

# FIRE PROTECTION Engineering

4<sup>TH</sup> QUARTER 2014

Issue No. 64



## ROUNDTABLE OF FIRE PROTECTION ENGINEERS WHO WORK IN THE FIRE SERVICE

### Preplanning

Fire Modeling for the Fire Research,  
Fire Protection, and Fire Service Communities

Effectiveness and Reliability of  
Fire Protection Systems

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For information on article submission to *Fire Protection Engineering*, go to [magazine.sfpe.org](http://magazine.sfpe.org).

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ON THE COVER: Eugene, Oregon, USA – November 3, 2011: Various fire departments from Eugene, Lane County, and other nearby emergency services.



From the **TECHNICAL DIRECTOR**

## So Long

**F**ire Protection Engineering magazine was first published in 1998. The first issue was simply called the “premier issue” because we were not yet ready to commit to a regular publication schedule. The second issue was published in spring, 1999, and the magazine has been a quarterly ever since.

The magazine was launched in response to widespread dissatisfaction among SFPE members with SFPE’s periodicals. During a series of regional meetings that were conducted in 1997 and 1998 to gauge member satisfaction, a common refrain was that SFPE published two periodicals (the *Bulletin* and the *Journal of Fire Protection Engineering*), and most members read neither of them.

Members were hungry for a publication that provided information that they could use in their day-to-day work. The SFPE board of directors decided to launch a magazine, with a goal of simply breaking even financially. The magazine would contain practice-oriented articles and provide information that fire protection engineers could use in their daily practice. To avoid creating another *Bulletin*, the magazine would avoid “member news”; instead this type of information would be published in a separate newsletter.

SFPE’s executive director at the time, Kathleen Almand, handled matters associated with publishing the magazine. Having recently been hired as the technical director, the content was delegated to me. An editorial advisory board was created to identify editorial themes, potential articles and authors, and review the articles prior to publication. We hired a freelancer, Bob James, to handle matters that were outside of our skill sets.

I was assigned the role of “Technical Editor” for the new magazine. As a relatively young fire protection engineer, I knew nothing about being the editor for a magazine. I simply decided to publish articles that I would like to read – a principle that has guided me for the last 17 years. Having previously written articles for other magazines, I was upset when an editor badgered me for graphics to include with an article that I had written. So, another guiding principle was that I would never shake-down an author for images. We would use images that were voluntarily provided, and if we felt additional graphics were needed, we would find them on our own.

Following the first year of publication, we partnered with Penton Media. When we launched the magazine, we didn’t think that we could afford a turnkey publisher like Penton, but we were pleasantly surprised by their offer when we approached them. In addition to handling publication of the print magazine, Penton has always ensured that the magazine reflected the state of the art in publishing and presentation. They proposed a website where the magazine’s content would be archived, and they proposed deploying articles exclusively online to generate traffic to the website. More recently, Penton has assisted us with creating a jobs board and sponsored webinar program.

While we outsourced publishing duties, we have always maintained strict editorial control. *Fire Protection Engineering* magazine quickly developed a loyal following, and we were unwilling to do anything that could damage that. I continued as the Technical Editor and, while some names have changed, the Editorial Advisory Board remained in place.

An artifact of the loyal readership of *Fire Protection Engineering* magazine was that we became popular with advertisers. Advertisers wanted to reach our readers, and they found that our magazine was a very efficient way to get their messages in front of people who influence buying decisions of their products. We quickly surpassed the SFPE board of director’s goal of breaking even, and the magazine and ancillary products now serve as a reliable source of non-dues revenue for the association.

This will be my last issue as the technical editor. I have no doubt that the magazine will continue to be a valuable resource for readers and advertisers alike.

**Morgan J. Hurley, P.E., FSFPE**  
Technical Director  
Society of Fire Protection Engineers

*Fire Protection Engineering* welcomes letters to the editor. Please send correspondence to [engineering@sfpe.org](mailto:engineering@sfpe.org) or by mail to *Fire Protection Engineering*, 7315 Wisconsin Ave., Ste. 620E, Bethesda, MD 20814.

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**By Chief George Healy**

The Fire Department of the City of New York (FDNY) has a long history of working with fire protection engineers, one that has ramped up significantly in the past decade and paid great dividends in improving the health and safety of our members.

In the early part of 2006, the FDNY experienced several challenging fires in high rise fireproof residential buildings. These fires were similar to several incidents that, in the past, had claimed the lives of firefighters and civilians. One fire in particular nearly claimed the lives of several firefighters, and multiple members went to the hospital with burns.

This fire occurred in a building that 10 years earlier was the scene of a line of duty death of a member from the FDNY. With this near miss incident, interest was renewed in developing tactics that would better protect both firefighters and civilians. In this effort, the FDNY requested the assistance of the National Institute of Standards and Technology (NIST). This request was answered by Dan Madrzykowski and Steve Kerber, fire protection engineers in the Firefighting Technology Group of NIST.

Fortunately, NIST was in the process of planning a series of tests for the spring of 2006 with the Toledo Fire Department; the focus of these tests was using positive pressure fans for stairwell pressurization and smoke control in high rise buildings. The concept was for a fire department to deploy portable fans to pressurize stairwells in high-rise buildings, allowing the fire units to limit smoke contamination of the stairwells and upper floors. A question that lingered was whether the portable fans would still be effective with increased pressures from actual fires. NIST validated the results from Toledo in December of 2006 in a series of live burns in a 17-story high-rise building in Chicago.

The fire service now began to request that the fire protection engineers study other tactics that possibly could provide an additional level of safety for firefighters and make for a more efficient operation. Of particular interest was the need for better understanding the effects that wind had on fire dynamics in high-rise buildings due to FDNY's past experience with the negative effects that wind had on these fires.

With this newly formed partnership proving so valuable, the FDNY was able to secure a high-rise on Governors Island

to test alternate strategies to combat wind driven fires. With the support of NIST and funding through the Department of Homeland Security and the Assistance to Firefighters grants, testing was conducted in February of 2008.

New tools such as wind control devices, high-rise nozzles and PPV fans were tested for their usefulness and ability to control these fires. A wealth of knowledge was gained through this testing, and the FDNY changed its tactics, trained and equipped line units and is better prepared today to fight fires in high-rise buildings. In the last several years, the FDNY has utilized these tactics in at least 20 serious high-rise fires with very positive results and has not experienced any serious firefighter injuries at these incidents.

This history that I have discussed is just the tip of the iceberg. The testing continues today with NIST and Underwriters Laboratories' Firefighter Safety Research Institute. The importance of the partnership between the fire service and fire protection engineers cannot be overstated. The fire service today has knowledge of fire dynamics like never before. Testing allows the fire service to validate tactics and make changes to better provide safety. Changes in the fire service today are not based purely on personal observation and judgment; they are based on the testing that proves and validates their effectiveness.

Since the start of this partnership, the FDNY can show a reduction of traumatic injuries to its members from changing fire conditions. The fire ground is constantly evolving with changes to building construction and fuels that fill our homes. The fire service will continue to benefit from this ability to see how these changes influence the fire and how we can deploy tactics and resources to combat the modern fire.

The fire service community owes a debt of gratitude to the dedication and support of fire protection engineers like Dan Madrzykowski and Steve Kerber. There continues to be requests from the fire service for better understanding of fire and means to control it; in the future, additional testing will further enhance our safety and effectiveness.

*Chief George Healy is with the New York City Fire Department.*

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## DiNenno Prize to Recognize Contributions to Fire Safety

In honor of the late Philip J. DiNenno, the National Fire Protection Association (NFPA) and Hughes Associates have established the DiNenno Prize.

In addition to honoring his memory, the DiNenno Prize will encourage and recognize significant technical developments that have an impact on public safety, including building, fire, and electrical safety. A prize committee will consider nominations submitted from around the world.

"Phil will be remembered as one of the most outstanding leaders that NFPA has ever had," said NFPA President Jim Shannon. "He was an extraordinarily effective advocate for fire safety and the most respected person in fire protection engineering of his generation. NFPA is honored to join with Hughes Associates to establish the DiNenno Prize."

DiNenno served in many leadership roles in the Society of Fire Protection Engineering (SFPE), including president, and was awarded the Guise Medal, SFPE's highest honor. He was the founding editor of the SFPE Fire Protection Engineering Handbook and provided leadership to NFPA within technical committees, as chair of the Standards Council, and as a member of the Board of Directors. He was a pioneer in the use of computer fire modeling and played a significant role in the development of non-ozone depleting fire suppression technologies, working with industry, NFPA, U.S. EPA, the World Bank, and the United Nations.

For more information, go to [www.nfpa.org/dinenno](http://www.nfpa.org/dinenno)

## New Public Service Announcements Promote Campus Fire Safety

Through a new initiative sponsored by FM Global, students from the University of Maryland's Department of Fire Protection (FPE) have produced and made available a series of public service announcement (PSA) videos to educate students about fire safety in residential living environments. The videos contain student interviews and narratives. The format is designed to engage students in thinking about the problem and educate them about common misconceptions.

The three PSAs, covering fire prevention, fire response, and fire technology, are available for use on any campus free of charge. To distribute, visit FPE's YouTube channel, choose a video, and click "share."

For more information, go to [www.fpe.umd.edu](http://www.fpe.umd.edu)



The SFPE Corporate 100 Partner Program was founded in 1976 to strengthen the relationship between industry and the fire protection engineering community. Membership in the Corporate 100 Partner Program recognizes those who support the objectives of SFPE and have a genuine concern for the safety of life and property from fire.

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ROUNDTABLE OF  
**FIRE PROTECTION  
ENGINEERS**

WHO WORK  
IN THE FIRE  
SERVICE

Facilitated by Gavin Horn, Ph.D.



**T**he fire protection engineering profession has been closely linked with the uniformed fire service from its very inception. The mutually supportive and beneficial relationship has led fire departments around the world to hire and directly incorporate fire protection engineers (FPEs) into their staff to support the department's mission.

These broad ranging duties have included providing a critical link between the fire departments and authorities having jurisdiction (AHJs), reviewing and evaluating plans, conducting inspections, leading post-fire investigations, and supporting public education needs.

FPEs are also critical resources for firefighters by providing scientific insight into standard operating procedures (SOPs), incident debriefs or tactic/strategy discussions and training.

As fire service budgets become tighter, the broad expertise provided by FPEs can help the department provide a comprehensive life safety strategy for their jurisdiction, potentially opening new business and funding opportunities.

The SFPE Fire Service Committee is committed to working with fire departments and fire protection engineers to promote their mutually supportive missions by providing information exchange and data sharing. For more information on this initiative, please see [www.sfpe.org](http://www.sfpe.org).

