick laminated plastic.

Double egress doors: A pair of swinging doors, each leaf of which swings in the opposite direction of the other.

Dutch door: A door divided horizontally so that the lower part can be shut while the upper part remains open.

Dynamic system: An HVAC system designed to maintain the movement of air within the system at the indication of a fire.

Egress side: The side of an opening from which traffic exits.

Elastic design: See allowable stress design.

Elastic: A mode of structural behavior in which a structure displaced by a force will return to its original state upon release of the force.

Electric strike: A strike that, when activated, either releases or retains a projected latch or dead bolt.

Essential facility: A facility where buildings and equipment are intended to remain operational in the event of extreme environmental loading from flood, wind, snow, or earthquake.

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).

Fail-safe device: A device that will provide its intended function upon loss of power.

Field modifications: Changes, not otherwise permitted by this standard, made to a listed assembly or component after it has been manufactured.

Finish frame: A subframe attached to a rough buck to which the door is attached.

Fire damper: A device installed in an air distribution system, designed to close automatically upon detection of heat, to interrupt migratory airflow and to restrict the passage of flame. Fire dampers are classified for use in either static systems or for dynamic systems, where the dampers are rated for closure under airflow.

Fire door: The door component of a fire door assembly.

Fire door assembly: Any combination of a fire door, a frame, hardware, and other accessories that together provide a specific degree of fire protection to the opening.

Fire door frame: A component forming the perimeter of an opening in a fire door assembly that is supplied welded or knocked down and anchored to the surrounding structure.

Fire door frame for lights: A frame that, in addition to a door opening, contains an opening(s) for use with glazing materials.

Fire door frame for panels: A frame that, in addition to a door opening, contains an opening(s) for use with fixed panels of solid metal or wood.

Fire door hardware: Door hardware furnished for swinging and sliding fire doors by the door manufacturer as a component part of the listed door assembly.

Fire exit hardware: Labeled devices for swinging fire doors installed to facilitate safe egress of persons and generally consisting of a crossbar and various types of latch mechanisms that cannot hold the latch in a retracted locked position.

Fire protection glazing: Glazing that has a fire protection rating.

Fire protection rating: For the purposes of this standard, the designation indicating the duration of the fire test exposure to which a fire door assembly or fire window assembly was exposed and for which it successfully met all acceptance criteria.

Fire protective curtain assembly: An assembly typically consisting of a fabric curtain, a bottom bar, guides, a coil, and an operating and closing system.

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 resistance glazing: Glazing that has a fire resistance rating.

Fire resistance rating: The time, in minutes or-hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of ASTM E119.

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.

Fire safety curtain: A curtain of fire-resistant fabric and noncombustible framing materials.

Fire safety curtain assembly: A fire safety curtain and all other components necessary to form a complete assembly.

Fire shutter: A fire door assembly used for the protection of a window opening in an exterior wall.

Fire window assembly: A window or glass block assembly having a fire protection rating.

Fire-rated damper mullion: A mullion used to separate multiple listed dampers in large openings.

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

Flame baffle: A hinged piece of sheet metal within the hood that, when released, closes the space between the top of the curtain and the hood of a rolling steel fire door.

Floor fire door assembly: A combination of a fire door, a frame, hardware, and other accessories installed in a horizontal plane that together provide a specific degree of fire protection to a through-opening in a fire resistance-rated floor.

FM Approved: Products and services that have satisfied the criteria for Approval by FM Approvals. Refer to the *Approval Guide* and Roof*Nav* for a complete list of products and services that are FM Approved.

Follow-up inspection procedure: Documents provided by the listing agency that are referenced in routine follow-up inspections and, where appropriate, field inspections.

Framed fire safety curtain assembly: A straight lift-type fire safety curtain assembly containing a rigid perimeter frame and internal members.

Fusible link: For the purposes of this standard, a listed device consisting of pieces of metal held together by low melting-point solder.

Glazing angle clips: Steel clips used to hold glass in place in windows glazed only with glazing compound.

Governor (sliding, vertical, and rolling steel fire doors): A device that limits the rate of descent of the door during automatic closure.

Guide (rolling doors): Vertical assembly in which the curtain travels and that is fastened to the jamb, retaining the edges of the door curtain, and closing the space between the curtain, edges, and the jamb.

Guide rail (sliding door, vertical): A steel member attached to the wall or frame; used with vertical sliding doors to guide the door.

Guide shoe (sliding door, vertical): A member attached to vertical sliding doors; used to guide and retain the door on the guide rail.

Guide wall angle (rolling steel doors): The component of the guide assembly that is fastened to the jamb.

Hanger (sliding door, horizontal): A member used to attach a horizontally sliding door to the track and to cause the door to roll on or in the track.

HC-1: Hazard category 1, see Data Sheet 3-26.

HC-2: Hazard category 2, see Data Sheet 3-26.

Heat-actuated device: Devices that include fixed temperature releases, rate-of-temperature-rise releases, and door closers with hold-open arms embodying a fusible link.

High-rise building: Any building with an occupied floor located more than 75 ft (23 m) above the lowest level of fire service vehicle access, with the exception of the following:

- Airport traffic control towers
- Open parking garages
- Amusement park structures
- Bleachers
- Grandstands
- Stadiums
- Special industrial buildings (e.g., BLRBs)
- Buildings with high-hazard occupancies

Hollow metal doors: Doors made in seamless, flush panels, rail-and-panel, or stile-and-panel design. They are manufactured from a suitable reinforced, minimum 20-gauge (0.9 mm) outer skin supplemented with an insulating or sound-deadening material, or both. These doors are available in single- and double-swinging units. When used in conjunction with passenger elevator entrance assemblies, they may be arranged for swinging, sliding, vertical bi-parting, or horizontal-slide operation. Hollow metal doors for freight elevators and dumbwaiters are counterbalanced.

Hollow metal frame: A frame formed from sheet metal.

Hood (rolling steel door): A sheet metal housing that mounts horizontally between the brackets, serving as an enclosure for the coiled curtain and closing the space between the door coil and the lintel.

Horizontal access door: An access door installed in the horizontal plane used to protect openings in ceilings of fire resistancerated floorceiling or roofceiling assemblies.

Importance factor: A factor used in building codes to increase, for example, the usual wind or earthquake design forces for important or essential structures, tending to make them more resistant to those phenomena.

Inactive leaf: One door of a pair of doors that ordinarily is latched closed; the second operating door of a pair.

Jackknife doors: Doors consisting of a curtain of interlocking steel slats that collapse horizontally when operated.

Keeper: A guide and a restraint used on latching devices.

Knocked-down frame: Door frame furnished by manufacturer in three or more basic parts for assembly in the field.

Labeled: Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Lap splicing: Preferred method used to get “continuous” reinforcing using several reinforcing bars laid end to end; works by transferring forces from one rebar through the surrounding concrete to the adjacent rebar. The length of the “lap” determines the strength of the connection for a particular rebar size and a particular concrete strength; lap splices are specified as a certain number of bar diameters since the strength of the lapped connection is a function of the contact area between the rebar and the concrete.

Lap-mounted door (sliding door, vertical door, horizontal door, swinging door): Doors mounted on the face of a wall and overlapping the opening by a prescribed dimension.

Latching device: A spring-loaded latch bolt or a gravity-operated steel bar that, after release by physical action, returns to its operating position and automatically engages the strike plate when it is returned to the closed position.

Limiting factor: A physical barrier that stops the spread of fire or provides containment of explosive force. The control of damage from these or other events is entirely dependent on structural integrity, susceptibility of contents, fire-resistant and damage-limiting construction or adequate space separation. Limiting factors can change over time and result in significantly larger losses than anticipated if improperly managed. These factors, therefore, warrant a high level of validation, documentation, and oversight.

Lintel: A horizontal member spanning and carrying the load above an opening.

Listed: Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Load and resistance factor design (LRFD): A method of designing structural members so computed stresses produced by service design loads multiplied by load factors do not exceed the theoretical nominal member strength multiplied by a strength reduction (resistance) factor: Also called strength design or ultimate strength design.

Make-up: The action of a client that is beyond their normal operating procedures and is intended to mitigate lost production, services or revenue.

Manual flush bolts: A mortised bolt installed near the top or bottom of the inactive leaf of a pair of doors in which the bolts are manually extended or retracted into or out of the header or sill by means of a lever.

Masonry: Brick, stone, tile, or concrete block bonded together with mortar. With reinforcing steel, it is defined as reinforced masonry; without reinforcing steel it is defined as unreinforced masonry (URM).

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.

MFL limiting factor: see “Limiting factor.”

Metal-clad doors: Doors consisting of a twoor threeply core of well seasoned wood covered with lock-jointed terneplate, Ductillite, or 30 gauge [0.012 in. (0.30 mm)] sheet metal. The covering is nailed to the core.

Metal composite material (MCM): A panel consisting of two sheets of corrosion resistant metal which are permanently bonded to an extruded thermoplastic polyethylene core. Formerly known as Aluminum Composite Material (ACM) before the introduction of copper and zinc facers.

MFL separation distance (SM): The distance recommended per this document to prevent ignition of a building or its contents due to an MFL fire in an adjacent building or yard storage.

Mortar: Type M or S mortars are mixed according to the proportions in the following table:

Mortar Type	*Parts By Volume of Portland Cement, or Blended Hydraulic Cement*	*Parts By Volume of Type N Masonry Cement*	*Parts By Volume of Hydrated Lime or Lime Putty*	*Parts By Volume of Aggregate, Measured in a Damp, Loose Condition*
M	11	1	0.25	Not less than 2.25 and not more than 3 times the sum of the separate volumes of the cements and lime used
S	0.51	1	over 0.25 to 0.5	

Note: Type M or S mortar may also be formulated using type M or S masonry cement respectively, without further addition of cements or hydrated lime.

Mullion: A fixed or removable vertical member set in a double door opening that allows both leaves to be active or set between a door and a side light or a separate, framed, glazed area.

Multiple opening door frame: A door assembly that consists of more than two doors.

Multi-story combustible construction: Any multi-story building (excluding basements) with a combustible building frame including wood frame, boards on joist, or plank on timber construction.

Muntin: A bar member supporting and separating panes of glass within a sash, door, or glazing frame.

Noncombustible (NC): Any material or assembly with a critical heat flux >12 Kw/m^2 and ≤27 kW/m^2 of indefinite exposure without ignition, penetration, the opening of joints, or failure.

Noncombustible walls: Any material or assembly with a critical heat flux >12 kW/m^2 and ≤27 kW/m^2 that can withstand indefinite exposure without ignition, penetration, the opening of joints, or failure. For a list of walls considered noncombustible, see the following table:

Table A-2. Noncombustible Walls[1]

Steel-faced panels w/o insulation on steel or reinforced concrete frame
Steel-faced panels w/ noncombustible insulation on steel or reinforced concrete frame
Cementitious panels w/o insulation on steel or reinforced concrete frame
Cementitious panels w/ noncombustible insulation on steel or reinforced concrete frame
FM Approved steel-faced class 1 panels on steel or reinforced concrete frame
FM Approved steel-faced noncombustible panels on steel or reinforced concrete frame
FM Approved wall panels w/ thermoset insulation on steel or reinforced concrete frame
FM Approved aluminum-faced class 1 panels w/ thermoset insulation on steel or reinforced concrete frame
Aluminum-faced panels w/ noncombustible 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
Any unrated precast, cast-in-place or tilt-up concrete panels (solid, hollow or insulated) on steel or reinforced concrete frame
Any unrated glass block
Any tempered glass panels in noncombustible frames on a steel or reinforced concrete building frame
Metal lath and plaster
Cementitious stucco
EIFS with noncombustible or Class 1 insulation over gypsum board sheathing

Note 1. Noncombustible exposed walls also can have no overhanging wood eaves.

Non-shear walls: Non-shear walls resist wind forces perpendicular to the face of the building façade and distribute the wind forces into the building frame; they provide the building frame with no resistance to lateral (horizontal) forces, such as those generated by wind or earthquake; examples are curtain walls (most mid-rise and high-rise office building facades with glass and either steel or aluminum frames), infill walls (concrete or masonry panels within the building frame (bounded by beams and columns), insulated metal or corrugated metal wall panels, and EIFS walls.

Open back strike: A strike applied to the inactive leaf of a pair of doors and cut away at the back to allow either leaf to open or close independently.

Operable windows: windows that can be opened by the normal occupants of the building without great difficulty, or could otherwise be expected to be opened with some frequency.

Overlapping astragal: A horizontal or vertical molding attached to one leaf of a pair of doors.

Parapet: A parapet is an extension of the wall above the roof being protected.

Pass door: A swinging door in a sliding door for personnel use.

Periodic inspection and verification: Part-time or intermittent observation of the work being performed, and the completion of the work, by an approved inspector.

Plant-on: A decorative trim applied to the surface of a door.

Pounding: The collision of adjacent buildings during an earthquake due to insufficient lateral clearance.

Power-operated fire doors: Doors that normally are opened and closed electrically, pneumatically, or hydraulically.

Prestressed concrete: A type of precast concrete panel where steel strands (wire) or bars are embedded in the concrete under high tension that is held in equilibrium by compressive stresses in the concrete after hardening.

Primary fire jump: fire spread directly from the MFL area to an exposed target across an open space.

Proscenium wall: The wall that separates the stage from the auditorium or house.

Purchase line (hand line): The line attached to the counterweight for manual opening and closing of the fire safety curtain.

Qualified person: A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with the subject matter, the work, or the project.

Ramp-up: Part of the normal post-loss restoration period that covers the time from the start-up of production until the time full production has resumed.

Reinforced concrete: Construction using a composite material made from concrete and steel (or another material, such as glass fiber-reinforced plastic) where the concrete and reinforcement work compositely. Examples of reinforced concrete walls are tilt-up construction and precast concrete construction.

Reinforced masonry: Masonry units, reinforcing steel, grout, and/ or mortar combined to act together to resist design loads. Reinforced masonry generally has both vertical and horizontal steel reinforcement.

Retaining angle: The metal angle used to retain the fire damper in the opening.

Retrofit operator: A device labeled as a “retrofit rolling steel fire door operator” intended to replace operator and governor systems (including automatic-closing devices) used on existing listed rolling steel fire doors.

Roller guide/metal track side edge guide system: Continuous tracks with captive trolleys or rollers at each vertical edge of the curtain used to guide and restrain the fire safety curtain.
Rolling steel door: Doors that have their housing and mechanism located at the head of the opening and are composed of a curtain of interlocking metal slats that coil upon a barrel. In most models the barrel is provided with a torsion-spring mechanism to counterbalance the weight of the curtain. A detector releases the torsion-spring mechanism that drives the door closed. In some newer models there is no spring. Automatic closure is powered by counterweights or simply the weight of the curtain. Rolling steel doors may be operated by hand, chain, crank, pneumatic, or electric power under normal operating conditions.

Rolling steel fire door: A fire door assembly consisting of a curtain, a bottom bar, a barrel, brackets, guides, a hood, and an automatic-releasing device.

RoofNav: An online resource of FM Approvals that lists FM Approved roofing products and assemblies.

Rough buck: A subframe, usually channel shaped, attached to an existing wall to which the finished frame is attached.

Secondary fire jump: subsequent fire spread to an exposed target across an open space from a primary exposed target.

Self-closing door: A door that, when opened and released, returns to its closed position.

Self-latching bolt: An automatic-latching device that engages in a keeper to hold a door leaf in a closed position and that can only be released manually.

Sensing edge (rolling steel fire door): A device added to the underside of the bottom bar of a power-operated rolling steel fire door or fire shutter that stops or reverses the door curtain upon contact with an obstruction when closing under power.

Service counter fire door: A labeled assembly consisting of a rolling steel fire door that incorporates a four-sided frame used for the protection of openings in walls where the primary purpose of the opening is for nonpedestrian use, such as counter service for food, a pharmaceutical dispensary, package and baggage transfer, or observation ports.

Shear walls: Shear walls provide the building frame with substantial resistance to lateral (horizontal) forces, such as those generated by wind or earthquakes; they provide resistance to forces parallel to the horizontal axis of the wall; they serve the same structural purpose as steel cross-bracing; they are typically constructed from concrete or masonry, and wood (plywood, for wood-framed structures).

Sheet metal doors: Uninsulated or insulated, these doors are two-piece, vertically or horizontally sliding, and may be either counterbalanced or telescoping. The uninsulated doors may consist of a single thickness of galvanized sheet-metal, corrugated or flat, riveted or welded in a structural steel frame. The insulated types are of sandwich-panel construction having mineral-core insulation between steel-faced sheets.

Shutter: A labeled door assembly that is used for the protection of a window opening in an exterior wall. (See also Fire Shutter.)

Side guide cable system: A continuous vertical cable at each vertical edge of the curtain used to guide and restrain the fire safety curtain.

Side light: An opening in a fire door frame alongside the fire door opening that is filled with glazing material.

Side light frame: A fire door frame prepared for the application of a glazing material alongside the door opening.

Side panel frame: A door frame prepared for the installation of a fixed solid metal or wood panel alongside the door opening.

Sidewall protection: an upgrade in the passive protection of the wall. For example, increasing the rating of the wall for noncombustible to 1-hour fire rating.

Sill: A structural component of the building that forms the bottom part of an opening over which a door closes.

Sill (rolling steel fire door): The bottom part of an opening onto which the door curtain and bottom bar come to rest when in the closed position.

Sill (service counter fire door): The bottom part of a frame onto which the door curtain and bottom bar come to rest when in the closed position.

Single-point latch: A latch located in the edge of a door to engage either in the frame or in the edge of the inactive leaf of a pair of doors.

Sliding hardware: A system of rails, hangers, rollers, guides, binders, and closing devices that are self-closing by means of gravity, weights, and pulleys or spring-actuated devices.

Smoke damper: A device within an air distribution system to control the movement of smoke.

Smoke detector: A device that detects visible or invisible particles of combustion.

Special purpose doors: Doors of special construction whose intended end use does not lend itself to being included in other classifications. Generally, these doors are not self-latching or provided with automatic closing devices. Examples include acoustical, radiant shielding, or pressure-resistant doors.

Split astragal: A horizontal or vertical molding attached to both leaves of a pair of doors.

Spring hinge: A closing device in the form of a hinge with a built-in spring used to hang and close the door.

Spring release device (rolling steel door): A device that, when activated, releases part of the spring counterbalancing force and causes the door to close.

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. To qualify as SFR, it must be reasonably foreseeable that the exposing wall will not collapse in an uncontrolled fire. This would include freestanding walls and walls that are laterally supported by structural framework that has adequate fire resistance. It is reasonable to expect walls made of standard 2 core hollow masonry units 12 in. (300 mm) thick up to 15 ft (4.5 m) in height, and 16 in. (400 mm) thick up 20 ft (6.0 m) in height to remain stable with wooden roof construction. Thinner, solid, or fully grouted masonry walls may also qualify as SFR. Precast or tilt-up concrete walls with a moment connection at the base of the wall and wood roof may also be considered SFR.

Static system: An HVAC system designed to stop the movement of air within the system at the indication of a fire.

