SCHULTE & ASSOCIATES
Building Code Consultants
880D Forest Avenue
Evanston, IL 60202
fpeschulte@aol.com
847/866-7479

A CRITIQUE OF THE TASK GROUP 400 REPORT-PART 1

By Richard Schulte

Background

The issue of whether or not automatic smoke/heat vents should be utilized in one-story industrial and storage buildings protected by a sprinkler system has been debated since at least the mid-1970's. The main concern of those opposed to the use of smoke/heat vents and draft curtains in buildings protected by a sprinkler system is that open smoke/heat vents may have an adverse effect on the operation of the sprinkler system protecting the building.

In 1993, research conducted by Factory Mutual Research Corporation (FMRC) determined that draft curtains may have an adverse effect on the operation of sprinklers. In 1997/1998, research work conducted at Underwriters Laboratories' (UL) test facilities in Northbrook, Illinois confirmed FMRC's finding regarding draft curtains. Further, the research work at UL determined that the operation of standard spray sprinklers will have an adverse effect on the operation of automatic smoke/heat vents. The research work at UL found that the operation of smoke/heat vents would be significantly delayed, or even prevented, if sprinklers activated prior to the operation of the vents.

The research work at UL found that the operation of smoke/heat vents would be significantly delayed or even prevented if sprinklers activated prior to the operation of the vents.

Subsequent to the tests at UL, the smoke/heat vent manufacturers claimed that the testing at UL was unfair to their product and, in September 1999, made a commitment to conduct further testing on the interaction between sprinklers and vents. To date, the smoke/heat vent manufacturers have not followed-up on their commitment with any further testing.

In the summer of 2006, the trade group which represents the smoke/heat vent manufacturers, the Smoke Vent Task Group, announced that Hughes Associates, Inc. (HAI) would perform a fire modeling study of the interaction of sprinklers and smoke/heat vents and that this study would provide documentation that smoke/heat vents do not have an adverse effect on the operation of sprinklers and that smoke/heat vents "work" in buildings protected by sprinklers.

> . . .HAI's client, the Smoke Vent Task Group, characterized HAI's fire modeling work as "*worthless*".

Hughes Associates, Inc. released a report documenting their modeling study on February 18, 2008. The HAI report introduced a new concept on the activation of smoke/heat vents in buildings protected by a sprinkler system-the concept of the "ganged" operation of vents. Rather than the individual activation of each vent, HAI proposed that multiple vents in a building, or a portion of a building, be opened automatically 60 seconds after the activation of the water flow indicating device in the sprinkler system.

Following the release of the HAI's report on the "ganged" operation of roof vents, it was determined that HAI utilized the Fire Dynamics Simulator (FDS) for purposes for which the model has not been "validated" and HAI's client, the Smoke Vent Task Group, characterized HAI's fire modeling work as "*worthless*".

While Hughes Associates, Inc. was in the process of working on their modeling study on the "ganged" operation of smoke/heat vents, code change proposals addressing the use of smoke/heat vents in buildings provided with sprinkler protection were introduced into the code development process for the International Building Code (IBC) and the International Fire Code (IFC). The approval of one of the code change proposals (E114-07/08) resulted in the removal of a provision which permitted the travel distance limitation in one-story sprinklered industrial and storage buildings to be increased from 250 feet to 400 feet where smoke/heat vents were provided. Given that a companion proposal (E113-07/08) to allow the travel distance in sprinklered industrial and storage buildings to be increased to 400 feet without smoke/heat vents was not approved, the maximum travel distance limitation was reduced to 250 feet in large one-story industrial and storage buildings in the 2009 edition of the IBC.

The Task Group 400 Report

With the above background, let's take a look at a report titled *"Report to the California State Fire Marshal on Exit Access Travel Distance of 400 Feet"* dated December 20, 2010. This report was developed by a committee which refers to itself as "Task Group 400". This committee was chaired by Chief Doug Dupree, San Bernardino City Fire Department, representing the Southern California Fire Prevention Officers, and included a number of California building and fire officials, as well as private sector representatives from both California and out-of-state.

The committee also included Rick Thornberry, The Code Consortium, and Julie Ruth, JRuth Code Consulting, representing the American Architectural Manufacturing Association (AAMA). Although Thornberry is listed as an "*industry consultant*" on the committee roster, Thornberry has previously represented the Smoke Vent Task Group on the NFPA 204 committee and the ICC Code Technology Committee (CTC) study group on roof vents. Ruth presently acts as the alternate to the Smoke Vent Task Group representative on the CTC study group on roof vents. Members of the CTC study group on roof vents, other than those representing the Smoke Vent Task Group, were not included on Task Group 400 committee, nor were they asked to participate or provide input to the committee.

Although Thornberry is listed as an "industry consultant" on the committee roster, Thornberry has previously represented the Smoke Vent Task Group on the NFPA 204 committee and the ICC Code Technology Committee (CTC) study group on roof vents. Ruth presently acts as the alternate to the Smoke Vent Task Group representative on the CTC study group on roof vents.

The following are excerpts from the "Task Group 400 " report. Commentary on the excerpts are shown in blue:

> "*Task Group 400 took on a task that blossomed into a much larger challenge than was expected. The goal was to provide mitigation measures which would allow the re-instatement of an exit access travel distance of 400 feet in Group F-1 and S-1 occupancies.*" (Page 3)

Members of the CTC study group on roof vents, other than those representing the Smoke Vent Task Group, were not included on Task Group 400 committee, nor were they asked to participate or provide input to the committee.

“*During this project, Task Group 400 identified two distinct issues. While developing a plan to address the ability to safely evacuate warehouses and factories it became apparent that allowing these larger travel distances resulted in larger buildings; larger buildings resulted in additional firefighting difficulties. It was felt that one issue could not be addressed without including the other.*” (Page 3)

“*Therefore, Task Group 400 produced code changes that address the mitigation required to allow an exit access travel distance of 400 feet, and also produced code changes to mitigate the increased difficulty created when fighting fire in these large buildings which utilize the increased travel distance allowance.*” (Page 3)

“*A change in the 2009 International Building Code and 2010 California Building Code has resulted in the elimination of the allowed exit access travel distance of 400 feet in large warehouses and factories. Previously, the installation of a fire sprinkler system and smoke/heat vents would result in an increased travel distance from 250 feet to 400 feet to the nearest exit.*” (Page 8)

“*The reasoning for code change was logical…ie. the smoke/heat vents will most likely not operate in a sprinklered building, therefore allowing an increase in exit access travel distance based on smoke/heat vents does not make sense. The code change was approved, which resulted in limiting the exit access travel distance to 250 feet.*” (Page 8)

“*While the reasoning for approving the Code Change E114-07/08 was logical, the result was the loss of the ability to utilize an exit access travel distance of 400 feet. California has successfully applied this allowance since 1998 in hundreds of buildings across the state. The application of the 400 feet allowance has not resulted in life loss in these buildings.*” (Page 8)

Commentary: Simply because there has been no life loss in these types of buildings does not mean that smoke/heat (roof) vents were wholly, or even partially responsible for safety record of these buildings. The reason why there has been no life loss in these buildings is that these buildings are “inherently safe”. The combination of sprinkler protection and the size of these buildings is responsible for the safety record for these types of buildings.

The reason why there has been no life loss in these buildings is that these buildings are “inherently safe”.