The Society of Fire Protection Engineers conducted a "roundtable" discussion with FPEs that work with fire departments around the globe, including a broad cross section of departments, varying in size and complexity, with FPEs working in one-person teams to departments that have 10 or more FPEs on staff. The purpose of the roundtable was to provide a glimpse into the lives and activities of FPEs within the fire service, the opportunities and challenges that they face, and their vision of the future.

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The participants in the roundtable include:

- Gavin Horn, Ph.D., Facilitator, Illinois Fire Service Institute
- Scott Adams – Park City (UT), USA
- Peter Arnevall – Uppsala, Sweden
- John Bryan – Baltimore County (MD), USA
- Tony Caro – Denver (CO), USA
- Ed Claridge – New Zealand
- Andrew Milliken – Stafford County (VA), USA

For additional content, please visit [magazine.sfpe.org](http://magazine.sfpe.org).

**Horn: Please describe your fire department.**

**Adams:** The Park City Fire Service District (PCFSD) is located approximately 50 km east of metropolitan Salt Lake City, Utah. The PCFSD serves an area of 280 square kilometers consisting of residential, commercial, and wildland zones. The PCFSD employs 79 full-time and 2 part-time firefighter/EMTs and 11 administrative personnel. It also employs and manages a paid-call ambulance transport service of 21 personnel for a neighboring 1,300 square kilometer rural community known as North Summit.

**Arnevall:** Uppsala Fire Department is responsible for rescue

services and prevention work in the Uppsala, Östhammar and Tierp municipalities. We have 5 full time fire stations and 12 part time stations, with a total of about 130 full time employees and 350 volunteer firefighters.

**Bryan:** The Baltimore County Fire Department covers an area of 1,600 square kilometers and serves more than 800,000 citizens, with 25 career stations and over 1,000 paid personnel. In addition, the community is served by 33 fully volunteer fire companies with over 2,000 volunteer fire fighters/EMS personnel. These personnel respond to over 114,000 incidents annually. The response area is very diverse, including heavy and light industrial, urban areas, small towns, suburban neighborhoods and farmland.

**Caro:** We comprise a medium sized department with 970 members staffing 35 fire stations. The fire prevention division conducts all fire code related functions and is comprised of approximately 50 personnel structured into five primary sections as follows: engineering, operational, administrative, hi rise, institutions and hazmat. All division personnel come from within the ranks, with the exception of the FPEs and administrative assistants.

**Claridge:** The New Zealand Fire Service (NZFS) is New Zealand's national fire service. It was established under the Fire Service Act in 1975 and has jurisdiction over the entire country. The NZFS is predominantly an urban fire and rescue service with responsibility for firefighting in urban fire districts. The NZFS comprises of approximately 1,700 professional career firefighters, 8,300 volunteer firefighters 450 support staff and 80 communication center staff. It is spread geographically throughout the whole of New Zealand, divided into five fire regions with 450 fire stations.

**Milliken:** The Stafford County Fire and Rescue Department is a team of 350 career and volunteer personnel providing all-hazard emergency services to nearly 135,000 residents within a 717 square kilometer area. Stafford County is one of the fastest growing communities in Virginia and the Washington, D.C. metro area.

**Horn: Describe the history of FPEs within your fire department.**

**Bryan:** Martin J. Hanna, P.E., was the first fire protection engineer hired by the Baltimore County Fire Department in the early 1970s. Jay was a former Washington D.C.



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— ADAMS

firefighter who attended and graduated from the U. of Md. school of fire protection engineering. Ted Tochterman was hired in September 1974 to replace Jay Hanna. In July 1978, Baltimore County added a second fire protection engineer, which was myself. Currently Baltimore County has a chief fire

protection engineer and two other fire protection engineer positions.

**Arnevall:** Fire protection engineers have been a part of the organization since the 1960s. Back in the early days, the FPE program was a two year government funded program. Since the “new” FPE program started at Lund University in 1986, Uppsala Fire Department has had 7-16 FPEs employed full time, from both the “old” and the “new” program.

**Adams:** When Salt Lake City received the 2002 Olympic Winter bid, major changes were headed for the Park City area. This would include the addition of high-rise hotels, temporary structures for spectators and Olympic venues, in addition to meeting the major changes that would take place in the Park City community as they hosted the world. It was decided at that time to recruit and hire an FPE to address the challenges and assist with the master planning for the fire protection and life safety needs for the public and district.

**Claridge:** Dr Paula Beever was appointed the principal fire engineer for the NZFS in 1998, eventually providing leadership to a team of 12 fire engineers located around the country. The establishment of a national fire engineering unit

occurred in 2005, which included the NZFS design review unit (DRU). The DRU is one specific function of the engineering unit and was established in response to the 2004 Building Act, which required alternative and performance-based fire engineering designs to be submitted to the NZFS for review.

**Caro:** The department hired its first FPE in the mid 1980s (an Illinois Institute of Technology graduate). Since that time, the department has evolved, and it currently has six FPE positions, with two being from an FPE background, one electrical engineer and three structural/civil engineers.

**Milliken:** Fire protection engineering was incorporated into the department’s life safety branch in 2007 in response to the rapid growth within the community as well as the need to be more proactively involved in fire protection systems and community development services.

**Horn: What role do FPEs currently fill within your fire department?**

**Milliken:** As a relatively small agency in a rapidly growing community, my role as the fire protection engineer is integrated into the department’s fire marshal’s office. I am one of five multi-discipline deputy fire marshals who are responsible for a wide variety of life safety, fire protection, hazardous materials and investigative services.

As the engineering expert to the chief deputy fire marshal and county fire chief, my role within the department’s command staff provides a strong and consistent voice in the community’s growth process. I also provide rapid, on scene access to technical expertise regarding a wide variety of hazards within the new and existing built environment.

This technical expertise extends not only to the divisions within the fire

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“ THE FIRE PROTECTION ENGINEER ROLES ARE PRIMARILY PLAN REVIEW FOR FIRE AND BUILDING CODE COMPLIANCE AS WELL AS REVIEW OF AUTOMATIC SPRINKLER SYSTEM PERMITS. — BRYAN ”

fire incidents, and undertaking research. NZFS FPEs also take a proactive role in influencing changes to standards and legislation in New Zealand.

**Bryan:** The fire protection engineer roles are primarily plan review for fire and building code compliance as well as review of automatic sprinkler system permits. Other functions include assisting fire marshals with difficult code or technical problems, code training and meeting with design professionals. The chief fire protection engineer assists in writing the state and county fire prevention codes, building code adopting ordinances, and updating

**Arnevall:** Generally in Sweden, the FPEs within fire departments work on a wide range of tasks. So, we have a wide range of roles, including head of the fire department, leading roles in the organizations, experts in the prevention department, and development of methods and tactics, and even being in charge at rescue operations. We provide the theoretical and analytical side to an otherwise experience-based organization.

**Caro:** FPEs work on a variety of tasks. They spend the majority of their time conducting plan reviews and permitting process tasks. Other duties include bringing existing buildings into compliance, assisting city attorneys with prosecution tasks, and regulatory program and code development. Time is spent on emergency response, acceptance testing of overly complex fire protection/life safety systems, association involvement, fire inspector/firefighter training, and conducting research.



**Adams:** The PCFSD has only one FPE, who serves as the assistant fire chief and district fire marshal. As the FPE and district fire marshal (FM), I oversee all enforcement of fire and life safety requirements for existing and new commercial, educational, industrial, institutional, and residential facilities. I assist with the review and approval of special events. I perform detailed reviews and inspections, and I witness acceptance tests for all fire sprinkler systems, fire alarm systems, specialized engineered fire protection and detection systems, smoke control systems and detailed water supply analyses. I provide interpretations on fire and building code questions for design professionals, I perform detailed fire and life safety drawing reviews, and I provide consultations and exiting analysis reviews for all new and renovation projects. I am also actively involved in the model building and fire code development process, both on a local and national level.

department, but also to other county agencies, including the building official, department of planning, etc. It also extends further to building owners and their architects, engineers and design professionals to help foster a fire service perspective in the earliest part of design and development.

**Claridge:** Fire engineers within the NZFS provide a variety of roles. These include provision of technical advice on building designs, supporting fire engineering and performance-based design through the fire engineering brief process, providing technical advice and support to fire risk management officers, supporting fire investigations and major

the county's five year emergency management plan.

The chief engineer is available 24/7 for emergency responses for fire dispatch, emergency management as well as public works. Emergency calls include structural issues, damage assessment, and carbon monoxide alarms. Non-emergency calls include designing and providing construction management for buried water storage tanks for rural fire fighting. I worked on the Insurance Services Office Municipal Grading Schedule update, and the department went from ISO Class 9 to ISO Class 6 in rural areas with a fire station within five road miles (8 km) of a structure.



“FPES ARE INVOLVED IN EVERY ASPECT OF HAZARD IDENTIFICATION AND MITIGATION, REVIEW AND PERMITTING, AND DIRECTING FIRE INSPECTORS TO VERIFY PERMITTED DESIGNS ARE PROPERLY IMPLEMENTED AND FUNCTIONALLY TESTED.”  
 - CARO



**Horn:** Describe a specific project where FPEs assisted your department.

**Claridge:** FPEs within the NZFS become involved in a wide range of projects. Just a few of the significant projects on which they were involved include: working towards a new NZ standard for home sprinkler systems; fire investigation related projects, including involvement in live fires and house burns; development of the NZ firefighting water code of practice, and collection of operational data.

**Caro:** An existing hospital is undergoing an approximate 1 million square foot (90,000 m<sup>2</sup>) highrise expansion. FPEs are involved in every aspect of hazard identification and mitigation, review and permitting, and directing fire inspectors to verify permitted designs are properly implemented and functionally tested. FPEs will direct all applicable smoke control system testing. In addition, FPEs see that all required operational permits are requested and secured.

**Adams:** The major benefit that I have been able to bring to PCFSD as an FPE is that I am better able to communicate and consult with design professionals on fire and building code

requirements, and bring the education, expertise and background needed to review and approve the design of fire and life safety systems. By applying my education, knowledge and experience, I have been able to assist with

major construction projects located in mountainous areas and major Olympic venues. I have assisted with the master fire protection planning for a community and resort town in the wildland urban interface.

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**Milliken:** One specific and key role of fire protection engineering in Stafford County has been coordination of integrated fire protection and building system commissioning. From security-laden government buildings to the local hospital and healthcare facilities, the complex and interconnected sequence of operations for building systems are constantly evolving. Having a fire protection engineer to coordinate these systems provides a comprehensive, yet local fire service perspective to

the installation, modification and overall synchronization of life safety system operations.