Stay chain: A chain used to support the fire safety curtain.

Stay rollers (sliding door, horizontal): A device used on horizontally sliding doors at their back lower corners to guide the door and prevent the door from moving away from the wall under fire conditions.

Storage occupancy: Storage of any commodity, ignitable liquid, plastic, roll paper, rubber tires, and any material judged to have a comparable or higher hazard. When palletized storage of Class 1, 2, or 3 commodities are no more than one tier or 6 ft (1.8 m) high, the hazard may be reduced to HC-2. Storage of noncombustible commodities with no combustible packaging can be considered HC-1.

Straight-lift fire safety curtain: A fire safety curtain consisting of one or more flat panel(s) that lifts up and stores above the proscenium opening.

Strength design: See “Load and resistance factor design.”

Strike plate: A wear plate for projecting hardware or a wear plate and keeper for a latch bolt.

Struts: Adjustable vertical members that extend from the head of the hollow metal door frame to the ceiling to hold the frame rigidly in place.

Swinging fire doors: Doors that swing on hinges in or out of a room or building.

Temperature rise: The temperature increase above ambient that has developed on the unexposed face of the fire door assembly at the end of 30 minutes of exposure to the standard fire test.

Threshold: A builders hardware component that is installed beneath a closed door.

Tilt-up concrete: A construction method where reinforced concrete panels are formed and placed on-site. Once the panel has cured to sufficient strength, the slabs are then lifted by crane and tilted into place. The ability to make the panels on-site eliminates the need to ship them and thus eliminates the restrictions on size that would apply if the panels had to be transported to the site.

Tin-clad doors: Doors that have the same specifications as metal-clad doors.

Track brackets (sliding doors): Hardware bolted to the wall that serves to support the track.

Transom and side light frame: A fire door frame prepared for the application of a glazing material above and alongside the door opening.

Transom and side panel frame: A fire door frame prepared for the application of solid metal or wood panels above and alongside the door opening.

Transom light frame: A fire door frame prepared for the application of a glazing material above the door opening that has a horizontal member such as a transom bar provided to separate the glazed opening from the door opening.

Transom panel frame: A fire door frame prepared for the application of a transom panel above the door opening that has a horizontal member such as a transom bar provided to separate the transom opening from the door opening unless the transom panel or the bottom of the panel and the top of the door are rabbeted.

Transom panel: A panel, fixed or removable, installed in a frame above the door.

Transom: An opening in a fire door frame above the door opening that is filled by a solid panel or with glazing material.

Two-ply cores: These doors are available in the standard sliding and swinging type. Metal-clad doors for freight elevators are two-piece vertical sliding, counterbalanced, bi-parting, or telescoping. Rated at 1 1/2-hours; three or more ply cores are rated at three-hours, as noted in the Approval Guide.

Ultimate strength design: See “Load and resistance factor design.”

Undercutting: Trimming the lowest edge of a door panel for clearance.

Unframed fire safety curtain: A straight lift fire safety curtain containing no internal vertical framing members.

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.

Unreinforced masonry: Masonry unit (e.g., bricks, concrete blocks) construction that does not incorporate steel reinforcement, or where reinforcement is minimal and therefore neglected in the structural design.

Vent (sliding door, vertical, and horizontal tin-clad only): A hole cut in a fire door to allow for venting of the products of combustion.

Vertical access door: An access door installed in the vertical plane used to protect openings in fire-rated walls.

Vertical guide pocket: A partial enclosure at the vertical edge of the proscenium that protects the vertical edges and guides of a fire safety curtain.

Vertically sliding door: Labeled single-piece doors and sectional doors operating in a vertical direction.

View factor: A configuration factor that expresses how much of the source fire is felt by the target compared to the total view, taking into consideration angular paths of some of the radiation.

Viewer: A viewing device installed in a door to allow observation of persons opposite the security side of the door without having to open the door.

Volume control damper: A fire damper, smoke damper, or combination fire/smoke damper that is also used to control the volume of air in an HVAC system.

Wedge (sliding door, horizontal tin-clad and flush sheet metal): A plate mounted on the face of a sliding door designed to force the door against the wall.

Window frame: The perimeter of a window.

Window mullion: The separate horizontal or vertical member or members used to join windows in a multiple window opening.

Window muntin: A tee-shaped bar in a frame or ventilator, dividing the glass.

Window sash: The horizontal or vertical sliding component of a window.

Window ventilator: The part of a projected window, casement window, or pivoted window that opens.

Window: Integral fabricated units, placed in an opening in a wall, primarily intended for the admission of light, or light and air, and not intended primarily for human entrance or exit.

Wire glazing clips: Small, spring wire clips used to hold glass in place where windows are glazed only with glazing compound.

Yield point: The stress at which there is a decided increase in the deformation or strain without a corresponding increase in stress. The strain is inelastic, resulting in permanent deformation.

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.
S_B = the base separation distance needed per figures and tables.
S_N = the needed safe separation distance for N unprotected openings.
S_M = the MFL separation distance.
SFR = stable fire resistive exposing wall.
TG = tempered glass.
U = unprotected opening adjustment factor.
WG = wired glass.
WS = window sprinklers.
Θ = exposure angle.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

April 2025. Interim revision. Minor changes made to clarify guidance related to space separation analysis to be consistent with revised guidance in FM Property Loss Prevention Data Sheet 1-20, *Exterior Fire Exposures*.

January 2023. Interim revision. A recommendation has been added to avoid mass engineered timber as part of an MFL wall.

January 2022. Interim revision. Minor editorial changes were made.

July 2021. Interim Revision. Revised MFL scenario guidance pertaining to above-ground, open-sided parking garages to reflect the increased hazard of passenger vehicles involved in fire.

April 2020. Interim revision. Minor editorial changes were made.

April 2019. This is the first publication of this document.

Data Sheet 1-42, *MFL Limiting Factors*, is a new document based on material previously included in DS 1-22, *Maximum Forseeable Loss*. All guidance related to MFL Limiting Factors was removed from DS 1-22 and incorporated into this new document, with the following changes:

A. Simplified guidance on the protection of conveyor openings in MFL walls.

B. Replaced some prescriptive material with performance-based recommendations.

C. Added improved, calculation-based space separation figures for combustible and noncombustible construction. Minimums are now directly related to the exposure length and approach 0 as the length approaches 0.

D. Simplified exposing fire hazard categories for space separation to HC1/HC2, HC3, storage, and ignitable liquids.

E. Added new ignitable liquids space separation curves rather than referring readers to OS 7-88, *Ignitable Liquid Storage Tanks*.

F. Added material on metal composite materials (MCM).

APPENDIX C MFL FIREWALL EARTHQUAKE DESIGN

C.1 Design of MFL Fire Walls in FM Earthquake Zones

The design intent for MFL walls in FM 50-year through 500-year earthquake zones is for the wall to withstand the shake forces from the design earthquake and the thermal forces of an MFL fire directly after the earthquake.

C.1.1 This section applies to MFL fire walls in facilities located in FM 50-year through 500-year earthquake zones as shown in Data Sheet 1-2, *Earthquakes*.

C.1.2 Ensure MFL fire walls are designed by an engineer familiar with earthquake design and registered to practice structural design in the jurisdiction in which the project is located.

Meeting earthquake design requirements may eliminate one or more options that would otherwise be allowed in non-earthquake areas. For example, preventing damage to a fire wall from steel expansion during a fire by aligning the steel members on both sides of the wall and providing essentially no clearance is not an option in active seismic areas if it will allow pounding during an earthquake.

C.1.3 Anchor MFL fire walls to those roofs, floors, columns, foundations, or other structural elements that are intended to provide lateral support for the wall with positive direct connections adequate to resist required forces. Do **not** attempt to transfer lateral forces perpendicular to the wall using friction, nails in withdrawal, wood ledgers bolted to concrete or masonry walls, or similar connections.

C.1.4 Design MFL fire walls located in the United States, Puerto Rico, the Virgin Islands, and Guam for earthquake loads in accordance with the requirements of SEI/ASCE 7, *Minimum Design Loads for Buildings and Other Structures*, Standard, or a building code based on this standard (e.g., the International Building Code). Use a seismic importance factor (I_E) of 1.5 for the design of MFL fire walls. Where MFL walls are intended to provide resistance to earthquake forces as part of the lateral-force-resisting system of the building (i.e., seismic shear walls), and if the overall building structure is designed using an I_E less than 1.5, increase all design forces for the wall to an I_E of 1.5; also design connections transferring forces to and from the MFL shear wall based on an I_E of 1.5.

C.1.5 In locations other than in Section C.1.4, MFL fire walls may be designed using the recommendations in Section C.1.4 if appropriate earthquake acceleration parameters are available. If these parameters are not available, use a seismic importance factor (I_E) of 1.5 and the values of S_{DS} provided below in the following equations (these forces are applied perpendicular to the face of the wall unless noted otherwise):

- FM 50-year earthquake zone: S_{DS} = 1.3 (g)
- FM 100-year earthquake zone: S_{DS} = 0.9 (g)
- FM 250-year earthquake zone: S_{DS} = 0.55 (g)
- FM 500-year earthquake zone: S_{DS} = 0.55 (g)

C.1.5.1 Calculate the forces on the walls as follows:

Cantilever walls - The wall is supported at the base only, with no attachment to the superstructure. Seismic design force = $0.4*S_{DS}*I_E*W_W$

The force distribution on a cantilever wall is assumed to be an inverted triangular shape (i.e., with the force resultant located above the base of the wall a distance equal to 2/3 of the wall height).

Tied, One-way, Double, and Panel walls - The wall is supported at the base and connected to the structure at floors and roofs.

A. Wall and wall connections to supporting base or columns:Seismic design force = $0.4*S_{DS}*I_E*W_W$

B. Wall connections to elevated floors and roof:

1. Concrete or masonry wall to flexible diaphragm (a diaphragm other than a rigid diaphragm) Seismic design force = $0.8*S_{DS}*I_E*W_W$

2. Concrete or masonry wall to rigid diaphragm (a roof or floor structure that is monolithic structural concrete, structural concrete topping over metal deck, or structural concrete topping over concrete planks) or MFL wall not of concrete or masonry material.

Seismic design force = $0.4*S_{DS}*I_E*W_W$

For rigid and flexible diaphragm construction, ensure the seismic design force perpendicular to the wall, for connections from concrete or masonry walls to floor or roof diaphragms, is not less than 280 lb/ft (4.1 kN/m) nor $400* S_{DS}*I_E$ (lb/ft) ($5.84* S_{DS}*I_E$ [kN/m]); also, the spacing of the connections does not exceed 4 ft (1.2 m) on center.

The force distribution on tied, one-way, double, and panel walls can be applied as a uniform force.

Parapets

A. Cantilever parapets

Seismic design force = $1.2*S_{DS}*I_E*W_W$

B. Braced parapets

Seismic design force = $0.5*S_{DS}*I_E*W_W$ (for wall and bracing elements) Seismic design force = $0.8*S_{DS}*I_E*W_W$ (for bracing connections)

Where:

S_{DS} is the site (soil) adjusted, 5% damped, design spectral response acceleration at a short (0.2- second) period, expressed as a portion of the gravitational acceleration (g).

I_E = seismic importance factor = 1.5. W_W = the weight of the wall in lb (kN).

These design forces are intended for use in load and resistance factor design (LRFD) also known as strength design or ultimate limit state design and are provided factored (i.e., no additional load factors are required). If allowable stress design (ASD) or working stress design (WSD) is used, the LRFD design forces shown can be multiplied by 0.7 to determine equivalent approximate ASD design forces.

The response modification factor (R-factor) is already embedded in these formulae. The forces should not be further reduced by an R-factor.

C.1.6 Where MFL walls are intended to provide resistance to earthquake forces as part of the lateral force resisting system of the building (i.e., seismic shear walls), design MFL walls using the recommendations in Section C.1.4.

C.1.7 Provide adequate clearance between adjacent independent structures (e.g., between double walls, or between a cantilever wall and the structure on either side) to minimize the potential for pounding.

Assume the actual deflection of a cantilever fire wall during an earthquake will be 2-1/2 times the deflection determined, assuming the wall behaves elastically and using the LRFD forces in Sections C.1.4 or C.1.5 with an importance factor (I_E) of 1.0. Criteria to determine the actual deflections of the building structures adjacent to cantilever fire walls, or to which double walls are attached, is beyond the scope of this document. The registered engineer responsible for the building structural design must determine these deflections (amplifying deflections from design forces as necessary) and provide clearance adequate to prevent pounding based on appropriate analysis.

APPENDIX D STRUCTURAL DESIGN DETAILS, DETAILING GUIDELINES, AND QUALITY ASSURANCE FOR MFL FIRE WALL CONSTRUCTION

D.1 Reinforced Concrete Masonry

Provide concrete masonry walls with sufficient strength, durability, and stability to meet or exceed the performance requirements. The provisions in this section represent the minimum requirements additional strength, durability, and stability may be needed to meet project-specific performance requirements.

Use 2-core concrete masonry units (blocks) installed in a running bond pattern. Do not use 3-core concrete masonry units or stack bond patterns. The thickness of the mortar bed joint is typically 3/8 in. (9 mm). Ensure it does not exceed 5/8 in. (16 mm).

Ensure the 28-day compressive strength of concrete masonry units is not less than 1500 lb/in^2 (10.3 MPa) and the units conform to ASTM C 90. Assume face shell mortar bedding in design calculations rather than full area mortar bedding.

D.1.1 Minimum Reinforcing Ratio

The sum of the cross-sectional area of vertical and horizontal steel reinforcement is not less than 0.002 times the gross cross-sectional area of the wall; and the minimum cross-sectional area of steel reinforcement in each direction (vertical and horizontal) is no less than 0.0007 times the gross cross-sectional area of the wall. The horizontal cross-sectional reinforcing area can include horizontal joint reinforcing wire and continuous bond beam reinforcing.

See Section 3.2.2 for an example calculation of reinforcing ratios.

D.1.2 Vertical Reinforcing

Space vertical reinforcement no greater than 4 ft (1.2 m), or 1/3 the wall length or 1/3 the height between support points, whichever is less. In all cases, ensure vertical reinforcing is continuous through bond beams and for the entire height of the wall. Where splices are required for continuity, lap reinforcement no less than 48 bar diameters (for example, 1/2 in. [13 mm] diameter reinforcing bars would be lapped at least 24 in. [600 mm]). Provide a minimum clearance of 1/2 in. (13 mm) between the reinforcement and the interior surfaces of the masonry unit. Use rebar positioners spaced no greater than 8 ft (2.4 m) to fix vertical reinforcing in place, ensuring the position assumed for design is held during construction.

Provide no fewer than two (2) full-height, reinforced grouted cores at each wall corner or intersection (See Figures 76 and 77).

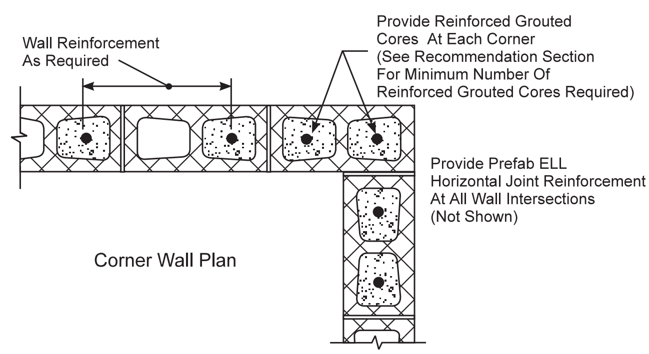


Fig. 76. Vertical reinforcing detail at concrete masonry wall corner

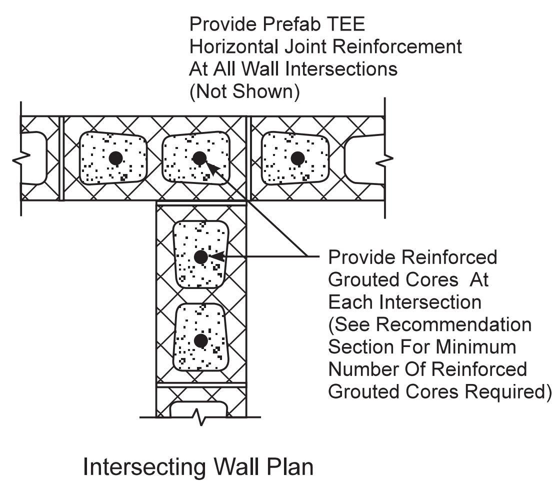


Fig. 77. Vertical reinforcing detail at concrete masonry wall intersection

Provide no fewer than two (2) full-height, reinforced grouted cores at each wall termination and at each side of horizontal wall openings 8 ft (2.4 m) and greater. Provide no fewer than one (1) full-height, reinforced grouted core at each side of horizontal wall openings less than 8 ft (2.4 m) and greater than 1.33 ft (0.4 m). See Figure 78.

Provide no fewer than two (2) full-height, reinforced grouted cores at each wall control joint or expansion joint, one on each side of the joint. See Figure 79.

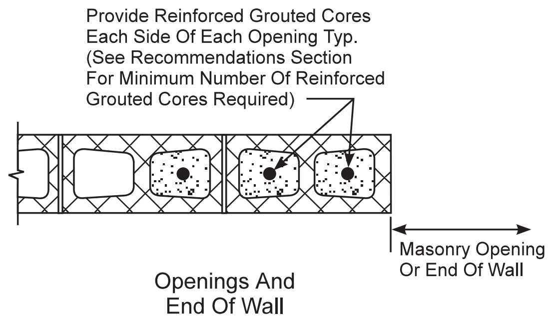


Fig. 78. Vertical reinforcing detail at concrete masonry wall opening or termination

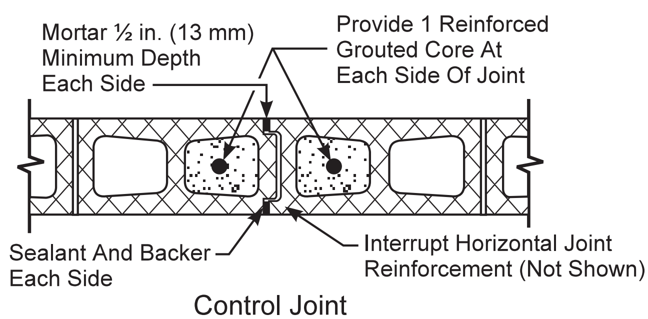


Fig. 79. Vertical reinforcing detail at concrete masonry wall control joint

For grouted reinforced cores at wall corners, intersections, terminations, openings, control joints, and expansions joints, use the same reinforcing bar size and number of reinforcing bars per core as used for the typical wall reinforcing.

