INTERACTION OF SPRINKLERS, SMOKE AND HEAT VENTS, AND DRAFT CURTAINS

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1.0 SCOPE

The intent of this data sheet is to describe the function and interaction of smoke-venting systems and draft curtains in sprinklered buildings, and to specify recommendations for new construction to prevent any adverse effects that venting may have on automatic sprinkler protection.

Guidelines for the minimum needed vent area are beyond the scope of this document, and if required, should be in accordance with local codes. The installation of smoke and heat vents in unsprinklered buildings is also beyond the scope of this document.

For guidance on smoke management in multistory buildings, see Data Sheet 1-3, *High-Rise Buildings*.

1.1 Changes

January 2011. This document has been completely revised. The following major changes were made:

- Revised the document to reflect the replacement of DS 2-8N, *NFPA 13 Standard for Installation of Sprinkler Systems* 1996 Edition, with DS 2-0, *Installation Guidelines for Automatic Sprinklers*.
- Relocated guidelines on draft curtains from DS 1-19, *Fire Walls, Subdivisions and Draft Curtains*, to this document and revised them to reflect testing and loss experience.
- Added more information regarding the interaction of sprinklers, smoke and heat vents, and draft curtains.
- Added a recommendation to use, when available, smoke and heat vents (if required by code) that have been FM Approved to the 2007 edition of test standard 4430, which includes wind and hail ratings. Also added a direction to refer to DS 1-28, *Design Wind Loads*, and DS 1-29, *Roof Deck Securement and Above-Deck Roofing Components*, for guidance on the selection of smoke and heat vents as regards wind and hail.
- Added more detailed guidance on acceptable types of materials for draft curtains, as well as test standards that draft curtains should meet (from a combustibility standpoint). This includes fabric draft curtains.
- Added an explanation of ″ganged vent operation.″
- Added reference documents to Section 4.0, including some ISO and European standards, as well as FM Global technical reports that provide support for recommendations.
- Added entries to Appendix A, Glossary of Terms.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

In most cases where smoke venting is provided, it is done to comply with local code. Codes usually require smoke venting to aid occupants' egress from the building and to support manual firefighting efforts. Draft curtains are also recommended by code to help improve the potential effectiveness of the vents, but may also be recommended in some FM data sheets to protect against specific hazards.

Smoke venting is not considered a substitute for sprinkler protection, as smoke vents obviously will not control a fire. For many buildings, the combustible loading within the occupancy and construction is quite high. In the absence of sprinklers, by the time alarm notification is received by the fire service and they can arrive and deploy hoses, a fire may spread too far to allow for manual fire suppression. Also, as more material is burned, more smoke is produced.

2.2 Protection

2.2.1 Install sprinklers and smoke and heat vents in accordance with Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, and the recommendations in this document.

2.2.2 Where the local authority having jurisdiction (AHJ, also referred to as the ″code official″) requires smoke and heat vents, use ones that are FM Approved (if they are available and acceptable to the AHJ). Refer to Data Sheets 1-28 and 1-29 for recommended ratings for wind uplift resistance and hail resistance. Where mechanical ventilation is to be provided as an alternative code requirement, see Section 2.2.4.

2.2.3 Provide one or both of the following where the building occupant desires to reduce damage to high-value goods that are vulnerable to smoke damage:

A. A sprinkler system designed to suppress the fire and thus minimize smoke damage (this would include the use of quick-response sprinklers and a strong water supply; ensure the design and installation is in accordance with DS 2-0 and DS 3-26, *Fire Protection Water Demand for Nonstorage Sprinklered Properties,* or DS 8-9,*Storage of Class 1, 2, 3, 4, and Plastic Commodities*, for the operation of 12 or fewer sprinklers)

B. Manually-operated mechanical ventilation at ceiling level

2.2.4 Arrange mechanical smoke ventilation for manual operation after it has been established that the fire is under control, where acceptable to the local code official. While this would typically be done by the fire service, it may be operated by trained and qualified members of the emergency response team (ERT). Use multiple smaller fans in lieu of one large fan to prevent plug-holing and provide more reliability should any individual unit become inoperable due to the fire.

2.2.5 Do not use stairwells, elevator shafts, or other portions of the building's system of egress as part of the venting system.

2.2.6 Arrange exhaust openings and ridge vents that facilitate climate control in accordance with DS 2-0.

2.2.7 Provide sufficient make-up air to allow smoke venting to operate effectively. For manually operated smoke venting, manual opening of exterior doors and windows may provide sufficient make-up air. For automatic vents, follow guidelines in NFPA 204, NFPA 92B, CEA 4020, or the equivalent local code (also see Section 3.2.5).

2.2.8 Do not use smoke and heat vents in building areas protected by water mist systems or automatic, total flooding, gaseous extinguishing systems.

2.3 Construction and Location

2.3.1 Separate occupancies that are highly susceptible to smoke damage from other occupancies using noncombustible, full-height partitions. Protect openings with FM Approved, minimum 20-minute-rated fire doors that are self-closing or automatic closing via smoke detection. Greater hourly fire ratings for the partitions and doors may be recommended for specific occupancies as noted in various 7-series or 8-series FM data sheets.

2.3.2 Provide sufficient aisle space below draft curtains in all storage areas where they are used. If the draft curtain is centered within the aisle, use a minimum aisle width equal to 1.5 times the spacing between ceiling sprinklers in the direction perpendicular to the curtain. Alternatively, ensure the minimum space between the face of storage and the draft curtain on both sides is at least equal to 0.75 times the spacing between ceiling sprinklers in the direction perpendicular to the draft curtain (see Fig. 1 and Section 3.3).

