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Engineering

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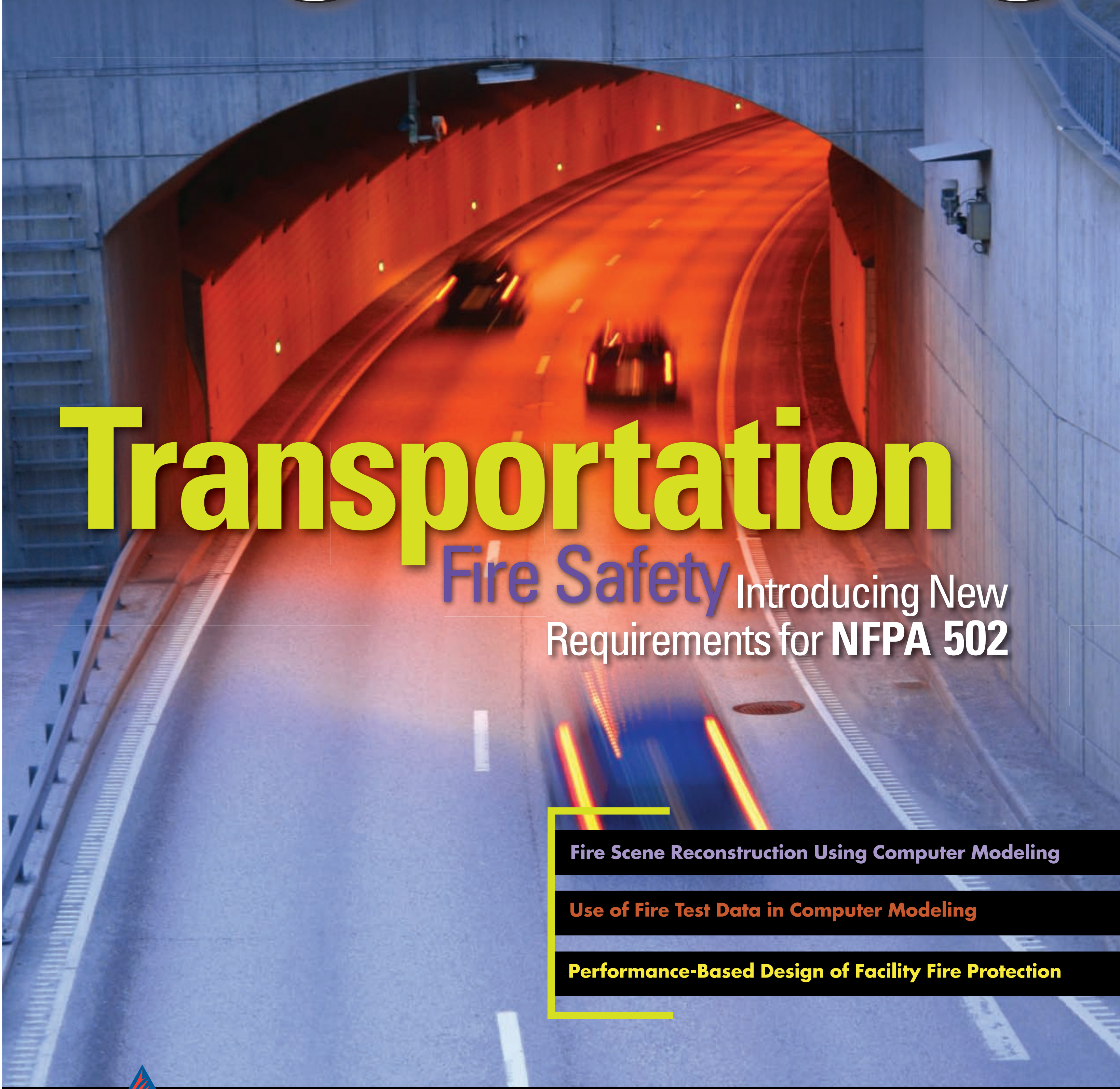

Transportation

Fire Safety Introducing New Requirements for NFPA 502

- Fire Scene Reconstruction Using Computer Modeling
- Use of Fire Test Data in Computer Modeling
- Performance-Based Design of Facility Fire Protection

SFPE

THE OFFICIAL MAGAZINE OF THE SOCIETY OF FIRE PROTECTION ENGINEERS

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From the TECHNICAL DIRECTOR

SFPE's Engineering Guides and Standards

In 1995, SFPE began to dedicate resources towards creating an infrastructure to better support performance-based fire protection design. A new staff position was created at SFPE, and several new task groups were created. The SFPE technical director position and the volunteer task groups were established to build upon the momentum that was created when the first edition of the *SFPE Handbook of Fire Protection Engineering* was published.

Publication of the *SFPE Handbook of Fire Protection Engineering* in 1988 was a landmark event for the fire protection engineering profession. For the first time, approaches to solve a variety of fire protection engineering problems were centralized in a single location. However, the chapters in the *SFPE Handbook of Fire Protection Engineering* were written by individual authors and without a formal peer-review process.

SFPE's vision was to create a series of engineering guides that could be used by engineers and authorities having jurisdiction to develop or review performance-based designs. Guides would be developed to provide methods to conduct specific aspects of performance-based fire protection engineering. The guides would be based upon accepted, mature fire protection engineering science.

These guides would be created by task groups of volunteers to achieve an agreement among the fire protection engineering community on how these specific engineering tasks could be performed. Since performance-based fire protection engineering is evolving, it is important to achieve agreement among a broad spectrum of fire protection engineers when describing how it should be done.

Initially, three areas were chosen for development of engineering guides: performance-based design, thermal radiation hazards and evaluation of the computer fire model DETACT-QS. The *Engineering Guide to Performance-Based Fire Protection* was created to identify a process by which one could develop a performance-based design. First published in 2000, this guide is now in its second edition, which was published in 2007.

Thermal radiation hazards were chosen for an area of guide development because the underlying science was well understood and there was a wealth of data available to evaluate available predictive methods. The initial scope was how to estimate thermal radiation from pool fires and the effect of this radiation on people and other targets. Ultimately, three guides were published: the *Engineering Guide on Assessing Flame Radiation from Pool Fires*, the *Engineering Guide on Piloted Ignition of Solid Materials Under Radiant Exposure* and the *Engineering Guide on Predicting 1st and 2nd Degree Skin Burns from Thermal Radiation*.

Because computer models are commonly used in performance-based design, SFPE also undertook to evaluate computer models for their applicability, use and limitations. These evaluations were intended to provide additional confidence to model users and reviewers of model results that the models were being used appropriately. DETACT-QS was chosen to be the first model evaluated because, at the time, it was the most widely used computer fire model. Conveniently, it was also one of the simplest. In due course, SFPE published the *Engineering Guide – Evaluation of the Computer Fire Model DETACT-QS.*

Since that start in 1995, SFPE has published five other engineering guides in addition to those mentioned above, and many more are in process. These guides have helped advance performance-based design, and in many cases, these guides have been referenced within the commentary of fire protection codes and standards.

More recently, SFPE has begun developing engineering standards. SFPE has developed a set of standards with criteria that meet the requirements of the American National Standards Institute. The advantage of developing standards is that they are suitable for incorporation by reference within the mandatory requirements of codes and standards.

Development of these guides and standards entails a tremendous amount of effort, and a debt of gratitude is due to everyone who has contributed their time and talent towards the development of these guides. There are many more opportunities to contribute – for a complete list of committees and task groups, visit *www.SFPE.org* and click on the "Technical" tab.

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

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

Corrections

1. The article entitled "Millennials – The New Source of Young Talent" in the Winter issue contained the following errors:
   - The word "Millennials" was misspelled on the cover and on pages 10-11.
   - In Figure 2, the values for school years 1997-98 and 1998-99 should be 28 and 22, respectively. Also, the source of the data in Figure 2 was the National School Safety Center.
   - There were errors in the data in Figures 1, 3 & 4. The corrected figures can be found at *http://fpemag.com/articles/article.asp?i=329*.
2. In Figure 1 on page 27, the labels for doctoral degrees and bachelor degrees were switched. Please see *http://fpemag.com/articles/article.asp?i=330* to view the correct chart.

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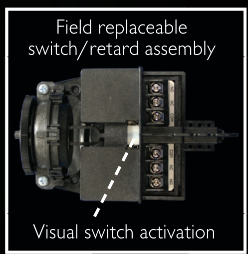

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By LCDR Doug Simpson, USCG

Transportation's changing. Although moving people and their stuff from here to there has always been important, transportation has never been more convenient or as integrated into society's daily routine as it is today. Transportation powers the workforce and supplies livelihoods. As the mobile population increases, so will the importance of transportation capabilities and infrastructure.

An online scan through various U.S. federal agency statistics reveals the same trend in all transportation sectors: throughput of highways, waterways, airports, seaports and pipelines is increasing. Even as congestion thickens, these sectors are being tasked to deliver more goods more rapidly.

This challenge is being met through expansion and the use of new technologies. In the maritime arena, ships are getting bigger and faster. Ports are expanding where they can, and when they can't, they are changing operations to leverage efficiency. Regardless how the face of transportation changes to meet increasing demands, the safe arrival of the people and things transported continues to be a fundamental requirement.

Fire protection's niche in transportation rests in this requirement, and expertise will be needed to effectively apply fire protection principles to transportation's changing designs, technologies and operations.

As an authority having jurisdiction over U.S.-registered vessels, the Coast Guard Marine Safety Center reviews the designs of high-occupancy ships for their compliance with domestic and international requirements.

Since ships are basically floating buildings, the requirements to which they are reviewed are remarkably similar to building code: How a space is used drives its boundary requirements, occupancy determines exit discharge component sizes, atria smoke must be managed and the like.

However, a building that floats and moves obviously introduces unique fire protection needs. Construction, exit discharge and emergency responder availability must all be considered when designing a ship's fire protection.

Concrete is too heavy to make an economically viable ship, so steel is typically used. Instead of the three-hour separation one might find on a land-based, concrete restaurant assembly, the most that is found on a steel ship is 60 minutes.

On land, it is possible to discharge a high-rise's occupants to ground-level safe refuge away from the affected building. Not so on a cruise ship, as salt water makes a poor substitute for a parking lot. Instead of exiting to ground level, exit paths must lead to protected refuge areas onboard. Since ships underway are further from assistance than typical buildings, they must often provide their own fire-fighting capabilities.

In the same way building code accounts for special-use facilities, the Coast Guard has policy and regulations that address unique design needs. For instance, high-speed passenger ferries are often built using aluminum, which is lighter than steel, to quickly move passengers along their commuting routes. Since it has a lower melting point, aluminum must be carefully insulated to provide protection similar to that of steel. In some applications, insulating the aluminum can be tricky and unwieldy, almost to the point of losing the benefit of its lighter weight. By implementing strict control of fire load in appropriate spaces, fire growth and heat-release potential are minimized, allowing for decreased insulation requirements and a lighter, faster ship.

The past few years have seen the maritime sector implement performance-based design. In 2001, the Coast Guard issued policy through its Navigation and Vessel Inspection Circular (NVIC) 3-01 that allows certain passenger vessels to use performance-based design as an alternative to meeting the prescriptive structural fire protection requirements contained in the Code of Federal Regulations. Internationally, the Convention for Safety of Life at Sea[1] (SOLAS) Chapter II-2, Regulation 17, entered into force in 2002, allowing for alternative designs to be evaluated and approved using performance-based principles.

The Coast Guard has reviewed vessels using both instruments and found that perhaps the most difficult (and beneficial) part of the process is agreeing to the entering arguments. From identifying heat-release rates to calculating response times, assigning mass fractions to applying toxicity, it is this exercise that digs into the first principles of fire protection and provides the most reasonable, safe engineering analysis.

As face of transportation changes, the requirement for people and their stuff to arrive safely at their destination remains unchanged. Fire protection engineers in the transportation industry have the opportunity and tools to provide creative, safe fire protection solutions while helping the transportation system remain flexible and robust.

LCDR Doug Simpson is with the U.S. Coast Guard Marine Safety Center.

References:

1 *International Convention of the Safety of Life at Sea, 1974, as amended,* International Maritime Organization, London, 2004.

Campaign Aims to End Fire Deaths Caused by Smoking Materials

On January 9, 2008, the U.S. Fire Administration (USFA) announced a Smoking & Home Fires Campaign to put an end to the number-one cause of preventable home fire deaths: fires started by smoking materials. The campaign is designed to alert smokers and those who live with smokers about simple steps they can take to stop the fire before it starts in their home. The USFA is encouraging smokers to "Put It Out. All the Way. Every Time."

"Most smoking-related home fires happen on beds, furniture or in trash when smokers do not put cigarettes all the way out, toss hot ashes in the trash or fall asleep while smoking," said U.S. Fire Administrator Gregory B. Cade. "Home fires caused by smoking can easily be prevented. It just takes a few seconds to light up – and a few seconds to make sure that cigarette is really out."

Every year about 1,000 people are killed in smoking-related home fires. According to the USFA, one in four people killed in home fires is not the smoker whose cigarette caused the fire. In fact, 34 percent were children of the smokers and 25 percent were neighbors or friends of the smokers. Too often, the victim is the firefighter trying to save them.

Campaign materials include a CD Toolkit with English and Spanish posters, brochures, fact sheets, public service announcements, PowerPoint presentations, an engaging video of a smoking-home fire demonstration and more. A video PSA for the Web is also available.

The materials are available online and can be ordered by visiting *www.usfa.dhs.gov/smoking.*

High Death Rates from Fire in Rural America

Communities with fewer than 2,500 residents have a per capita fire death rate almost twice the national rate. A joint project between the U.S. Fire Administration (USFA) and the National Fire Protection Association (NFPA) has been formed to examine what can be done to address this problem.

A new report, "Mitigation of the Rural Fire Problem – Strategies Based on Original Research and Adaptation of Existing Best Practices," provides implementation strategies for the reduction of rural fires. Some of the topics covered include fire protection and suppression; human issues, such as public fire safety education; and technical factors, such as fire and smoke detection, codes, consumer product safety and residential fire sprinklers.

