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1.0 SCOPE

This data sheet provides guidelines for fire barriers and opening protection recommended in other FM Global
data sheets. General information is included on the construction, installation, operation, and maintenance
of fire barriers, fire doors, dampers, and shutters.

1.1 Changes

April 2012. This document has been completely revised to reflect the replacement of Data Sheet 2-8N, NFPA
for Automatic Sprinklers.

Material on protection of openings in maximum foreseeable loss (MFL) fire walls and other limiting factors
has been relocated to Data Sheet 1-22, Maximum Foreseeable Loss.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Fire Barriers

2.1.1 Vertical Fire Barriers (Fire Partitions and Fire Walls)

2.1.1.1 Determine the fire resistance rating of recommended fire barriers using the guidelines in Data Sheet
1-21, Fire Resistance of Building Assemblies, or by fire tests conducted by a recognized independent
laboratory in accordance with ASTM E 119, NFPA 251, or equivalent test standards.

2.1.1.2 Building codes may require certain fire resistance ratings in specific circumstances. Where these
ratings differ from those recommended in FM Global data sheets, use whichever is the higher rating.

2.1.1.3 Fire barriers, partitions, and walls should be stable for the entire time they are expected to endure
a fire exposure (i.e., the required fire resistance). If the structural support for the barrier (partition or wall) was
not part of the tested assembly or is not specified in the assembly listing and is to be exposed to the fire,
(a) provide a structural support with a fire resistance rating equal to or greater than that of the barrier, or (b)
protect the structural support with automatic sprinklers. In certain high-challenge occupancies, additional
sprinklers (in conjunction with ceiling sprinklers) may be needed to protect a steel frame (see Data Sheet
8-9, Storage of Class 1, 2, 3, 4 and Plastic Commodities, Data Sheet 8-24, Idle Pallet Storage, and other data
sheets dealing with high-challenge occupancies).

2.1.1.4. Seal all penetrations in fire barriers with an FM Approved wall penetration fire stop with a fire
resistance rating equal to or greater than that of the barrier. Penetrations should not reduce the integrity
of the barrier as a fire and/or smoke barrier, partition, or wall.

2.1.1.5 Protect air-handling ducts and pneumatic conveyors in accordance with this data sheet (see Sections
2.2.4 and 2.2.5), as well as Data Sheet 1-45, Air Conditioning and Ventilating Systems, and Data Sheet 7-78,
Industrial Exhaust Systems, as applicable.

2.1.1.6 Seal penetrations and protect openings in exterior walls designed for exposure protection. Refer to
Data Sheet 1-20, Protection Against Exterior Fire Exposure, for further information on exposure protection.

2.1.1.7 When using fire barriers to separate occupancies containing ignitable liquids, provide curbs, ramps,
and/or drainage trenches at openings in the wall to prevent the passage of liquid. Fire doors or water spray
will not normally prevent the spread of ignitable liquid or other flowing material through an opening in a fire
wall. (See Data Sheets 1-24, Protection Against Liquid Damage, 7-32, Ignitable Liquid Operations, and 7-83,
Drainage Systems for Ignitable Liquids.)

2.1.1.8 Windows may be provided on vertical fire barriers. Refer to Section 2.2.2.

2.1.2 Horizontal Fire Barriers (Floors, Ceilings, Floor/Ceiling Assemblies)

2.1.2.1 When horizontal assemblies are used as a fire barrier, provide a fire-resistance rating as
recommended by the specific standard and in accordance with Data Sheet 1-21, Fire Resistance of Building
Assemblies, or tests conducted by a recognized independent laboratory according to ASTM E 119, NFPA
251, or equivalent.
2.1.2.2 Provide floor/ceiling assemblies with a minimum one-hour fire-resistance rating when the floor/ceiling is used to provide compartmentation or segregation of hazardous occupancies. Floors used to provide fire subdivision should have a minimum two-hour fire rating. Additional information can be found in Data Sheet 1-3, High-Rise Buildings.

2.1.2.3 Protect openings or penetrations in horizontal fire barriers, such as utility and service openings (see Section 2.2). Protect openings and penetrations that are impractical to protect with fire shutters or dampers with an FM Approved fire stop assembly Approved for the type of penetration involved and with a fire-resistance rating equal to or greater than that of the barrier.

A generic fire stop design can be accepted in lieu of FM Approved floor/ceiling penetration fire stops provided the installation uses mineral wool, ceramic fiber, cement mortar, or other suitable fire-resistant fill material.

2.1.2.4 Use an FM Approved fire stop assembly that has a water leakage rating to protect floor penetrations.

2.1.2.5 Protect air-handling ducts and pneumatic conveyors in accordance with this data sheet (see Sections 2.2.4 and 2.2.5), as well as Data Sheet 1-45, Air Conditioning and Ventilating Systems, and Data Sheet 7-78, Industrial Exhaust Systems, as applicable.

2.1.3 Elevator and Stairway Enclosures

For high-rise buildings, also refer to Data Sheet 1-3.

2.1.3.1 Provide elevator and stairway enclosures with a fire-resistance rating of:
- not less than 2 hours where connecting four stories or more.
- not less than 1 hour where connecting fewer than four stories.
- not less than the floor assembly penetrated.

Include basements but not mezzanines when determining the number of stories connected by the enclosure.

2.1.3.2 Construct shaft enclosures as fire barriers providing continuity both horizontally and vertically.

2.2 Protection of Openings

2.2.1 General

2.2.1.1 Keep the number of openings in fire barriers to a minimum. In no case allow the total width of openings to exceed 25% of the length of the fire barrier. The fewer the openings, the greater the integrity and reliability of the fire barrier.

2.2.1.2 Provide FM Approved opening protection on fire barriers. Ensure architectural drawings and construction specifications call for the use of FM Approved products.

2.2.1.3 Ensure the opening protection is adequate for the fire barrier and in accordance with Table 1. The protection need not have a rating greater than that of the fire barrier.

<table>
<thead>
<tr>
<th>Fire Barrier Rating (hr)</th>
<th>Minimum Fire Door Rating (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>½</td>
<td>¾</td>
</tr>
<tr>
<td>1</td>
<td>¾</td>
</tr>
<tr>
<td>1½</td>
<td>1½</td>
</tr>
<tr>
<td>2</td>
<td>1½</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1. Minimum Opening Protection Fire Ratings

1 Per NFPA 252, Standard Methods of Fire Tests of Door Assemblies

2.2.1.4 Protect openings for material-handling systems in accordance with Section 2.2.4.

2.2.1.5 Protect openings for air-handling systems in accordance with Section 2.2.5.
2.2.2 Windows

2.2.2.1 When windows are provided, install listed frames and glaze with listed wired glass or other listed fire-rated glass. Ensure wired glass is a minimum of ¼ in. (6.4 mm) thick. Use an FM Approved frame to allow adequate support without developing excessive stresses, which may lead to premature cracking.