**Bryan:** Specific projects include updating the five-year Emergency Management Plan, writing the building code adopting ordinance, and designing and undertaking construction management for buried 30,000 gallon (140 m<sup>3</sup>) fiberglass water storage tanks for rural firefighting.

**Arnevall:** We have participated in building and egress safety inspections, risk and hazardous materials analyses and commanding rescue operations. In our department, FPEs have been appointed as the fire chief.

**Horn:** Considering the great work underway by fire protection engineers at NIST, UL, ATF and others, do fire protection engineers in your department provide insight into standard operating procedures (SOPs), incident debriefs or tactic/strategy discussions and training?

**Arnevall:** Since we lead rescue operations on a daily basis, we participate in debriefings and

tactics/strategy discussions continuously. We also participate when we create new standard operations procedures. Hence, it's natural that we bring new findings and the latest research that we find externally to discussions and decision making.

**Claridge:** As well as assisting in fire investigations and providing support to NZFS fire investigators, fire engineers within the NZFS become involved in large fires and those of special interest where something out of the ordinary has occurred. Depending on the incident, fire engineers provide advice and support on building performance which can influence future SOP development and firefighting tactics.

**Milliken:** As fire protection engineers in the fire service, we should be the ambassadors of this work to help our crews connect the technical with the tactical as it applies to the local community and fire environment. Although we do push these great resources to our personnel and have some input with both local and regional SOP development, training beyond our recruit academy is an area that fire protection engineering could offer greater emphasis and support in the future.

**Adams:** Yes, we do provide input. We are part of the command staff at any major working fire or incident to provide assistance as needed, and in particular with the operation of the specialized fire and life safety systems in our major high-rise buildings. We are also able to provide our expertise in the review of SOPs to verify that all safety measures are considered. We provide bi-annual training to suppression crews on the operation of the specialized fire and life safety systems, assist crews with pre-planning target hazards, and instruct new candidates at the fire recruit academy.

**Bryan:** FPEs in Baltimore County provide training on such subjects as codes, water supply, etc.

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**Caro:** Historically, direct involvement has been limited. Officers that have left fire prevention and returned to the operations division had new knowledge and understanding of building construction and the associated fire protection/life safety systems. Occasionally, station officers have requested field visits to provide training.

**Horn:** How do you envision the role of the FPE within the fire service advancing in future years?

**Bryan:** I see the FPE in the fire service playing a much larger role due to the complexity of the built environment, presence of performance based code alternatives, as well as a cost effective alternative to using uniform fire fighters. Uniform fire fighters have a large amount of training and certifications that they must obtain and maintain, often at the expense of learning codes in detail and applying those skills in the plan review process. Many uniform personnel rotate out of these positions in a few years just when they become proficient in the correct application of codes.

**Milliken:** In much the same way the advanced life support or

“ FPEs WITHIN THE NZFS ARE INTIMATELY LINKED WITH NEW ZEALAND'S PERFORMANCE-BASED BUILDING CODE AND THE PROVISION OF ADVICE ON BUILDING DESIGN AND FIREFIGHTING NEEDS. - CLARIDGE ”

hazardous material services have been increasingly incorporated into the fire services over the past decades, it's not unreasonable to suggest that the demand for in-house, advanced technical expertise regarding the rapidly evolving fire protection and built environment will continue to spread throughout the fire service. Whether it's greater involvement in development services, department training, or emergency response, incorporating staff fire protection engineers to help fill these gaps will likely no longer be only a luxury only for larger departments.

**Claridge:** FPEs within the NZFS are intimately linked with New Zealand's performance-based building code and the provision of advice on building design and firefighting needs. Supporting performance-based building codes requires technical knowledge combined with the application of fire science and engineering principles. While there remains a performance-based building code, there will always be a need for the fire service to be represented within the building design process. Fire service FPEs are necessary to influence the built environment and provide the necessary link between legislation, standards, lessons learned from incidents and research into operational firefighting.

**Adams:** I see the FPE becoming more involved in the management team of the fire department. In see the FPE bringing that missing piece of the puzzle to the team, in that they will be able to bridge the gap between tradition and new technology, by applying their skills to evaluate and research different challenges or difficulties the fire department may encounter – both from a tactical and a managerial application and approach.

**Arnevall:** I think we have to continue working on a lot of different tasks and be wide in our field of expertise. But, I also think that the fire departments are going to employ a wider range of expertise, from building engineers and lawyers to HR personnel, since the complexity and vulnerability of today's society is growing at a rapid rate.

**Caro:** FPEs will play a more integral part in bridging the gap between the fire service's knowledge of codes and systems and their intended use on the emergency fireground.

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# PREPLA

By **Greg Jakubowski, P.E., FSFPE**



# NNNING

**F**irefighters are often trained in generalizations. Because of the constant variety of threats they face, they are often trained to fight fires in a general sense, and they learn about building construction and features in a general sense. They receive training and instruction manuals on their

equipment – but rarely do they have a “user’s manual” specifically designed for emergency response to the buildings in which they are expected to work.

They may get some sort of walkthrough training on the building and its fire protection features and equipment, but they are often expected to document or perhaps just



remember the building functions and performance in a fire or other emergency situation.

Things were simpler when building construction and fire protection features typically followed prescriptive codes and firefighting tactics could be standardized. As the performance-based design concept has grown in popularity, and building design and fire protection features have become more tailored to the specific building, there are increasing expectations on fire department performance when responding to these buildings. Even

prescriptively designed buildings can present challenges to firefighters, such as pressure vessels that may relieve upon exposure to the heat from a fire, or doors that may have alternative locking mechanisms. Firefighters also have concerns that lightweight construction elements may be subject to early collapse.

Engineers are designing structures, stadiums, transportation facilities, and a host of other venues, using sophisticated tools that allow them to more finely tune the fire protection and safety features of a building to its specific construction and occupancy.

Some firefighters and building officials understand those sophisticated tools, but some do not.

### SIZE-UP

Firefighters are taught to “size up” the building or facility where an emergency is occurring based upon any prior knowledge they may have, and their observations of the building when they pull up to an emergency. This look may be skewed depending upon if it is day or night or if smoke or something else limits their full view of the building. They may







make general assumptions about the building and its construction based upon this assessment, and these assumptions directly translate into fire attack tactics.

If they have little or no pre-incident knowledge of the facility, they are at a disadvantage when they develop their tactics. Buildings with unusual features are not just limited to city environments; even in the suburbs, small medical office buildings can hold sophisticated medical equipment that uses gamma radiation requiring concrete shielding walls and doors – with a building exterior that looks like any other office building.

There are many obstacles to effective preplanning, which can include a lack of interest by both the emergency responders and the building owner, and limited technical knowledge in completing the preplans themselves.

The gap in knowledge of a facility and its protection/safety features may, at the least, result in one or more of these features being ignored or used incorrectly, potentially



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leading to a more damaging fire than what might have occurred if that gap did not exist. If no or ineffective preplanning is done, the responding personnel will have little to no knowledge of the building's protection features and they will not have been properly prepared to use those features properly.

For example, one common fire service generalization is that if a building is sprinklered, the sprinkler system will handle a fire, making their efforts in that building easy. Many firefighters may not be aware that different densities are needed for different heights of storage, and be unable to differentiate between different commodity classifications when viewed in the field. There are many communities where code enforcement and inspections are limited, or even non-existent, which then limits the oversight to verify that the installed protection will work properly when it is needed.

### EFFECTIVE PREPLANNING

There are many obstacles to effective preplanning, which can include a lack of interest by both the emergency responders and the building owner, and limited technical knowledge in completing the preplans. This is where fire protection engineers can help.

A firefighter's world changes regularly. Companies may be out-of-service due to staffing issues, training, or on another emergency. It is not unusual in city departments for companies to respond to 10 or more runs per day. Even if resources are adequate and available, traffic



Essentially, the fire service can become the de facto historian of buildings in their response areas, and the facility managers might find the fire service preplan information quite useful as well.

jams and severe weather events can impede the provision of rapid service.

Severe storms can topple trees and power lines, completely blocking roads that provide access to various buildings. EMS responses and training can be a major focus of a fire department due to the demands of providing that service effectively, but this can limit the time available to study buildings and the protection features, provided in them along with how those features work.

Not only does custom building design present new challenges, but building operation and management concepts have changed over the years as well. No longer does a facility manager stay with one building for the life of that building. This responsibility is often contracted to a third party, and these facility managers often deal with multiple buildings across a wide area. It

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## Fire Suppression Rating Schedule Requirements

The ISO *Fire Suppression Rating Schedule*<sup>4</sup> (FSRS) has the following requirement – *The fire department should make building familiarization and pre-incident planning tours of each commercial, industrial, institutional, and other similar building at least annually. Records of the inspections (whether in electronic or other formats) should include complete and up-to-date notes and sketches, which must be available to the responding incident commander.*

*Building familiarization and pre-incident planning should be in accordance with the general criteria of NFPA 1620, Standard for Pre-Incident Planning.*

Effective pre-incident planning of these buildings can secure ISO FSRS points, therefore having a positive effect on the insurance rating and insurance rates for an entire community.

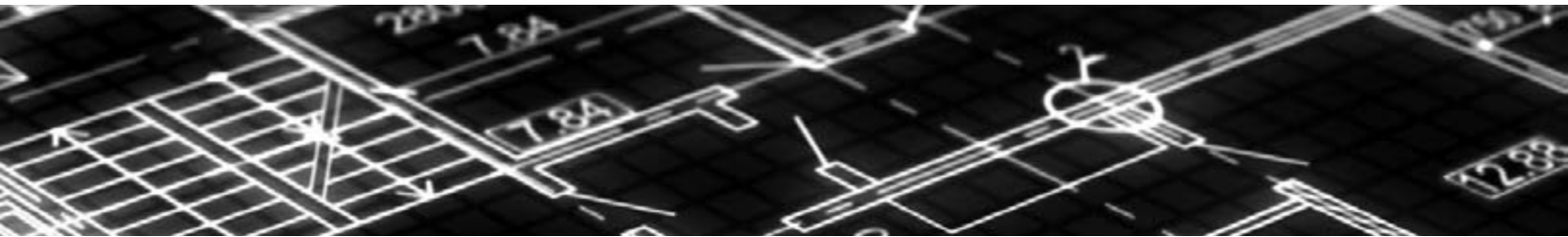
is difficult to expect them to know about every intricacy of every building they cover.