Some of the key findings include:

- Rural communities have "separation" issues. The communications challenges some businesses face due to separation may impact the quality and ease of communication within and to a rural community. This is an example of something that may limit the distribution of safety information.
- Poverty was found to be the most significant factor driving the higher fire risk in rural America. Less income means potentially fewer resources to help prevent fire deaths.

The report includes "Train-the-Trainer" presentations for the rural fire service and community leaders on administering successful outreach programs, and a separate presentation for citizens highlighting key fire safety and preparedness messages.

For more information, go to *www.nfpa.org.*


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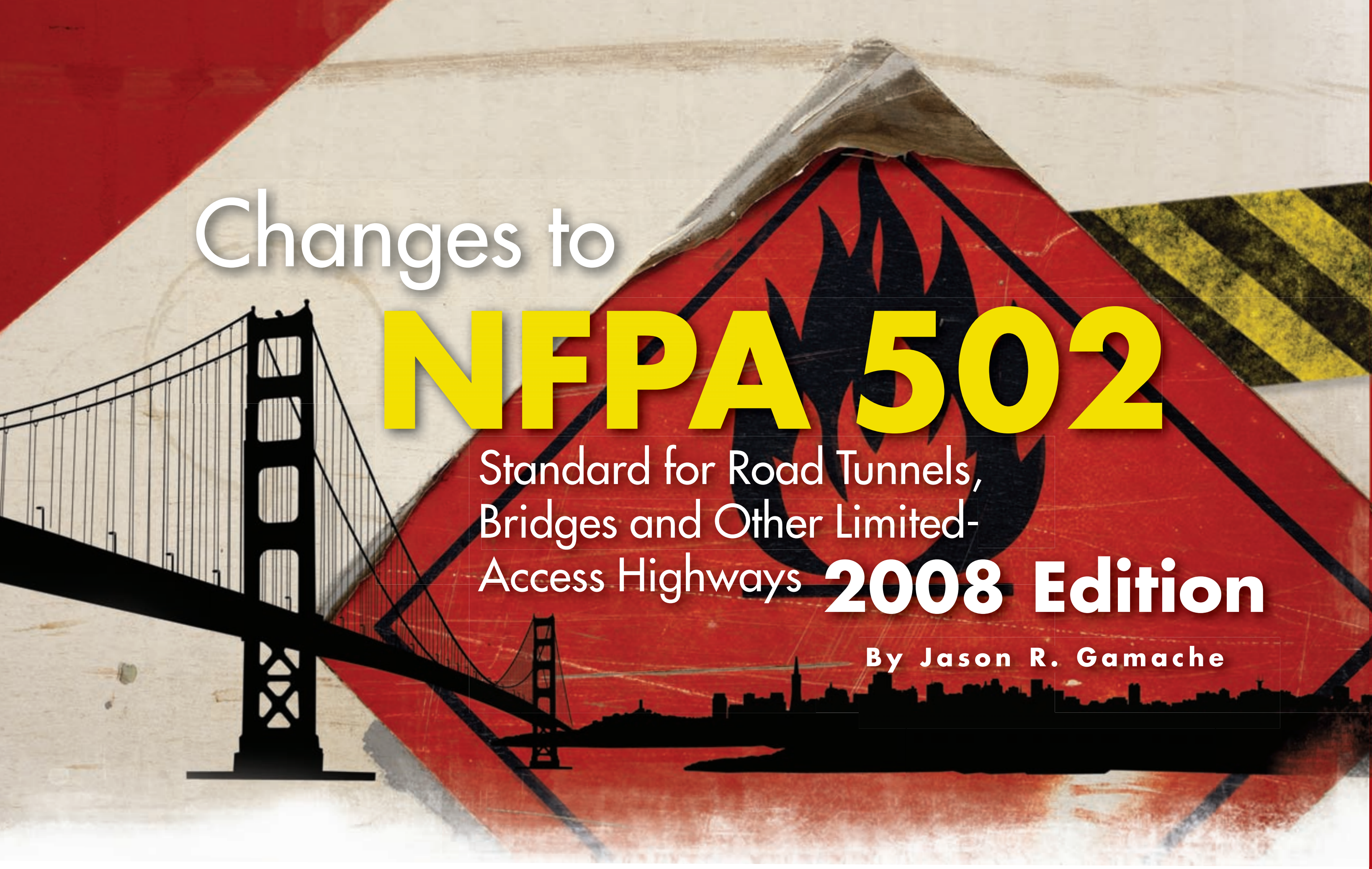
Changes to NFPA 502

Standard for Road Tunnels, Bridges and Other Limited-Access Highways 2008 Edition

By Jason R. Gamache



In recent years, road tunnel fires and subsequent international research projects have suggested that vehicle fires within tunnels are likely to develop more rapidly than expected, degrade the tenability of an environment more quickly than originally calculated, burn for longer periods of time and at higher temperatures, and resist intervention of fire-fighting operations.[1]

In light of this, the NFPA Technical Committee on Road Tunnel and Highway Fire Protection determined it was timely for NFPA 502, *Standard for Road Tunnels, Bridges and Other Limited-Access Highways,*[2] to revisit a number of its provisions with respect to fires in road tunnels. The 2008 edition includes revisions that further clarify the categorization of road tunnels; a revision of the discussion topics in the Annex on fixed fire-suppression systems; and revisions regarding ventilation and tenable environments, protection of structural elements, hazardous goods transport and design fire size.

In particular, there has been a broad reconsideration of the requirements and recommendations for:

- Fixed fire-suppression systems.
- Ventilation (and its effect on tenability of environment).
- Protection of structural elements.
- Hazardous goods transport.
- Design fire size.

FIRE-SUPPRESSION SYSTEMS

In the past, the use and effectiveness of fixed fire-fighting systems in road tunnels were not universally accepted. One of the reasons why most countries were reluctant to use fixed fire-fighting systems in road tunnels is that many fires start in the motor compartment of a vehicle, and fixed fire-fighting systems are of limited use in suppressing the fire until the fire is out in the open. Fixed fire-fighting systems can be used, however, to cool down vehicles, to stop the fire from spreading to other vehicles (i.e., to diminish the fire area and property damage) and to stop secondary fires in tunnel lining materials. Experiences from Japan show that fixed fire-fighting systems have been extremely effective in cooling down the area around the fire, so that firefighting can be performed more effectively.[3]

The 2008 edition of NFPA 502 now has annex language that acknowledges the use of fixed fire-fighting systems in road tunnels. Fixed fire-fighting systems can be used as part of an integrated approach to the management of safety. To be used, the fixed fire-fighting systems must be shown by engineering analysis to provide an acceptable level of safety. Additionally, an engineering installation, inspection and maintenance schedule must be developed to maintain the level of performance intended.

Where fixed fire-fighting systems are installed in road tunnels, they must be installed, inspected and maintained in accordance with the applicable NFPA standard for the design of the system.

The addition of water-based fixed fire-fighting systems in road tunnels also protects mechanical ventilation equipment from exposure to extreme heat conditions due to fire. Currently, mechanical ventilation equipment is required to be designed to remain operational for a minimum of 1 hour in an airstream temperature of 250°C (482°F). The use of water-based fixed fire-fighting systems will control the exposure temperature to the mechanical ventilation equipment and allow for proper operation of the ventilation equipment during a high-temperature fire.

NFPA 502 now contains the following responses to the major concerns expressed by tunnel designers, engineers and authorities regarding fixed fire-fighting system use and effectiveness in road tunnels:

Concern (1) Fires in road tunnels usually occur inside vehicles or inside passenger or engine compartments designed to be waterproof from above; therefore, fixed fire-fighting systems might not have an extinguishing effect.

Response: The purpose of a fixed fire-suppression system is to prevent fire spread to other vehicles so that the fire does not grow to a size that cannot be attacked by the fire service.

Concern (2) If any delay occurs between ignition and fixed fire-fighting system activation, a thin water spray on a very hot fire could produce large quantities of superheated steam without materially suppressing the fire.

Response: Fire tests have now shown this concern not to be valid.[4] A properly design fixed fire-fighting system suppresses the fire and cools the tunnel environment. Since a heavy-goods vehicle fire only needs 10 minutes to exceed 100 MW and 1200°C,[1] which are fatal conditions, it is important to operate the fire-suppression system as quickly as possible.

Concern (3) Tunnels are very long and narrow, often sloped laterally and longitudinally, vigorously ventilated and never subdivided, so heat normally will not be localized over a fire.

Response: Advances in fire detection technology have now made it possible to pinpoint the location of a fire in a tunnel with sufficient accuracy to operate a zoned fixed fire-fighting system.

Concern (4) Because of stratification along the tunnel ceiling, a number of the activated sprinklers would not, in all probability, be located over the fire. A large number of the activated sprinklers would be located away from the fire source, producing a cooling effect that would tend to draw this stratified layer of smoke down toward the roadway level, thus impeding the rescue and fire-fighting effort.

Response: Any activated fixed fire-fighting system not over the fire would cool the tunnel to help rescue services to intervene. Zoned systems are released by a detection system that is accurate even with forced ventilation.

Concern (5) Water spraying from the ceiling of a subaqueous tunnel could suggest tunnel failure and induce panic in motorists.

Response: This was a hypothetical concern not borne out in practice. In the event of fire, motorists are likely to recognize water spraying from nozzles as a fire safety measure. Behavioral studies have shown that people do not panic in a fire, even when they are unable to see.[5]

Concern (6) The use of sprinklers could cause the disruption of the smoke layer and induce turbulence and mixing of the air and smoke, thus further threatening the safety of persons in the tunnel.

A fixed fire-fighting fire-suppression system reduces temperatures and the risk of fire spread to other vehicles.

Response: This has been shown not to be a valid concern. Fire tests have demonstrated that smoke does not usually form a layer at the top of the tunnel but quickly fills the cross-section. Normal air movement in the tunnel accelerates this process.[6] A fixed fire-fighting fire-suppression system reduces temperatures and the risk of fire spread to other vehicles.

Concern (7) Testing of a fixed fire-fighting system on a periodic basis to determine its state of readiness could be impractical and costly. Inspection can be performed when other facilities are inspected.

Response: A full discharge test is normally only performed at system commissioning. During routine testing, the system can be configured to discharge flow to the drainage system.

PROTECTION OF STRUCTURAL ELEMENTS

The 2004 edition of NFPA 502 introduced new requirements for the protection of structural elements. In the 2008 edition, several requirements were added to further support this important function of the tunnel as it pertains to user safety.

Regardless of tunnel length, all primary structural concrete and steel elements are required to be protected in accordance with this standard in order to:

- Maintain life safety and provide a tenable environment.
- Mitigate structural damage and prevent progressive structural collapse.
- Minimize economic impact.

The structure is required to be capable of withstanding the Rijkswaterstaat (RWS) (Netherlands) time/temperature curve,[7] or other curve that is acceptable to the authority having jurisdiction.

Table 1. Time-Temperature Development.

Time (minutes)	Temp ºC	(ºF)
0	20	68
3	890	1634
5	1140	2084
10	1200	2192
30	1300	2372
60	1350	2462
90	1300	2372
120	1200	2192

The time/temperature development is shown in Table 1. After a 120-minute period of fire exposure, the following failure criteria must be satisfied:

(1) Tunnels with cast in-situ concrete structural elements shall be protected such that:
- The temperature of the concrete surface does not exceed 380°C (716°F).
- The temperature of the steel reinforcement within the concrete [assuming a minimum cover of 25mm (1 in)] does not exceed 250°C (482°F).

(2) Tunnels with precast, high-strength concrete elements shall be protected such that explosive spalling is prevented.

(3) Steel or cast iron tunnel linings shall be protected such that the lining temperature does not exceed 300°C (572°F).

(4) Structural fire protection materials shall satisfy the following performance criteria:
- They shall be noncombustible in accordance with ASTM E 136[8] or equal international standard.
- They shall have a minimum melting temperature of 1350°C (2462°F).
- They shall not produce toxic smoke or fumes under a fire exposure in accordance with ASTM E 84[9] or equal international standard.
- They shall meet the fire protection requirements with <5% humidity by weight and also when fully saturated with water in accordance with RWS Fire Test Procedure 1998-CVB-R1161 (Rev 1).[7]

(5) Any fire protection material should satisfy the following performance criteria:
- Be resistant to freezing and thawing;
- Withstand dynamic suction and pressure loads;
- Withstand both hot and cold thermal shock from fire exposure and hose streams;
- Meet all applicable health and safety standards;
- Not itself become a hazard during a fire; and
- Be resistant to water ingress.

The level of fire resistance of structures and equipment must be proven by testing or reference to previous testing.

Fire tests must meet the following requirements:

- Concrete slabs used for the application of fire protection materials for fire testing purposes have dimensions of at least 1400x1400 mm and a nominal thickness of 150 mm.
- The exposed surface will be approximately 1200x1200 mm.
- The fire protection material must be fixed to the concrete slab using the same fixation material (anchors, wire mesh, etc.) as will be used during the actual installation in the tunnel.
- In the case of board protection, a minimum of one joint in between two panels must be created to judge if any thermal leaks will occur in the case of a real fire in the tunnel.
- In case of spray materials, the number of applications (amount of layers) must be recorded when preparing the test specimen. The same number of layers must be used when applying the spray material in a real tunnel.
- Temperature recordings must be made by thermocouples located at the interface in between the concrete and the fire protection material, at the bottom of the reinforcement and on the nonexposed face of the concrete slab.

The installation of fire protection materials should be done with anchors having the following properties:

- The diameter should be limited to maximum of 6 mm (0.25") in order to reduce the heat sink effect through the steel anchor into the concrete. It is reported that thicker anchors can create a local spalling effect of the concrete.6 This local effect is only temporary because the spalling can spread over the surface once a small part of the concrete is directly exposed to fire.
- The use of stainless steel anchors is recommended. Types that can be used are A4, 316, 1.4401 and 1.4571. In some countries, even higher requirements are applied, such as 1.4529.
- If necessary, a washer must be used to avoid a pull-through effect when the system is exposed to dynamic loads.
- The anchors should be suitable for use in the tension zone of concrete (cracked concrete).
- The anchors should be suitable for use under dynamic loads.

