What every chief should know about performance-based codes

Whether the fire service likes it or not, the performance-based code is on the way. Here are some strategies to help fire departments cope with this new animal.

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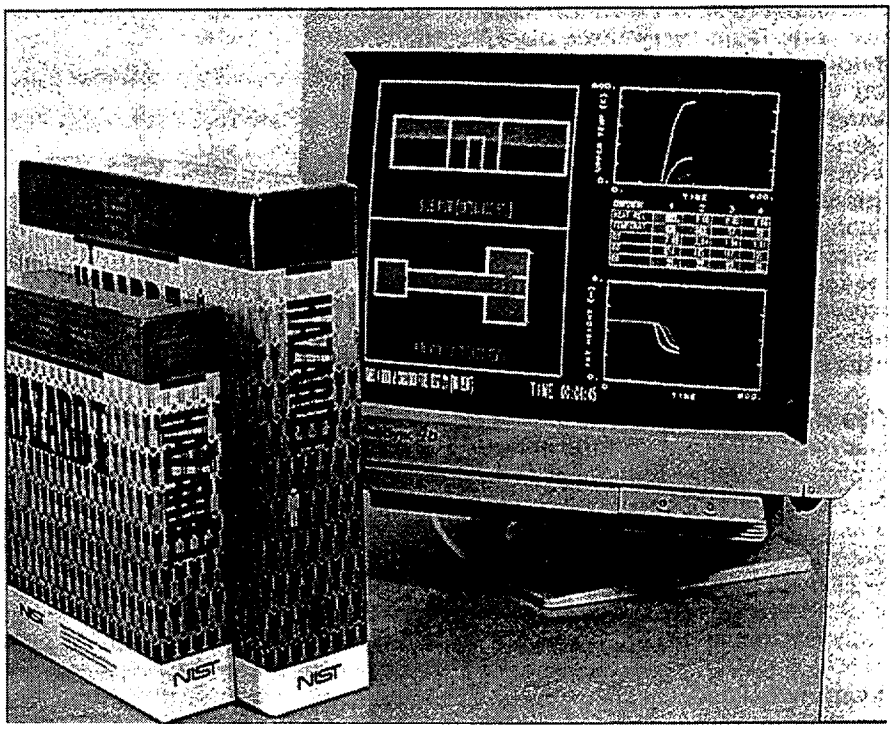
Many countries have made a formal commitment to implementing performance-based codes for regulating building fire safety. England, Wales, New Zealand, Australia, Sweden and Norway have performance-based regulations in place. Canada, Japan, Poland, Romania and China are actively restructuring their regulations to embrace performance-based codes in the next three to five years.

In the United States, the three model code organizations, the International Conference of Building Officials, Building Officials and Code Administrators International, and Southern Building Code Congress International, have formed the International Code Council. The ICC has begun development of a single model code, which will include performance statements of intent, by 2000. A full performance-based code is to follow as soon as possible.

The development of performance-based codes has not been without controversy, especially for the fire service. For example, there is debate over whether such regulations should have as a goal the protection of firefighters from structural collapse during suppression operations.

The argument is that the fire service should know when a building is safe. Given that structural collapse is the second most common cause of firefighter line-of-duty fatalities (after heart attack), this ability to recognize imminent collapse in the "heat of battle" is not obvious. This is only one of the reasons fire chiefs need to understand what is happening and why they need to become involved in the process.



Photos courtesy NIST

NIST's HAZARD I software can realistically simulate the effects of fire in a structure, giving fire departments a way to verify that a given design meets the criteria of a performance-based code. NIST has also developed many related computer models.

Why performance codes?

A hundred years ago, townhouse separation walls were specified as two courses (8 inches) of brick. By the mid-20th century, the ASTM E119 test brought in component performance by allowing the specification of fire-resistance ratings as the duration that the assembly could resist a standard fire.