During evenings and weekends, the experience and knowledge level of those facility managers may further deteriorate from that which is available during normal working hours. Buildings also may change ownership, which may cause a change in the facility manager, thus losing the institutional knowledge that is so critical when an emergency

occurs. Essentially, the fire service can become the de facto historian of buildings in their response areas, and the facility managers might find the fire service preplan information quite useful as well.

From a design engineer's perspective – will that valuable work during the design phase be for naught when something happens in that building years later? Will someone really know the intent of how that building was designed





to perform when the emergency occurs? Preplans can prepare firefighters for success.

### REQUIREMENTS

There are a variety of code requirements for preplanning. The *International Fire Code*<sup>1</sup> (in Chapter 33 – “Fire Safety During Construction and Demolition”) places the responsibility for fire prevention on the owner, and the owner is required to designate a fire prevention program superintendent

who is responsible for developing and maintaining a preplan in cooperation with the fire chief. There also are various requirements for fire safety and evacuation plans for a variety of occupancies outlined in Chapter 4 of the *International Fire Code*.

These plans have several required items, almost all of which are included in a pre-fire plan that meets the requirements of NFPA 1620<sup>2</sup>. NFPA 1<sup>3</sup> – also requires pre-fire planning during construction, alteration, or demolition. There also are requirements for emergency

plans for a variety of occupancies outlined in NFPA 1. NFPA 1620 encourages cooperation in preplanning between building owners, occupants, designers, insurers, and firefighters.

Besides preplans for buildings, other facilities and occupancies can be preplanned successfully. Confined spaces are a key interest to OSHA; the openings and access information can be preplanned, listed and provided for emergency responders. Rail, vehicle, and other types of tunnels

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with limited access and ventilation also can be preplanned. The rail lines and highways – particularly interchanges – can be preplanned, even accessing cameras and other tools to help provide intelligence for responders. Cameras in schools and other buildings can similarly be embedded into electronic preplans. NFPA 1620 provides a standard for the data that is needed for an effective preplan.

Once a preplan is developed, there are many schools of thought on how to disseminate it. Many find hard copy preplans to be reliable and effective under most conditions. However, these copies are only as accurate as the last time they were updated, copied, and disseminated. PDF or similar electronic systems also require an effective dissemination plan.

A cloud-based system allows changes to be made at almost any time. Cloud-based preplans also can be shared with users located almost anywhere – essentially everyone that might need to access the information will have it when needed. However, this requires each user to have a working connection to the cloud system.

An additional concern is change management in the preplans – i.e., who is authorized to make changes. It is important to balance the need to make the preplans as current as possible with the technical accuracy of the plans – making sure that changes are done correctly.

Preplans are most effective when they are used to train personnel before incidents occur. Facility managers can take them in the field



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and validate the information, and verify that shutoffs are correctly identified and located, and verify that any changes that may have occurred are addressed. Firefighters can take the preplans, and using different available apps, conduct simulations of various incidents and discuss options for handling those incidents. If they have handled the incident before, even virtually, it will make it easier when they are faced with it in real-time.

### FUTURE OF PREPLANS

Preplans should be available to initial arriving company officers, as well as to incident commanders and planning chiefs at the command post immediately when needed. Preplans, when linked to wearable personnel tracking devices, will allow identification of the locations

of firefighters operating in the buildings right at the command post or for the operations chief or safety officer. This concept is under development and may be available in the near future.

In the not-too-distant future, preplans may be provided in displays in the masks of firefighters – allowing them to identify where they are in the building, and what hazards, exits, or other concerns are around them. At some point, fire modeling of buildings that determine how long the environment is tenable in a fire situation could be tied to building sensors and alarms that will enable fire officers to more effectively predict how long firefighters can safely operate in buildings. In all of these cases, fire protection engineers can be a huge asset to firefighters by helping to develop and maintain preplans, as well as the tools necessary to facilitate these concepts.

*Gregory Jakubowski is with Fire Planning Associates, Inc.*

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- 1 International Fire Code, International Code Council, Washington, DC, 2012.
- 2 NFPA 1620, *Standard for Pre-Incident Planning*, National Fire Protection Association, Quincy, MA, 2010.
- 3 NFPA 1, *Fire Code*, National Fire Protection Association, Quincy, MA, 2012.
- 4 *Fire Suppression Rating Schedule*, Insurance Services Office, Jersey City, NJ, 2013.

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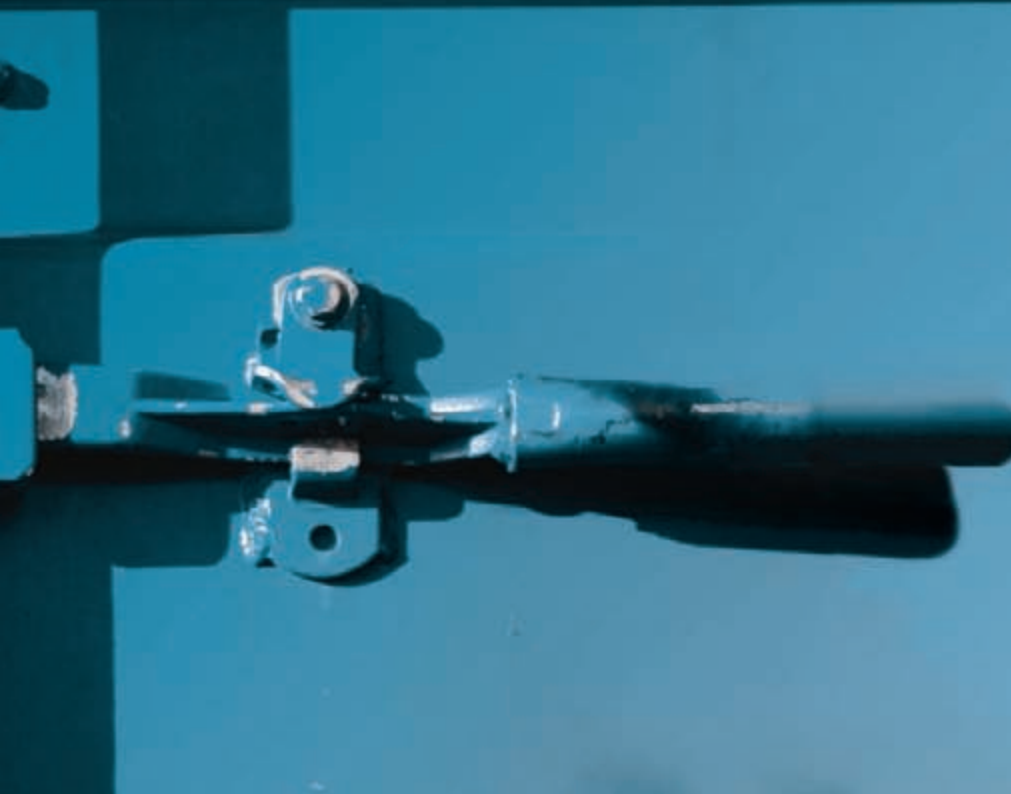
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# FIRE MODELING

## FOR THE FIRE RESEARCH, FIRE PROTECTION, AND FIRE SERVICE COMMUNITIES

By Kevin McGrattan, Ph.D., Randall McDermott, Ph.D.,  
Glenn Forney, Ph.D., Kristopher Overholt, Ph.D.,  
Craig Weinschenk, Ph.D. and Jason Floyd, Ph.D.



**T**he Fire Dynamics Simulator (FDS), first publicly released in 2000, has recently undergone its fifth major revision. Since its first release, FDS has been applied in three major areas: basic research in fire dynamics, performance-based design, and forensic reconstructions of actual fires.

As its applications widen in scope, there is a need to develop new capabilities, while at the same time to verify and validate new and existing algorithms. This is a difficult task because the variety of applicable scenarios is vast and growing.

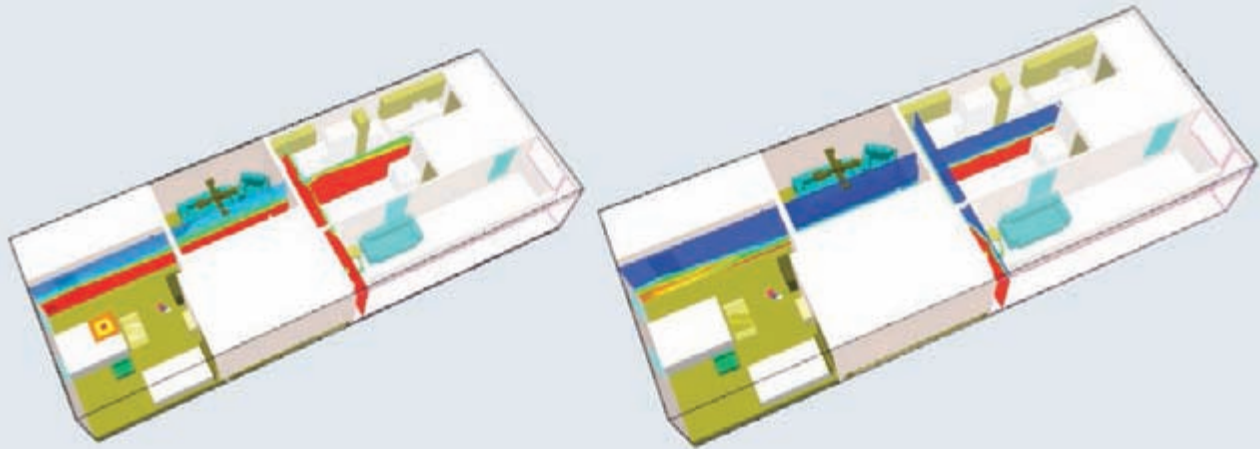


Figure 1: Smokeview snapshots of two simulations of a house fire that were intended to assess the consistency of eyewitness accounts. *Courtesy: Hughes Associates*

Take, for example, the images shown in Figure 1 through Figure 3. Figure 1 shows a few snapshots of a simulation of a house fire that were used to assess the consistency of eyewitness accounts. Figure 2 provides an example of how FDS was used to complement field experiments, which were designed to study the impact of crew size, alarm assignments, and vertical response modes on occupant survivability, firefighter safety, and property protection for high-rise fire scenarios.<sup>1</sup> Safety concerns prevented live fires during the experiments, so FDS was used to simulate potential thermal and toxic hazards representative of fires in a high-rise office building.

Figure 3 shows a simulation of the dispersion of toxic gases in the atmosphere. This model includes a portion of the FDR Drive along the East River in New York City where there were concerns about the accumulation of carbon monoxide from a partially enclosed roadway that was part of planned new construction.