If a full-height partition is used in lieu of a draft curtain, normal aisle spacing is acceptable.

2.3.3 Use 2 ft (0.6 m) deep, noncombustible draft curtains installed per DS 2-0 to separate quick-response and special-response sprinklers from areas protected by standard-response sprinklers. For this use, avoid draft curtains of greater depth to prevent obstructing sprinkler water flow (see DS 2-0). Where draft curtains are otherwise required, see Section 2.3.4.

Acceptable materials for draft curtains include minimum 26 gauge (0.018 in., 0.5 mm) sheet steel, cementitious panels, and gypsum board (glass- or paper-faced). Other materials can be considered if, in their finished form, they pass a qualifying test such as:

- ASTM E 136, or
- ASTM E 2652, using the pass-fail criteria from ASTM E 136, or
- ISO 1182.

An interior or exterior, full-height partition wall can also serve as a draft curtain if it is made from the materials noted above or one of the following:

- Masonry
- Concrete
- FM Approved, Class 1, noncombustible core metal sandwich panels
- Solid steel beams or girders, if of sufficient depth.

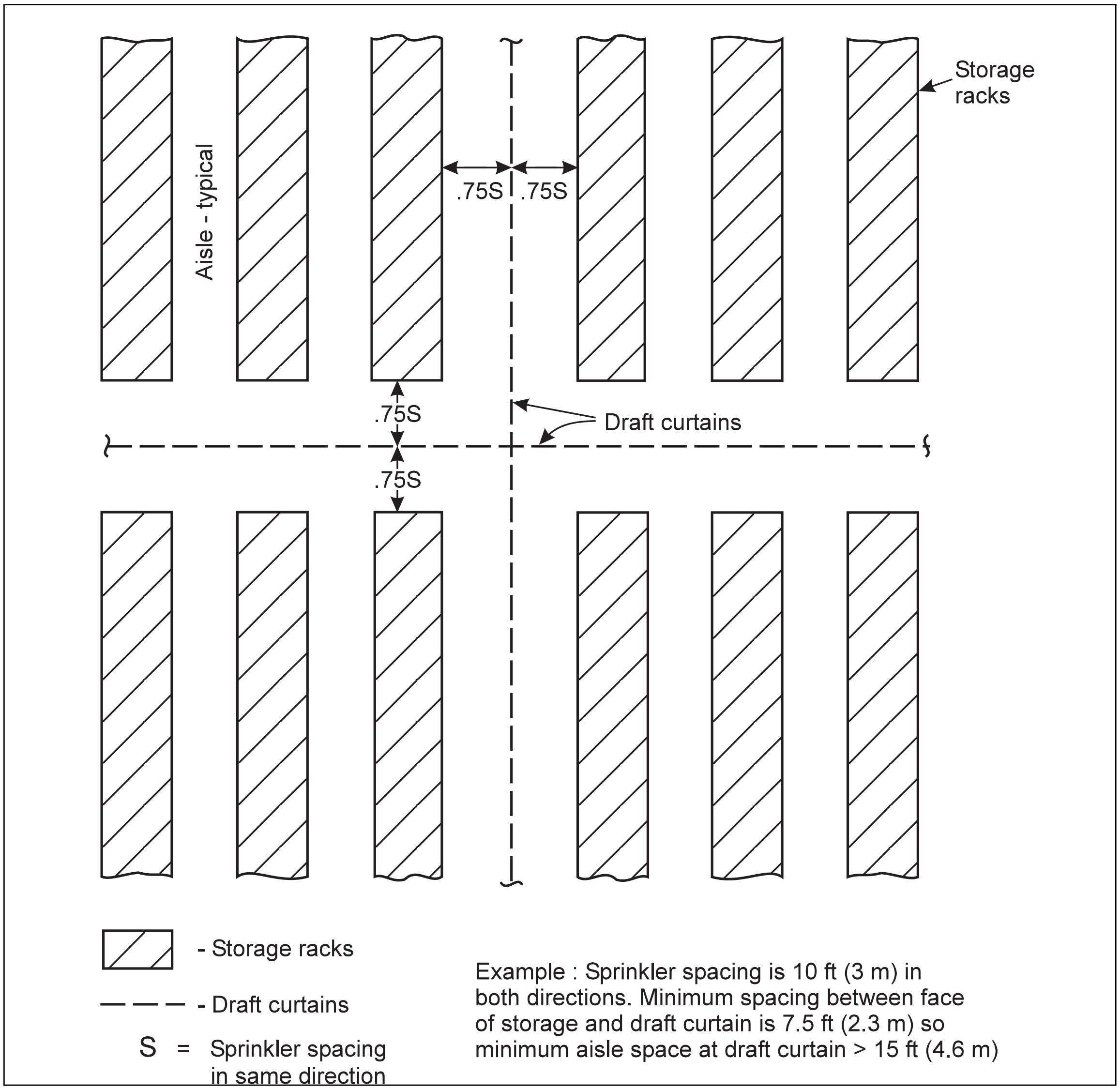

Fig. 1. Recommended location of draft curtains

2.3.4 Where they are required by local code, provide draft curtain depths that meet minimum code requirements. Where draft curtains are recommended by FM data sheets, ensure the minimum depth of the draft curtain (d_{min} measured down from H_{max}) is the **greater** of:

a. $d_{min} = H_{max}/8$, or

b. d_{min} = 4 ft (1.2 m), and the draft curtain extends at least 1 ft (0.3 m) below H_{min}.

