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FIRE PROTECTION Engineering

1ST QUARTER 2010

Issue No. 45

Existing Buildings:

From Rehabilitation Codes to
Performance-Based Design

Why a Rehabilitation Code?

Reducing Response Time

New Jersey's Rehabilitation Subcode

Fire Alarm Systems in Existing Buildings



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From the **TECHNICAL DIRECTOR**

Guidelines for Model Substantiation

The use of fire models has flourished over the last few decades. Models are used to simulate fire phenomena to determine if a proposed design strategy is acceptable, to test hypotheses developed during fire investigations, or to simulate tests as part of fire research. Each of these applications has potential impacts on public health, safety or welfare, so it is incumbent on model users to make sure that they can have confidence in model results.

The American Society of Testing and Materials (ASTM) published a guide for evaluating models in 1990.¹ The ASTM guide provides an approach to evaluating models that consists of defining the model and the scenarios for the evaluation, verification of the appropriateness and the theoretical basis of the model, verifying the mathematical and numerical robustness of the model, and quantifying the uncertainty and accuracy of model results.

The ASTM guidelines are useful where someone wishes to evaluate a model for a broad range of applications. However, the methodology requires a level of effort that is prohibitive for specific, individual project applications. For example, the Society of Fire Protection Engineers evaluated DETACT-QS using the ASTM E-1355 methodology.² DETACT-QS is one of the simplest fire models that have been published (it has less than 200 lines of code); the evaluation required more than a person-year of effort and the report is 140 pages in length.

The standard of care that is applied to use of model predictions is that the model should either be accepted by the relevant professional community or the user should demonstrate that the model is acceptable.³ Only a few models have been formally evaluated using the ASTM E-1355 process - including DETACT-QS and five models that were evaluated for application in nuclear power plants⁴ (Fire Dynamics Tools, Fire Induced Vulnerability Evaluation, CFAST, MAGIC and FDS.)

In 2003, 168 fire models were identified,⁵ and several more have been published since then. Additionally, the published evaluations do not address every possible application of the models that were evaluated, so in most cases it will fall to the person who uses a model to show that the model is appropriate for the intended use. However, there are no published guidelines that describe how this can be done.

In 2007, the Society of Fire Protection Engineers began developing guidelines for substantiating that a computer model

is appropriate for a given application. A task group was assembled comprised of engineers with experience in using models for design, fire investigations and research. The task group created a draft guide that provides a framework for determining if a fire model is suitable for use for a specific fire protection application.

The draft guidelines address definition of the problem for which modeling will be used, selection of a candidate model, verification and validation of the model for the application of interest, and consideration of uncertainty in the model results. Extensive appendices provide descriptions of fire phenomena that are commonly modeled and techniques that are typically employed by fire models to predict those phenomena.

The guidelines are available for public review and comment through March 31, 2010. The draft guide is available at www.sfpe.org. Final publication is anticipated in late 2010.

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

References:

- 1 ASTM E-1355, Standard Guide for Evaluating the Predictive Capability of Deterministic Fire Models, American Society of Testing and Materials, West Conshohocken, PA, 1990.
- 2 Engineering Guide - Evaluation of the Computer Fire Model DETACT-QS, Society of Fire Protection Engineers, Bethesda, MD, 2002.
- 3 SFPE Code Officials Guide to Performance-Based Design Review, Society of Fire Protection Engineers, Bethesda, MD, 2004.
- 4 NUREG-1824 and EPRI 1011999, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications," Vols. 1-7, U.S. Nuclear Regulatory Commission, Washington, DC and Electric Power Research Institute, Palo Alto, CA, 2007.
- 5 Olenick, S., and Carpenter, D., "An Updated International Survey of Computer Models for Fire and Smoke," *Journal of Fire Protection Engineering*, 13 (2), 2003, p. 87-110.

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Flexhead

By David S. Collins

More today than perhaps ever, it is becoming increasingly important to draw upon the resource found in the existing building infrastructure. Whether it is a social or economic imperative that recognizes the limitation on resources, existing buildings are an essential player in the future of the building construction industry.

"Rehabilitation" is a common term in the industry today that encompasses what has traditionally been identified as repair, alteration and change of occupancy in existing buildings and moved buildings. Because of the breadth of issues included within these types of construction activities, it is important to know the role that each part of the design team plays, including the fire protection engineer, to develop rational solutions.

In sheer number, projects that include physical changes to existing buildings comprise the vast majority of construction within major cities. Not surprisingly, codes that are designed to provide a regulatory framework for such activities have grown in number. Virtually every one of these codes involves criteria for improved life safety, depending on the level of work involved and whether there is added risk associated with the conditions created by the rehabilitation. The International Code Council has two options for communities to use to regulate rehabilitation; Chapter 34 of the *International Building Code*¹ or the *International Existing Building Code*.² NFPA has developed similar criteria in both their NFPA 5000³ and NFPA 101.⁴ Some communities have had criteria for rehabilitation far longer than either of the model code groups, including Massachusetts Chapter 34.⁵ New York City's Local Law 5⁶ for high-rise office buildings was the springboard for ICC's alternate compliance methods, and the City of Chicago⁷ used a variation of the alternate compliance method to evaluate the need for retroactive fire suppression in high-rise buildings.

Political and pragmatic issues surround regulation of work in existing buildings, including complex decisions that may affect not only the specific project but may include other aspects of a building that are not contemplated by clients when they initiate such work. As part of a design team that is developing a rehabilitation project, fire protection engineers provide critical information about the accuracy of the scope of the work and its impact beyond what had been originally outlined.

The complicating factor in accurately predicting and understanding the impact of a rehabilitation project is the fact that existing buildings have a high probability of not having been constructed using current codes and standards. Buildings that were recently completed and occupied have few issues that raise serious concern because they already have features that are required and (hopefully) include elements to support anticipated changes of occupancy that may need to be made. However, today, buildings built as little as 10 years ago face significantly different codes that may cause problems for the tenant, the owner and the

design team if they attempt to conform to the current codes. As buildings get older, the probability that significant rehabilitation work will require significant upgrades to the life safety systems rises dramatically.

It has long been believed that occupied and used buildings are much safer than an empty and abandoned structure. Similarly, unless there are serious issues, existing occupied buildings are presumed to be safe and are allowed to remain as they were built under the "grandfathering" of regulations. Codes that are designed to address rehabilitation of existing buildings have taken serious steps toward establishing measured criteria based on levels of risk and even recognize features of older buildings that do not exist in modern building codes.

How then does the design team establish the full scope of work necessary to successfully execute the client's wishes when a rehabilitation project is anticipated? Becoming acquainted with the physical condition and capabilities of the existing structure is key to any type of rehabilitation, even one as simple as a repair. However, when significant alterations or change of occupancy is anticipated, intimate knowledge and understanding of the life safety systems within the structure as well as public utilities and services and their ability to conform to today's standards are a critical factor in the success of a project.

Architects are familiar enough with life safety systems to determine their presence, but may lack the understanding to fully assess their capabilities. Fire protection engineers are an important resource that can establish the existing systems base line of performance and what it is capable of or not capable of doing as part of the planned changes. Establishing the limits of the existing building and accurately predicting the necessary and appropriate changes to provide a better solution is fundamental to a successful rehabilitation project.

Buildings are the legacy of each generation; how they are treated and passed down to future generations is the measure of success.

David Collins is with the Preview Group.

References:

- 1 *International Building Code*, International Code Council, Washington, DC, 2009.
- 2 *International Existing Building Code*, International Code Council, Washington, DC, 2009.
- 3 NFPA 5000, *Building Construction and Safety Code*, National Fire Protection Association, Quincy, MA, 2009.
- 4 NFPA 101, *Life Safety Code*, National Fire Protection Association, Quincy, MA, 2009.
- 5 *Massachusetts State Building Code*, Boston, MA, 2008.
- 6 *New York City Building Code*, New York, 1973.
- 7 *Building Code and Related Excerpts of the Municipal Code of Chicago*, Chicago, IL, 2009.

System Sensor Ad

FEMA Reaches Milestone with Integrated Public Alert and Warning System

The Integrated Public Alert and Warning System (IPAWS), the nation's next-generation infrastructure of emergency alert and warning networks, has cleared an important hurdle. The Organization for the Advancement of Structural Information Standards (OASIS) voted in October 2009 to approve the OASIS Common Alerting Protocol (CAP) v1.2 USA IPAWS Profile as a technical specification for public alert systems. The profile will enable emergency managers across the country to use a common format for creating emergency alert messages that can travel across multiple alert systems. The availability of such a profile furthers FEMA's objective of increasing interoperability across federal, state and local alert systems.

"We are pleased with the recent progress," says Antwane Johnson, director, IPAWS. "The input received from industry and other stakeholders has been vital to developing a profile that will meet the needs of the emergency alerting community."