TENABLE ENVIRONMENT

The 2008 edition includes a complete revision to the Annex material relating to tenable environment. This is intended to correlate with the material in NFPA 130, *Standard on Fixed Guideway Transit and Passenger Rail Systems.*[10] The purpose of the Annex is to provide guidelines for the evaluation of tenability within the tunnel evacuation paths. Current technology is capable of analyzing and evaluating conditions to provide proper ventilation for emergency conditions.

The same ventilating devices might or might not serve both normal operating conditions and emergency requirements. The goals of the ventilation system, in addition to addressing fire and smoke emergencies, are to assist in the containment and purging of hazardous gases and aerosols, such as those that could result from a chemical/biological release.

Environmental conditions, geometric considerations and time considerations should be taken into account. Some factors that should be considered in maintaining a tenable environment for periods of short duration are:

Heat Effects. Exposure to heat can lead to life threat three basic ways:

- Hyperthermia,
- Body surface burns, and
- Respiratory tract burns.

For use in the modeling of life threat due to heat exposure in fires, it is necessary to consider only two criteria—the threshold of burning of the skin and the exposure at which hyperthermia is sufficient to cause mental deterioration and thereby threaten survival.

Air Carbon Monoxide Content. Air carbon monoxide (CO) content should be as follows:

- Maximum of 2000 ppm for a few seconds;
- Averaging 1150 ppm or less for the first six minutes of the exposure;
- Averaging 450 ppm or less for the first 15 minutes of the exposure;
- Averaging 225 ppm or less for the first 30 minutes of the exposure;/
- Averaging 50 ppm or less for the remainder of the exposure; and
- These values should be adjusted for altitudes above 1000 m (3000 ft).

Smoke Obscuration Levels. Smoke obscuration levels should be continuously maintained such that a sign internally illuminated at 80 lx (7.5 ft-candles) is discernible from 30 m (100 ft), and doors and walls are discernible from 10 m (33 ft).

Air Velocities. Air velocities in the enclosed tramway should be $\geq$ 0.76 m/s (150 fpm) and $\leq$11.0 m/s (2200 fpm).

Noise Levels. Noise levels should be a maximum of 115 dBA for a few seconds and a maximum of 92 dBA for the remainder of the exposure.

REGULATED AND UNREGULATED CARGOES

Recent road tunnel fires suggest that goods traditionally not characterized as "hazardous," e.g., flour

and margarine (1999 Mont Blanc Tunnel), paint (1999 Gothard Tunnel) and tires (2005 Frejus Tunnel), may constitute a greater risk to tunnel users and tunnel structures than expected. As a result, Chapter 13, "Control of Hazardous Materials," has been retitled "Regulated and Unregulated Cargoes" to provide guidance on developing rules regarding any and all cargoes traveling through the tunnel.

The authority having jurisdiction must adopt rules and regulations that apply to the transportation of regulated and unregulated cargoes. Design and planning of the facility must address the potential risk presented by regulated and unregulated cargoes.

When developing rules and regulations, fire, accident and research experience of the vehicles and cargo of the type expected within the tunnel, particularly of goods and vehicles not normally characterized as hazardous or otherwise regulated, should be considered. Some types of cargos not normally considered hazardous may, in certain circumstances, in confined spaces within tunnels behave as, or equivalent to, hazardous materials in terms of the rate of fire growth, the intensity of the fire, discharge of noxious materials, destruction to infrastructure and threat to users' safety.

In developing regulations, the following must be addressed:

1. Population density.
2. Type of highway.
3. Types and quantities of hazardous materials.
4. Emergency response capabilities.
5. Results of consultation with affected persons.
6. Exposure and other risk factors.
7. Terrain considerations.
8. Continuity of routes.
9. Alternative routes.
10. Effects on commerce.
11. Delays in transportation.
12. Climatic conditions.
13. Congestion and accident history.

These revisions to the standard are intended to correlate NFPA 502 with the current state-of-the-art research and technology and provide tunnel designers, engineers and authorities with an immediate source for requirements for creating a fire safe tunnel environment.

DESIGN FIRE SIZE

Large-scale fire tests[11] have shown that vehicle fires within tunnels are likely to develop more rapidly and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have higher peak heat release rates than expected. The results of these tests have led to the revision of Table A.10.5.1, "Fire Data for Typical Vehicles," which now reads as follows:

- Car 5-10 MW
- Multiple passenger cars (2-4 vehicles) 10-20 MW
- Bus 20-30 MW
- Heavy goods truck 70-200 MW
- Tanker 200-300 MW

There are substantial increases over the 2004 edition values of 20 MW for buses, 20-30 MW for heavy goods trucks and 100 MW for tankers. In addition, a value has been added for multiple passenger car fires.

Jason R. Gamache is with the National Fire Protection Association.

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Fire Scene Reconstruction Using Computer Modeling

By Flora Chen, P.E.

The NFPA 921 *Guide for Fire and Explosion Investigation*[1] is one of the most commonly accepted protocols of practice in the fire investigation community. The guide identifies the scientific method as the most appropriate basis for undertaking complex fire investigations. In the context of using the scientific method, fire engineering analysis is an important aspect of advanced forensics.

Fire Dynamics Simulator (FDS),[2] commonly recognized and used in fire engineering, has been embraced by the

Table 1. Fire victims.

Victims	Ages	Positions
Victim 1	Adult male	At the entrance of the hallway, face down, as if he was going toward the bedrooms.
Victim 2	9 years	Just below the window at the foot of the bed.
Victim 3	5 years	In the top bunk bed.
Victim 4	5 months	In the crib.

forensic fire investigation community for complex analyses.[3] The broad acceptance of FDS has resulted in part because of its availability at no cost, and in part due to its capability of displaying information visually in three dimensions. FDS has been used to study, model and investigate a wide variety of fires, from the World Trade Center to apartments, mansions, LPG spills, fireplaces, flame rollout and gas diffusion.[4]

This article discusses fire scene reconstruction by FDS via a case study of a fatal mobile home fire in December 2005 in Peoria, Arizona. The model is used to investigate the fire ignition, growth and spread, ultimately revealing the plight of the fire victims. The fire resulted in four deaths, one adult and three children, as detailed in Table 1.

FIRE SCENE RECONSTRUCTION

The prefire condition was determined through scene inspection and from interviews, diagrams and photographs. The plan view in Figure 1 and the elevation view in Figure 2 depict a single-story mobile home manufactured in 1982. The gross building area was about 820 square feet (76 m^2), constructed with a plywood interior and sheet metal exterior. There were no fire alarm systems or sprinklers installed.

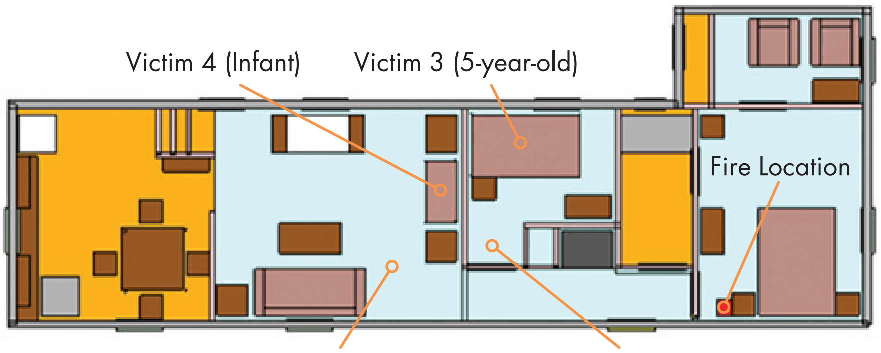

Figure 1. Plan view.

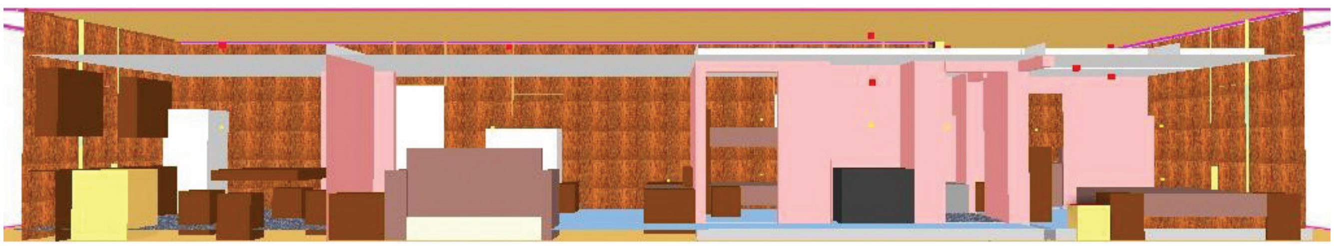

Figure 2. Elevation view.

The fire area of origin represented in the model (Figure 3) was carefully reconstructed because of the importance of properly predicting the impact of the configuration and initial fuel load on the fire growth. For a number reasons, it was not feasible to reconstruct the fire scene exactly. While major furnishings were placed in the model, some minor contents outside of the area of origin were not input in the model. Examples of items that were not modeled include clothing and kids' toys. It is believed that these miscellaneous combustible fuel items would not dramatically change the fire sequence or the analysis results in the context of the overall scale of the simulation. Sensitivity analyses were conducted to confirm this belief.

FIRE DEVELOPMENT

Based on a preliminary investigation of the fire, it was determined that the subject fire was not started by electrical causes, smoking, ignitable liquids or natural gas. The point of fire origin was in one of the bedrooms, as determined from available evidence and information. The ignition source was suspected to be a candle, which the occupants were known to use as part of their normal routine. The candle ignited a trash can next to it.

The surviving family member, who was out of home at the time of fire started, denied that the candle was lit when she left the house. This left the fire cause as "undetermined."

The fire was determined to have started in a trash can located in the master bedroom, as shown in

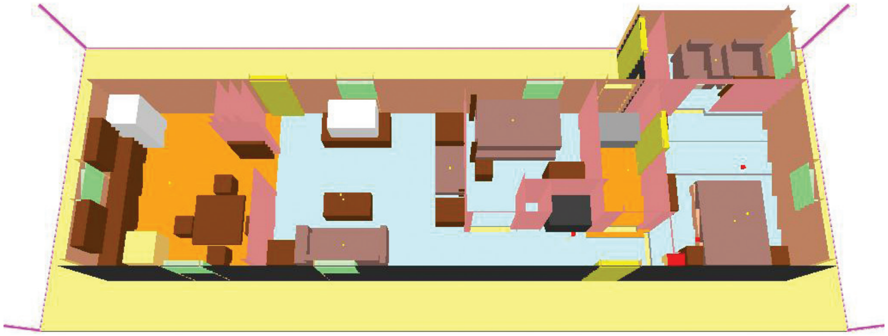

Figure 3. FDS model of house.

Table 2. Initial design fire inputs.

Initial Fires	Description
Fire Scenario 1 (Figure 4)	Two trash bags, total mass=2.34 kg (5.1 lbs).
Fire Scenario 2 (Figure 5)	One trash bag, total mass=1.17 kg (2.6 lbs).
Fire Scenario 3 (Figure 6)	A free burn of a small bathroom-size (6.6 liters) plastic wastebasket stuffed with 12 milk cartons. The input fire was assumed to ramp 50 kW in 10 seconds, decay after 200 seconds of stable burning and go out after 300 seconds.

Figure 1. Therefore, trash bag design fire inputs were applied in the model.

The *SFPE Handbook*[5] indicates that a small bathroom-size (6.6 liters) plastic wastebasket stuffed with twelve milk cartons exhibits a heat release rate of about 50 kW for about 200s. The *Handbook* further indicates that the range of 50 kW to 300 kW covers the bulk of the expected fires from normal residential, office, airplane or similar occupancy trash bags and trash baskets. Three fires were developed to represent the fire in the model, as listed in Table 2.

Fire Scenario 1 was used as the base case. Fire Scenarios 2 and 3 were studied as part of a sensitivity analysis. The sensitivity analysis was undertaken because of the importance of understanding the impact of varying design fire conditions on the overall confidence of the model.

RESULTS AND ANALYSES

The onset of flashover usually occurs when the upper-layer temperature reaches 500°C (900°F) to 600°C (1100°F) and the direct radiation at floor level reaches about 20kW/m^2. In a small-scale experimental compartment, flashover was reported to occur at 450°C (850°F).[6] In general, it is not possible to survive a post-flashover fire because of the high temperatures, high concentrations of toxic gases and the low oxygen concentration.

The model determined that the ceiling was ignited at around 2.2 minutes. Flashover in the room of origin occurred at around four minutes, and then fire spread into the hallway. The living room was involved in the fire at 7.5 minutes, and finally the kitchen was involved at 8.5 minutes. The fire development is outlined in Figure 7.

Figure 8 shows the fire after one minute, and Figure 9 depicts the flame spread pattern, which corresponds with evidence collected at the fire scene. The modeled couch located in the living room (Figure 10) demonstrated an excellent correlation with the scene photograph (Figure 11).

To quantify the likely time when the fire victims lost the capability to escape, both toxicity effects and heat effects were evaluated. A practical method for evaluating the effects of toxic fire gases on people is the concept of Fractional Effective Dose (FED).[7] In the context of the modeling effort, data sampling points were placed in the model at locations where the victims were found.

The incapacitation times calculated using the FED are summarized in Table 3. The data indicates that the heat and toxicity of fire gases would cause incapacitation of the victims at approximately the same time. The data reveals that the fire victims likely lost their capability to escape within six to seven minutes of the start of the fire, which was before flashover. Children will take up CO much more rapidly than adults and succumb to it much earlier.[7] Therefore, the predicted incapacitation time is likely overpredicted for the children.

The impact of carbon monoxide adequately explains the death of the adult victim. Loss of consciousness would occur at approximately 40% COHb but can occur at lower levels.[7] Death is predicted at COHb concentrations of 50% to 70% but could also occur at lower concentrations.

It has been determined that the adult victim had ingested some alcohol before falling asleep on the couch in the living room. During the early stages of the fire, the CO effects likely put him into a state of deeper sleep. Following the breaking of glass due to the occurrence of flashover in the fire room of origin, the adult male would have likely awakened. The action of rising from a horizontal sleeping position to an upright walking position would have resulted in an increase in CO uptake, subsequently resulting in a rapid collapse adjacent to the couch, where he was found. The adult male's position on the ground at the entrance of the hallway with his face down, as if he was going toward the bedroom, was very consistent with the rational analysis.