Where:

d_{min} = minimum depth of the draft curtain measured down from H_{max} (ft, m)

H_{max} = maximum roof height above the finished floor (ft, m)

H_{min} = minimum roof height above the finished floor (ft, m)

For additional information, see Section 3.3. Where draft curtains are provided to separate quick-response sprinklers from standard-response sprinklers, ensure the minimum draft curtain depth is in accordance with Section 2.3.3.

2.3.5 Securely support draft curtains, fitting them tightly against the underside of the roof deck and making them reasonably smoke tight.

2.3.6 Construct the bottom edge of the draft curtain at a constant height above the finished floor (parallel with the floor), except where the installation should otherwise comply with Section 2.3.3.

2.4 Human Factor

2.4.1 Where continuous mechanical ventilation is employed for climate control, train members of the emergency response team (ERT) to shut down ventilation within the fire area during the early stages of a fire.

2.4.2 Perform emergency pre-planning with the fire service and trained members of the emergency response team (ERT), including noting the location and operation of controls for all smoke-removal equipment.

2.4.3 Ensure there is a manual method available for removing heat and smoke, where roof-level venting is not provided for single-story, sprinklered buildings that have combustible occupancy or construction. Portable equipment brought by the public fire service and used in conjunction with door and/or window openings is usually suitable for this purpose.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Venting Principles

Although the scope of this document is limited to sprinklered buildings, understanding the principles of heat and smoke venting in unsprinklered buildings helps one appreciate the interaction of sprinklers and vents.

Historically, natural or gravity roof vents have been required by local codes to aid egress and/or aid manual firefighting in unsprinklered buildings. In such cases, vents take advantage of the principle that hot air and gases rise. When a fire occurs in an unsprinklered building, the smoke and hot gases rise until blocked by the roof or ceiling. They then move in a radial direction until they reach walls or draft curtains and sink to floor level, making manual firefighting difficult. The walls and/or draft curtains create a smoke reservoir below the roof level. The buoyant force caused by the difference between the hot gas layer temperature below the roof and the outside air temperature allow smoke to flow through the vent(s). See Figure 2.

As the difference between these two temperatures decreases, the rate of smoke removal also decreases. Additionally, the temperature of the smoke layer in an unsprinklered building is much hotter than in a sprinklered building. The combination of cooling of the smoke layer by sprinkler water flow and potential hot outside air temperatures can significantly reduce the rate of smoke flow through gravity vents. Also, cooled smoke migrates below draft curtains and can then continue to move laterally.

The convective heat release rate of the fire and the height from the base of the fire to the vent location are key factors affecting the amount of smoke produced by the fire. Smoke consists mainly of air, as air is entrained around the perimeter of the fire plume. All else being equal, the amount of smoke entrained will depend on the location of the fire with respect to other construction features (such as walls or balconies) that can limit the flow of air toward the fire plume or disturb the fire plume.

For open floor areas, it is most conservative, with regard to vent design, to assume the fire starts away from all the walls (axisymmetric fire plume), such that air can be entrained around its entire periphery. For taller story heights, more air is entrained around the periphery of the fire plume. This creates more smoke, but also provides more cooling, resulting in potential stratification of smoke.

It is important that sprinklers be allowed to control the fire, as the larger the fire becomes, the more smoke will develop. The operation of vents will have no direct effect on controlling the fire. Thus, all things considered, and where acceptable to the local code official, it is preferable for vents to operate **after** sprinklers have established control of the fire (from a property loss prevention point of view).

Automatic gravity vents are of less value for fighting most fires in sprinklered buildings than in unsprinklered buildings. They can have a detrimental effect by actually increasing burning intensity and fire spread. The passage of hot air and smoke through the vents draws fresh air into the building through any other available opening, resulting in greater fuel consumption and, in some cases, an increased water demand. Furthermore, sprinkler water absorbs much of the heat, thereby reducing the temperature differential between the smoke or hot gases and the outside air. The lower air temperature, in turn, reduces the rate of smoke passage through

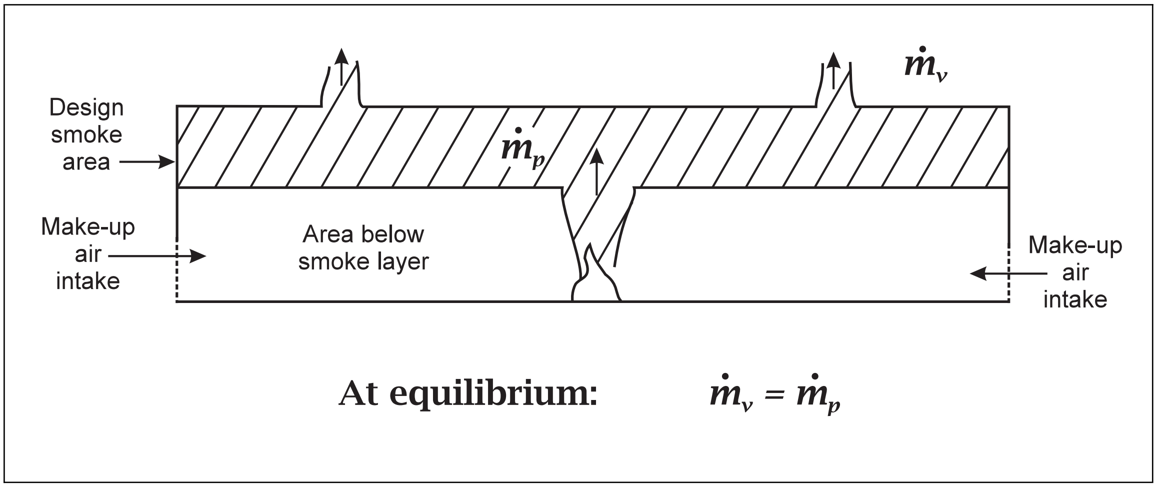

Fig. 2. Equilibrium ventilation rate.
Ideally, the rate of smoke ventilation ($\dot{m}_v$) equals the rate of smoke produced ($\dot{m}_p$); thermal and mechanical effects of sprinkler operation, however, result in some smoke below the design smoke layer

the vents, reducing the intended venting benefit. These findings were verified by FM in a series of more than 70 tests conducted in a 1:12.5 scale model.