FEMA has informed the communications industry along with its federal alert partners that it may adopt the technical standard as early as the third quarter of 2010.

IPAWS is a critical part of FEMA's plan to upgrade the existing national warning systems, which allow the president and authorized officials to communicate with the public in times of emergency via television, radio, telephone, cell phone and other communications pathways.

For more information, go to www.fema.gov/emergency/ipaws.

Commercial Property Insurer FM Global and Home Fire Sprinkler Coalition (HFSC) Form Partnership to Study Environmental Effects of Home Fires

The nonprofit Home Fire Sprinkler Coalition (HFSC) is partnering with FM Global on a research project to identify, analyze and evaluate the environmental impact caused by home fires.

When sprinklers activate, they control the heat, flames and smoke of a home fire, effectively mitigating the products of combustion. "The expectation is that a reduction in combustion also results in lessened pollution," according to Gary Keith, HFSC chair. "It's time to formally determine those qualities as well as the potential for reduced water-related impact. There's never been a better time to do a study like this because interest is at an all-time high."

The results of the research will establish:

- The types, quantity and duration of air and water pollutants released from a home fire as well as the water usage from fire sprinklers and firefighters' hoses.
- The environmental impact resulting from burning household furnishings and finish materials as well as disposing the fire-damaged contents of a home.
- The carbon footprint associated with rebuilding a burnt home.

"Understanding the environmental benefits of fire protection in our homes provides a common basis to improve sustainable residential and commercial development," says Dr. Louis Gritzco, vice president and manager of research at FM Global. "This joint project is a natural tie-in to recently released technical research by FM Global showing ways businesses can be more environmentally sustainable by reducing their vulnerabilities to fire and natural disaster risks."

For more information, go to www.fpe.umd.edu/news/news_story.php?id=4450.



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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FIRE PROTECTION ENGINEERING IN EXISTING BUILDINGS:

From Rehabilitation Codes to
Performance-Based Design

By William E. Koffel, P.E., FSFPE

Several years ago, this author was contacted by someone who was considering purchasing an existing, high-rise residential building that was not protected with an automatic sprinkler system. In order to make the purchase and future ownership of the building attractive, the prospective owner wanted to make some improvements to various areas and systems throughout the building. The prospective owner asked if it was necessary to install an automatic sprinkler system because he was proposing to make some improvements to the building. The prospective owner did not intend to make any changes to the use or occupancy of the building, and there were no existing requirements imposed by the fire official to install sprinkler protection in the building.

At the time of the inquiry, a typical answer might have been "it depends on how this is viewed by the appropriate code officials." Such an answer would not be responsive to the prospective owner's request. There may have been reasons why at that time, the prospective owner did not want regulatory officials involved.

Typically, existing codes required that "alterations to" or "modernizations of" an existing building require the building to comply with the requirements for new construction to the extent practicable.¹ The applicable codes would require that new high-rise buildings be protected throughout with an automatic sprinkler system. Ultimately, the code official had the authority to determine what was practicable and therefore, it would have been necessary to explain the project to the code official and have him or her render an opinion.

In addition, some codes as adopted at state or local levels would tie the need to comply with the requirements for new construction to the cost of the construction activity as compared to the value of the building. If a certain percentage was exceeded, the entire building needed to comply with current codes for new construction. While clearly an argument could have been made that, from a fire protection standpoint, sprinkler protection made sense and may eventually be required regardless of whether any work is done in the building, at that particular point in time that was not the question posed by the prospective owner.

THE PURPOSE OF REHABILITATION CODES

The above scenario is one example of why rehabilitation codes started to come into play in the United States in the late 1990s. Whether perceived or reality, many felt that the re-use of existing buildings and improvements to existing buildings was discouraged by the current regulatory environment.² The inability to provide specific responses to questions such as posed above could lead a developer to invest his or her money elsewhere, possibly in a new building where the impact of code requirements was more easily defined, and the uncertainty of doing rehabilitation work in an existing building, and what would be found when doing such work, would not add to the financial uncertainty associated with the project.

Application of the Maryland Building Rehabilitation Code

By Mark A. Aaby, P.E.

In 2007, building improvements were designed for an existing high-rise residential building consisting of the rehabilitation of the existing dwelling units, the upgrade of selected mechanical and electrical systems, elevator improvements, and consolidation of some common use areas on the Ground Floor. The Maryland Building Rehabilitation Code¹ (MBRC) was applied to the project to identify mandatory fire protection and life safety requirements that were triggered by the building rehabilitation.

Through a review of the architectural concept drawings and scope of work for the project, the category of work for the various rehabilitation work areas were classified according to the MBRC. Based on the various classifications of work for this project, a majority of the rehabilitation work areas did not trigger compliance with the codes for new construction. Accordingly, existing code compliant conditions were for the most part deemed acceptable and remained. As an example, at the time the building was constructed in the late 1970s, the exit stairs were not required to be smokeproof enclosures. The MBRC does not require the exit stairs to be smokeproof enclosures. Accordingly, upgrades to the existing stairs to create smokeproof enclosures, as would be required for new high-rise construction, were not required as part of this rehabilitation project.

Another example was the existing limited area sprinkler system which protects common areas. Based on the classifications of work, the MBRC analysis did not require the installation of sprinklers in the non-sprinkler protected portions of the building, unless the work areas included exits or exit access corridors. Furthermore, in lieu of an emergency voice/alarm communication system as is required for new high-rise construction, the existing fire alarm system and dwelling unit smoke alarms were permitted to remain.

As illustrated by this case study, utilization of the MBRC facilitated the investment in an existing building, while ensuring that the basic health, safety, and welfare of the building occupants was preserved.

Reference:

- 1 Maryland Building Rehabilitation Code, Maryland Department of Housing and Community Development, Annapolis, MD, 2009.

Gilman Hall Case Study

By Clay P. Aler, P.E.

Gilman Hall was the first major academic building on the Charles Street campus of Johns Hopkins University (JHU) in Baltimore, MD. Gilman Hall was carefully based upon Homewood House (1803), beginning the tradition of Federal style academic buildings on campus. The original construction of Gilman Hall was completed in 1915. It is five stories in height with a utility basement, and is considered a historic structure by the Commission for Historic and Architectural Preservation of Baltimore City. JHU retained the New York City architectural firm of Kliment Halsband Architects to rehabilitate and modernize the existing building through the use of the Maryland Building Rehabilitation Code (MBRC), which references the International Existing Building Code (IEBC).

The rehabilitation of Gilman Hall provides supplementary fire protection and life safety features that do not currently exist in the building, which will include a complete automatic sprinkler system, a standpipe system within the exit stairs, and a new addressable voice evacuation fire alarm system. Egress for Gilman Hall is via two new enclosed exit stairs, which will replace the eight existing open stairs. The original building included an enclosed courtyard open to the environment. As part of the rehabilitation project, the courtyard will be covered with a skylight supported by a state-of-the-art lightweight steel framing system, in effect, creating a four-story tall atrium space. A performance-based analysis was used to size the smoke exhaust system for the atrium. In addition, qualitative analysis was used to justify omission of sprinkler protection at the skylight level of the atrium. The design team worked closely with the Baltimore City Fire Marshal to incorporate the supplementary fire protection and life safety features into Gilman Hall while still maintaining its important historic architectural features.

Choosing new construction over the re-use of existing buildings resulted in an increased number of unoccupied buildings in many urban areas. In addition, since land was either more available or less expensive in suburban areas, the new construction took place on land that was not previously developed, resulting in what many refer to as "urban sprawl."

At the time, there were various codes available for adoption in the United States. Each of the codes contained requirements that addressed various activities in existing buildings, including repair, alterations, change of occupancy classification and additions. The requirements were typically found in a single chapter at the end of the code or, in another case, a section of a chapter on general requirements. Performance-based codes, clearly another alternative for existing buildings, were in the process of being developed at about the same time.

Going back to the question posed by the prospective owner, the work proposed was not repair nor did it involve a change in occupancy. Therefore, it fell into the broad category of "alteration", which could involve anything from rebuilding an existing wall to the total rehabilitation of the building. One of the things that rehabilitation codes do is to separate the work category referred to as "alteration" or "modernization" into multiple work categories, typically at least three separate work categories. With the additional work categories, today one is more able to respond to questions similar to those posed by the prospective owner. More information on the requirements contained in "rehabilitation codes" can be found in the *International Existing Building Code*,³ NFPA 5000⁴ and NFPA 101.⁵

The case study in the sidebar on page 9 provides an overview of some aspects of a project in which a rehabilitation code was applied. The Maryland Building Rehabilitation Code predated the model codes cited above and was in fact used as a basis for some of the requirements contained in the model codes that more specifically address existing buildings.² It should be noted that the building referenced in the case study was not subject to any requirements to upgrade the building prior to the rehabilitation project. The requirements came into play due to a voluntary rehabilitation project proposed by the building owner. Therefore, the base line for the project was that the building complied with all codes in effect that apply to existing buildings not undergoing a rehabilitation project. The new work could not make the building less conforming to existing codes and, as noted in the case study, resulted in some fire protection



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improvements to the building. The use and occupancy of the building did not change as part of the rehabilitation project.

