SCHULTE & ASSOCIATES
Building Code Consultants
880D Forest Avenue
Evanston, IL 60202
fpeschulte@aol.com
504/644-8900

ANNEX F.3, NFPA 204 (2007 EDITION): A CRITIQUE

By Richard Schulte

The issue of the use of automatic (individually-activated) roof vents in buildings protected by a sprinkler system has been debated since, at least, the mid-1970's. Two years ago, the debate was pretty much ended when the NFPA 13 committee developed provisions which addressed the use of roof vents in sprinkler buildings. The roof vent provisions included in the 2010 edition of NFPA 13 are as follows:

> "**12.1.1.1** *Manually operated roof vents or automatic roof vents with operating elements that have a higher temperature classification than the automatic sprinklers shall be permitted.*
>
> **12.1.1.2** *ESFR sprinklers shall not be used in buildings with automatic heat or smoke vents unless the vents use a high-temperature rated, standard response operating mechanism.*
>
> **12.1.1.3** *Draft curtains shall not be used with ESFR sprinklers.*
>
> **12.1.1.3.1** *Draft curtains separating ESFR sprinklers at system breaks or from control mode sprinklers or between hazards shall be permitted.* (*See 8.4.6.4.*)

> "*The intent of the standard is that roof vents and draft curtains should not be used in conjunction with storage protection. Previous language was unenforceable.*"

The substantiation provided for this proposal reads as follows:

> "**Substantiation:** *The intent of the standard is that roof vents and draft curtains should not be used in conjunction with storage protection. Previous language was unenforceable.*"

Research conducted at Underwriters Laboratories (UL) in Northbrook, Illinois in 1997/1998 clearly demonstrated that the activation of sprinklers interferes with the opening of individually-activated roof vents where the temperature rating of the fusible element provided for the roof vents is the same as temperature rating of the sprinklers. In many of the tests conducted at UL, the roof vents failed to open. (In Test P-2, a roof vent located directly over the ignition point of the fire failed to open.)

Based upon the results of the 1997/1998 tests at Underwriters Laboratories, it can be concluded that automatic roof vents with an activating mechanism with a temperature rating one temperature classification higher than the temperature classification of the sprinklers as required by NFPA 13 will not open (provided that the sprinkler system is adequate for the hazard and is operable). In other words, the NFPA 13 provisions addressing vents specifically intend to only permit the manual operation of vents.

In other words, the NFPA 13 provisions addressing vents specifically intend to only permit the manual operation of vents.

While the roof vent provisions included in NFPA 13 are straight-forward, these provisions have not be coordinated with the provisions contained in NFPA 204, the *Standard for Smoke and Heat Venting*. The following is a critique of various passages included in Annex F.3 in the 2007 edition of NFPA 204. (The excerpts contained in NFPA 204 are shown in light blue, while commentary on these excerpts is shown in dark blue.)

"*Objectives can include the following:*

(1) *Provide for fire fighter safety and facilitate post-fire smoke removal by the fire department. . .*"

Commentary: The issue of fire fighter safety is addressed in two publications issued by the National Institute for Occupational Safety and Health (NIOSH). **NIOSH 2005-132**, *Preventing Injuries and Deaths of Fire Fighters due to Truss System Failures*, and **NIOSH 2010-153**, *Preventing Deaths and Injuries of Fire Fighters using Risk Management Principles at Structure Fires*. These two publications recommend against aggressive interior manual fire fighting anticipated in the statement above. Annex F.3 does not mention either of these two documents, nor does the Annex address the issue of fire fighter safety and roof vents in the context of the recommendations contained in **NIOSH 2005-132** and **NIOSH 2010-153**.

"(2) *Allow extended egress travel distances.*"

Commentary: Annex F.3 does not address the use of roof vents to permit extended egress travel distances based upon the roof vent provisions contained in the 2010 edition of NFPA 13. The purpose of the roof vent provisions included in the 2010 edition of NFPA 13 is to prevent the opening of roof vents early in a fire. The ability of roof vents to be utilized to extend egress travel distances is compromised by compliance with the roof vent provisions included in the 2010 edition of NFPA 13.

"*(3) Reduce smoke damage to the contents.*"

Commentary: There are no studies that support the statement that smoke/heat vent/draft curtain installations "*reduce smoke damage to contents*". If smoke/ heat vent/draft curtain installations significantly reduced smoke damage to contents, it would be expected that property insurers would require that smoke/heat vents and draft curtains be provided in industrial and storage buildings provided with sprinkler protection. To the best of my knowledge, there are no property insurers in the United States which require the installation of smoke/heat vents in industrial and storage buildings protected by a sprinkler system.