3.2 Venting Methods

3.2.1 Unit Vents

Unit vents are relatively small, specially designed, packaged units that are individually installed on a building roof. The gross venting area of FM Approved units ranges from 4 ft^2 (0.4 m^2) to about 96 ft^2 (8.9 m^2). There are three types of FM Approved smoke and heat vents (per FM Approval standard 4430). The fusible-link actuated type, the drop-out type, and the motor-operated type (see Appendix A). While all three types can be arranged for automatic operation, if acceptable to local code officials, only the fusible-link or motor-operated types can be arranged for manual operation only. These vents can also be made operable from floor level using electro-mechanical devices, or they can be opened from the roof. FM Approval includes testing vents expected to open upward to ensure sufficient opening force will be provided to overcome a minimum of 10 psf (49 kg/m^2) load of snow or ice. FM Approved vents are also available that have been tested for higher snow or ice loads, which may be preferable depending on regional conditions and other local factors.

FM Approved thermoplastic drop-out vents should be used only where automatic operation is desired.

An optional FM Approval rating is available for vents that are to be used with quick-response sprinklers. A modified fire test is conducted to ensure the vent will not operate until a 360°F (182°C) fusible link has actuated.

It is difficult to install unit vents in roofs not originally designed for them. Besides cutting a hole in the roof deck and sealing the roof cover at its junction with the vent curb, reinforcing beneath the perimeter of the vent opening is needed. This is necessary because the vent will usually be placed between joists, and will not rest directly above them. To prevent damage to the deck, the vent opening is usually boxed in by structural framing, which is then attached to the joists.

3.2.2 Ganged Vent Operation

Ganged vent designs assume a number of individual smoke vents within a smoke zone will all open simultaneously. The smoke zone is bounded on four sides by draft curtains and/or walls. Gang venting requires the use of fusible-link actuated or motor-actuated (pop-up) type vents, as thermoplastic drop-out vents are designed to operate only individually. It also requires that a detection system be connected to a release mechanism for each individual vent. Because of the additional equipment required, the cost is significantly higher than that of individually operated smoke vents. The benefit is that gang venting may allow for enough vent area to remove the estimated volume of smoke calculated for the design fire, whereas the vent area from one or two vents that might open automatically with individually activated vents would generally not have such capacity. In some cases, this may require a large area within a smoke zone in order to provide sufficient vents. The maximum area allowed by local code within a single smoke zone, however, is sometimes relatively small. In contrast, the maximum distance in either direction between draft curtains and/or walls within a single smoke zone per NFPA 204 is eight times the ceiling height.

Ganged vents within the smoke zone of fire origin must not open before sprinklers that will help control the fire have operated. For storage areas, this means that a sufficient time delay must be provided between when the first sprinkler actuates and the vents within that smoke zone are opened to allow sufficient time for both the first and second ring of sprinklers around the fire origin to operate. While the first ring of operating sprinklers is important in putting water on the fire, the second ring of operating sprinklers is needed to pre-wet unburned product and thus slow or halt the advancement of the fire. This time delay will vary considerably, depending on the specific details of the stored commodities and sprinkler protection. It may vary from just a few minutes to perhaps 20 minutes. While it typically takes a significant amount of time for the public fire service to respond, deploy hoses, and assesses the degree of fire control, only manual operation of ganged vents is recommended.

There has been no testing of ganged vent operation to verify its effectiveness.

3.2.3 Mechanical Ventilation

Mechanical smoke ventilation (MSV) consists of fixed, motor-driven fans that can be mounted on the roofs of single-story buildings. Since vent capacities vary widely depending on the depth of draft curtains and building temperatures during a fire, it is difficult to give exact fan capacities that would supply equivalent results.

There are some advantages and disadvantages in using mechanical ventilation vs. gravity vents. Disadvantages of mechanical ventilation include loss of electrical power in a fire, and potential fire damage to related electrical and mechanical equipment. There are ways to minimize those effects. One is to connect the power feed for the mechanical smoke exhaust system from ahead of the main breaker, similarly to that done for a fire pump. The other is to use listed equipment and electrical cables, to the extent practical, that has been tested for resistance to heat from an exposure fire.

One advantage of using MSV is that the exhaust from a single fan of significant size can be equivalent to several smoke and heat vents opening. Another advantage is that the public fire service can remotely activate one or more MSVs as required for the fire conditions. Powered ventilation may be more effective than gravity vents in removing stratified smoke that has lost buoyancy due to the cooling of smoke by sprinkler water or ambient air in taller story heights.