2.2.2.2 Ensure fire windows have a minimum fire rating in accordance with Table 2.

Table 2. Fire Window Ratings

<table>
<thead>
<tr>
<th>TYPE OF FIRE BARRIER</th>
<th>FIRE BARRIER RATING(^1) (hours)</th>
<th>MINIMUM FIRE WINDOW ASSEMBLY RATING(^1) (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior walls:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire walls</td>
<td>All</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Fire barriers</td>
<td>&gt;1</td>
<td>Not permitted</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>¾</td>
</tr>
<tr>
<td>Smoke barriers</td>
<td>1</td>
<td>¾</td>
</tr>
<tr>
<td>Fire partitions</td>
<td>1</td>
<td>¾</td>
</tr>
<tr>
<td></td>
<td>½</td>
<td>½</td>
</tr>
<tr>
<td>Exterior walls</td>
<td>&gt;1</td>
<td>1½</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>¾</td>
</tr>
<tr>
<td>Party wall</td>
<td>All</td>
<td>Not permitted</td>
</tr>
</tbody>
</table>

\(^1\) Per NFPA 257, Standard on Fire Test for Window and Glass Block Assemblies

2.2.2.3 The maximum glass area per unit should not exceed the limits of the listing or a maximum area of 1,296 in\(^2\) (0.84 m\(^2\)) and a maximum dimension of 54 in. (1.4 m).

2.2.2.4 For windows that have no thermal resistance, provide a clear space (free of combustibles) per Figure 1.

Fig. 1. Clearance area for fire windows that have no thermal resistance
2.2.2.5 When plain glass is used or the window does not have a fire rating consistent with the fire barrier, protect the window with an automatic closing fire door or shutter of suitable fire rating or water spray per Section 2.3.9 and provide a clear space per Figure 1.

2.2.3 Fire Doors

Water spray can be an acceptable substitute for fire doors (refer to Section 2.3). For general information on door types, refer to Appendix C of Data Sheet 1-22, Maximum Foreseeable Loss.

2.2.3.1 Ensure fire doors are FM Approved and labeled (see Figure 2) and have a minimum fire rating in accordance with Table 3.
Fig. 2. Labels for FM Approved doors
Table 3. Minimum Fire Door and Fire Shutter Ratings

<table>
<thead>
<tr>
<th>TYPE OF BARRIER</th>
<th>BARRIER RATING(^1) (hours)</th>
<th>MINIMUM FIRE DOOR RATING(^1) (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire walls and fire barriers having a</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>required fire-resistance rating greater</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>than 1 hour</td>
<td>2</td>
<td>1½</td>
</tr>
<tr>
<td></td>
<td>1½</td>
<td>1½</td>
</tr>
<tr>
<td>1-hour shafts, exit enclosures, and</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>exit passageway walls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other 1-hour fire barriers</td>
<td>1</td>
<td>¾</td>
</tr>
<tr>
<td>Fire partition corridor walls</td>
<td>1</td>
<td>½</td>
</tr>
<tr>
<td></td>
<td>½</td>
<td>½</td>
</tr>
<tr>
<td>Other fire partitions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>¾</td>
</tr>
<tr>
<td></td>
<td>¾</td>
<td>½</td>
</tr>
<tr>
<td></td>
<td>½</td>
<td>½</td>
</tr>
<tr>
<td>Exterior walls</td>
<td>3</td>
<td>1½</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1½</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>¾</td>
</tr>
<tr>
<td>Smoke barriers</td>
<td>1</td>
<td>½</td>
</tr>
</tbody>
</table>

\(^1\) Per NFPA 252, Standard Methods of Fire Tests of Door Assemblies

2.2.3.2 Install doors in accordance with the manufacturer’s instructions, the FM Approval listing, and FM Approval requirements to ensure proper operation and tightness.

2.2.3.3 Ensure doors are self-closing (including normally closed doors). Initiate closure by either fire detection or sprinkler water flow (see Figures 3a and 3b). Locate the closing mechanism where it will be protected against mechanical damage.
Fig. 3a. Single swinging fire door.
2.2.3.4 Locate automatic fire detectors in accordance with Data Sheet 5-48, *Automatic Fire Detection*. For the location of fusible links, refer to spot-type heat detectors.

2.2.3.5 Where activation is by electric or pneumatic power, arrange the system so the door will close if power is interrupted.

2.2.3.6 Limit the size of wired glass (or other type of listed glazing material) in opening protection in accordance with Table 4.

<table>
<thead>
<tr>
<th>OPENING FIRE PROTECTION RATING</th>
<th>MAXIMUM AREA $\text{in.}^2 (\text{m}^2)$</th>
<th>MAXIMUM HEIGHT in. (mm)</th>
<th>MAXIMUM WIDTH in. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 hours</td>
<td>Not permitted</td>
<td>Not permitted</td>
<td>Not permitted</td>
</tr>
<tr>
<td>1½ hour doors in exterior walls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 and 1½ hours</td>
<td>100 (0.0645)</td>
<td>33 (840)</td>
<td>10 (250)</td>
</tr>
<tr>
<td>¾ hour</td>
<td>1,296 (0.836)</td>
<td>54 (1370)</td>
<td>54 (1370)</td>
</tr>
<tr>
<td>20 minutes</td>
<td>Not limited</td>
<td>Not limited</td>
<td>Not limited</td>
</tr>
<tr>
<td>Fire window assemblies</td>
<td>1,296 (0.836)</td>
<td>54 (1370)</td>
<td>54 (1370)</td>
</tr>
</tbody>
</table>

*Fig. 3b. Swinging fire door with door closer.*

Reprinted with permission from NFPA 80, *Fire Doors and Windows.*
2.2.3.7 When purchasing fire doors, specify the hardware, frame (swinging doors), operators, and related devices as part of the assembly.

2.2.3.8 When selecting fire doors used to separate warehousing areas, consider using a door with a temperature-rise rating.

2.2.3.9 When it is necessary to protect an opening larger than any FM Approved fire door, use a door that has an FM Approvals “Oversize” label.

2.2.3.10 Where side-by-side egress doors swing in opposite directions, provide separate doors latching into a fixed mullion (vertical framing member).

2.2.3.11 Where side-by-side egress doors swing in pairs in the same direction, provide a device to coordinate door closure and ensure the doors either latch into a mullion or are equipped with an astragal that conforms to National Fire Protection Association (NFPA) Standard No. 80, *Fire Doors and Windows* (Fig. 4).

---

![Fig. 4. Doors swinging in pairs: flush mounted](image-url)
2.2.3.12 Where personnel swinging doors (up to a maximum size of 4 by 8 ft [1.2 × 2.4 m]) are used, provide the doors with a positive latch and door closer.

2.2.3.13 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. (102 mm). Ensure steel sectional vertical sliding doors lap the top and sides of the openings by at least 2 in. (51 mm).

2.2.3.14 When horizontal sliding doors are mounted in pairs (bi-parting), ensure the center joint is rabbeted or provided with an astragal (Figs. 5a, 5b, and 5c) to provide a minimum lap projection of ¾ inch (19 mm).

---

**Fig. 5a. Pair of metal-clad sliding fire doors (biparting) on inclined track**

Reprinted with permission from NFPA 80, Fire Doors and Windows.
Fire Barriers and Protection of Openings

Fig. 5b. Sliding door on level track

Pair of rabbeted doors

Pair of doors with an astragal

Reprinted with permission from NFPA 80, Fire Doors and Windows.
2.2.3.15 Size all doors that are designed for mounting on the face of the wall to lap or rabbet the sides and the top of the opening by at least 4 in. (102 mm) except for steel sectional vertical sliding doors where the lap at the top and sides of the opening need not exceed 2 in. (51 mm).

2.2.3.16 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 6a, 6b, and 6c).
Fig. 6b. Vertically sliding door
2.2.3.17 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.