“*The loss of the exit access travel distance of 400 feet has a significant negative impact on new warehouse and factory facilities. The fact that the original reasoning which provided the allowance of 400 feet was faulty, did not justify eliminating the requirement in its entirety. Therefore, Task Group 400 brought stakeholders together to evaluate and determine what mitigation measures are necessary to justify exit access travel distances of 400 feet.*” (Page 8)

Commentary: It should be noted that code change proposal E113-07/08 addressed the issue under review by Task Group 400. (The proponent of the proposal was Richard Schulte, Schulte & Associates.) The acceptance of proposal E113-07/08 was opposed at public hearings held in Palm Springs, California in February 2008 by the fire service and a lobbyist representing the Smoke Vent Task Group, Rick Thornberry, The Code Consortium, Inc.

Excerpts from the Reason Statement for code change proposal E113-07/08 include the following:

> "*For more than 20 years, an exception has been included in the model building codes used in the United States which permits an increase in travel distance to 400 feet in single-story Group F-1 and S-1 occupancies protected by a sprinkler system and provided with automatic smoke and heat vents. This exception has been based upon the assumption that the automatic smoke and heat vents would operate and vent heat and smoke from the building, thus increasing the time that occupants have to evacuate the building. Since the allowable travel distance is the means by which the code limits evacuation time, an increase in the time available for evacuation translates into an increase in the distance which can be safely traveled during an evacuation. Hence, an increased travel distance is permitted when a building containing a Group F-1 or S-1 occupancy is provided with automatic smoke and heat vents and sprinkler protection.*"

> "*Given the above, it can be concluded that smoke and heat (roof) vents do not actually operate as expected in buildings protected by a sprinkler system. Hence, the logic behind the increase in travel distance to 400 feet is flawed.*"

> "*In other words, automatic smoke and heat vents provide no additional protection for occupants evacuating a storage or industrial building and it is the sprinkler protection (along with the size of the building) which is providing all of the protection necessary to permit an extended egress travel distance.*"

The fire service opposed the approval of code change proposal E113-07/08 based upon fire fighter life safety. From a fire fighting standpoint, a travel distance of 400 feet means that a hose lay of roughly 400^+ feet could potentially be required. Given the limited capacity of self-contained breathing apparatus, advancing a hose line for a distance of 400 feet would provide little actual time for fire fighting before personnel would need to leave the building due to a low air supply.

Given the limited capacity of self-contained breathing apparatus, advancing a hose line for a distance of 400 feet would provide little actual time for fire fighting before personnel would need to leave the building due to a low air supply.

While the reason stated above is logical, it assumes that fire fighters will make an interior attack on the fire, rather than waiting for the sprinkler system to perform its intended function. Per NFPA 13, a control mode sprinkler system is capable of returning temperatures in a building to ambient within 30 minutes without fire fighter intervention. Given this, making an interior attack on the fire is unnecessary in a building protected by a properly designed and maintained sprinkler system. In the event of a sprinkler system failure, an interior attack on the fire is too risky and should not be undertaken.

> Per NFPA 13, a control mode sprinkler system is capable of returning temperatures in building to ambient within 30 minutes without fire fighter intervention.

The risk of an interior attack on a fire in a building containing high-piled storage with a travel distance of 400 feet should be apparent based upon the results of the fire at the Sofa Super Store in Charleston, South Carolina on June 18, 2007. The Sofa Super Store Building in Charleston was a one-story building roughly 15,000 square feet in floor area. Obviously, if nine fire fighter fatalities occurred in a relatively small single-story furniture store, the risk of fire fighter fatalities in buildings which are 500 thousand square feet or more in floor area are even greater.

> Obviously, if nine fire fighter fatalities occurred in a relatively small single-story furniture store, the risk of fire fighter fatalities in buildings which are 500 thousand square feet or more in floor area are even greater.

The recommendations regarding interior fire fighting contained in NIOSH 2010-153, *Preventing Deaths and Injuries of Fire Fighters using Risk Management Principles at Structure Fires*, and NIOSH 2005-132, *Preventing Injuries and Deaths of Fire Fighters due to Truss System Failures*, are certainly applicable to the use of interior fire fighting tactics in single-story industrial or storage buildings which are 500 thousand square feet in floor area or even larger.

Excerpts from NIOSH 2005-132 and NIOSH 2010-153 include the following:

> "*Unfortunately, fires are not predictable: conditions often deteriorate quickly, and fire-damaged building components, including trusses, can collapse with little warning. . .*" (NIOSH 2005-132)

> "*. . .Lives will continue to be lost unless fire departments make appropriate fundamental changes in fire-fighting tactics involving trusses. . .*" (NIOSH 2005-132)

"*Use defensive strategies whenever trusses have been exposed to fire or structural integrity cannot be verified. . .*" (NIOSH 2005-132)

" ***Ensure that fire fighters performing fire-fighting operations under or above trusses are evacuated as soon as it is determined that the trusses are exposed to fire (not according to a time limit.)***" (NIOSH 2005-132)

"***Use extreme caution when operating on or under truss systems.***" (NIOSH 2005-132)

"*Results of these NIOSH investigations suggest that fire departments, incident commanders, incident safety officers, and fire fighters may not fully consider information related to building occupancy, structural integrity, and fire involvement before entering structures to initiate interior operations and while performing offensive operations. . .*" (NIOSH 2010-153)

"*. . .The top priority at all fire scenes should be saving and preserving lives—both civilian lives and the lives of all fire fighters at the scene.*" (NIOSH 2010-153)

"*. . .The top priority at all fire scenes should be saving and preserving lives—both civilian lives and the lives of all fire fighters at the scene.*"
(NIOSH 2010-153)

"*. . .Risks to fire fighters' lives must be balanced against gains when deciding whether to use an offensive or defensive attack . . .The challenge for the incident commander is to recognize when the level of risk becomes excessive and to call for a defensive strategy in situations where no lives are at risk.*" (NIOSH 2010-153)

"*Include the age of the structure, structural integrity, the type of roof structure and supports (i.e., lightweight trusses, bowstring trusses, and heavy timber construction), the type of interior support structures (i.e., floor trusses, wooden I-joists, and support columns), the type of materials used in the structure (i.e., wood, steel, plastics, foam, or materials that produce toxic gases when subjected to heat), storage of flammable or toxic materials, the amount of load on roof structures that could weaken the supports (e.g., heavy heating and cooling units), water supply, and the presence of automatic sprinkler systems.*" (NIOSH 2010-153)

"*Ensure the availability of adequate resources, such as a rapid intervention team (RIT), backup hose lines, and emergency medical services (EMS) personnel.*" (NIOSH 2010-153)

Based upon the recommendations contained in NIOSH 2005-132 and NIOSH 2010-153, it can be concluded that interior fire fighting operations in large one-story industrial or storage buildings are not recommended since most of these types of buildings utilize unprotected (exposed) metal deck roof construction supported on unprotected (exposed) steel bar joists or long-span steel trusses. Although these buildings are protected by a sprinkler system, the sprinkler protection provided could fail at any time due to obstructed sprinkler orifices (by gravel), obstructed or broken overhead or underground supply piping, "blown out" underground fittings or fire pump failure.

While failure of operating sprinkler systems due to these causes are relatively rare, should sprinkler system failure occur while interior fire fighting operations are underway, the results of a sprinkler system failure could be catastrophic in terms of fire fighter fatalities and injuries. Hence, it seems to be logical that interior fire fighting tactics in these large buildings should not be utilized.