D.1.3 Horizontal Reinforcing

Provide horizontal joint reinforcing consisting of minimum two (2) No. 9 (0.1483 in. [4 mm] diameter) diameter longitudinal steel side wires, one at each face shell, with No. 9 (0.1483 in. [4 mm] diameter) cross wires spaced at 16 in. (400 mm). Use ladder-type horizontal joint reinforcing rather than truss-type (truss-type diagonals can interfere with the proper placement of the vertical reinforcing). Ensure horizontal joint reinforcing shall be factory fabricated and shall conform to ASTM A 82 (minimum yield strength 70,000 psi [480 MPa], minimum tensile strength 80,000 psi [550 MPa]); do not use tack welded construction. Provide joint reinforcement in flat sections not less than 10 ft (3 m) in length; lap splice longitudinal side wires not less than 6 in. (150 mm). Provide factory formed tees and ells for continuity of horizontal joint reinforcing at wall intersections and corners. Ensure all joint reinforcing is hot-dip galvanized in conformance with ASTM A 153 Class B2 (zinc coating 1.5 oz/ft^2 [450 g/m^2]) unless exposed to extremely humid or corrosive atmospheres, in which case use stainless steel in conformance with ASTM A 580 Type 304.

Place steel joint reinforcement in every second horizontal joint of concrete masonry walls (spaced not more than 16 in. [400 mm] on center) for stiffening and additional shrinkage control (see Figure 7). In addition, place joint reinforcement in every first and second bed joint above and below wall openings and extend it at least 2 ft (0.6 m) horizontally beyond the openings. Provide joint reinforcement in the three joints immediately below the top of the wall. Interrupt joint reinforcement at control joints and expansion joints.

Incorporate at least one (1) continuous bond beam located at the same elevation of each level of adjacent structural floor or roof framing. Bond beams (Figure 8) spaced at a maximum of 3.3 ft (1.0 m) on center vertically may be used in lieu of horizontal joint reinforcement; however, horizontal joint reinforcement still must be provided midway between bond beams. Provide bond beams with minimum steel reinforcement of two (2) #4 (1/2 in. [13 mm] diameter) bars for 8-inch (200 mm) nominal concrete masonry units, or two (2) #5 (5/8 in. [16 mm] diameter) bars for 10 in. (250 mm) nominal and larger concrete masonry units. Provide continuous steel reinforcing for bond beam by means of lap splicing, including at wall intersections and corners. Provide lap lengths of not less than 48 times the diameter of the lapped reinforcing bar (see Figure 9). Provide a minimum clearance of 1/2 in. (13 mm) between the reinforcement and the interior surfaces of the masonry unit.

Fill all bond beams solid with grout; do not use mortar or other materials. Ensure bond beam reinforcing extends uninterrupted through control joints.

Position continuous bond beams to incorporate lintels at the same elevation whenever practicable. Where lintels cannot be incorporated into continuous bond beams, provide no less than 8 in. (200 mm) of lintel bearing length at each side of the opening. Limit lintel deflection due to combined dead load and live load to 1/600 of the span, or 0.3 in. (8 mm), whichever is less.

Provide lintels at all openings greater than 16 in. (400 mm).

D.1.4 Grout and Mortar

Provide grout in conformance with ASTM C 476. Ensure the compressive strength of the grout is equal to or greater than the compressive strength of the masonry unit, but never less than 2000 lb/in^2 (13.8 MPa). Determine the compressive strength of grout in accordance with ASTM C 1019. Ensure the grout mix has a consistency such that the measured slump is between 8 in. and 11 in. (200 to 280 mm). Where openings are restricted or congested with reinforcing, use only fine grout. Ensure the maximum aggregate size is less than 1/5 the narrowest clear dimension within the grout space; under no circumstances use an aggregate size greater than 3/8 in. (9 mm) for coarse grout.

Place grout using low-lift grouting procedures; use 5 ft (1.5 m) maximum lifts. If low-lift grouting procedures are not used, ensure cleanouts are provided at the base of the wall at each grouted core. For solid grouted walls, provide cleanouts at a maximum spacing of 32 in. (810 mm) on center. For each grout lift, stop grout pours at least 1 in. (25 mm) below the top of the masonry in order to form a grout key with the next lift (except for final grout pour at the top of the wall).

Use only Type M or Type S mortars for masonry walls. (See Appendix A, Glossary of Terms, for a description of each.)

D.2 Reinforced Concrete

D.2.1 Provide reinforced concrete walls with sufficient strength, durability, and stability to meet or exceed the performance requirements. The recommendations in this section represent the minimum requirements; additional strength, durability, and stability may be needed to meet project-specific performance requirements.

D.2.2 Provide concrete with a 28-day compressive strength of not less than 3,500 psi (24 MPa).

D.2.3 Ensure the cross-sectional area of steel reinforcing in each direction (vertical and horizontal) is at least 0.0025 times the effective gross cross-sectional area of the wall. Space horizontal and vertical reinforcing no greater than 18 in. (0.46 m).

D.2.4 Provide continuous steel reinforcing by means of lap splicing, including at all wall intersections and corners.

D.2.5 Provide lap lengths of not less than 60 times the diameter of the reinforcing bar. Do not use welding or mechanical couplers to join reinforcing steel.

D.2.6 Provide steel reinforcing oriented diagonally at all wall openings greater than 8 in. (200 mm); provide not less than two (2) #5 (0.625 in. [16 mm] diameter) reinforcing bars at each corner of each opening.

D.3 Detailing and Inspection of MFL Fire Walls in FM Earthquake Zones

D.3.1 Ensure MFL fire walls located in FM earthquake zones (50, 100, 250, and 500-year zones) are in conformance with the recommendations in Sections 2.2.1 and 2.2.2 unless specifically noted otherwise.

D.3.2 Provide walls with sufficient strength, durability, and stability to meet or exceed the performance requirements. The recommendations in this section represent the minimum requirements; additional strength, durability, and stability may be needed to meet project-specific performance requirements.

D.3.3 For all vertical reinforcing bars, and all bond beam and lintel reinforcing bars, use reinforcing steel conforming to the following specifications: Actual tested tensile strength not less than 1.25 times the actual tested yield strength; minimum 14% elongation (over 8 in. [200 mm]) at tensile failure for reinforcing bars not greater than 0.75 in. (19 mm) in diameter; minimum 12% elongation (over 8 in. [200 mm]) at tensile failure for reinforcing bars greater than 0.75 in. (19 mm) in diameter. These specifications can be met by using reinforcing bars in conformance with ASTM A 706; alternatively, ASTM A 615 steel reinforcing may be used provided that mill certificates are submitted that indicate the material meets the specifications noted above.

D.3.4 Do not credit heavily reinforced localized portions of the wall - for instance, at pilasters, chords, or wall openings - when determining the amount of reinforcing providing shear resistance for the wall.

D.3.4.1 Reinforced Concrete Masonry

D.3.4.1.1 Provide Level 2 Special Inspection in accordance with Chapter 17 of the latest edition of the International Building Code (IBC), with the addition of item 1 in Table 6. In locations where the IBC is not available or not in force, provide construction inspection in accordance with Table 6.

Table 6. Verification and Inspection of Masonry MFL Wall Construction

	Verification and Inspection	*Continuous*	*Periodic*
1	Inspect wall penetrations and associated specified clearances and fire-proofing.	x	
2	Verify proportioning of site-prepared mortar, grout, and pre-stressing grout for bonded tendons.		x
3	Inspect placement of masonry units and construction of mortar joints.		x
4	Verify size, grade, and type of reinforcement.		x
5	Inspect placement of reinforcement.		x
6	Inspect grout space (cores or cells) prior to grout placement.	x	
7	Inspect placement of grout, including pre-stressing or post-tensioning grout.	x	
8	Inspect anchors, bolts, and other embedded structural connections.	x	
9	Inspect protection of masonry during cold weather (below 40°F [4°C]) and hot (above 90°F [32°C]) weather.		x
10	Inspect application of stressing force for pre-stressed or post-tensioned walls.	x	
11	Inspect grouting of bonded strand for pre-stressed or post-tensioned walls.	x	
12	Inspect sample preparation and verify testing of any required grout and mortar specimens, and test prisms.	x	

Notes:
1. Periodic inspection and verification: Part-time or intermittent observation of the work being performed, and the completion of the work, by an approved inspector.
2. Continuous inspection and verification: Full-time observation of the work being performed by an approved inspector.
3. Approved inspector: Personnel trained in conducting and evaluating tests and inspections; employed by an independent inspection/ testing agency hired by the owner, or by the design professional in responsible charge acting as the owner's agent; approved by the building official.

D.3.4.1.2 Vertical Reinforcing

Provide no fewer than five (5) full-height reinforced grouted cores at each wall corner or intersection (see Figures 76 and 77).

Provide no fewer than three (3) full-height reinforced grouted cores at each wall termination, at each side of expansion joints, and at each side of horizontal wall openings 8 ft (2.4 m) and greater. Provide no fewer than two (2) full-height reinforced grouted cores at each side of horizontal wall openings greater than 3 ft (0.9 m) and less than 8 ft (2.4 m).

Provide no fewer than one (1) full-height reinforced grouted cores at each side of horizontal wall openings greater than 1.33 ft (0.4 m) but less than 3 ft (0.9 m) (see Figure 78).

D.3.4.1.3 Horizontal Reinforcing

Provide minimum horizontal joint reinforcing consisting of minimum two (2) 3/16 in. (5 mm) diameter) longitudinal steel side wires, one at each face shell, with No. 9 (0.1483 in. diameter [4 mm]) cross wires spaced at 16 in. (400 mm). Lap splice longitudinal side wires not less than 8 in. (200 mm). Enclose vertical reinforcing bars at pilasters with horizontal joint ties. Space horizontal joint ties no greater than 16 in. (400 mm). Ensure horizontal joint ties are the same size and material as horizontal joint reinforcing, and are provided with 135-degree hooks.

Provide 180-degree standard hooks for all bond beam, lintel, and sill reinforcing terminations; ensure each reinforcing bar hook encompasses at least one vertical reinforcing bar (See Figure 10).

Provide reinforced sills at all wall opening requiring lintels; ensure sills are of similar type, size, reinforcing, and detailing as lintels.

Where masonry lintels 16 in. (400 mm) or more in height are provided, ensure #3 (3/8 inch [10 mm] diameter) shear stirrups spaced at 16 in. (400 mm), and two (2) #4 (1/2 in. [13 mm] diameter) top reinforcing bars are provided for the entire length of the lintel; these stirrups and top bars are to be provided in addition to the required bottom reinforcing bars.

D.3.4.2 Reinforced Concrete

D.3.4.2.1 Provide Special Inspection in accordance with Chapter 17 of the latest edition of the IBC, with the addition of item 1 in Table 7. In locations where the IBC is not available or not in force, provide construction inspection in accordance with Table 7.

Table 7. Verification and Inspection of Reinforced Concrete MFL Wall Construction

	Verification and Inspection	*Continuous*	*Periodic*
1	Inspect wall penetrations and associated specified clearances and fire-proofing.	x	
2	Verify size, grade, and type of reinforcement		x
3	Inspect reinforcing steel and placement, including depth of concrete cover.		x
4	Inspect anchors, bolts, and other embedded structural connections.	x	
5	Verify use of specified concrete design mix.		x
6	Inspect sample preparation and verify concrete testing (sampling for strength tests, slump, entrained air, temperature, density).	x	
7	Inspect concrete placement.	x	
8	Inspect for maintenance of specified curing temperatures and techniques.		x
9	Inspect protection of concrete during cold weather (below 40°F [4°C]) and hot (above 90°F [32°C]) weather.		x
10	Inspect application of stressing force for pre-stressed or post-tensioned concrete.	x	
11	Inspect grouting of bonded strand for pre-stressed or post-tensioned concrete; or grouting of splice sleeves.	x	
12	Inspect erection of precast concrete members.		x
13	Verify in-place concrete strength prior to stressing of post-tensioning tendons.		x

Notes:1. Periodic inspection and verification: Part-time or intermittent observation of the work being performed, and the completion of the work, by an approved inspector.
2. Continuous inspection and verification: Full-time observation of the work being performed by an approved inspector.
3. Approved inspector: Personnel trained in conducting and evaluating tests and inspections; employed by an independent inspection/testing agency hired by the owner, or by the design professional in responsible charge acting as the owner's agent; approved by the building official.

D.3.4.2.2 Provide at least two curtains of steel reinforcing throughout the entire wall.

D.3.4.2.3 Provide steel reinforcing oriented diagonally at all wall openings greater than 8 in. (200 mm); provide not less than two (2) #5 (0.625 in. [16 mm] diameter) reinforcing bars at each corner of each opening.

D.3.4.2.4 Provide boundary elements (see Figure 80) with lengths not less than 1/8 the wall segment length. Ensure all vertical reinforcing bars within the boundary element are confined within transverse hoop reinforcement.

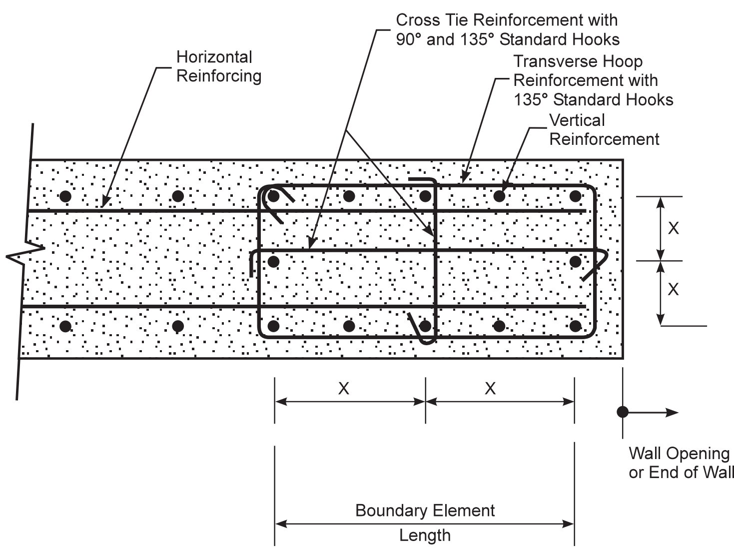


Fig. 80. Boundary element reinforcing detail (plan view) for concrete walls in FM earthquake zones

D.3.4.2.5 Ensure the cross-sectional area of vertical reinforcing contained in the boundary element is from 0.01 to 0.06 times the gross cross-sectional area of the boundary element. Ensure the minimum cross-sectional area of transverse hoop and cross-tie reinforcement is at least 0.008 times the gross cross-sectional area of the wall at the boundary element location. Provide vertical spacing of transverse hoop and cross-tie reinforcement based on local code requirements, but never less than 4 in. (100 mm) or more than 6 in. (150 mm). Provide transverse hoop and cross-tie reinforcement such that the distance between reinforcing bar bends (see dimension “X” on Figure 80) is no greater than 14 in. (360 mm). Ensure horizontal reinforcing can develop its full yield strength within the boundary element; if the length of the boundary element is insufficient to develop full yield strength, use 135-degree standard hooks to anchor the horizontal reinforcing bars to the vertical reinforcing bars located closest to the wall opening.For cross-tie reinforcing oriented perpendicular to horizontal reinforcing and engaging the same vertical reinforcing bar, install consecutive cross-tie reinforcing so the 135-degree standard hooks will be located on opposite sides of the wall.

The wall segment length is defined as the distance between wall openings; if there are no wall openings, the wall segment length is equal to the wall length.

D.3.4.2.6 Where ACI 318, Building Code Requirements for Structural Concrete, is available, providing walls in accordance with ACI 318 requirements for Special Structural Walls with Special Boundary Elements will ensure conformance with the recommendations noted here.

D.3.4.2.7 Where multiple openings in the walls are proposed, creating horizontal wall segments (coupling beams between multiple openings vertically aligned) or vertical wall segments (wall piers or columns), special reinforcing and detailing is required to ensure adequate performance of the wall. Addressing these conditions is beyond the scope of this document.

APPENDIX E FIRE DOORS AND PROTECTION OF OPENINGS

E.1 Recommendations

E.1.1 Protection of Openings in Fire Walls

E.1.1.1 General Requirements for All Opening Protection

E.1.1.1.1 When purchasing fire doors, specify the hardware, frame (swinging doors), operators, and related devices as part of the assembly.

E.1.1.1.2 When it is necessary to have an opening in a fire wall that is larger than any FM Approved fire door, protect the opening with a door that has an FM Approvals oversize label (see Figure 100).

E.1.1.1.3 When an elevator is to be located next to a fire wall, arrange it so the elevator door is not in the plane of the fire wall.

E.1.1.1.4 Ensure doors that are normally closed doors are also self-closing (see Figures 81 and 82) and are equipped with a latch. Install weights, door closers, or spring hinges if necessary.