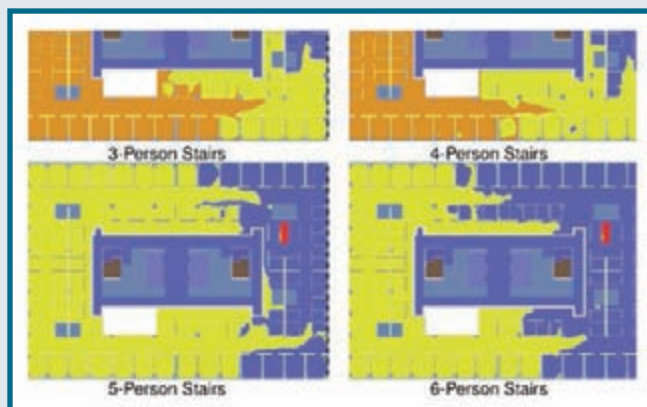


Figure 2: Predicted fractional effective dose contours on the high-rise fire floor. Higher values represent more toxic environments.<sup>1</sup>

These three examples highlight very different applications, with length scales varying from tens to thousands of meters and physical phenomena ranging from millimeter-scale pyrolysis of common household materials to kilometer-scale atmospheric boundary layer phenomena. Applications such as these have driven the development of FDS since its first release; this article reviews some of the major changes in the most recent version.

### IMPROVEMENTS IN FDS 6

Many of the improvements in FDS 6 are not immediately obvious. Most of the input parameters remain the same, as does the overall look and feel of the graphics program Smokeview. However, some very important changes have been made to improve the basic flow solver, in particular how the governing equations are approximated on the numerical grid and how the sub grid-scale turbulence is represented. In addition, algorithms have been added to Smokeview for solving the fractional effective dose equation in a slice plane (contours in Figure 2) and the radiative transport equation for visible light (volume rendered smoke and fire in Figure 4).

The flow model in FDS is essentially a set of partial differential equations known as the Navier-Stokes equations. These equations cannot be solved exactly. Instead, the partial derivatives are written in approximate form as finite differences; the accuracy of the approximation is determined by the size of the numerical grid.

There are many different ways to write the finite difference terms; versions 1 through 5 of FDS used a simple central difference scheme that was reasonably fast and accurate. It did have one drawback, however, for regions where temperatures would change rapidly; for example, at the edge of the fire, the numerical scheme would allow

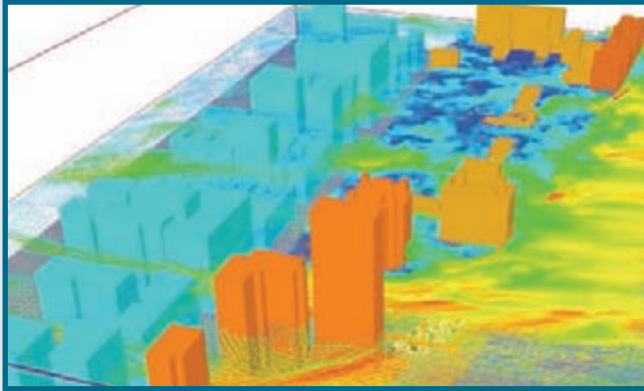


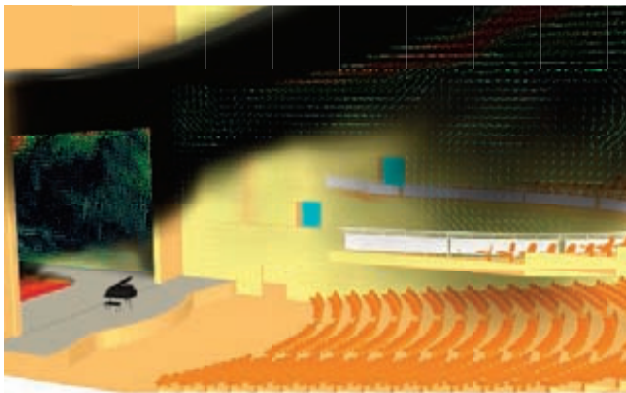
Figure 3: Smokeview snapshot showing the wind field over a proposed semi-enclosed roadway along the east side of Manhattan. *Courtesy: Hughes Associates*

the temperature, density, and species concentrations to oscillate above and below their ambient values. This was, of course, simply a numerical artifact related to the fact that the finite difference scheme is only an approximation; however, it was nevertheless noticeable and could sometimes lead to spurious results, especially when the numerical grid was relatively coarse.

To correct this problem, a more sophisticated finite difference scheme was implemented that removes the spurious oscillations. This scheme is more costly in terms of CPU time, but it was decided that the improvement in accuracy was more important than speed, especially because the steady increase in computer speed will soon make up the difference.

The second major change to the flow solver is the turbulence model. FDS uses a technique known as large-eddy simulation (LES) to represent the fluid motion that is too fine to resolve on the numerical grid. This technique has been around since the 1960s, when it was first developed for weather simulations.

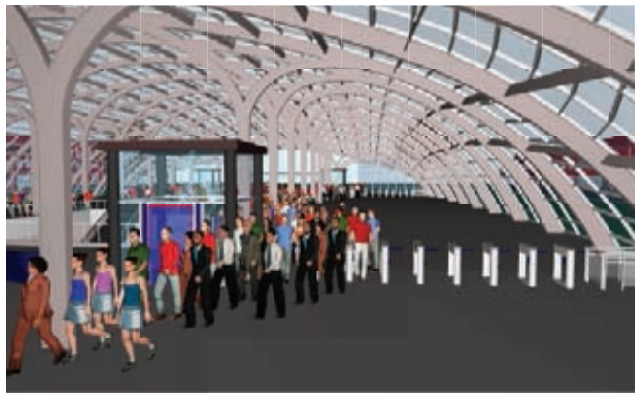
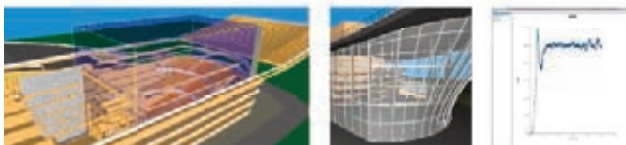
Since that time, a number of enhancements have been made to its treatment of sub grid-scale turbulence. FDS versions 1 through 5 used the original LES-turbulence model developed in 1963 by meteorologist Joseph Smagorinsky.<sup>2</sup> However, this technique proved to be overly dissipative, meaning that simulating realistic plume dynamics on a relatively coarse numerical grid was difficult. Several variations of the Smagorinsky approach were investigated, and a simplified form of the model of another meteorologist, James Deardorff,<sup>3</sup> was chosen on the basis that it is relatively cheap and performs well at both coarse and fine resolution.



### Fire Dynamics and Smoke Control

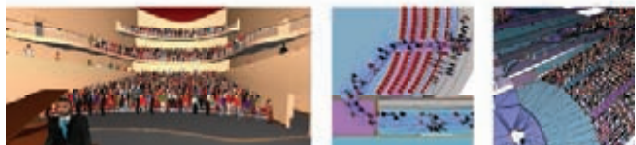


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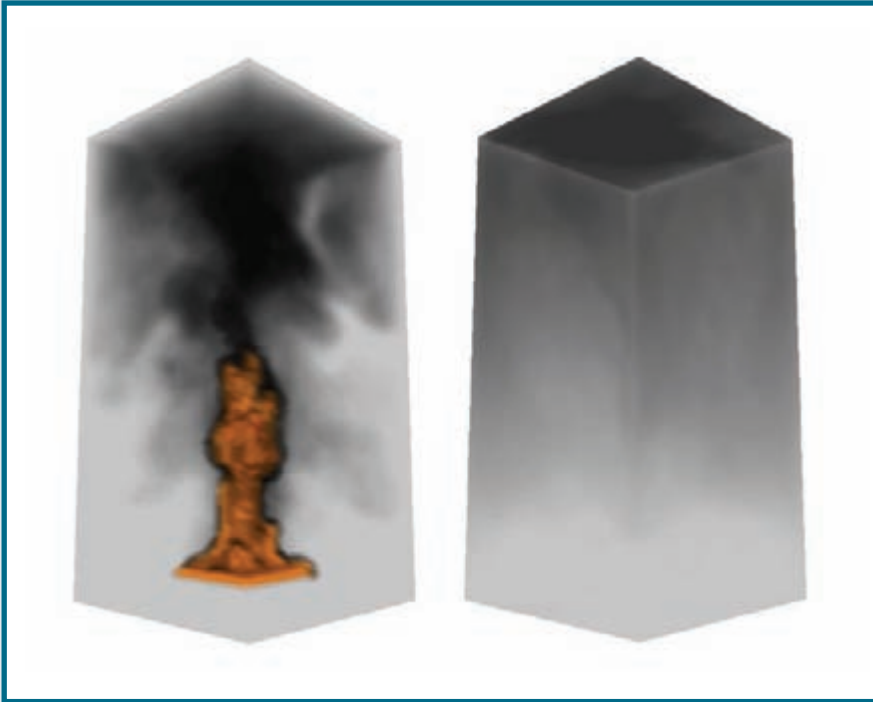


Figure 4: Simple demonstration of smoke deposition to wall and ceiling surfaces during (left) and after (right) fire exposure.



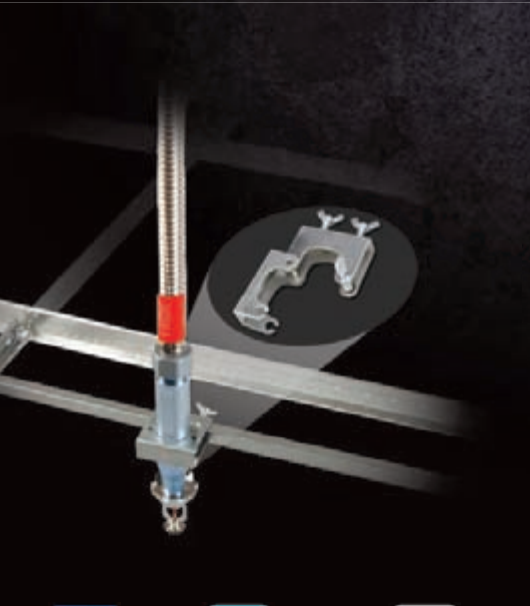
Other improvements in FDS 6 include:

**Combustion:** There is increased flexibility to define a detailed combustion scheme that goes beyond the simple “fuel meets air and burns” approach. For many typical fire applications, much of the new combustion machinery is not needed, and one can specify a predetermined design fire with little change from past versions. However, for topics such as CO production, under-ventilated fires, suppression, and soot formation and oxidation, the new chemistry and combustion framework will make it easier to explore alternative reaction schemes.