"*Over a period of 10 weeks, Task Group 400 held nine separate meetings.*" (Page 9)

"*Fire modeling studies by Boeing Corporation which indicated that ceiling heights of 25 feet and 50 feet combined with fire sprinklers provided adequate escape time to accommodate an exit access distance of 400 feet. This study was conducted as part of the justification for ICC Code Change E109-09/10.*" (Page 9)

Commentary: The Life Safety Code has permitted a travel distance of 400 feet in storage buildings with ordinary hazard contents protected throughout by a sprinkler system for decades. There was no need to do fire modeling to demonstrate the obvious. See the reason statement for code change proposal E113-07/08.

Based upon the recommendations contained in NIOSH 2005-132 and NIOSH 2010-153, it can be concluded that interior fire fighting operations in large one-story industrial or storage buildings are not recommended since most of these types of buildings utilize unprotected (exposed) metal deck roof construction supported on unprotected (exposed) steel bar joists or long-span steel trusses.

"*Fire modeling studies sponsored by National Association of Industrial and Office Properties which indicated that a ceiling height of 30 feet combined with early suppression fast-response (ESFR) sprinklers provided adequate escape time to accommodate an exit access distance of 400 feet.*" (Page 9)

Commentary: Once again, the Life Safety Code has permitted a travel distance of 400 feet in storage buildings with ordinary hazard contents protected throughout by a sprinkler system for decades. There was no need to do fire modeling to demonstrate the obvious. See the reason statement for code change proposal E113-07/08.

"*Reinsert the requirement for smoke/heat vents as is currently found in the 2007 CBC and CFC. . .*

> *Cons: As was shown in the ICC code development process, the reasoning which allowed the increased exit access travel distance when smoke/ heat vents are installed was invalid. To simply reinsert the language after it has been shown to be invalid would not be sound engineering practice.*
>
> *Action: This option was eliminated because lacked sound engineering justification."*
>
> (Page 9)

Once again, the Life Safety Code has permitted a travel distance of 400 feet in storage buildings with ordinary hazard contents protected throughout by a sprinkler system for decades. There was no need to do fire modeling to demonstrate the obvious. See the reason statement for code change proposal E113-07/08.

"*Require Smoke/heat vents to all open at once with activation based on water flow from the fire sprinkler system. This is commonly referred to as "ganged release".*

> *Pros: This solution would ensure that the smoke/heat vents would open. It would also ensure that the smoke/heat vents opened after the initial fire sprinkler operation.*
>
> *Cons: There was a possibility that firefighting operations could be negatively affected when all of the smoke/heat vents opened automatically. When all the smoke/heat vents open and provide maximum open area in the roof, it is possible that the actual air velocity in any given area would be so low that it would impede the ability to exhaust the smoke using fire department power fans.*"

(Pages 9 and 10)

Commentary: The concept of the "ganged" operation of smoke/heat vents was proposed by the Smoke Vent Task Group in the ICC 2007/2008 code change cycle and the Hughes Associates, Inc. (HAI) report titled "*Analysis of the Performance of Ganged Operation of Smoke and Heat Vents with Sprinklers and Draft Curtains*" dated February 18, 2008 was submitted as documentation that the "ganged" operation of smoke/heat vents would not have an adverse effect on the operation of the sprinkler system. The Hughes Associates, Inc. fire modeling study was shown to be an inappropriate (*i.e.*, not "validated") use of the Fire Dynamics Simulator (FDS) and the Smoke Vent Task Group has characterized the Hughes Associates, Inc. study as "*worthless*".

> . . .the Smoke Vent Task Group has characterized the Hughes Associates, Inc. study as "*worthless*".

The concept of the "ganged" operation of roof vents violates the (new) provisions for the installation of roof vents contained in the 2010 edition of NFPA 13. If there is a concern that the opening of one or two roof vents would have an adverse effect on the operation of a sprinkler system, it seems obvious that the "ganged" operation of multiple roof vents would have a far more serious adverse effect on the operation of the sprinkler system.

Sprinkler protection is the primary fire protection system provided to protect large industrial and storage occupancies. The installation of any other fire protection system, or fire protection feature, which potentially has an adverse effect on the operation of the sprinkler system should be considered to be "poor engineering practice".

It should be noted that the substantiation statement for the inclusion of the (new) roof vent provisions in the 2010 edition of NFPA 13 is as follows:

> "*The intent of the* [NFPA 13] *standard is that roof vents and draft curtains should not be used in conjunction with storage protection.*" 13-325 Log #CP43 AUT-SSD

The substantiation statement for the roof vent provisions contained in the 2010 edition of NFPA 13 couldn't be any clearer.

"*Require mechanical ventilation rather than smoke/heat vents.*

> *Cons: In order for the mechanical ventilation to be effective for occupant egress, it needs to be activated automatically. There is a possibility that the automatic operation may cause ventilation to occur when it is not necessary which could affect the fire spread.*

The volume of air currently required in the code appears to be excessive. There is a discussion occurring in the ICC Code Technology Committee and the NFPA 204 committee with regard to the volume of air changes needed. Until that issue is settled, it was decided not to make mechanical ventilation mandatory."

(Page 11)

Commentary: As has been documented, automatic roof vents in buildings which are protected by standard spray sprinklers will likely not operate if the temperature rating of the activating mechanism for the vents is the same temperature classification as the ceiling sprinklers. (The new provisions addressing the installation of roof vents contained in NFPA 13 specifically require that the temperature classification of the activating mechanism of roof vents be one classification higher than the sprinklers.)

To paraphrase Forrest Gump, "logical is as logical does".

As previously indicated, editions of the IBC prior to the 2009 edition permitted an increase in the travel distance to 400 feet in one-story industrial and storage buildings protected by a sprinkler system and provided with automatic smoke/heat vents. If the automatic smoke/heat vents will not operate due to sprinkler activation, then the rate of smoke removal provided by the smoke/heat vents is zero (0). If a smoke removal rate of zero (0) was acceptable to increase the travel distance from 250 feet to 400 feet, then it seems reasonable to conclude that the rate of mechanical exhaust to allow an increase in the travel distance which should be acceptable would be the same, zero. To paraphrase Forrest Gump, "logical is as logical does".

In the event of a sprinkler system failure, it should be noted that the entire roof system of a building constructed with an exposed metal deck supported on exposed steel bar joists or exposed long-span trusses is a roof vent. At the fire at the McFrugal's Warehouse in New Orleans on March 21, 1996, the fire burned a hole in the metal roof deck and the New Orleans Fire Department was able to operate in the building for 5 hours without going to the roof to vent the building. The hole that was burned in the roof acted like a smoke/heat vent system.

(It should be noted that the travel distance in the McFrugal's Warehouse was 600 feet (500 feet horizontally and 100 feet vertically) and that the McFrugal's Warehouse was designed without smoke/heat vents and draft curtains. The failure of the sprinkler system protecting the McFrugal's Warehouse was caused by the failure of the building owner to install in-rack sprinkler protection in multi-row racks with a storage height of 21 feet. The building owner requested a quote from Grinnell Fire Protection Systems Company to install in-rack sprinklers in the multi-row racks, but made a decision not to provide in-rack sprinklers in the multi-row racks.)

The use of logic is a two-way street.

"*The typical building using increased travel distance is a large open space, quite often with just four exterior walls. There are no interior walls where the increased fire resistive construction would slow the fire spread.*" (Page 12)

Commentary: Note h to Table 2306.2 reads as follows:

> "*High-piled storage areas shall not exceed 500,000 square feet. A 2-hour fire wall constructed in accordance with the International Building Code shall be used to divide high-piled storage exceeding 500,000 square feet in area.*"

It should be noted that the application of Note h to Table 2306.2 is limited to buildings which contain high hazard commodity classification. The IFC indicates that the high hazard commodity classification includes Group A plastics, other than Group A plastics which can be classified as Class III or Class IV commodities.

