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ROOF VENTS AND SPRINKLERS: 1998 to 2011 (Version 1.0)

By Richard Schulte

The use of smoke/heat (roof) vents in buildings protected by a sprinkler system has been a controversial issue since the mid-1970's and, perhaps, even earlier. Since the publication of NISTIR 6196-1 in September 1998, the debate over the use of roof vents in one-story buildings protected by a sprinkler system has shifted from whether or not vents have an adverse impact on the operation of the sprinkler system to whether or not vents will even open in buildings protected by a sprinkler system.

The following are a few excerpts from various sources on the use of roof vents in buildings provided with sprinkler protection beginning with NISTIR 6196-1:

"***Sprinkler, Smoke & Heat Vent, Draft Curtain Interaction -- Large Scale Experiments and Model Development*** " **(NISTIR 6196-1)**, Kevin B. McGrattan, Anthony Hammis and David Stroup, September 1998:

> "*The tests and model simulations showed that when draft curtains were installed, up to twice as many sprinklers activated compared to tests performed without curtains.*" (Executive Summary, Page *ii*)
>
> "*The significant cooling effect of sprinkler sprays on the near-ceiling gas flow often prevented the automatic operation of vents. This conclusion is based on thermocouple measurements within the vent cavity, the presence of drips of solder on the fusible links recovered from unopened vents, and several tests where vents remote from the fire and the sprinkler spray activated. In one cartoned plastic commodity experiment, a vent did not open when the fire was ignited directly beneath it. The model simulations could not predict this phenomenon.*" (Executive Summary, Page *ii*)
>
> "*Model simulations showed how the activation times of the first and second sprinklers had a substantial impact on the overall number of activations in the plastic commodity tests. In the simulation of one test, it was shown that a delay of approximately one minute in the activation of the second sprinkler led to the activation of four times as many sprinklers as in a simulation of a test with no delay.*" (Executive Summary, Page *ii*)

"*There has been a long-standing debate in the fire protection community about the combined use of roof vents, draft curtains (curtain boards) and sprinklers.*" (Page 1)

"*There is no nationally recognized standard for the combined installation of sprinklers and roof vents. Indeed, NFPA 204M, Paragraph 6-1 states:*

> *A broadly accepted equivalent design basis for using both sprinklers and vents together for hazard control (e.g. property protection, life safety, water usage, obscuration, etc.) has not been universally recognized.*" (Page 3)

"*Even though the practice of installing vents in sprinklered buildings has been debated for decades, and in spite of several projects involving large scale tests and numerical modeling, there is still disagreement about how roof vents and draft curtains affect the time, number and location of sprinkler activations; and how sprinklers and draft curtains affect the activation time, number and discharge rates of roof vents.*" (Page 3)

> "*The significant cooling effect of sprinkler sprays on the near-ceiling gas flow often prevented the automatic operation of vents.*"

"*However, a position paper by N.E. Gustafsson of Industrial Mutual, Helsinki, interprets the results of the Ghent tests completely differently [19]. He argues that for the rapidly growing fires, a significant delay in sprinkler activation was caused by the presence of vents. Even though the delay was about 10 to 20 s in most cases, this allowed the fire to grow from 10.2 MW in the unvented case to as much as 14.2 MW in one of the vented cases. He also cites the inability of the sprinkler system to surround the fire in the vented cases.*" (Page 4)

> "*There is no nationally recognized standard for the combined installation of sprinklers and roof vents.*"

"*Rack storage fire tests conducted at Factory Mutual in the late 1960's raised the issue of the possible detrimental effects of smoke and heat vents in sprinklered buildings [11].*" (Page 4)

"*With the curtains installed, the fire opened more sprinklers and caused more damage to the fuel array, apparently due to the disruption of the sprinkler discharge pattern and the lack of prewetting of the commodity (FMRC Standard Plastic test commodity). The report concluded that ". . .the presence of draft curtains close to the fire origin will (1) result in the development of a more severe fire and (2) deleteriously affect sprinkler protection."* " (Page 5)