It is recommended to limit fan size to prevent ″plug-holing.″ Plug-holing is caused by excessive localized airflow that draws relatively fresh air from below the smoke layer up through the smoke layer to the outside, instead of just exhausting completely from the smoke layer. The size of each individual exhaust fan should be determined based on the ceiling height, size of the design fire, smoke layer depth, and resulting smoke layer temperature. Using a larger number of smaller fans would help prevent plug-holing and provide more reliable protection in case the fire starts too close to any given fan. Formulae to limit fan size to prevent plug-holing are in NFPA 92B. Plug-holing is generally not a concern with smoke and heat vents as the airflow rate through them is relatively low. The rare exception would be if a number of smoke and heat vents were placed immediately adjacent to each other.

3.2.4 Venting for Combustible Storage Occupancies

Smoke and heat vents have been required by codes for many years in an effort to aid the manual control of storage fires or egress. However, testing shows that, for sprinklered storage fires, vents are at best of limited value. In some cases they can be detrimental. If a fire originates directly below a vent, it may cause that vent to operate at about the same time as the first sprinkler, delay operation of the other sprinklers in the first ring around the area of fire origin, and allow more product to burn Also, all testing to date has been done only with standard-response sprinklers, not with quick-response sprinklers. For additional information, see NISTIR 6196-1.

Although the vents may delay the time of smoke obscuration, their premature operation may result in increased fuel consumption. This is the result of fresh air being drawn into the building through all available openings to offset the volume of gases discharged by the vents. As more fuel is consumed, more smoke is produced. If draft curtains are installed, water demand may increase, with more surrounding sprinklers operating. The oxygen content of the air, therefore, remains high enough to encourage efficient burning.

Gravity venting (non-mechanical) during a sprinklered fire is quite inefficient. Venting in a sprinklered fire does not remove heat and smoke for manual access as effectively as in an unsprinklered fire because sprinkler water entrains smoke and absorbs much of the heat. With sprinklers preventing smoke layer temperatures from reaching very high levels, the temperature differential between the inside and outside air is fairly small, so the rate of smoke passage through the vents is minimized. Therefore, depending on certain variables, venting a sprinklered storage fire is not always effective or desirable. During the initial stages of the fire, it is usually best to keep the building closed to limit the supply of air while sprinklers gain control.

Venting may be desirable for manual firefighting during the overhaul period after sprinklers have gained control. Alternatives to smoke and heat vents include the use of windows, monitors, doors, and gravity or manually operated mechanical exhaust systems. Use of high-pressure fog can also be effective.

If vents have already been installed, manual operation is preferred if their purpose is to remove smoke to aid manual firefighting. If vents are closed until firefighters arrive, sprinklers have a better chance of controlling the fire. Then the firefighters can decide if venting is needed.

Power ventilation from one or more permanently mounted exhaust fans can be effective in quickly clearing a smoke filled building. While potential smoke effects may not always necessitate the installation of this equipment, it would be justified at locations having construction or occupancy that is combustible and highly susceptible to smoke damage.

If a ventilation system were designed to maintain the smoke produced for an assumed design fire, the specified total fan ventilation rate would be expressed in cfm (m^3/min) and could be quite large. The amount of ventilation needed varies considerably and depends on the assumed fire size and ceiling height. For post-fire smoke ventilation, the ventilation system should be sized for at least 10 air changes per hour; however, a minimum of at least 2 air changes per hour may be acceptable. The ventilation rate may also be designed specifically for the design fire, such as by using NFPA 92B. Fewer air changes will simply prolong the time required to clear the volume subjected to the smoke. In some cases, existing ventilation systems can be modified to provide this type of smoke removal. The system should be arranged to go to a total exhaust mode rather than its usual partial exhaust/partial recirculation function.

Mechanical power ventilation should be activated by manual methods. Actuation by smoke, heat, or flame detection is generally not recommended for property protection. If automatic power venting is required by the code official, it is recommended that it be operated using sprinkler water flow using a time delay. As the time required for sprinkler operation to control a fire varies depending on specifics of the storage and protection, a delay time of 20 minutes is recommended for storage areas. A manual override should be provided to allow operation by the fire service if they establish that the fire is being controlled before the fans are automatic operated. Automatic operation prior to sprinkler control may have the same detrimental side effects as automatic roof vents.

3.2.5 Make-up Air

A source of fresh air into the building, called ″make-up air,″ is needed to make the venting effective.

For manually operated venting systems, door openings fairly evenly spaced on all exterior walls are preferred, but openings on at least two exterior sides may be acceptable.

If automatic venting is provided, automatic make-up air inlets should open after the first unit vent or fan has opened or operated. Wall make-up air inlets should be evenly distributed and located below the smoke layer. They should be as close as practical to the floor, but at least within the lower half of the wall. The make-up vent area should be large enough to limit the velocity of make-up air to 200 ft/min (1 m/s). Additional guidance can be found in NFPA 204, NFPA 92B, and CEA 4020 (minimum free inlet area per CEA 4020 is twice that of smoke vent area within the largest smoke zone).

3.3 Draft Curtains

Draft curtains are used to separate quick-response sprinklers from other types of sprinklers to prevent a fire originating in the adjacent area from opening the quick-response sprinklers. Draft curtains also are required by local code officials as aids for automatic smoke and heat vents in limiting the spread of heat and smoke.