FIRE PROTECTION IN EXISTING BUILDINGS

The introduction of rehabilitation codes in the United States provided a more easily understood and more consistent regulatory environment regarding work in existing buildings. However, even with the rehabilitation codes, work in existing buildings presents interesting challenges to the design team. Unlike new buildings, in which concepts can be more easily changed to address the specific needs, most projects in existing buildings come with bounding conditions. There are aspects of the existing building that may restrict the options available

to the design team.

The Gilman Hall case study (see sidebar on page 10) illustrates one such restriction. When working in historic buildings, there are aspects of the historic building that must be preserved since they are of historical significance. In the case study, those historical features were able to be maintained by upgrading other fire protection and life safety features of the building using concepts commonly found in prescriptive codes. In other instances, operational features may need to be implemented as a means to compensate for an existing condition that cannot be modified due to its historical significance. When working in historic buildings, the fire protection engineer needs to work closely with the historical preservationist to determine what aspects of the building are of histori-

cal significance and then determine an approach that will result in an acceptable level of safety. NFPA 914 provides requirements for protection of historic structures from fire while protecting the elements, spaces and features that make these structures historically or architecturally significant.⁶ The document contains both a prescriptive approach and a performance-based approach.

When one hears about the application of performance-based codes, it generally involves some new structure that has unique needs and considerations. However, performance-based codes have tremendous application to existing buildings where, like Gilman Hall, some existing features cannot be changed and alternative approaches need to be identified to provide an acceptable level of safety. A prescriptive code, no matter how well it is

Performance-Based Case Study

By William E. Koffel, P.E., FSPFE

The goals for the design were limited to life safety from fire and preservation of the features determined to be of historical significance. Although recommended by the fire protection engineer on the project, an automatic sprinkler system was not installed since it was not required by applicable codes. As such, property protection and preservation of the historic structure were not necessarily considered by the stakeholders as critical goals to be met.

A hazard analysis and subsequently a risk analysis were performed to address the life safety considerations. Typical fire scenarios were developed based upon the contents of the building, which were representative of the Colonial Period and therefore did not include many of the contents found in modern buildings. Using computer fire modeling, the level of protection provided was analyzed with the single means of egress from the building. It was determined by the fire protection engineer that an acceptable level of safety (as determined by comparing available safe egress time to time required to safely egress the building) was provided for all but one identified fire scenario. After reviewing the fire scenario and the location and security provided to the site, the stakeholders determined that the fire scenario in question was not a reasonably credible fire scenario. That scenario involved an incendiary fire at the single exit door.

As a result, it was determined that a single means of egress was acceptable. With respect to the door swing, the risk analysis indicated that changing the direction of door swing could result in an increased risk of trips and falls since the floor was not at the same elevation on both sides of the door (there was an immediate step down on the outside of the door). Therefore, operational requirements were put into place to require that a staff person be present at the door during all reenactments and that an announcement be made prior to the reenactment indicating that there is a single means of egress and that the door swings inward.

With automatic detection installed in areas separated from the assembly space, limitations on the fuel packages permitted in the building, the features identified above and after receiving peer review comments, the stakeholders determined that an acceptable level of safety was provided.

written, cannot envision all the possible issues that may arise when working in existing buildings, especially buildings of historical significance.

Although not in existence at the time of design for the project cited, many of the concepts of modern performance-based codes were applied to the case study project on page 12. The project involved the change of occupancy, using traditional prescriptive codes, from a business occupancy to an assembly occupancy due to an increase in occupant load. The use of the building would include the reenactment of a trial during the Colonial period in the U.S. Most likely, there would be more than 50 people in the building during the reenactment. The existing building had a single exit, the door did not swing in the direction of travel, and the floor level was not at the same elevation on both sides of the door. All three features were considered to be of historical significance and all three features were not acceptable using existing prescriptive codes.

One aspect of work that commonly occurs in existing buildings that has not been addressed by the three case studies is to add onto an existing building. The addition may involve an increase in height, an increase in building area, an increase in aggregate floor area, or an increase in the number of stories (not necessarily involving an increase in building height). In addition to making sure that the new work complies with the applicable code requirements, consideration must also be given to maintaining compliance in the existing portion of the building. For example, it is not uncommon for the design team to provide a fire wall to separate the addition from the existing building. The reason for providing the fire wall is that it creates a new building, and therefore the impact on the existing building does not need to be considered. Unfortunately, building area limits in U.S. building codes generally take into account the

open perimeter around the building. Adding on to an existing building using a fire wall between the addition and existing building results in a reduced open perimeter for the existing building, so the building area may need to be re-evaluated.

OTHER POSSIBLE APPROACHES

While the content of this article focused on some new construction or activity within the existing building, there are also projects that involve upgrading existing buildings to meet the requirements of an applicable fire code. The rehabilitation codes

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referenced in this article do not apply to such projects, but clearly the use of equivalencies, alternative methods and performance-based codes could apply.

With respect to new construction or some new use or occupancy of existing buildings, there are a number of options available. Many jurisdictions now adopt a code that contains rehabilitation provisions that are intended to encourage the re-use of existing building while still providing an acceptable level of safety. The use of equivalencies and alternative methods may be used in addition to the specific prescriptive code requirements. Alternatively, performance-based codes may provide a methodology for determining acceptable protection strategies that would not otherwise be identified.

Lastly, the fire protection engineer should give due consideration to a wide range of protection strategies that may be available. One resource that can be used to determine alternative protection strategies is NFPA 550.⁷ The risks to be addressed can be determined using a fire risk assessment methodology as outlined in the

*SFPE Engineering Guide to Fire Risk Assessment.*⁸ The limitations presented by the existing building can be overcome by a thorough analysis of the options available to provide an acceptable level of safety.

William Koffel, Mark Aaby and Clay Aler are with Koffel Associates.

References:

- 1 NFPA 101, *Life Safety Code*, National Fire Protection Association, Quincy, MA, 2000.
- 2 "Nationally Applicable Recommended Rehabilitation Provisions," Prepared for the U.S. Department of Housing and Urban Development, May, 1997.
- 3 *International Existing Building Code*, International Code Council, Country Club Hills, IL, 2009.
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WHY A REHABILITATION CODE

By John R. Hall, Jr., Ph.D.



There is growing interest in so-called "rehabilitation codes." This article will evaluate the risks in existing buildings, as opposed to new construction. There are two settings in which rehabilitation codes are offered as a solution to two types of problems:

- Vacant or abandoned buildings. These are seen as magnets for bad events, including but not limited to fires, resulting in a wider negative impact on their neighborhoods and even their communities.
- "Under-utilized" buildings whose owners wish to improve their value and marketability through improvements and/or repurposing, such as changes in occupancy.

VACANT OR ABANDONED BUILDINGS

There is a lot of statistical information on vacant housing and very little on vacancy rates in other kinds of properties.

Vacancy rates in housing have been rising since at least the early 1980s. Since the recent bursting of the housing bubble, the rate of increase in housing vacancies has accelerated. Vacancy rates around 9% in the early 1980s have given way to a new high of 14% in 2008.¹

Vacancy rates are generally higher in apartments than in other homes. In 2005, for example, all housing combined averaged a 13% vacancy rate. Single family homes (including manufactured homes) averaged a 9% vacancy rate, and the one- and two-family home category averaged a 9-12% vacancy rate. (The range reflects the fact that housing unit data combines buildings with 2-4 units. The upper rate applies if all 2-4 unit buildings are actually two-unit buildings, the lower rate if none are.) Meanwhile, apartments averaged a vacancy rate of 17%.


Rates of fires per thousand housing units are typically lower in vacant housing than in non-vacant housing.

While the overall housing vacancy rate was 13%, the vacant-building percentage of all home fires was 5-6%. (This range reflects different assumptions about whether buildings under construction or demolition are counted in housing statistics and whether "idle" buildings are also vacant buildings.) The vacant-building percentages were 1% for civilian fire deaths and civilian fire injuries and a slightly higher 7-8% for direct property damage.

Since the recent bursting of the housing bubble, the rate of increase in housing vacancies has accelerated. Vacancy rates around 9% in the early 1980s have given way to a new high of 14% in 2008.