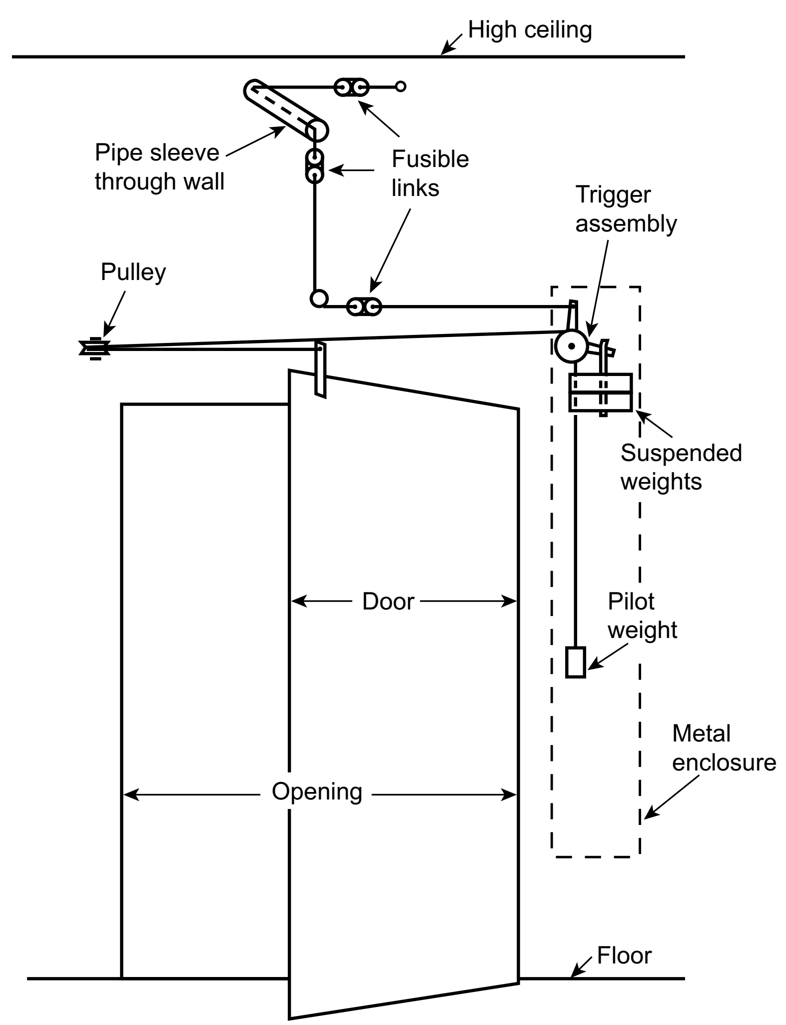


Fig. 81. Single swinging fire door (reprinted with permission from NFPA 80, Fire Doors and Windows)

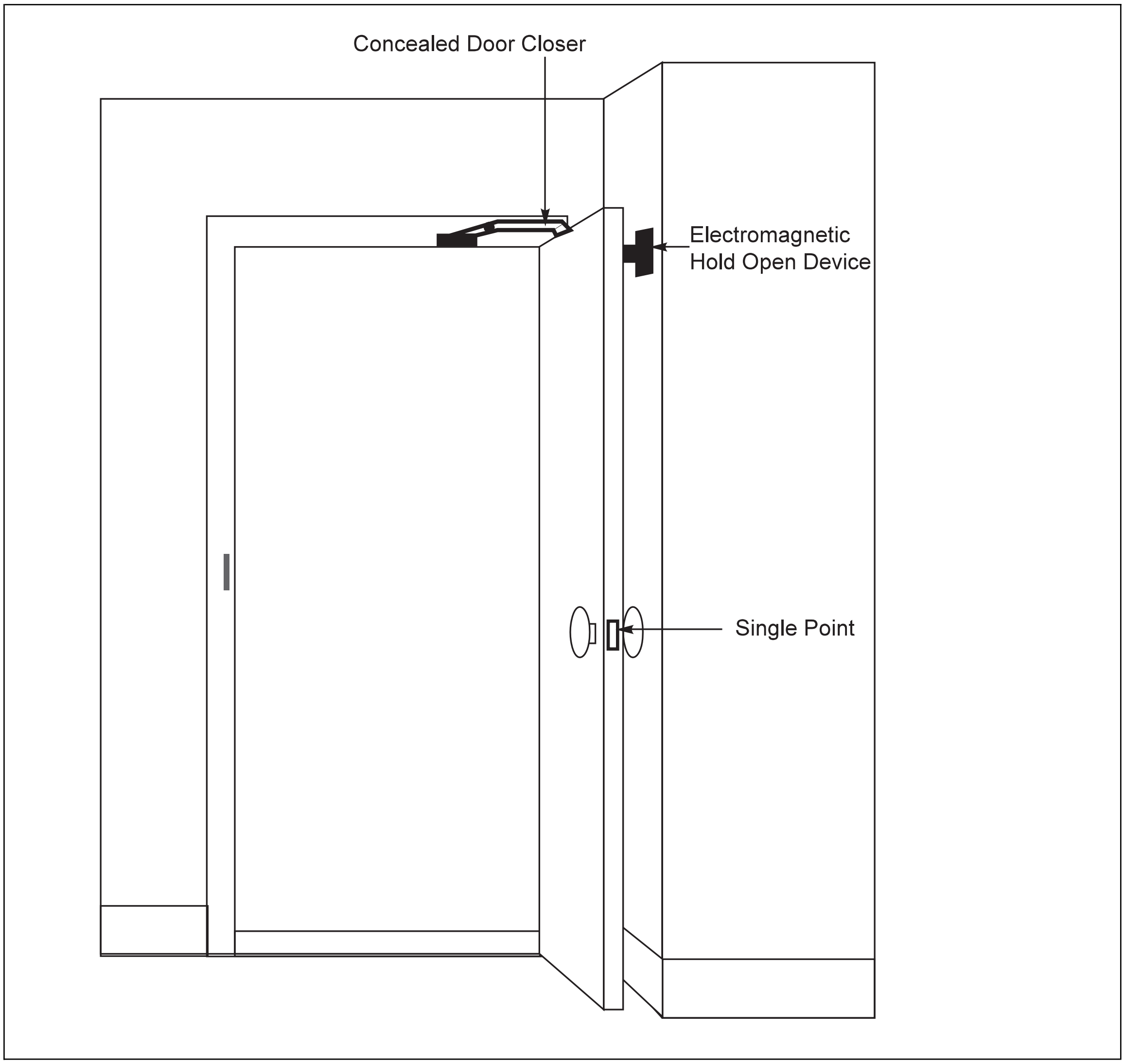


Fig. 82. Swinging fire door with door closer (reprinted with permission from NFPA 80, Fire Doors and Windows)

E.1.1.1.5 Ensure doors that are normally open are also self-closing by installing a mechanism that will close the door automatically when activated by a detector (see Figures 81 and 82). Locate the activating mechanism where it will be protected against mechanical damage.

E.1.1.1.6 Install doors in accordance with the manufacturer's instructions and their FM Approval requirements to ensure proper operation and tightness.

E.1.1.1.7 Use FM Approved or listed hardware where applicable. Ensure all bolts supporting guides/tracks extend completely through the wall. As an alternative in concrete, brick, or grouted (filled) concrete masonry units, expansion anchors may be used (see Figure 83). Ensure expansion anchors engage the brick or masonry unit and not the mortar joint.

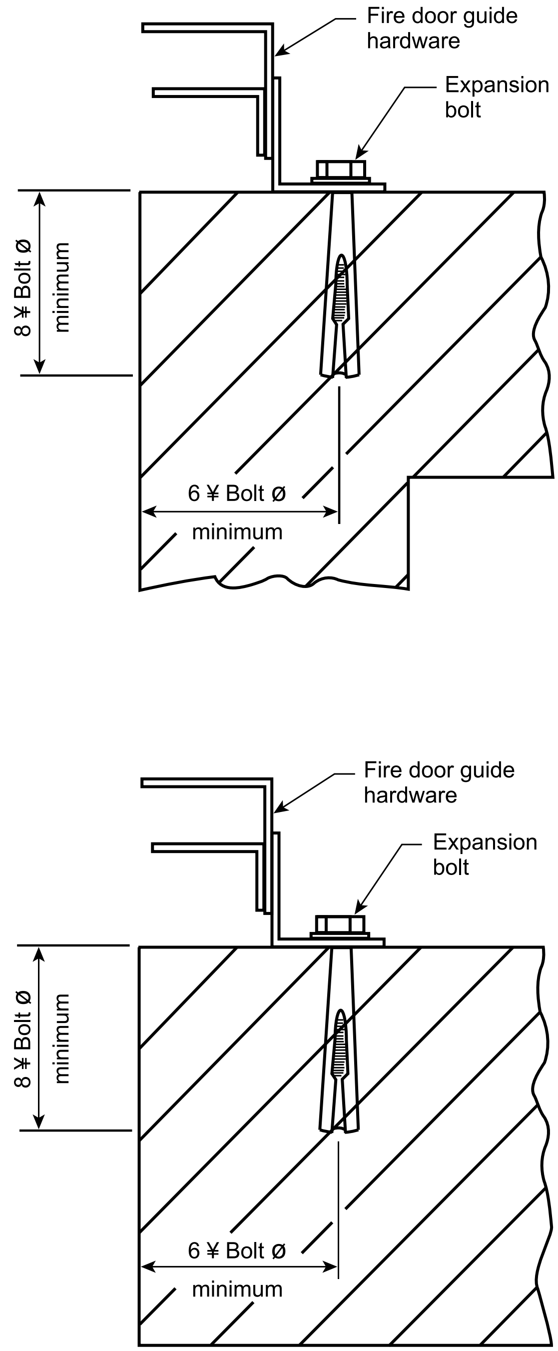


Fig. 83. Use of expansion anchors to secure guides/tracks(reprinted with permission from NFPA 80, Fire Doors and Windows)

E.1.1.1.8 Enclose all weights (counterweights, hold-open weights, etc.) used for automatic closing mechanisms in substantial metal enclosures for the entire length of travel. Provide slots in the enclosure to permit raising the weight manually during inspection of the doors (see Figures 84, 85, and 86).

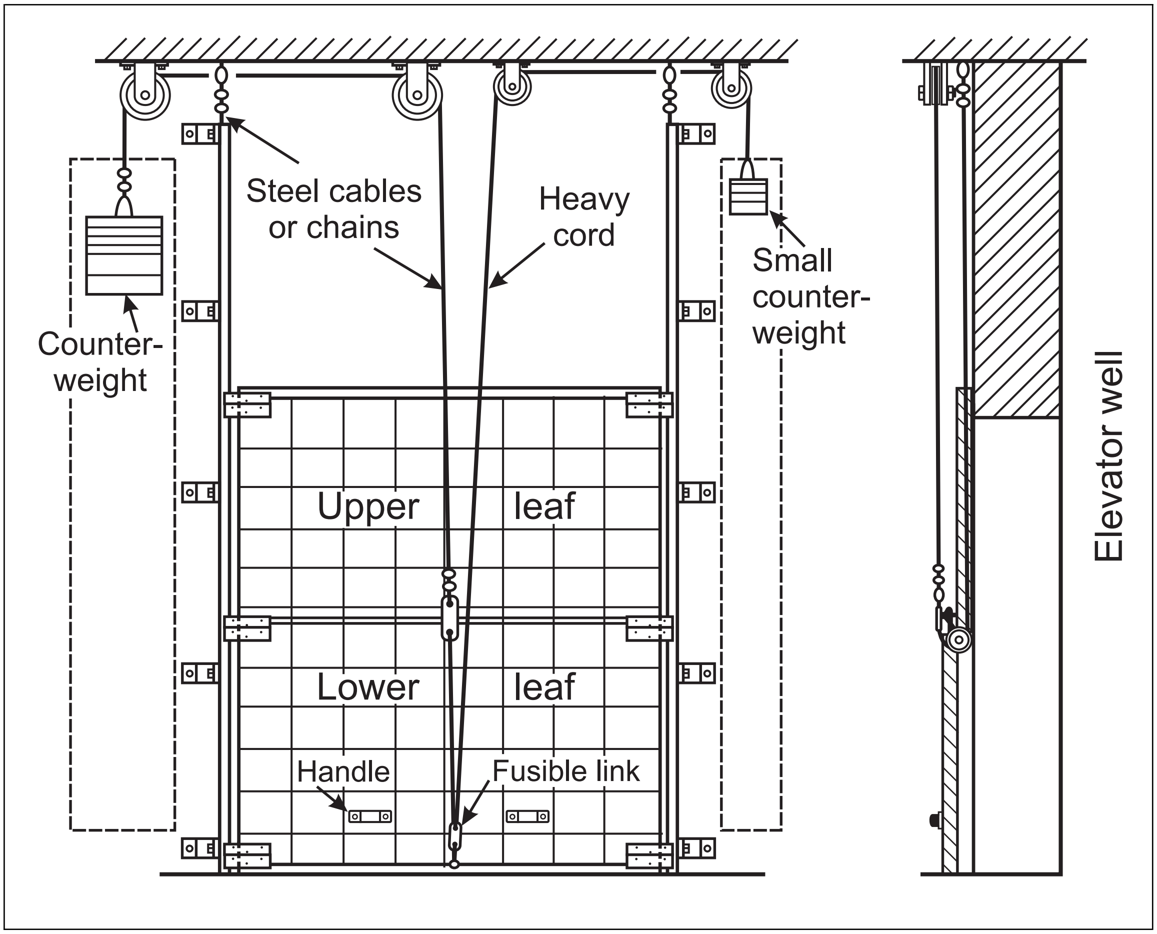


Fig. 84. Telescoping vertically sliding doors (reprinted with permission from NFPA 80, Fire Doors and Windows)

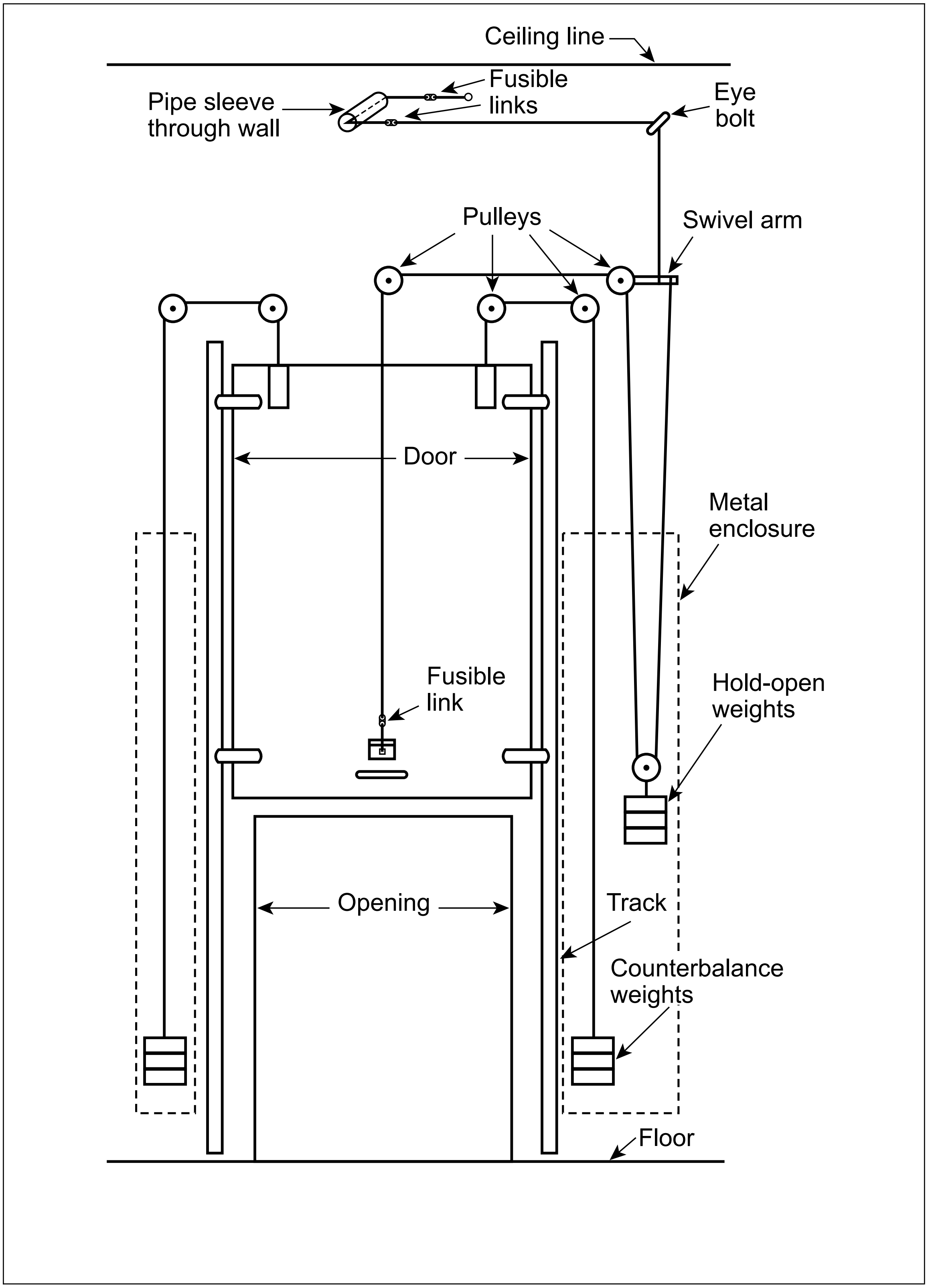


Fig. 85. Vertically sliding door (reprinted with permission from NFPA 80, Fire Doors and Windows)

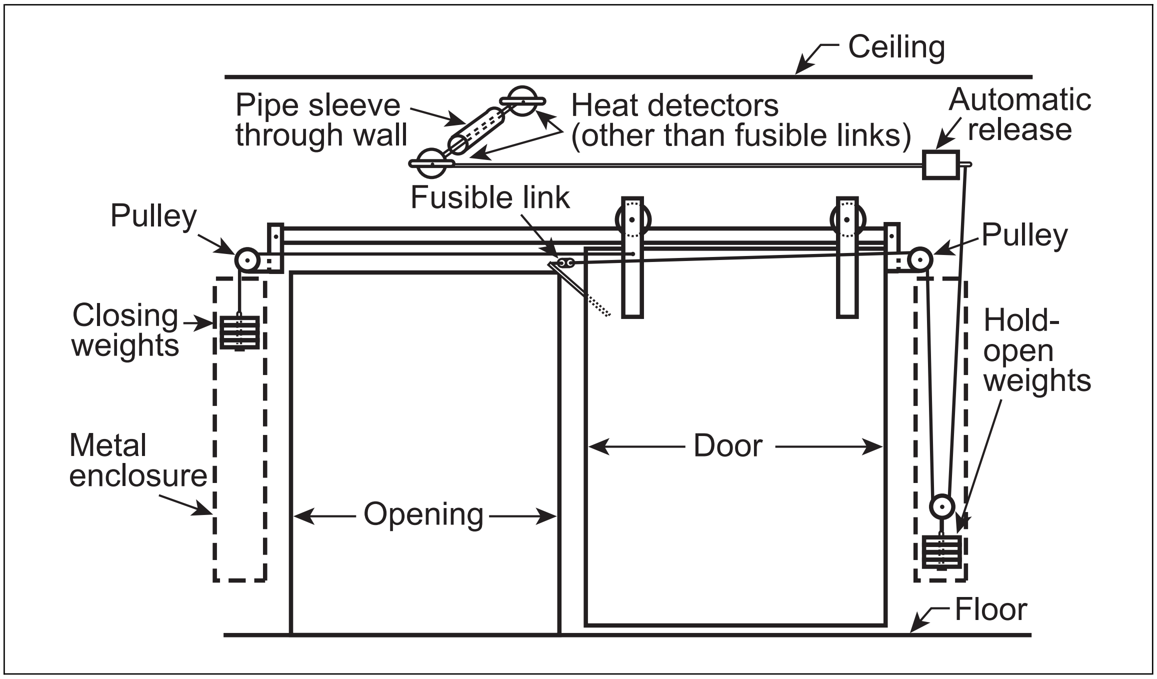


Fig. 86. Horizontal sliding level track counterweight closure (reprinted with permission from NFPA 80, Fire Doors and Windows)

E.1.1.2 Detection and Actuation Devices

E.1.1.2.1 Where activation is by electric or pneumatic power, arrange the system so the door will close if power is interrupted.

E.1.1.2.2 Arrange doors on an opening to close automatically upon activation of a detector on either side of the wall.

E.1.1.2.3 Fusible Links

E.1.1.2.3.1 The particular fusible link used should depend on the temperature and load requirements of the application.

E.1.1.2.3.2 Multiple links are permitted to be used to meet the load rating requirements where the load rating of a single link is exceeded.

E.1.1.2.3.3 Fusible links should be placed with one fusible link located near the top of the opening, and additional links located per Data Sheet 5-48, *Automatic Fire Detection*.

E.1.1.2.3.4 Fusible links should be installed on both sides of the wall and interconnected so that the operation of any single fusible link causes the door to close.

E.1.1.2.3.5 Fusible links installed on both sides of the wall should pass through a sleeve installed through the wall to provide an open pathway for the cable or chain connecting the fusible links.

E.1.1.2.3.6 The sleeve should be 1⁄2 in. (13 mm) diameter galvanized steel conduit or pipe, with ends deburred, and fitted with a collar or bushing at each end to secure the sleeve around the wall and allow free movement of the cable or chain through the sleeve upon fusing of the links.