If the installation of draft curtains and aisle spaces is not done in accordance with Section 2.3.2, it can have a detrimental effect on sprinkler operation. It can obstruct sprinkler water flow needed to control the fire and channel heat away from the fire origin, thus opening sprinklers well beyond the fire, which will not aid fire control. This is evidenced by loss experience (see NFPA fire investigation report, Bulk Retail Store Fire: Tempe, Arizona, March 19, 1998) and testing by FM (see report 0X1R0.RR by Troup, 1994). In the 1994 test program, two of the tests (Nos. 1 and 6) were identical, except in Test 6 perpendicular draft curtains were provided over a storage rack in one direction and crossed over storage racks in the other direction. These draft curtains were centered between sprinklers in both directions. In Test No. 1, without the draft curtains, only four sprinklers operated. In Test No. 6, with draft curtains (not installed per recommendations in this document), thirty-five sprinklers operated. In a second set of tests (Test No. 3 and 7), Test No. 3 had no draft curtains, and Test No. 7 had draft curtains over the face of one storage rack and crossed over storage racks in the other direction. In Test No. 3 only seven sprinklers operated, but in Test No. 7 eighteen sprinklers operated.

Structural stability of the draft curtain can be achieved by firmly attaching the curtains to roof trusses, or by constructing a light metal framework to carry them. Corrugated or sheet steel, cementitious panels, or gypsum board (glass- or paper-faced) are also acceptable.

Since the smoke tends to work its way downward from the roof in a fairly level manner, it is desirable to keep the bottom edge of the curtain relatively level. In buildings with peaked roofs, it is important to keep the bottom edge of the curtain at a constant height above floor level while the height of the upper edge varies with the roof height.

Section 2.3.4 gives general guidelines outlining the minimum recommended depth of draft curtains. The following examples utilize the three criteria (H_{max}/8, dmin = 4 ft , H_{min} +1 ft) in Section 2.3.4 to determine the minimum depth of the draft curtain for three roof types.

Example No. 1

The building is 100 ft (30 m) wide with a roof slope of 1 in. per foot (83 mm per m). The eave height is 20 ft (6 m) and the peak height is 24.2 ft (7 m).

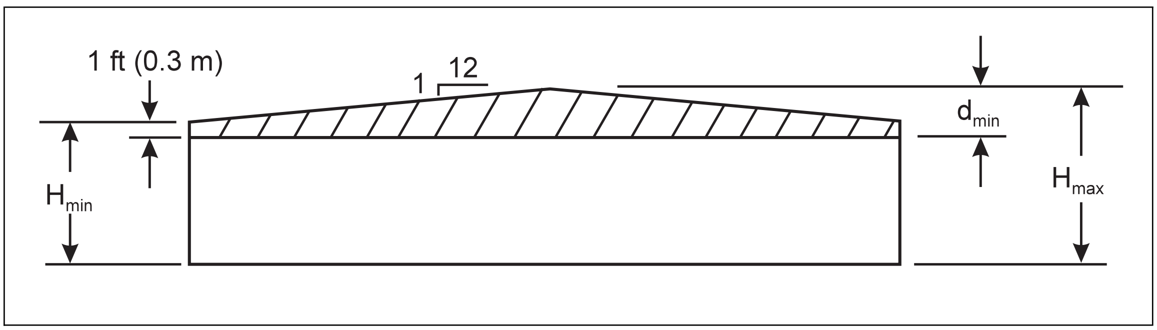

Fig. 3. Calculating minimum draft curtain depth: Example 1

Solution: In this case, H_{max} = 24.2 ft (7 m) and H_{max}/8 = 3 ft (0.9 m). However, the draft curtain should extend at least 1 ft (0.3 m) below H_{min}, which is 20 ft (6 m). Therefore, the minimum depth of the draft curtain (d_{min}) should be 5.2 ft (1.6 m) as measured down from the peak (H_{max}).

Example No. 2

The building is 100 ft (30 m) wide with a roof slope of 1?4 in. per foot (20.8 mm per m) from one eave to the other. The higher eave is 22 ft (6.7 m) and the lower eave is 20 ft (6 m).

Solution: In this example, H_{max} = 22 ft (6.7 m) and H_{max}/8 = 2.75 ft (0.8 m). If the draft curtain were to extend only to 1 ft (0.3 m) below the H_{min}, it would only be 3 ft (0.9 m) deep (measured down from H_{max}). This is less than the minimum 4 ft (1.2 m) depth. Therefore, dmin should be 4 ft (1.2 m) measured down from the higher eave (H_{max}).

Example No. 3

This airplane hangar has a curved roof with a maximum height of 64 ft (20 m). The hangar is 200 ft (60 m) wide and has an eave height of 54 ft (16 m).