Heat exposure could have also been a factor. $2.5 kW/m^2$ is the tolerance limit of radiant heat.[7]

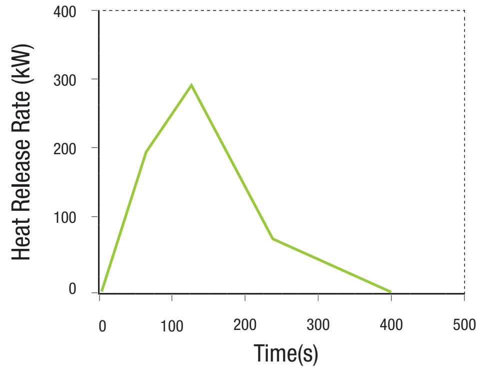

Figure 4. Fire Scenario 1.

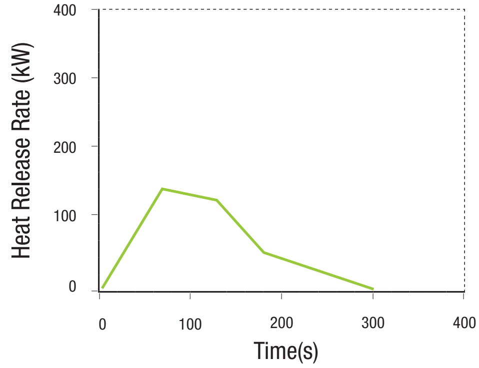

Figure 5. Fire Scenario 2.

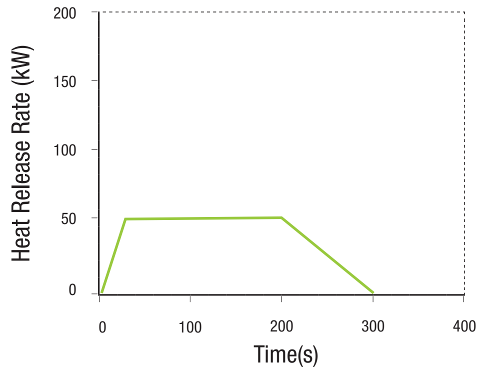

Figure 6. Fire Scenario 3.

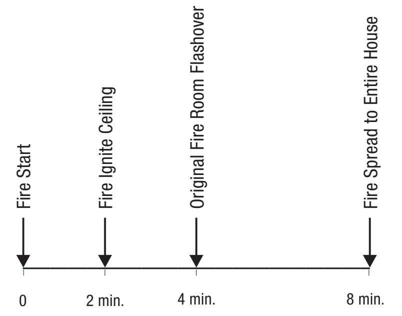

Figure 7. Fire development time line.

Figure 8. Fire growth in the model (t=1min).

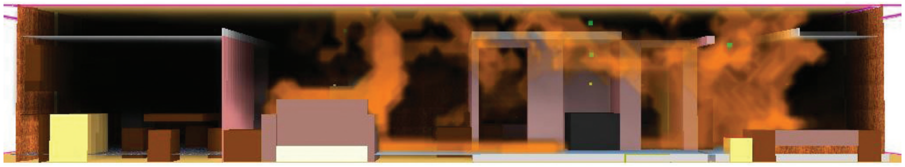

Figure 9. Fire spread in the model (t=7.5 min).

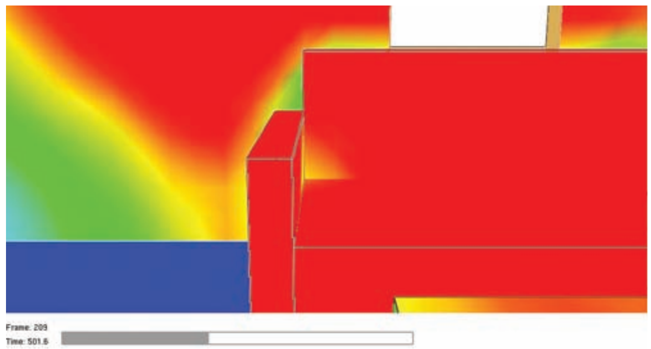

Figure 10. Burning rate of the couch in the model.

Figure 11. Scene photograph of the couch in the living room.

Below this intensity, radiant heat can be tolerated for several minutes, but above this intensity, occupants can only remain functional for a few seconds prior to becoming incapacitated. A thermal limit from convected heat is 120°C (248°F)[7] for unprotected skin. Above this temperature, considerable pain is quickly incurred along with burns. Depending upon the length of exposure, convective heat below this temperature may result in incapacitation due to hyperthermia.

A time period of 10 to 12 minutes is the estimated time that had elapsed prior to the fire condition being recognized, reported and responded to by the fire department. Victims would have likely lost their ability to escape within six to seven minutes. At the time the fire department arrived at the scene, the survival window for the victims was extremely small.

Table 3. Summary of incapacitation time.

Locations	Incapacitation	Incapacitation	Predicted
	Time caused from toxicity of gas (seconds)	Time caused from heat exposure (seconds)	Incapacitation time (seconds)
Couch in Living Room (Victim 1, Sleeping Position)	400	400	**400**
Living Room (Victim 1, Standing Up)	500	400	**400**
Bedroom (Victim 2, Crawling Position)	400	400	**400**
Bedroom (Victim 3, Sleeping Position)	500	400	**400**
Crib in Living Room (Victim 4, Sleeping Position)	400	400	**400**

SENSITIVITY ANALYSIS

Sensitivity analysis is used to determine how a given model output depends upon the input parameters. This is an important step for checking the quality and reliability of the model findings. If a small change in an input value results in a large change in the output, the output is said to be sensitive to that input parameter. This means the input parameter should be determined accurately in order to achieve a reasonable result. When a change in the parameter produces only a minor change in the output, the output is said to be not sensitive to that parameter. This means that the accuracy of that input is of lesser significance.

Six fire scenarios with four input fires were studied to evaluate the sensitivity of the simulation results to initial input fires. The results are summarized in Table 4. It should be noted that the scenarios employing upholstered material on all surfaces of the end table next to the trash can were used to simulate the effects of miscellaneous combustibles around the area of fire origin.

The results indicate that both the peak heat release rate and the average heat release rate are independent of the initial fires once free-burning combustion was established. The simulation results further demonstrated that the smaller design fire would take a longer time to reach flashover.

The configurations of the point of origin were shown to have a significant impact on the fire growth and flashover time. An additional finding of the study is that the combustibility of the ceiling plays a critical role in the fire spread in the dwelling. If the ceiling were not combustible, the fire would not necessarily have penetrated into the attic, subsequently spreading into the other rooms. If both the ceiling and walls were noncombustible, the fire might have been contained in the room of origin.

The study also examined the sensitivity of the assumed ignition temperature of a plywood interior wall. An ignition teperature of 346°C is a reasonable value for plywood.[8] Babrauskas[9] indicates a range of 210°C-497°C for piloted ignition and 200°C-500°C for auto ignition and direct-flaming ignition normally is caused at the surface temperatures of 300°C-365°C. Therefore, the ignition temperatures of 280°C, 350°C and 390°C were selected to evaluate the sensitivity to this parameter.

Table 4. Summary of sensitivity analyses of initial fires.

Initial Fires	Fire Spread	Time to Flashover (seconds)	Peak HRR (MW)	Average HRR (MW)
Fire Scenario 1	Yes	350	22	15
Fire Scenario 2	No	N/A	N/A	N/A
Fire Scenario 2 with a doily on the end table next to the trash can	Yes	370	22	15
Fire Scenario 3 with a doily on the end table next to the trash can	No	N/A	N/A	N/A
Fire Scenario 3 with upholstered material on all surfaces of the end table next to the trash can	Yes	870	22	15
15 kW fire source with upholstered material on all surfaces of the end table next to the trash can	No	N/A	N/A	N/A

The results shown in Figure 12 indicate that the lower ignition temperature would result in a faster flashover and higher peak heat release rate. The steady heat release rate is not sensitive to this factor.

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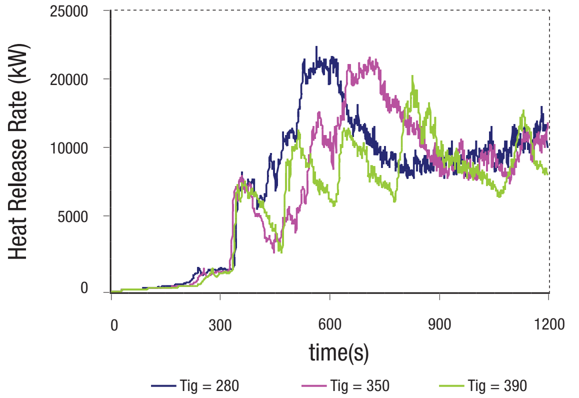

Figure 12. Sensitivity to interior ignition temperature.

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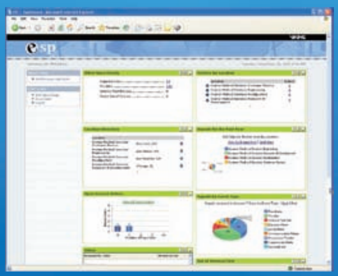

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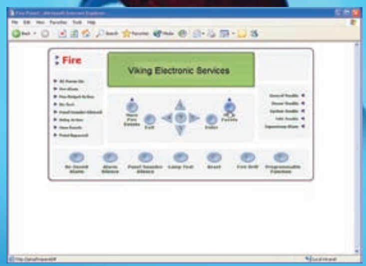

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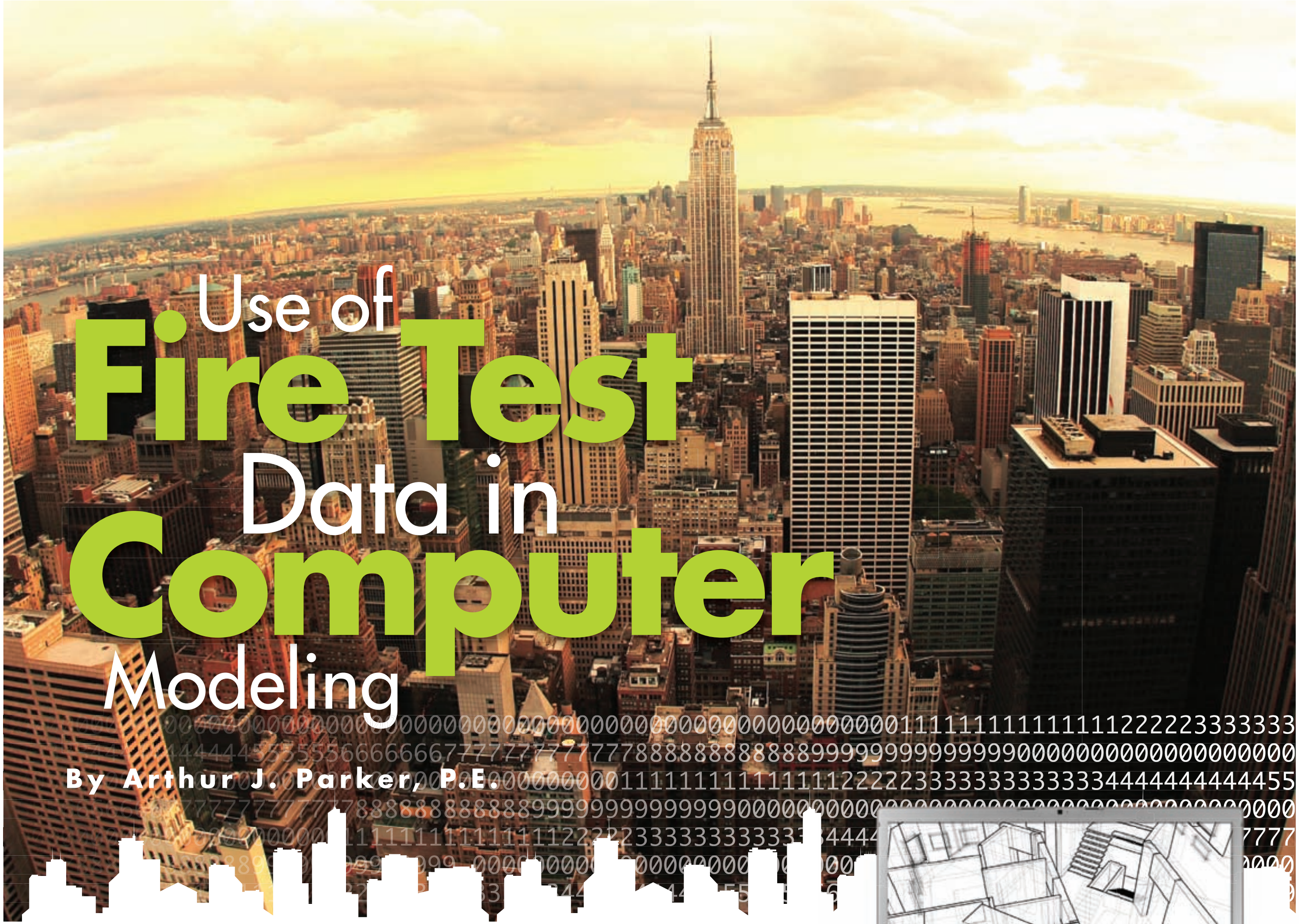
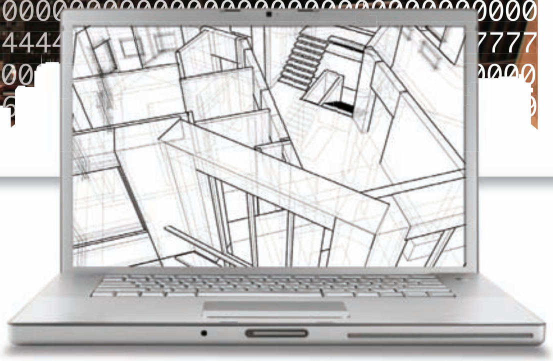


Use of Fire Test Data in Computer Modeling

By Arthur J. Parker, P.E.



INTRODUCTION

Fire protection engineering is in the early stages of transitioning from designing buildings to meet prescriptive code requirements to utilizing performance-based design (PBD) solutions. One important element of the PBD process is the use of computer models. These models are used to predict heat transfer, fire and smoke spread, detector activation, building occupant egress and many other fire-related phenomena.

