WINTER 2003 FIRE PROTECTION Issue No.17

Making an Impact:
FIRE PROTECTION
ENGINEERS

AND THE DESIGN PROCESS

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Engineering

Fire Protection Engineering (ISSN 1524-900X) is published quarterly by the Society of Fire Protection Engineers (SFPE). The mission of Fire Protection Engineering is to advance the practice of fire protection engineering and to raise its visibility by providing information to fire protection engineers and allied professionals. The opinions and positions stated are the authors' and do not necessarily reflect those of SFPE.

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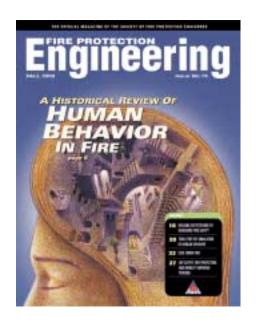
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Dear Editor,

The series of human behavior articles in the Fall 2002 issue provided fire protection engineers with an excellent review and focus on one of the evolving, yet least considered, areas by fire protection engineers.

However, it was particularly troubling to find that ignorance abounds in the area of human behavior as evidenced by the two-page "Panic Kills" advertisement, using a blurred photograph of a crowd to suggest a panic event. While I understand the need for marketing staffs to develop attention-grabbing copy, I am compelled to note that this advertisement is contrary to the facts and studies noted by Guylene Proulx, Ph.D. in her article entitled, "Cool Under Fire."

Proulx notes that researchers have long ago rejected the concept of panic as it is portrayed in the media and movies. I only hope that fire protection engineers and others reading the Fall 2002 edition take note of Proulx's review of prior research and factual discussion on the erroneous concept of panic, rather than the artificial notion of panic suggested by the graphic advertisement. Such advertising copy simply fosters mistruths and bolsters concepts contrary to the mission of the SFPE.

Daniel J. O'Connor, P.E. Vice President-Engineering Schirmer Engineering Corporation

Dear Editor,

We agree that fire protection engineers must be cognizant of the fact that people will react differently under different evacuation conditions and that they must continue to specify systems that provide voice communication with clear instructions during fire events. We also agree that human behavior in fire situations is an evolving field of study.

As the writer points out, the advertisement in question is designed to grab attention and it is obviously successful in this respect. But once that attention is gained, the copy below the image explains that the flipside of panic – apathy – is also a danger. In essence, the advertisement merely acknowledges that it is difficult to predict how people will behave in a fire situation, and that clear communication is the best means of removing

ambiguity from a potentially confusing (and dangerous) situation.

At EST we have a profound respect for the ability of fire protection engineers to base their work on sound principles and current research in their field. When it comes down to it our products and systems speak for themselves, and we find it unlikely that an image in a paid magazine advertisement would exert such influence as to compromise in any way the professionalism of your readers.

I would like to take this opportunity to say how much we appreciate the high caliber of your magazine. Our engineering and marketing staff read each issue with great interest. Keep up the excellent work!

Mike Browning

Director of Business Development

Edwards Systems Technology, Inc.

Correction

On page 3 of the Fall, 2002 issue, Norman Groner's name was misspelled.

Book Review

Lataille, Jane I.

Fire Protection Engineering in Building Design

Elsevier Science (USA), 2003



Ire Protection Engineering in Building Design provides an excellent overview of fire protection engineering and its role in the building design process. Aimed at architects and engineers in related disciplines, it does not explain how to design fire protection for facilities and processes. Rather, it offers insight into the multitude of fire-related issues that impact the design of a building and presents a cogent argument for integrating fire protection engineering (FPE) into the design team at the earliest stages of a project.

Targeted at an audience that may be unfamiliar with the discipline, the book starts with an explanation of fire pro-

tection engineering. It points out that a P.E. exam in fire protection engineering is offered through the National Council of Examiners for Engineering and Surveying (NCEES), and provides the subject headings from the exam syllabus for this exam along with the NCEES standard of minimal competence for fire protection engineers. The discussion then turns to why it is important to have adequate fire protection, what types of fire protection systems are available, why various systems might be installed, and what function these systems serve. How fire protection design is undertaken is discussed in chapters on performance-based and prescriptive-based design.

A significant portion of the book is dedicated to the topic of interfacing with other disciplines, a key element in an integrated design approach. The discussion identifies several areas where fire protection and other systems interface, outlines specific concerns that should be addressed relative to these interfaces, and provides examples of relevant standards. For the non-FPE, this discussion is extremely useful in providing insight into the wide range of fire-related considerations that go into an integrated building fire safety design. However, if there is any place that the book misses an opportunity, it is in not providing more discussion and examples of what could go awry if systems integration is not done properly. Pointing out the range of information one needs to know is very helpful: Explaining what could happen if things are not done correctly helps keep people from working outside of their area of expertise.

The book closes with a brief discussion on issues associated with new and existing buildings, and spends a good deal of time on the drafting of fire protection specifications. Numerous references are provided throughout the text, and a comprehensive list is provided as the final section. Although the focus on reference standards is the NFPA, the document titles will assist persons from outside of the United States identify relevant standards in their countries.

As an introduction to fire protection engineering for non-FPEs, *Fire Protection Engineering in Building Design* is on target. It presents a concise treatment of key issues that all members of a building design team should understand about fire protection engineering and helps them understand why having a qualified fire protection engineer on the team is essential to the success of the project.

Brian J. Meacham, Ph.D., P.E., FSFPE Principal Risk & Fire Consultant Arup Fire

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fire protection industry news

Partnership for Safer Buildings Formed

ALBANY, NY – The National Association of State Fire Marshals (NASFM) recently formed The Partnership for Safer Buildings to study U.S. building codes and propose changes that will help protect the lives of people escaping burning buildings and the firefighters working inside them.

The Partnership will bring together experts from the fire service industry, standards organizations, and major fire engineering schools to apply lessons learned from the World Trade Center collapse to the everyday business of fire protection. The goal is to ensure that the codes address reasonably foreseeable and potentially catastrophic fire hazards, and require the highest levels of building performance in the interest of public safety and property protection.

For more information, visit www.firemarshals.org.

IAFC Presents Strategic Plan for 2003-2004

FAIRFAX, VA – On November 19, 2002, the International Association of Fire Chiefs (IAFC) announced publication of its Strategic Plan for 2003-2004. The plan outlines specific strategies to meet key objectives in seven categories: Building Relationships and Partnerships; Fire and Life Safety; Leading the Fire Service; Legislative/Political Action; Marketing, Branding, and Communications; New Revenue and Association Growth; and Professional/Executive Skills Development.

More than 100 fire service leaders collaborated in the plan's development. Contributing to the effort were representatives from every IAFC division and section plus nearly 30 state fire chief association officers and a number of prominent fire service industry partners.

To view the plan, visit www.ichiefs.org.



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By Andrew Bowman, P.E.

FPEs AND THE DESIGN PROCESS

hile fire protection engineers are found in many different segments of the workforce with many different responsibilities, a large number of them are involved in the design and review of fire protection and life safety systems, fulfilling a role as a key member of a design team.

How does the fire protection engineer's role best fit into the design team process, and what does this process entail? Generally, engineering design and consulting services are conducted in three major phases: concept development, system design, and construction. Each of these three phases has many subparts that benefit from the participation of fire protection engineers. Each of these three phases is part of any design,

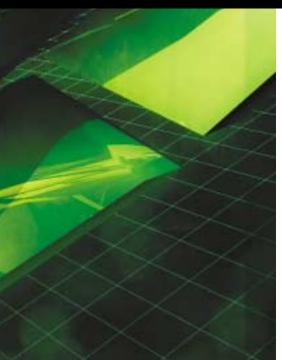
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whether it is a full building design with many team members or a stand-alone retrofit project pertaining solely to a fire protection or life safety system.

The first contribution from fire protection engineers occurs during the concept phase. The concept phase is where the overall scope of the project is determined. It is during this phase that the applicable codes are determined and then evaluated. Typically, key building code issues that affect the project can be identified and dealt with in this phase. It is also at this phase where a fire protection engineer can identify if it would be beneficial to evaluate the building or portions of the building in a performance-based manner in lieu of prescriptive code compliance. Additionally, the design criteria for fire protection systems are usually developed during this phase. The development of design criteria involves a determination of the requirements that pertain to the design and installation of the fire suppression, fire alarm, and smoke control systems. This includes preparing an analysis of various options available to the design team based on the intended fire protection and building code approach.

Once all of the fundamental building and fire protection code requirements have been conceptually fleshed out, the actual design typically starts. The design is often divided into three general stages: Schematic Design, Design Development, and Construction Documents. It is during these stages that the system design is completed, usually in an iterative manner. The process leads from the design basis information developed in the conceptual phase to the completion of construction documents. During this phase, the fire protection engineer works closely with the design team members to not only adapt the fire pro-

Fire Protection Engineers and the Design Process



tection system design to whatever architectural and engineering changes may occur, but to also identify when and if those changes necessitate an evaluation of the design basis created during the conceptual phase. In addition to system design, it is during the design phase that the fire protection engineer can provide valuable insight into building code requirements that may have a significant impact on the overall plans for the building.

After the design has been finalized and a contractor has been selected, the role of the fire protection engineer changes. It is during the construction phase that the fire protection engineer performs a variety of services, including responding to contractor Requests for Information (RFIs), conducting site visits to observe the installation process, reviewing shop drawings, and conducting final acceptance tests.

THE VALUE OF FIRE PROTECTION ENGINEERS

Fire protection and life safety are components of nearly every design project. However, fire protection engineers are not always automatically asked to provide these services. It is not unusual to see fire protection systems designed by mechanical engineers, fire alarm systems as part of the electrical submission, and the evaluation of building code compliance left to the architect. While there may be situations where this approach is sufficient, more and more architects and building owners are recognizing the value associated with having fire protection engineers aboard. This value is associated with retaining engineers with education, experience, and licensure specifically dedicated to the responsible and thorough design and evaluation of fire and life safety systems.

SPECIALIZED EXPERTISE

Despite the unique qualifications of fire protection engineers, it is not enough to merely be experts in fire protection and life safety. Until the actual value associated with having licensed fire protection engineers on a design team can be properly communicated, many may feel that fire protection design is a component of typical mechanical, electrical, and plumbing (MEP) services and that code compliance is best evaluated by the architect. However, there are no other engineering disciplines that can provide the same level of education, expertise, and industry involvement relating to all aspects of fire protection, life safety, and code compliance as fire protection engineering. That being said, what value does this level of capability bring to a design team?

Installation standards such as NFPA

131 and NFPA 722 are referenced in the International Building Code3 and the new NFPA 5000 Building Code.4 Therefore, any fire protection and life safety system will have to be designed in accordance with these standards. In addition, many building code requirements impacting architectural design are directly related to fire protection and life safety. As fire and life safety system technology changes at an ever-increasing pace, the heavy emphasis on fire protection and life safety in the building codes and installation standards has created a need for the specialized expertise provided by fire protection engineers.

Does this mean that fire protection engineers are needed on every project? Not necessarily. Fire protection engineers have been instrumental in codifying much of the testing and research in fire protection and alarms systems into easily used standards aimed at knowledgeable, but not necessarily expert, design professionals. This means that one does not necessarily have to be a fire protection engineer to lay out and detail a basic sprinkler or fire alarm system because the many years of research, testing, and codes and standards development by fire protection engineers and others have provided a sufficient roadmap. However, design projects rarely come in a neat and tidy package. More often than not, there are many design decisions involving either issues of compliance with installation criteria, aesthetics, or cost that need to be evaluated on an individual basis. The most creative and cost-effective solutions to these concerns are not usually found in the codes and standards. This is where the specialized expertise of fire protection engineers provides significant value. Using a fire protection engineer provides the best opportunity to design a system that will function as required,

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will be sensitive to the aesthetics of the building, and will be cost-effective.

Mark Goska with the Facilities Division of the University of Alabama – Birmingham has witnessed the value of specialized fire protection expertise.

As he explains: "The University of Alabama – Birmingham has a major medical school and hospital on its campus. The ages and construction types of the buildings vary, which has on occasion been problematic during renovations. This can also be problematic when buildings of different ages and construction type are located immediately adjacent to each other, such as one would typically see in a teaching hospital setting. Oftentimes, utilities will connect through multiple buildings and reach a point where they no longer meet current code and guideline requirements."

"This is the situation that we encountered with a fire pump that was installed in the 1970s. The original fire pump was designed to provide both sprinkler and standpipe protection for several buildings based upon the codes and standards at that time. Over time, the university renovated several floors within these buildings, and these renovations were done in accordance with the current edition of the codes and standards as adopted by the local and state Authorities Having Jurisdiction (AHJ). The existing fire pump was sized adequately to meet these demands until there was a change in the code that increased the minimum required pressure at the highest point to 100 pounds per square inch (psi) (690 kPa). The original fire pump was not capable of meeting this requirement. Unfortunately, this deficiency was discovered during a test of a system to get final approval on a renovation project. A fire protection contractor was contacted to investigate and to determine what it would cost to correct the problem. Their solution was to replace the existing fire pump with a new pump and to upgrade the existing standpipes to accommodate the increased water pressure. The estimated cost for this solution was \$1.000.000."