"*Design features such as ganging all vents within a sprinkler zone, and automatically activating all vents within one zone following sprinkler activation might achieve objectives 2 and 3; however, additional research is needed to validate this concept.*"

. . .there are no property insurers in the United States which require the installation of smoke/ heat vents in industrial and storage buildings.

Commentary: It is questionable whether the concept of the "ganged" opening of roof vents caused by the activation of the sprinkler system water flow indicator is permitted by the roof vent provisions contained in the 2010 edition of NFPA 13. A formal interpretation of whether or not the "ganged" operation of roof vents is permitted by the roof vent provisions contained in the 2010 edition of NFPA 13 has been requested.

"*Chapters 4 through 10 represent the state of technology of vent and draft curtain board design in the absence of sprinklers. A broadly accepted equivalent design basis for using sprinklers, vents, and curtain boards together for hazard control (e.g., property protection, life safety, water usage, obscuration) is currently not available. Designers are strongly cautioned that the use of venting with automatic sprinklers is an area of ongoing research to determine its benefits and effect in conjunction with automatic suppression.*"

Commentary: To the best of my knowledge, there is no "*ongoing research*" on the effect of the use of roof vents in buildings provided with sprinkler protection at present. Hence, the reference to "*ongoing research*" is inaccurate.

"(7) *In tests where the vents were opened by fusible link, a number of the vents failed to open, which was attributed to either the cooling effects of the control mode sprinklers on the smoke layer or direct spray cooling of the fusible links.*"

Commentary: The statement above omits a key piece of information. In these tests, the temperature rating of the fusible links used to activate the roof vents had the same temperature rating as the sprinklers. The roof vent provisions included in the 2010 edition of NFPA 13 require that the temperature rating of fusible links used to activate automatic roof vents be at least one temperature classification higher than the temperature classification of the sprinklers. Given this information, it can be concluded that automatic roof vents will not automatically open if the roof vent installation complies with the vent requirements contained in the 2010 edition of NFPA 13 (and the sprinkler system is adequately designed for the hazard and is operable).

"*Draft curtains and open vents of venting systems should not adversely affect sprinklers that are capable of discharging water onto the fire, either in time of operation or in the water discharge pattern.*"

Commentary: This statement was written prior to the inclusion of the roof vent provisions in the 2010 edition of NFPA 13. If this statement were correct, there would have been no reason to include roof vent provisions in NFPA 13.

The statement above omits a key piece of information. In these tests, the temperature rating of the fusible links used to activate the roof vents had the same temperature rating as the sprinklers.

"(b) *If the vent spacing is several times as large as the sprinkler spacing, model fire tests simulating a 1.2 m x 1.2 m vent in a 7.6 m high building [Heskestad, 1995] showed that sprinkler operations were significantly delayed whenever ignition occurred anywhere under the area of the open vent. Otherwise, there was little delay. This delay can be important for systems with early suppression fast response (ESFR) sprinklers.*"

Commentary: This statement was written prior to the inclusion of the roof vent provisions in the 2010 edition of NFPA 13. If this statement were correct, there would have been no reason to include roof vent provisions in NFPA 13.

"(c) Use of high-temperature, heat responsive actuation mechanisms, compared to the sprinklers, can mitigate the problem of open vents. For example, for 74°C rated ESFR sprinklers, a minimum of 180°C activation temperature should be provided for vents. Another approach would be to provide gang operation of the vents at the moment a conservative number of sprinklers are operating."

Commentary: The use of high temperature activating devices for roof vents has been incorporated into the roof vent provisions included in the 2010 edition of NFPA 13 for both control mode and ESFR sprinklers. It is questionable whether it is the intent of the roof vent provisions included in the 2010 edition of NFPA 13 to permit the "ganged" operation of vents as suggested above.

"(c) *The layout of the sprinkler protection and the width of the aisle below the draft curtain should be sufficient to prevent the fire from jumping the aisle space. Accordingly, if a draft curtain is positioned midway between two sprinklers, the nearest possible ignition point should be at least 3/4 of one sprinkler spacing away from the draft curtain. In other words, there can be no storage of combustible material within 3/4 of one sprinkler spacing of a draft curtain.*

Aisles free of combustible storage, centered under draft curtains, should be at least 1-1/2 sprinkler spacings wide (e.g., a minimum of 15 ft wide for 10 ft sprinkler spacing in the direction perpendicular to the draft curtain). For situations where such an aisle is not practical, the aisle space can be reduced to 8 ft, when a line of sprinklers is provided on each side of the draft curtain, 4 in. to 12 in. horizontally from the face of the draft curtain. For existing sprinkler installations, these sprinklers near the draft curtain might need to be staggered horizontally with respect to adjacent line[s] *of sprinklers, in order to maintain the minimum separation required by NFPA 13, Standard for the Installation of Sprinkler Systems, and to prevent sprinkler skipping.*"

The recommendations above involve sprinkler system design. Sprinkler system design criteria should be determined by the NFPA 13 committee, not the Smoke Management Committee.