E.1.1.2.3.7 When cable is used to interconnect fire door closing mechanisms and detectors on both sides of the fire wall, ensure it passes freely through 1/2 in. (13 mm) inner dimension steel pipe embedded in the wall. Ensure the distance between the inlet to the pipe or eyelets and the detector on each side is at least adequate to allow the door mechanism to fully release and allow the door to close. Cut the steel pipe flush with the face of the wall on each side and grind it smooth at each end to prevent abrasion and resistance to cable movement (see Figure 57). It is not necessary to penetrate the wall at the ceiling level. Other arrangements that meet the intent of this recommendation are acceptable.

E.1.1.2.3.8 Use aircraft cable (see Figure 56) for connecting fusible links and weights (counterweights, hold-open weights, etc.) to automatic closing mechanisms. Ordinary cable may take a permanent set, and chain can kink or hang up on other components. Avoid sharp changes in direction (>90°) unless pulleys are used.

E.1.1.3 Supporting Construction

E.1.1.3.1 In buildings with noncombustible floors, a sill is not required, provided the floor extends through the door opening.

E.1.1.3.2 In buildings with combustible floors or combustible floor coverings, a sill is required if the floor extends through the door opening.

E.1.1.3.3 Door openings required to be protected by 1⁄2-hour to 1½-hour rated fire door assemblies are exempt from the requirements of E.1.1.3.2

E.1.1.3.4 Combustible floor coverings should not extend through openings protected by ≥3-hour fire door assemblies.

E.1.1.3.5 Where it is important to prevent the passage of liquids through openings, install sills, curbs, or ramps made of fire-resistive construction at the opening above floor level (see Figure 87), and provide adequate floor drains nearby.

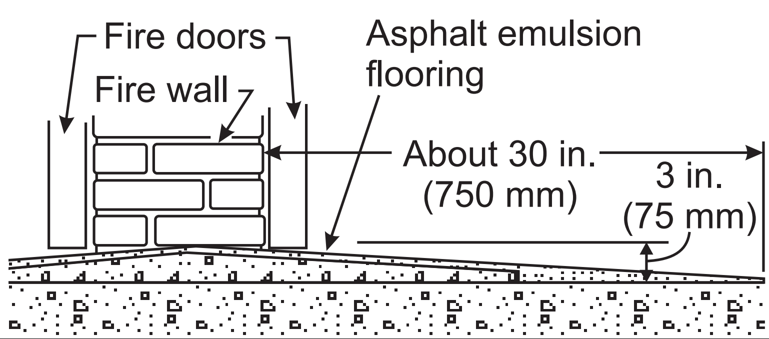


Fig. 87. Asphalt emulsion floor over concrete ramp

E.1.1.3.6 Ensure lintels and opening framing are of fire-resistive construction, such as brick, reinforced concrete, concrete masonry, or protected steel (see Figure 88).

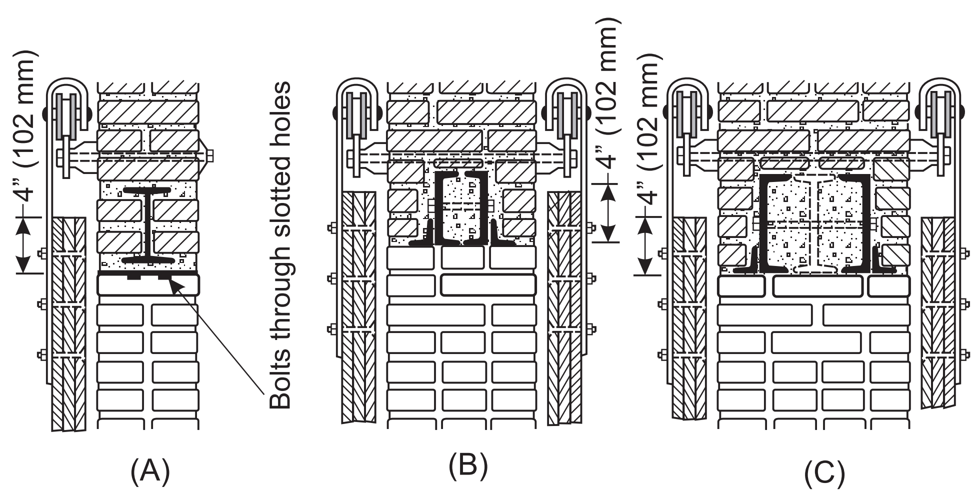


Fig. 88. Lintels of fire-resistive construction

E.1.2 Inspection, Testing, and Maintenance

E.1.2.1 Inspection and Testing

E.1.2.1.1 Inspect doors, hardware, and closing devices for all fire doors weekly. Replace when necessary, using parts obtained from the original manufacturer. Check the doors to ensure they are free-moving and otherwise in proper operating condition and free from obstructions. Record inspections.

E.1.2.1.2 Trip-test fire doors at least semiannually by fusing a link (using an electric heat gun and standing back to avoid solder splatter) or setting of a detector. Trip-testing by shutting off the power supply or other means is acceptable provided the method constitutes an actual test of the door-closing mechanism.

Cutting or removing the links could give false results as this could loosen dirt and debris that might otherwise restrain the door.

For convenience in higher buildings, it is acceptable to fuse the link near the top of the door opening. However, ensure there is enough room for movement in both directions between fusible links or S-hooks to allow sufficient chain movement for the door to close. The direction of movement of a section of chain may be reversed depending on which link actually fuses.

Example: An eyelet is located immediately below a ceiling-level fusible link. If the link located near the top of the opening is fused, the chain is free to move upward. However, if the ceiling level link is fused, the chain cannot move sufficiently downward to release the door.

E.1.2.2 Maintenance

E.1.2.2.1 Keep fire doors and accessories in good working condition. Remove dust, lint, and debris. Lubricate parts in contact as recommended by the door manufacturer.

E.1.2.2.2 Replace a fire door if either of the following is true:

A. The door is obsolete and parts cannot be obtained. (Do not have parts fabricated by installers, contractors, or maintenance personnel.)

B. The door has failed more than once for the same or for related mechanical reasons.

E.1.3 Horizontal Sliding Doors

E.1.3.1 When horizontal sliding doors are mounted in pairs (bi-parting), ensure the center joint is rabbeted or provided with an astragal (Figures 89, 90, and 91) to provide a minimum lap projection of 3/4 inch (19 mm).

E.1.3.2 Ensure all horizontal sliding doors and metal-clad or sheet metal vertical sliding doors lap the sides and the top of the opening by at least 4 in. (100 mm). Ensure steel sectional vertical sliding doors lap the top and sides of the openings by at least 2 in. (51 mm).

E.1.4 Rolling Steel Doors

E.1.4.1 After installation, have rolling steel fire doors satisfactorily tested, reset, and tested again to ensure the installer/operator has reset the door-closing mechanism correctly. When spring tension is used to close the door, make chalk marks noting the gear alignment to the release lever until the proper spring tension has been established. The door can then be reset and placed back in service.

E.1.4.2 If an end cover (closing device housing) is provided, it should be in place during testing. Ensure it is reinstalled after the door is reset. Ensure the closing device housing (end cover) on all rolling steel fire doors (Figure 92) is reinstalled after the door is reset. The housing must also be in place during testing.

E.1.5 Material Handling Systems

E.1.5.1 All Material Handling Systems Except Automatic Guided Vehicle Systems (AGVS)

The following recommendations apply to all material handling systems, with the exception of automatic guided vehicle systems (AGVS). For AGVS recommendations, see Section E.1.5.4.

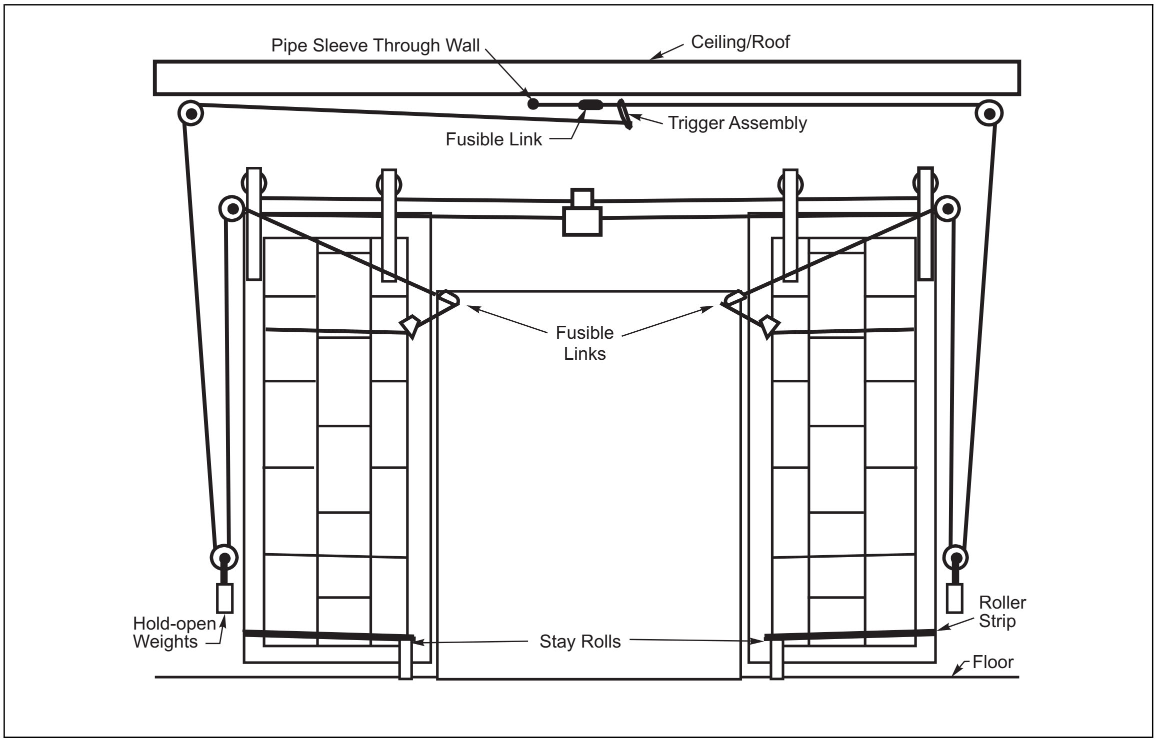


Fig. 89. Pair of metal-clad sliding fire doors (biparting) on inclined track (reprinted with permission from NFPA 80, Fire Doors and Windows.)

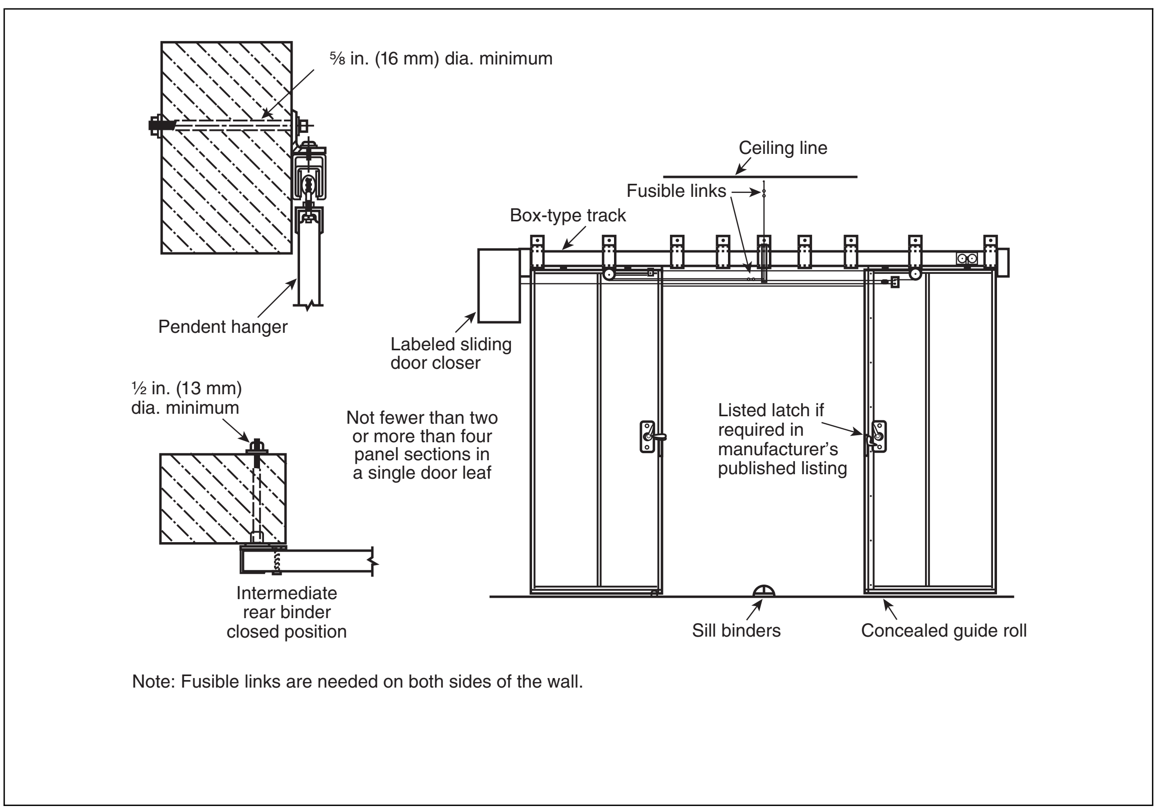


Fig. 90. Sliding doors on level tracks (reprinted with permission from NFPA 80, Fire Doors and Windows)

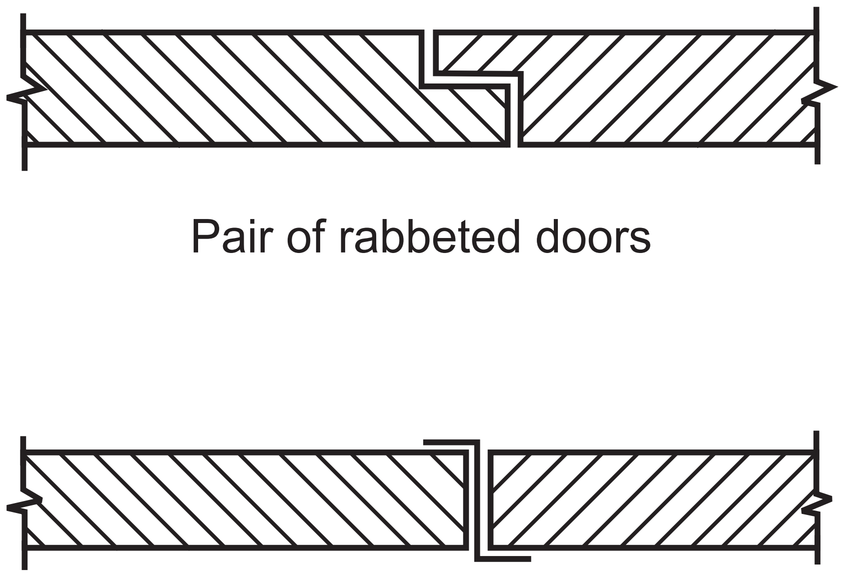


Fig. 91. Preferred details at center joint of doors mounted in pairs (reprinted with permission from NFPA 80, Fire Doors and Windows)

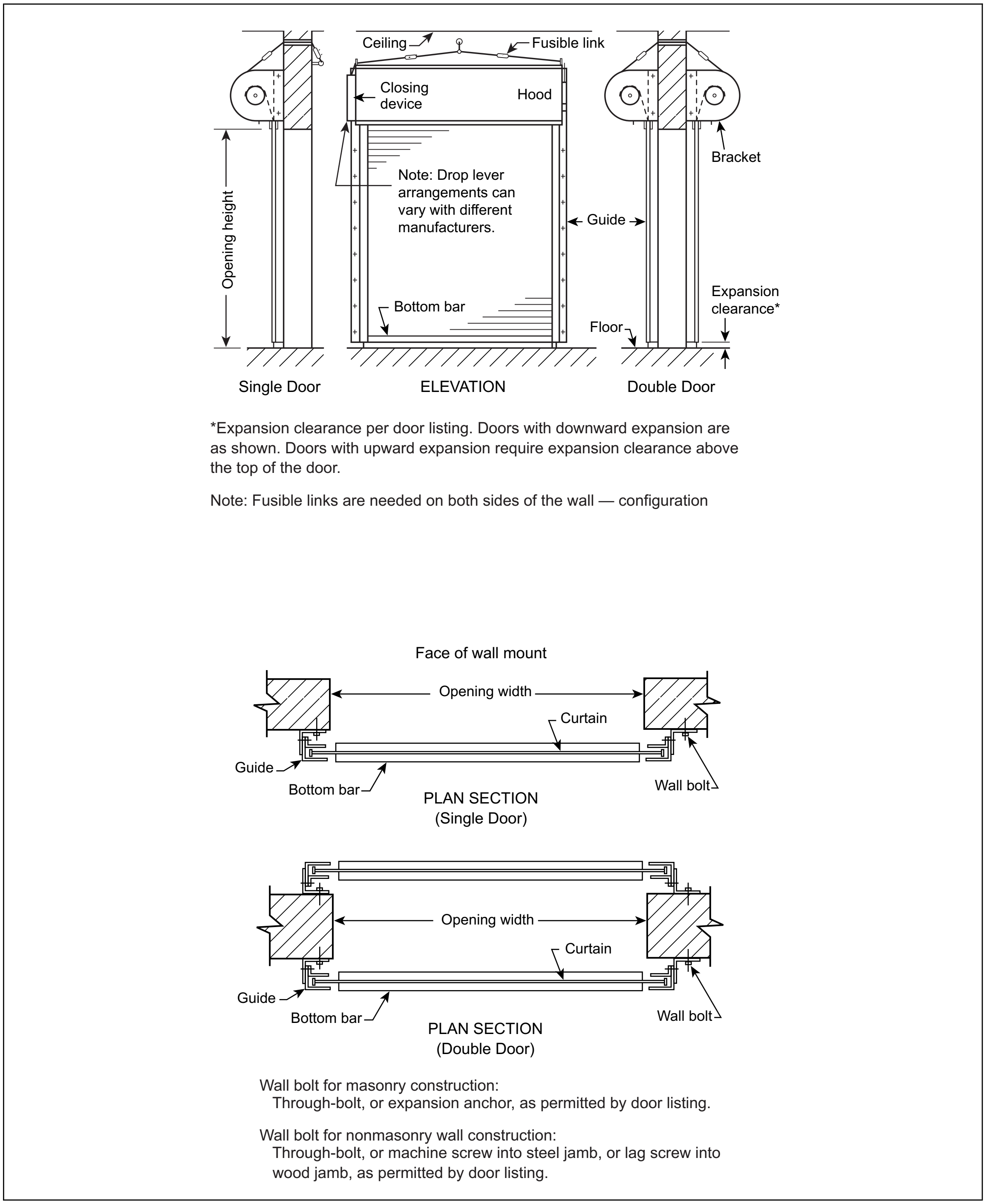


Fig. 92. Rolling steel doors—surface mounted (reprinted with permission from NFPA 80, Fire Doors and Windows)

E.1.5.1.1 Ensure clearance around rails or chains is a maximum of 3/8 in. (10 mm) and a special factory applied label (see Figure 93) is attached to the door. Small openings for clearance around conveyor rails or chains are acceptable if necessary (see Figure 94), except in occupancies with a significant amount of combustible dust or lint.