These lower percentages suggest that the risk of having a reported home fire in a vacant housing unit – overall or weighted by severity of loss in monetary terms – was roughly half the corresponding risk in a non-vacant housing unit.

The patterns are different in degree if one- and two-family homes are separated from apartments. While the overall vacancy rate in one- and two-family homes was 9-12%, the vacant-building percentage of one- and two-family home fires was 7-8% (and 8-9% for direct property



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damage), indicating a marginally lower fire risk than for non-vacant units. While the overall vacancy rate in apartments was 17%, the vacant-building percentage of apartment fires was 2% (and 3% for direct property damage), indicating a much lower fire risk than for non-vacant apartments.

A vacant housing unit will have less human activity, less powered equipment and less use of heat sources than a non-vacant housing unit. The only exceptions are cases of arson or playing with fire, where the absence of occupants means an absence of supervision. A vacant apartment in an otherwise occupied building may have the benefits of vacancy – less use of energy in the unit – and few of the problems.

Fire statistics distinguish between vacant secured buildings and vacant unsecured buildings. Abandoned buildings probably constitute part of the second group. There are roughly as many fires in vacant secured housing as in vacant unsecured housing. However, there is no data to split vacant housing units between secured and unsecured. Therefore, there is no way to check the hypothesis that secured vacant housing units have less fire risk than unsecured vacant housing units.

The relative size of the intentional-fire problem in the two types of vacant housing units can be distinguished from all housing units combined. Intentional fires accounted for 8% of all home fires in 2003-2006, 35% of vacant secured home fires and 61% of vacant unsecured home fires. Intentional fires accounted for 8% of all one- and two-family home fires in 2003-2006, 36% of all vacant secured unit fires and 61% of all vacant unsecured unit fires. Intentional fires accounted for 6% of all apartment fires in 2003-2006, 24% of all vacant secured apartment fires and 62% of all vacant unsecured apartment fires. In every type of housing, vacancy increases the relative risk of having an intentional fire versus the risk of having another type of fire, and the absence of security further increases that relative risk of fire occurring.

Putting this all together, vacancy does not make a housing unit more likely to have a fire, but it may make it more likely to have an intentional fire, and abandonment probably raises both the risk of intentional fire and the overall risk of fire, at least for one- and two-family homes. On the other hand, abandonment means there is no owner seeking to rehabilitate the property.

If there is a vacant housing unit with an identifiable owner, local authorities can compel the owner to secure the property until it is sold, and that may take care of their interest in the situation. If there is a vacant housing unit without an identifiable owner – an abandoned housing unit – then local authorities will want to secure it and/or divert it to some acceptable use. That could mean transferring ownership to someone who will take on the costs of converting the property to a useful form. It could mean demolishing the property.

Thanks to the housing bubble, there is more housing than households seeking housing. Homelessness and foreclosures reflect increased difficulty in matching housing with households, but that is not the same as lack of supply. Vacancy is also probably on the rise for other types of buildings, such as mercantile properties, offices and hotel rooms, but again, there are probably enough units for those who can afford them and for those who would rent or buy if they could afford them.

In a situation like this, the community may not have an interest in keeping every building occupied. To reduce "sprawl," there may be a desire in densely populated cities for more open spaces than buildings. With an appropriate campaign of demolition and landscaping, one may add more value by removing buildings than by rehabilitation.

"UNDER-UTILIZED" BUILDINGS

Suppose there is an old building that is not compliant with the current building code. Suppose it is kept in good repair, but it lacks the size or the features found in competing properties in today's market. Or suppose it is no longer viable for its original purpose (e.g., a factory) but might be viable for a different purpose (e.g., a mall for craft stores). An owner could be looking at a substantial cost to make the changes needed to make the property either competitive in its



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old market or viable in its intended new market. If there are enough changes, provisions may be triggered that require the building to meet new construction requirements. The business case may not look so workable.

A building code is the expression of a community's shared views on what it takes to make a building acceptably safe for a particular use – safe for neighbors and safe for occupants, most of whom are not owners, including employees, guests, patients, customers, students and even inmates. (The reason there are property maintenance codes, like NFPA 1®, *Fire Code*®,² is that the same community realizes that the level of safety provided during construction may not remain in place indefinitely without maintenance.)

The cost of providing a defined level of safety can be much higher for an existing building than for a new building, and the gap will be different for some features than for others. Changes to locks may be easy and inexpensive. Changes to detection and alarm systems may be relatively inexpensive. Changes to sprinklers may be more expensive. Changes to basic construction would be the most expensive and least practical of all.

The reason there are different provisions for existing buildings – as in NFPA 101®, *Life Safety Code*®,³ and NFPA 5000®,⁴ *Building Construction and Safety Code*®,

Chapter 15 – is that the same community that set levels of acceptable safety also has decided that the margin of additional safety is not large enough to justify the much greater additional cost involved in retrofitting every element required for new construction. Rehabilitation codes are an expansion of that concession. Instead of having two codes – one for existing buildings and one for new construction or any change of sufficient size to existing buildings – rehabilitation codes create multiple sets of requirements, depending on the type and magnitude of changes. The U.S. Department of Housing and Urban Development (HUD) called this "adaptive reuse" and supported it in 1995 through what they termed Nationally Applicable Recommended Rehabilitation Provisions (NARRP).⁵

There are a couple other precedents for this kind of thinking. One is codes for historic buildings and cultural resources. These properties have non-cost reasons for avoiding new-construction requirements. The other is performance-based design. This is a systematic procedure for demonstrating equivalent performance. Both precedents have benefits in the area of rehabilitation.

Rehabilitation codes at their best are well-considered variations on the rules used to assure that public values are properly included in private decisions that affect everyone. They often are more complex, but for good reason. Many of the arguments used to promote rehabilitation codes do not withstand close examination. Vacant buildings are everywhere and do not attract fires. Abandoned buildings do, but those aren't the buildings whose owners are seeking to rehabilitate. Under-utilized buildings are a problem for their owners but not necessarily for the larger community. As with the professional sports team owners who try to sell the community on paying for a big new facility, the economic case for relaxed rules for building conversions or enhancements may not withstand close examination.

All of these caveats are reasons why the published rehabilitation codes deserve informed support. The volunteers who wrote these codes took seriously the upside potential and the downside risk of introducing this approach, and they have installed both guidance to make it possible and circuit-breakers to keep it safe.

John Hall is with the National Fire Protection Association.



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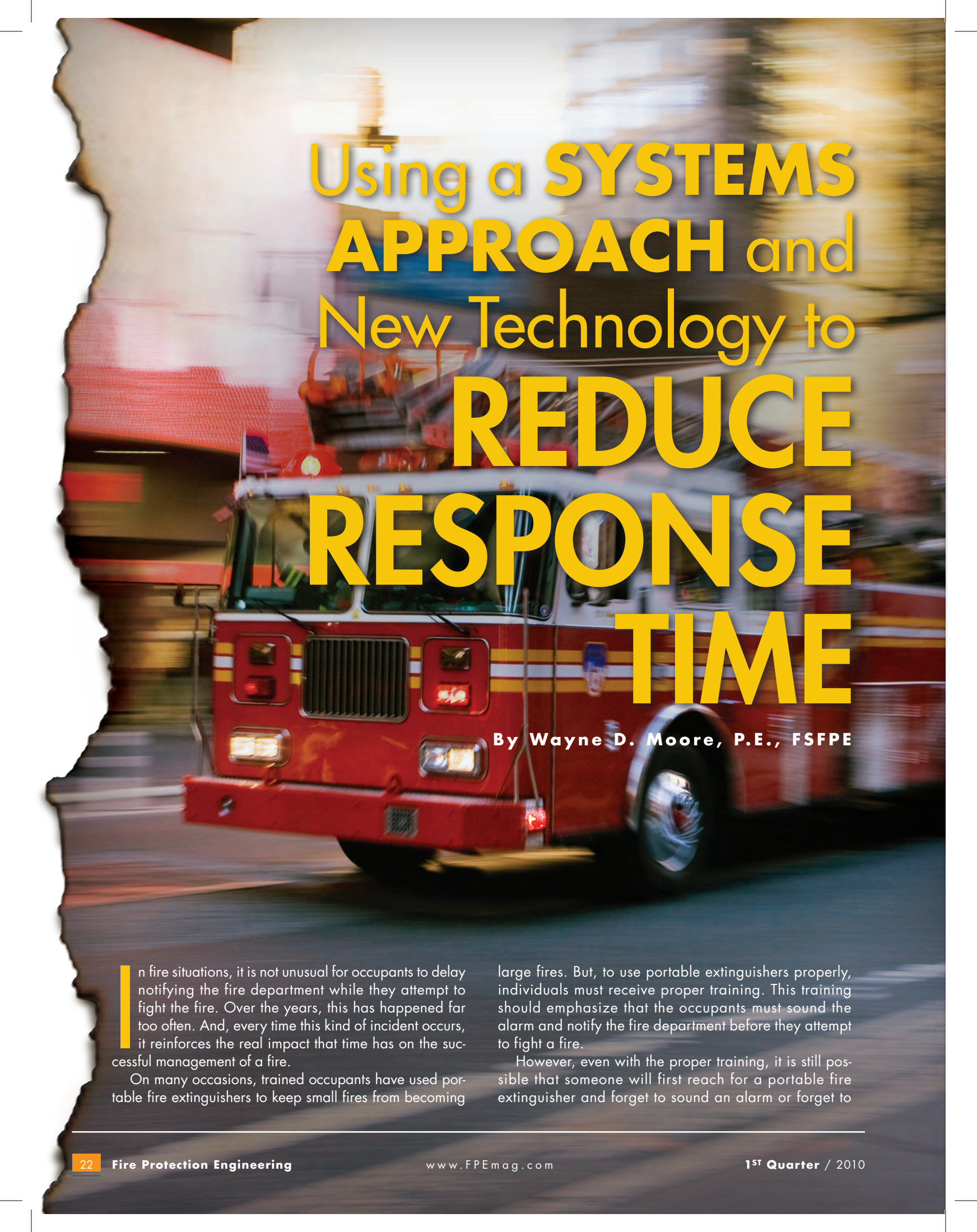
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Using a **SYSTEMS APPROACH** and New Technology to **REDUCE RESPONSE TIME**