"*Most of the past work on sprinkler, vent, and draft curtain interaction has focused on the effects of vents and draft curtains on a sprinkler system. There has been much less work examining the effects of sprinklers on vents.*" (Page 5)

"*Test P-2 was intended to present an extreme situation as far as venting is concerned. The ignition point was put directly under a vent. The objective was to see how vent activation soon after ignition could affect sprinkler response. In the experiment, flames reached the top of the central array at about 65 s and the vent cavity at about 70 s. The first sprinkler activated at 100 s, followed 8 s later by the sprinkler on the opposite side of the vent. The vent above the ignition point did not open at any time during the 30 min test. However, the vent 6 m (20 ft) to the west of the ignition point did open at 6:04.*" (Page 42)

"*Rack storage fire tests conducted at Factory Mutual in the late 1960's raised the issue of the possible detrimental effects of smoke and heat vents in sprinklered buildings [11].*"

"*Given the difference in sprinkler activity between Test P-1 (20 activations) and Test P-4 (5 activations), it was decided to repeat Test P-4, only now the vents were to be manually opened following the first sprinkler activation. It had become clear by this time in the project that the vents were unlikely to open when the fire was ignited more than about 4.6 m (15 ft) away.*" (Page 54)

"***Interaction of Sprinklers With Smoke and Heat Vents***", Craig L. Beyler and Leonard Y. Cooper, Hughes Associates, Inc., February 1999:

"*The studies of smoke and heat venting used in conjunction with sprinklers show clearly that venting does not have a negative effect on sprinkler performance.*" (Page 1)

"*The studies of smoke and heat venting used in conjunction with sprinklers show clearly that venting does not have a negative effect on sprinkler performance.*"

"*The experimental studies have shown that early vent activation has no detrimental effects on 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 sprinkler operations.*" (Page 1)

"*The development of the technology of smoke and heat vents has been ongoing since 1954 when the first significant research on smoke and heat vents [Busby and Pigman 1955] was initiated in response to a disastrous fire which destroyed the Livonia automobile factory in 1953 [Waterman et al. 1982; Waterman 1984] and a similar automobile factory in Saginaw where manually opening skylights allowed an effective attack on the fire.*" (Page 2)

"*In fact, it appears that the fusible link for the vent cold soldered (as in the case of sprinkler skipping, while the solder of the vent link was in the process of melting, cooling by water droplets was apparently initiated and fusing of the link, i.e., melt-through of the solder, never occurred) and did not operate during the test.*" (Page 16)

"*Based on these rack test results, it is not possible to identify any adverse effects of smoke vents and draft curtains on sprinkler performance.*" (Page 17)

"*While modeling of the fluid mechanical aspects of the problem were quite successful in predicting aspects of sprinkler activation in the first heptane spray fire series, the model was unable to predict the corresponding results in the rack storage tests beyond first sprinkler activation.*" (Page 18)

"*Reproducibility is a significant issue in this type of testing. . .As such, reaching conclusions based on individual tests cannot be justified.*" (Page 19)

"*In the 1998 UL tests, visibility was maintained during the active burning period, but smoke logging was observed after fire control was achieved.*" (Page 20)

"*The claim that the use of smoke and heat vents will enhance burning rates has been actively made by Factory Mutual (e.g., Battrick 1986; Ward 1985].*"

"*In the 1998 UL tests [McGrattan, Hamins, and Stroup 1998], vents did not operate reliably when fires were remote from the vent in both heptane fires and rack fires. Indeed, no more than one vent operated in any test, and in a number of tests, no vents operated. In one extreme case, where the rack fire was started directly below the vent, the vent failed to operate due to cold soldering though a neighboring vent did operate. This raises legitimate concerns with this claim, but further raises concerns with the effectiveness of vents in general.*" (Pages 20 and 21)

"*The claim that the use of smoke and heat vents will enhance burning rates has been actively made by Factory Mutual (e.g., Battrick 1986; Ward 1985].*" (Page 21)