The IFC indicates that the high hazard commodity classification includes Group A plastics, other than Group A plastics which can be classified as Class III or Class IV commodities.

The application of Note h would limit the floor area of buildings designed to house contents classified as Group A plastics to a maximum of 500,000 SF.

"*Install a fire alarm system consisting of audible and visual signaling devices throughout the area with the increased exit access travel distance*.

> *Cons: The fire modeling reports reviewed were all based on buildings where no fire alarm was present for early notification of the occupants.*"

(Page 12)

Cons: The fire modeling reports reviewed were all based on buildings where no fire alarm was present for early notification of the occupants."

Commentary: The analysis conducted by Aon FPE included in this report assumes that a fire alarm system will be provided in the building which was modeled.

"*Task Group 400 decided that the most viable solution was to develop a set of parameters which considered the vast volume of the large building could be utilized to contain the smoke before it fills the space down to a point where egress is affected.*" (Page 16)

“*The early suppression fast-response (ESFR) sprinkler technology is specifically designed for the high-challenge storage occupancies. The ESFR technology is designed to operate earlier and provide an adequate flow of water to suppress the fire. Control Mode Density Area (CMDA) sprinklers are designed to control the spread of fire. While the CMDA sprinklers may also extinguish a fire, a satisfactory result from CMDA is to just stop the continued spread of the fire. . .If the control mode sprinkler design provides adequate results, the ESFR sprinkler design will provide for improved results.*” (Pages 16 and 17)

Commentary: The following statements have been included in NFPA 13/NFPA 231C for decades:

> “*Sprinkler protection* [utilizing standard spray sprinklers] *installed as required in this standard is expected to protect the building occupancy without supplemental fire department activity.*”

> “*During the testing program, the installed automatic extinguishing system was capable of controlling the fire and reducing all temperatures to ambient within 30 minutes of ignition.*”

Based upon the statements above, it should be clear that both ESFR sprinklers and standard spray sprinklers are both capable of extinguishing “high challenge” fires.

> “*Sprinkler protection installed as required in this standard is expected to protect the building occupancy without supplemental fire department activity.*” NFPA 13

ESFR and standard spray sprinklers utilize different concepts in order to achieve fire extinguishment. ESFR sprinklers utilize a “heavy discharge” of water to directly attack and overwhelm the fire. Rather than directly attacking a “high challenge” fire, standard spray sprinklers initially cool the ceiling directly over the fire and “pre-wet” combustibles adjacent to the ignited combustibles. Pre-wetted combustibles will not ignite and the fire eventually consumes combustibles ignited prior to the activation of sprinklers. Once the combustibles ignited prior to the activation of sprinklers are consumed, the sprinklers operating directly over the fire complete the extinguishment of the fire.

In other words, the end results achieved by both ESFR sprinklers and standard spray sprinklers is the same. The difference is the time it takes to achieve the results. Where rack storage arrays are only protected by standard spray sprinklers provided at the ceiling, ESFR sprinklers are more time-efficient than are standard spray sprinklers. Where rack storage arrays are protected by a combination of standard spray sprinklers at the ceiling and in-rack sprinklers, the protection provided by standard spray sprinklers is more time-efficient than are ESFR sprinklers.

Hence, the general statement that ESFR sprinklers provide better fire protection than standard spray sprinkles is factually incorrect. Sprinkler systems which include in-rack sprinkler protection provide superior fire protection to that provided by ESFR sprinklers, and, from a fire protection standpoint, are still the preferred method of providing sprinkler protection for rack storage arrays.

"*In the discussions of determining a solution for to allow the exit access travel distance of 400 feet, Task Group 400 recognized that the allowed increase would have an impact on firefighting operations. When a building is designed utilizing the travel distance of 400 feet, it results in larger buildings. Utilizing exit access travel distances of 400 feet to the closest exit, buildings can easily be designed with a narrow dimension of 600 to 700 feet. This results in firefighting operations where fire hose needs to be dragged into the building that same distance of 400 feet.*" (Page 17)

Sprinkler systems which include in-rack sprinkler protection provide superior fire protection to that provided by ESFR sprinklers, and, from a fire protection standpoint, are still the preferred method of providing sprinkler protection for rack storage arrays.

Commentary: See the recommendations contained in NIOSH 2005-132 and NIOSH 2010-153. Both these two NIOSH Alerts recommend against the use of interior manual fire fighting operations in buildings which are constructed with exposed steel roof decks and exposed steel bar joists or exposed long span trusses. Given the recommendations contained in NIOSH 2005-132 and NIOSH 2010-153, the need to address the issue of interior manual fire fighting operations is certainly questionable, particularly when cuts in fire department staffing are now under consideration in many jurisdictions. (The effects of reduced staffing at a fire are discussed in NIOSH 2010-153.)

"*Require smoke/heat vents with all ESFR sprinkler systems.*

> *Pros: Smoke/heat vents can be a tremendous asset during firefighting operations. Assuming that the smoke/heat vents don't open as a result of the fire, they are still on the roof and available for manual operation.*
>
> *The current California Building Code and California Fire Code require a method of manual activation. During a fire, firefighters could access the roof, travel to the appropriated smoke/heat vents, operate the manual release, and retreat quickly from the roof. Anytime firefighters are on the roof, they are in a dangerous situation. The less time spent on the roof, the less time firefighters are at risk.*

California is an area where seismic activity can disable water supply and damage water supply piping and fire sprinkler piping. The requirement for smoke/heat vents in buildings protected with ESFR sprinklers provides a backup for this event. If the sprinkler system is disabled for any reason, the smoke/heat vents will prove invaluable. They will operate automatically and provide a release for the smoke and heat allowing occupants to egress. The release of smoke and heat will also benefit the firefighting operation."

(Page 19)

Commentary: The capability of smoke/heat vents to perform their intended function is, of course, dependent upon the time at which the vents are opened. Vents have a finite capability of venting smoke/heat which is dependent upon the size of the vents, the number of vents which open, or which are opened, the depth of the combustion products layer which collects under the roof and the temperature of the combustion products layer which collects under the roof. The longer the opening of vents is delayed, the more smoke/heat will collect under the roof. Hence, the manual operation of smoke/heat vents after fire fighting personnel arrives is not optimal from the standpoint of the performance of a smoke/heat vent system. This was clearly demonstrated at a fire in a bulk merchandising store (Home Depot) in Tempe, Arizona on March 19, 1998.

The bulk merchandising store in Tempe had dimensions of approximately 250 feet by 400 feet (100,000 SF) with a ceiling height which varied between 24 and 29 feet. The building was provided with sprinkler protection designed to deliver a density of 0.495 gpm/SF applied over 2,000 SF with a hose stream demand of 500 gpm. The building was protected by large orifice sprinklers with a temperature rating of 286°F. The hydraulic calculations assumed that 29 sprinklers would operate.

In addition to the sprinkler protection provided, the building was provided with 93 skylights and 29 automatic roof vents. The roof vents had nominal dimensions of 4 feet by 8 feet and were activated by fusible links with a temperature rating of 165°F. The building was also provided with draft curtains which were 6 feet, 6 inches in depth.

In the fire, 66 sprinklers activated. When the Phoenix Fire Department arrived at the building, the visibility at floor level was "zero". A ladder company sent to the roof reported that 3 roof vents had opened and that one skylight had burned through. The ladder company opened an additional 42 roof vents and skylights.