"The university then retained the services of a fire protection engineer to investigate options for how this problem could be resolved. The engineer met with the maintenance staff to discuss the existing system in order to determine

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the existing conditions, how the system was fed, and to review the test records for the system. They then reviewed the as-built drawings, traced the system, and proceeded with their code analysis. Once the code analysis was complete, the university received a written report with recommendations on an approach to upgrade the existing system. This report referenced sections of the building and NFPA codes and guidelines in order to support the recommendations. This was very important since the proposed solution required review and approval by both local and state AHJs. The fire protection engineer met with the AHJs and was able to successfully describe the existing conditions and explain the proposed solutions in a manner that they were able to fully understand. Both the local and state AHJs agreed to the proposed solution, and the fire protection engineer were authorized to produce the required construction documents."

"The project is in the final stage of design, and the current estimated cost for construction is \$700,000, which is substantially less than the original estimate received. This savings is due not only to the fire protection engineer's knowledge of the governing codes and standards, but also due to their experience with similar situations and the ability to develop alternative solutions to a problem."

SINGLE POINT OF CONTACT

Besides the value of specialized fire protection expertise from a technical design standpoint, it is important to have a single point of contact dealing with the fire protection, fire alarm, and building code requirements during design. This is especially important because these requirements are often interdependent and are best evaluated as a composite as opposed to individually.

There are often choices in how to achieve code compliance. For example, there are many buildings in which the building code does not require sprinkler protection. However, providing sprinkler protection, even if not required, may eliminate or reduce many other requirements. These "trade-offs" can be significant enough that providing sprinklers becomes an attractive option from a cost standpoint in addition to the improved life safety and property protection.

While there are many permutations of the costs and benefits associated with mixing and matching code requirements and fire protection systems, one factor remains consistent. The full benefits of trade-offs in the code are only likely to be realized if all components are evaluated together. Many of these trade-offs can be overlooked if not overseen in a coordinated effort, and the fire protection engineer is perfectly positioned to provide this oversight and guidance.

The following example illustrates the cost implications associated with addressing fire and life safety without the assistance of a fire protection engineer. The project involved a complex of four new four-story residential buildings. Each building was to be of Type 5-A construction (per BOCA5), which included protected combustible construction throughout. Without a fire protection engineer on the project, the plumbing engineer completed the fire protection drawings, and the electrical engineer completed the fire alarm drawings. The architect completed the code analysis. The engineering design drawings were completed independently of each other, and independent of the code analysis. Both sets of design drawings used generic notes to describe the extent of the system and the contractor's obligations. Essentially, the design documents indicated that the contractor was to design the fire protection system per NFPA 131 and the fire alarm system per NFPA 72.2

This was a situation where the relative lack of importance placed on thorough fire protection and fire alarm design had a significant cost impact on the project. For example, all four of these buildings were candidates for being protected with NFPA 13R6 sprinkler systems specifically provided for residential occupancies up to and including four stories in height. This evaluation, if it had been conducted, would have identified an estimated \$450,000 in savings relating to eliminating sprinklers in the attic spaces, reducing hydraulic demands, and eliminating sprinklers in the small closets. Furthermore, the use of residential sprinklers was not specified (either for an NFPA 13 system or automatically if using an NFPA 13R system). As a result, the fire alarm drawings (specifying compliance with NFPA 72) did not pick up the permitted omission of smoke detec-

tors in bedrooms protected by residential sprinklers. This oversight had a cost impact of approximately \$55,000.

While certainly possible, it is unlikely that the potential cost savings would have been picked up and identified by the contractor early enough to provide a benefit to the owner or design team. Had a fire protection engineer been aboard during the design process, these cost savings could have been weighed against the lower level of protection. From this evaluation, an informed decision could be made early enough to benefit the owner and the design team.

Nancy Pickens, senior vice president with Peck Peck and Associates of Woodbridge, VA, routinely uses the services of fire protection engineers and offers insight into the benefits she has witnessed. "As an architect specializing in government contracts, my experience has been that fire protection engineers provide a level of expertise not available from other disciplines. Our company, Peck Peck and Associates, routinely utilizes the services of fire protection engineers, and the benefits are numerous."

"Fire protection engineers provide specific overall knowledge of the building and fire codes that most architects do not possess. In the case of the fire protection engineering firm that we work with, many of the staff are members of the committees who write and propose changes to the codes. Fire protection engineers have the training and ability to see the big picture, the cause and effect of actions and changes within a building, and to provide workable solutions to problem areas in a timely and cost-effective manner."

"Fire protection engineers contribute their knowledge of life safety and fire protection systems to provide more creative solutions to issues encountered in a project. Having a separate consultant focused on fire and life safety keeps those issues in the forefront of a project, where they belong."

"In many instances, owners require an evaluation of their facility in order to plan for future projects and program upgrades. While there is inherently some overlap between disciplines when walking through a building evaluating deficiencies, the fire protection engineer provides additional insights into life safety and code issues due to his/her specialized training and experience. The

architect or mechanical or electrical engineer can make an evaluation of many life safety issues, but the fire protection engineer sees and evaluates the larger scope."

FOCUS ON FIRE

Quality in design can be attributed to many factors including technical expertise, priorities, and available resources. While possessing the necessary technical expertise to develop quality design documents is obviously essential, it is also extremely important to believe that the design of these fire and life safety systems should be a top priority. This requires the dedication of the necessary resources to ensure that the quality of the system design is commensurate with its future role as a fire protection and life safety system. This is one of the greatest benefits of working with fire protection engineers. They are focused solely on providing a complete, thorough, and coordinated fire protection design. This is not always the case when the design of these systems is merely a footnote to mechanical, electrical, and plumbing designs. It is purely a matter of priorities.

In addition to the value placed on quality, from a practical standpoint, the advent of electronic architectural design drawings has driven the need for responsiveness and dedicated expertise. Architectural backgrounds come to engineers with less and less time to make adjustments and finalize designs in preparation for an upcoming submission. When treating fire protection and life safety as a component of the mechanical, electrical, and plumbing design, it is more likely that, as the project deadline looms, the issues pertaining to the other disciplines will take precedence. This often leaves the fire protection and fire alarm design as an afterthought and can lead to design by specification. This approach may ultimately result in meeting the deadline, but does little to ensure that the fire protection systems have been properly designed. A haphazardly designed system may not provide the required level of protection while minimizing the cost of installation. This is a situation where having a fire protection engineer as part of the design team facilitates a smoother submission process and increases the quality in the design submission.

This is another area where architects who work with fire protection engineers can benefit. According to Nancy Pickens, "The expertise of fire protection engineers in completing construction documents contributes to the overall quality of the project. Since fire protection engineering is a specialty, fire protection engineers can provide a more accurate and complete set of construction documents including drawings, specifications, cost estimates, and analyses required by the owner/jurisdiction. My experience is that the work is better coordinated with all disciplines because the fire protection engineer is more focused on his/her tasks. The most cost-effective and 'best' solution is achieved because various and creative fire protection options are explored and designed rather than using 'textbook' solutions."

"The Gerald R. Ford Presidential Library in Grand Rapids, MI required an addition to house additional museum staff and artifact storage. The fire protection engineer was able to contribute his expertise and provide special fire protection systems for the collection storage area. Strobe devices required throughout the building were placed so as to be unobtrusive to visitors. Egress issues were resolved early in the project. The ideas and quick response time of the fire protection engineer helped to make this a successful project."

"However, as we discovered, fire protection engineers do not always end up as a subconsultant. St. Elizabeth's Hospital, in Washington, D.C., required extensive renovations in the early 1980s in order to keep its accreditation. A fire protection engineering firm was selected as the prime consultant on the project with architectural, structural, mechanical, and electrical firms as the subconsultants. The construction documents and entire renovation were completed with life safety as the number one priority. The project was completed on time and under the original budget."

"Architects are in the business of creating ideas. Fire protection engineers are valuable members of the team and help document and turn these dreams into reality. Design teams and owners benefit from the added expertise in designing the fire protection and life safety systems. This is true no matter the size of the project."

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COMMUNICATION WITH THE OWNER OR AHJ

Fire protection and fire alarm system design services are not the only reason for having fire protection engineers on a design team. Fire protection engineers are typically well suited to deal with the inevitable building code compliance discussions with the Authority Having Jurisdiction. Specific code requirements and design objectives are often subjective, and many critical decisions affecting the design of a building or its fire protection systems can come down to interpretations of the intent of the code. Since many of the advances and insight into fire protection and life safety within buildings have made their way into very carefully crafted code requirements, fire protection engineers are usually heavily involved in developing and applying the requirements in the code. Because of this, there is value in having fire protection engineers assisting with determination of code compliance and the subsequent negotiations with the AHJ.

Due to the preponderance of fire and life safety requirements in building codes, a growing number of localities and government agencies are hiring fire protection engineers. These fire protection engineers are charged with ensuring that the fire and life safety provisions of the codes are being applied correctly in addition to dealing with the review of fire protection and alarm system designs. Given the interrelation between these three areas, dealing with a fire protection engineer on the design team is typically enthusiastically welcomed. The design team benefits because they know that their interests are being watched over during the permit process, and the AHJ feels that a member of the design team is sensitive to their concerns.

Tim Tess, the site senior fire protection engineer with the Environmental Safety & Health oversight office for Argonne National Laboratories outside of Chicago, IL, prefers to deal with fire protection engineers.

"A problem I have seen all too often at large architecture and engineering (A/E) firms is the absence of qualified fire protection engineers. Often, fire protection engineering tasks are spread out to the various design groups. Often fire protection is not given adequate priority, and the installing contractors are relied upon to actually design the systems. This creates real problems for everyone involved."

"Often, the architectural group is not fully aware of life safety requirements, which creates interior designs that do not meet the life safety and local building codes. In addition, they are unfamiliar with equivalency concepts and the newer thinking in the area of performance-based design. The electrical engineers rarely keep up with changes in fire alarm system hardware and software, and typically the specifications they put out are not current. The mechanical engineers are often in the same position as the electrical engineers when it comes to fire protection. They rarely provide a true sprinkler system design because, in part, they do not understand the system and they have not kept up with all the advancements in sprinkler head technology. Unfortunately, it is common practice in the construction industry to rely on the installing contractor to make up for the weaknesses in the design and to know what should be installed even though it was not specified."

"As a facility owner with nearly 5 million square feet of space to maintain, it is very important that the facility has a common approach to fire protection and life safety. Consistency is needed from building to building, so that on-site maintenance personnel become experts in the systems we have and therefore do not have to rely on many different manufacturers for parts and service. Consistency is also needed in the approach to life safety, particularly in older facilities in which equivalent approaches to meeting the Life Safety Code were applied. A common design and installation methodology is desirable for all sprinkler systems that allow flexibility for future changes and which have water supplies designed to meet HPR requirements. The way to easily and effectively get these things is to utilize a qualified fire protection engineering firm for the design of fire protection systems and the assessment of fire protection and life safety conditions. Additionally, on large projects, it is very important that qualified fire protection engineers be involved throughout the project to insure that an integrated final product that is consistent with our existing facilities is produced."

PERFORMANCE-BASED DESIGN

In most of the current and prior building codes, the requirements are set forth in a manner that dictates precisely how a building will be built. This is the prescriptive approach to building design. The prescriptive approach is useful in that the requirements are easily enforceable and fairly obvious to those involved with the design of a building. The downside of the prescriptive approach is that most buildings have unique design features or required uses that have not properly been addressed in the code. Compliance with all of the requirements of the prescriptive code can come at the expense of functionality, aesthetics, or additional cost with little or no additional benefit.

Fire protection engineers understand that evaluating the level of safety within a building is not necessarily limited to verifying the compliance with the building code. A new generation of analytical tools has been developed that allows the evaluation of a building for its own unique inherent ability to withstand a fire and discards the notion that all buildings must be treated by a cookbook prescriptive approach. This is performance-based design.

Performance-based design is a concept that has been around for many years but is only recently being formally recognized in the prescriptive codes. The 2000 Edition of the *Life Safety Code*³ comes complete with a new chapter that provides the framework for a performance-based design option. The 2000 *International Building Code*³ comes with a complementary 2001 *International Performance Code*. These two instances clearly demonstrate that performance-based design is becoming a viable alternative to traditional prescriptive code compliance.

The potential benefits of performance-based design can be significant but are most likely to be realized if identified early in a project's design. This is where it is extremely beneficial to have a fire protection engineer on the design team during the concept phase. As the project progresses, many of the design details start to firm up. As these details become critical components of the design, the flexibility afforded by performance-based design diminishes. Eventually, at the latest stages of a design project, the value of a performance-based design solution can be significantly reduced.

Fire protection engineers are essential

in the performance-based design process. By the nature of their experience, education, and training, they are best positioned to understand the complexities and intent of the prescriptive codes governing the building, the scientific basis for the necessary evaluation methods, and the necessary measures to apply this knowledge to a practical situation. Furthermore, fire protection engineers have the ability and the necessary professional experience to communicate with the AHJ during the process.

There is no question that when used prudently and competently, performance-based design can be a powerful option to prescriptive code compliance. The implementation of these techniques will likely grow as the benefits of performance-based design become more widely known within the architecture and engineering design community.

AN EYE TOWARDS SAFETY

The design of a building is a complicated process. Not only are there immeasurable architectural hurdles to clear, but also the engineered systems within the building must work together (or at least coexist) for the design to be a success. This is true for the mechanical, electrical, and plumbing systems among many others, and is most certainly true for the fire protection and life safety systems.

Fire protection engineers possess a unique expertise, an ability to deal with components of other disciplines, and a belief that fire protection and life safety are a top priority, which makes them a valuable and important member of any design team.

Fire protection and life safety design should never be treated as a minor element of the design process. One of the fundamental guiding principles for every building design should be to ensure that, no matter what form or function the building eventually takes, the occupants should be safe from the threat of fire. This is the role of the fire protection engineer.