2.2.3.18 Provide adequate clearance between the curtain end locks and the guides on rolling steel doors to allow for horizontal expansion and to prevent buckling of the curtain slats at elevated fire temperatures (see Figure 7).
2.2.3.19 Use FM Approved or listed hardware where applicable. Ensure all bolts supporting the track extend completely through the wall. As an alternative in concrete, brick, or grouted (filled) concrete masonry units, expansion anchors may be used according to Figure 8. Ensure expansion anchors engage the brick or masonry unit and not the mortar joint.
Fig. 8. Use of expansion anchors to secure guides/tracks

Fire door guide hardware
Expansion bolt

8 x Bolt Ø minimum

6 x Bolt Ø minimum
2.2.3.20 Ensure lintels and opening framing are adequate for the fire door to be used based on strength, stability, and fire resistance.

2.2.3.21 For openings in fire barriers with 3 hours or more fire resistance, ensure lintels and opening framing are of fire-resistive construction such as brick, reinforced concrete, concrete masonry, or protected steel (see Figure 9).

![Fig. 9. Lintels of fire-resistive construction](image)

2.2.3.22 Ensure combustible flooring does not extend through the fire barrier.

2.2.3.23 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 (Fig. 10), and provide adequate floor drains nearby. Where ignitable liquids are involved, refer to Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers*.

![Fig. 10. Asphalt emulsion floor over concrete ramp](image)

2.2.3.24 After installation, have fire doors satisfactorily tested, reset, and tested again to ensure the door-closing mechanism has been reset correctly. Have only properly trained and qualified personnel test, reset, repair, or adjust fire doors.
2.2.3.25 Ensure the closing device housing (end cover) on all rolling steel fire doors (see Figure 11) is reinstalled after the door is reset. This will prevent the accumulation of dirt and debris, which could hamper the door closure.

2.2.3.26 Provide flame baffles (to close the space created when the curtain unrolls; see Figures 11 and 12) on rolling steel fire doors.

---

*Fig. 11. Rolling steel doors—surface mounted*
Fig. 12. Rolling steel doors between jamb mounted.
2.2.3.27 Provide governors, which control the rate of curtain descent, on rolling steel fire doors over 5 ft (1.5 m) in height.

2.2.3.28 To prevent mechanical damage to fire doors, provide the following at openings designated for fork lift and other vehicle traffic:

A. 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.

B. 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.

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.

2.2.3.29 When cable is used to interconnect fire door closing mechanisms and detectors on both sides of a fire wall, ensure it passes freely through ½ inch (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 enable 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 13). It is not necessary to penetrate the wall at the ceiling level. Other arrangements that meet the intent of this recommendation are acceptable.

![Fig. 13. Interconnection of trip assemblies through fire wall](image-url)
2.2.3.30 Use aircraft cable (Fig. 14) 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.

![Fig. 14. Section view of 7 x 19 aircraft cable](image)

2.2.3.31 Where the cable must be routed to make sharp changes in direction (greater than 90°), use pulleys. Provide a closed shield around the pulley to prevent the cable from slipping off. The minimum sheave diameter should be about 30 times the diameter of the cable.

2.2.3.32 The following recommendations apply to all doors protecting openings where the occupancy is highly susceptible to smoke damage:

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 (4.6 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 this is only a few seconds. In either case, connect the door holder to a backup power supply using an uninterruptible power supply (UPS) system. This will prevent premature door closure during a power failure.

D. Equip doors with listed 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 fire door gasket material.

E. Ensure openings protected by horizontal sliding doors are equipped with continuous front, rear, and top binders (see Figure 15), 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).

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

2.2.3.34 Use FM Approved horizontal sliding fire doors in FM Global earthquake zones 50-year through 500-year.

2.2.4 Material-Handling Systems

The following recommendations apply to all material-handling systems, with the exception of automatic guided vehicle systems (AGVS). For AGVS recommendations, see Section 2.2.4.11.

2.2.4.1 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 direct as possible.

2.2.4.2 Arrange detectors to do the following:

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.

2.2.4.3 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.

2.2.4.4 Ensure the fire door(s) at the opening are capable of effective closure regardless of whether or not any section of the conveyor is operating.

2.2.4.5 Provide devices to stop the conveyor if a door drifts into a fouling position, and before allowing automatic closure.

2.2.4.6 Where emergency stops are recommended 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).
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.

2.2.4.7 On tow conveyors, 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 (see Section 3.4.4).

2.2.4.8 House lowerators in an enclosure with a minimum fire-resistance rating equal to that of the fire barrier. Provide fire doors at each end of the enclosure with a fire-resistance rating in accordance with Table 3.

2.2.4.9 On chain or rail conveyors, ensure clearance around rails or chains is a maximum of ½ in. (12 mm) and a special factory-applied label (see Figure 16) is attached to the door. Small openings for clearance around conveyor rails or chains are acceptable if necessary (see Figure 17), except in occupancies with a significant amount of combustible dust or lint.

2.2.4.10 Pneumatic Conveyors

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2.2.4.10.1 Minimize the number of fire compartments penetrated by a pneumatic conveyor carrying combustible material.

2.2.4.10.2 Protect pneumatic conveyors having fire dampers with a minimum fire-resistance rating in accordance with Table 5. Arrange the dampers for automatic closure by activation of detectors rated at 135°F or 165°F, or 50°F above ambient temperature (57°C or 74°C, or 28°C above ambient temperature) located on each side of the opening (see Figure 18).

![Diagram of fire dampers]

Table 5. Fire Damper Rating

<table>
<thead>
<tr>
<th>TYPE OF PENETRATION</th>
<th>MINIMUM DAMPER RATING (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 3-hour fire-resistance-rated assemblies</td>
<td>1½</td>
</tr>
<tr>
<td>3-hour or greater fire-resistance-rated assemblies</td>
<td>3</td>
</tr>
</tbody>
</table>

(Courtesy of the Sheet Metal and Air Conditioning Contractor’s National Association, Inc. [SMACNA].)
2.2.4.10.3 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.

2.2.4.11 Automatic Guided Vehicle Systems (AGVS)

2.2.4.11.1 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 normally closed and equipped with power operators. Arrange the AGVS for automatic door control. A high-service door may be needed.

B. Provide a vestibule with a fire resistance equal to or greater than that of the fire barrier. Ensure the vestibule has at least one 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 3.4.2) 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 protected opening is at least the maximum dimension of the opening away from the fire wall. Ensure the first zone station beyond the opening 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 fire door on each side of the opening.

2.2.4.11.3 Provide fire door interlocks to immediately stop any oncoming vehicles a minimum distance of the maximum dimension of the opening upon fire door closure.

2.2.4.11.4 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.

2.2.4.11.5 If two-way travel is needed, arrange controls so oncoming vehicles clear the opening prior to approach by the second vehicle.

2.2.4.11.6 Ensure an adequate clearance width is marked and maintained along the entire length of vehicle paths.

2.2.5 Air-Handling Systems

2.2.5.1 Protect openings for ductwork with a listed fire damper located in the plane of the fire barrier.

2.2.5.2 Ensure dampers have a minimum fire rating in accordance with Table 5.

2.2.5.3 Arrange dampers for automatic closure by activation of a 135°F, 165°F, or 50°F above ambient temperature (57°C, 74°C, or 28°C above ambient temperature) rated detector (see Figure 18).

2.2.5.4 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.