The fire at the bulk merchandising store in Tempe clearly demonstrates that visibility will may not be maintained in a building provided with a failing sprinkler system if the automatic smoke/heat vents do not open early in the fire. Hence, providing smoke/heat vents in a building is no guarantee that visibility will be maintained at the floor at the time the fire department arrives at the building.

Of course, the building in Tempe was only 100,000 SF in floor area. Larger buildings, or buildings with higher roofs, would perform better, however, the conditions present at the time of the arrival of the fire department will be dependent upon the response time. In many communities, response time far exceed 5 minutes and often times there is insufficient personnel available at the scene to immediately go to the roof to open vents and then conduct interior fire fighting operations.

One other point which needs to be considered when addressing the efficacy of providing smoke/heat vents in buildings protected by a sprinkler system using spray sprinklers is that spray sprinklers are extremely effective in rapidly reducing ceiling temperatures. The efficiency of smoke/heat vents is dependent upon the temperature differential between the smoke/heat layer under the roof deck and the ambient temperature. NFPA 204 recommends that mechanical smoke removal be used if the temperature differential between the heat/smoke layer is less than 200^{o}F (110^{o}C). In other words, gravity venting (smoke/heat vents) is not a very efficient means of venting when the smoke layer is cooled by sprinkler operation.

Given the above, it is not difficult to conclude that providing smoke/heat vents in buildings protected by spray sprinklers is problematic at best. The same can be said for the use of smoke/heat vents in buildings protected by ESFR sprinklers, because ESFR sprinklers are efficient in rapidly “knocking down” a fire with heavy water discharge.

With respect to the point concerning seismic activity, if the municipal water supply for the sprinkler system is damaged due to an earthquake, smoke/heat vents will not perform any fire protection function. Smoke/ heat vents are intended to facilitate interior manual fire fighting operations. If seismic activity damages the water supply, interior manual fire fighting operations cannot be conducted.

> Damage to the municipal water supply piping occurs where cast iron mains are still in use (*e.g.*, the Marina District in San Francisco in the Loma Prieta quake in 1989).

Based upon the fire record after seismic activity in California, fires typically occur in manufactured housing (mobile homes) after the breaking of gas supply lines. Damage to the municipal water supply piping occurs where cast iron mains are still in use (*e.g.*, the Marina District in San Francisco in the Loma Prieta quake in 1989).

Where multiple fires occur in manufactured housing, or where water distribution lines are damaged, the available water supply for fire fighting will either be reduced or, perhaps, be non-existent. In either case, controlling fires in buildings which are 500 thousand to a million square feet in floor area will likely be impractical-actually impossible. Since these building are typically surrounded by open spaces which are 60 feet or more in width, there will be little likelihood of fire spreading to an adjacent building, hence, it would seem that it would be more logical for fire fighters to concentrate their efforts on residential areas in event of seismic activity, particularly mobile home parks.

Also, with respect to seismic activity, if the overhead sprinkler supply piping is damaged and the system is no longer functional, the building becomes an unsprinklered building. In this case, the recommendations against interior manual fire fighting operations contained in NIOSH 2005-132 and NIOSH 2010-153 would be applicable. The installation of smoke/heat vents in buildings provided with sprinkler protection as a "backup" in the event of sprinkler system failure contemplates that the recommendations contained in NIOSH 2005-132 and NIOSH 2010-153 will be ignored by the responding fire fighting personnel.

The recommendations contained in these two NIOSH documents have, more or less, become the standard for fire fighting practices throughout the United States. The loss of fire fighters in purely property protection operations should never be acceptable.

"*This option was considered to be an appropriate mitigation measure for firefighting operations in these large buildings. The sprinkler operation is more critical than the smoke/heat vent operation. Criteria would need to be included to restrict the vent operation from impacting the sprinkler operation.*" (Page 20)

The loss of fire fighters in purely property protection operations should never be acceptable.

Commentary: Provisions which explicitly address the use of smoke/heat vent systems are now included in the 2010 edition of NFPA 13. Once again, the substantiation for the proposal for these provisions reads as follows:

"*The intent of the* [NFPA 13] *standard is that roof vents and draft curtains should not be used in conjunction with storage protection.*" 13-325 Log #CP43 AUT-SSD

Further, the documentation for the provisions addressing the installation smoke/heat vents in buildings protected by a sprinkler system contains the following comment by one of the members of the NFPA 13 subcommittee which developed the vent provisions:

"*The intent of the* [NFPA 13] *standard is that roof vents and draft curtains should not be used in conjunction with storage protection.*" 13-325 Log #CP43 AUT-SSD

"**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.*

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. References to control mode sprinklers in other building standards pertain to standard spray sprinklers that were not specifically tested by the laboratories for storage applications. 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. 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.*"

"**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.*"

"*One of the most dangerous aspects of firefighting operations is working on the roof of a building when the fire is just below. Although it is frequently and routinely done, there are many dangers when working on the roof of a building which is burning. But ventilating the building, or exhausting the smoke, is a critical function. Releasing the smoke and heat from a building allows the firefighters to make entry and attack the fire in a safer environment. Releasing the smoke reduces property loss as a result of smoke damage during the fire.*" (Page 24)

Commentary: The recommendations contained in NIOSH 2005-132 and NIOSH 2010-153 specifically pertain to sending ladder companies to the roof to open smoke/heat vents which have not opened automatically, as well as to the use of interior manual fire fighting operations.

The statement "*that releasing smoke reduces property loss as a result of smoke damage during a fire*" has never actually been documented in any research studies. If this were actually the case, it would seem logical that property insurers would mandate the installation of smoke/heat vent systems in large industrial and storage buildings. If fact, no property insurance companies require that smoke/heat vents systems be provided in industrial and storage buildings protected by a sprinkler system.

The statement regarding smoke damage above can only be considered to be an "*old wives*" tale, particularly in light of the research conducted at Underwriters Laboratories in 1997/1998 and the provisions addressing the use of smoke/heat vents in buildings protected by a sprinkler system now included in the 2010 edition of NFPA 13. If automatic smoke/heat vents are unlikely to open in buildings protected by a sprinkler system, it would be difficult to argue that providing smoke/heat vents in sprinklered buildings will have any impact on smoke damage in a building.

If automatic smoke/heat vents are unlikely to open in buildings protected by a sprinkler system, it would be difficult to argue that providing smoke/heat vents in sprinklered buildings will have any impact on smoke damage in a building.

It seems clear that the installation of smoke/heat vents in the roof of the bulk merchandising store in Tempe, Arizona, where a fire occurred on March 19, 1998, did not reduce smoke damage to the building and contents. When the Phoenix Fire Department arrived at the scene, the visibility at the floor of the building was zero (0). The smoke damage which occurred in this building had already occurred prior to the arrival of the fire department at the building.

In order to substantially reduce property damage caused by smoke, automatic smoke/heat vents must open early in the fire. The provisions addressing the installation of smoke/heat vents in buildings protected by a sprinkler system included in the 2010 edition of NFPA 13 are specifically intended to prevent the opening of smoke/heat vents early in the fire.

Any claims that smoke/heat vents reduce property damage caused by smoke are merely theoretical and need to be re-examined in light of the new smoke/heat vent provisions contained in NFPA 13.