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winter 2003 www.sfpe.org



This essay is based on the Arthur B. Guise Honors Lecture presented by Professor David Lucht on May 20, 2002.

The Role of
Post-Secondary
Education in Advancing
Fire Protection
Engineering

By David A. Lucht, P.E.

he question is asked from time to time as to why so few schools offer fire protection engineering degree programs. After all, for decades the demand for FPE graduates has been exceptionally strong.. well in excess of the supply. One might think engineering schools would be eager to establish new programs where there is a recognized demand. This essay will offer some thoughts on this question and suggest some strategies for expanding the availability of degree programs worldwide.

THE FINANCIAL CRUNCH

It will come as no surprise that fiscal constraints are a major inhibitor to the startup of new degree programs. Private schools, like Worcester Polytechnic Insti-

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tute (WPI), are nonprofit corporations which must be operated on a sound business footing. The income must at least equal the outgo on a continuing basis. State universities may receive subsidies from the state government, but they, too, have fiscal constraints, and the demand for resources usually exceeds the supply.

In recent decades, engineering schools have had to raise their prices (tuition) faster than the rate of inflation in order to stay even. For example. American universities have increased tuition at twice the rate of inflation over the past 10 years (75% tuition increase vs. 36% inflation). During the same decade, the median family income only increased about 10%.1 This, along with other factors, has heavily increased the pressure for the university to provide financial aid. Over the past 20 years federal assistance has shifted from scholarship grants to loans, which place additional debt burdens on students and their families. In 1980, about 42% of federal aid was in the form of loans: in 2000, the proportion had increased to approximately 60%.2 It's a vicious cycle.

To compound matters, the "customer

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base" of potential engineering students has shrunk significantly over the past 20 years. The fraction of high school graduates interested in engineering has declined from 12% of the graduating class in the early 1980s to 9% last year... a 25% drop. This is further exacerbated by the fact that the overall population of college age students declined 20% between 1981 and 2000. All of this means that the engineering schools have had to compete for a bigger piece of a smaller pie. This has caused universities to incur added costs for marketing and advertising to increase market share and fill the freshman class. This year, WPI launched a multimillion-dollar television and radio marketing campaign in order to compete for market share. This is a first-ofits-kind investment for this 137-year-old institution.

While universities have been facing increased costs and a shrinking market, it should also be noted that they do not have the same cost-cutting flexibilities as do industry and many other nonprofit businesses. University professors are tenured... making it more difficult to execute layoffs, terminations, or reassignments. And most physical plant costs for classrooms, laboratories, and other support functions are fixed. Schools can't easily downsize or move to a cheaper labor market. It is difficult for university administrators to justify new investments in an entirely new academic degree program... especially in a nontraditional, little-known discipline like FPE.

SHORTAGE OF PROFESSORS

University professors are the backbone of any academic program, and it is extremely hard to find candidates who fit the profile universities normally demand when hiring new faculty.

The typical university professor has three degrees – B.S., M.S., and Ph.D. – in the discipline within which he or she is hired. A new assistant professor has typically spent 10 years studying at several universities and has conducted significant Ph.D. dissertation research under the direction of a senior expert in the field. Fire protection engineering does not have this luxury. WPI's FPE program has five fire protection engineering professors. None of them has three degrees

in the FPE discipline. They all received their fundamental education in one of the founder disciplines: mechanical or civil engineering.

If one thinks about this within the context of the university culture, FPE professors are somewhat at a disadvantage. New professors in the founder disciplines begin their first faculty job with many years of academic momentum. A mechanical engineering professor, for example, has been studying mechanical engineering at the B.S., M.S., and Ph.D. level for a decade. Teaching a junior- or senior-level ME course is relatively easy... the subject matter is very familiar. The new ME professor has more time and energy to spend on preparing for tenure and promotion, while the FPE professor has the added burden of getting up on the learning curve in new fire-specific areas he or she never studied in their own undergraduate or graduate coursework. Unlike the founder disciplines, there is not a robust feeder system of faculty candidates for new positions, candidates who have completed formal undergraduate and graduate education in FPE.

SHORTAGE OF RESEARCH FUNDING

Research is of importance to engineering degree programs of all kinds for several reasons. First, part of the role of academe is to uncover and disseminate new knowledge through teaching and publication in the archival literature. Research keeps university professors on the cutting edge. And their involvement in the research community helps them bring fresh, state-of-the art information to the classroom. On the operational side of the equation, there are some more pragmatic reasons research is important. This has to do with the fiscal crunch of engineering schools in general and the issue of tenure.

Tenure is certainly a concept that distinguishes the academic institution from most other workplaces. Once a professor earns tenure, it lasts for the remainder of his or her career. Basically, a tenured professor can only be involuntarily terminated for misconduct or when the academic program is shut down. The tenure decision is basically made by a tenure committee of profes-

sors. Typically the decision comes in the professor's sixth year. If the decision is no, the professor is terminated. If the decision is yes, he or she is granted tenure.

The tenure decision is based on the candidate's record and potential for future excellence in three areas of performance: teaching, service, and scholarship. To receive tenure, the candidate must demonstrate good teaching, service to the profession, and good scholarly performance (research). A professor's research is expected to contribute to the body of knowledge as documented in scholarly journals, textbooks, and other forms of the literature.

The research or "scholarship" criterion weighs heavily in the tenure equation and can be the big challenge for any new professor in any discipline, but especially FPE. The phrase "publish or perish" is more than a slogan. It is a sober reality.

How does a professor get research accomplished? The answer to this question most often involves graduate students. Most university professors are very busy people. They are usually employed on a nine-month salary, and the academic year is very intense, with preparation for class, teaching, advising, service, and a host of other duties. Graduate students are recruited to do a bulk of the research legwork, under the supervision of the seasoned professor. And the research forms the basis for the student's thesis or dissertation.

Normally, in engineering disciplines, graduate students do not agree to work on a professor's research without remuneration. They usually receive research assistantships which cover tuition and a stipend for living expenses.

For the most part, the money for supporting graduate student tuition and stipends, and summer pay for professors doing research, is not funded by the university operating budget. Most often the funding comes from off-campus sources. Research grants and contracts also provide revenue for the university.

A typical graduate student would be paid about \$30,000 a year for serving as a research assistant. This, combined with charges for the professor's time plus university overhead, brings the total cost to sponsor a graduate student to a total of \$50,000 to \$60,000 per year. The

M.S. with thesis normally requires two years' time; the Ph.D. another three or four years.

Following this research support model, it is clear that, in addition to their teaching and research skills, professors must have entrepreneurial talent in order to secure the external funding needed to establish and operate a robust research program... skills in addition to those needed to be a good teacher and scholar. The money normally does not come from the school, it must come from outside sources. And, like everything else, there is a lot of competition for the research dollar.

FUNDING SOURCES

Research dollars come from external sources such as government or industry. Some government agencies, such as the National Science Foundation (NSF), are mandated by Congress to fund research. Other agencies, like the military services, FAA, and Department of Energy (DoE), fund research that supports their mission. And industries fund graduate students and professors who are willing to work on projects that are in the sponsor's commercial interest.

The National Science Foundation is the prime research funding source for university professors and their graduate students. The NSF budget is currently about \$5 billion, with support going not only to engineering and the physical sciences but also mathematics, biology, computer and information science, geoscience, and the social and behavioral sciences. In years past, there was a fire research program at NSF. In 1973, NSF fire research funding totaled \$2.2 million (which, with inflation, would be \$9.6 million today). While modest in amount, this NSF program did support some important research outcomes... fire modeling to name one. Harvard Professor Howard Emmons, universally known as the father of computer fire modeling, received ongoing fire research support from NSF. During his career, Emmons produced 50 Ph.D. graduates, several dozen of whom concentrated on fire research. This program was shut down in 1973, and NSF has not had a fire research focus since.

The Emmons story is a great example of the importance of ongoing research

funding. NSF support was robust enough to enable high-quality research over a long enough period of time to vield real tangible results. And the value of Harvard's output was not limited to the research results themselves. Many of Emmons' students went on to contribute lifetimes of fire safety work to society. These include noted professionals like Dr. John deRis at FM Global Research, Dr. David Evans at NIST, and Dr. Craig Beyler at Hughes Associates. There was critical mass at Harvard, a community of talented scholars who, over the years, made incremental progress toward major accomplishment. Research funding was the enabler. When Emmons retired and the funding ended, Harvard lost in-

In 1974, the Fire Prevention and Control Act created the Center for Fire Research at the National Bureau of Standards, now the Building and Fire Research Laboratory (BFRL) at the National Institute of Standards and Technology. At that time, a \$2 million fire research grant program was put in place, with the idea of continuing support of some of the former NSF-sponsored research. The fire research grant program at BFRL is now about \$1.4 million (compared to \$8.7 million if the original grant program had simply grown with inflation).

Other government agencies support fire research that assists them in fulfilling their specific mission-related objectives. The SFPE recently released a survey which documents federally funded research totaling some \$37 million.3 The bulk of these research expenditures goes to support the salaries of federal research staff workers, consultants, and contractors, with a smaller amount for university research grants. About 14% of the dollars go to supporting university professors and students; about 1.2% to FPE schools. Indeed much of the work is shorter-term, "contract-deliverable-oriented" and is not particularly amenable to higher-risk M.S. thesis or Ph.D. dissertation work.

In the end analysis, sources of fire research funding for university FPE professors and students are limited, which is a key factor inhibiting the startup of new programs. New programs need new professors; professors need tenure; tenure needs research papers; research

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needs graduate students; graduate students need financial support from offcampus sources. A break anywhere in this chain can make for a difficult situation. The existing FPE programs must struggle and juggle to keep all these variables working in the right direction.

THE FUTURE

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So far, the picture painted above could be viewed as pretty grim. The climate has not been favorable for universities to decide to create new programs in nontraditional disciplines. In fact, during the most recent decades, several established FPE degree programs were shut down. The Illinois Institute of Technology's BSFPE program was terminated in the mid-1980s. It was the flagship program, having been the first in the U.S., started in 1903. The MSc program at the University of Edinburgh was shut down during the same era. In fact, WPI president Jon Strauss proposed shutting down the WPI FPE program in 1989... it was only the protests of friends and alumni that saved the day. Dr. John Bryan, the founding FPE department head at the University of Maryland, reports similar threats during his tenure. The University of British Columbia started and terminated a program as

well over the past decade.

There is little doubt the demand for FPE graduates will continue to grow. The demand has been wholesome for generations: there is no reason to believe it will not continue. The emergence of performance-based building codes in Australia, New Zealand, and the UK, as well as other countries, has been another employment driver for FPEs. In 1999, Australian fire protection engineer Peter Johnson reported, "There is now a major fire engineering consulting industry in Australia that was not evident at all in 1991."4 The first American model performance-based building code was just released by the International Code Council (ICC) in 2001. As it is adopted into law in states, cities, and counties throughout the U.S., it, too, will be a driver for more FPEs. And the World Trade Center event has set a new context for the use of FPEs on the design teams of the future.

And so we find ourselves in this conundrum. On the one hand, FPE offers a wonderful product which is in high demand and which serves the public good. On the other hand, we see a somewhat grim picture as to the future of FPE degree programs, at least for establishment of more new programs. Yet there are reasons for optimism.

• Fire research funding may get better

Most of us have been hoping for a very, very long time that our federal government would place stronger policy-level emphasis on fire research. Hope was piqued in 1973 when, in its report to Congress, the National Commission on Fire Prevention and Control recommended that the federal fire research investment be increased by \$26 million per year (\$113 million in today's dollars).5 This was to come to naught, but some renewed efforts are being seen. Hearings have been held by the House Science Committee in the wake of the World Trade Center collapse, and \$16 million has been appropriated to further investigate the incident. (It is interesting to note that the SFPE Research Agenda⁶ developed in 1999 did not mention structural fire protection on its list of priorities. The agenda was created during a two-day workshop involving 70 participants from all segments of fire

protection practice. Priorities then were risk-based concepts, fire phenomena, human behavior, and data.)

And, prior to the September 11 disaster, on its own initiative NSF took a renewed interest in fire research. In 2001, NSF engaged the National Research Council to "develop a clearly articulated statement of research, education, and technology transfer needs for improved fire safety in the United States." A workshop was held in Washington, D.C., in April 2002; its report is expected in early 2003. It is hoped that this NRC report will add another credible focus to national fire research needs in the U.S.

• Expanding degree programs using advanced technology

There is reason for optimism about future opportunities for expanded FPE degree programs, worldwide. The future may see creation of some additional "bricks-and-mortar," on-campus programs of the type we are used to seeing, with professors lecturing to students in the on-campus classroom... programs which can produce more graduates and provide the research laboratories needed to do scholarly work and contribute to the body of knowledge. And real breakthrough opportunities are available through advanced communication technology, the same technology the for-profit industrial sector uses every day to conduct global business operations.

Today the professor does not always need to be in the same room with the student. Distance learning technology can bridge the oceans and link students in any country with professors in any other country. It is estimated that 86% of American colleges and universities will offer distance learning of one kind or another in 2002, up from 62% in 1998. It has been estimated that distance learning enrollments increased from 500,000 to 2,000,000 during the same period. This approach to higher education in FPE can open up entirely new ways of thinking.