While the predictions made by computer models differ, basic inputs are needed to initiate the calculation process and provide useful results. Typical model inputs include characterizing the building geometry, such as the location and size of the space and ventilation/compartment connection openings; location of fire protection equipment; and material properties of room boundaries, such as thermal conductivity, density, specific heat capacity and thickness.

How the fire impacts the fire protection features in the building being investigated depends on many factors. When performing fire modeling, these factors are represented as inputs into the fire model. Inputs describing the fire include burning rate, heat of combustion, gas yields, and carbon dioxide and soot yields.

These inputs are generally determined from testing materials in either standard test configurations or in specially designed fire tests where additional instrumentation is included to characterize the impact of the fire on the structure or assembly being evaluated.

When modeling a fire with a well characterized fuel source and a known heat release rate, such as alcohol or polymethylmethacrylate (PMMA), the modeling effort is relatively easy. The modeling effort becomes more difficult when the goal is to predict the heat release rate for a particular fire scenario in advance of conducting a test and the fuel chemistry values are unknown or not well characterized. This article describes how these parameters

are measured and developed, and how they are input into fire models to solve real-world problems.

Prescriptive requirements for conducting fire performance evaluations of products, materials and assemblies are currently provided in building codes; federal regulations, such as the Code of Federal Regulations (CFR); military specifications (MIL SPECS); and industry standards. Standard fire resistance tests, such as ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction Materials,*[1] provide an hourly fire resistance rating based on subjecting a test sample to a prescribed time-temperature exposure.

An hourly fire resistance rating provides little useful input data for computer modeling purposes. Other standard fire test methods, such as NFPA 286, *Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth*[2] (Room-Corner Test), and ASTM E 1354, *Standard Test Method for Heat and Visible Smoke Release Rated for Materials and Products Using an Oxygen Consumption Calorimeter*[3] (Cone Calorimeter), directly measure the heat release rate and smoke production of the sample being evaluated.

In the NFPA 286 Room-Corner Test, full-scale fire performance of interior finish materials is assessed, while in the ASTM E 1354 Cone Calorimeter small-scale test samples (100 mm x 100 mm) are exposed to various incident heat flux levels. The data generated from the Room-Corner test and from the Cone Calorimeter test provide useful heat and smoke release data for computer modeling purposes.

In standard fire resistance tests, inclusion of additional instrumentation in the test specimen or inside the test furnace can provide data describing heat transfer to the test sample, through the layers of the assembly or to nearby surroundings. One aspect of conducting a heat transfer analysis through an assembly subjected to a well-characterized fire exposure is to verify and validate (V&V) computer models. Improved fire performance data will permit appropriate V&V of models for use in PBD where the baseline test data may be different than the modeled scenario.

APPLICATION OF TEST DATA

For certain applications, the "standard" suite of test data may be sufficient, if applied correctly. In other instances, increased instrumentation is required to adequately understand the assembly reaction

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to a specified fire exposure and provide useful data to allow application to real-world problems.

Various organizations are developing documents or standards to provide the fire protection engineer guidance on how to quantify existing conditions and apply test data during a PBD process. The National Fire Protection Association (NFPA) Hazard and Risk of Contents and Furnishings technical committee is working on the development of NFPA 557, *Standard for Fire Loads for Engineering Design of Structural Fire Resistance in Buildings*. This document is intended to support PBD analysis by establishing a basis for selecting fire loads in calculating the fire resistance of structural building elements. This type of information can be used to develop the design fire for assessing the fire performance of a structure or assembly.

The Society of Fire Protection Engineers (SFPE) is developing two standards to address methods for calculating fire exposures to building structures and predicting the thermal performance of fire-resistive assemblies to expected (nonstandard) fire exposures. All of these ongoing efforts feed into providing data which can be input into computer models to predict material or system performance under varying exposure conditions. The key for this approach to work is to adequately instrument the test assemblies in such a manner that the proper amount and type of data are generated.

Two examples of this type of analysis are provided below to illustrate how computer models have been used to predict product performance in meeting the building code requirements based on standard fire test configurations with and without extra instrumentation.

HEAT TRANSFER ANALYSIS OF INSULATION MATERIALS

Ventilation for a specialized 13-story laboratory building includes dedicated supply and exhaust ducts serving each laboratory floor. Due to clearance constraints, the ductwork was located in the overhead of the floor below the floor the ventilation system served. Fire dampers were required to be installed in each run of ductwork which penetrated the fire-resistance-rated floor slab to maintain the rating of the floor.

The building owner indicated that, given the large number of fire dampers that would be required to be installed in the building, the inspection and maintenance required to maintain the dampers over the life of the building could pose an issue.

An analysis was conducted to evaluate the feasibility of eliminating the fire dampers by protecting each dedicated run of ductwork within a rated enclosure system such that it would be considered a fire-resistance-rated shaft assembly. By creating a fire-resistance-rated duct assembly, these dedicated ducts could be considered rated shafts, and fire dampers could be eliminated.

Due to the specialized nature of the laboratory, the exhaust ducts were provided with dedicated power such that they would always operate, even during a fire event. A fire was conservatively assumed to be drawn into the ductwork from a breach of an unprotected section of the ductwork located within the fire zone. An analysis was conducted to establish installation requirements such that a fire located inside the ductwork would not cause ignition of combustible materials installed near the duct, as well as contain the fire within the duct.

Full-scale fire testing was conducted to confirm that a single 38-mm-thick layer of ceramic fiber insulationinstalled on the exposed side of areinforced steel duct assembly would achieve a two-hour fire-resistance rating. For an external fire engulfing the ductwork, this successful test confirmed that fire would not be expected to breach to the inside of the ductwork.

Using this test data, the finite-element (FEM) heat transfer model HEATING 7[4] was implemented to estimate the specific heat and thermal conductivity of the insulation. The thickness and density of the insulation material were well characterized prior to the test and reported in the final test report.

After reproducing the test measurements using the known fire exposure and the insulation material properties, the fire performance of the insulated duct was assessed. The results of the modeling predicted that the insulation surface temperature after 120 minutes of exposure was approximately 200°C and approximately 480°C under a standard ASTM E 119 thermocouple pad.

Given the large unexpected disparity in predicted surface temperatures (with and without the thermocouple pad cover), a small-scale fire-resistance test was conducted to measure the temperature profile through the

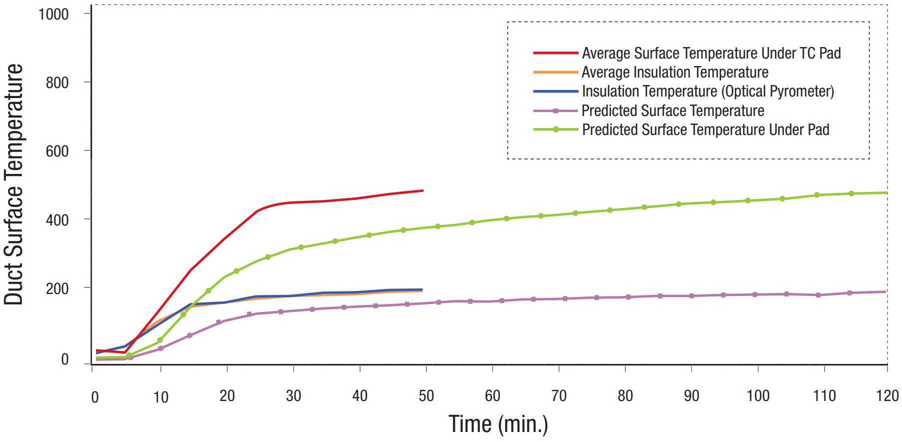

Figure 1. Measured and predicted unexposed insulation duct surface temperatures.

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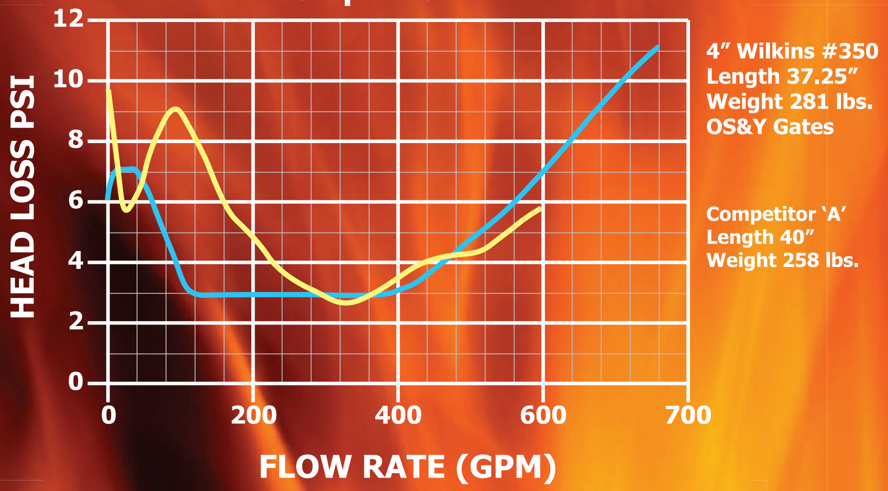

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insulated assembly. A steel panel was insulated on the unexposed side with a single layer of 25-mm-thick ceramic fiber insulation material. Thermocouples covered with the ASTM E 119 thermocouple pads were installed on the unexposed surface. A bare thermocouple was placed on the surface of the insulation material immediately adjacent to each ASTM E 119 thermocouple pad. An optical pyrometer was positioned to measure the surface temperature at the center of the unexposed surface. Additional thermocouples were installed at the steel/insulation interface located underneath the ASTM E 119 thermocouples.

The unexposed transient surface temperatures measured by the thermocouples with and without the ASTM E 119 insulating pad are shown in Figure 1. The measured test data was in general higher than the predicted temperatures due to insulation material installed on the tested assembly being 33% thinner than used in the model (due to availability). Disregarding the absolute temperature comparison, the measured difference in the surface temperature (with and without the ASTM E 119 thermocouple pad cover) was similar to the predicted surface temperatures. The results of this test indicated that the model predictions were applicable and the analysis results were valid within the context of the analysis conclusions.

As a result of this analysis, it was demonstrated that each run of dedicated ductwork could be considered to be a fire-resistance-rated shaft enclosure from the point of penetration of the rated fire zone boundary to the point of discharge, and fire dampers were not required to be installed in the floor line.

TENABILITY CONDITIONS AND OCCUPANT EGRESS

A product intended to function as an interior finish material for walls or ceilings incorporated a plastic facing material. To meet the interior finish requirements specified in the building codes, this exposed plastic surface was required to be classified as a Class A material when tested in accordance with ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*.[5]

Testing was conducted in accordance with the alternate interior finish materials provisions of the building code, which permits evaluating the fire performance of a material in accordance with NFPA 286.[2] The test results indicated that when the material was installed on the walls only or the walls and ceiling, limited flame spread was observed, but the smoke production limits were exceeded. Computer fire modeling was used to determine if the installation configurations, which did not meet the building code requirements, would not be expected to result in the development of untenable conditions within the installed configurations, thus impeding occupant egress.

The Consolidated Fire and Smoke Transport (CFAST) computer model[6] was used to predict the smoke spread, smoke accumulation and reduction in visibility within various unsprinklered building configurations. The predicted times for the development of untenable conditions were compared to the predicted egress times to assess if the building occupants would be expected to safely egress the building during a fire event.

The egress time must be greater than the time to reach untenable conditions in order for the occupants to safely egress the building. The time for the development of untenable conditions was defined as the time when either the smoke accumulation limited visibility to less than 10 m or the smoke layer descended to 1.8 m above the floor.

Fire and smoke conditions within the test arrangement were simulated based on the data generated during the Room-Corner test. Upper-layer temperatures were measured within the test compartment, and heat release rate and smoke production were measured within the exhaust hood.

The test compartment/hood configuration was replicated as the test compartment in CFAST. The total measured heat release rate curve (burner input and the contribution from the interior finish material) was used as the fire input to for the model. The smoke production measured in the exhaust duct was

modeled by adjusting the carbon/carbon dioxide (C/CO_2) ratio until the predicted and measured total smoke release rates matched.

Smoke spread modeling was performed to determine the rate at which smoke accumulated, formed an upper layer and descended within the specific building configuration being evaluated. CFAST calculated a smoke layer height (measured above the floor) as a function of time and an optical density (OD) which was used to calculate a visibility.

Comparison of the calculated egress times and times for the onset of untenable conditions indicated that the occupants would be expected to be capable of exiting from the building before the onset of untenable conditions. These analysis results indicated that the installation of this product as an interior finish material would not present a hazard to the occupants and met the intent of the building code requirements.

LIMITATION OF MODELS

The results generated by models are only as good as the models themselves and the quality of the inputs. Properly defined sets of fire test data provide the ability to V&V the models as well provide appropriate inputs for a particular scenario. Increasing the amount of available test data for the design engineer is one key aspect to improving the confidence in the computer model outputs.

The limitations of the models are just as important as the quality of the inputs. These limitations should have been evaluated during the V&V process; however, in most cases, the fire protection engineer was not involved in this evaluation process. A thorough understanding of the model calculation algorithms, including the listed limitations, is required before proceeding with any calculations.

Arthur J. Parker is with Hughes Associates, Inc.

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Factors in Performance-Based Design of Facility Fire Protection

By Jane I. Lataille, P.E., FSFPE

The differences between performance-based design and prescriptive design are now well-known to most fire protection engineers. Less well-known are the differences in initial design and review costs, cost of long-term maintenance of design validity, cost of redesign when new use is not covered by the original design and the effects performance-based design can have on operating and maintaining a facility.

This article reviews general features of performance-based design of fire protection, gives some specific examples of the effects of these designs and describes using fire models and new technology in performance-based designs. It also describes the cost elements of performance-based designs and discusses the possible implications to stakeholders of using these designs.

GENERAL FEATURES OF PERFORMANCE-BASED DESIGN

As the name implies, performance-based design is design that meets a specified performance level. The structural and mechanical engineering disciplines have been using performance-based design for many years.

For example, structural engineers size the structural members of a bridge to support the weight of the bridge plus expected live loads, dead loads and loads from snow, wind earthquake and other sources. They demonstrate that the bridge can support these loads with structural calculations.