Commentary: The recommendations above involve sprinkler system design. Sprinkler system design criteria should be determined by the NFPA 13 committee, not the Smoke Management Committee.

"(5) *Determination of the smoke layer temperature should take into account the operation of the control mode sprinkler system. Control mode sprinklers operate when a temperature-rated element fuses in each individual control mode sprinkler head. Since in most fires only a small number of control mode sprinkler heads close to the seat of the fire operate, it follows that the bulk temperature of the smoke layer and/or the ceiling jet beyond the operating control mode sprinklers cannot be significantly higher than the control mode sprinkler fusible element operating temperatures, due to the cooling effect on the smoke of the operating control mode sprinklers. Therefore, once the first control mode sprinkler has operated, if calculations show the smoke layer temperature to be above the control mode sprinkler fusible element operating temperature, the smoke layer temperature should be modified to reflect this effect. A possible approach when vents are used would be to set the smoke layer temperature equal to the control mode sprinkler fusible element operating temperature, this being a reasonably conservative design solution.*"

Commentary: Section A.4.4.3 in the 2007 edition of NFPA 204 specifically states that the temperature differential between ambient and the smoke layer must be 110°C (198°F) or higher in order for roof vents to operate effectively. The discussion above does not address the effect that the operation of control mode sprinklers has on the temperature of the smoke layer. Given the delay in opening of vents caused by compliance with the roof vent provisions included in NFPA 13, in most, if not all cases, the temperature differential between the smoke layer and ambient will be less than 110°C (198°F) (if the sprinkler system is adequate for the hazard protected and operates). This statement is supported by the time/temperature data for the five large scale tests included in the research referred to as McGrattan et al [1998].

Annex F.3 does not make reference to the information provided in A.4.4.3 in NFPA 204. It should be noted that section A.4.4.3 in NFPA 204 recommends a mechanical smoke removal system be provided where a temperature differential of less than 110°C (198°F) exists when the vents are opened. No mention of the use of a mechanical smoke removal system is mentioned in Annex F.3.

Section A.4.4.3 in the 2007 edition of NFPA 204 specifically states that the temperature differential between ambient and the smoke layer must be 110°C (198°F) or higher in order for roof vents to operate properly.

"*(7) The effect of control mode sprinkler cooling may limit the number of vents opening if control of the vent is only by fusible link or if drop-out panels are used. If the fusible link or if drop-out panel operating temperature is equal to or higher than the control mode sprinkler fusible element operating temperature, then vents outside the outer ring of operating control mode sprinklers are unlikely to open. This could significantly limit the effectiveness of the smoke vent system. Use of ganged vents operated from detectors or a sprinkler flow switch is a way to avoid this situation.*"

Commentary: It is questionable whether the concept of the "ganged" opening of roof vents caused by the activation of the sprinkler system water flow indicator or a fire detection system is permitted by the roof vent provisions contained in the 2010 edition of NFPA 13. Schulte & Associates has submitted a request for a formal interpretation of whether or not the "ganged" operation of roof vents is permitted by the roof vent provisions contained in the 2010 edition of NFPA 13.

"*A recent paper examines the interaction of control mode sprinklers with smoke and heat vents [Beyler and Cooper, 2001]. . .*"

Commentary: The excerpt above makes reference to a "*recent paper*". The paper referred to was first published in February 1999. This paper is now over 12 old and is no longer a "*recent paper*".

"*The studies of smoke and heat venting used in conjunction with control mode sprinklers do not provide evidence that venting has a negative effect on control mode sprinkler performance.*"

Commentary: If the statement above is accurate, there would be no reason why roof vent provisions were included in the 2010 edition of NFPA 13. The substantiation statement for the roof vent provisions included in the 2010 edition of NFPA 13 reads as follows:

If the statement above is accurate, there would be no reason why roof vent provisions were included in the 2010 edition of NFPA 13.

> "*The intent of the standard is that roof vents and draft curtains should not be used in conjunction with storage protection.*"

An excerpt of a comment submitted on the proposal to include roof vent provisions in the 2010 edition of NFPA 13 is as follows:

". . .the use of smoke vents and draft curtains can be detrimental to all sprinklers that are specifically tested for storage applications. FM Global's recommended storage protection designs are based upon vents not being provided and that the use of automatic vents may increase the sprinkler water demand." (13-325 Log #CP43 AUT-SSD)

Given the above, it appears that there is a difference in opinion between the NFPA 13 Committee and the Smoke Management Committee regarding the effect of roof vents on sprinkler protection.

". . .the use of smoke vents and draft curtains can be detrimental to all sprinklers that are specifically tested for storage applications."