The proof of concept has already been accomplished for development and delivery of high-quality, university-level FPE courses to students continents away from the professor. WPI has been doing this since 1993 and now offers 14 full-semester courses via distance. Over one-third of WPI's FPE en-

rollees are practicing professionals who cannot leave their jobs and come to Worcester for instruction. The technology works well. WPI has graduated students with the MSFPE degree who have never set foot in Massachusetts. But much more can be done, especially with the younger college-age population and with interscholar cooperation.

Talent sharing

When we open our minds to the new paradigm which allows that the professor and the students do not have to be in the same room at the same time, lots of interesting ideas can emerge. For example, WPI realized that it is possible for on-campus students to be taught by professors at other universities. Last year, UC Berkeley Professor Patrick Pagni taught a course in fire safety science for his UCB students in California and simultaneously delivered it to WPI on-campus and distance learning students. He was merely appointed as a WPI adjunct professor, and the technology took care of the rest. This was a highly successful course, bringing a specialized expert to the WPI curriculum in a way that would otherwise have been impossible.

Last year, one of WPI's distance learning students in the State of Washington wanted to take a lab course to learn how to use a specialized ignition apparatus which was available in a local laboratory. Dr. Vyto Babrauskas happened to live in the area, and he was agreeable to teaching the lab course to the student... again as a WPI adjunct professor. There are experts at universities and government/industrial fire research labs worldwide, of the caliber of Pagni and Babruaskas, who can potentially serve as specialized teachers for engineering students at any engineering school, using remote-learning strategies.

• Interuniversity networking

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Over past years, the line of thinking for universities starting FPE programs has followed the path that has been familiar to WPI and all other schools, i.e., an on-campus program, with on-campus professors, staff, offices, and laboratories. But again, the distance learning paradigm can open up new lines of thinking. Does each and every FPE

school need to have all the program elements, or can elements be shared? Sharing and collaboration are definite possibilities.

In 1999, WPI and the University of Costa Rica (UCR) began working together to help UCR get an FPE program started. The University of Costa Rica had approval from the university leadership, but did not have the resources to hire a cadre of FPE experts to form a complete, self-sufficient academic department. WPI worked with UCR, making WPI's distance learning courseware available to UCR professors. For example, UCR used WPI video-recorded lectures as "video textbooks" for UCR students. Over the past three years, UCR has made remarkable progress in developing and delivering FPE courses tailored to their local needs.

Another approach is underway in Korea, under a new Memorandum of Understanding with Seoul National University (SNU). There, some 18 FPE students are meeting as a class on a weekly basis to receive graduate instruction which will lead to the MSFPE degree. Courses are taught in various formats: (1) directly by WPI professors via distance learning; (2) jointly by WPI and SNU faculty; or (3) by SNU professors working in areas where they have specialized expertise, such as process safety management and industrial fire protection. The program in Seoul would not have been possible were it not for the school-to-school cooperation and distance learning technology.

• Reaching college-age students

The recruiting of young men and women into FPE is an "easy sell." For some young folks, there is an attraction to careers that make a difference, something "different." Fire protection engineering can be seen as fun and cool. But it is difficult to reach high school students, because of the large numbers and the small fraction that is even interested in engineering (less than 9%).

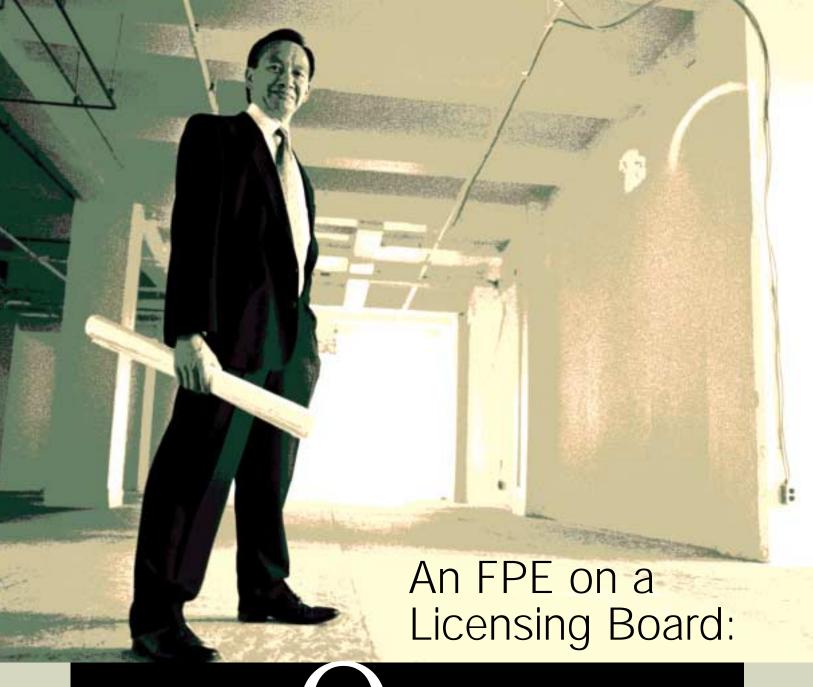
There are over 300 engineering schools in the U.S., with nearly 400,000 young men and women who have been "prescreened" with an interest in engineering. A surprising fraction of them really do not know what discipline they might end up choosing. They are also candidates for recruiting into FPE.

To take this a step further, the distance learning paradigm can open up new lines of thinking for this group of potential FPEs. All of these 300+ engineering schools teach the fundamentals needed by any FPE - math, physics, chemistry, statics, dynamics, fluid mechanics, thermodynamics, and heat transfer. And potentially they can gain access to FPE courses via distance learning. This is a chance to introduce them to the formal discipline of FPE while they are still undergraduate students at their home universities. For example, one young woman graduated last year from Illinois Institute of Technology with a BSCE degree and a minor in FPE. She earned FPE credits by taking several courses from WPI by distance learning, using them as transfer credits toward her IIT civil engineering degree. She has now taken a job with Rolf Jensen & Associates in Chicago. Ultimately, she has the option of going on to finish her MSFPE having already completed some of the M.S. degree requirements at WPI.

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Person's View

When first appointed to the Board, it was very apparent to me that no one truly comprehended and appreciated the technical discipline of fire protection engineering (i.e., what and who we are). At the time of my appointment, the Board was struggling with licensing issues with respect to sprinkler design and layout. This proved to be one of the major reasons I was appointed to the Board - to help sort out this dilemma. The Board unsuccessfully struggled to claim sprinkler design as within the realm and purview of a licensed design professional. Minnesota law, initiated by the State Fire Marshal's office, pre-empts the Board's authority and allows a NICET Level III or higher technician to design and lay out sprinkler systems. During the debate, I established a voluntary technical advisory group (a wonderful way for fire protection engineers to get involved with their licensing board) comprised of industry representatives, engineers, contractors, a few Board members, and even an occasional lobbyist. The jurisdictional authorities believed the sprinkler contractors were as competent (if not more) than the practicing engineers at large (i.e., mechanical) and that there were just not enough FPEs to suffice the demand if the law were changed. It was the old chicken-and-egg argument. In the end, the law remained but the lively discourse resulted in building a communications bridge between the State Fire Marshal's office and the Board.

Similarly, the Board became more proactive with the State's Building Codes Division. The design professionals gained a better understanding of the jurisdictional authority challenges and needs, and vice versa. The professional attributes of fire protection engineering were elevated. While those intimately involved in this debate enjoyed a better understanding of fire protection engineering, it was very apparent that other regulatory groups, professional associations and the public at large were still ignorant of the role of the FPE in the design process.

The Minnesota Designer Selection Review Board, which is responsible for the selection of design teams for select state construction projects, asked me to make a presentation to the Selection Board, describing the role of the fire protection engineer in the design process. It was quite evident by the questions asked by the Selection Board that their understanding of the discipline of fire protection engineering was extremely limited to that of sprinkler design. It still persists today, and the definition the SFPE community uses to describe our profession is foreign to mainstream design stakeholders. The Selection Board concluded that there were non-FPE-licensed engineers competent to design sprinklers and fire alarm systems, yet wrongly neglected the other attributes of a fire protection engineer.

By Michael A. O'Hara, PE

erving as an FPE on the Minnesota Board of Architecture, Engineering, Land Surveying, Geoscience, and Interior Design (Board) expanded my knowledge and appreciation of the diverse needs of licensed design professionals. Being appointed by former Governor Arne Carlson and serving for four years, two as chair, were both an honor and a privilege.

The Board's mission is to provide reasonable assurance that design professionals practice competently and ethically in order to protect the health, safety, and welfare of the citizens of Minnesota. Education, examination, and experience establish the foundation of professional practice enforced by the Board. The 21-member Board, 16 from the design professions and 5 from the public at large, had responsibility for 17,000 licensees and certificate holders, less than 40 of which are fire

protection engineers. Minnesota "licenses" design professionals in general related to their general profession (engineer, architect, etc.) and not by specific engineering discipline. The Board's activities center on the design and construction process, given the presence of industrial licensing exemptions for engineers in certain employment settings such as government or manufacturing.

During my tenure as chair, I inherited a Board with scarce resources and an

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"I set aside my personal professional interest so that I could adequately serve the design professions, execute our mission, and protect the health, safety, and welfare of the citizens of the State of Minnesota."

unstable budget; communicated with legislators concerned about ineffective statutes and overregulation; withstood an unsuccessful lawsuit against the Board: skirted a movement to abolish the Board by a disenfranchised minority; wrestled with the development, maintenance, and enforcement of Minnesota Statutes and Promulgated Rules; tackled fire sprinkler licensing issues; addressed title and practice act issues; and managed formidable continuing education, ethics, examination, and licensing issues. Through it all, I was blessed with competent and collaborative Board members and a gifted Executive Secretary. Along the way there were some tough decisions - sometimes the choices were between two unpopular options, other times it was more clear-cut. At times, rigid state statutes and rules blocked commonsense decisions. For the most part, the Board effectively met its mission head on. The most difficult part of my job, even when the facts were indisputable, was the emotional strain of revoking a license of a practicing professional. I always did it in person.

I rarely thought of issues specific to fire protection engineering during my time as chair. Essentially, the broader challenges facing design professionals affected FPEs. I set aside my personal professional interest so that I could adequately serve the design professions, execute our mission, and protect the health, safety, and welfare of the citizens of the State of Minnesota.

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There are several issues into which I gained an insight as a result of my experience on the Minnesota Board.

These include:

Civic Issues

- 1. The value of the profession of engineering is being challenged from many directions. The public questions the value of having a PE license. Is engineering dead as a profession as we know it? Call it apathy, market efficiency, or professional abdication; having a PE isn't what it used to be. The public and even some state agencies question the value of mandating a licensed professional in design. For example, in certain circumstances, Minnesota law does not require a licensed engineer to design bridges.
- Licensing boards cannot increase the value of a profession. Daily conduct and a continuous effort to demonstrate the value of an engineering license to the public accomplish this. A mandated license only temporarily raises the bar. A license will not protect an engineer's career.
- 3. A new design and construction paradigm is emerging, and state licensing boards, with the help of the engineering community, will need years to figure it out. The lines between design, layout, and installation are blurred. Today, design and construction is a collaborative process which is fluid and flexible. The public is demanding breaking down the walls and ending turf battles between the different entities in the building design process. As engineers, we must listen to the public, view the trends, and embrace the challenges. Our survival depends upon it! The licensing board lags behind in the development of appropriate regulations.
- 4. Laws can mandate requirements for a licensed professional, and in the short term, they may create a demand. But the public at large can find other ways to satisfy their needs. The public is way too clever

- and will find ways to avoid (not evade) licensing laws. Of the fastest-growing design-construction-related firms in the State of Minnesota, none of them are pure consulting engineering or architectural firms. A one-stop shop is a mantra to many.
- 5. Budget pressures continue to challenge boards to find means of effectively conducting their duties. The Minnesota Board focused energy on hiring investigators to follow through on complaints received and enhance educational efforts. Increasing the number of volunteers to participate in the process has far greater benefits than just relieving budgetary pressures. License fees do not necessarily go directly back to a board; Minnesota's license fees went to a general fund.
- 6. An informed public best achieves enforcement of licensing laws. Too many individuals are practicing engineering design without a license. Technology, from simplified CAD programs to boilerplate, off-the-shelf design packages, makes it easy for unlicensed professionals to perform design. Hiring investigators to handle cases is one thing; an educated public regarding licensing laws casts a wider net of compliance. Unlicensed practice is a major threat to the design profession and public safety. Code officials are the single greatest resource to curb problems of non-compliance.
- 7. Boards sometimes forget they are there to serve the public in a timely manner. Elected officials are there to remind them of their duty in case they forget. The Board is not a police officer, but rather a promulgator of regulations and an enforcer analogous to a judge and jury.
- 8. There is a talent crisis in the engineering profession. Most high school students shy away from engineering in general, creating vast shortages of engineering talent to begin with. Compounding the problem is the fact that many universities in Minnesota would rather produce

- engineers who would invent the next revolutionary heart valve, supercomputer, or prosthetic limb, not grovel in something as mundane as building design.
- 9. Engineers think in concrete terms; black and white. Life is an inconsistently shifting shade of gray. Harry Beckwith's classic business book Selling the Invisible quotes actress Meryl Streep: "Life is more like high school." High school typically involves cliques, self-interest, illogical events, shifting alliances, and an unbridled moodiness. With licensing boards, the political arena frequently clashes with the regulatory structure of a licensing board. Many engineers struggle to deal with shades of gray when trained to quantify and solve problems in a logical framework.
- 10. Minnesota mandated continuing education for design professionals. Lifelong learning should be an instinctual habit, yet it seems that it needs to be mandated, because many professionals don't see the purpose or value of continuing education. Continuing education builds professional assets, builds competency, and protects the public. Technology changes so quickly, and all professionals need to stay abreast. The science of fire protection engineering is a classic example of the changing body of knowledge that needs to be transferred to the practicing engineer. Take advantage of the plethora of educational opportunities simply for the joy of learning.
- 11. Engineers should cherish this license. If they don't, who will? The

public is already cynical about politics and Wall Street. If engineers make unethical choices, the skeptical public will be given a reason to mistrust the profession. Unethical practice dumbs down the value of the license.