Mechanical engineers design HVACR systems to cool spaces by so many degrees in a certain amount of time based on the expected heat loads. They demonstrate that the systems can provide this cooling with heat exchange calculations.

Performance-based design is a newer development in fire protection engineering. One type of performance-based fire protection design ensures that smoke will not reach occupants before they can safely evacuate the building. Fire protection engineers demonstrate this with calculations of smoke development and occupant egress based on an evaluation of the types of fires that may be expected to occur in the facility.

Another type of performance-based fire protection design ensures that fire in a compartment with a given amount and type of combustibles will not proceed to flashover. Fire protection engineers demonstrate this with calculations of layer temperatures or heat release rate as the fire burns. Determining when flashover will occur then helps determine whether the fire will spread beyond the room of origin and what effect it will have on the rest of the facility and its occupants.

These types of designs are becoming more popular because they allow maximum flexibility in meeting the fire-protection needs of buildings. However, the decision to use performance-based design in fire protection engineering is not as cut and dry as it is in the other engineering disciplines. The main reason is that assumptions about expected fire loads are more likely to change than assumptions about expected structural and heat loads. A second reason is that structural loads are standardized, codified and accepted by society. Fire loads are not. Another reason that performance-based design is not as common in fire protection engineering as it is in the other engineering disciplines is because these design methodologies, along with an understanding of what design bases are acceptable, are still evolving. Predicting fire behavior is comparable in complexity to modeling weather. However, weather modeling has many more years of research to support it than fire modeling does. Furthermore, the accuracy of weather forecasts is not as critical as accuracy in prediction of fire behavior.

Modeling the effect of suppression systems on fire is similarly complex. In addition, fire models encompass substantial limitations, and these models can be difficult to understand and use appropriately.

EXAMPLES OF PERFORMANCE-BASED DESIGN

Prescriptive codes apply to facilities with widely varying characteristics. For example, the same prescriptive codes apply to an office building whether it has one or several stories, small or large building footprint, or low or high combustible loading. Different provisions in these codes might apply to different buildings, so the prescriptive


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protective scheme can vary from building to building. But some features are unlikely to change from one office building to another.

A performance-based design creates a unique set of requirements for each building based on specific assumptions derived from the project design goals. The sidebar below describes three possible examples of such designs.

Three Examples of Performance-Based Design

A performance-based design for an office building would be based on specific assumptions about the building. It could use models to show that the proposed protection is adequate for these assumptions. Assumptions could include:

- Each office will have a maximum of two four-drawer, normally closed metal file cabinets, with no more than 100 kilograms of combustibles stored in any cabinet.
- Each office will have a maximum of four five-sided, normally closed, overhead metal storage bins, with no more than 25 kilograms of combustibles stored in any bin.

The advantage of this design is that a sprinkler system that does not necessarily comply with all portions of NFPA 13 could effectively protect the building.

The disadvantage of this design is that changing any of the assumptions could easily invalidate it. For example, the sprinkler system may not be adequate to protect open offices separated by combustible partitions or offices with combustible loading that exceeds the assumptions.

Similarly, **a performance-based design for a laboratory building** could assume:

- The only hazardous materials will be small amounts of flammable liquids.
- Each lab will store flammables in a UL-listed flammable-liquids cabinet.

A performance-based design for a mall could use a smoke-management system to assure adequate egress time for occupants. The design would be based on particular fire scenarios. These scenarios might restrict the activities of tenants and possibly not meet their future needs.

Such a design would also determine where smoke will accumulate within the building space. This allocated volume would then not be available for future construction. For example, new stores could not be added in the space allocated for smoke accumulation.

These three examples of performance-based design are hypothetical and simplified. Performance-based designs would normally use a bounding scenario (worst case) to assure some future flexibility in the building. However, the design assumptions can still restrict the future use of a facility. This is why prescriptive designs are not always less flexible than performance-based designs, as is often believed.

Implementing performance-based design requires close cooperation with the authority having jurisdiction (AHJ) throughout the design and construction process. AHJs usually want experienced fire protection engineers to review these designs.

USING FIRE MODELS IN PERFORMANCE-BASED DESIGN

Computer fire models are increasingly being used to substantiate performance-based design of fire protection systems. Most computer fire models don't model fire so much as the effect of fire on the compartment where it is burning. For example, the models estimate temperature,


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Examples of the many effects that fire models simulate are:

- Temperatures of fire plume, fire jet and smoke layer
- Plume velocity
- Height of smoke layer
- Time to flashover
- Ventilation limits
- Mass flow through openings and vents
- Time to ignition of a target
- Flame spread
- Sprinkler/detector actuation
- Fire endurance of structural materials
- Smoke travel
- Occupant egress

smoke descent, flame spread, time to flashover and many other effects. (See sidebar above.)

The fire models simulate these effects in many ways. Because accurately modeling fire at the molecular level is beyond the capability of today's computers, fire models consider only the large-scale features of flames and rooms, and they use many approximations. They also put limits on such things as compartment and flame geometry.

Using these models appropriately requires knowing which effects they estimate, what approximations they make, what limitations apply and how closely the results can be expected to reflect the risk in the facility being modeled. This level of knowledge comes from having a background in fire protection engineering and experience with using the models.

Fire modeling software can be difficult to use. Furthermore, the output from fire models can be difficult to review. The pretty picture is not necessarily what would actually happen. Close review of the input and detailed understanding of how the model processes the input are necessary to judge whether the model was used appropriately.

Some models use results from fire tests to characterize the computerized fires. These models are good for analyzing fires similar to those in the tests (same commodity burning in the same configuration and the same size fire). Using the results of a test to model different conditions must be done with a good understanding of what effect the differences could have.

Computer fire models are becoming more popular, but they are still not the answer to every fire protection design problem. These models are still evolving and must be applied with care. Even experienced fire protection engineers still struggle with some fire modeling applications.

USING NEW TECHNOLOGIES IN PERFORMANCE-BASED DESIGN

In addition to computer fire models, performance-based design of fire protection can also use new fire protection hardware technologies. Well-known devices for which new technologies are being developed include sprinklers and fire alarm systems. Other new hardware is also being developed.

New technologies for both sprinklers and fire alarm systems have prescriptive rules. The prescriptive rules usually lag the introduction of new technologies. Performance-based design can be used to implement new technologies before they are formally recognized by prescriptive codes.

Sprinkler Technologies

The standard spray sprinkler flows water through a standard orifice against a deflector that produces a particular spray pattern. This spray sprinkler was used almost exclusively in North America until 1981, when the residential sprinkler was developed. The engineering required to develop the residential sprinkler was quickly applied to sprinklers for nonresidential areas of certain geometry or containing particular hazards.

Many sprinklers are now available for special geometries. Other sprinklers are available for protecting particular hazards. (See sidebar on page 45.)

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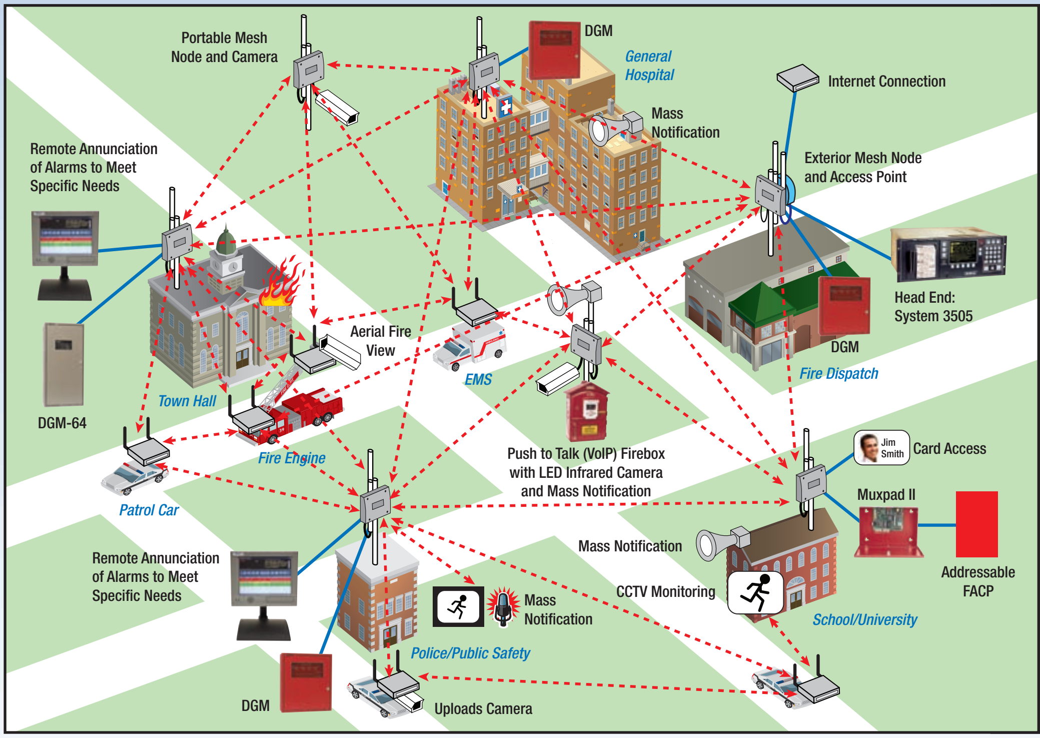

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- Extended coverage sprinklers

Some of the sprinklers now available for protecting particular hazards include:

- Very large orifice sprinklers
- Large drop sprinklers
- Early Suppression Fast Response (ESFR) sprinklers
- Special sprinklers

In the realm of prescriptive codes, special-geometry sprinklers must be installed according to the rules for location and spacing that are cited in their product listings. Likewise, sprinklers for protecting particular hazards must be installed in accordance with very strict rules. For example, ESFR sprinklers can protect limited types of storage commodities to maximum heights, with an allowable range of clearance from the top of storage to the roof. ESFR sprinklers must conform to strict rules for location and spacing, and they must meet strict hydraulic criteria.

Using sprinklers designed for particular geometries and hazards requires extensive knowledge about their designs and limitations. The more specialized a sprinkler, the more likely a design change would be needed if the occupancy changes.

Choosing a sprinkler is now more complex than ever.

Fire Alarm System Technologies

Fire alarm systems monitor buildings for adverse conditions. Conditions include alarms (operation of a sprinkler, manual pull station, smoke detector or heat detector), supervisory conditions (loss of heat or closure of a sprinkler system control valve) and trouble (loss of power or an open circuit).

Older fire alarm systems send generic signals to the alarm receiving station but do not provide responding plant or fire department personnel with detailed information on the alarm or its location. For example, the systems would report a fire alarm, but not the device that actuated or its location. Responders would have to investigate for themselves.

Today's electronic alarm systems are far more advanced. Their circuits are much simpler, and they can monitor many more devices. These systems interrogate, or poll, each connected device to always know its status. The devices themselves are smart and can tell the panel when something is wrong. For example, a smoke detector knows when it is dirty, adjusts its own sensitivity and reports this to the panel.

These alarm systems can be programmed to display any information desired to responders. For example, the system can tell a responder where every device is located and what type of device it is. It can report that if a particular zone is in alarm then certain additional actions should be taken.

Graphic annunciators are the norm. Overlaid on a plan of the building, they visually display the exact location of the device that actuated, the alarm type and the action required. These annunciators are installed where the fire department would be expected to enter the building. They can also be installed at central alarm-monitoring locations.

These advanced fire alarm systems put digital technology to work to enable the fastest and most-effective response to fire alarms. Today's fire alarm systems also integrate many nonfire protection features. Examples of these features could include paging and security systems. The systems are designed so that failure of any nonfire protection function cannot disable the alarm-monitoring function.

New features are constantly being designed into fire alarm systems. These features can take years to be addressed by code. Whenever the codes lag development of new fire alarm technology, performance-based design can be used to fill the gap.

Other Technologies

Another example of a newer fire protection technology that is being worked into performance-based design is the very early warning fire detection system.[1]

THE TRUE COST OF PERFORMANCE-BASED DESIGN

As with other designs, performance-based design should be justifiable from a cost-benefit standpoint. Estimating the benefits is usually fairly straightforward. But determining the costs is usually more tricky.

Some of the costs associated with performance-based design of fire protection include the following:

Cost of the design. Performance-based designs take more time to develop than prescriptive designs and require much more documentation. It can take some effort to find a designer familiar with the best methods for a particular facility. With fewer engineers qualified to develop performance-based designs, demand and backlog can be high.

Cost of the review. Once the design is complete, it must be reviewed. Finding qualified reviewers is as hard as finding qualified designers. Once again, demand and backlog can be high.

Risk of added uncertainty. Unique performance-based fire protection designs can be difficult to judge and to review. Each design has uncertainty, as does the thoroughness of each review. Performance-based designs are not tried-and-true like prescriptive designs. The level of risk is more uncertain.

Cost to "maintain" the design. All the facility features that are tied into the performance-based design assumptions must be routinely confirmed as still applying. Examples could include the location and construction of interior walls, the location and amounts of hazardous materials and the volume of a smoke-containment space. Features like these might not be required by a prescriptive design, so building owners are not used to "maintaining" them.

Cost to redesign. If any original design assumptions cannot be maintained, then another performance-based design that incorporates the new assumptions needs to be undertaken. With many unanticipated changes in a facility's use, it may be possible that a particular performance-based design needs more-frequent redesign than a prescriptive design would require.

Performance-based design is most effective for buildings whose functions are highly unlikely to change, like sports arenas. Using performance-based design for other buildings requires excellent judgment in selecting the design assumptions. Applying the least-expensive performance-based design to a building with high chance of change runs two risks: (1) extra costs for design changes, or (2) operating at higher risk than anticipated by the original design.

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Use of Fire Models in the Design of Fire Alarm Systems

Fire models are increasingly being used to support the design of fire protection systems and components. These models can be used to help develop a performance-based design or to better understand fire performance of a building. They can also be used to support the design of a fire alarm system.

For the purpose of this article, "models" are defined as any calculation-based method for predicting fire or fire effects. As defined here, "models" would not include physical models, although these tools have important roles in fire protection engineering as well.