"*If the building is a Group F-1 or S-1 occupancy with an exit access travel distance in excess of 250 feet, smoke/heat vents will be installed in all cases even when ESFR sprinklers are installed.*" (Page 24)

"*As was mentioned previously, there is a concern with smoke/heat vents impacting the operation of ESFR sprinklers. To address this situation, revisions are also proposed to CFC/CBC Section 910.3.2.2 (Part 4) and Section 12.1.1.2 of NFPA 13 (Part 6).*" (Page 25)

"*Therefore, smoke/heat vents are required to be installed, and must be equipped with a fusible link that is above the sprinkler operating temperature. This will ensure that the sprinklers operate prior to the smoke/heat vent. It might also result in smoke/heat vents that do not open on their own during a fire situation. However, California is susceptible to earthquake activity. During a seismic event, the water system could be incapacitated. In that case, the sprinklers will be inoperative, but the smoke/heat vents will operate automatically.*" (Pages 25 and 26)

Commentary: The logic used in the above statement is flawed. If the water system serving a building is incapacitated and a fire occurs, then smoke /heat vents perform absolutely no function. Smoke/heat vents are (theoretically) intended to assist manual interior fire fighting operations. Without a water supply at the fire scene, other than the water supply carried on fire department apparatus, manual interior fire fighting operations are not feasible.

Without a water supply at the fire scene, other than the water supply carried on fire department apparatus, manual interior fire fighting operations are not feasible.

Once again, the fire at the Sofa Super Store which occurred in Charleston, South Carolina on June 18, 2007 clearly illustrates the risk of interior manual fire fighting operations without a sufficient water supply being established prior to entering a building.

"*This part adds amendments to NFPA 13. These revisions specifically address the temperature rating of the thermal element of smoke/heat vents when utilized with ESFR sprinkler systems. The 360ºF rating comes from the requirements in the FM 4430 Standard, and the 100ºF requirement simply provides a specific separation between the thermal element of the sprinkler and the thermal element of the smoke/heat vent.*" (Page 26)

"*Task Group 400 (Client) engaged Aon FPE* [formerly Schirmer Engineering Corporation] *to perform fire modeling analysis of a fire incident in a typical large, high ceiling, control-mode sprinkler system equipped warehouse building in order to perform this analysis.*" (Page 1, Aon FPE Report)

"*The analysis incorporates current code requirements for these facilities, as well as compares the calculated occupant egress time in relation to the tenability of the space.*" (Page 2, Aon FPE Report)

"*Although it is known that exposed, expanded plastics are more challenging to control/ extinguish by sprinkler operation, modern day computer programs cannot account for this factor, including the difference in smoke production rates. Thus the heat release rate of cartoned, expanded plastics was used in the modeling evaluation.*" (Page 2, Aon FPE Report)

Once again, the fire at the Sofa Super Store which occurred in Charleston, South Carolina on June 18, 2007 clearly illustrates the risk of interior manual fire fighting operations without a sufficient water supply being established prior to entering a building.

"*It takes over 10 minutes before the smoke begins to descend from the ceiling.*" (Page 2, Aon FPE Report)

Commentary: This statement is made based upon an analysis which does not include smoke/heat vents.

It should also be noted that this statement is made based upon an analysis of a building size which is not permitted by the International Fire Code.

"*Therefore, this fire model shows that a 400 foot exit travel distance will not provide untenable conditions for the occupants in typical large, high ceiling, control-mode sprinkler system equipped warehouse buildings.*" (Page 3, Aon FPE Report)

Commentary: Once, again, this statement is made based upon an analysis which does not include smoke/heat vents.

It should also be noted that this statement is made based upon an analysis of a building size which is not permitted by the International Fire Code.

"*The building used for this analysis is considered representative of this type of large, high ceiling warehouse, and includes the following specifications: 680 feet wide, 1,460 feet long, and 24 feet to the underside of the roof deck at the perimeter, increasing to 30 feet to the underside of the roof deck at the ridge line.*" (Page 3, Aon FPE Report)

Commentary: The provisions contained in Note h to Table 2306.2 in the International Fire Code read as follows:

> "*High-piled storage areas shall not exceed 500,000 square feet. A 2-hour fire wall constructed in accordance with the International Building Code shall be used to divide high-piled storage exceeding 500,000 square feet in area.*"

The application of Note h is limited to buildings containing high-piled storage classified as a high hazard commodity. High-piled storage which consists of Group A plastics, not classified as either a Class III or Class IV commodity, is considered to be a high hazard commodity. Hence, Note h would be applicable to the building analyzed.

The building modeled in the report by Aon FPE is twice the size of that permitted by the International Fire Code.

"*The efficacy of smoke and heat vents has been the subject of an on-going debate at the National level. As a product of that debate, the 2006 IBC Section 1016.2 has been deleted in its entirety in the 2009 IBC effectively eliminating this 400-ft exit access travel distance. This deletion will also eliminate the 400-ft exit access travel distance in the 2010 CBC, which will be enforced as of January 1, 2011. The result of this code change is the elimination of a longstanding exit travel distance provision from the IBC and CBC.*" (Page 3, Aon FPE Report)

"*This analysis is not intended to take sides on the smoke and heat vent debate. . .*" (Page 3, Aon FPE Report)

Commentary: Schirmer Engineering Corporation has actively opposed the use of automatic smoke/heat vents in buildings protected by a sprinkler system since the mid-1970's until at least June 2010. The statement above does not reflect the 35+ year history of Schirmer Engineering Corporation's position on the use of smoke/ heat vents in sprinklered buildings prior to 2010.

The statement above does not reflect the 35+ year history of Schirmer Engineering Corporation's position on the use of smoke/heat vents in sprinklered buildings prior to 2010.

"*Control Mode Density Area (CMDA) sprinkler protection is the oldest and still most commonly used sprinkler technology for the protection of storage.*" (Page 4, Aon FPE Report)

"*The early suppression fast-response (ESFR) sprinkler technology is specifically designed for the high challenge storage occupancies. The ESFR technology is designed to operate earlier and provide an adequate flow of water to suppress the fire. CMDA sprinklers are designed to control the spread of fire. While the CMDA sprinklers may also extinguish a fire, a satisfactory result from CMDA is to just stop the continued spread of the fire. The CMDA sprinkler was chosen as the more conservative approach father than ESFR technology. If the control mode sprinkler design provides adequate results, the ESFR sprinkler design will provide for improved results.*" (Page 4, Aon FPE Report)

Commentary: The combination of standard sprinklers at the ceiling and in-rack sprinklers provided in storage racks is still the preferred method of providing sprinkler protection for rack storage of combustible goods from a fire protection standpoint. Providing in-rack sprinkler protection is a superior means of providing fire protection relative to the protection provided by ESFR sprinklers.

The "problem" with in-rack sprinkler protection is that care must be exercised in placing and removing pallets loads in the racks and that in-rack sprinklers are often damaged while placing pallet loads in the storage racks. The development of ESFR sprinklers was intended to eliminate the "problem" associated with the use of in-rack sprinklers.

The statement that "*if control mode sprinkler design provides adequate results, the ESFR design will provide for improved results*" only applies to a comparison between ceiling only designs with standard spray sprinklers and ESFR sprinklers. If in-rack sprinkler protection is provided to supplement ceiling protection with standard spray sprinklers, it is highly likely that the standard spray sprinkler system will out-perform an ESFR system (with far less water damage).

"*The analysis is based upon computational modeling utilizing the Fire Dynamic Simulator (FDS), Version 5.4.3 software produced by the National Institute of Standards and Technology (NIST). A computational model is a virtual representation of a physical object or space. Computational Fluid Dynamics (CFD) is the application of mathematical tools to study the dynamics of fluid flow within this virtual model.*" (Page 4, Aon FPE Report)

"*The type and form of the commodity are the most influential factors in determining the heat release rate of a storage fire. The heat content of the material, the burning rate, the exposed surface area, and how the commodity reacts to the application of water determine the protection requirements. Rack storage fires are generally more severe than solid-piled storage because of better air access and stability of the burning product. Storage height is a key determinant of heat release rate. As more material is exposed vertically, the burning rate increases with increasing storage height.*" (Page 5, Aon FPE Report)

Commentary: The statement above does not address the use of in-rack sprinkler protection. The installation of in-rack sprinkler protection to supplement the protection provided by ceiling sprinklers completely changes the fire expected in storage racks. Hence, the statement above only applies to sprinkler protection which consists of ceiling sprinklers only.