(COMPANY NAME)
(CITY AND STATE)
THIS DOOR CONFORMS TO A 3 HOUR RATED CONSTRUCTION BUT IS NOTCHED FOR A CONVEYOR
IT WAS PRODUCED UNDER THE FM GLOBAL AUDIT INSPECTION PROGRAM
ACCEPTANCE IS THE PREROGATIVE OF THE AUTHORITY HAVING JURISDICTION
SERIAL NO.

Fig. 93. Notched fire door label

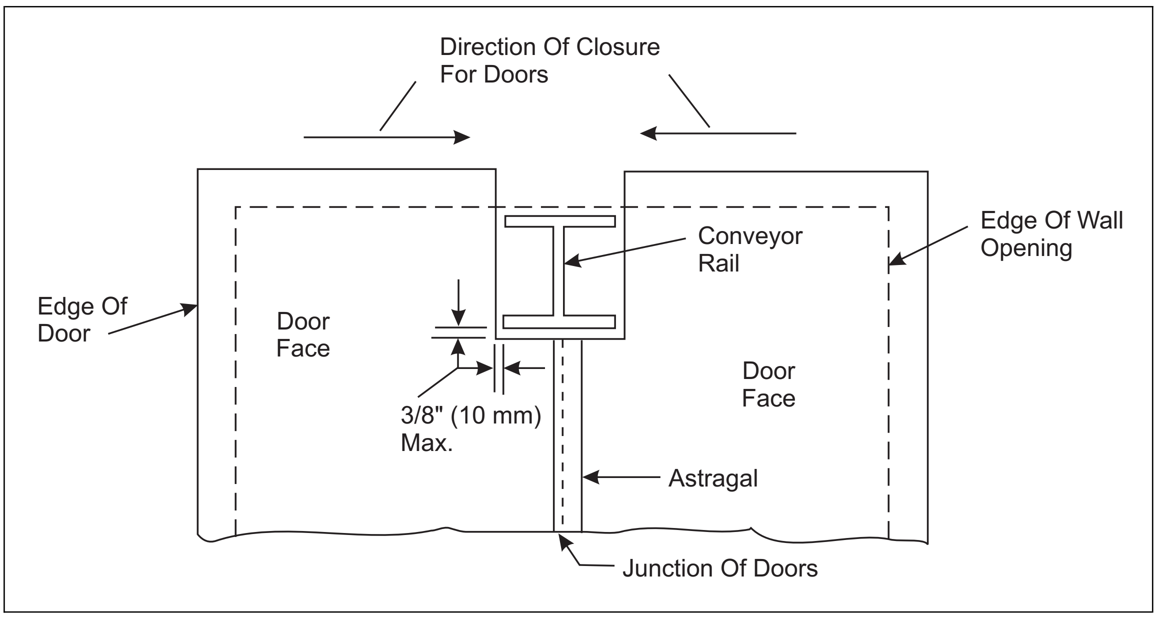


Fig. 94. Fire door arrangement around conveyer rail

E.1.5.1.2 Arrange the conveyor drive mechanism to shut down the conveyor if conveyed material can become lodged in one position and obstruct closure of the fire door. Ensure sections of the conveyor downstream of the obstruction can continue to operate.

E.1.5.1.3 Ensure the fire door at the opening is capable of effective closure regardless of whether or not any section of the conveyor is operating.

E.1.5.1.4 Where it is impractical to provide inclined sections at the junction of the fire wall with roller or belt conveyors, special design is necessary to allow a clear path for the fire door to close. Detectors must still be provided as outlined in Section 2.5.9.1.4.

E.1.5.1.5 Ensure tow conveyors use vestibules with a fire door at each end, and that vestibule walls, roof, and floor have a fire-rating equal to or greater than that of the fire wall.

E.1.5.1.6 Ensure the clear distance between carts on tow conveyors is greater than the vestibule length, including the fire door widths. Ensure the clear distance between doors is greater than the length of the carts. Only use carts at clip-on points (points where carts are attached to drive chain). Do not place carts between clip-on points and allow them to be pushed by the carts behind them (ee Sections 3.4.3 and 3.4.4).

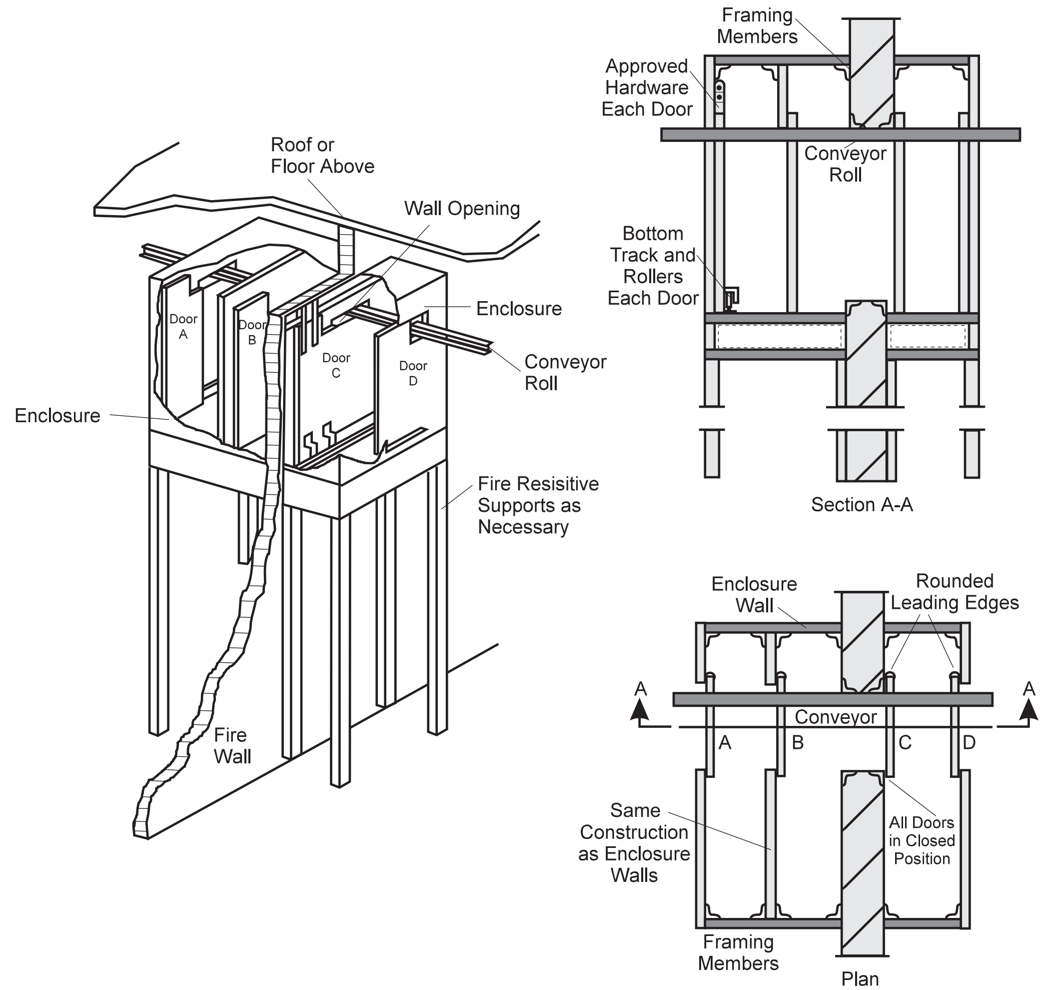


Fig. 95. Door-pack installation (reprinted with permission from NFPA 80, Fire Doors and Windows)

E.1.5.1.7 Provide devices to stop the conveyor if a door drifts into a fouling position, and before allowing automatic closure.

E.1.5.1.8 House lowerators for handling of roll paper in a fire-rated enclosure. Provide fire doors at each end of the enclosure. Keep at least one door closed at all times.

E.1.5.1.9 Where emergency stops are required on material-handling systems, arrange them in such a manner as to not compromise the reliability of fire door closure. This can be accomplished on conveyor systems by providing an inclined gravity section at the wall, and separately powered feed and take-away sections. Another alternative is to provide three separately powered sections (feed, middle, and takeaway sections) with the middle section at the wall enclosed in a cage that would thus not require an emergency stop mechanism. The feed and take-away sections could then be equipped with the necessary emergency stop mechanisms.

E.1.5.2 Roller and Belt Conveyors with Inclined Gravity Sections

E.1.5.2.1 Interlock the sections of conveyor on each side of the wall so the feed section can only move when the downstream takeaway section is moving. Arrange the feed conveyor to stop prior to operation of the fire door, allowing the gravity roller section to clear the opening. Provide a sufficient gap in the roller conveyor to allow the fire door to close fully (Figure 66).

E.1.5.2.2 Ensure combustible conveyor belts are not continuous through an opening in a fire wall. Arrange conveyor belts to turn back on each side of the wall, and use an inclined section of roller conveyor of adequate length at the opening. Make arrangements to prevent stock from backing up into the inclined section or wall opening.

A. Provide interlocks so that, if primary power is lost or shut down to the take-away section, the feed conveyor will automatically shut down and cannot be started until the take-away section is operating. Provide photo-eyes at the take-away side of the wall opening so that if a back-up of goods is sensed they will shut down the feed conveyor. Provide a time-delay switch so that, during normal shutdown, the take-away section will continue to operate briefly after the feed section has been shut down so the opening is clear.

B. Ensure the distance between the upper end of an inclined gravity section and the face of the fire door on its respective side (Y) of the fire wall is at least equal to the maximum dimension of the opening (Figures 66 and 67). When this is not practical, provide fire doors with a 30-minute temperature rise rating of 250°F (121°C) on the opening.

C. Ensure the distance between the lower end of the inclined gravity section and the face of the fire door on its respective side (X) is at least equal to the maximum dimension of the opening plus twice the length of the longest parcel to be conveyed (2L) (Figures 66 and 67). A distance of 2L is acceptable if fire doors with a 30-minute temperature rise rating of 250°F (121°C) are provided. If this is still not practical, provide the above rated doors with a downstream incline at least equal to L, and the following:

1. Totally enclose the control panel for the take-away section nearest to the fire wall in metal casing, and interlock it so the control panel will not operate unless its access door is closed.

2. Ensure the motor for the same section has a totally enclosed metal housing, and wiring in conduit.

3. Locate the control panel and motor adjacent to the door opening.

4. Connect the take-away section of the conveyor to a back-up power supply. The back-up power supply may consist of a pneumatic system, a flywheel system, or float-charged batteries with dc-ac inverters capable of powering the take-away section for a long enough period to clear the opening (usually only a few seconds).

If it is not practical to install the control panel and motor near the wall opening, provide a 135° or 165°F (57° or 74°C) detector (or minimum 50°F [28°C] above ambient) over the control panel and motor, or extend a temperature-detection wire over the take-away section nearest the fire wall. Arrange the detector to shut down the feed conveyor. This will help ensure proper fire door closure before the panel or motor on the take-away section is damaged by a fire. Interlock control panels so they will not operate unless the control panel door is closed.

E.1.5.3 Roller and Belt Conveyors without Inclined Gravity Sections

E.1.5.3.1 Where it is impractical to provide inclined sections at the junction of the fire wall, special design is necessary to allow a clear path for the fire door to close. The design generally relies on a normal electrical feed as the primary power supply. In case of a failure of the primary power supply, provide a secondary power supply to temporarily power the intermediate and take-away portions of the conveyor (Figure 68). This secondary power supply may electrical (i.e., batteries), pneumatic, or mechanical.

E.1.5.3.2 Do not connect the secondary power feed to a switchboard common to the main power feed. Ensure wiring is in conduit, and control panels and motors are totally enclosed in metal casings and located as close to the fire wall opening as possible.

E.1.5.3.3 Regardless of the power supply arrangement, provide a photo-eye on the take-away side of the opening to prevent back-up of goods near the door. Arrange it to shut down the feed conveyor before goods can back up within a distance equal to the maximum opening dimension.

E.1.5.4 Automatic Guided Vehicle Systems (AGVS)

E.1.5.4.1 Provide a central control station and electromagnetic guidance.

E.1.5.4.2 To maintain the reliability of the opening protection, use one of the following methods:

A. Keep one of the two fire doors at each vehicle opening in fire walls normally closed and equipped with power operators. Arrange the AGVS for automatic door control. A high-service door may be needed.

B. Provide a 4-hour fire-rated reinforced concrete vestibule. Ensure the vestibule has at least one 3-hour rated fire door at each end and the clear space between fire doors is longer than the longest vehicle or group of vehicles. Station the zones (see Section 3.4) so the horizontal clear space between vehicles or groups of vehicles is greater than the length of the vestibule (including fire door widths). This alternative is more practical when individual vehicles are used.

C. Provide a vehicle block system. Ensure the first zone station before the fire wall is at least the maximum dimension of the opening away from the fire wall. Ensure the first zone station beyond the fire wall is further away from the fire wall than the length of the vehicles (based on the maximum number of vehicles that can be coupled together, if applicable), plus the maximum dimension of the opening. Ensure the block system allows only one vehicle between the stations at one time. Provide the vehicles with a backup on-board power supply that will power the vehicle to the next station in the event of a loss of power to the central control station. Provide one 3-hour rated fire door on each side of the opening.

E.1.5.4.3 Provide fire door interlocks to immediately stop any oncoming vehicles at the first zone station prior to the fire wall upon fire door closure.

E.1.5.4.4 When multiple detectors are used to create a time delay provide detectors at each door opening and at ceiling level over the door opening on each side of the fire wall (in close proximity to each other). Use a 165°F (74°C) rated, fail-safe combination rate-of-rise, fixed temperature detector to stop all vehicles at the next zone station. Use a 286°F (141°C) rated detector to initiate door closure.

E.1.5.4.5 If two-way travel is needed, arrange controls so oncoming vehicles clear the opening prior to approach by the second vehicle(s).

E.1.5.4.6 Ensure an adequate clearance width is marked and maintained along the entire length of vehicle paths.

E.2 Support for Recommendations

E.2.1 Fire Door Construction

For door sizes and fire-protection ratings, see the latest edition of the *Approval Guide*.

There is a maximum size limitation on FM Approved fire doors because larger units cannot be tested. The actual size limit is noted in the Approval Guide and varies, depending on manufacturer and model, up to 152 ft^2 (14 m^2). Where protection of larger openings is necessary, the practice is to use doors that are of the same design and construction as those that have been fire-tested. Factors considered in determining adequacy of oversized doors for a given situation include the building area, type of construction, and the arrangement and hazard of the occupancy-all with relation to the location of the opening. When an opening that is too large for an FM Approved fire door is contemplated, consult FM Approvals for advice as to the suitability of an oversized door.

For sample labels, refer to Figure 100.

Oversized doors (larger than those tested and listed in the *Approval Guide*) must be specially labeled to verify construction is similar to that of an FM Approved door. Labeling of oversize doors applies only to rolling steel or sliding doors.

An additional label (see Figure 93) is available to accommodate sliding doors for use in openings in fire walls penetrated by conveyors. Such doors are notched to provide as much closure as practical around the conveyor track (see Figure 94). As the track size may vary, so too may the notch; however, the maximum clearances must not exceed those noted in Figure 94.

Vision panels may only be installed on fire doors having a maximum fire rating of 1 ½-hours (interior) or ¾-hours (exterior). Consequently, they may not be used in fire doors protecting openings in MFL fire walls, where a 3-hour fire door rating (Class A opening; see section E.2.8) is needed, or in exterior fire doors where a severe exposure exists (Class D opening). The maximum area and dimensions of glazing for doors in Class B, C, or E openings are given in Table 8.

Table 8. Allowable Glazing Area For Fire Doors

Fire Door Rating, hour	*Maximum Area, in^2 (cm^2)*	*Maximum Dimension, in. (cm)*
1/2 & 1/3	Maximum area tested	Maximum tested
3/4	1296 (8360)	54 (137)
1, 1-1/2, 2, 2-1/2	100 (645)	33 (84)
3, 4	0	NA

Fire door hardware used with the fire doors is an important part of the overall door installation. Only FM Approved hardware may be used when hardware has been FM Approved for that type door; otherwise, appropriate listed hardware must be used.

Fire door hardware is classified as either builders' hardware or fire door hardware. Builders' hardware has a subcategory of "fire exit hardware," which consists of devices FM Approved or listed for both fire and panic protection.

Builders' hardware applies only to swinging doors and consists of hinges, locks, latches, top and bottom bolts, and door closers. Builders' hardware is not required to be shipped from the factory with the fire door. Labels on swinging doors will generally provide the minimum latch throw distance required for that size and type door.

Fire door hardware applies to both swinging and sliding fire doors. This hardware consists of surface-mounted hinges, latches, and door closers. This type of hardware is shipped from the factory with the fire door.

E.2.2 Detectors

Detectors are devices such as fusible links, heat detectors (fixed temperature and/or rate-of-rise), and smoke detectors. Detectors operate the release mechanism that allows door closers to close the doors.

When heat detectors are used, they must be a restorable type and a combination fixed-temperature and rate-of-rise type. Smoke detectors must be suitable for the environment. Smoke detectors may experience false operation in dusty environments, etc. For more information, refer to Data Sheet 5-48, *Automatic Fire Detection, and the Approval Guide*.

FM Approved fusible links are used to operate fire doors, shutters, dampers, and other devices at the predetermined temperature. The fusible-type link consists mainly of two metallic plates joined together by a special solder alloy. The solder melts at a predetermined temperature allowing the plates to separate. Other types of FM Approved links operate by the bursting of a glass bulb due to the expansion of an enclosed liquid or the liquefying of a chemical compound when exposed to heat.

FM Approved fusible links are stamped with the following information:

- Manufacturer's name
- Listing agency logo
- Load rating
- Temperature rating
- Model designation
- Year of manufacture

The load rating generally varies from 5 to 50 lb (2.3 to 2.7 kg), and can be as high as 500 lb (227.3 kg).

The load rating of the links must be at least equal to the load required to hold the door open. This load will vary, depending on the type and size of the door and the counterweights used (if applicable).

E.2.3 Door Closers

Door closers can be spring-operated arms located at the top of the door or spring hinges and are used to make swinging doors self-closing. Their application must not exceed the sizes and weights listed in the *Approval Guide*, and they must be used in the quantities indicated therein. No hold-open points are permitted in this type of device.

E.2.4 Power Operators

Occasionally, conditions are such that either pneumatic or electric power operators are desirable for the normal opening and closing of a fire door. Such a practice is acceptable, provided FM Approved or listed power operators or power operator-release devices are used with the appropriate fire doors. Unless the power operator is a fail-safe design, it must physically disconnect from the door when automatic closure is initiated. This prevents accidental opening of the door after automatic closure.