Fire models can be used to perform several types of predictions. Models can be used to predict temperatures and velocities of fire plumes and ceiling jets, temperatures and thicknesses of hot smoke layers, and a variety of other fire-related phenomena. Models can also be used to predict the response of spot-type smoke and heat detectors.

PREDICTION OF THERMAL DETECTOR RESPONSE

Models have been used to support the design of fire alarm systems for several years. The 1984 edition of *NFPA 72E*[1] was the first edition to contain an appendix that provided a performance-based methodology for spacing heat detectors. This methodology related detector sensitivity (response time index), tempeature rating or rate-of-rise threshold, spacing and fire growth rate. If any three of these variables were known, the fourth could be determined through the methodology in the appendix. The tables and charts that previously existed in Appendix C of *NFPA 72E* have been replaced with equations and the engineering methodology that is now in Appendix B of *NFPA 72*®.[2]

The approach in *NFPA 72E* and *NFPA 72* assumes that a thermal detector could be approximated as a "lumped mass," which assumes that the detector sensing element could be modeled as being uniform in temperature and is heated only via convective heat transfer. For some detector types, this assumption may not be appropriate.

One of the first computer fire models to be published was DETACT-QS,[3] which was published in 1985. DETACT-QS enabled the prediction of thermal detector response to fires with arbitrary heat release rates, not just to fires that grew in proportion to time squared. DETACT-QS also assumed that heat detectors could be approximated as lumped masses.

The methodologies in *NFPA 72* and DETACT-QS are based on an assumption that the thermal detector is installed below a flat, infinite ceiling or a ceiling that does not intersect any walls. The presence of walls could result in the formation of a hot smoke layer, which would cause ceiling-level temperatures to be higher than would be predicted if an unconfined ceiling was assumed. Since the temperatures at the ceiling would be higher, thermal detectors would activate sooner than would be predicted if the hot gas layer were not considered.

In 1999, a model called Jet[4] was published. Jet is a zone model that predicts the activation of thermal detectors. As a zone model, Jet predicts the formation of a hot gas layer and its effect on temperatures of fire plumes and ceiling jets.

Jet is an evolution of the model LAVENT,[5] which was published in 1989. Jet is a two-zone, single-compartment model. The temperature of the upper layer is determined by the amount of heat and mass transfer from the fire, and the lower layer is assumed to remain at ambient temperature. Each zone is assumed to be a uniform temperature. Like other predictive methods, Jet approximates thermal detectors as lumped masses.

DETACT-QS, Jet and the methodology in *NFPA 72* all contain limitations on the types of geometries to which they can be applied. Jet is limited to compartments that are rectangular in plan view and are enclosed by a combination of floor-to-ceiling walls and draft curtains, and the other methods are limited to compartments where an assumption of an unlimited ceiling is appropriate. For other cases, one could use Fire Dynamics Simulator to predict the operation of thermal detectors.

Fire Dynamics Simulator (FDS)[6] is a computational fluid dynamics model that numerically solves the fundamental conservation equations of mass, momentum and energy. FDS allows a space to be divided into a user-defined number of cells. Within each cell, the conditions are assumed to be uniform (e.g., temperature, velocity, species concentration, etc.). Because the user has a tremendous amount of flexibility in the types of geometries that can be created, FDS does not share the geometric limitations of other detector activation models.

> Models can also be used to predict the response of spot-type smoke and heat detectors.

Because of the flexibility of FDS, detector location is not limited to the ceiling. However, the resolution of the grid spacing in the location of the detector will affect the accuracy of predictions of temperature and velocity at the detector location. FDS will model any rectilinear space. Curved or sloped surfaces can also be modeled, although they must be approximated by using a "sawtooth" pattern.

FDS uses a solution technique known as "large eddy simulation" to numerically solve the fundamental conservation equations and predict gas temperatures and velocities. Based on the predicted local gas temperature and velocity, FDS predicts the response of thermal detectors using the same technique that is imbedded within other thermal detector response models.

PREDICTION OF SMOKE DETECTOR RESPONSE

Prediction of smoke detector operation is much more complicated than the prediction of heat detector operation. First, the two types of spot-type smoke detectors (ionization and photoelectric) operate differently. (Some smoke detectors use both ionization and photoelectric technologies.) Second, many more factors influence smoke detector response, namely, aerosol characteristics, aerosol transport, detector aerodynamics and sensitivity.[7,8]

The generation of smoke aerosols by a fire is a function of the fuel, the type of combustion (smoldering or flaming) and the amount of ventilation air available. Smoke aerosols can vary in particle size and distribution, composition, color and refractive index. The generation of smoke aerosols can vary over the course of a fire as ventilation conditions change and the fire spreads.

Smoke particles can change as they travel from the fire source to the detector due to sedimentation ("sticking" to walls, ceilings or other objects), agglomeration ("sticking" together) and coagulation (congealing and precipitating). Additionally, it takes time for the smoke to travel from the fire to the detector. The aerodynamics of the detector affects how easily smoke enters the detector.

Frequently, the data needed to model smoke detector response are neither predicted by models nor measured in experiments.

One of the first methods of estimating the response of smoke detectors was to model them as a high-sensitivity (RTI ≈ 0) heat detector with a low operating temperature. While the title of the documentation that accompanied DETACT-QS implied that the model could be used to predict the operation of smoke detectors, doing so required an assumption of the temperature rise of a smoke detector at activation. This assumption would not be appropriate in many cases.[8]

Underlying the temperature rise method is an assumption that the smoke density in the vicinity is proportional to the temperature of the smoke. A minimum temperature rise of 13°C is commonly used as a threshold for smoke detector response.[3]

The temperature rise threshold of 13°C is based on the combustion of wood. Most of the variables that were used in developing this value could be expected to vary. Some variables are fuel-dependent, so determining the threshold temperature rise at detector activation requires knowing what fuel is burning.

Another method that is available for predicting the response of smoke detectors is the "mass optical density method," which involves calculating the expected optical density in a space and comparing it to the optical density at which a detector is expected to operate.[9]

A number of assumptions were made when this method was developed. These assumptions include that smoke does not change as it travels to the smoke detector differently in the enclosure of interest than it did in the enclosure in which the optical density at which the detector operates was measured. Smoke characteristics will generally change as smoke travels from the fire source due to sedimentation, agglomeration and coagulation, and this may be different in the enclosure of interest than in the enclosure in which the optical density at which the detector operates was measured.

> FDS models the response of smoke detectors based upon the calculated smoke optical density within the detector chamber. Unlike other methods, FDS also accounts for the entry resistance into the smoke detector.

The mass optical density method also assumes that there is no resistance to smoke entry into the detector, and that the sensitivity of the detector determined from a test is indicative of its sensitivity for all fuels. Smoke detectors will respond differently to smoke from different fuels, so the labeled sensitivity determined in a test may not correspond to the sensitivity for all fuels.

FDS[6] is also able to model the response of smoke detectors. FDS models the response of smoke detectors based upon the calculated smoke optical density within the detector chamber. Unlike other methods, FDS also accounts for the entry resistance into the smoke detector. Two models are incorporated within FDS to calculate the lag time for smoke to enter the detector sensing chamber as a result of the entry resistance. The user must select which of the two models will be used. Additionally, each model requires empirical constants as input, which are a function of the detector selected.

As with the "mass optical density method," FDS assumes that smoke does not change as it travels to the smoke detector differently in the enclosure of interest than it did in the enclosure in which the optical density at which the detector operates was measured. FDS also assumes that the sensitivity of the detector determined from a test is indicative of its sensitivity for all fuels. FDS does model the resistance smoke entry into the detector, which the other methods described in this article do not. However, modeling smoke entry requires determining detector-specific coefficients, which can be difficult to obtain.

Spot-type smoke and heat detectors are frequently used as part of a fire protection design strategy in which an objective is to detect the presence of fire for the purposes of alerting occupants or first responders. Methods are available to predict the response of spot-type detectors for the purpose of better understanding the performance of the detectors. However, these methods all have limitations about which users should be aware.

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9 Schifiliti, R., and Pucci, W., "Fire Detection Modeling: State of the Art," Fire Detection Institute, 1996.

A Tradition of Leadership in Linear Heat Detection

In today's highly competitive world, it's nice to know there is a company that believes success is measured by providing quality products and the highest level of customer service, with the integrity to stand behind their products. We call it Leadership.

Founded 70 years ago, Protectowire was the first company in the industry to develop, patent, and market continuous line heat detection systems. Today, The Protectowire Company continues to offer an ever-growing global network of distributors, superior products, service, and a reputation for excellence.

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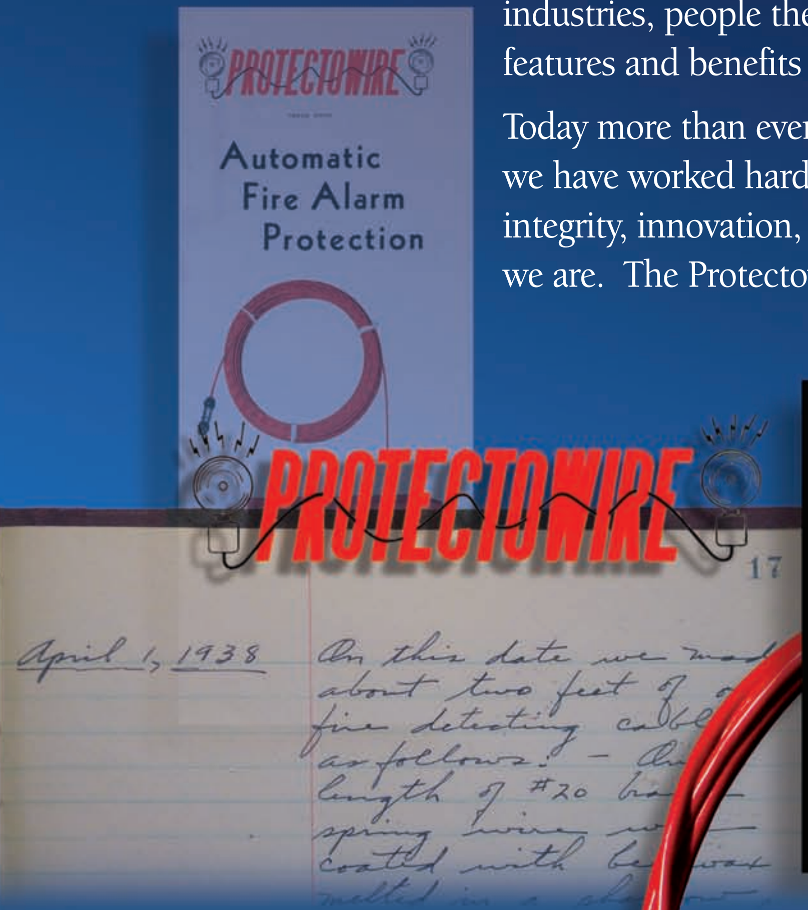
Today more than ever, Leadership must be earned. For 70 years we have worked hard everyday to realize that goal. Quality, integrity, innovation, and customer satisfaction . . . that's who we are. The Protectowire Company.



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2008 SFPE Professional Development Conference and Exposition: The Annual Meeting

October 12–17, 2008

Renaissance Suites Hotel Charlotte, NC

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for the **2008 SFPE Professional Development Conference and Exposition,** which will be held at the Renaissance Suites Hotel in Charlotte, NC. Building upon the success of last year's event, SFPE will feature a two-day Engineering Technology Conference format highlighting presentations on advanced, cutting-edge fire protection engineering practices.

Leading the conference with keynote presentations are:

- Dr. Kazunori Harada, Japan
- Dr. Barbara Lane, United Kingdom
- David A. Lucht, P.E., USA
- Dr. James A. Milke, P.E., USA
- Wayne D. Moore, P.E., USA
- Jon Nelson, USA

The Exposition and a series of seminars taught by the profession's leaders will follow the conference.

Seminars scheduled to be held are:

- Principles of Fire Protection Engineering
- Sprinkler Design for the Engineer
- Introduction to Fire Dynamics Simulator and Smokeview
- Advanced Fire Dynamics Simulator and Smokeview
- Advanced Fire Alarm Systems Design
- Smoke Control I: Fundamental and Pressurization Systems
- Smoke Control II: Design Fire, Atrium Control and Tenability Systems
- Smoke Control III: CONTAM Analysis of Pressurization Systems
- *Revised!* Dust Explosion: Hazard Recognition, Assessment and Management
- *New!* Forensic Fire Engineering Analysis.

For the most up-to-date information, visit *www.SFPE.org*.

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Prepare for the 2008 Fire Protection Engineering PE Exam from wherever you can access the Internet – your home, office or even while traveling. This effective, online review class will help you organize and navigate through the massive amount of reference material.

Each session is taught live by an expert instructor using Web conferencing technology. You will work with a live instructor over several weeks and can ask questions throughout the review period.

This course is an excellent exam preparation tool. The 14 live 1.5-hour sessions allow for maximum retention.

Who Should Attend?

Anyone preparing for the PE Exam! Even if you are not taking the exam this year but want to assess your readiness for a future exam, this course is for you. The course is also an excellent refresher for existing engineers, fire marshals, loss control specialists and anyone else who needs to understand the principles of fire protection engineering.

Topics Include:

- Exam Preparation & Exam-Taking Strategies
- Fire Protection Systems
- Fire Protection Analysis
- Fire Alarm Systems
- Fire Protection Management
- Smoke Management
- Human Behavior
- Explosion Protection
- Fire Dynamics
- Passive Building Systems

Enrollment Fee:

- $1,295 for SFPE members or $1,750 for nonmembers

Enrollment Includes:

- Participation in weekly online sessions
- Two hours of access to instructors outside of class hours
- Electronic copies of the course slides

Required Materials:

- A copy of the *PE Exam Reference Manual*, 3rd Edition (**Sold separately** at *www.SFPE.org*)

Additional information, registration, instructions and payment options are available on the SFPE Web site (*www.SFPE.org*).