Fire Protection Engineering Issues

12. Fire protection engineering is grabbing for pieces of a shrinking and ever-changing pie. Where does a fire protection engineer fit in at the design table? Is the fire protection engineer relegated to being a code consultant or called in special situations only? What other services do fire protection engineers offer to increase their value? The public at large or the licensing board does not under-

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stand the role of a fire protection engineer in the design process. It is not their fault; it is the profession's fault for not effectively articulating who we are. Boards need help from the profession to sort it all out. Otherwise, the public will do it for the profession.

- 13. The Authority Having Jurisdiction may be a fire protection engineer's best friend if they are convinced of the value of a fire protection engineer in the design process.
- 14. The definition of a fire protection engineer in the *SFPE Engineering*
- Guide to Performance-Based Fire Protection Analysis and Design of Buildings' is ineffective in terms of making the public at large understand the fire protection professional. This definition is not only foreign to the public at large but fails to capture in pragmatic terms the role of a fire protection enginneer in the design process. Boards desperately need to be educated. Minnesota in general views a fire protection engineer as one who designs sprinklers and maybe fire alarm systems.
- 15. Fire protection engineers must take an active role in their licensing boards. The Minnesota chapter of SFPE has a link on the Board's Web site. But it is just the first step. Fire protection engineers should attend meetings of the licensing board.
- 16. Fire protection engineers must continue to educate the major stakeholders in the design and construction process. They should be a missionary for the profession and show its value.
- 17. Performance-based design will either be the savior or demise of the fire protection profession. Is it all smoke and mirrors? The Board and jurisdictional authorities have enough trouble with the basic definition of fire protection. A legal counsel aptly stated at WPI's Second Symposium on Fire Protection Design in the 21st Century that a jury decides how safe is safe.² Licensing boards decide on their own terms.
- 18 Fire protection engineers should become involved in the issues that affect the profession. Fire protection engineering is a specialty profession in a crowded field. Fire safety is not necessarily the compelling safety aspect of a project. The fire protection engineer's fate is joined at the hip with the fate of all other licensed engineering professions. We can't go it alone.
- 19 The U.S. fire problem, other than wildfires, is perceived by the public

at large and many legislators to be "statistically solved" and that increased expenditures to reduce fire losses provide diminishing returns. With competing problems and scarce resources to allocate, obtaining additional resources to promote licensure activities, let alone fire protection, continues to be a daunting task. Legislators have bigger issues to tackle (and make headlines with). Based upon state statistics produced by the Minnesota State Fire Marshal's office, fire losses in Minnesota cost the State of Minnesota approximately \$175 million in the year 2000. As tragic as fire losses are, they pale in comparison to some of the other public health and safety challenges we face.

20. Volunteerism makes life great. Getting involved for the cause of the profession is the earmark of a true professional. Don't know how? Every board has a Web site. Know the names of the board members. Make them aware of SFPE. If we don't care, neither will the licensing board.

The issues facing fire protection are only a microcosm of broader underlying trends within the design professional's sphere. Being licensed means meeting a certain level of competency that is demonstrated through education, testing, and experience. As design professionals, we work very hard to obtain and maintain our licenses. However. obtaining a license is just the first step, because in the long run its true worth and value are based upon consistent ethical conduct and relentlessly finding ways to solve the needs and challenges to the public. When we look at our license or that plaque on the wall, we should reflect upon where the fire protection engineer fits into the bigger scheme of things. We must deserve our licenses; Winston Churchill once said, "One must 'deserve' victory." A design professional must deserve receiving the true value of the professional license that is granted, which comes as a result of hard work, persistence, integrity, education, insight, and preparation. Success comes to those deserve it. A

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ENGINEERING FAILURE or

Failure to Engineer?

odes and standards often require specific fire protection features for certain occupancies, construction methods, and hazards. In situations not covered by the prescriptive code approach, engineers are using "performance-based" solutions. Failures, when they do occur, can often be attributed to either a failure in the engineering of the fire protection or a failure to apply engineering methods to the selected situation or solutions. This article explores a few examples to show how engineers and technicians can contribute to success or to failure.

With sprinkler systems, the actual piping layout and support details are often left to a technician. Using "pre-engineered" solutions and well-established routines for calculations, the technicians can correctly lay out a system. However, selecting the type and performance characteristics of the system often requires a thorough engineering analysis. The application of science and scientific principles is needed to match the proposed sprinkler system to the hazard and to coordinate the system with other fire protection and prevention measures. For example, regardless of whether you are in favor of or against the use of automatic roof vents in sprinklered warehouses, there is no doubt that, if they are present, the sprinkler system requires specific engineering to properly work with the vents.

One of the most common failures associated with fire detection and alarm systems is the failure to provide fire protection. A fire detection and alarm system is not a fire protection system unless it does something to affect the fire, the property, or the people. For example, a complete fire detection system with smoke detectors and heat detectors in every room and space does little good if the system sounds a local alarm in the middle of the night when the building is not occupied and does not automatically communicate to the fire department. If it

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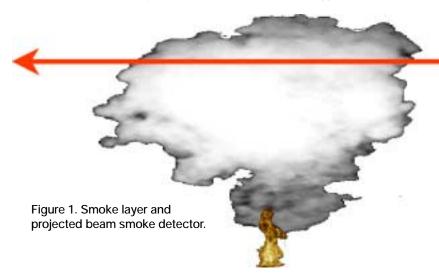
does summon the fire department, what good is it if the fire is too large for the arriving firefighters to safely attack? Perhaps this system is protecting an historic library in a community with part paid fire company whose nearest apparatus is five miles distant – uphill. This is a failure to engineer.

A technician that specializes in fire detection and alarm systems may fail to recognize the greater benefits of suppression or containment that might be possible in the example above. Almost exclusively, technicians specialize in one aspect of fire protection - fire alarm, special hazards suppression systems, or sprinkler systems. They often lack the overall fire protection engineering experience to evaluate the risks rather than just the hazards. Combined with detection and alarm, a fire protection strategy that includes even just containment, by the closing of fire doors and dampers, may provide the time needed to allow firefighters to contribute to successful fire management.

Engineers sometimes fail to provide engineering. Projected beam smoke detectors are often employed in large, clear-span spaces to provide early warning of a fire. For example, in a warehouse used to store battery packs for a certain product, the owner may wish to detect a fire before sprinkler operation to allow a trained fire brigade the opportunity to safely extinguish the fire with the result being a lower level of damage and no down time.

Figure 1 shows a beam being projected through a smoke layer. In the earliest stages, there may be an undefined plume as smoke from low-heat, smoldering combustion creates a haze in the space. Later, as open flaming occurs, there may be a defined plume and ceiling jet. Then, a defined layer may develop. Using simple calculation methods or more complex fire modeling, it is possible to estimate the total obscuration or the optical density that the projected beam smoke detector experiences at these different fire development stages. It is also possible to engineer the detector response by asking at what level of total obscuration or optical density the detector should be set to trigger an alarm. (See Example 16 in Chapter 4-1 of the SFPE Handbook of Fire Protection *Engineering* for sample calculations.¹)

Projected beam smoke detectors have variable sensitivity. For one particular model, the range is from 20% to 70% total obscuration in 10% increments before an alarm is triggered. The manufac-





turer's instructions contain recommended sensitivity settings based on the total projected distance. These settings are in turn based on requirements in the product listing standard. For example, in a space 30 m (98 ft) long, the recommended setting is on the order of 40% total obscuration, or a total optical density (D) of about 0.22. If the smoke layer is well defined and well mixed, this would correspond to a unit optical density (D_n) of about 0.0074 m⁻¹, or a unit obscuration of about 0.52% ft1 across the entire 30 m (98 ft) path length. However, if the project goals require earlier detection, it may be necessary to set the detector to a sensitivity higher than the manufacturer's recommendation - perhaps 20% total obscuration, or a total optical density (D) of about 0.097.

Certainly, an engineering sensitivity analysis is needed to understand the effects of having a plume and ceiling jet without a well-mixed layer, as well as the effects of stratification and the smoke-production characteristics of different fuels or combinations of fuels. Failure to determine the required settings is a failure to engineer. Failure to select the correct data for the variables and failure to conduct engineering sensitivity analyses are engineering failures.

Another failure that might occur for the example above would be if the resulting system were prone to false or nuisance alarms. Will a setting of an alarm level at 20% total obscuration (0.09 total optical density) result in nuisance alarms from the exhausts of fork lift trucks or due to atmospheric haze or the combined smoke from 10 workers puffing on cigars and blowing the smoke towards the detector? Do some engineering. Estimate and calculate the resulting cloud size and obscuration. The unit optical density needed to get 20% total loss across 30 meters is 0.0032 per meter which is 0.00098 per foot. But could they produce a higher unit optical density across a smaller path? Could they smoke enough cigars to block 20% of the light beam? What size clouds (obscuration path lengths) at what unit optical densities will result in 20% total obscuration?

Another, less common, failure mechanism occurs when the proper operation

of one protection system causes the failure of another system. In fire protection, because of the many uncertainties we face, we often use the "belt-and-suspenders" approach - two systems, either of which will meet our protection goals. Perhaps our belt is successfully holding up our pants with little or no load on the suspenders. We've tested the system and know that the suspenders are properly adjusted and can hold up our pants just fine without a belt. However, if the belt suddenly fails, the resulting momentum and impact load on the suspenders may cause failure of the clasp. We might call this an exposure failure. The same sequence can occur with protection systems.

Consider an oven used in a coating process involving flammable solvents. Explosion relief is provided by the use of shear bars on relief doors. We must calculate the range of expected pressures, the area of the doors, and the resulting forces. In consultation with the owner, it is decided that this is a missioncritical process, and it would be better if we suppressed the deflagration before an explosion occurs. This can be done using high-speed suppression systems actuated by pressure sensors capable of sensing the initial pressure rise as the flame progresses outward in the vapor/ air mixture from the point of ignition.

Failure to engineer occurs if the designer fails to check which will happen first: the sensing by the pressure detectors or the relieving of the pressure by the explosion relief doors. Engineering failure occurs if the designer calculated the incorrect range of possible pressures or failed to account for relief through the normal ductwork and vapor incinerator. It is possible for the doors to relieve before the pressure sensor actuates. The resulting decrease in pressure prevents the suppression system from operating.

An everyday example of similar failures involves personal computers. A computer may have transient protection to guard against damage caused by lightning or other faults. The computer may also employ some level of line conditioning to be sure the power being supplied is clean and at a steady voltage. If they are not engineered to work together and in the correct sequence, it is possible that

the conditioning system will change the characteristics of a voltage spike sufficiently to cause the transient protection to delay or fail to operate before damage is done to the computer.

As fire protection engineers, our work is subject to both types of failures - failure to engineer and engineering failure. Pre-engineered solutions are often successfully deployed and used without any engineering taking place. Our codes and standards such as NFPA 13,2 NFPA 72,3 and NFPA 964 help engineers and technicians to employ proven pre-engineered solutions. As engineers, it is incumbent upon us to understand the limitations, assumptions, and bounds of pre-engineered solutions that we specify or review. It is also the responsibility of the manufacturers of pre-engineered systems or design guides, as well as the developers of codes and standards that permit their use, to document and convey this information to the users who may not be expected or even qualified to do detailed engineering analyses. **\(\Lambda \)**

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Editor's Note - About This Article

This is a continuing series of articles that is supported by the National Electrical Manufacturer's Association (NEMA), Signaling Protection and Communications Section, and is intended to provide fire alarm industry-related information to members of the fire protection engineering profession.

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IN FIRE PROTECTION ENGINEERING PRACTICES

By Ralph Transue, PE, and David Czajka, SPHR

successful fire protection engineering practice achieves client satisfaction, provides technically sound and practical professional services, and maintains a supportive and rewarding working environment for its people. The key to accomplishing all three of these corporate objectives begins and ends with excellent "human capital." These are the talented technical professionals who have confidence in their engineering science, knowledge of its technology and art, and the ability to develop effective solutions for clients that achieve desired fire protection objectives.

Human Resource Challenges Faced by Managers of FPE Professionals

Although simple in concept, acquiring this top-caliber talent is a difficult task for engineering firms, particularly for firms that have not invested in a hu-

man resources program. Adding to the dilemma is the current state of affairs in the world in general and the fire protection engineering profession specifically.

Driven by the new economy, the fire protection engineering profession's competitive landscape is changing rapidly. Global expansion, high-speed delivery of products and services, technical advances, and redefined business models represent changes that this new economy has introduced. Organizational leaders are beginning to realize that the ability to acquire, develop, retain, and motivate the "right talent" remains a key to establishing competitive advantages in their marketplaces. In fact, according to Development Di-

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mensions International, a noted leadership development company, many CEOs around the world have placed human capital initiatives at the top of their business agendas for the new millennium.

The tragic events of September 2001 have also heightened public and corporate awareness of the importance of the services that fire protection engineers provide. This awareness has created an even greater demand on an already tight labor supply of fire protection engineering professionals.