"*Plastics materials are manufactured as unexpanded and expanded. Generally, the heat release rate for expanded plastics is greater than for unexpanded plastics due mainly to the relatively low density and resulting high burning rate4. The heat of combustion for a given plastic material is about the same whether it is expanded or unexpanded4. Existing sprinkler design criteria to protect uncartoned expanded plastics commodities in open frame rack storage arrangements utilizing ceiling-level protection was researched. Recommendations to use control model* [mode] *sprinklers are provided in the latest FM Global Loss Prevention Data Sheet 8-9.*" (Page 5, Aon FPE Report)

"*An idealized fire model that is of considerable use is the t-square* [t^2] *fire. . . The growth time,* t_g*, is the interval between the time of effective ignition and the time when the heat release rate of the fire reaches 1,055 kW. For an ultrafast fire, the fire growth rate follows the t-square* [t^2] *fire curve and reaches 1,055 kW in 75 seconds or 10,000 KW in 231 seconds.*" (Page 6, Aon FPE Report)

"*The detailed fire growth and spread over these three-dimensional fuels is neither explicitly validated by the FDS software, nor is it essential for the evaluation of fire development in this project.*" (Page 7, Aon FPE Report)

"*Available full-scale test data for heat release rates of Group A plastics were gathered from the Factory Mutual Research Corporation (FMRC) Standard Plastic Commodity (polystyrene cups in compartmented cartons).*" (Page 7, Aon FPE Report)

"*Utilizing the stoichiometric coefficients polystyrene along with the yields of CO, soot, the following parameter were input in the combustion model:*

C = 8
H = 8
Soot Yield = 0.164
CO Yield = 0.06
Heat of Combustion = 41,960 kJ/kg"

(Page 7, Aon FPE Report)

"*The 150°F (65°C) temperature limit is a conservative value based on the effects of heat stroke, or hyperthermia.*" (Page 9, Aon FPE Report)

"*In the NFPA report, Operation School Burning (1959), a criteria of 150°F (65°C) is established, although it is recognized that a human can stand temperatures "considerably above" 150°F for short periods of time. A value of 150°F has been chosen for this analysis to add a factor of safety.*" (Page 9, Aon FPE Report)

"*In the NFPA report, Operation School Burning (1959), a criteria of 150°F (65°C) is established, although it is recognized that a human can stand temperatures "considerably above" 150°F for short periods of time.*"

"*Smoke is tracked along with all other major products of combustion and is used to determine visibility.*" (Page 9, Aon FPE Report)

"*For these simulations, 30-foot visibility at and below 6 feet above the highest walking surface is deemed appropriate for providing occupants a means to move away from the fire.*" (Page 10, Aon FPE Report)

"*The fire in the simulation is allowed to burn for twenty (20) minutes (1,200 seconds). This time interval allows the tenability in the space to reach a steady state. In an actual fire scenario, the fire would have decayed significantly. Therefore, the twenty-minute simulation provides a conservative analysis of tenability in the space.*" (Page 14, Aon FPE Report)

"*Additional sprinkler activation was simulated by locating the fire on the center of thirty six (36) sprinklers spaced at 10-ft x 10-ft apart. The objective was to determine the time and heat release rate at which the first four (4) sprinklers activate.*" (Page 14, Aon FPE Report)

Commentary: The report does not provide an explanation for why it was assumed that the heat release rate was assumed to be constant after the activation of only 4 sprinklers. Testing conducted on the interaction between sprinklers and smoke/heat vents conducted at Underwriters Laboratories in 1997/1998 indicated that often times more than 4 standard spray sprinklers activated. While the activation of the first sprinklers may initially "knock down" the fire, the fire may still continue to spread within the racks. Hence, the assumption that the heat release rate from the fire will be constant after the activation of only 4 sprinklers may not necessarily be correct.

"*A model is really an idealized version of a physical system too complex to analyze easily in full without simplification.*" (Page 15, Aon FPE Report)

"*The software, which was created by the National Institute of Standards and Technology (NIST) was designed to model fire-driven fluid flow and has been validated for a number of fire protection engineering applications in the built environment.*" (Page 15, Aon FPE Report)

Commentary: The statement above does not constitute a "validation" of the use of the Fire Dynamics Simulator model for the purposes utilized in this analysis.

The Society of Fire Protection Engineers (SFPE) has published a draft document titled "*Guidelines for Substantiating a Fire Model for a Given Application*" dated September 2009. This document was released on December 9, 2009. Excerpts from this document include the following:

The Society of Fire Protection Engineers (SFPE) has published a draft document titled "*Guidelines for Substantiating a Fire Model for a Given Application*" dated September 2009.

> "*Currently, fire models and their use is an evolving process, and with a few exceptions, there is no formal process by which fire models are approved. It is therefore incumbent upon the user of the fire model to determine the suitability of a fire model and, if required, upon the authority having jurisdiction to evaluate the acceptability of that determination. This guide serves both the user of the fire model and the consumer of the results of the fire modeling.*" (Page 7)

> "*The appropriate level of knowledge is required to prevent users from treating a fire model as a black-box tool, which can result in using a fire model beyond the scope of its capability.*" (Page 11)

> "*Regardless of which model is chosen to perform the analysis, consideration should be given to verification and validation of the model, as is discussed in Chapter 5.*" (Page 17)

> "*Care should be taken to ensure that a model is chosen for its appropriateness for a given problem and its ability to deliver results within a specified range of accuracy.*" (Page 20)

> "*Prior to selecting a model for a particular problem, the model user needs to determine if the model is capable of generating a useful result.*" (Page 21)

"*The appropriate level of knowledge is required to prevent users from treating a fire model as a black-box tool, which can result in using a fire model beyond the scope of its capability.*"

"*Typically, model validation involves a large amount of data, both model predictions and experimental measurements, and it can be difficult to succinctly display the results of the study.*"

"*Validation is a check of the physics–are the equations an appropriate description of the fire scenario? Most often, validation takes the form of comparisons with experimental test data. Validation does not mean that a model makes perfect predictions, only that the predictions are good enough for its intended use. The meaning of "good enough" is up to the model user, and to say a model has been validated only means that an end user has decided that the model is sufficiently accurate for a particular application. Thus, the existence of prior validation work does not always mean that a model is good enough for a new application.*" (Page 24)

"*Typically, model validation involves a large amount of data, both model predictions and experimental measurements, and it can be difficult to succinctly display the results of the study.*" (Page 26)

"*Input data, often based on assumed values or experimental data, is subject to many sources of uncertainty, including uncertainty in theory (for deriving the parameter) and measurement. Such uncertainty in input imposes a limit on the confidence in model output.*" (Page 32)

"*A mathematical model is defined by a series of equations, input factors, parameters, and variables aimed to characterize a process under investigation. Most mathematical problems are too complex for an easy appreciation of the relationship between input and output. Nevertheless, understanding how a model behaves in response to changes in its inputs is of fundamental importance to ensure a correct use of the model.*" (Page 32)

"*The value of the safety factor or safety margin is related to the lack of confidence in the design process. Selection of an appropriate safety factor or margin depends on the predictive capability and accuracy of a given model or analysis technique. Appropriate safety factors/ margins may, but not always, be derived from references on model validation and verification. Sometimes, bounding exercises (discussed in more detail below), used to determine outcomes given the most challenging input, can be useful in determining whether a selected safety factor/margin is appropriate or adequate.*" (Page 33)

"*Documenting the process recommended by this Guide is an important component of the fire model substantiation analysis. A documentation report should serve as the primary reference for demonstrating the validity and applicability of the subject analysis.*"

"*As part of the process of substantiating the appropriateness of a model in a particular application, the results of the uncertainty analysis should be documented to demonstrate that the model predictions are within the intended and reasonable range of accuracy, by taking into account the uncertainties in the relevant or important input parameters.*" (Page 38)

"*Documenting the process recommended by this Guide is an important component of the fire model substantiation analysis. A documentation report should serve as the primary reference for demonstrating the validity and applicability of the subject analysis.*" (Page 39)

Aon FPE's report does not incorporate the recommendations contained in the draft SFPE guidelines on the use of fire models.