5:30am
San Diego, CA Room 523
Please Do Not Disturb.
EMCOR IS HERE
Day two of yet another conference is about to begin. And EMCOR is here.
Hilton Hotels Corporation selected EMCOR to provide fire-protection services for its new 30-story, one-million-square-foot hotel at the San Diego convention center. EMCOR is installing fire-alarm, smoke-control, and CCTV video surveillance and security systems for the hotel, as well as other mechanical and electrical systems such as voice/data, TV, audio-visual, and digital HVAC controls. Our integrated fire-protection and security systems keep you safe and secure, while others—which keep your room warm, the water soft, and the lights dim—let you relax in comfort and peace. Even if that salesman (you know the one) won't.
Wherever and whatever your facility, EMCOR is here.
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UPCOMING EVENTS

May 4–6, 2008
2nd Algeria Fire, Safety & Security Expo
Algiers, Algeria
Info: new-fields.com/afsse2/index.php

May 19–21, 2008
International Symposium on Fire Investigation (ISFI)
Cincinnati, OH, USA
Info: www.isficonference.com

May 20–28, 2008
5th International Conference – Structures in Fire (SiF '08)
Singapore
Info: www.ntu.edu.sg/cee/SIF-08/

June 2–5, 2008
NFPA World Safety Conference and Exposition
Las Vegas, NV, USA
Info: www.nfpa.org

June 9–11, 2008
19th Annual Conference – Recent Advances in Flame-Retardancy of Polymeric Materials
Stamford, CT, USA
Info: www.bccresearch.com/flame2008.htm

September 21–26, 2008
9th IAFSS Symposium
Karisruhe, Germany
Info: iafss.org/html/events.htm

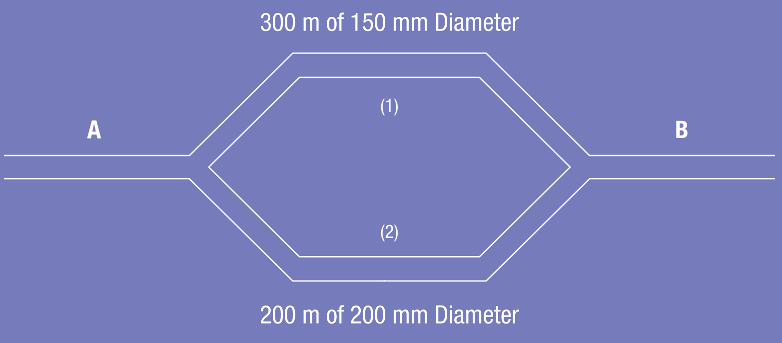
October 12–17, 2008
SFPE Progessional Development Conference and Exposition: The Annual Meeting
Charlotte, NC, USA
Info: www.sfpe.org

November 2–3, 2008
2007 International Symposium on Elevator Evacuation During High-Rise Fires
Shanghai, China
Info: www.isee-sh.org

BRAINTEASER > Problem/Solution

Problem

[In the parallel pipe network A-B shown below, what fraction of the flow would travel through the 200 mm diameter pipe? Neglect pipe fittings such as tees and elbows. The Hazen-Williams "C" factor is the same for all of the pipe.]



Solution to Last Issue's Brainteaser

What numeral will be in the ones place of 2^{200}?

The first six powers of two are as follows: 2, 4, 8, 16, 32 and 64. If this series is extended, the ones digit will follow the sequence 2, 4, 8, 6, 2, 4, 8, 6, …. This sequence repeats every fourth power, so a "6" will be in the ones place of 2^{200}.

1

Inspection Software

Tyco Fire & Building Products' SprinkCAD group has entered into an exclusive license agreement with Asurio Inspection Systems to provide its leading mobile fire protection inspection software. The Asurio software is a mobile system designed for fire sprinkler, alarm and extinguishing companies' electronic inspections, and will be offered alongside SprinkCAD's already broad line of fire protection software. One of the key benefits of this system is the opportunity for contractors to increase field inspection and service sales. By using the automated equipment information included in the software package and listing any deficiencies for service follow-up, contractors have immediate access to potential work orders.

www.sprinkcad.com
—Tyco Fire & Building Products

2

Firefighting Navigational Tool

ONYX FIRSTVISION™ is a *wayfinding* navigational tool for firefighters and other emergency responders. This PC-based touch screen graphically displays critical information on the origin and spread of a fire, allowing firefighters to quickly locate and extinguish the fire, reducing property loss and saving lives. The interactive display summarizes building floor plans, showing the location of all fire alarm devices, water supplies, evacuation routes, access routes, fire barriers, gas, power and HVAC shutoffs, as well as chemical and structural hazards in the building.

www.honeywell.com
—NOTIFIER

3

Attic Vents

Brandguard Vents has developed a series of vent products that prevent fire embers from entering a home. The baffle design changes the flow of air several times, creating an effective heat trap, preventing damage from radiant and direct heat sources. The design has comparable net-free vent area and allows for sufficient exchange of moist air, thus preventing mold issues. Dormer, round, access, soffit and gable-end vents are available.

www.brandguardvents.com
—Brandguard Vents

4

UL-Listed Electric Fire Pump Drivers

Clarke Fire Protection Products, Inc., has been granted UL certification for its flexible metal couplings for use with electric motor fire pump drivers. Applications for the metal couplings include new fire pump sets, retrofits of existing fire protection systems or wherever the use of listed, certified couplings is required.

www.clarkefire.com
—Clarke Fire Protection Products, Inc.

CASE STUDY

GAMEWELL-FCI

Advanced Life Safety System Connects & Protects Growing Assisted Living Complex

Goodwin House, a luxurious residential/healthcare facility located in Bailey Crossroads, Virginia, consists of a 360,000 square foot, 12-floor tower where more than 350 retirees conduct their daily lives.

"One floor is used for health care and another one for assisted living. The other nine are used for independent living with one floor used as a common area," says Director of Environmental Services Jim Colston with Goodwin House.

This high-rise tower was recently joined by a newly-constructed Health and Wellness Center. Future development plans also call for a new 15-story tower to provide 106 additional condominium-style apartments with room for more Goodwin House offices. Once construction is complete, all three structures will interconnect, providing residents and employees the convenience of ready access.

Gamewell-FCI
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Northford, CT 06472 -1653
203.484.7161
www.gamewell-fci.com

Given the nature of this community and its new campus-style environment, fire protection and life safety were a major concern of its management.

"Because we're adding two new buildings that require a fire alarm in them, we decided it would be best if all three fire alarm systems were able to talk to each other," Colston adds.

Desiring an integrated solution that ties all three structures together, Goodwin House management chose the E3 Series® Expandable Emergency Evacuation system, manufactured by Gamewell-FCI, provided by Alarm Tech Solutions, LLC of Severn, Maryland and installed by Freestate Electrical Construction of Beltsville, Maryland.

Installation of a new fire and life safety system began with the existing 12-story tower. By way of digital signal technology for the SLC (signaling line circuit), Alarm Tech was able to utilize the existing metallic wire installed throughout the building, saving time and money while preventing destruction of a beautiful facility.

"The way we installed the E3 Series system resulted in no down time in protection and virtually no cutting, patching and painting, which would have been a significant cost to Goodwin House," says Marty Smith, General Manager with Alarm Tech Solutions.

Relying on true peer-to-peer, token ring passing network technology, the system will support up to 64 nodes, currently allowing 2 to 128 SLCs, each one accommodating up to 159 devices and 159 modules.

From firefighter phones to elevator control, detection to fire control, the E3 Series is the only system of its kind to integrate it all over a single twisted-pair cable between nodes, equaling installation ease at a lower cost.

"The system also features emergency evacuation with special messaging that's part of the facility's evacuation plan. Plus, we included smoke control, stair pressurization and exhaust and monitoring of the gas detection system," says Smith.

The 12-story tower's system includes full fan control with five separate smoke zones on a typical floor, utilizing fans and dampers to exhaust the fire floor and pressurize the floor above and floor below. In addition, magnetic door holders were utilized to isolate fire zones on each floor.

Recently extended to encompass the new Health and Wellness Center, the Goodwin House system is planned to expand again into the soon-to-be-constructed 15-story tower.

Ultimately, it was the expertise of Alarm Tech Solutions, combined with the E3 Series' expandable, cost-effective features that succeeded in meeting the end user's expectations head-on.

CASE STUDY

SIMPLEXGRINNELL

InfoAlarm™ Command Center Strengthens Response Capability of Simplex® 4100U Fire Alarm System

SimplexGrinnell has advanced the capabilities of its flagship Simplex 4100U fire alarm system with the introduction of the InfoAlarm™ Command Center – an expanded large-screen panel display and intuitive user interface that can help speed the response to emergencies.

Designed to facilitate quick, easy operation in emergency situations, the Simplex 4100U InfoAlarm Command Center enhances fire and life-safety protection by expanding the amount of information that can be displayed on the panel. The multi-line display and the intuitive soft control keys enable system users, maintenance personnel, and first responders to access clear, easy-to-understand information that can identify the location, nature, and severity of an emergency or fire alarm system condition.

Fire protection and command operations can be further supported by placing remote, compact-sized InfoAlarm command centers in building entrances, lobbies, and other key locations.

"Today more than ever, access to information via the fire alarm system is critical in an emergency, whether it's a fire or other threatening situation," says John Haynes, director of Product Line Marketing at SimplexGrinnell. "That's why the Simplex 4100U InfoAlarm Command Center is such an important advancement. In simplest terms, it gives system operators and emergency responders more 'at-a-glance' information about an event, without having to scroll or push buttons. As a result, the response can be more rapid and accurate."

In addition to the extended information display, the InfoAlarm Command Center, one of the first products listed to meet the new UL 864 fire alarm equipment testing standard, gives the Simplex 4100U system added flexibility to meet application-specific customer requirements. Key features and benefits include:

- Easy, cost-effective upgrades
- Remote panel option
- "On the fly" instant-switch language selection
- Site map
- Watermark background
- Custom activity display choices

For more information, visit *www.simplexgrinnell.com.*

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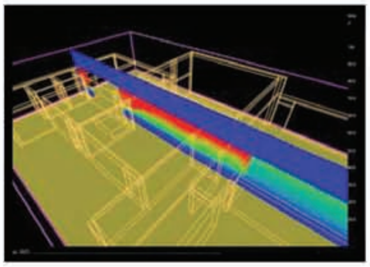

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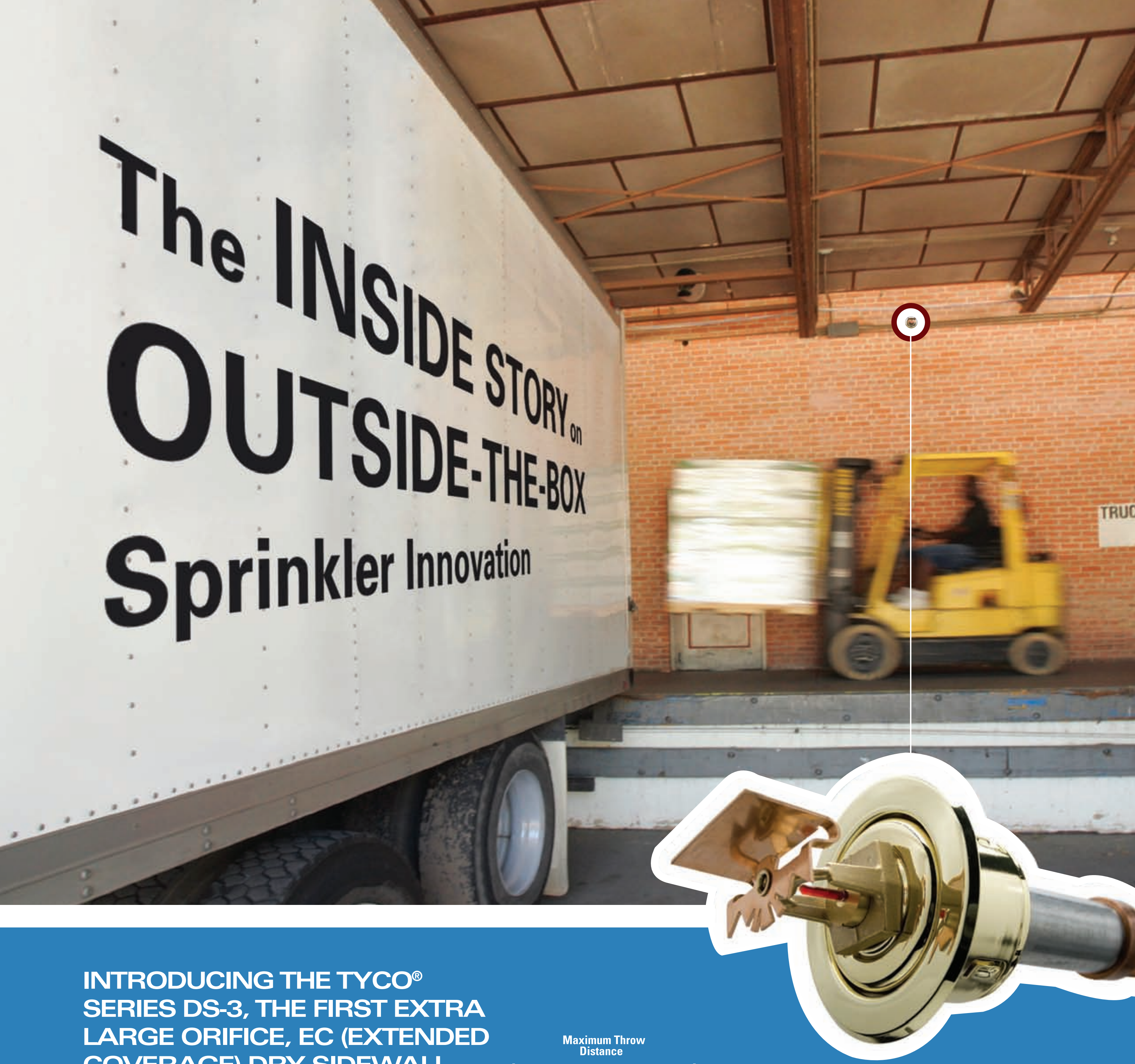

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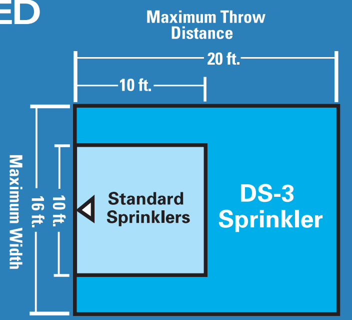

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Comparison Chart

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