**Radiation:** FDS uses a set of sub-routines called RadCal to calculate the absorption and emission properties of hot gas mixtures. One limitation of RadCal had been its use of methane as a surrogate for all fuel types. FDS 6 now includes the radiative absorption properties of fuel gases other than methane. These properties are based on measurements by Prof. Greg Jackson and students at the University of Maryland,<sup>4</sup> and the implementation in FDS was done by Vivien Lecoustre. This can improve the radiation calculations in detailed flame simulations or fuel-rich fires.

**Ventilation:** In previous versions of FDS, one could only specify pre-defined inlet and outlet flows for mechanical ventilation. To improve the ability of FDS to model buildings, a heating, ventilation, and air conditioning (HVAC) sub-model was added, based on the solver in MELCOR, a U.S. Nuclear Regulatory Commission code for analyzing containment buildings. This model treats an HVAC system as a collection of nodes and junctions. With the HVAC model, one can define the following components:

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**Soot Deposition:** An accurate prediction of smoke concentration and smoke deposition to surfaces is important in various fire model applications, including visibility for human tenability studies and fire patterns for forensic reconstructions. Smoke that deposits to surfaces can reduce the gas-phase smoke concentration and affect visibility and detector activation time. The deposition of particulate matter also is important for predicting the dispersion characteristics of aerosol toxicants (e.g., ash, radionuclides, or other particulate matter). In FDS 6, soot and aerosols can accumulate on surfaces due to gravitational settling, thermophoretic deposition (where temperature gradients near walls push particles towards or away from walls), and turbulent flows near surfaces (where particles impact surfaces due to turbulent motion). Figure 4 is a simple example showing soot deposition to surfaces.



## VERIFICATION AND VALIDATION (V&V)

In 2007, the U.S. Nuclear Regulatory Commission (NRC) and the Electric Power Research Institute



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(EPRI) published the results of a validation study of five different fire models commonly used by the commercial nuclear power industry.<sup>5</sup> The study was prompted by the NRC's adoption in 2004 of NFPA 805.<sup>6</sup>

In particular, NFPA 805 requires fire models to be verified and validated. The standard does not state explicitly what is meant by this. Guidance documents, such as the SFPE *Guidelines for Substantiating a Fire Model for a Given Application*,<sup>7</sup> and standards documents such as ASTM E 1355<sup>8</sup> and ISO 16730<sup>9</sup>, all provide a basic framework for evaluating models. However, these documents do not have specific requirements as to how the model uncertainty is to be reported and how this information is to be used in a regulatory context. As a result, the NRC and EPRI took it upon themselves to develop a relatively simple framework for reporting and applying model uncertainty in day-to-day design analyses.

With the support of the NRC, FDS and the NIST zone model, CFAST, have adopted the basic framework

of the NRC/EPRI V&V study. In addition, the way in which FDS is developed, tested, and released has greatly improved in recent years because of the boom in free and open source software development tools. Using a procedure that is commonly referred to as "continuous integration," an automated script runs hundreds of FDS test cases and regenerates all of the plots and figures for the FDS manuals each night. This greatly reduces the likelihood that new bugs will be created with each new routine.

## FIRE SERVICE APPLICATIONS

Even before it was publicly released, the Fire Research Division at NIST has used FDS to provide insight into the development and thermal conditions of fires that have caused injuries or fatalities.<sup>10, 11, 12, 13, 14, 15, 16</sup> In addition, FDS has been used in firefighter staffing studies, firefighter training studies, and the impacts of various tactical operations such as ventilation or suppression operations. The overall objective of the use of fire models in

Using a procedure that is commonly referred to as "continuous integration," an automated script runs hundreds of FDS test cases and regenerates all of the plots and figures for the FDS manuals each night.



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these studies is to improve firefighter safety and operational effectiveness.

These applications are challenging to model because they incorporate advanced features such as the pyrolysis of real materials, under-ventilated combustion, and complex geometries. In fact, many current FDS development activities are driven by fire service applications, primarily because fire growth and spread are to be predicted, and not just specified as in most fire protection design applications. This demands a more thorough knowledge of material properties and complex fire physics. ■

*Kevin McGrattan, Ph.D., Randall McDermott, Ph.D., Glenn Forney, Ph.D., Kristopher Overholt, Ph.D., and Craig Weinschenk, Ph.D., are with the National Institute of Standards and Technology. Jason Floyd, Ph.D., is with Hughes Associates, Inc.*

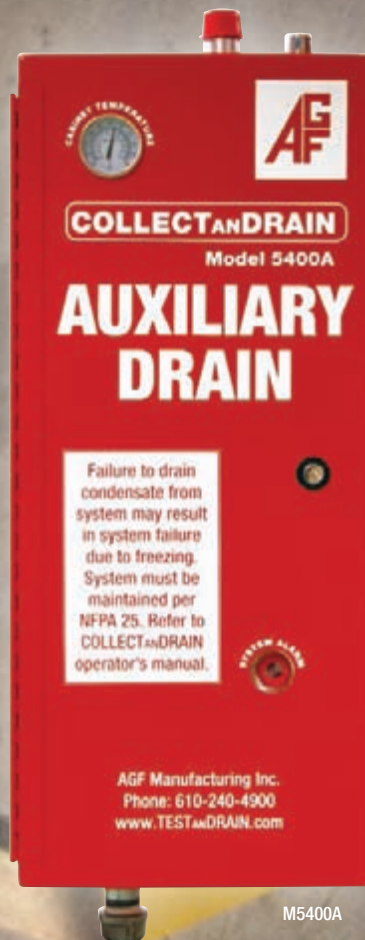
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# EFFECTIVENESS AND RELIABILITY OF **FIRE PROTECTION SYSTEMS**

By James A. Milke, Ph.D., P.E., FSFPE



**P**erformance based design analyses often involve a comparison of the contributions of a variety of fire protection systems to achieve specified design objectives. Fire protection systems can be divided into two categories: passive and active systems. Passive systems include fire-rated barriers and protection of openings in fire-rated barriers, while active systems include systems such as fire detectors and sprinklers.

An analysis of the contribution of a particular fire protection system to the achievement of specified objectives should include an assessment of the effectiveness and reliability of the proposed fire protection systems. For the purposes of this article, “reliability” is defined as the probability that a product or system will operate under designated operating conditions for a designated period of time or number of cycles. “Effectiveness” refers to the ability of a system to achieve desired objectives.

While reliability data for sprinkler systems has been included in NFPA analyses,<sup>1</sup> few compilations of reliability data are available in the open literature for other types of fire protection systems. This article provides an overview of the results of recent research that has been conducted to assemble such data from a variety of available sources.

Reliability data may be derived from fire incident statistics considering the entire fire protection system to be a single entity. Alternatively, the reliability of a system may be determined from an engineering analysis based on failure and repair rates of the components of the system, accounting for any redundancy in system components. For this article, the reliability data comes from considering the system to be one entity.

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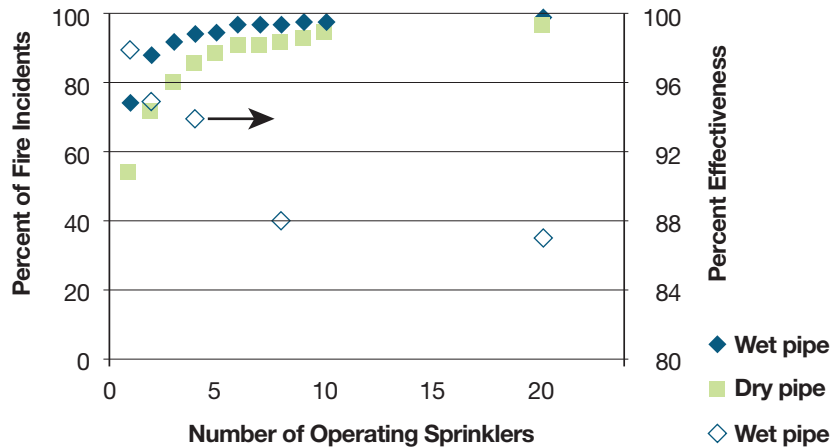


Figure 1: Effectiveness of Sprinklers in U.S. Fire Incidents<sup>1</sup>

Occupancy	Fire death rate* without auto extinguishing system	Fire death rate* with wet pipe sprinkler	Percent reduction
All public assembly	0.4	0.0	100%
Residential	7.4	1.2	84%
Store/Office	1.2	0.2	81%
Manufacturing	1.8	0.3	84%
Warehouse	1.2	2.0	-67%
Total	6.2	0.9	85%

\* Fire death rate: civilian deaths/1000 fires

Table 1: Fire Death Rates With and Without Sprinklers<sup>1</sup>

Reason for failure	All	Wet pipe	Dry pipe
System shut off	65%	61%	74%
Manual intervention defeated system	16%	19%	8%
Lack of maintenance	7%	8%	4%
System component damaged	7%	6%	10%
Inappropriate system for type of fire	5%	6%	3%
Total fires per year	738	564	130

Table 2: Reasons for Sprinkler Ineffectiveness<sup>1</sup>

Sources of information include expert opinion, NFIRS data, surveys by insurance companies, surveys by researchers, and in-depth fire incident analyses by selected sectors of the industry. This review will begin with a review of the effectiveness and reliability for two types of active

systems – sprinklers and fire alarms, then proceed to passive systems.

### ACTIVE SYSTEMS Sprinkler Systems

The effectiveness of sprinkler systems in U.S. fire incidents is



summarized in Figure 1.<sup>1</sup> As indicated in the figure, when sprinklers operate in fire incidents, only one sprinkler operates in almost 70% of all fires and that one sprinkler is effective in 98% of the incidents. An interesting trend indicated in the figure is that the effectiveness of

sprinklers declines with an increasing number of operating sprinklers.

The significant reduction in fire death rates in a wide variety of occupancies with sprinklers is presented in Table 1.<sup>1</sup> The fire death rate in sprinklered warehouses is likely an anomaly due to the small number of fire deaths that

occur in warehouses and should not be used as justification to eliminate sprinklers from warehouses.

The reasons for sprinklers to be ineffective are indicated in Table 2.<sup>1</sup> As indicated in the table, the dominant cause for ineffectiveness is the system being turned off.