2.2.5.5 Ensure duct coverings meet the following criteria:

A. Combustible insulation does not extend through the wall.

B. Insulation and other wrappings do not interfere and are in compliance with the fire stop design.

C. No material interferes with the use of any service opening(s).

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

2.2.6 Elevator and Stairway Enclosures

2.2.6.1 Ensure doors have a fire rating at least equal to that of the construction. However, the fire rating of the door must not be less than three-quarters that of the construction rating, as required by building codes.

2.2.6.2 Arrange doors to close automatically in case of fire or, in the case of elevator doors, ensure they are of the type that must be closed before the elevator can be operated.
2.3 Sprinkler and Water Spray Protection

Automatic sprinklers, water spray, water curtains and deluge systems can be an acceptable substitute for fire doors.

2.3.1 Conveyor Opening Water-Spray Protection

2.3.1.1 Use spray nozzles that are FM Approved open-type to ensure water will discharge simultaneously from all of them.

2.3.1.2 Since objects passing through an opening on a conveyor will interfere with water distribution, choose the number of nozzles, the discharge angles, and their distance from the opening to ensure the opening is well covered with dense spray.

A. Wall openings: For protection in both directions, provide spray protection on both sides of the wall (see Figure 19a), using a separate system of spray nozzles in a separate enclosure on each side of the wall. Ensure water flow in each system is controlled independently. Ensure the controls for each system are on the opposite side of the wall from the nozzles being controlled. For protection in one direction, provide water spray and an enclosure on the side to be protected (see Figure 19a and b).

B. Floor/ceiling openings: Provide spray nozzle protection above the floor (see Figure 20). In addition to the enclosure extending above the floor, provide a noncombustible draft curtain extending 20 to 30 in. (51 to 76 m) into the story below.
2.3.1.3 For effective counter-draft action, place the center line of the discharge at an angle of at least 60°, with the plane of the opening protected (see Figure 20) and aimed toward the exposure.

2.3.1.4 Locate FM Approved detectors on the side of the opening opposite the nozzle and connected to the release so it will quickly open the water supply valve. Provide detectors and spray nozzles on both sides of the fire partition.

2.3.1.5 Ensure the water supply is adequate to meet the simultaneous demands of the assumed fire area and the water spray system on the opposite side of the opening(s) that is aimed toward the fire area. Have the water supply for spray nozzles at all openings come from sprinkler piping or another reliable source on the same side of the wall as the nozzles. Do not allow sprinkler piping to penetrate the fire partition. For openings in the floor (see Figure 20), ensure the water supply is capable of simultaneously supplying the full ceiling sprinkler system and hose demand on the assumed fire floor, the demand for the water spray nozzles protecting the opening, and (density as determined by occupancy on that floor) the demand for four ceiling sprinklers on the floor above (and located immediately over) the opening.

2.3.1.6 To obtain the required discharge, coverage (or spray pattern), and satisfactory spray velocity, provide a minimum pressure of 25 psi (172 kPa).
Fig. 19b. One-way spray-nozzle protection for wall openings
2.3.1.7 To provide sufficient cooling and an adequate counter draft for wall or floor openings, use the minimum discharge densities indicated in Table 6.

Table 6. Minimum Recommended Discharge of Spray Nozzles

<table>
<thead>
<tr>
<th>Opening Height Above Floor, ft (m)</th>
<th>Discharge for Each Opening, gpm/ft² (mm/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤14 (4.3)</td>
<td>2 (82)</td>
</tr>
<tr>
<td>15-20 (4.6-6.1)</td>
<td>2-1/2 (102)</td>
</tr>
<tr>
<td>21-30 (6.4-9.1)</td>
<td>3 (122)</td>
</tr>
<tr>
<td>≥31 (9.4)</td>
<td>4 (163)</td>
</tr>
</tbody>
</table>

1 As measured from the top of the floor below to the top of the opening above.
2.3.1.8 The maximum distance between the nozzle and the plane of the opening is indicated in Table 7.

<table>
<thead>
<tr>
<th>Individual Nozzle Discharge, gpm (dm³/min)</th>
<th>Distance Away from Opening, ft (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With Enclosure</td>
</tr>
<tr>
<td>10-15 (38-57)</td>
<td>5½ (1.7)</td>
</tr>
<tr>
<td>16-15 (61-95)</td>
<td>7 (2.1)</td>
</tr>
<tr>
<td>25-35 (98-132)</td>
<td>8 (2.4)</td>
</tr>
<tr>
<td>36-50 (136-189)</td>
<td>9 (2.7)</td>
</tr>
<tr>
<td>51-75 (193-284)</td>
<td>9 (2.7)</td>
</tr>
</tbody>
</table>

2.3.1.9 Automatic sprinklers can be used as an alternative to spray protection for small (8 ft² [0.75 m²] maximum) conveyor openings located near the floor level. Install sprinklers, baffles, and noncombustible partial enclosures according to Figure 21. Enclose the conveyor for at least 3 ft (1 m) on both sides of the fire barrier and install automatic sprinklers within the enclosure, approximately 12 in. (300 mm) from each side of the partition.
Fig. 21. Protection of small conveyor openings in walls with automatic sprinklers

Fire partition
To sprinkler feed

To sprinkler feed

Baffle
C.L. of conveyors

Non-combustible partial enclosure
Closed automatic sprinklers 3 to 4 ft (1 to 1.2 m) apart on centers

3 ft (1 m) min.

Plan

Fire partition

Ceiling line

Baffle
12 in. (300 mm) deep

Conveyor rail

Wall opening

Floor line

Elevation A-A

Closed automatic sprinkler

Baffle

Non-combustible partial enclosure, full depth at sides of conveyor

Floor line

Elevation B-B

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2.3.2 Water Curtains

2.3.2.1 Design sprinklers in water curtains to provide a discharge of 3 gpm per lineal foot (37 L/min per lineal meter) of water curtain, with no sprinklers discharging less than 15 gpm (56.8 L/min).

2.3.2.2 For water curtains using automatic sprinklers, calculate the demand using the number of sprinklers in the water curtain equal to the number in a corresponding length of a branch lines in the area determined by the section on linear and area spacing of nonstorage sprinklers in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*.

Number of sprinklers on branch line $= \frac{1.2\sqrt{A}}{S}$

Where:

A = design area.
S = distance between sprinklers on branch line.

Round any fractional sprinkler up to the next higher whole number.

In systems having branch lines with an insufficient number of sprinklers, extend the design area to include sprinklers on adjacent branch lines supplied by the same cross main.

2.3.2.3 If a single fire can be expected to operate sprinklers within the water curtain and within the design area of a hydraulically calculated system, add the water supply to the water curtain to the water demand of the hydraulic calculations and balance to the calculated area demand.

2.3.2.4 In hydraulic design calculations, select a design area that includes ceiling sprinklers adjacent to the water curtain.

2.3.3 Escalator Sprinkler Protection

2.3.3.1 Protect floors served by escalators with automatic sprinklers if the construction or occupancy is combustible (see Figure 22).
2.3.3.2 Ensure automatic sprinkler installation includes concealed spaces housing escalator stairs and motor drives.

2.3.3.3 In unsprinklered buildings, provide a fire-rated enclosure (equivalent to the rating of the floor) around the escalator, and a self-closing or automatic-closing fire door installed at the top and bottom opening for the escalator.

2.3.3.4 As an alternative to recommendation 2.3.3.3, the escalator opening may be protected by a combination of draft curtains and water curtains (see Figure 23). Locate the draft curtain adjacent to the opening, ensure it is at least 18 in. (457 mm) deep, and of noncombustible or limited-combustible material that will stay in place before and during sprinkler operation. Space sprinklers not more than 6 ft (1.8 m) apart, and 6 to 12 in. (152 to 305 mm) from the draft curtain on the side opposite the opening. Design the water curtain in accordance with Section 2.3.2. The number of sprinklers calculated in this water curtain should be the number in the length corresponding to the total perimeter of the draft curtain.