By **Wayne D. Moore, P.E., FSFPE**

In fire situations, it is not unusual for occupants to delay notifying the fire department while they attempt to fight the fire. Over the years, this has happened far too often. And, every time this kind of incident occurs, it reinforces the real impact that time has on the successful management of a fire.

On many occasions, trained occupants have used portable fire extinguishers to keep small fires from becoming

large fires. But, to use portable extinguishers properly, individuals must receive proper training. This training should emphasize that the occupants must sound the alarm and notify the fire department before they attempt to fight a fire.

However, even with the proper training, it is still possible that someone will first reach for a portable fire extinguisher and forget to sound an alarm or forget to

notify the fire department before trying to extinguish the fire. Another possible scenario is that someone inadvertently blocks access to the portable fire extinguisher. Similarly, a trained individual may attempt to use a fire extinguisher that isn't pressurized or is missing.

Fortunately, building owners can employ modern technology to bridge the gap between what they expect to happen when someone discovers a fire and what actually happens. Active monitoring systems are available for portable fire extinguishers. This new extinguisher monitoring system connects to the building fire alarm system or to any other centralized monitoring equipment. Whenever someone lifts a portable fire extinguisher, the interface module will initiate either a fire alarm signal or a supervisory signal on the fire alarm system. The type of signal will depend upon the building fire plan that the owner has developed and on the requirements of the authority having jurisdiction.

If someone blocks access to a portable fire extinguisher, the interface module can detect the blockage and, after a suitable and selectable time delay, initiate a supervisory signal on the building fire alarm system. This will notify management of the facility that something has blocked access to an extinguisher.

In addition, the extinguisher monitoring system will monitor the stored pressure inside the portable fire extinguisher and initiate a supervisory signal on the building fire alarm system to notify maintenance personnel that the extinguisher needs service.

The basic system and its interface module monitor the pressure gauge signals and contain the obstruction detection technology. The interface module with the specially enabled extinguisher allows a portable fire extinguisher to become a fully supervised component of a monitored fire alarm system. The system is listed and meets the requirements of NFPA 10¹ and NFPA 72.² Its use also eliminates 11 of the monthly visual inspections required by NFPA 10.

The extinguisher monitoring system offers many benefits. But just the benefit of interfacing with the building fire alarm system to monitor the portable fire extinguisher can improve the overall effectiveness of the fire protection for a building.

This aspect of the integration allows the occupants to receive training so they will understand that they can have confidence that, when they lift the extinguisher off of the holder to attempt fire suppression and control, others will receive immediate notification of the situation. They will also be assured that the extinguisher is charged and ready to use.

The point behind the value of the extinguisher monitoring system rests with an understanding of the critical importance of time to truly effective fire protection. The common thread to every successful or unsuccessful outcome of a fire suppression effort relates to time. Time represents the yardstick of fire suppression.³

The times associated with a fire scenario include detection time, occupant response time, escape time, fire department response time, fire suppression set-up time and suppression time. A typical fire safety goal is to reduce all response-related times and increase the amount of time for escape. Where response times are reduced, the outcomes are more likely to be favorable, whether in terms of loss of life or reduction of the property loss.

In many new buildings constructed over the last 10 to 15 years, there will be an automatic fire sprinkler system monitored by a fire alarm system, which is connected to an off-site monitoring station. There may also be fire extinguishing or suppression systems that protect hazards unique to the occupancy of the building. In addition, portable fire extinguishers may be used to enable occupants to take action prior to the fire becoming large enough to operate one of the fixed fire protection systems.

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Portable fire extinguishers can play an important part in allowing the occupants of a building to control or extinguish a fire. However, occupants can also misjudge the ability of a portable fire extinguisher to extinguish a fire. This, in turn, can introduce a delay in notifying the fire department and affect the response time.

When a person sees a fire, he or she may either choose to evacuate or choose to fight the fire.⁴ The ideal response for a person who discovers a relatively small fire and decides to fight that fire is to sound the alarm and grab a readily available portable fire extinguisher and attempt to extinguish the fire, or at least try to contain the fire for a short period of time. It is imperative to ensure that the extinguisher is operational and accessible.

Sadly, in some instances, people who have not received proper training will attempt to fight a fire with an extinguisher. Even worse, a trained person may “forget” the training when faced with the crisis of a real fire. In both cases, the individual will begin to fight the fire but fail to operate a manual fire alarm box to allow the fire alarm system to notify the other building occupants and the fire department.

When a person chooses to fight the fire before notifying the other building occupants and the fire department, he or she not only delays notification to the occupants and the fire department, he or she increases the danger to the

other occupants of the building and delays the response of the fire department. If his or her efforts to fight the fire fail, emergency responders will not immediately respond to the fire because they have not received proper notification.

Using the extinguisher monitoring system allows system designers to integrate the use of portable fire extinguishers as part of the alarm notification process. This will reduce the response time of the fire department and reduce the “detection” time.

In addition to using this technology to reduce response time and increase escape time, the extinguisher monitoring system provides active monitoring of the extinguisher. This ensures that the portable fire extinguisher remains present and accessible, as well as properly charged and ready for use.

The gauge portion of the extinguisher monitoring system provides an active pressure gauge. This pressure gauge offers a visual pressure status, an electronic output for signaling when someone removes a fire extinguisher from its designated location, and an electronic output to signal when the fire extinguisher pressure falls below a safe operating level. The gauge’s pressure monitoring circuitry utilizes a magnet on the underside of the indicating pointer that trips a switch as the internal pressure falls. The gauge’s electronic signal actuates circuitry within the accompanying interface module. The interface module in turn provides an output for direct interface with most types of fire alarm systems.

The interface module also provides the base for the obstruction detection technology. The obstruction detection circuit senses when something continuously blocks access to the fire extinguisher. The interface module also manages the power circuitry and provides a trouble signal when the input power falls below a safe operating level. ■

Wayne Moore is with Hughes Associates, Inc.