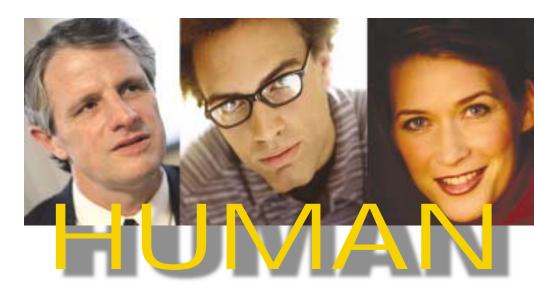
Against this backdrop of an evolving workplace, there are human resource challenges that remain constant for an engineering firm.

CHALLENGE ONE: RECRUITING

To meet human capital requirements, management in engineering firms must understand the core competencies they require and target them in their recruiting efforts. One advantage to this target competency approach is that it permits a firm to look outside the fire protection specialty into other engineering disciplines while still focusing on the factors that are critical for the company's technical and business success. It also lays a foundation for development and management of each employee's career growth by maximizing and leveraging their individual potentials.

For example, as part of a best practices regimen, Rolf Jensen & Associates, Inc. (RJA) encourages their offices to develop relationships with local engineering schools. The purpose is to identify individuals who are interested in FPE and who have core engineering skills. Distance learning programs, tuition assistance for engineering students attending local colleges, and internships contribute to developing new FPEs by building on students' core engineering competencies. This is beneficial in two ways. First, the approach has opened up the recruiting pipeline beyond the traditional FPE schools. Second, and possibly more important, it has provided the exposure of fire

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protection engineering as a viable option to individuals who may not have otherwise known about or considered FPE as a career choice.

Of course, not all human capital is recruited out of college. Since there is no replacement for experience, engineering firms need to recruit veteran individuals, provide challenging assignments, and motivate them to mentor others. A company's system of performance rewards must include recognition of the importance of a senior engineer in building teamwork and providing mentoring to younger engineers with less practical experience. Often the quality of the project assignments and the caliber of the engineering team are as important to a senior engineering recruit as the compensation package.

Even as market conditions have temporarily slowed some of the funding for recruiting, the labor pool of FPEs has remained tight. Many firms may have experienced a downturn in business as a result of delayed or cancelled projects. Consequently, there has been a recent increase in available FPEs in the job market. However, this situation will quickly reverse as projects resume and client spending increases. We will once again be faced with a major shortage of FPE professionals.

CHALLENGE TWO: RETENTION

Once hired, the next challenge is to retain the FPE. Retention efforts are not "canned," off-the-shelf programs.

Rather, a good retention program focuses on all aspects of the employment experience. A company's success in retaining excellent employees is the result of the effectiveness of its entire human capital program including recruiting, employee orientation, training and development, mentoring; performance management; compensation and benefits, and career growth.

The changing dynamics of fire protection engineering employment and shifting client demands have required organizations to refine the way they operate. Management's challenge to constantly balance professional staff activities among business development, client relations, technical delivery, project management, and collections is difficult for large and small firms alike. More and more, companies are looking to a core competency approach to increase their human capital efficiency and become more proactive to market changes.

The high cost of engineering specialists presents yet another challenge. It is no secret that FPE firms have been subject to rising salary costs over the last several years. This is a result of many factors. First, by the pure nature of being schooled in a specialty engineering discipline, FPEs may demand a premium in the labor market compared to other engineering disciplines. Second, in recent years, FPE firms have escalated salaries while competing for talent fresh out of college as well as experienced engineers. Companies that have met the rising salary costs now



find themselves faced with the need for higher billing rates. Billing-rate escalation has created an opportunity for non-FPE firms to enter the FPE marketplace, typically with lower rates.

Naturally, one could argue that the depth of knowledge in fire behavior may be somewhat limited in non-FPE firms. They may not fully meet the needs of the client, but they still represent competition and yet another challenge in how firms market and position professional services and their value to the client. This threat from non-FPE organizations is best met by constant promotion of the SFPE image and the attributes of the FPE specialty discipline to all types of clients.

Along with rising salary costs, firms are also are faced with escalating benefit and healthcare costs. In 2002, many companies experienced increases of up to 30%. This trend of escalating healthcare costs is likely to continue over the next several years, causing a negative impact on firms' ability to recruit and retain exceptional talent. The answer lies in balancing a market-competitive salary with a comprehensive, affordable benefits package. Gaining a better understanding of the attitudes and motivating factors of the FPEs a firm is seeking to attract and retain will provide insight on how to achieve that balance. Organizations must design employee programs that are flexible enough to accommodate the differences in motivational factors while still providing a common focus toward achieving the organization's goals and objectives.

CHALLENGE THREE: MOTIVATION

In a recent survey at RJA, the quality of engineering assignments was the number one reason FPEs joined the firm, followed by the reputation of the firm, salary, office location, and benefits. This indicates that RJA has succeeded in creating an atmosphere in which fire protection engineers want to come to work each day, because they enjoy the project challenges and they believe that they are growing in their professional and personal lives.

Professionals who are motivated primarily by money are usually not the best fit for a professional services position. Successful FPEs tend to be motivated by performing at a high professional level for their clients, working closely with an excellent team, and being rewarded – both financially and in terms of professional recognition – for building their consultancies.

The apprenticeship of engineering is a professional development concept that requires individual initiative, personal responsibility, and the support of the organization. Even when given challenging work assignments, the FPE feels most comfortable if surrounded by a team of available mentors and peer reviewers.

In some cases, young professionals perceive that their value is greater to the organization than it may really be. Managers may find that reconciling the salary expectations of younger, less-experienced professionals with the fiscal

realities of a modest profit margin business can be difficult.

CHALLENGE FOUR: MENTORING

Career development in fire protection engineering is an apprenticeship. Over time, the fire protection engineer develops a broader understanding of his/her science and its art. FPEs learn from those who are practicing and leading the profession now, as well as those who have led in the past. Since fire protection engineers tend to identify with their profession even more than with their employer, mentors can be found in both their own organizations and throughout the fire protection industry.

The need for mentoring is immediate and constant. According to engineering managers within RJA, certain practical knowledge is missing in some new FPE graduates. They may be able to describe the principle of operation of a smoke sensor or configure the input file for a computer fire model, but they may never have seen a hydrant flow test or inspected a fire pump. This may be even more acute in graduates from other disciplines. In the long term, getting the proper engineering core competencies in school is more important than watching a flow test, but the absence of the practical orientation in new graduates places the responsibility for practice training directly on a firm's mentoring program - the apprenticeship of engineering.

CHALLENGE FIVE: TRAINING

Building on an FPE's core competencies through mentoring and practical project experience is the number one priority in an individual's professional development program. A great engineer does not necessarily make a great consultant or a great manager. But to consult or manage in this profession requires a sound technical education.

Beyond the technical aspects of the job lie skill sets equally important to the success of the FPE and his/her firm. These skills include the ability to

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develop new business, manage time efficiently, and communicate effectively with clients and team members. As FPEs move up the ladder in their firms, they will undoubtedly become involved in managing people and directing activities ranging from billing and collecting fees to developing business plans.

While on-the-job training and mentoring are valuable tools in support of professional development, they should not be the only form of training. Specialized training and education are required to develop the knowledge and skills necessary to meet a firm's organizational goals as well as the needs of its individuals. Such training should be broadly supported by the organization.

RJA has taken a very robust approach to the challenge of ongoing training by developing an internal education center: The RJA Academy. The Academy provides opportunities for

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orientation and training in the areas of leadership, operations management, finance, business development, and project management. Technical training programs – in audio, video, and print formats – are developed by RJA's sister company, Protection Knowledge Concepts, and made available to all RJA offices for ongoing education of FPEs and support staff.

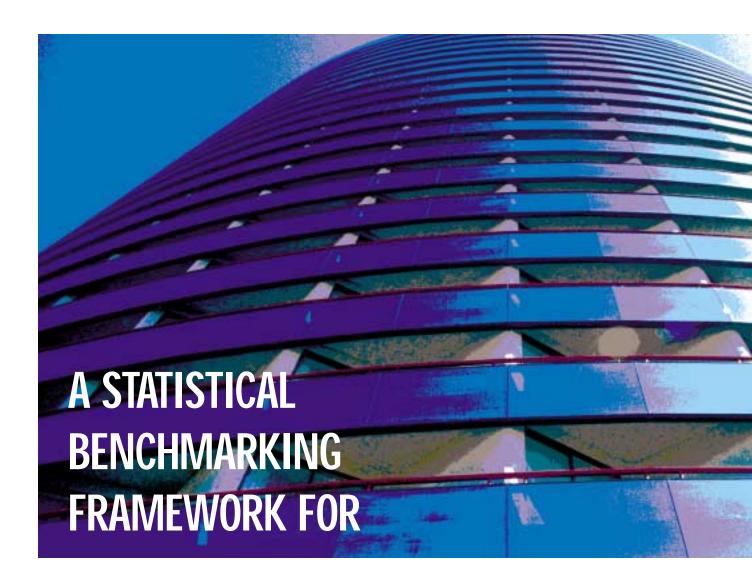
THE HUMAN CAPITAL BOTTOM LINE: COMMITMENT AND CONSISTENCY

The common denominator with all the challenges we've discussed is that they involve human resources. However, the managers faced with these challenges are not HR professionals. They are FPEs managing a group or operation for a larger company, or presidents and CEOs of smaller companies. Some companies have dedicated

HR professionals on staff, others do not. If the human capital of an organization represents its true differentiator and competitive advantage, then the firm must make a commitment to develop an effective HR program.

The program may involve establishing an HR department or at the very least, providing additional training for the people entrusted with the human capital responsibilities within the company. The HR function must be planned and funded. It must prioritize the tasks – from recruiting to ongoing training – to be accomplished and provide a way to measure the progress. But above all, the HR effort must be consistently implemented, in periods of downturn as well as good times.

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DEVELOPING STAKEHOLDER CONSENSUS

Fire Protection Engineering Number 17

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By Edward L. Fixen, P.E.

The fire safety goals and objectives underlying modern building code requirements have become obscured with time and can be difficult to objectively define. In addition to the benefit of enabling cost-effective design, the development of performance-based design is intended to provide an alternative process to prescriptive codes that reduces subjectivity and facilitates consensus-building. At the foundation of performance-based design is the development of clearly understood fire safety goals and objectives that reflect stakeholder consensus.

One of the key challenges of establishing acceptable goals or objectives is that it inherently involves an assessment of uncertainty and risk. For numerous reasons, this assessment is most often qualitative in nature rather than quantitative. Arguably, the largest obstacle to successful implementation of performance-based design is not the technical evaluation of fire in the built environment or the exercise of engineering judgment, but the lack of widely recognized "acceptable" building fire risk criteria. Most building officials and fire officials are reluctant to reach consensus on the issue of determining what is "acceptable" in fire risk terms in lieu of prescriptive code terms. This challenge is not limited to building or fire officials. In general, fire protection engineers are more willing to address issues of "acceptable risk" but can have very divergent views on the appropriate criteria. This should not come as a surprise since, as noted by Watts and Hall, determination of "acceptable" fire risk is more of a philosophical issue than a technical one.1

The use of risk criteria seems to be further complicated by the fact that

while risk is generally understood on an abstract level, the units of risk and its' use in design criteria are not always easily or intuitively understood. For these reasons, it seems that one approach suited to developing stakeholder consensus with regard to "acceptable risk" is on a comparative basis. It is suggested that one alternative to overcome the issue of "acceptable risk" criteria is the use of risk benchmarking to establish risk-based fire safety goals.

The framework discussed in this article utilizes a combination of The National Estimates Approach to U.S. Fire Statistics² and revisits an approach to correlate fire hazard analysis with fire frequency data originally presented in The National Fire Risk Assessment Project Final Report.³ To demonstrate one potential application of the framework, a case study of benchmarking building construction type is presented.

ACCEPTABLE RISK VS. BENCH-MARKING

Although it may appear to be a somewhat subtle distinction, the use of a benchmarking approach in lieu of specifying acceptable risk can reduce the barriers to developing stakeholder consensus on subjective issues involving fire and societal risk. Identifying "acceptable risk" requires a philosophical judgment that is unlikely to be shared in common by all stakeholders. On the other hand, utilizing benchmark levels of risk eliminates the need for judgment and instead relies on statistical data to establish a benchmark level of risk.

There are numerous pros and cons associated with using a benchmark approach to establish acceptance criteria. Most notably, implicit in a benchmarking approach is an assumption that historical risk is a surrogate measure of acceptable risk. While the use of historical risk for evaluating acceptable risk can be controversial, it is nonetheless a valuable tool for benchmarking. While improvement (i.e., reduced risk) is always desirable, there is a point of diminishing return at which additional improvement may not be beneficial (e.g., too costly) to society as a whole. This optimal point of riskbenefit often requires a rigorous analysis beyond the technical and financial means of most projects. It is suggested that a benchmarking framework not only elimi-

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nates many of the hurdles associated with determining acceptable risk criteria but perhaps more importantly provides a repeatable, objective method for determining risk-based goals and objectives.

It is beyond the scope of this article to resolve the numerous technical and philosophical issues related to establishing acceptable risk criteria. In fact, it is because of the philosophical trappings of determining what is "acceptable" that benchmarking is suggested as a practical and objective method of establishing acceptance criteria.