![Fig. 23. Protection of an escalator opening using closely spaced sprinklers and draft curtains](image)

2.3.4 Vertical Shaft Sprinkler Protection

2.3.4.1 If the recommendations in Sections 2.3.4.2 or 2.3.4.3 cannot be met, install one sprinkler at the top of shafts.

2.3.4.2 Noncombustible or limited-combustible (i.e., Class 1), inaccessible vertical duct shafts do not require sprinkler protection.

2.3.4.3 Noncombustible or limited-combustible, inaccessible vertical electrical or mechanical shafts do not require sprinkler protection.

2.3.4.4 Shafts with Combustible Surfaces

2.3.4.4.1 Where vertical shafts have combustible surfaces, install one sprinkler at each alternate floor level.

2.3.4.4.2 Where a shaft having combustible surfaces is trapped, install an additional sprinkler at the top of each trapped section.

2.3.4.5 Accessible Shafts with Noncombustible Surfaces

Where accessible vertical shafts have noncombustible surfaces, install one sprinkler near the bottom.
2.3.5 Stairway Sprinkler Protection

2.3.5.1 Combustible Stairways
Install sprinklers beneath all stairways of combustible construction.

2.3.5.2 Noncombustible Stairways
2.3.5.2.1 In noncombustible stair shafts having noncombustible stairs with noncombustible or limited-combustible finishes, install sprinklers at the top of the shaft and under the first accessible landing above the bottom of the shaft.

2.3.5.2.2 Where noncombustible stair shafts are divided by walls or doors, provide sprinklers on each side of the separation.

2.3.5.2.3 Install sprinklers beneath landings or stairways when the area is used for storage.

2.3.5.3 Stairs Serving Two or More Fire Subdivisions
Install sprinklers in the stair shaft at each floor landing where two or more doors open from that landing into separate fire subdivisions.

2.3.6 Vertical Opening Sprinkler Protection

2.3.6.1 General
Protect unenclosed floor openings with closely spaced sprinklers (i.e., not more than 6 ft [1.8 m] apart) in combination with draft curtains per Sections 2.3.6.2 and 2.3.6.3 unless all of the following are true:
- The openings have horizontal dimensions between opposite edges of 20 ft (6 m) or more.
- The openings have an area of 1000 ft² (93 m²) or greater.
- The openings join levels and spaces protected by automatic sprinklers in accordance with FM Global data sheets.

2.3.6.2 Draft Curtains
Where draft curtains are recommended as part of the protection of vertical openings, do all of the following:
   a) Locate the draft curtains immediately adjacent to the opening.
   b) Provide draft curtains at least 18 in. (500 mm) deep.
   c) Provide draft curtains of noncombustible or limited-combustible material that will stay in place before and during sprinkler operation.

2.3.6.3 Sprinklers
2.3.6.3.1 Space sprinklers 6 ft (1.8 m) apart and place them 6 to 12 in. (150 to 300 mm) from the draft curtain on the side away from the opening. Do not space sprinklers more than 6 ft (1.8 m) apart.

2.3.6.3.2 If sprinklers are spaced less than 6 ft (1.8 m) apart, provide cross baffles as follows:
- Install baffles midway between sprinklers arranged to protect the actuating elements.
- Provide baffles of noncombustible or limited-combustible material that will stay in place before and during sprinkler operation.
- Provide baffles not less than 8 in. (200 mm) wide and 6 in. (150 mm) high.
- Extend the tops of baffles between 2 in. and 3 in. (50 mm and 75 mm) above the deflectors of upright sprinklers.
- Extend the bottoms of baffles downward to a level at least even with the deflectors of pendent sprinklers.
2.3.7 Elevator Hoistway and Machine Room Sprinkler Protection

2.3.7.1 Install sidewall spray sprinklers at the bottom of each elevator hoistway not more than 2 ft (600 mm) above the floor of the pit unless the elevator shaft is enclosed, noncombustible, and does not contain combustible hydraulic fluids.

2.3.7.2 Install upright, pendent, or sidewall spray sprinklers at the top of elevator hoistways unless the hoistway is for passenger elevators, is noncombustible or limited-combustible, and the car enclosure materials meet the requirements of ASME A17.1, Safety Code for Elevators and Escalators.

2.3.7.3 Install sprinklers at the tops and bottoms of elevator hoistways where elevators use a combustible belt material.

2.3.7.4 Ensure automatic sprinklers in elevator machine rooms or at the tops of hoistways have an ordinary or intermediate temperature rating.

2.3.8 Building Service Chute Sprinkler Protection

2.3.8.1 Where the design area consists of a building service chute supplied by a separate riser, the maximum number of sprinklers that needs to be calculated is three each with a minimum discharge of 15 gpm (57 L/min).

2.3.9 Window Sprinkler Protection

In cases where it is not practical to block up window openings or provide fire doors/shutters to protect windows in fire barriers, adhere to the following recommendations.

2.3.9.1 Use a wet sprinkler system. Where water damage is not a critical factor, an open-head deluge system using window sprinklers can be used with activation by combination rate-of-rise, fixed-temperature (nominal 135°F, 57°C) heat-actuated detectors. Locate detectors just above the window sprinklers at ceiling/roof level, but at least 6 in. (150 mm) from the wall and a maximum of 10 ft (3.0 m) on center parallel to the window.

2.3.9.2 Provide FM Approved, 165°F (74°C) rated, quick-response, 1/2 in. (13 mm) orifice sprinklers.

2.3.9.3 Install sprinklers on the exposed side, or on both sides if exposed in that manner. Space the sprinklers 6 to 10 ft (1.8 to 3.0 m) on center.

2.3.9.4 Locate sprinklers adjacent to and near the top of the windows, but at least 6 in. (150 mm) below the ceiling.

2.3.9.5 Arrange sprinklers to provide a minimum water flow of 4 gal/min/ft (50 L/min/m) of window width. Ensure the water supply and piping are adequate for the ceiling sprinkler demand (abutting the windows), hose streams, and window sprinklers within the ceiling demand areas.

2.3.9.6 Install pendent sprinklers with the deflector facing and parallel with the window, and the deflector located 12 in. (300 mm) from the face of the glass.

2.3.9.7 Ensure the window height does not exceed 13 ft (4.0 m). Provide water shields or baffles (if window sprinklers are near ceiling level) as needed to prevent pre-wetting of the window sprinklers by ceiling sprinklers. If window heights over 13 ft (4.0 m) are unavoidable, provide an additional level(s) of window sprinklers with water shields, with each level covering an approximately equal vertical area below.

2.3.9.8 Provide separate piping and valving for window sprinklers as outlined for in-rack sprinklers in Data Sheet 2-0, Installation Guidelines for Automatic Sprinklers.

2.3.9.9 Provide window glazing consisting of listed fire-rated tempered, laminated, or min ¼ in. (6 mm) thick wired glass; or glass blocks.

2.3.9.10 Provide fire-rated window frames that allow for glass expansion and are equipped with gasketing.

2.3.9.11 Sprinkler protection for the windows may be dispensed with under the following conditions:

1) The window is listed for a duration equal to at least three-quarters that of the fire partition in which it is installed.