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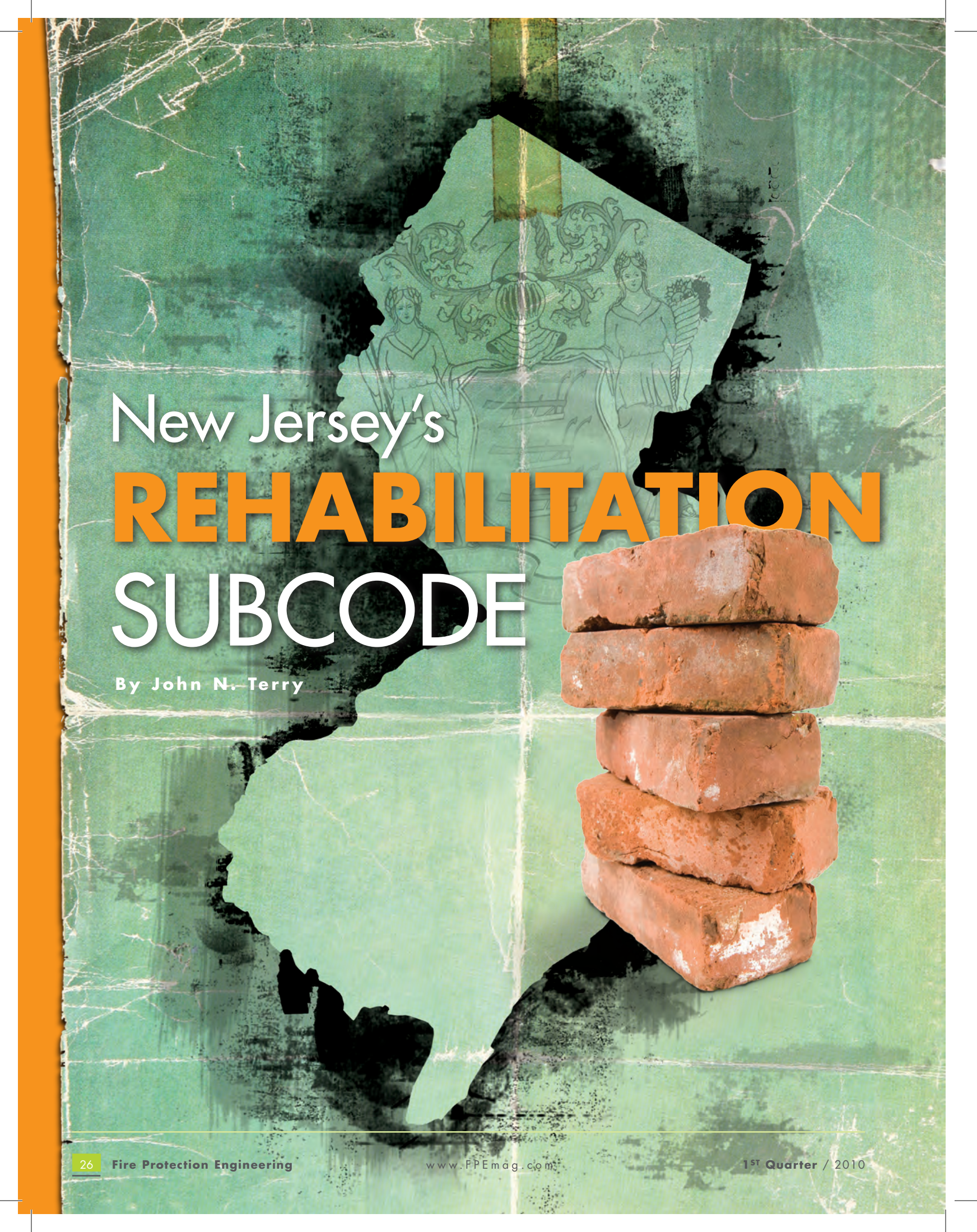
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New Jersey's **REHABILITATION** SUBCODE

By John N. Terry

Many existing buildings throughout the United States were built to comply with an earlier building code or with no code, yet are often still safe and sound. Many of these buildings continue to be occupied, used and maintained. However, existing buildings in many urban areas remain vacant, in part because rehabilitation projects trigger requirements to bring existing buildings into compliance with building codes for new construction.

For new buildings, complying with the construction code is a straightforward process. Materials to be used, processes to be followed and safety standards to be met are clearly stated, and the cost of compliance is predictable. Compliance is less straightforward in the case of existing buildings. Construction

standards written for new buildings have been applied to rehabilitation work on existing buildings with often prohibitive costs. Building codes developed with new construction in mind are difficult to apply rationally and predictably to existing buildings. If developers and building owners cannot predict with certainty what will be required to bring a deteriorated building back into use, projects in existing buildings will be less attractive.

Prior to the development of the Rehabilitation Subcode,¹ the New Jersey regulations triggered code requirements for work in existing buildings based on the cost of the construction project. The greater the ratio of the cost of the project to the replacement value of the building, the more the building needed to comply with the standards for new buildings. Other approaches, such as the method outlined in Chapter 34 of the

*International Building Code (IBC)*², use new building construction as the benchmark against which existing buildings are measured.

Chapter 34 of the IBC begins with the premise that altered portions of the building must meet requirements for new structures. As an alternative, the code allows the user to go through an extensive evaluation of the building. The building is given points for fire safety systems and features that meet or exceed the code requirements for a new structure. Negative points are assessed for features that are viewed as hazardous; no points are awarded for features deemed to have neither a positive nor negative effect on the fire safety



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of the building. If the existing building does not meet a specified point value after assessing these features, the building owner is required to provide improvements. This often requires building owners to add features and fire safety systems to the building that would not be required if the building were new.

Basing requirements for existing buildings on the standards for new construction causes several problems:

1. In many cases, the requirements for new structures cannot be met in existing buildings. Code requirements for new construction contain numerous dimensional requirements that can be difficult, if not impossible, to meet. For example, new building requirements for stairway geometry (minimum tread and maximum riser dimensions) often mean that existing stairways are too steep and need to be replaced. Stairways with shorter risers and longer treads require more room and often cannot fit into existing buildings without totally reconfiguring the space. Other new construction dimensional requirements that cannot be easily met in existing buildings are ceiling height requirements, egress window requirements, corridor and door-way width requirements, and sometimes the most difficult to meet, building height and area requirements.
2. A second problem is predictability. Code officials generally recognize that making an existing building meet all of the requirements of the code applicable to new buildings is impossible. However, it is equally impossible for the building owner or design professional to predict which requirements of the code the enforcing agencies will deem necessary to improve safety. Quite often, this information is

not known until the project has been submitted for permitting. There is an additional level of uncertainty because it is difficult to predict what obstacles will be encountered when trying to place a new building system into an existing structure. This uncertainty makes cost estimations arbitrary, at best.

3. Rules that aim to impose new construction standards on existing buildings penalize building owners who want to

The additional costs associated with expanding the applicant's scope of work can make the rehabilitation project financially infeasible, causing the building owner to abandon planned improvements.

improve their buildings. Basing code compliance on the ratio of the cost of work to the value of the building places an undue burden on the building owner who chooses a "higher end" product. Furthermore, similar rules can expand the applicant's scope of work by requiring renovation of features that are neither unsafe nor in disrepair. The additional costs associated with expanding the applicant's scope of work can make the rehabilitation project financially infeasible, causing the building owner to abandon planned improvements.

NEW JERSEY'S APPROACH

The challenge accepted by New Jersey was to develop rational and predictable code requirements for existing buildings that delivered safe and sound rehabilitated structures.

Instead of basing requirements on the cost of the work to be performed, the Rehabilitation Subcode bases requirements on the nature of the work. The code establishes specific requirements for each category of work. These requirements are:

Products and practices. Products and practices list the items that are required and those that are prohibited.

Materials and methods. The Materials and methods section identifies the provisions of the codes for new construction that are required for the building components being introduced. This section does not contain any of the scoping requirements of the codes for new construction; it contains the requirements for the materials and the installation methods for building components that are within the owner's intended scope of work. For example, the section of the code for the installation of gypsum wallboard is included in the materials and methods section; however, there are no scoping provisions that require the wall being constructed to be afforded a fire-resistance rating in this section.

New building elements created as part of a rehabilitation project. Each item listed in this section must conform to requirements for new construction as provided in the new building elements section of the Rehab Subcode. Some examples of new building elements are new atriums, new corridors and new door openings.

Basic requirements. Basic requirements cover topics such as capacity of means of egress, dead-end corridors and exit signs. They are imposed only within the work area when the work is a reconstruction project. In New Jersey, the "Basic Requirements" are rooted in the New Jersey Fire Safety Code

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(which is based on the 2006 edition of the *International Fire Code*³). The New Jersey Fire Safety Code® establishes the minimum level of life and fire safety for all existing buildings. The "Basic Requirements" in the Rehabilitation Subcode match the requirements contained in the New Jersey Fire Safety Code. If an existing building that complies with the New Jersey Fire Safety Code not undergoing a construction project is deemed safe, an existing building that is undergoing a construction project is equally safe if it complies with the same requirements.

Supplemental requirements are imposed when the work is a reconstruction project and the work area exceeds a certain size. There are times when the construction project is so large that expanding the scope of the project is reasonable. For example, if a construction project encompasses more than 50 percent of the gross enclosed floor area of a building that must be provided with a fire alarm system, the alarm system is required to be expanded to the entire building. The scope of the intended project is expanded in a rational and predictable manner.