NATIONAL ESTIMATES APPROACH TO U.S. FIRE STATISTICS

Key to the development of fire risk benchmarking is the use of The National Estimates Approach to U.S. Fire Statistics.2 The National Estimates Approach uses a combination of the NFIRS database and the NFPA Annual Survey to estimate fire experience for the U.S. NFIRS is a national database designed to document and report fires and the casualties caused by fire. As of 1995, fire departments in 39 states and the District of Columbia participated in the program. Using NFPA 901,4 data from these different departments are standardized. NFIRS captures roughly one-third to one-half of all U.S. fires each year and provides the most detailed incident information of any national fire-incident database.

However, the NFIRS data underreports the total number of fires in the U.S. Therefore, to project NFIRS results to national estimates one needs at least an estimate of the NFIRS fires as a fraction of the total so that the fraction can be inverted and used as a multiplier or scaling ratio. The NFPA annual fire department survey provides this scaling ratio. Although not nearly as detailed as the NFIRS database, the NFPA survey provides a much broader picture of the overall U.S. fire problem. Incorporation of both data sets allows the detailed data of NFIRS to be projected to the entire country. A more detailed discussion of The National Estimates Approach can be found in Hall and Harwood.2

Historical fire data obtained from The National Estimates Approach to U.S. Fire Statistics can be used to estimate the likelihood or probability of fire in a building based on several attributes such

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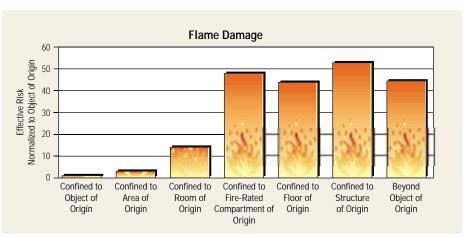


Figure 1. Risk Aassociated with Extent of Flame Damage

NFIRS Database Extent of Flame Damage	Radiant Flux from Upper Layer (kW/m²)	Max. Upper Layer Temperature (°C)
Object of Origin	1	100
Area of Origin	3	200
Room of Origin	15	450
Beyond Room of Origin	20	600

Table 1. NFIRS Flame Damage Linked to Fire-Spread Criteria

as occupancy, building height, sprinkler protection, construction type, etc. Additionally, the NFIRS data can be used to estimate the conditional probability of a specific fire consequence given a fire, characterized by extent of flame or smoke damage. For example, the conditional probability of a fire confined to the room of origin would be the number of fires confined to the room of origin divided by the total number of fires for that occupancy. The probability of fire and the conditional probability of a hazard given a fire can be combined to estimate the risk associated with a defined fire severity or consequence.

For example, Figure 1 was created from NFIRS data for one- to six-story apartment buildings over the last decade. Figure 1 identifies the risk associated with extent of flame damage. The effective risk in deaths per fire associated with flame damage was normalized to one by dividing each category of flame damage by the risk associated with "Confined to Object of Origin" to provide a means to directly compare the risk of each category.

From Figure 1 it is possible to draw several conclusions and/or establish target risk levels. For example, the risk of death in a one- to six-story apartment building is roughly 3-1/2 times greater when fire is confined to the area of origin when compared to fire confined to the object of origin. Figure 1 indicates that the risk of death increases substantially, on the order of 48, when fire spreads beyond the room of origin. The increased risk associated with fire spread beyond the room of origin, often associated with flashover, appears to substantiate the commonly recognized fire safety goal of preventing flashover.

CORRELATING FIRE SEVERITY WITH FIRE DATA

As originally suggested in The National Fire Risk Assessment Research Project Final Report,³ the NFIRS database provides a mechanism for correlating fire data and fire consequence. The fire data are not correlated with fire consequence in the statistical sense but rather from an engineering standpoint. One of the data-

base fields included in the NFIRS database is "Extent of Flame Damage." The "Extent of Flame Damage" category can be used to estimate the probability associated with a specific fire scenario. The "Extent of Flame Damage" field includes seven potential categories ranging from "Confined to Object of Origin" to "Beyond Structure of Origin." Clarke, et al.,3 developed an approach, summarized in Table 1, to link the categories of flame damage with fire-spread characteristics such as radiant heat flux and maximum upper laver temperature. Table 1 does not include flame damage categories more severe than "Beyond Room of Origin" because this event can be considered representative of flashover, generally considered unacceptable for most fire protection analyses.

Using available fire models and/or fire protection engineering calculations, it is possible to estimate one or both of the parameters identified in Table 1 for a given fire scenario. The predicted value of radiant flux or maximum upper layer temperature can then be linked to one of the "Extent of Flame Damage" categories. Once a category is identified for each fire scenario, the risk associated with each scenario can be estimated. This method of linking a fire scenario with a risk value would be useful in determining the overall risk associated with all credible fire scenarios. The resulting estimated risk value could then be compared against "acceptable risk" criteria.

CASE STUDY: CONSTRUCTION-TYPE BENCHMARK

There are many instances in modern building codes where the intent of the code can be qualitatively outlined but not quantified for the purpose of objectively evaluating an equivalency or performance-based design. The following case study is intended to demonstrate one potential application and use of risk benchmarking to develop stakeholder consensus.

The allowable areas and heights associated with building construction types are a prime example of code requirements that have become obscured with time and are difficult to establish quantitative goals and objectives. Construction height and area limitations have not changed dramatically over the past sev-

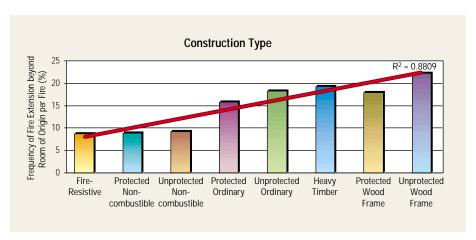


Figure 2. Frequency of Fire Spread beyond Room of Origin per Fire vs. Construction Type

eral decades despite significant advancements in fire protection engineering, structural engineering, and construction materials and methods.

The basis for the area and height limitations can be qualitatively described but are difficult to objectively define, much less quantify. For example, it would seem reasonable that a comprehensive fire protection and life safety strategy could be developed that would result in a six-story building of 1-hour construction being as safe as a building of 2-hour construction. The ability to quantitatively substantiate the strategy and reduction in construction is difficult at best and highly subjective. However, if a baseline risk benchmark can be established for the 2-hour building and the 1-hour building without the enhanced fire protection features, it would be possible to establish a risk benchmark for the acceptable goal (i.e., 2-hour building) and a reference point (i.e., 1-hour building) with which to evaluate the effects of enhanced fire protection features.

Correlating Construction Type with Extent of Flame Damage

Using the same data compiled for one- to six-story apartment buildings identified in Figure 1, the following analysis shows an application to develop a risk benchmark for building construction type. The first step is to determine if the type of construction has any effect on the extent of flame damage and ultimately life safety. Fig-

ure 2 was created by dividing the number of fires that spread beyond the room of origin by the total number of fires for each construction type. A best-fit regression line through the data does show a trend that the frequency of fire extension beyond the room of origin does in fact increase for lesser construction types. Per the regression line, fire will extend beyond the room of origin 7.5 percent of the time for fire-resistive construction and approximately 22 percent of the time for unprotected wood frame construction.

An R-squared analysis of the data shows a value of 0.88. The R-squared value is an indication of the precision with which the regression line explains the variability or uncertainty in the data or measure of goodness of fit. An Rsquared value of 1.0 would indicate 100% precision and is ideal. The best-fit line is a linear fit of the data. The Rsquared value can be interpreted as the proportion of the variance in y attributable to the portion of the variance in x. The accept/reject value for R-squared depends on the application, but a value of 0.88 shows a strong relationship between construction type and fire spread. Based on the strength of the relationship, it is reasonable to conclude that construction type can be used on a comparative basis to estimate liklihood of flashover. Further, it is reasonable to establish a benchmark level of risk associated with flashover (i.e., flame damage beyond room of origin) for each construction type. It must be acknowledged that construction type

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may be a surrogate measure of multiple attributes such as sprinkler protection and other life safety factors that affect fire spread, but from a statistical perspective, this predictive model can be considered statistically significant.

Correlating Construction Type with Property Damage

In addition to life safety, the goal of building codes is to protect property. Using a similar approach, it is possible to establish a property protection risk benchmark for each construction type. Figure 3 is a graph of average property damage per fire for one- to six-story apartment buildings of various construction types. As might be expected, fireresistive construction suffers the least amount of damage per fire, \$4,000, and unprotected wood frame construction suffers the most, \$11,000. A best-fit, regression line through the data shows an R-squared value of 0.975. The graph was created by dividing the total direct property damage per construction type by the total number of fires in that construction type yielding the average property damage per fire.

While the trend of increasing average property damage is not surprising, the strength or precision of the relationship is impressive. The strength of the relationship provides strong support for use of the data for developing property protection risk benchmarks using this approach. For example, the average property damage of \$4,700 for protected noncombustible construction could be used as the property protection risk benchmark to evaluate the ability of enhanced fire protection features in a protected Ordinary building to reduce average property damage from \$7,000 to \$4,700.

Correlating Construction Type with Fire-Related Deaths

Based on Figures 1 and 2, it would seem reasonable to expect that the frequency of death per fire will increase for lesser construction types. Figure 3 appears to strongly reinforce the hierarchical ranking of construction types in relation to fire hazard. Figure 4 is a graph of the risk of death per fire versus construction type in one- to six-

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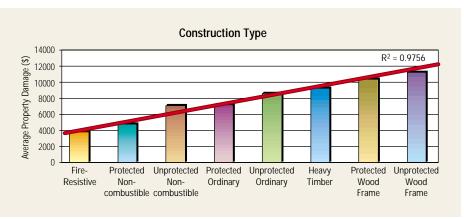


Figure 3. Average Property Damage per Fire vs. Construction Type

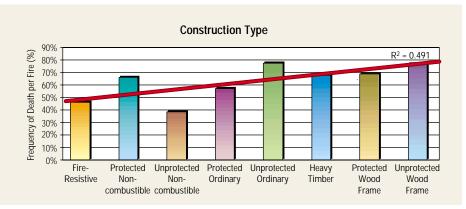


Figure 4. Deaths per Fire vs. Construction Type

story apartment buildings. The graph was created by dividing the number of deaths by the total number of fires for each construction type. A best-fit line through the data shows an increase in the risk of death per fire for lesser construction types. However, the R-squared value for this line is 0.498 and suggests a weak-to-moderate degree of predictive precision.

Figure 4 indicates that, while there is a positive upward trend, there are factors other than construction type that more strongly influence and explain the frequency of death than construction type only. Use of a multiple regression analysis considering sprinklers, smoke detection, or other features would likely result in a better predictive model for estimating the risk of death per fire. Although the relationship between construction type and risk of death per fire is not as strong as fire spread and property damage previously discussed, Figure 4 still provides a useful tool for

comparative analysis and establishing a risk benchmark. ▲

Edward Fixen is with Schirmer Engineering Corporation.

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- 2 Hall, J., and Harwood, B., "The National Estimates Approach to U.S. Fire Statistics," *Fire Technology*, May 1989, pp. 99-113.
- 3 Clarke, F., Bukowski, R., Stiefel, S., Hall, J., and Steele, S., The National Fire Risk Assessment Research Project Final Report, The National Fire Protection Research Foundation, Quincy, MA, July 1990.
- 4 NFPA 901. "Standard Classifications for Incident Reporting and Fire Protection Data," National Fire Protection Association, Quincy, MA, 2001.

Products/Literature

Specialized Integrated Security Capabilities

SimplexGrinnell delivers application-specific integrated security solutions for healthcare, education, office towers, manufacturing, technology, and other vertical markets. Examples of solutions

include complete environmental control systems that can integrate emergency communications, paging, access control, and occupant and asset monitoring. Solutions may include direction-control systems, vandal-resistant video, and more.

www.simplexgrinnell.com —SimplexGrinnell





Xtest™ Emergency Systems are designed to ease the process of maintaining life safety lighting. They are self-diagnostic and self-testing; the technology combines a micro-controller and surface-mount chip technology to accurately and effectively

allow for complete control. Because Xtest can signal the failure of a single LED lamp in an exit sign, it ensures the exit will remain evenly illuminated and meet code-specific light output requirements.

www.dcolighting.com
—Day-Brite Lighting

New Testing for Lightning Conductors

Determined to ensure the quality of its lightning conductors, INDELEC has set up a new test system using real light conditions at a facility in Brazil.

According to the company, it is the only Electronically Activated Streamer Emission manufacturer to use this type of test, which makes it possible to



obtain more conclusive results, due to the differences between an electric arc from natural lightning and an artificial electric arc.

www.indelec.com
—INDELEC

Dry Type Sprinkler Guidelines

Tyco Fire & Building Products announces the availability of a technical analysis for the "Use and Maintenance of Dry Type Sprinklers." Produced after completion of an extensive analysis of the design, use, and maintenance of dry type sprinklers, the guidelines are available for free upon direct request or may be downloaded from the Tyco Web site.

www.tyco-fire.com
—Tyco Fire & Building Products



PRO Rupture Disk

Oseco has improved lowpressure reliability with the release of its new PRO (Precision Reverse-Operating) Rupture Disk. The PRO, developed for liquid or vapor



environments, features low burst pressures in a single-membrane configuration. The disk offers temperature service of up to 900°F and is guaranteed for operating pressures up to 90% of the disk rating.

www.oseco.com —Osceo

FM-Approved Preassembled Units

Viking announces FM approval on the TotalPac product line. According to Viking, TotalPac is the first fully UL-listed and FM-approved integrated fire protection system. TotalPac units are compact and come fully assembled with individual serial numbers, which are kept in a database for easy maintenance and reference for many years. Each system is subjected to water and air pressure tests, and each function and every component are tested and certified before shipping.