2) The glass/glazing is listed for use in fire barriers with up to a one-hour fire rating.
3) The window frame is listed with up to a one-hour fire rating.

4) A clear space free of combustibles in accordance with Figure 1 is provided.

Note that most fire-rated glass/glazing are only tested and listed to prevent the passage of flame or hot gas and have little insulating value. They will not prevent the autoignition of nearby combustibles on the unexposed side of the glass.

If an adequate clear space free of combustibles cannot be provided, if the dimensions of the glass exceed the limits of the FM Approval or listing, or if the fire rating of the barrier exceeds one hour, provide window sprinkler protection per Sections 2.3.9.1 through 2.3.9.10.

2.3.9.12 Maintain an aisle space adjacent to the protected window to allow complete coverage by sprinklers.

2.4 Operation and Maintenance of Opening Protection

2.4.1 Keep fire doors and accessories in good working condition. Remove dust, lint, and debris. Lubricate parts in contact as recommended by the door manufacturer.

2.4.2 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.

2.4.3 Trip test fire doors at least annually by fusing a link or setting off 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 located 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.

2.4.4 Close fire doors during idle periods as this increases the reliability of protection for the openings and helps to detect some potential mechanical problems.

2.4.5 Ensure adjustments of counterbalancing mechanisms are made by factory-trained personnel or comparably trained, qualified employees.

2.4.6 Instruct facility personnel in the importance of keeping openings clear of stock and equipment (see Figure 24).

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

2.4.8 Keep doors clean and painted (except as otherwise noted below), 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.

After installation, 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. This includes detectors, chain, cable, cords, rope, gears, pulleys, springs, the inside of tracks, or any part that must slide, pivot, rotate, or drop.

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

2.4.9 Keep door tracks clean at all times.

2.4.10 Test the AGVS interlocks at least every six months.

2.4.11 Instruct AGVS operators to do the following:

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.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Fire Barriers

3.1.1 General

Fire walls and partitions, other than MFL fire walls, are generally recommended as protection from either internal or external exposures. As such, they help limit fire spread, control the number of sprinklers that will open, and reduce smoke damage.

The terms “fire wall” and “fire partition” are interchangeable for the purpose of this data sheet. The term “fire partition” is sometimes used for barriers with two hours’ resistance or less, and “fire wall” is used for barriers with more than two hours’ resistance. The practice is not universal, and an hourly rating should be attached to either term (e.g., a one-hour fire partition or a one-hour fire wall). The term “fire wall” is used throughout this data sheet.

Fire walls are used to subdivide areas of high value, separate different occupancies or isolate hazardous processes and storages. Fire walls provide an important element of fire protection. They help to restrict the flow of heat and smoke from the area of fire origin. This containment helps limit sprinkler operation (preventing the depletion of the water supply), reduces smoke and water damage, and provides manual firefighting efforts with a barrier from which to control the fire spread.

3.1.2 Fire Resistance

In areas with automatic sprinkler protection, the appropriate fire resistance depends on the type of exposure.

In areas where a barrier is used to temporarily halt a flash fire until automatic sprinkler protection has gained control (e.g., lint in textile mills or dust in sawmills), noncombustible sheathing or tight wood sheathing on
wood studs may be satisfactory. If the partition is intended to contain a high-challenge fire that would produce high temperatures (e.g., ignitable liquid spill), greater fire resistance is needed. A one-hour fire-rated barrier should be provided unless the specific data sheet recommends a higher rating.

Data Sheet 1-21, *Fire Resistance of Building Assemblies*, provides guidelines to estimate the fire resistance of existing building assemblies and general design information for new construction.

Masonry walls are often provided to separate manufacturing areas from storage areas. Such walls generally have sufficient fire resistance to function as acceptable separation. However, openings and penetrations may need protection.

### 3.2 MFL vs. Non-MFL Fire Walls

A maximum foreseeable loss (MFL) fire wall is designed to stop the spread of an uncontrolled fire when there is an impairment to the facility’s fire protection equipment and manual firefighting is limited or delayed.

In order to do this, the wall must be designed with certain stability parameters as well as fire resistance, and must confine an uncontrolled fire to the side of origin. The design of an MFL fire wall must also consider the effects from the collapse of the structure on the exposed side. Additional safeguards and a greater degree of reliability are needed for an MFL fire wall.

Non-MFL fire walls are used to control fires in conjunction with the location’s fire protection equipment, emergency response team, and the public fire service. The physical barrier of the wall itself is not intended to stop the spread of fire unassisted. *This data sheet applies only to non-MFL fire walls.*

### 3.3 Fire-Rated Glass

In the past, the only acceptable fire-resistant glazing (glass) materials to be used in fire doors, fire barriers, and exposure walls were minimum ¼ in. (6 mm) thick wired glass or glass blocks. Tests have shown that wired glass cracks and deteriorates enough in one hour to allow significant amounts of heat and smoke to breech the fire wall. The heat radiating from, or through cracks in, exposed uninsulated windows could ignite combustibles on the unexposed side of the wall.

Other proprietary materials and assemblies have passed fire tests for ratings up to 1½ hours.

### 3.4 Protection of Openings

Openings are breaks in a fire wall where objects, personnel, vehicles, or materials pass through via an open system. Openings present the biggest threat to the integrity of fire walls. A fire wall is only as reliable as the protection of its openings. The fewer the openings in a wall, the greater its reliability.

Openings are usually protected using fire doors, door packs, water spray, or fire dampers. Fire doors, door packs, and fire dampers should have an hourly fire-rating suitable for the rating of the fire wall. Fire doors should be FM Approved and labeled.

#### 3.4.1 Material-Handling Systems

The intent of the recommendations in Sections 2.2.4.1 through 2.2.4.5 are to ensure that neither the material-handling system nor the material being conveyed will prevent the fire doors from complete automatic closure. Other arrangements that meet this intent with the same degree of reliability are acceptable.

Protecting openings for material-handling systems 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 fire-rated assemblies. When this is not possible, the openings in the wall must be protected with an arrangement of automatically closing fire doors.

For any material-handling system passing through a protected opening, 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 roller or belt conveyors, the feed conveyor is stopped.
immediately and the take-away conveyor continues to operate (at least briefly) until the opening is cleared, after which the door is allowed to close (see Figures 25, 26, and 27).

Fig. 25. Roller conveyor with gravity section

Fig. 26. Belt conveyor with gravity section
Unless a gravity section is provided through an opening (see Figures 25 and 26), conveyor protection may not work if the power fails. Systems not using a gravity section are consequently less reliable unless a standby power supply, UPS, or mechanical system is provided.

3.4.2 Automatic Guided Vehicle Systems (AGVS)

Automatic guided vehicle systems (AGVS) consist of electric-powered, driverless vehicles that can be programmed to follow various paths and load and unload at various stations. AGVs can be controlled in any of the following manners:

A. Controls can be located on the vehicle.

B. Programming panels can be located at various fixed stations throughout the systems.

C. A single central control can be provided.

The central control station (CCS) is the most elaborate of the three control methods. The CCS can be programmed to interrogate 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.

There are several types of guidance systems for AGVs:

Wired: An electromagnetic sensor is placed on the bottom of the vehicle. The vehicle follows a radio frequency transmitted through a guide wire embedded in the floor.

Guide Tape: The vehicle is fitted with a guide sensor to follow the path of either magnetic or colored tape applied to the surface of the floor.