To apply these requirements uniformly, the Rehabilitation Subcode establishes four categories of rehabilitation work: repair, renovation, alteration and reconstruction. The four categories of work are mutually exclusive and are defined as follows:

1. "Repair" means fixing a building component that is worn or broken. Under this category, materials and assemblies may be replaced with like materials and assemblies. There is no limit to how much repair may be undertaken in connection with a project. There are only a few specific exceptions to this rule. These exceptions include requiring certain products and practices, such as the installation of safety glazing in specific hazardous locations, and prohibiting other items, such as certain electrical materials or supplies.
2. "Renovation" is restorative in nature, such as the replacement of interior finish, trim, doors or equipment, but involves the use of different materials. There is no reconfiguration of space. As with "Repairs," there are certain products and practices that must be used or are prohibited. Additionally, the materials used and the methods of installation must conform to the requirements found in the materials and methods section. This type of work contains no requirements that will expand the scope of the intended project.
3. An "alteration" project involves the reconfiguration of an existing space. Products and practices and materials and methods requirements apply to alteration work. New building elements installed as part of the alteration project must comply with the referenced sections of the codes for new construction.

In an alteration, the portion of the building being altered does not need to be brought up to the standard established in the basic requirements. The basic

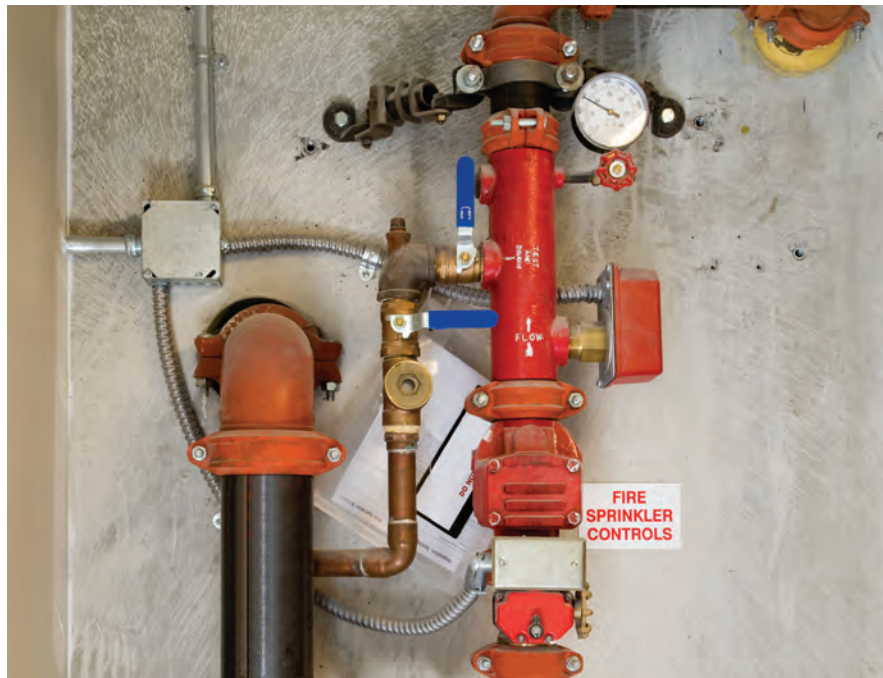
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requirements are used as a measuring stick. The work being done cannot make the building less conforming to the basic requirements than it was before the work was undertaken.

4. "Reconstruction" is a project that consists of the other categories of work where the work includes an entire tenancy (a portion that is under the ownership or control of one owner or tenant) and precludes occupancy during the project. This category is more of a "quantity" of work rather than a category of work and is commonly referred to as a "gut rehab." Reconstruction includes repair, renovation and/or alteration in any combination.

Repair, renovation and alteration work that make up a reconstruction project must comply with the requirements for the applicable category of work. The entire work area must comply with basic requirements. Certain reconstruction projects also must meet the supplemental requirements, which apply only when the work area for a reconstruction project exceeds a specific size.

Another type of project that can be undertaken as an existing building is a "Change of Use." A "change of use" results from one of two conditions: a change of the building occupancy classification or a change in the nature or intensity of the use. The "Change of Use" section details what must be done, for example, when a building that has been a store (Group M) is changed into a restaurant (Group A) or when a small restaurant is expanded. The change in the use of the building space may initiate requirements of one or more of the codes for new construction. For example, the plumbing subcode may require additional toilet fixtures, the electrical subcode may require ground fault circuit interrupters, or the mechanical subcode may



require that the heating, ventilation and air conditioning system be upgraded. The amount of work required depends on whether the occupancy change creates a greater hazard or intensity as defined in the code.

The "Change of Use" section contains six "hazard" tables. These tables establish the concept of an increase in hazard that may be associated with the change in the occupancy classification of the building. The first table categorizes the overall hazard associated with the new use group relative to the existing use group. The next five tables address specific hazards associated with the following technical issues: means of egress, height and area, exposure of exterior walls, fire suppression systems and structural loads. These tables operate independently of one another. Additionally, there are separate requirements for vertical openings, fire alarm, fire detection and smoke detectors. There are also separate sections that address work required by the plumbing, electrical, mechanical or accessibility codes.

The last type of project that can be undertaken on an existing building is an "addition." Simply put, an addition is required to comply with the provisions of the codes for new construction; however, the other sections of the Rehabilitation Subcode apply to the existing portion of the building.

John Terry is with the State of New Jersey.

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FIRE ALARM SYSTEMS IN EXISTING BUILDINGS



For a fire protection engineer, there are several jobs related to fire alarm systems in existing buildings, and each requires a slightly different approach. The most common include:

- Evaluating an existing fire detection and alarm system.
- Reviewing local codes to decide whether an existing building and occupancy requires a fire alarm system and, if so, what features are required.
- Determining if a fire detection and alarm system can be used to provide a desired level of fire protection.
- Determining how best to install a fire alarm system in an existing building.
- Determining when repairs trigger upgrades.

This article addresses some of the most common considerations in these categories.

EVALUATING A SYSTEM

When evaluating an existing fire detection and alarm system, the first question that should be asked is: Evaluating

for what? Most evaluations are done to determine if the existing system meets local code requirements. That simply requires some knowledge of, or research into, the local codes and is addressed below in the section, "Is a System Required." Some evaluations are done to determine if the existing system is still capable of performing its intended function. This is addressed in the section titled, "Is a System Desired."

Another reason to evaluate an existing system is to determine if the system should be replaced or upgraded to help control life-cycle costs. Just like people, as fire detection and alarm systems age, some require a greater amount of maintenance. Smoke detectors may accumulate dust and dirt even when they are regularly cleaned using manufacturer's instructions. Eventually, their sensitivity might drift to the point where replacement is warranted.

A higher sensitivity could directly result in a false alarm as the unit approaches its response threshold. Higher sensitivity can also increase the likelihood of nuisance alarms from sources such as cooking odors, steam or tobacco smoke that normally might not be sufficient to alarm the detector. There is no code requirement for the replacement of aging system smoke detectors. This is because a regular inspection and testing program is an effective method of assuring detector operability.¹ The code requirement for smoke alarms installed in one- and two-family dwellings is different in that a 10-year replacement is required.² This is predicated on the assumption that homeowners are less likely to periodically test and clean their smoke alarms.

NFPA 72, the *National Fire Alarm and Signaling Code*, requires owners to keep records of system activations and operation for a period of one year after the next regular test.² Owners should be encouraged to keep records for longer periods to assist in evaluating aging effects on system performance.

A system that alarms when there is no fire is effectively "crying wolf" and reducing its effectiveness.³ In addition, there are more direct costs, such as lost productivity for the occupants, alarm company service calls and possibly even fines imposed by local authorities. The benefits of replacing an aging system include reduction or elimination of these costs and might include a reduction in the regular cost of ownership.

Depending on the age of the existing system, a replacement system might add features, such as built-in sensitivity testing, sensitivity drift monitoring and management and

logging of system events. Printers that automatically maintain the records required by NFPA 72 are another option. These features can directly reduce the costs of periodic testing and maintenance and recordkeeping.

Existing systems often are evaluated for their ability to provide adequate occupant notification. Many systems installed to meet older codes might lack adequate occupant notification in the form of audible signal levels in sleeping areas. Older codes simply required a system to be audible so that it could be "heard in all areas" or "adequate to perform its intended function." There was no requirement for a specific audible level. As research was done on awakening effectiveness, new requirements were introduced into codes and standards.^{4, 5, 6, 7, 8} Most recently, research has shown that the frequency (pitch) of the alarm signal, in addition to its sound pressure level, is an important factor in waking effectiveness.^{2, 9, 10}

A common question raised by owners is whether a system has to be upgraded to meet the levels required by current codes. Many jurisdictions and circumstances permit a system to remain unchanged if that system met the code that was in place at the time the system was installed. However, a fire protection engineer should question whether a system actually meets the require-

ment of that older code to "perform its intended function" if it does not meet the sound pressure level necessary to awaken and alert someone. Similarly, existing systems are often evaluated for their ability to provide adequate visual signaling to meet current accessibility codes.

If an existing system does require or warrant detector replacement or notification appliance upgrades, the engineer must evaluate whether a total replacement is necessary or whether the existing control system and wiring can be used. This might involve issues of component compatibility.