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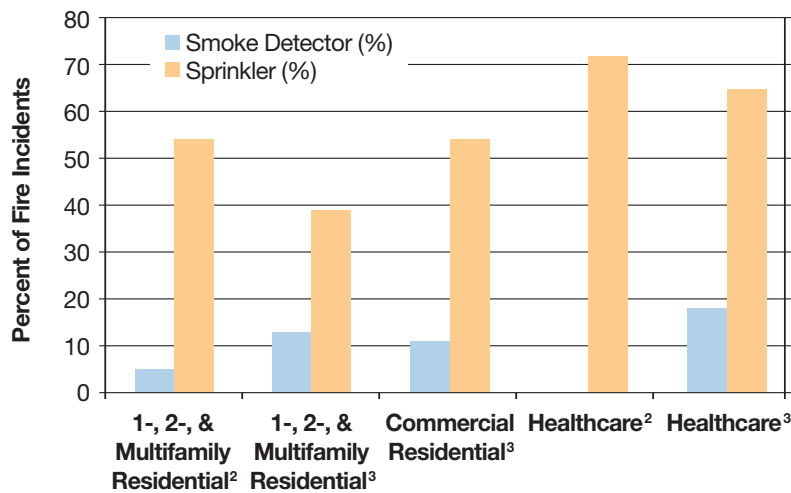


Figure 2: Fires "Too Small" for Smoke Detector and Sprinkler Operation<sup>3</sup>

### Fire Alarm Systems

Analyzing data from fire incidents that occurred from 2003-2006 in U.S. homes, Hall<sup>2</sup> determined fatal casualty rates in homes without operating smoke detectors to be 1.10 deaths per 100 reported fires compared to 0.52 deaths per 100 fire incidents with operating smoke detectors, a decrease of more than 50%. In a study by Milke, et al.,<sup>3</sup> the effectiveness of sprinklers and smoke detectors was assessed via an analysis of approximately 200,000 U.S. fire incidents that occurred from 2003 to 2007 in residential, commercial residential, and health-care facilities. The casualty rate (including both fatal and non-fatal casualties) was substantially less in residences with operating sprinklers (2.06 casualties per 100 fire incidents) than operating smoke detectors (3.17 casualties per 100 fire incidents).

An indication of the relative sensitivity of smoke detectors and sprinklers is provided in Figure 2. This indication is gleaned from the fires that were judged by the individual completing the fire incident form to be too small for the operation of sprinklers and smoke detectors. As indicated in the figure, with

fewer fires judged to be "too small" for smoke detector operation than sprinklers, smoke detectors are characteristically more sensitive to early fire conditions than sprinklers.

In a second study by Milke, et al.,<sup>4</sup> the response of individuals to the operation of smoke detectors in U.S. fire incidents in commercial occupancies is indicated in Figure 3. This study included 30,900 fire incidents that occurred from 2003-2010. As indicated in Figure 3, occupants responded in only 36% of the fire incidents where an audible alarm was

As indicated in Figure 3, occupants responded in only 36% of the fire incidents where an audible alarm was produced as a result of an operating smoke detector.

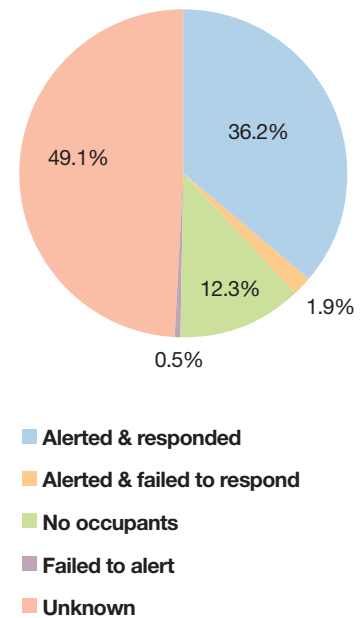


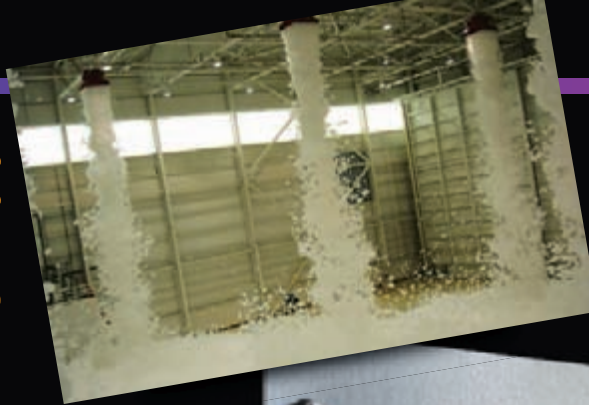
Figure 3: Response of Occupants to Audible Fire Alarms in Commercial Occupancies<sup>4</sup>

produced as a result of an operating smoke detector. In the previous study by Milke et al.,<sup>3</sup> involving residential occupancies, using the same categories as reflected in Figure 3, 83% of the occupants in residences responded to an audible alarm produced by an operating smoke alarm.

### PASSIVE SYSTEMS

In a survey of experts in the 1980s as part of the Warrington Study in Australia, the reliability of fire-resistant construction in commercial occupancies was estimated to be 70% (as compared to reliabilities of 95% for sprinklers and 75% for smoke detectors).<sup>5</sup> Rosenbaum conducted an analysis of data from U.S. fire incidents that occurred from 1989-1994 in commercial occupancies to compare the extent of thermal fire damage where different fire protection systems were installed. In his study, the extent of thermal damage was divided into three categories: fires that were limited

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Protection	Room	Floor	Structure
None	59%	4%	37%
Detection (D)	85%	4%	11%
Sprinklers (S)	89%	3%	8%
Fire-resistant-rated construction (FRRC)	77%	4%	19%
D+S	92%	2%	6%
D+FRRC	92%	3%	5%
S+FRRC	91%	3%	7%
All	95%	2%	3%

Fire death rate: civilian deaths/1000 fires

Table 3: Extent of Damage in U.S. Fire Incidents, 1989-1994<sup>5</sup>

to the room of fire origin, the floor of origin or multiple floors (i.e., the structure). The results of Rosenbaum’s analysis are included in Table 3.

As indicated in Table 3, fires are limited to the room or floor of origin in 63% of all fire incidents where no protection is provided. In comparison, fires in buildings of fire-resistant-rated construction are limited to the room or floor of origin in 81% of all fire incidents, a difference of 18% over the baseline case consisting of buildings without any protection systems. In contrast, the proportion of fires limited to the room or floor of origin is 89% when only a detection system

is installed and 92% when only a sprinkler system is installed.

### Fire Doors

Photographs depicting the desired performance of a fire door are presented in Figure 4. These photographs were taken during the FEMA World Trade Center analysis during a tour of WTC 5. The office space adjacent to the door had a well-developed fire that consumed virtually all of the combustibles. As illustrated in the photographs, the inside of the stairwell is almost absent any effects of the severe fire that occurred on the other side of the door.

Reliability data for fire doors is available from four sources. FM Global examined 1,600 installations of fire doors.<sup>6</sup> Several types of fire doors were included in the survey, including rolling steel, horizontal sliding on inclined tracks, counterweight closures or spring closures, vertical sliding and swinging doors.

On average, 82% operated properly, with rolling steel doors having the lowest reliability of 80% and vertical sliding doors having the greatest (93%). CIGNA Property and Casualty Loss Control staff evaluated the in-place performance of 805 fire doors. “41.1% of all doors had

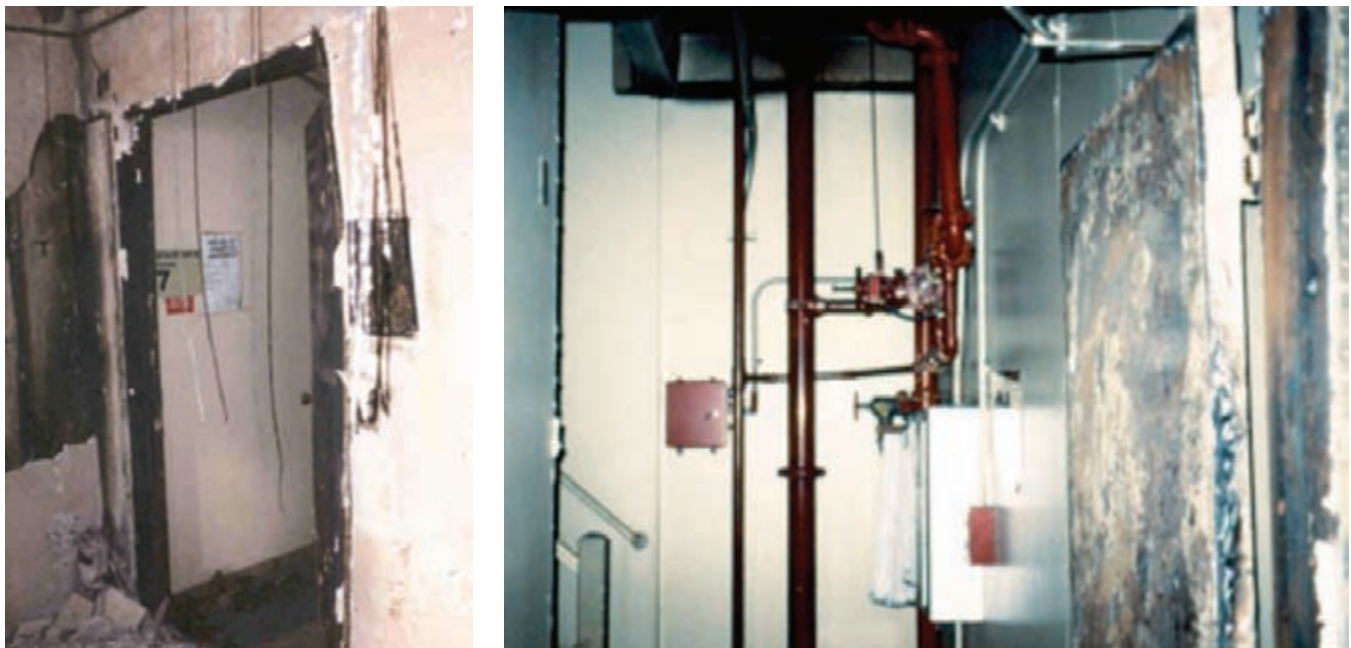


Figure 4: Fire Door Performance in WTC 5 during 9-11 (on left looking inside stairwell, on right viewed from inside stairwell)

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some type of physical or mechanical problem that would prevent them from operating properly during a fire event".<sup>7</sup> This results in a modest reliability of 58.9%.

Dusing, Buchanan and Elms<sup>8</sup> surveyed 91,909 installed fire doors in several occupancies. Of those doors, 12,349 (13.4%) were propped open. The problem was at its worse in institutional occupancies (39% of the doors were propped open) and least in assembly occupancies (only 5% of the doors were propped open). Scarff reported that fire doors were blocked open or had kick-down stops in 50 of the 275 hotels surveyed (18%) from June 1992 to June 1993.<sup>9</sup>

### Fire Dampers

The performance of a fire damper is depicted in Figure 5 in WTC 5. This damper is near the location of the stairway door included in Figure 4. In this photograph, the damper has closed with the steel HVAC duct having collapsed away from the wall.