The difficulty is that this standard fire may bear no relation to any fire that might be expected in the space on either side of the assembly. It was hoped that the standard fire would represent a worst-case exposure, making the rating conservative, but in recent years experiments have demonstrated that faster, hotter fires such as the so-called "ultra-fast" fire are a real possibility. However, it is generally recognized that the overall effect of conservative assumptions associated with each code provision may lead to significant overdesign and excessive costs for little improvement in safety.

Improved understanding and a greater assurance of a specified level of safety are the considerations that underlie the move toward performance-based codes. Performance codes make the code's intent explicit in the form of goals and objectives, along with performance criteria by which meeting the objectives can be verified.

How the objectives are met is left to the designer. This results in design flexibility within a common understanding of what should or should not happen. Redundancy is intentional to compensate for imperfect reliability, and uncertainty is addressed through factors of safety. Unnecessary redundancy can be eliminated, reducing cost. It's then up to the designer to demonstrate that the proposed design satisfies the code's intent.

The new age of performance codes involves system performance, that is, the contributions of every component are considered in the context of the way the entire building responds to the situation, and fires are related to the actual conditions found in the

building. This kind of detailed systems performance analysis has only become possible over the last 10 years, thanks to advances in fire science and engineering and to the widespread availability of computer models and computers that can run them.

It is recognized that the additional expense of performance analysis is only justified where the prescriptive code is difficult to apply: in unique projects where special architectural, functional or operational features are needed, such as in large shopping malls, airport terminals and exhibition halls. The majority (90–95%) of ordinary projects will continue to be built according to traditional code provisions, which would be retained in the performance code as "acceptable solutions."

"In a high-rise, you expect that the fire will be at least controlled and that there will be a protected stairwell with a standpipe from which to advance hose lines." This is a high-rise training exercise that NIST helped organize.

What are they, exactly?

In a performance code, the intent is clearly stated, the expected performance is specified both as what is to be accomplished and to what level, and the methods by which performance is to be measured are listed. Performance-based codes generally follow a five-part format, beginning with a **goal statement** for each chapter or section to clearly establish the intent. For example, the section on means of egress might begin:

"The goal of this section is to safeguard people from unreasonable risk of death or injury from fire while escaping to a safe place and to facilitate fire department operations."

Next would come a series of **functional objectives** that describe the functions that need to be assured to achieve this goal. One such functional objective might be:

"Buildings shall be provided with protected escape routes which ensure that adequate time is provided for occupants to escape without exposure to levels of smoke or temperature which might cause injury or death."

Third are **performance criteria** by which to judge compliance with the objectives. Performance criteria for this section might be:

"Conditions at any occupied location within an escape route shall not exceed 93°C (200°F) at eye level (i.e., 1.6 m or 5.25 feet above the floor), a ceiling temperature of 260°C (500°F), or a carbon monoxide concentration of 0.15% by volume."

These sections constitute the mandatory portions of the performance code and are followed by two sections of advisory material. The first of these is **verification methods**, which cite test methods or calculations that can be used to verify that the performance criteria are met. In this example, the code might cite BFRL's FASTLite or HAZARD I computer models as means to predict values for the limiting conditions.

Last are **acceptable solutions** that represent "deemed to satisfy" approaches and generally include the prescriptive approaches from the prior codes. Here the provision of escape routes with specified widths, fire-resistant separations, travel distances and markings consistent with acceptable practice would be found.

Participation

As the performance code system in this country develops over the next few years, the fire service can take steps to ensure a reasonable level of comfort. The first is to **develop a set of performance goals and objectives.**

When you arrive on the scene, you expect certain things. In a residential fire, you expect that the smoke detectors have operated and the occupants are all outside to greet you, so you can concentrate on suppression and not rescue.

In a high-rise, you expect that the fire will be at least controlled and that there will be a protected stairwell with a standpipe from which to advance hose lines. In any case, fire safety features should be working and should limit the incident so as not to require extra alarms. These objectives then become a valuable tool for preplanning and the basis for discussions with designers as to the intent of the code in your jurisdiction.