"*The claim that smoke and heat vents will delay sprinkler activation is not supported by the available data except when the fire is directly below the vent. . .The overwhelming evidence is that vents do not affect sprinkler operations even if opened at the start of the test. This is consistent with the European practice of ganging the vents and operating them by smoke detector or first sprinkler activation [Heselden 1985]. This result relates to the concerns over the reliable operation of smoke vents. Current U.S. practice is to impede the operation of vents to assure that sprinklers operate first. This concern is unwarranted based on the data. Early activation of vents and ganging vents are viable strategies which should be employed to improve venting reliability.*" (Page)

"*It is well known that vent flow rate is reduced at temperatures below 200°C (392°F) [Hinkley 1995] and that sprinklers can cause cooling of upper layer smoke to well below this level. For example, in sprinklered fires, it would not be unreasonable for smoke layer temperatures to be 70°C (158°F). At such a temperature, the theoretical flow rate relative to the maximum possible high temperature flow rate would be halved. . .Despite these results, it must be acknowledged that there may be a reduction in vent flows due to sprinklers both in terms of reduced temperatures and direct spray effects.*" (Pages 22 and 23)

"*First, it is clear that the current focus on assuring that vent operation is delayed has an adverse effect on system performance. It is important that design attention be paid to causing vents to operate more rapidly and in greater numbers. The data indicate that the European approach of ganged operation of vents based on early detection is a viable and desirable strategy.*" (Page 23)

"*First, it is clear that the current focus on assuring that vent operation is delayed has an adverse effect on system performance. It is important that design attention be paid to causing vents to operate more rapidly and in greater numbers.*"

"***Analysis of the Performance of Ganged Operation of Smoke and Heat Vents with Sprinklers and Draft Curtains***", Hughes Associates, Inc., February 18, 2008:

"*The objective of this study was to evaluate the performance of gang operated smoke and heat vent systems in sprinklered facilities. The gang operation concept involves opening all the vents within the coverage area of the sprinkler system in which the fire originates one minute after the first sprinkler has operated.*" (Page 11)

"*Comparison of sprinkler operations between vented and unvented cases clearly shows that the operation of sprinklers was not affected by smoke and heat vents or by smoke and heat vents with draft curtains. The time to first sprinkler operation, the number of sprinkler operations and the pattern of operation were not impacted by the venting system. The use of a one minute delay in vent operation allowed all sprinklers capable of applying water to the fire to operate before the vents operated, thus assuring that the sprinkler system performance would be unimpeded by the venting.*" (Page 11)

"*Current US design of smoke and heat vents typically utilizes thermal activation of individual vents. In Europe, it is typical to have smoke and heat vents operate in a ganged fashion. Ganged operation can provide more efficient venting in sprinklered facilities where the activation of individual vents is limited by the thermal management provided by the sprinklers. To eliminate any potential effect of venting upon the operation of sprinklers that provide water to the burning area, vent operation one minute after the first sprinkler operates will allow the sprinklers to operate without potential interference, yet provide effective venting of smoke and heat.*" (Page 13)

"*Comparison of sprinkler operations between vented and unvented cases clearly shows that the operation of sprinklers was not affected by smoke and heat vents or by smoke and heat vents with draft curtains.*"

"*In this investigation, the effectiveness of smoke and heat venting with ganged operation of vents was evaluated using computational fluid dynamics (CFD).*" (Page 13)

"*FDS4 uses Lagrangian droplet transport to simulate the delivery of water from suppression systems. The droplets and the fluid mechanics are coupled. The flow of air and gas components affect the drag on the droplets. The force that the droplets exert on the surrounding gas shows up as a body force in the Eulerian momentum equations. This coupling allows the model to simulate sprinkler-smoke layer interaction.*" (Page 14)

"*FDS4 uses Lagrangian droplet transport to simulate the delivery of water from suppression systems. The droplets and the fluid mechanics are coupled. . .This coupling allows the model to simulate sprinkler-smoke layer interaction.*"

"*While excellent smoke and heat vent performance was realized even without draft curtains, the inclusion of draft curtains delineating sprinkler coverage areas enhanced smoke extraction and limited lateral movement of smoke to areas outside the sprinkler coverage area where the fire occurred.*" (Page 91)