"*Experimental studies have shown that venting does limit the spread of products of combustion by releasing them from the building within the curtained compartment of fire origin. This improves visibility for building occupants and fire fighters who need to find the seat of the fire to complete fire extinguishment. Limiting the spread of smoke and heat also reduces smoke and heat damage to the building. In the event that control mode sprinklers do not operate, venting remains a valuable aid to manual control of the fire.*"

Commentary: The research conducted in 1998 [McGrattan et al] clearly demonstrated that the activation of control mode sprinklers interferes with the opening of individually activated automatic roof vents where the temperature rating of the roof vent activating device is the same as the temperature rating of the sprinklers. Based upon this research, it seems reasonable to conclude that individually-activated automatic roof vents which comply with the roof vent provisions included in the 2010 edition of NFPA 13 will not open automatically. If the roof vents do not open (as intended by the NFPA 13 roof vent provisions), then the statement above would be incorrect.

"*The experimental studies have shown that early vent activation has no detrimental effects on control mode sprinkler performance and have also shown that current design practices are likely to limit the number of vents operated to one and vents may in fact not operate at all in very successful control mode sprinkler operations. Design practices should move to methods that assure early operation of vents, and vent operation should be ganged so that the benefits of roof vents is fully realized. Control mode sprinkler design with vents and draft curtains needs to take full account of draft curtains as obstructions.*"

Commentary: As previously indicated, it should be noted that it is questionable as to whether "ganged" roof vent operation would comply with the intent of the roof vent provisions contained in the 2010 edition of NFPA 13.

"*Following the publication of the paper by Beyler and Cooper [2001], in a letter to the editor Heskestad [2002] reviewed the conclusions of the authors that: (1) venting clearly does not have a negative effect on sprinkler performance, (2) venting limits spread of combustion products, and (3) venting remains a valuable aid to manual control of the fire in the event the sprinklers do not operate. He argues the view that the first two of these conclusions are performance measures that are not met, or well met, by current technology based on the studies cited by the authors. With respect to the third conclusion, Heskestad refers to the FM Global position that venting, installed as backup to an automatic sprinkler system that is inadequate or impaired, is not cost-effective because it is unlikely [that] a large loss will be averted solely due to the presence of vents.*"

Commentary: The above appears to have mis-stated FM Global's position on the use of roof vents in buildings protected by sprinklers. The following is an excerpt of a comment submitted on the NFPA 13 roof vent provisions proposal:

> *". . .the use of smoke vents and draft curtains can be detrimental to all sprinklers that are specifically tested for storage applications. FM Global's recommended storage protection designs are based upon vents not being provided and that the use of automatic vents may increase the sprinkler water demand.*" (13-325 Log #CP43 AUT-SSD)

Discussion

The intent of the provisions contained in section 12.1.1.1 in the 2010 edition of NFPA 13 is to prevent the automatic opening of roof vents early on in a fire. The reason why these provisions have been included in NFPA 13 is summarized in an excerpt of a comment on Proposal 13-325 Log #CP43 AUT-SSD submitted by T. Multer:

> ". . .*With the advent of K-11.2 and larger sprinklers for storage applications and now Specific Application Control Mode sprinklers (being revised to CMSA), we need to realize that ESFRs are not the only storage sprinklers and that the use of smoke vents and draft curtains can be detrimental to all sprinklers that are specifically tested for storage applications*. . ."

As previously indicated above, Annex F.3 in NFPA 204 includes the following passage:

> "*Design practices should move to methods that assure early operation of vents, and vent operation should be ganged so that the benefits of roof vents is fully realized*."

Clearly, the passage cited from Annex F.3 contradicts the purpose of the roof vents provisions included in the 2010 edition of NFPA 13.

Given this, it seems obvious that the recommendations for the design of roof vent systems included in Annex F.3 in NFPA 204 are in conflict with the intent of the 2010 edition of NFPA 13.

It should also be noted that section A.12.1.1.1 in Annex A in the 2010 edition of NFPA 13 includes the following statement:

> "*Sprinkler protection criteria are based on the assumption that roof vents and draft curtains not being used. (See Section C.6.)*"

NFPA 13 contains no guidance as to the design parameters which apply where sprinkler protection and roof vent systems are utilized together. Given that, it would appear that there is no basis for the design of a sprinkler system in storage buildings provided with either roof vents and draft curtains, or both.

If there is no basis for the design of a sprinkler system in a storage building provided with roof vents and/or draft curtains included in NFPA 13, how does a sprinkler system designer demonstrate compliance with NFPA 13 and on what basis does an enforcing authority approve a sprinkler system design in storage buildings provided with roof vents?

It would seem reasonable that the publication of the next edition of NFPA 204 should be postponed until the conflicts with the roof vent provisions contained in the 2010 edition of NFPA 13 are resolved.

* * * * *