All initiating devices must be listed as compatible with the fire alarm equipment unless they interface only by contact (switch) closure.² For example, if the control unit uses addressable technology to communicate with the initiating devices, those devices must be listed to work with that particular control unit. However, initiating devices connected to conventional, zoned systems operate differently. They signal an alarm by either creating a direct short circuit or by changing the amount of current flow on the initiating device circuit (IDC). Therefore, conventional (non-addressable) devices that do require power to operate, such as manual pull boxes and heat detectors, do not have to be compatibility listed with the control unit because they operate by simply shorting the IDC.

NFPA 72, the National Fire Alarm and Signaling Code, requires owners to keep records of system activations and operation for a period of one year after the next regular test.

Conventional smoke detectors operate in one of two ways. One type connects to an IDC using dry (non-energized) contacts (just like a light switch) and requires a separate power circuit. Those detectors would not have to be compatibility listed to connect to a conventional fire alarm control unit. The second type gets its operating power from the IDC and signals an alarm on the same IDC by increasing the flow of current above some threshold established by the control unit manufacturer. Thus, that type of detector must be compatible with the control unit to ensure that operating and alarm currents are properly balanced. Those types of detectors often are called circuit-powered detectors. They also are commonly called “two-wire” detectors, although that is a poor description.

In general, notification appliances do not require any compatibility listing. They must simply be matched for the proper voltage. There are two types of notification appliance that would require compatibility listing to the control unit. The first is addressable notification appliances. They must be compatible to ensure proper communication with the control unit. The second type that must be listed to be compatible with a particular control unit are those that have a “Special Application” listing. In that case, the manufacturer has designed the notification appliance and the notification appliance circuit specifically to work together. In the case of DC voltage notification appliances, the quantity of appliances on a circuit is limited by the amount of current they draw and the rating of the notification appliance circuit. In the case of AC voltage appliances (speakers), the quantity is limited by the power available from the amplifier.

NFPA 550 provides engineers with a tool to evaluate systems and combinations of systems for their ability to meet protection goals.

Quantities of appliances might also be limited by the size of existing wires and the resulting voltage drop. Power supply capacity and existing wire sizes might require panel replacements or adding booster panels to accommodate additional notification appliances and circuits. These issues require specific information from the system manufacturer. If the existing system and wiring have adequate capacity and compatibility for new appliances and detectors, battery capacity still must be checked to ensure the ability to supply the new load.

IS A SYSTEM REQUIRED

A fire protection engineer might be asked to determine if an existing building requires a fire alarm system. If the property is being renovated or if there is a change in occupancy, local codes might require installation of a new system or an upgrade of features for an existing system. Changes in fire codes might also require the installation of a system in a building that did not previously require one. The Spring 2007 article in this series provides more discussion of building and fire codes and local requirements.¹¹ If a system is required, the codes usually spell out the need for one or more of the following:

- Manual activation
- Automatic fire detection
- Occupant notification
- Emergency forces notification
- Supervision of other protection systems
- Activation of emergency control functions

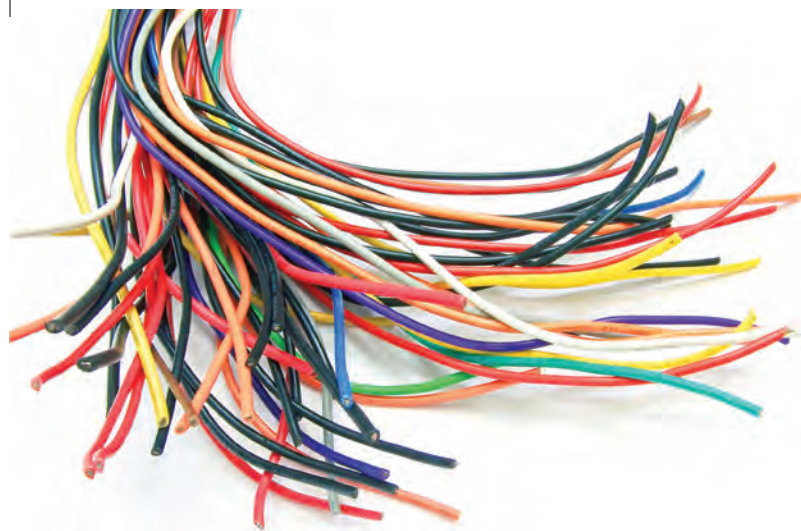
The code may not require all of these features. For instance, a code might require a system that supervises a sprinkler system and provides emergency forces notification, without any requirement for occupant notification.

IS A SYSTEM DESIRED

Even if a system were not required in an existing building, one might be effectively used to meet the owner's fire protection goals. More often than not, a system is already in place and additional features are evaluated to determine if they will contribute to the overall fire safety goals. By itself, a fire detection and alarm system is not a complete fire protection system. However, it is a vital component for several fire protection strategies. For example, people cannot be expected to exit a building unless a fire is detected and a warning is signaled early enough to provide adequate egress time. This fire protection system requires a sufficient number of adequately sized and constructed means of egress in addition to an adequately designed detection and occupant notification system.

Similarly, manual extinguishing efforts cannot begin unless the fire is discovered and emergency forces are notified. However, fire department notification by itself does not mean that fire protection goals will be met. For example, it is possible in some situations that a fire will be beyond the capability of the local fire department to control even if detection and signaling are nearly simultaneous with ignition. It might be necessary to have a combination of systems to achieve the desired level of fire protection.

NFPA 550 provides engineers with a tool to evaluate systems and combinations of systems for their ability to meet protection goals.¹² The decision trees in that guide



are also useful for explaining fire protection concepts to owners and in getting owners to establish realistic goals.

HOW TO INSTALL THE SYSTEM

If a system is to be installed or upgraded in an existing building, exactly how that system will be installed can be a challenge and can greatly affect costs – and therefore the viability of the project. Obviously, the building construction features play a large role in system installation methods and costs. Unless the engineer has actual field installation experience, it is most often best to work with a qualified contractor to establish circuit routing and installation methods.

However, there are some strategies that engineers should consider and review with the contractors. For example, wall mounting of detectors can make installation of concealed wires fished up from a basement more economical than ceiling mounting, which might require surface wiring using raceways. Where there are suspended ceilings, the use of ceiling-mounted notification appliances usually is less expensive than wall-mounted units. For both detectors and notification appliances, adding some additional units might reduce installation costs by placing them in locations where it is easier to install them. For spot-type detectors, determining locations using the concept of a protection radius rather than square spacing can reduce the number of detectors required to cover a space.²

Fire protection in existing buildings is usually more challenging than in new construction. When the costs of suppression systems, fire barriers and other protection systems are considered, strategies that include properly designed fire detection, alarm and signaling systems are often necessary to meet goals and local code requirements.

REPAIRS

When does a repair trigger a requirement to upgrade? And, when does a component upgrade trigger a full system design upgrade? If a detector or notification appliance is physically damaged or fails

during a test, a simple one-for-one replacement is permitted. In the case of a damaged control unit, the answer varies from jurisdiction to jurisdiction.

If a panel is damaged to the point where a replacement is needed, that means that all, or a large part of the system, might not be operational. Therefore, a fast one-for-one replacement is warranted. Many authorities, governing laws, codes or standards would permit the panel to be replaced with comparable and compatible equipment. In other cases, authorities simply insist on getting the latest and greatest system upgrades that are available, regardless of whether they have a properly adopted regulation, code or ordinance requiring such upgrades.

Most governing laws, codes and standards do not specifically state when a component replacement or upgrade will trigger a complete system upgrade to current requirements. Some laws, codes or standards have a value limit at which an upgrade to current codes would be required. In making a recommendation to an owner, it is incumbent on a fire protection engineer to consider the many factors discussed in this article regarding evaluating the system and risks, as well as the system needs and desired performance. ■

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Problem / Solution

Problem

A train is one kilometer long. If the train is traveling 33 km/h, how long will it take for the train to completely pass through a 10 km tunnel?

Solution to Last Issue's Brainteaser

Joe says that if he adds two times his age two years from now to three times his age three years from now, he gets six times his current age. How old is Joe now?

This can be expressed as the following equation:

$$2(A + 2) + 3(A + 3) = 6A$$

Where A is the age in years.

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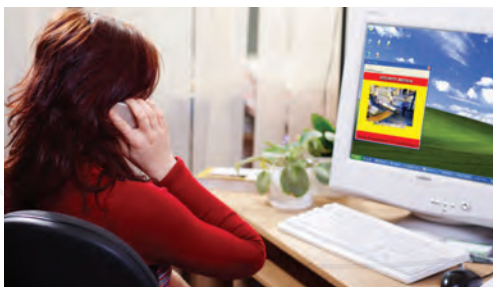
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