Gyroscopic Navigation: The CCS directs the vehicles. Transponders are embedded in the floor of the building. The vehicle reads the transponders and the CCS determines the vehicle location. A gyroscope in the vehicle is used to direct the vehicle and correct any deviation from the assigned path.

Laser Guidance: Wireless navigation is done by mounting reflective tape on various points throughout the building. The vehicle uses a laser transmitter and receiver on a rotating turret. The laser is transmitted and
received and the location of the vehicle is automatically calculated through triangulation. The AGVS has a map of the reflectors stored in memory and can correct its position based on the comparison between the map and the calculated location. It can then navigate to a destination target using the constantly updating position.

Modulated Lasers: The use of modulated laser light gives greater range and accuracy over pulsed laser systems. By emitting a continuous fan of modulated laser light a system can obtain an uninterrupted reflection as soon as the scanner achieves line of sight with a reflector. The reflection ceases at the trailing edge of the reflector which ensures an accurate and consistent measurement from every reflector on every scan.

Pulsed Lasers: A typical pulsed laser scanner emits pulsed laser light. The vehicle emits the laser pulse and then reads the intensity of the reflected laser light, to identify the center of known reflector locations.

Natural Features Navigation: Thus method uses no additional features added to the building environment. There are no guide wires, reflectors, or transponders. Rather, the vehicle is equipped with a range-finding sensor(s) (e.g., a laser range-finder) and a gyroscope or inertial measurement units (or both). Using these, the vehicle is able to determine its location and navigate around obstacles.

An AGV may be 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 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

Chain and rail conveyors are most reliably protected with a door pack (see Figure 28). A door pack consists of a set of fire doors spaced in relation to the stock on the conveyor so 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 where the length of stock (perpendicular to the fire barrier) exceeds a maximum of about 2 1/2 times the clear distance between the stock. This needs to be taken into consideration when the conveyor is designed and ample spacing given between main hangers. If a 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.

The number of doors needed in a door pack can be determined using the following formula:

\[ N = \frac{S_h}{S_c - T_d} \]

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).
Door spacing for door packs in chain and rail conveyors should be even and meet the following criteria:

\[
\begin{align*}
S_d &\leq S_c - T_d \\
S_d &\geq \frac{(L_s + T_d)}{(N-1)}
\end{align*}
\]

Where:
- \( S_d \) = center-to-center spacing of doors, in. (mm)
- \( L_s \) = length of stock perpendicular to wall, in. (mm)
- \( N \) = number of doors

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

Given:
- \( S_h = 65 \text{ in. (1651 mm)} \).
- \( L_s = 45 \text{ in. (1143 mm)} \).
- \( T_d = 3 \text{ in. (76 mm)} \).
1) Is a door pack practical?

2) How many doors are needed?

3) What is the center-to-center spacing of the doors?

Solution:

1. $S_c = S_h - L_s = 65 - 45 = 20 \text{ in.}$
   
   $L_s = 45 \text{ in.} = (2.25)(S_c) = 45 \text{ in.}$
   
   $L_s = 1143 \text{ mm} = (2.25)(S_c) = 1143 \text{ mm}$
   
   Impractical if $L_s > 2.25(S_c)$
   
   Yes. A door pack is practical.

2. $N = S_h/(S_c - T_d)$
   
   $N = 65/(20 - 3) = 3.8$  
   
   Use four doors a maximum of 3 in. (76 mm) thick.

3. $S_d = S_c - T_d = 20 - 3 = 17 \text{ in.}$
   
   $S_d = (L_s + T_d)/(N - 1) = (45 + 3)/(4 - 1) = 16 \text{ in.}$
   
   Use center-to-center spacing of the doors $S_d = 16.5 \text{ in.}$ (420 mm)

3.4.4 Tow Conveyors

Because of the length of carts on tow conveyors, the most reliable opening protection includes the use of a vestibule. 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-resistant 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 barrier.

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

$$D_c > L_v + 2T_d$$

$$D_d > L_c$$

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.

$L_c = 4 \text{ ft (1.2 m)}$

$D_c = 12 \text{ ft} - 4 \text{ ft} = 8 \text{ ft (3.7 m - 1.2 m = 2.5 m)}$

$L_v = 6 \text{ ft (1.8 m)}$

$T_d = 0.25 \text{ ft (0.1 m)}$

$D_c = 8 \text{ ft} > 6 \text{ ft} + 2 \text{ (0.25 ft) = 6.5 ft, OK}$

$(D_c = 2.5 \text{ m} > 1.8 \text{ m} + 2 \text{ (0.1 m) = 2.0 m, OK})$

$D_d = 6 \text{ ft} > 4 \text{ ft, OK}$

$(D_d = 1.8 \text{ m} > 1.2 \text{ m, OK})$
3.4.5 Air-Handling Systems

Penetration of fire barriers with ductwork should 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 (Table 8).

<table>
<thead>
<tr>
<th>Class</th>
<th>ft³/min/ft²</th>
<th>m³/s/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I</td>
<td>4 (0.0204)</td>
<td>0.0087</td>
</tr>
<tr>
<td>II</td>
<td>10 (0.0510)</td>
<td>0.0510</td>
</tr>
<tr>
<td>III</td>
<td>40 (0.2041)</td>
<td>0.4082</td>
</tr>
<tr>
<td>IV</td>
<td>60 (0.3061)</td>
<td>0.6122</td>
</tr>
</tbody>
</table>

3.4.6 Water Spray Protection

Water spray is a substitute for fire doors only when the supply of water is unimpaired. To take full advantage of the cooling and counter-draft effect of the water spray, an open-ended, noncombustible housing or partial enclosure is recommended around the opening, extending 3 ft (900 mm) into the area to be protected. The higher the opening is above the floor, the greater the stack effect of hot gases becomes.

The most effective type of spray nozzle for conveyor openings produces a solid, conical spray pattern.

When providing conveyor openings in walls with a separate system of spray nozzles on each side of the wall, the water flow in each system must be controlled independently because if both sets of nozzles were operated simultaneously they would be ineffective in preventing the movement of hot gases through the opening.

3.4.7 Elevator and Stairway Enclosures

Elevator and stairway enclosures are carefully regulated by municipal codes. However, they also deserve special attention by the fire protection engineer. In general, codes require the enclosure to have a fire endurance rating equivalent to that of the floor-ceiling assembly, with a minimum rating of two hours.

This applies to all types of construction except boards on joists. With boards on joists, the rating required is generally one hour. This will vary from code to code.

Suitable enclosures can be reinforced concrete, hollow masonry units, or rated gypsum board assemblies.

3.5 Protection of Openings in FM Global Earthquake Zones

The risk of a major fire can increase substantially after an earthquake (see Data Sheet 1-11, Fire Following Earthquake). Research has shown that fire door performance can be significantly reduced due to ground motion. As much as 30% of fire doors in the affected area can be damaged. Currently, fire doors are not tested, FM Approved, or listed for their ability to function properly after an earthquake. The increased likelihood of a fire after an earthquake and the increased risk that openings will be unprotected combine to result in a significant increase in the risk of a major fire.
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 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.

3.6 Escalators

In department stores, escalators provide convenience for shoppers and, at the same time, enable them to look out upon displayed merchandise. The use of enclosures has been resisted since they cancel the merchandising aspect of the escalator. Open escalators have been widely condoned by building code authorities on the basis that (1) the escalators are not considered part of the safety-to-life facilities, and (2) such openings can be tolerated in a building with automatic sprinkler protection.