"*The operation of the smoke and heat vent system had no effect on the operation of sprinklers and as such maintained the operational effectiveness of the sprinkler system while improving the conditions within the building in support of fire department operations.*" (Page 92)

Proposal 13-325 Log #CP43 AUT-SSD, Report on Proposals (ROP)-2009 Annual Revision Cycle, National Fire Protection Association, 2008

"**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.*"

"**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.*"

"**Substantiation:** *The intent of the* [NFPA 13] *standard is that roof vents and draft curtains should not be used in conjunction with storage protection.*"

"**MULTER, T.:** *The following original proposal on ROP documents dated 10/20/2007 should be accepted as proposed but with a change to the annex statement.*

12.1.1 *Roof Vents and Draft Curtains. Roof vents and draft curtains shall not be used in conjunction with the sprinkler protection criteria for storage in this standard.*

"*Roof vents and draft curtains shall not be used in conjunction with the sprinkler protection criteria for storage in this standard* [NFPA 13]."

A.12.1.1 *The design parameters in NFPA 13 were developed based upon the absence of roof vents or draft curtains. (See Annex C.6) Fire tests for sprinklers specifically listed for storage applications are tested without vents or draft curtains. . .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.*"

Smoke Vent Task Group (SVTG) Teleconference Minutes-March 24, 2009, 2009 AAMA 72nd Annual Conference, February 22-25, 2009 (May 11, 2009 Revision with Conference Call Minutes):

> *". . .the study is worthless."*

"*. . .The concern remains that if C. Beyler is not willing to support the $100K SVTG Modeling Study, then the study is worthless. The members questioned why no other groups, organizations, or Fire Protections Engineers have come forward to defend the FDS program, particularly, Kevin McGratten* [McGrattan]*, from NIST, who wrote the original version of FDS, and has been intimately involved in it since its development. B. Sampson will contact K. McGratten* [McGratten] *to obtain his thoughts on this.*" (Page 129)

William Koffel, Koffel Associates, Inc., ICC Code Technology Committee Meeting, Birmingham, Alabama, April 2009:

"*Roof vents work* [in sprinklered buildings]."

Testimony of William Koffel, Koffel Associates, Inc., ICC Code Development Meeting, Baltimore, Maryland, October 2009:

> *"So the 13 committee recognizes that this is a viable technology in sprinklered buildings."*

". . .*Secondly, they talk about a recommendation of the NFPA 204 committee. I sit on the NFPA smoke management committee responsible for 204. I'm not representing that committee here. I sit on NFPA 13 discharge criteria committee which is responsible for Chapter 12. I'm not representing that committee. But I think this committee* [referring to the ICC Fire Code Changes Committee] *needs to know that NFPA 13 now allows vents and draft curtains in buildings protected throughout with a sprinkler system. . .So the 13 committee recognizes that this is a viable technology in sprinklered buildings. 204 has a proposal, or a comment, that is being balloted now that has a new chapter for designing smoke vents in buildings protected with a sprinkler system, so the technology is being addressed by the appropriate NFPA committees.*"

Testimony of William Koffel, Koffel Associates, Inc., NFPA Technical Meeting-NFPA 204, Las Vegas, Nevada, June 9, 2010:

> "*So I think the real question for you today relative to this motion is: What is the harm? Has the maker of the motion proven to you that there's anything technically wrong or that any harm will really come from including Chapter 11 in this edition of NFPA 204?*"
>
> "I *think my previous testimony was mischaracterized. I didn't say move this forward because there's no harm.*"

"*Has the maker of the motion proven to you that there's anything technically wrong or that any harm will really come from including Chapter 11 in this edition of NFPA 204?*"

"I *think my previous testimony was mischaracterized. I didn't say move this forward because there's no harm.*"

[To be continued]

Version 2.0 of this article will include further statements addressing the use of roof vents in buildings provided with sprinkler protection and, as well as an analysis of the above.

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