FM Approved operators are equipped with an automatic closing feature that must be capable of closing the door completely under fire conditions without power. The electrical components of the operator must be suitable for the occupancy where installed as required by the National Electrical Code (NFPA 70).

E.2.5 Electromagnetic Door Holder Releases

Electromagnetic door holder releases are designed to hold open fire doors until they are de-energized by FM Approved detectors or by power failure. Fire doors held open with these releases must close automatically by either gravity or a door-closing device.

E.2.6 Electromechanical Door Holders

Electromechanical door holders are designed to hold fire doors open during normal use and release them to close upon receipt of a signal from a detector.

There are two types: one type is normally energized and will release when de-energized, while the other type is normally de-energized and will release when energized. The normally de-energized units are not fail-safe when power is lost; thus, they are not acceptable for use on MFL fire walls.Doors equipped with these units must be automatic closing upon their release by either gravity or a door-closing device.

E.2.7 Fire Door Operation and Inspection

E.2.7.1 Horizontal Sliding Doors

Horizontal sliding doors may be installed on inclined tracks or level tracks (Figures 89, 90, and Figure 86). Either a single door to one side of the opening or two doors (biparting) may be used. Horizontal sliding doors are mounted on tracks that are bolted to the face of a fire wall. They are generally used to protect openings for vehicle traffic. They move across the track over the opening to seal off the fire wall penetration. Binders (Figure 101) are bolted to the face of the wall on the side of the opening opposite the door. They help to hold the leading edge of the door against the wall at the edge of the opening. A stay-roll (Figures 96, 98, and 99) is provided at floor level near the edge of the opening where the door is held in the open position. The stayroll helps to prevent the door from swaying during operation, and also helps to hold the closed door against the face of the wall at this edge of the opening. A roller strip (Figure 96) is installed across the face of the door in the plane of the stay-roll to prevent wearing of the door face. The average closing speed for all types of horizontal sliding doors should be between 6 and 24 in./s (0.15 and 0.60 m/s).

There are three methods of operation for a horizontal sliding fire door. They are inclined track, straight track with counterweight closure, and straight track with spring closure.

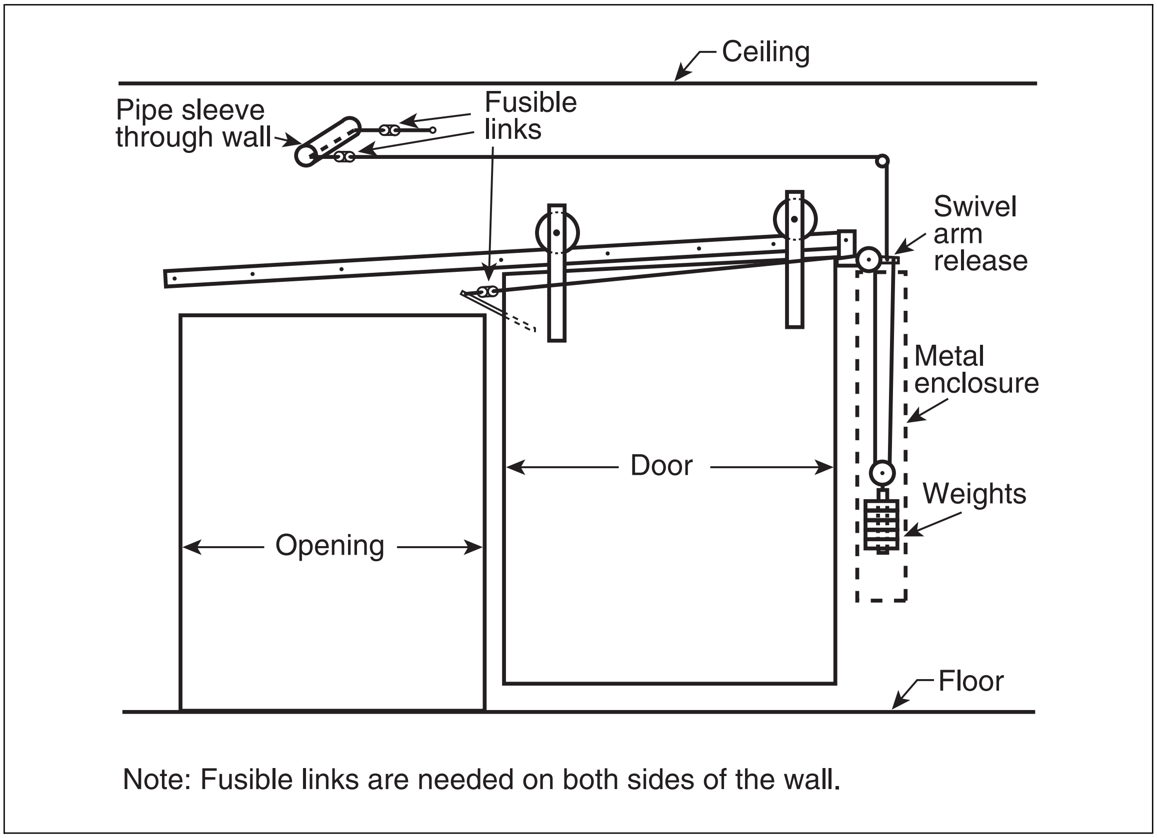


Fig. 96. Horizontal sliding door; inclined track (reprinted with permission from NFPA 80, Fire Doors and Windows)

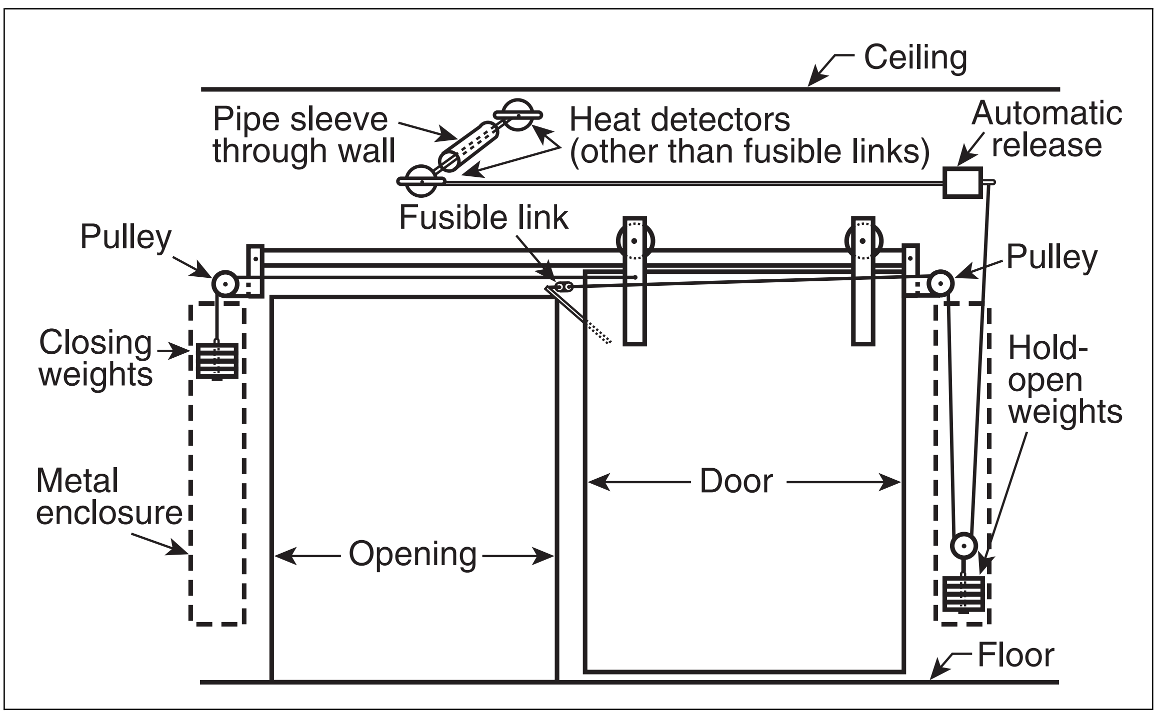


Fig. 97. Horizontal sliding door; level track, counterweight closure (reprinted with permission from NFPA 80, Fire Doors and Windows)

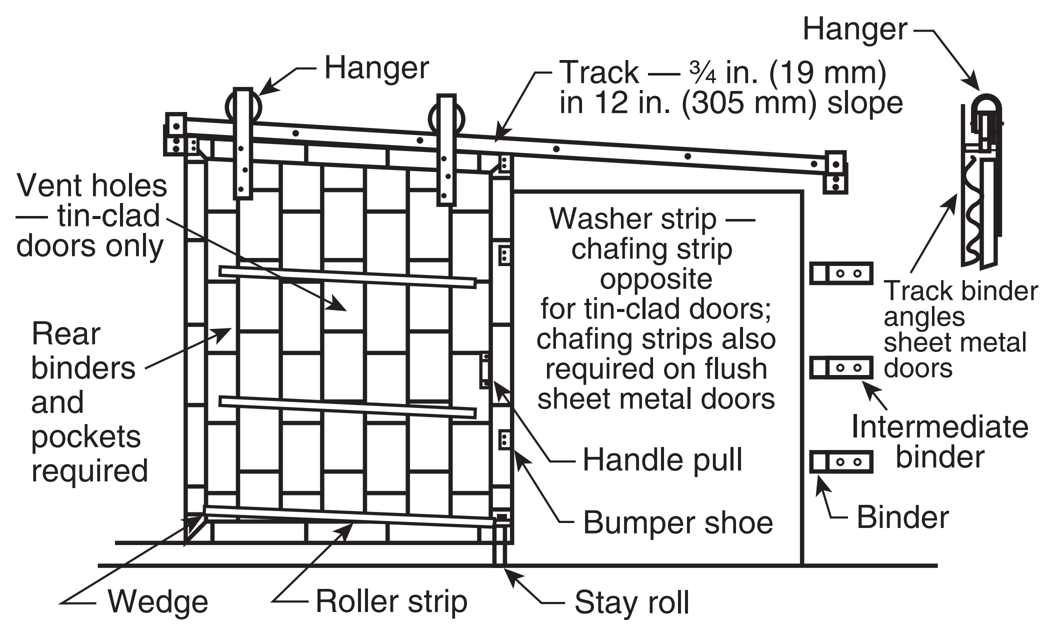


Fig. 98. Horizontal sliding inclined track fire door showing stay rolls and binders (reprinted with permission from NFPA 80, Fire Doors and Windows)

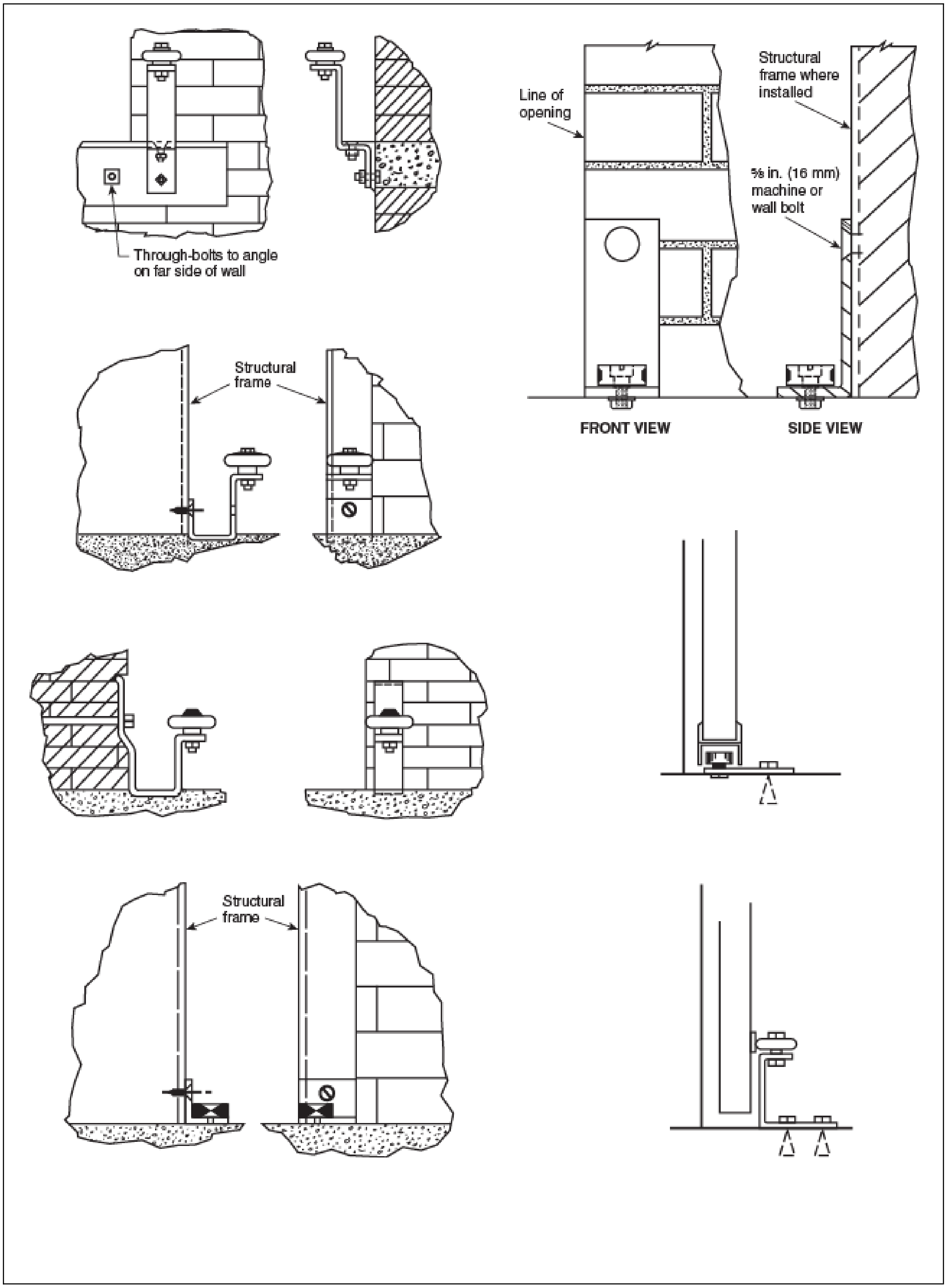


Fig. 99. Stay roll for horizontal sliding fire door (reprinted with permission from NFPA 80, Fire Doors and Windows)

E.2.7.2 Inclined Track

The overhead track (Figures 96 and 98) is inclined at a slight (¾ in./ft, 63 mm/m) downward angle toward the opening to allow for gravity closure. The door is mounted on the track so that, when open, it is on the high side of the track. The door is kept open by hold-open weights that are connected by sash chain, cable, or rope with fusible links in line. The cable must be flexible so as to not develop a permanent set or bind in any way.

One link should be located near the top corner of the opening and another link should be located just below ceiling level and centered over the opening (Figure 97). When one of the links fuses, the hold-open weight drops and allows gravity closure of the door. Counterweights are used to limit the closing speed to 6 to 24 in./s (0.15 to 0.6 m/s).

It is important that the track be installed at the correct angle and elevation above the floor. If the track is too low or the angle is too steep, the door may hit the floor and stop before closing completely. If the track is too high there may be a gap between the floor and door bottom when the door is in the closed position. In some cases dirt or debris can accumulate at floor level and prevent complete closure of the door.

Also, improper or poorly maintained installation of the track anchor bolts can cause the track to sag resulting in the bottom of the door hitting the floor prematurely, thus preventing complete closure. Careless placement of storage can pin the door against the wall, thus preventing movement when the counterweight is released. This can be avoided by the installation of a guard rail placed in front of the door in the open position.

Brief weekly (MFL fire walls) or monthly (other fire partitions) inspections can be made to detect the above problems. Lifting the hold-open weight can help to detect any obvious problems with the door operation.

Since this is the simplest closure method for horizontal sliding fire doors, the failure rate is lower and its use is preferred to that of the other two types.

E.2.7.3 Straight Track with Counterweight Closure

In this installation the track is installed in the level position. One or two sets of counterweights are used.

When two sets of weights are used, the hold-open weights are connected in line with a fusible link(s) (Figure 97). This stabilizes the door in the open position during normal conditions. When a link fuses, the hold-open weights are dropped and the closing weights pull the door closed.

When one set of weights is used, the closing mechanism uses a swivel arm and catch ring arrangement (Figure 86). The cable connecting the weights to the swivel has no fusible links along its length. At the swivel arm is a catch-ring that hooks the cable onto the swivel arm when it is in the vertical position. Another cable, with fusible links, is attached to the swivel arm opposite the catch ring and runs across the door and opening. When a link in this cable fuses, the swivel arm is released and allowed to rotate. As it rotates, it releases the catch ring. The weights pull the cable and catch ring to the leading edge of the door where the catch ring is caught by the catch bracket. The weight then pulls the door closed by the catch bracket.

Potential problems to be noted during inspections include dirt or debris accumulations at floor level near the door path, improper or poorly maintained installation of track anchor bolts, and storage against or in the path of the door. In addition, storage against the wall can prevent adequate movement of the closing weight. A substantial metal enclosure should be provided for the entire length of travel for the closing weight. Lifting the hold-open weight can help detect obvious problems with the door operation. Guard rails should be provided in front of the door in the open position.

E.2.7.4 Straight Track with Spring Closure

This installation uses a level track and a spring-actuated closing mechanism to pull the door closed (Figure 90). The closing mechanism utilizes cable wound around a reel and is powered by springs. Normal door operation should not result in activation of the reel; however, fusing of a link or activation of a detector releases spring tension, allowing the door to be pulled closed. The reel must be pre-wound to ensure there will be enough spring tension to close the door.

Consult the manufacturer’s literature for the proper number of revolutions, which increases according to door size.

Weekly/monthly inspections must include a check for dirt and debris in the path of the door, the presence of storage near the door, and the track condition, as well as manual operation of the door.

E.2.7.5 Swinging Doors

Swinging fire doors are doors that swing on hinges in or out of a room or building (Figure 81 and 82). Composite and hollow-metal door assemblies can be normally closed, but are also designed to accommodate a normally open position with detector-activated door closure.

Swinging sheet-metal or metal-clad doors can be normally closed or arranged for automatic-closing under fire conditions. Normally open doors with counterweights have a detector that releases a heavy closing weight that drops into a bob weight used to keep the closing chain or cable taut, and both weights close the door (Figure 81). Normally closed doors can be equipped with either spring hinges or a spring-actuated door closer (Figure 82).

Doors arranged to swing in pairs should be equipped with a coordinator that will permit the active leaf to close last. Hardware provisions for these double openings must include appropriate latch devices to maintain the doors in a closed position. Various types of fire exit hardware, either flush or surface-mounted, are available for this application.

E.2.7.6 Telescoping Vertical Sliding Doors

A telescoping vertical sliding door (Figure 84) is divided horizontally into two leaves and, when opening, the lower leaf overlaps the upper. A large and small counterweight are attached separately to the lower leaf, which, in rising, lifts the upper leaf by means of an additional set of cables. The counterweights together keep the door in balance in all positions. A detector causes release of small counterweights, permitting both leaves to close. The size of the large counterweight controls the speed of closing. This type of fire door requires minimum space overhead and is particularly adaptable for installations at existing elevator-well openings.