A study of conditions that exist in department stores indicates the likelihood of fire spreading from one floor to another is remote with sprinklers in service. Favorable factors are listed below:

1. Department store merchandising areas where escalators are normally located are not a serious challenge to automatic sprinkler protection.

2. The fire record of sprinklered department stores is good.

3. If a fire occurred at a point remote from an escalator opening, it would be unlikely to spread to the opening with sprinklers in service. If a fire occurred near the opening, lack of combustibles at the escalators would be a favorable factor limiting horizontal spread to the opening and limiting the number of sprinklers that might open in the upper stories.

On the other hand, normal protection means for such openings, if in place and operating, will not prevent the movement of smoke to upper stories. Considerable smoke will move upward before the buildup of sufficient heat to operate fusible link-actuated doors. To stop the upward movement of smoke, expensive smoke-detecting and door-closing equipment would be needed. This equipment would also have to be arranged to shut down air-handling equipment, which is another potential means of circulating smoke throughout a building. Current loss experience does not justify such recommendations.

3.7 Penetrations

Penetrations in fire walls or draft curtains consist of materials and/or equipment passing through the barrier usually involving a closed system. Penetrations are generally smaller than openings, and the space around the penetration must be sealed with an insulating (fire-stopping) material and/or be completely cut off via a damper in order to prevent the passage of water, smoke, heat, and fire. Penetrations include, but are not limited to, electrical conduit, duct work, cable trays, sprinkler piping, mill-use water piping, and steam pipes.

As with openings, the fewer the penetrations in a fire wall, the greater the reliability.

4.0 REFERENCES

4.1 FM Global

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 1-22, Maximum Foreseeable Loss
Data Sheet 1-24, Protection Against Liquid Damage
Data Sheet 1-44, Damage-Limiting Construction
Data Sheet 1-45, Air Conditioning and Ventilating Systems
Data Sheet 2-0, Installation Guidelines for Automatic Sprinklers
Data Sheet 3-26, Fire Protection Water Demand for Nonstorage Sprinklered Properties
Data Sheet 5-48, Automatic Fire Detection
4.2 Other


APPENDIX A GLOSSARY OF TERMS

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.

Class 1: A material or assembly that has limited combustibility such that it will not self-propagate.

Compartmentalization: The process of separating a floor area by fire-rated walls and/or partitions into smaller spaces.

Compartmentation: The international building code defines compartmentation as not having an open floor area that exceeds 15,000 ft² (1395 m²). Walls extend from floor slab to the underside of the slab or deck above and are built with noncombustible materials.

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.

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

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

Fire barrier: A fire-resistance-rated assembly designed to restrict the spread of fire and the movement of smoke in which continuity is maintained. Fire barriers are continuous fire separations with terminations at exterior walls, fire walls, another fire barrier, or the roof in order to constitute a complete fire separation. Fire barriers are continuous through concealed spaces, such as the space above a suspended ceiling. Openings are protected with fire doors having a minimum rating of 20 minutes.

Fire compartment: The space bounded by exterior walls or fire barriers, fire partitions, or horizontal fire-rated assemblies (floors or floor-ceiling assemblies). Penetrations are sealed and openings are protected with fire stops and self-closing or normally closed fire doors having the appropriate fire-resistance rating. When a floor/ceiling is used to provide compartmentation or segregation of hazardous occupancies it should have a minimum one-hour fire-resistance rating.

Fire partition: A vertical fire barrier that is a fire-rated assembly designed to restrict the spread of fire in which openings are protected.

Fire subdivision: The space bounded by exterior walls or fire barriers, fire partitions, or horizontal fire-rated assemblies (floors or floor-ceiling assemblies) with a minimum two-hour fire resistance rating. Penetrations are sealed with fire stops and openings are protected with self-closing or normally closed fire doors having the appropriate fire-resistance rating.

Fire wall: A vertical fire barrier that is a fire-rated wall designed to restrict the spread of fire in which continuity is maintained, openings are protected and penetrations sealed.

FM Approved: The phrase “FM Approved” is used to describe a product or service that has satisfied the criteria for Approval by FM Approvals. Refer to the Approval Guide for a complete list of products and services that are FM Approved.
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 (0.91 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.

Ignitable liquid: Any liquid or liquid mixture that is capable of fueling a fire, including flammable liquids, combustible liquids, inflammable liquids, or any other reference to a liquid that will burn. An ignitable liquid must have a fire point.

Interconnected floors: Two or more floors connected by an unprotected, open stairway or equivalent (escalators, atria, shafts, etc.) The letter N is used to designate the number of interconnected floors.

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

Limited-combustible construction: Materials that will not release sufficient fuel so as to allow a self-propagating fire.

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.

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

Lowerator: A material-handling mechanism that works in conjunction with a conveyor to raise or lower the material from one floor to another. It is typically used when the material being conveyed is very heavy (e.g., roll paper) and it is not possible to simply incline or decline the conveyor.

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).

Metal-clad doors: Doors consisting of a two- or three-ply 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.

MFL fire wall: A 4-hr fire wall which extends continuously from the foundation to or through the roof and has sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall.

Party wall: Any fire wall located on a property line between adjacent buildings, which is used or adapted for joint service between the two buildings.

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

Poke-through: Floor penetrations for vertical water pipes, pipes, telephone cables, etc.

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.

Reinforced concrete: 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.

Rolling steel doors: 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.

**Room:** Rooms can range in size from 100 ft² (10 m²) to 10,000 ft² (1000 m²). Room partitions may or may not have a fire rating. The partitions may extend from slab-to-slab or stop at or just above suspended ceilings. Rooms can have non-rated doors or a self-closing or normally-closed fire door. Small, subdivided rooms that will further enhance compartmentalization can be found in buildings such as hotels, apartments, or hospitals.

**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 sheet-faced sheets.

**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.

**Smoke barrier:** A continuous membrane, either vertical or horizontal, such as a wall, floor, or ceiling assembly, that is designed and constructed to restrict the movement of smoke.

**Smoke compartment:** A space within a building enclosed by smoke barriers on all sides, including the top and bottom. Openings are protected with minimum 20-minute normally closed fire doors.

**Smoke control:** A method used to limit the spread of smoke from a fire by exhausting smoke from a fire floor or compartment and pressurizing adjacent floors or compartments to prevent smoke from entering.

**Smoke proof enclosure:** An exit stairway designed and constructed so that the movement of the products of combustion produced by a fire occurring in any part of the building into the enclosure is limited.

**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.

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

**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, avoiding 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.

**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.

**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.

**APPENDIX B DOCUMENT REVISION HISTORY**

April 2012. This document has been completely revised to reflect the replacement of Data Sheet 2-8N, NFPA 13 Standard for Installation of Sprinkler Systems, 1996 Edition, with Data Sheet 2-0, Installation Guidelines for Automatic Sprinklers.

Material on protection of openings in maximum foreseeable loss (MFL) fire walls and other limiting factors has been relocated to Data Sheet 1-22, Maximum Foreseeable Loss.

September 2007. Recommendations 2.1.1.1.30, 2.1.1.1.31 and 2.1.1.1.32 were added to increase the reliability of fire doors on MFL walls in FM Global earthquake zones 50-year through 500-year. The document was also edited and reorganized.

May 2003. Clarification was made to recommendation 2.1.2.3 on fire doors testing.

July 1999. This revision of the document has been reorganized to provide a consistent format.
APPENDIX D BIBLIOGRAPHY