Fire Retardants/Foams

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Astaris' Phos-Check fire retardants and foams are used in many applications, including battles against wild land fires. Once the



powder form is mixed with water, it becomes the familiar red liquid that is dropped from planes and helicopters to extinguish stubborn fires. Phos-Check's retardants meet stringent corrosion requirements for critical magnesium components in helicopters with fixed tanks.

www.astaris.com
—Astaris LLC

New SpectrAlert® Literature

New System Sensor literature focuses on SpectrAlert® ceiling- and wall-mounted fire notification products that feature low-draw electrical circuitry for energy-efficient horn/strobe/speaker systems that are easy to install and synchronize. A complete specifi-



cation table with product name/model number spans two pages of the foldout, which makes for a handy reference guide.

www.systemsensor.com —System Sensor

Filtering Indoor Smoke Detector

The Filtrex™ Smoke Detector is a specially enclosed intelligent photoelectric smoke detector. The sealed enclosure contains two high-density air filters that capture dust, dirt, and water spray while allowing smoke to pass through the sensor. A small fan draws in filtered air samples. One filter is field-cleanable, and the other is permanent to



protect the sensing chamber. Internal circuitry can detect a clogged filter or fan failure. May be interior-ceiling or wall-mounted.

www.systemsensor.com
—System Sensor

New Nursecall Systems

Edwards Systems Technology announces two new nursecall systems. The StaffCallPro patient/staff communication system is a networkable platform engineered to provide a flexible and cost-effective audio and visual communications solution in healthcare settings. The StaffAlert tone-visual nursecall system offers a reliable means of providing call and



staff presence annunciation in a simple-to-install and easy-to-use configuration. Benefits include greater caregiver mobility, enhanced patient safety, and improved overall patient satisfaction.

www.est.net —Edwards Systems Technology

Integrated Networking

The UniNet 2000 integrates fire, security, access control, and CCTV on a single network. UL-listed for fire, safety, and access control, it is designed with new features and options offering operators integrated networking with a comprehensive interface for diverse systems. Its state-of-the-art client-server technology



allows easy upward migration as new features become available and can also monitor non-NOTIFIER fire alarm panels.

www.notifier.com —NOTIFIER

Free CD-ROM Highlights Product Line



System Sensor has released a MAC- or Windows-compatible, interactive EoDOCS™ CD-ROM, which is free to qualified individuals. It includes information about Innovair™ Duct Smoke Detectors, as well as product data sheets, installation manuals, part numbers, UL two-wire compatibility listings,

agency listings, and a full-line product catalog.

www.systemsensor.com
—System Sensor



Fire-Resistant Glass

Pilkington Pyrostop™ Fire-Resistant Glass has been UL-tested and approved for a 45-minute fire rating. Typical applications include highactivity areas such as recreational and indoor court facilities in schools,

colleges, and health clubs. Specific applications include transoms, windows, and doors, including hollow metal doors. Pyrostop $^{\text{TM}}$ is approved for 45-, 60-, 90-, and 120-applications, and maximum areas of 4,500 square inches.

Web-Based Monitoring

UniNet™ Online is a Web-based service designed to offer facility managers convenient access to information on building systems integrated on the UniNet network. Via the Internet or an intranet, facility managers may monitor systems such as fire, security, CCTV, card access, and more – all from one main source. Operators may view event informa-

tion and track system history, whether on- or off-site.



www.notifier.com —NOTIFIER

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klers that may be installed without protection (exposed).

www.blazemaster.com
—BlazeMaster® Fire Sprinkler Systems

Fast Reporting Via Internet/Intranets

The Radionics D6600 NetCom System has a patented design that allows it to handle alarm communications from almost all manufacturers' alarm panels. It uses the Internet and private intranets for reporting over local and wide area



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networks. In addition to reducing signal reporting time from minutes to milliseconds, the D6600 provides cost-effective, real-time supervision of the reporting path that is unavailable with telephone dialers and most other existing forms of alarm communication technologies.

www.boschsecurity.us — Bosch Security Systems



Society of Fire Protection Engineers Spring Professional Development Week **March 24-27, 2003**

Continuing education is essential in today's fast-changing workplace. To meet the demands of our Members, Allied Professionals, and, increasingly, state licensing boards, the SFPE Spring Professional Development Week (PDW) will be held in Las Vegas from March 24-27, 2003.

A total of eight seminars, ranging from an Introduction to the Fire Dynamics Simulator and Smokeview Computer Model to Sprinkler Design for Engineers, will be offered. These intensive four days will provide the construction community with state-of-the-art training in Fire Protection Engineering from beginner to advanced levels. Continuing Education Units will be granted for all completed events.

Detailed information on each course may be found on SFPE's Web site, www.sfpe.org, or by contacting Julie Gordon, Program Manager, at Headquarters at 301.718.2910.

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Seminars

Principles of Fire Protection Engineering

This ten-session, four-day seminar will review the basics of fire protection engineering. Topics include combustion, fire endurance, material applications, sprinkler system developments, and much more.

Fire Alarm Systems Design

This three-day seminar will address equipment selection, systems design, specification writing, and performance-based design concepts, and development of inspection, maintenance, and training programs.

Changes to NFPA 72 and 13

This seminar will provide highlights of all the major changes made to the codes in 2002 along with useful information to incorporate the changes in fire alarm system designs and installation of sprinkler systems, respectively.

Tenability Systems for Smoke Management

This seminar will provide information about smoke management systems designed to maintain tenable conditions. The five subject areas covered are design fires and Heat Release Rate (HRR), tenability, people movement, smoke transport, and CONTAMW.

Performance-Based Design and the Codes

This one-day seminar will review in detail the performance-based design process and its application with the *ICC Performance Code for Buildings and Facilities*, and the performance options in the NFPA Life Safety Code and the NFPA *Building Construction ans Safety Code*.

Sprinkler Design for Engineers

Aspects of both introductory and advanced sprinkler system design for engineers will be reviewed in this four-day seminar. Topics include design approaches, water supply, sprinkler spacing, fire pumps, hydraulic calculations, and much more.

Introduction to Fire Dynamics Simulator and Smokeview

The Fire Dynamics Simulator (FDS) is the newest model developed by NIST, consisting of two programs – FDS and Smokeview. Review the features and application of this model, as well as its strengths and weaknesses.

How to Study for the FPE/P.E. Exam

Prepare for the FPE/P.E. Exam! Formulate preparation strategies, obtain an overview of the exam process and technical scope, discuss resource materials, and determine the solution to sample problems from each of the eight technical areas.

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Info: jscheffey@haifire.com

February 26-18, 2003

Fire Asia 2003

Hong Kong

Info: lesliestevenson@uk.dmgworldmedia.com

March 24-27, 2003

SFPE Spring Professional Development Week

Las Vegas, NV

Info: www.SFPE.org

April 6-8, 2003

Taipei International Exhibition on Fire, Safety, &

Disaster Management

Taipei, Taiwan

Info: www.secutech.com

May 8-10, 2003

Strategies for Performance in the Aftermath of the

World Trade Center

Kuala Lampur, Malasia

Info: www.cibklutm.com

May 18-22, 2003

NFPA World Safety Conference and Exposition

Dallas, TX

Info: www.nfpa.org

June 8-13, 2003

Third Mediterranean Combustion Symposium

Marrakech, Morocco

Info: www.combustioninstitute.it

June 22-25, 2003

13th World Conference on Disaster Management

Toronto, Canada

Info: www.wcdm.org

August 20-22, 2003

2nd International Conference in Pedestrian and Evacuation

Dynamics (PED)

Greenwich, London

Info: http://fseg.gre.ac.uk/ped2003/

September 8-12, 2003

4th International Seminar on Fire and Explosion Hazards

Northern Ireland, UK

Info: www.engj.ulst.ac.uk/4thisfeh/

September 22-25, 2003

6th Asia-Oceania Symposium on Fire Science and Technology

Info: yhpark@office.hoseo.ac.kr

Fire Protection Engineering

Number 17

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RAINTEASER

Water discharges through an Underwriters playpipe with a 29 mm diameter nozzle. The playpipe is oriented at a 45° angle to the horizontal. A pitot gauge measures the velocity pressure at the nozzle discharge as 200 kPa. If the playpipe is located on a level surface, how far from the nozzle will the stream land?

Solution to last issue's brainteaser

You have six weights. One pair is red, one pair is white, and one pair is blue. In each pair, one weight is slightly heavier than the other, but otherwise looks exactly like its mate. The three heavier weights all weigh the same, as do the three lighter weights.

How can you identify the heavier weights in only two separate weighings on a balance scale?

Place a red weight and a white weight on one side of the scale and a red weight and a blue weight on the other side. Either the scale will balance or it will not.

If the scale balances, one of the weights that is not red is light and the other is heavy. Now compare the red weights. The heavy red weight was with the light white weight or light blue weight in the first weighing. The light red weight was with the heavy white weight or heavy blue weight. All weights are then determined.

If the scale does not balance, whichever side is heavier has the heavy red weight. The three possibilities are:

 $\begin{aligned} &1. \ R_{\rm H}W_{\rm H} > R_{\rm L}B_{\rm H} \\ &2. \ R_{\rm H}W_{\rm H} > R_{\rm L}B_{\rm L} \\ &3. \ R_{\rm H}W_{\rm L} > R_{\rm L}B_{\rm L} \end{aligned}$

Now, compare the two red weights with the other two weights already on the scale. If the red weights are lighter, then case 1 is determined. If the red weights are the same, then case 2 is determined. Otherwise, if the red weights are heavier, then case 3 is determined.

CORPORATE 100

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

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What Can We Learn from Enron and Worldcom?



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

MORCA

lthough the dust has begun to settle, for awhile the daily newspapers were filled with stories of unethical accounting practices. While these instances identified in the newspapers undoubtedly involved only a very small fraction of accounting professionals, the impact to the financial industry and the public at large was tremendous. In the wake of these scandals, billions of dollars of market capitalization were erased, careers and companies were ruined, and investors lost significant investments. The repercussions of these lapses were felt around the globe. So what can the engineering community learn from these events?

Financial auditors review accounting and financial records to evaluate whether they conform to accepted industry practices. The purpose of a financial audit is to provide independent oversight of private entities so that others, including regulators and investors, will have confidence in financial records and statements.

Financial auditors and engineers have several things in common, including having specialized knowledge that the public at large does not possess and possessing the public's trust that they will hold the

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public's best interest above the interest of others, including clients. Historically, financial auditors and engineers were trusted by the public to police themselves, which was done through licensing or certification and through development, and if need be enforcement, of codes of ethics by their respective professional organizations.

In the cases of Enron and Worldcom, auditors did not reveal accounting irregularities that resulted in people outside of these companies having an incomplete picture of the financial conditions. When the facts were revealed, investors, employees, and financial markets suffered.

In the wake of the collapse of these companies, the public began to lose trust in the financial auditing profession. The public lost confidence in the ability of the accounting industry to police itself, and in the United States, the federal government was directed to publish rules of professional conduct for financial auditors. Similarly, a government board was created and given the power to set auditing rules, inspect accounting firms, and punish people who did not follow the rules. These actions represent a major shift for the financial profession, from a system of self-regulation to a system of government regulation.

The individual auditors of Enron and Worldcom undoubtedly faced moral dilemmas in the conduct of their work. They may have received pressure from clients or supervisors to take actions that were not in accordance with standard accounting practices. The auditors may have been tempted by promises of financial reward if they reached certain conclusions. Or they may have feared repercussions if their reports did not meet real or perceived expectations.

As engineers, we may face similar pressures. The classic engineering ethics case of the Citicorp tower in New York can be used to examine the type of moral dilemma that an engineer might face by having to tell clients bad news or risking a personal reputation. The lot in New York upon which the Citicorp tower was built came with an unusual constraint, which required cantilevering a portion of the Citicorp building over a church.¹

William LeMessurier was the structural engineer for the building, and to accom-

modate the constraint posed by the lot, he designed the main structural supports at the middle of the tower's walls, instead of the corners. After the tower was built, an inquiry from a student who was studying LeMessurier's design prompted LeMessurier to analyze the effect of quartering winds, or winds that impact the building at a 45° angle to one of the building's exterior walls.

LeMessurier's calculations revealed higher stresses in quartering winds in some of the structural members and joints than he had originally determined. This was exacerbated by a change from welded connections to bolted connections during fabrication. Ultimately, it was determined that the building was vulnerable to total collapse in a 16-year storm. The public inside and around the building was exposed to a higher-than-assumed risk. With this knowledge, LeMessurier commenced efforts to correct the problem in the building, including contacting the building's owner, the building owner's insurance company, and regulatory officials. After corrective measures were implemented, the building was determined to be able to withstand a 750-year storm.

Although he risked his reputation in coming forward, it can be argued that his standing in the structural engineering community was elevated by his decision. Interestingly, despite having to make a large payment, LeMessurier's professional liability insurance premiums decreased as a result of his actions. If he had made a different choice in the face of this moral dilemma, the outcome could have been much different.

As engineers, we may be faced with moral dilemmas similar to those faced by Enron's or Worldcom's auditors, or to those faced by William LeMessurier. However, the lessons of Enron and Worldcom serve as a reminder that if we make a wrong choice, we as individuals can suffer, as well as the profession and the public at large.

 Whitbeck, C., Ethics in Engineering Practice and Research, Cambridge University Press, Cambridge, UK, 1998.