Aon FPE's report does not incorporate the recommendations contained in the draft SFPE guidelines on the use of fire models.

"*The accuracy with which FDS predicts temperatures and heat release rates has been validated with large-scale tests. Testing has shown that FDS temperature predictions were within 15% of the measured temperatures, and heat release rates were within 20% of measured values. The overall accuracy of models (i.e. duplicative of real world results) is within + or – 30%.*" (Page 15, Aon FPE Report)

Commentary: The data on which these statements are based has not been included in Aon FPE's report.

"*Full-scale test show that the heat release rate decreases after the first sprinkler activation. As a conservative design, the activation of the four (4) sprinklers was simulated to control the fire. After the fourth sprinkler, the heat release rate was assumed to remain constant.*" (Page 15, Aon FPE Report)

Commentary: The data on which this statement is based has not been included in Aon FPE's report.

"*The temperature away from the immediate vicinity of the fire stays near room temperature.*" (Page 19, Aon FPE Report)

"*As the smoke accumulates on the far ends of the building, the visibility decreases. However, the concentration is maintained above critical level, thus allowing occupants clear view of exit signs.*" (Page 20, Aon FPE Report)

"*Carbon monoxide and carbon dioxide concentrations were also measured at 6-ft above the finished floor. As noted on the Tenability Criteria Section, the critical CO concentration of 754 ppm and CO_2 concentration of 10,000 ppm were measured.*" (Page 21, Aon FPE Report)

"*Smoke builds up at the perimeter of the building. Figure No. 20 shows smoke after 15 minutes at an elevation of 6-ft above the finished floor.*" (Page 23, Aon FPE Report)

"*The temperature away from the immediate vicinity of the fire stays near room temperature. As hot gases propagate and accumulate at the perimeter of the building, the temperature at 6-ft does not exceed 21°C (70°F).*" (Page 23, Aon FPE Report)

"*Soot concentration was measured as the smoke accumulates and descends from the ceiling to obscure visibility. Figure No. 22 shows visibility is maintained at 30 m (100-ft) for 10 minutes.*" (Page 24, Aon FPE Report)

"*An average concentration CO of 1,500 ppm was measured at the worst-case location. Refer to Figure No. 26 for CO concentration. As noted on the Tenability Criteria Section, CO concentration of 4,000 ppm is lethal to occupants. The average concentration of 4% (40,000 ppm) was measured for* CO_2*.*" (Page 26, Aon FPE Report)

"*At the CO concentration of 1,500 ppm concentration, the* CO_2 *concentration is not a credible threat to life.*" (Page 26, Aon FPE Report)

"*Exposure to toxic gases is a complex issue that may be reasonably approached with a focus on the combined effects of exposure to carbon monoxide, carbon dioxide and decreased levels of oxygen. The intake of carbon monoxide is hazardous due to the generation of carboxyhemoglobin in the blood stream of the exposed persons. This hazard may be magnified by the presence of increased levels of* CO_2 *and decreased* O_2*, which promote more rapid breathing (as well as decreased pH levels in blood) and therefore an increased rate of uptake of toxins.*" (Page 28, Aon FPE Report)

"*Furthermore, sprinkler activation is expected to control the fire. The fire model scenario assumes the fourth sprinkler activates at 4 minutes and 1 second. As a conservative approach, a sprinkler-controlled fire was assumed to keep the fire at 10 MW for the duration of the simulation (20 min). Tenable conditions away from the vicinity of the fire are maintained at 6-ft above the finished floor.*" (Page 29, Aon FPE Report)

The data on which this assumption is based has not been included in Aon FPE's report.

Commentary: The data on which this assumption is based has not been included in Aon FPE's report.

"*Time-based egress analyses can be utilized to determine the evacuation time of an individual from a building during a fire event. The evacuation time includes three (3) main components; the amount of time from ignition of the fire until notification, the delay time between hearing the fire alarm and beginning to evacuate the building, and the amount of time it takes that individual to reach an exit or other safe location.*" (Page 29, Aon FPE Report)

"*The time until notification is the amount of time it takes from ignition of the fire until the fire alarm activates. Based on the results of the full-scale fire testing, the device activation is (232 seconds) 3 minutes, 52 seconds. The activation time used in this analysis assumed a more conservative activation time of (241 seconds) 4 minutes and 1 second, which is the activation of the fourth sprinkler.*" (Page 29, Aon FPE Report)

Commentary: The text above makes reference to "*full-scale fire testing*", however, no "*full-scale fire testing*" is mentioned in the report. To what "*full-scale fire testing*" is the report referring?

The text states that it has been assumed that the fire alarm system will be activated at 4 minutes and 1 second. Typically, there is a delay in the activation of an alarm in a wet pipe sprinkler system with a water flow indicator This delay in activation of an alarm is typically between 30 and 60 seconds. The purpose of the delay is to avoid false alarm from "surges" which may occur in the system.

The report assumes that a fire alarm system is provided in the building. It should be noted that the 2009 edition of the International Building Code does not require that a fire alarm system be provided in a moderate hazard (S-1) storage occupancy. Given that the IBC does not require that a fire alarm system be provided for an S-1 storage occupancy, further explanation as to how the activation time of the water flow alarm in the sprinkler system is relevant.

It should be noted that the 2009 edition of the International Building Code does not require that a fire alarm system be provided in a moderate hazard (S-1) storage occupancy.

"*The average walking speed of an able-bodied adult walking alone is 3.74 feet per second* [224.4 feet per minute; 2.55 miles per hour]*. This is a conservative estimate as people tend to run rather than walk during an emergency.*" (Page 30, Aon FPE Report)

Commentary: It should be noted that the walking speed assumed is for able-bodied adults and that no factor of safety has been applied.

It should also be noted that Rick Thornberry, representing the Smoke Vent Task Group, has challenged the use of this data in ICC code development hearings.

"*The intent of this analysis is to predict whether a 400 foot exit travel distance will provide safe conditions for occupant or emergency responder egress during a fire event. A computer model of the entire building, utilizing the computational fluid dynamics (CFD) software known as Fire Dynamics Simulator (FDS), was utilized to predict tenable conditions throughout the entire space.*" (Page 30, Aon FPE Report)

"*Tenable conditions, i.e. safe temperatures, ample visibility, and the absence of unsafe toxic gasses, are maintained at 6 feet above the finished floor throughout the facility for the entire duration of the model (20 minutes).*" (Page 31, Aon FPE Report)

Part 2 of this article will provide further analysis of the above.

* * * * *