Second, **develop ground rules by which designers must abide.** As suggested in draft criteria being developed by the Society of Fire Protection Engineers, written reports should be provided for review in advance of meetings or hearings, and should:

- Identify and document project participants.
- Document participants' qualifications (e.g., licensure as a professional engineer).
- Describe the purpose of the analysis or design.
- Provide site or project information.
- State the design goals, objectives, requirements and criteria.
- Describe design scenarios and assumptions.
- Describe and justify design fires.
- Describe any design alternatives considered and how these meet the goals and objectives.
- Describe and document the engineering tools and methods used.
- Reference the sources of methods and data.
- Include drawings and specifications for the resulting design.
- Document the test, inspection and maintenance requirements.

Third, **identify in advance individuals who can assist in the review.** These might be state, local or federal experts at colleges or agencies, or even engineers in private practice who are willing to answer questions or provide occasional guidance. More and more fire

departments have their own fire protection engineers who can provide support and who might also be available to assist other departments. Codes and standards organizations have staffs who will answer questions about their documents or about test methods referenced in them. On large or complicated projects, be prepared to require that the submitter pay for a second opinion from a qualified individual who is acceptable to you. (See sidebar.)

Continuing involvement

Performance designs tend to rely more on active systems like detectors and sprinklers and less on fire-rated construction. This approach brings with it the need for regular testing and maintenance to ensure that the systems will function when called on. The responsibility for this must rest with the building owner.

An example is the process devised in New Zealand to deal with this issue. The requirement is that the designer provide the owner with an "owner's manual" for the building that describes the systems, their purposes and functions, and testing, inspection and maintenance requirements. The owner must follow these requirements and certify annually to the fire service that they have been performed by qualified people. The owner is issued a "warrant of fitness" to display in the building in the same way as an elevator inspection certificate. This ensures that the responsibility for continuing maintenance of required systems rests clearly with the owner.

One problem that will remain with the fire service is ensuring appropriate use of the building. The performance design will assume certain uses or conditions when determining design scenarios and design fires. For example, an exhibition facility might assume that additional security personnel will be engaged for activities that attract a high proportion of children. These additional personnel will then be available to provide evacuation assistance.

It's important that these conditions continue to be met for such use as a condition of operation. Owners and operators may forget that design approvals were based on the assumption that certain functions would not be held in a facility. This is another case where written reports on file can be invaluable in reminding an owner of prior commitments.

Wanted: Fire service input

As mentioned above, the U.S. model code organizations are involved in developing performance codes for 2000. The initial part of this effort, currently under way, is to develop performance statements, goals and objectives to be incorporated into the codes as clear statements of intent.

It's crucial to the process and to the fire service that fire chiefs participate in this effort. The fire service in Australia was unable to participate when the goals and objectives were developed for their performance code, and much of the fire service there believes that the code does not adequately address their needs for rescue and suppression.

The IAFC and its Southeastern and Southwestern divisions were represented at the last ICC performance code meeting, and a few active or retired fire officers attend regularly to provide the fire service perspective. Unless more people become involved in the process, however, the resulting codes might not meet the future needs of the fire service, because the activities under way today will shape the buildings of tomorrow. FC

Code help from NIST

NIST's Building and Fire Research Laboratory provides models and methods for predicting building performance. (See "The pyro," FC, December 1993.) All NIST software is available from the NFPA; call Nancy Schwartz at 617-984-7450. ☐

In addition, BFRL's Fire Research Information Services operates a bibliographic computer service called FIREDOC that can be searched via modem connection or the Internet (http://www.bfrl.nist.gov).

Some BFRL publications are written for non-scientists. For example, an article in the March/April 1995 NFPA Journal, "How To Evaluate Alternative Designs Based on Fire Modeling," discussed issues related to appropriate computer models, data and assumptions used to justify alternative designs or for performance code applications. Copies can be downloaded from the BFRL Web site (http://www.bfrl.nist.gov/fris/fsedpubs.html).

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