Figure 5: Fire Damper Performance in WTC 5

### Through Penetration Seals

In a survey of large loss fires in the early 1970s, it was found that in 38% of all large loss fires (based on direct property damage of at least \$250K), horizontal fire spread was attributed to non-fire stopped areas including floors and concealed spaces above and below floors and ceilings.<sup>10</sup> This was prior to the development of ASTM E814<sup>11</sup> (the first edition was in 1981) and may have been part of the motivation for development of the standard test method for through penetration firestop systems. Spruce<sup>12</sup> estimated that in buildings that were at least five years old, 95% of the openings in fire-rated barriers were inadequately protected (i.e., a reliability of only 5%).

The quality of any data highly depends on the input inserted onto inspection or incident forms. Further, while data from the U.S. National

Fire Incident Reporting System is publically available, those from other sources is rarely reported openly. The availability of limited data or lack of quality data constrains the ability of engineers to make informed decisions on design options. This constraint can be withdrawn, but requires a concerted effort starting with those entering the information from inspections and fire incidents.

*James A. Milke is with the University of Maryland.*

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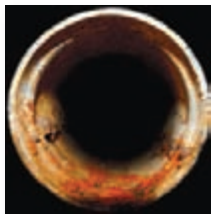
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## POTTER ELECTRIC SIGNAL

## POTTER ELECTRIC STUDIES EFFECTS OF USING NITROGEN GAS IN FIRE SUPPRESSION SYSTEMS

Internal corrosion of dry and pre-action fire suppression systems is a growing concern for the fire sprinkler industry. Corrosion in these systems causes failures resulting in property damage, production downtime, and increased maintenance costs. Additionally, corrosion impacts



system hydraulics and reduces the efficiency of fire sprinkler system designs. Historically, dry and pre-action fire suppression systems have used compressed air as the supervisory gas to pressurize their piping. Compressed air, however, contains both oxygen and moisture causing the system piping to corrode. Nitrogen, acting as a supervisory gas in piping, is a well documented inhibitor of corrosion and has been implemented in industries such as gas and oil, pharmaceutical and the marine transit industry. Potter's Corrosion Solutions team performed a yearlong study analyzing the corrosion-inhibiting effects of 98% nitrogen gas when applied to both carbon steel and galvanized steel, in an environment simulating a dry pipe fire sprinkler system.



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The conclusions are as follows:

1. The use of 98% nitrogen in lieu of compressed air as a supervisory gas reduces corrosion in both galvanized and black steel systems regardless of whether or not trapped water is present. The corrosion reduction potential ranges from 48% to 91% when compared to compressed air.
2. Using 98% nitrogen gas in lieu of compressed air increases the life expectancy of a dry or pre-action system on an average of 5.3 times.
3. The use of galvanized steel instead of black steel results in higher metal loss rates when compared in equivalent environments.
4. The use of 98% nitrogen gas in a relatively dry, black steel environment has the lowest corrosion rate overall.

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UL162 Test Standard – 5 Minute Water Application

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Mitigation techniques often seem ineffective, largely because of the blind shotgun approach to system repair. Steps taken are often misapplied due to insufficient knowledge, and therefore have less effective results. Imagine taking an aspirin as the cure for everything: headache, stomach flu, diabetes, cancer, etc. Sometimes it helps, but often not. Knowledge is the key. Unfortunately, today's most commonly used diagnostic methods are inefficient and ineffective, providing limited useful information.

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is even recognized by the NFPA to satisfy the Internal Piping Condition and Obstruction Investigation requirement defined under chapter 14 of NFPA 25.

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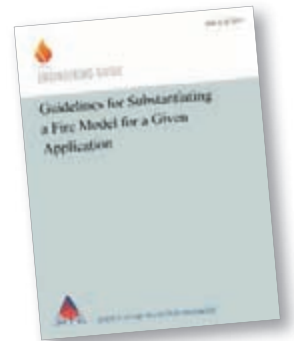
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# RESOURCES

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### November 10-14, 2014

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### November 20, 2014

Seminar on "Fire Protection with Water Mist"  
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### June 16-18, 2015

2<sup>nd</sup> European Symposium on  
Fire Safety Science  
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### June 22-25, 2015

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### September 28-30, 2015

6<sup>th</sup> International Symposium Human  
Behaviour in Fire 2015  
Cambridge, UK  
**Info: [www.intersciencecomms.co.uk](http://www.intersciencecomms.co.uk)**

### November 8-13, 2015

SFPE Annual Meeting – Professional  
Development Conference & Exhibition  
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## BRAINTEASER [ Problem / Solution ]

### Problem

**A** merchant can place 8 large boxes or 10 small boxes into a carton for shipping. In one shipment, the merchant sent a total of 104 boxes. If there are more large boxes than small boxes, and at least one carton of small boxes, how many cartons did the merchant ship?

### Solution to Last Issue's Brainteaser

$x$  is an integer, and  $9 < x^2 < 99$ . What is the largest possible value of  $x$  minus the smallest possible value of  $x$ ?

18. The largest possible value of  $x$  is 9, and the smallest possible value of  $x$  is -9.

# New Publications



## 2014 SFPE Compensation Survey

Do you want to know how your pay stacks up against that of your peers? The 2014 SFPE Fire Protection Engineering Compensation Survey is now available at the SFPE Online Store. Nine hundred engineers, from 35 countries, completed this survey, a 20% increase in participation over 2012. For the first time, participants were asked about their plans for retirement. This data can be used to gauge the expected job turnover due to retirements in the profession.

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## SFPE To Launch Fire Safety Engineering Europe

SFPE to launch a new digital edition for European fire safety professionals, Fire Safety Engineering Europe, which will feature timely and relevant content regarding the practice of fire safety, methods and principles, technology developments, regional and international code updates, events and other topics of specific interest to this region. This publication is distributed to fire safety and other professionals involved in design and specification, product selection, approvals, ownership and purchasing, and shared via social media. Expert content is provided by fire safety engineers from the region, and will include news and educational and events listings for Europe.

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## LED Series Ceiling Notification Appliances



Eaton's Cooper Notification business has expanded its Wheelock Exceder LED Series to include ceiling models for horns, horn strobes, strobes, speakers, and speaker strobes. The Wheelock Exceder Series uses high-efficiency light emitting diodes (LEDs) as the strobe light source to help reduce costs in fire alarm and emergency communication systems. Available in small footprints with a frequency response range spanning 300 to 8,000 Hertz.

[www.coopernotification.com](http://www.coopernotification.com)

– Eaton

## Rupture Discs with Inconel® 625



Fike has expanded its Atlas rupture disc product line to include Inconel 625 material of construction. The material will now be offered in sizes 1" (DN25), 1.5" (DN40), 2" (DN50), 3" (DN80), and 4" (DN100). Inconel 625 paired with Fike's G2 technology creates a rupture disc with outstanding corrosion resistance at a wide range of temperatures. Burst pressures range from 60-1500 psig.

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## Pipe Concealment

JG Innovations has added the ALumA-Fit™ Concealment System to its line of enclosure systems. The system is made from .030 aluminum and was designed to cover one or multiple exposed mechanicals. A non-obtrusive pipe enclosure, it is independent from any pipe or mechanical layout, and may be fabricated to the dimensions required right on the jobsite.

[www.jgius.com](http://www.jgius.com)

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## Fire & Suppression System

Mircom's new FX-3500 Intelligent Fire Alarm & Suppression System includes intelligent fire alarm control units, which support Advanced Protocol (AP) as well as Classic Loop Interface Protocol (CLIP) devices. The FX-3500 control units are UL 864 Rev 9 and ULC S527-2011-Listed for fire control and releasing service. The series is recommended for both new and retrofit special-hazard, critical-infrastructure suppression, and special agent applications.

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## Recessed Flush Dry Sprinkler

The Model VK482 "recessed flush" dry sprinkler has a 5.6 (81) K factor, and is cULus-Listed for both light and ordinary hazard occupancies. Its fusible element can be recessed up to .5-inch above the ceiling. Available in 165°F and 205°F temperature ratings. The VK482 provides an aesthetically pleasing alternative to a concealed dry sprinkler for protecting unheated areas in structures such as nursing homes, restaurants, schools, and freezers.

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## Intelligent Voice Communication

Siemens Intelligent Voice Communication systems deliver to small and mid-sized buildings technology once reserved only for high-end facilities. Available on both the Desigo® Fire Safety and Cerberus® PRO portfolios, these flexible, networkable fire panels leverage VoIP technology to deliver multiple unique messages simultaneously via high-quality digital voice. Customized messages reach specific areas at the same time.

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– Siemens





# ENGINEERING GUIDE: FIRE SAFETY FOR VERY TALL BUILDINGS

This new guide, co-published by the International Code Council (ICC) and SFPE, identifies critical fire safety challenges unique to very tall buildings. *Engineering Guide: Fire Safety for Very Tall Buildings* examines how these special challenges can be addressed worldwide through an integrated performance-based design.

This engineering guide was written in response to an increase in the global design and construction of very tall buildings. Building codes in some countries may not contemplate all aspects of fire safety in very tall buildings—some of which approach a half mile, or 800 meters, in elevation. Buildings that are hundreds of meters tall pose challenges far different from those in average-sized tall buildings.

The guide emphasizes the importance of taking an integrated approach to the design of fire safety in tall buildings based on expected fire performance. This integrated approach looks beyond compliance with codes and standards, and considers how the height of the structure impacts fire safety and how various fire safety systems complement each other to achieve fire safety goals. These systems include smoke control, fire suppression, building evacuation, structural fire resistance and fire fighter access.

The *Engineering Guide: Fire Safety for Very Tall Buildings* recommends performing a fire risk analysis to determine how best to address the fire safety challenges unique to a specific building. Although fire hazards in very tall buildings are similar to those in shorter buildings, the consequences of a fire can be more severe given the large numbers of occupants, the inherent limitations in egress, and the sheer height of the structure. The risk analysis will identify which hazards should be addressed by the design, where the hazards may include accidental fires, fires following earthquakes, or terrorist threats.

## *Engineering Guide: Fire Safety for Very Tall Buildings* is available for purchase in hardcopy

**\$49.95 for SFPE Members (\$59.95 for non-members)**

*Engineering Guide: Fire Safety for Very Tall Buildings*

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