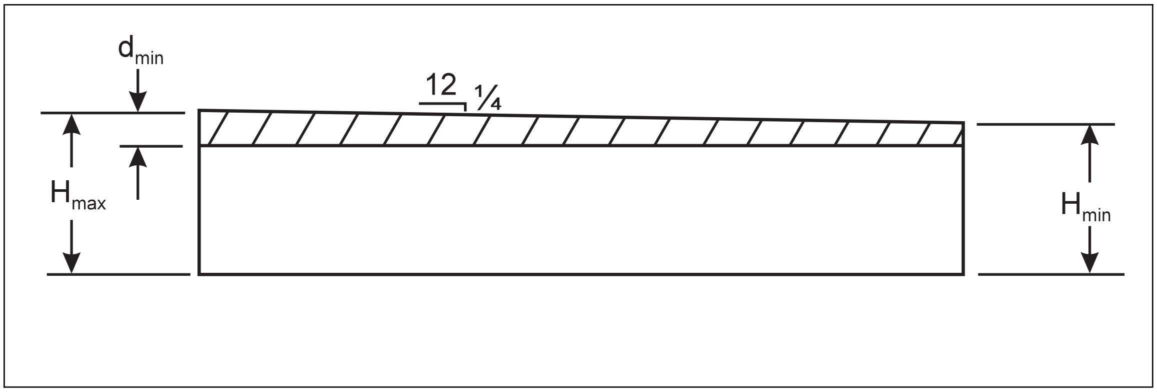

Fig. 4. Calculating minimum draft curtain depth: Example 2

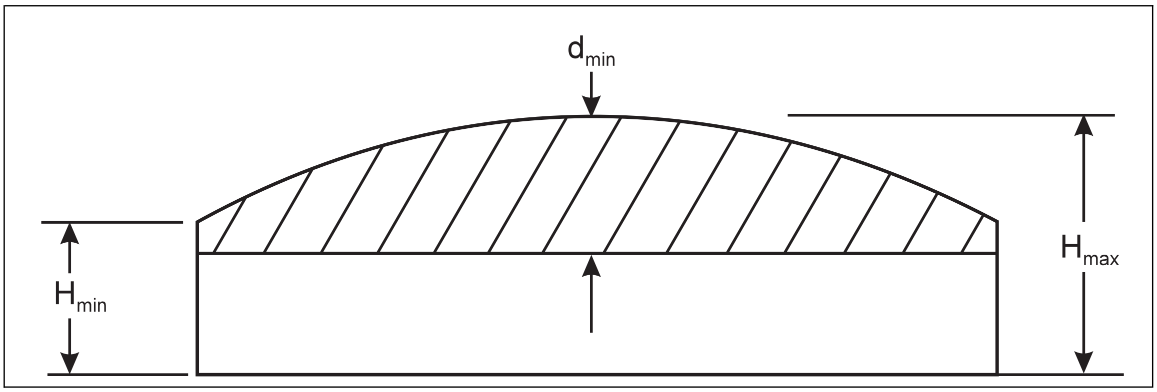

Fig. 5. Calculating minimum draft curtain depth: Example 3

Solution: In this example, H_{max} = 64 ft (20 m) and $H_{max}/8$ = 8 ft (2.4 m). If the curtain extends to 1 ft (0.3 m) below the eave (H_{min}), it would be 11 ft (3.3 m) deep at the maximum. Since $H_{max}/8$ exceeds 4 ft (1.2 m), but not 11 ft (3.3 m), d_{min} = H_{min} +1 ft (0.3 m) = 11 ft (3.3 m).

3.4 Code Requirements

Local codes may require automatic vents at certain manufacturing and storage occupancies when they are over a certain size, even if sprinklers are to be provided. The amount of venting may, in some cases, be based on a ″rule of thumb″ and may not be required to be scientifically calculated considering the size of the design fire or the exact height of the building. Required venting can vary from 1 ft^2 of venting for every 30 ft^2 of floor area (1 m^2 for 30 m^2) to 1 ft^2 of venting for every 100 ft^2 of floor area (1 m^2 for 100 m^2).

NFPA 204 contains guidance primarily for the use of smoke and heat vents in unsprinklered buildings. There are very limited consensus requirements regarding the design for the interaction of smoke and heat vents with sprinklers. However, there is considerable discussion on that subject in the NFPA 204 Annex. There is agreement between NFPA 204 and this document regarding the size and location of aisle spaces with regard to draft curtains, however, NFPA 204 is somewhat more conservative in some cases with respect to the depth of draft curtains.

The Committee of European Assurance (CEA) has published the standard, *Natural Smoke and Heat Exhaust Systems (NSHES) Planning and Installation*. Section 7.5 of this document allows for an option of manual vs. automatic operation of vents.

3.5 Alternative Venting Methods

3.5.1 Venting Through Wall Openings

For buildings without smoke and heat vents or mechanical exhaust at roof level, windows and other wall openings near the eave-line can be used for venting in most circumstances.

If it is not practical for the fire service to cut through the roof, and windows are to be the sole means of venting, wind direction could be an adverse factor. Window venting is still acceptable, however, if the windows are located on multiple walls.

If venting is to be achieved by breaking the windows, single-pane tempered glass is best. While stronger than ordinary annealed glass, it can be broken with a firefighter's axe. That glass will break into smaller, non-jagged pieces that are less likely to cut fire hoses or cause injury. Wired glass would be very difficult to break and would still remain essentially in place, thus reducing the venting area.

3.5.2 Sawtooth Roofs

Many existing buildings have sawtooth roofs. The sawteeth are usually spaced evenly over a building and are relatively long and narrow, extending over nearly the entire length or width of the roof. In cross section, they consist of a solid roof section sloping at about 30 degrees and a steeply sloping or vertical glazed section. Most codes required wired glass for this application at the time of construction for personnel safety. Therefore, it can be difficult for firefighters to make a sizeable opening. Their effectiveness is also subject to wind action because they all face one direction. The approximate effective venting area is considered to be about 50% of the total opening, even less where wired glass was used. In many cases, the glass windows on these steeply sloped or vertical sections have been replaced or covered with insulation and weatherproofing.

4.0 REFERENCES

4.1 FM

Data Sheet 1-3, *High-Rise Buildings*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 7-10, *Wood Processing and Woodworking Facilities*
Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*
FM Approval Standard 2000, *Automatic Control Mode Sprinklers for Fire Protection*
FM Approval Standard 2008, *Early Suppression Fast Response Automatic Sprinklers*
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APPENDIX A GLOSSARY OF TERMS

Draft curtain: Also referred to as a curtain board, a draft curtain is a solid, continuous, non-combustible material that is installed perpendicular to a ceiling with the intent of preventing the flow of hot gases from a fire from traveling horizontally beyond the curtain. Solid steel beams or girders may serve as draft curtains if of sufficient depth. Draft curtain are typically not recommended for buildings equipped with sprinkler protection except as specifically outlined in this data sheet.