E.2.7.7 Counterbalanced Elevator Doors

The counterbalanced elevator doors part at mid-height, the upper leaf rising and the lower leaf descending. The two leaves counterbalance each other by means of a chain at each side running over a ball-bearing sheave. The regular-type doors are arranged so the two leaves butt together when in the closed position. In the pass-type, the upper leaf is offset so that in the open position it bypasses the bottom leaf of the door in the story above. In the closed position a formed closure plate fits over the top of the lower leaf. The pass-type is used mainly where the vertical distance between openings and adjacent storage is limited.

Installation in existing shafts may require extensive structural modification on the car or shaft Simple automatic safety interlocks are usually provided to permit opening a door only when the car is at the same floor, and also to prevent the car from moving when the door is open.

E.2.7.8 Passenger-Elevator Doors

The operation of hollow metal doors used in passenger-elevator entrance assemblies is arranged to accommodate vertical transportation needs. Doors may be obtained for swinging or horizontal slide operation. The sliding doors may be bi-parting.

E.2.7.9 Rolling Steel Doors

Rolling steel doors (Figures 92 and 102) are designed to be used as both service and fire doors. They are equipped with a mechanism that closes the door automatically from any position when the mechanism is released by a detector. One or more coil torsion springs provide counterbalancing for normal use and under fire conditions drive the door to the closed position. Adjustment of the counterbalancing mechanisms requires experience.

Rolling steel fire doors may be either face-of-wall (surface) mounted (Figure 92) or between-the-jamb mounted (Figure 102). Listed frames are not needed for these doors. Steel plate and/or structural steel must be used for door jambs. Pressed steel frames must not be used with this type of installation. The steel jambs are needed for impact resistance rather than for fire rating. The door bracket assembly should be attached to the wall with through-wall bolts. When walls are unusually thick or zinc- or cadmium-coated, steel expansion anchors may be used in concrete, brick, or grouted concrete masonry units following guidelines in Figure 83. Bolts securing door guides for double fire walls must not penetrate both walls.

The steel guides for rolling steel fire doors are not usually protected by a fire-resistive coating and therefore heat up and expand when exposed to fire conditions. When vertical steel guides are connected using bolts in the bottom of slotted holes and adequate clearance is provided between the bottom of the guide and the floor, the guide is free to expand with minimal stress from frictional resistance. When the guides are welded in place or there is not adequate clearance below the guides, expansion is restricted: the guides tend to bow, high stresses can develop, and the guides may become partially or totally disengaged from the wall, allowing the opening to be breached.

Manual operators or power operators must be arranged so the fusing of a single detector will allow the operator to disconnect from the door mechanism, enabling the door to close automatically in a fire situation. The average closing speed should be from 6 to 24 in. per second (0.15 to 0.60 m/sec).

E.2.7.10 Vertical Sliding Doors

A vertical sliding door operates in a vertical direction but does not use a spring as does a rolling steel fire door. The door is in one solid piece when it is installed vertically over the opening (see Figure 85). Alternatively, a sectional type door is used in conjunction with a sloped track (like that of a garage door).

Doors installed vertically over the opening are suspended by a system of weights and ropes, cable (as described previously), or sash chain over pulleys. The hold-open weights keep the door in the open position until a fusible link is actuated. Two sets of counter-balance weights, one on each side of the opening, allow the door to close at a safely regulated speed. A substantial metal closure should be provided for the entire length of travel for all weights. Otherwise, storage adjacent to the fire wall may prevent proper operation. Pulleys should be shielded to prevent the cable/chain from jumping off. The average closing speed should be from 6 to 24 in. per second (0.15 to 0.60 m/s).

Sectional doors are counterbalanced by an overhead horizontal helical spring on a shaft. The shaft is attached to a reel with a steel cable, which is attached to both sides of the door near the bottom edge.

Guides for vertical sliding doors must be installed plumb to prevent binding during operation. Guides can be shifted or crimped by lift trucks, resulting in incomplete closure. Guard posts should be installed in front of the vertical guides to prevent such an occurrence. During weekly/monthly inspections, in addition to a visual check of the guide, the door should be manually lowered and raised to detect potential problems with the guides.

E.2.8 Rating Practices for Fire Doors

Fire doors are rated for the type of openings for which they are suited. The designations are based on a letter class.

For a given class of opening as defined by NFPA Standard No. 80, *Fire Doors and Windows*, the class of door must match the class of opening. The classes differ according to expected exposure and use (internal or external).

Architectural specifications may call for a door by class only, with no fire protection rating. (Note that Class B has two ratings.) Table 9 relates class to uses and fire protection rating.

Table 9. Classification of Fire Wall Openings

Class	*Type of Opening*	*Fire Rating*
A	Openings in fire walls separating buildings or dividing a single building into fire areas. Generally fire doors are required on both sides of the wall at such locations.	3[1]
B	Openings in enclosures for vertical communication within buildings, and 2-hour rated partitions providing horizontal fire separations.	1 1/2[2]
C	Openings in corridor and room partitions having a fire rating of 1-hour or less	
D	Openings in exterior walls subject to severe external fire exposure.	1 1/2
E	Openings in exterior walls subject to moderate or light fire exposures.	3/4

[1] Only Class A or 3-hour fire rated FM Approved doors are acceptable for use on MFL fire walls.
[2] A 1-hour fire rated door is also available for this class of opening, but should only be used when the rating of the subdivision does not exceed 1-hour.

The rating for fire doors in North America is based upon results of tests conducted according to ASTM E152. There is an important difference between this specification and ASTM E119 for fire walls. For ASTM E152, satisfactory performance for a given period is primarily a measure of the deformation of the door. For ASTM E119, a wall assembly must prevent the passage of flame, and the average temperature on the unexposed face must not exceed 250°F (121°C) above ambient temperature for the rated period. Combustible material placed too near the unexposed face of a fire door could ignite from radiant heat in a time period less than the door's rated period (hourly rating) (Figure 55).

Although the insulating value of the door is not part of the mandatory pass/fail criteria for fire doors as it is with fire walls, this desirable property can be the deciding factor when considering the choice of otherwise "equal" doors. Some types of doors are better insulators than others. Composite, kalamein, and metal-clad fire doors have some insulating ability, although not necessarily the same as an equivalently rated fire wall.

In the United States, during the first 30 minutes of a fire door test, the temperature rise on the unexposed side of the door is measured. If the average temperature rise on the unexposed side does not exceed 250°F (121°C), 450°F (232°C), or 650°F (343°C), the door receives that respective maximum temperature-rise rating. The temperature-rise rating is independent of the fire-endurance rating (hourly rating) of the fire door. A fire door may receive an-hourly fire-endurance rating even if the temperature rise exceeds 650°F (343°C) in the first 30 minutes. In Europe, a similar rating is provided. The time it takes for the average temperature to reach 121°C (250°F) is monitored, and that number of minutes is assigned as an insulation rating. Consequently, a European door with a minimum 30 minute insulation rating could be considered comparable to a U.S. door with a maximum 250°F (121°C) temperature rise rating.

For new construction or door replacement on MFL fire walls, doors with a minimum 30-minute temperature rise rating of 250°F (121°C) are preferred. This rating ensures the door has some thermal resistance to limit heat conduction through it. Providing such doors is critical where, despite good preventive efforts, temporary storage may be left too close to openings where autoignition may result from an uncontrolled fire on the opposite side of the door. This is a particular concern in warehouses where the probability of having combustible storage adjacent to openings in fire walls is high. The described door does not offer the same protection a fire wall, however, and is not considered as a substitute for adequate space separation between door openings and combustible storage.

The temperature-rise rating is noted on the fire door label. When it is not practical to use a door with a 250°F (121°C) maximum temperature-rise rating, the next preference is to use one with a 450°F (232°C) maximum temperature rise rating. Except where noted, all openings in MFL fire walls should be protected with two automatic closing, minimum 3-hour rated fire doors, one on each side of the opening. Two doors are recommended for all such openings to increase the probability of at least one door closing.

E.2.9 Selection of Fire Doors

Selection of a suitable fire door is mainly dependent upon its intended use, available clearances, and appearance.

Doors with insulating value are preferred as noted above. When the use of such doors is impractical due to space limitation, rolling steel doors may be used.

In general, single fire doors that close the entire opening without a center joint are preferred. The center joint of doors mounted in pairs is a weakness that can be overcome by rabbeting or dividing with an astragal (Figures 89, 90, 91, and 100). Such paired doors are useful where wall space is limited; where conveyors or other obstructions are such that doors can be arranged to close around them; for certain elevator enclosures; and for other special applications.

Fire door installations include hardware, frame (where applicable), operators, and related devices. These items are all important and deserve the same careful consideration as the door itself. Assemblies requiring simple closing hardware are preferable to those with complicated arrangements.

Typically, doors and frames are identified by a metal label upon which all information is etched or embossed. A printed, self-adhesive plastic film label may also be used, or the information may be embossed into the door frame using a die. Labels for individual doors will have their own individual serial number. Since it is impractical to make a new die for each frame manufactured, the marking will contain a die code number assigned to that manufacturer.

Personnel door frames are FM Approved separately from the fire door. Guide rails for rolling or sliding doors are considered part of an FM Approved door. The inside of the wall opening is protected against mechanical damage by generic structural steel (channel, angle, or plate).

Labels are located on the hinge edge of the door, near the top hinge for personnel doors. On rolling doors, they are located near the middle of the face of the bottom bar. On sliding doors, they are located in the middle of the face of the door. For sample labels, see Figure 100.

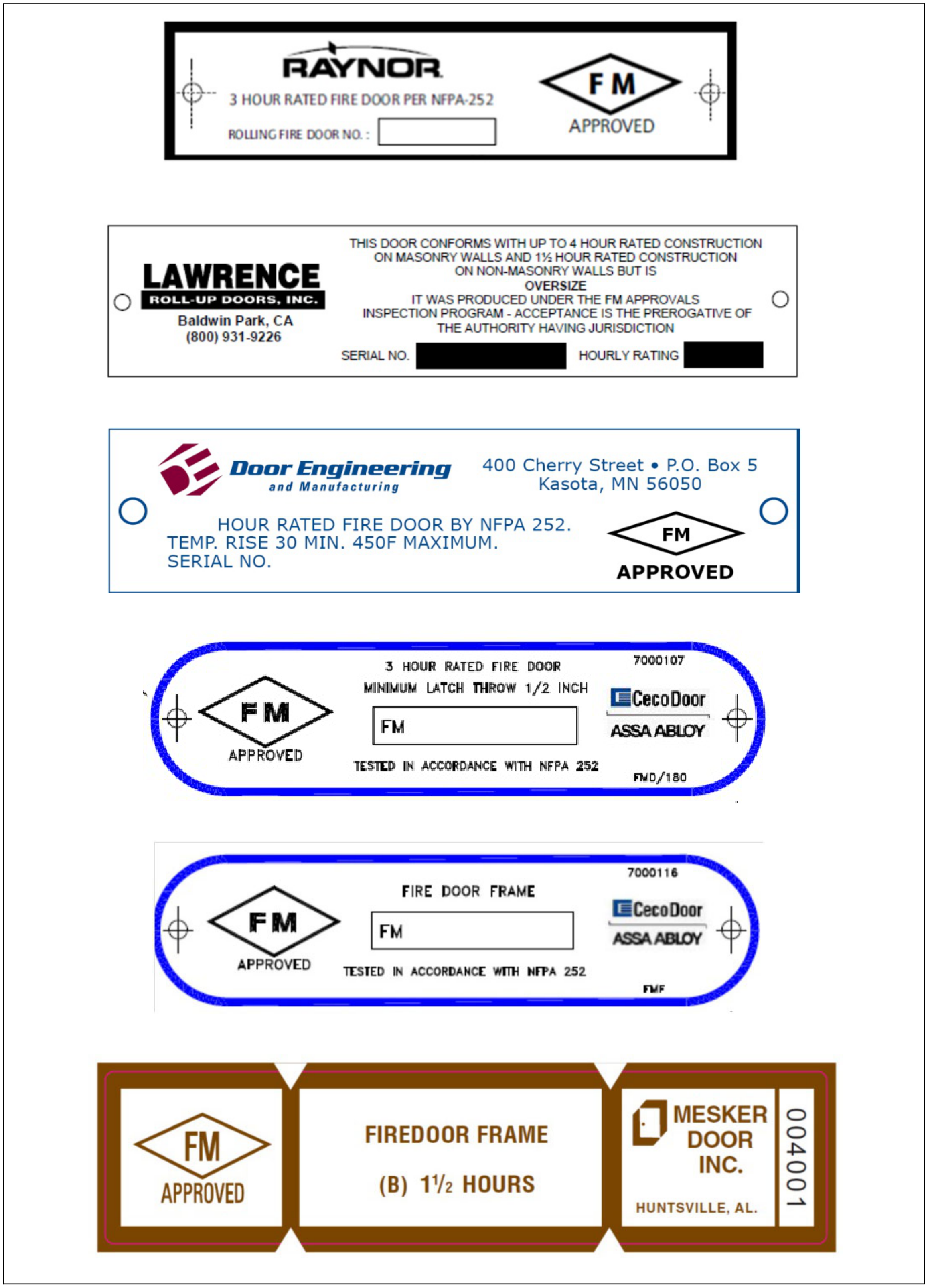


Fig. 100. Labels for FM Approved doors

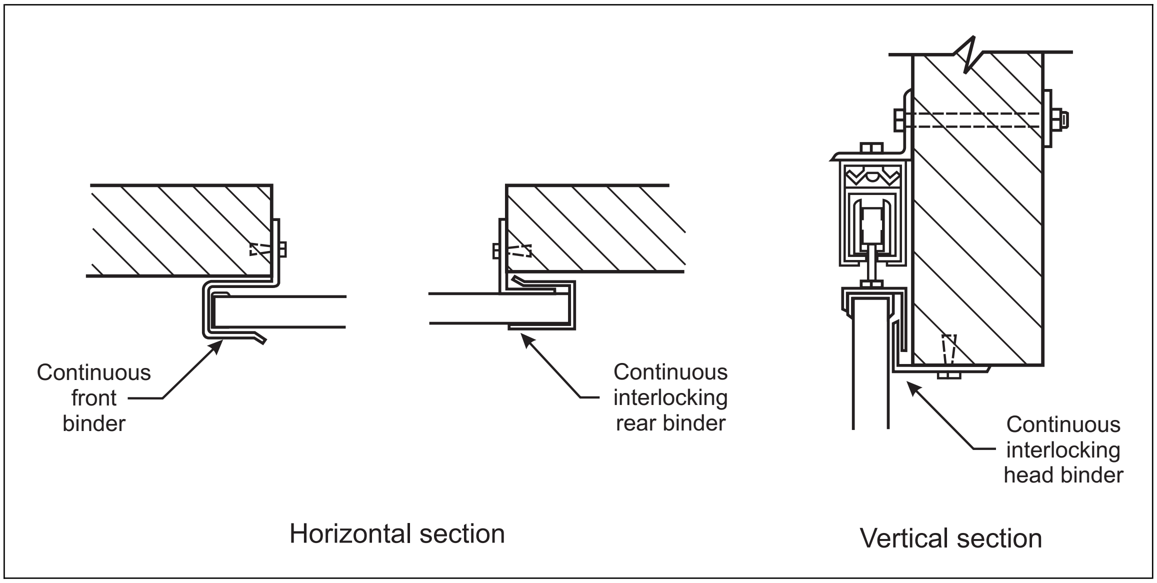
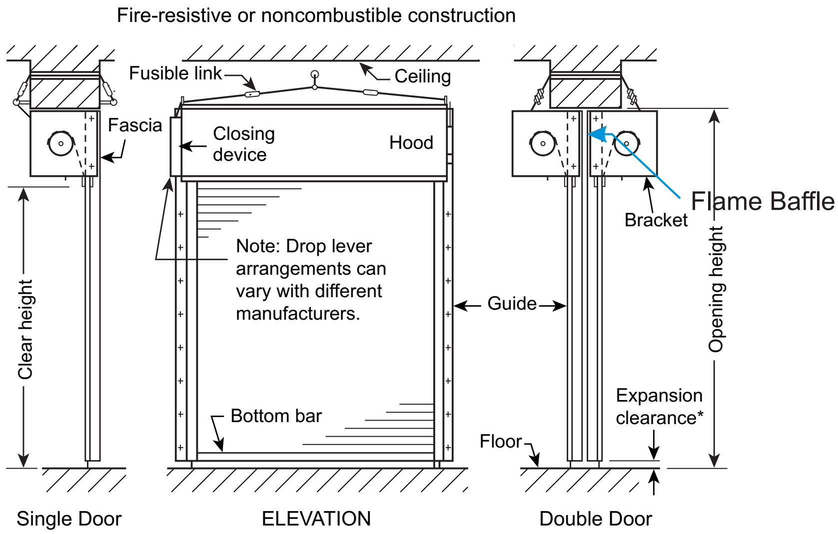
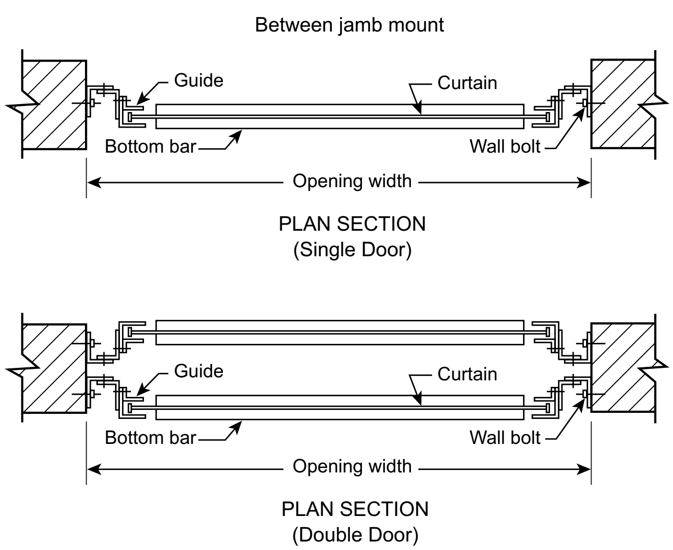


Fig. 101. Binder arrangements to reduce smoke penetration around horizontal sliding doors (reprinted with permission from NFPA 80, Fire Doors and Windows).



*Expansion clearance per door listing. Doors with downward expansion are as shown. Doors with upward expansion require expansion clearance above the top of the door.

Note: Fusible links are needed on both sides of the wall — configuration



Wall bolt for masonry construction:
Through-bolt, or expansion anchor, as permitted by door listing.

Wall bolt for nonmasonry wall construction:
Through-bolt, or machine screw into steel jamb, or lag screw into wood jamb, as permitted by door listing.

Fig. 102. Rolling steel doors between jamb mounted (reprinted with permission from NFPA 80, Fire Doors and Windows)