Drop-out plastic vents: Smoke vents made of temperature sensitive thermoplastic which deforms from its setting and individually drops out of the roof. The smoke flow rate depends on the buoyancy created by the temperature difference between the ″hot″ smoke layer and the outside air temperature, and not on fans.

FM Approved: References to ″FM Approved″ in this data sheet mean the products or services have satisfied the criteria for FM Approval. Refer to the Approval Guide, an on-line resource of FM Approvals, for a complete listing of products and services that are FM Approved.

Fusible link actuated vents: Smoke and heat vents using a temperature-rated fusible link to trip the lid mechanism, opening the vent by springs or pressurized pistons. Upon release the vent cover moves upward to open the vent. The smoke flow rate depends on the buoyancy created by the temperature difference between the ″hot″ smoke layer and the outside air temperature, and not on fans.

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.

Motor operated vents: Smoke and heat vents that depend on an electrically driven operator. The smoke flow rate through the vent depends on the buoyancy created by the temperature difference between the ″hot″ smoke layer and the outside air temperature, and not on fans

Nonstorage sprinkler: A sprinkler that has been categorized by FM as acceptable for protecting non-storage-type occupancies and/or any other low to moderate heat-release type fires as permitted in an occupancy-specific data sheet.

Nonstorage occupancy: An occupancy consisting of combustible or noncombustible materials that are not maintained in a storage arrangement.

Quick-response sprinkler: A sprinkler that, when submitted to a plunge tunnel Test, has a resulting response time index (RTI) value that is typically equal to or less than 90 (ft/sec)$^{0.5}$ (50 [m/sec]$^{0.5}$) and a Conductivity Factor that is equal to or less than 1.81 (ft/sec)$^{0.5}$ {1.0 [m/sec]$^{0.5}$}. See FM Approval Standards 2000 and 2008 for further details.

Response time index (RTI): A numerical value that represents the sprinkler's sensitivity to heat and is used to predict the response of a sprinkler in fire environments defined in terms of gas temperature and velocity versus time.

Special protection sprinkler: A sprinkler that is designed for a hazard not associated with storage or typical room hazard occupancies. Examples are sprinklers intended to protect the inside of ductwork and cooling towers, as well as sprinklers used on exposure-protection sprinkler systems.

Special-response sprinkler: A sprinkler that, when submitted to a plunge tunnel test, has a resulting response time index (RTI) value that is greater than 90 (ft/sec)$^{0.5}$ (50 [m/sec]$^{0.5}$) and less than 145 (ft/sec)$^{0.5}$ (80 [m/sec]$^{0.5}$). FM Approval Standards 2000 and 2008 do not currently recognize this type of sprinkler response rating.

Standard-response sprinkler: A sprinkler that, when submitted to a plunge tunnel test, has a resulting response time index (RTI) value that is typically equal to or greater than 145 (ft/sec)$^{0.5}$ (80 [m/sec]$^{0.5}$), but does not exceed 635 (ft/sec)$^{0.5}$ (350 [/sec]$^{0.5}$), and a conductivity factor that is equal to or less than 3.62 (ft/sec)$^{0.5}$ (2.0 [m/sec] $^{0.5}$). See FM Approval Standards 2000 and 2008 for further details.

Storage sprinkler: A sprinkler that has been categorized by FM as acceptable for protecting storage-type occupancies and/or any other high heat-release-rate fires as permitted in an applicable occupancy-specific data sheet.

Storage occupancy: An occupancy consisting of combustible or noncombustible materials that are maintained in a storage arrangement covering a minimum area of 200 ft^2 (18.5 m^2) and have a minimum height of 5 ft (1.5 m) for commodity hazards that are plastic or worse in content or have a minimum height of 10 ft (3.0 m) for commodity hazards that are cellulosic or less hazardous in content.

APPENDIX B DOCUMENT REVISION HISTORY

January 2011. This document has been completely revised. The following major changes were made:

- Revised the document to reflect the replacement of DS 2-8N, *NFPA 13 Standard for Installation of Sprinkler Systems* 1996 Edition, with DS 2-0, *Installation Guidelines for Automatic Sprinklers*.
- Relocated guidelines on draft curtains from DS 1-19, *Fire Walls, Subdivisions and Draft Curtains*, to this document and revised them to reflect testing and loss experience.
- Added more information regarding the interaction of sprinklers, smoke and heat vents, and draft curtains.
- Added a recommendation to use, when available, smoke and heat vents (if required by code) that have been FM Approved to the 2007 edition of test standard 4430, which includes wind and hail ratings. Also added a direction to refer to DS 1-28, *Design Wind Loads*, and DS 1-29, *Roof Deck Securement and Above-Deck Roofing Components*, for guidance on the selection of smoke and heat vents as regards wind and hail.
- Added more detailed guidance on acceptable types of materials for draft curtains, as well as test standards that draft curtains should meet (from a combustibility standpoint). This includes fabric draft curtains.
- Added an explanation of ″ganged vent operation.″
- Added reference documents to Section 4.0, including some ISO and European standards, as well as FM Global technical reports that provide support for recommendations.
- Added entries to Appendix A, Glossary of Terms.

May 2007. This document was reformatted and a recommendation was added to prevent unnecessary analysis for common situations where ordinary ventilation is provided in non-storage areas.

December 1978. First edition of this document, which superseded pages 5-17 through 5-23 of the Handbook of Industrial Loss Prevention. Policy changes regarding smoke and heat vents were revised in 1975.