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STATUS OF PERFORMANCE FIRE CODES IN THE USA*

INTRODUCTION

The purpose of this paper is to report on the status of performance fire codes in the United States. The bottom line is that construction related research and development in the USA are seeking to guide the construction industry through the same transformation manufacturing industry is experiencing. This involves exploiting advances in science and technology, and modern concepts of manufacturing quality to assure life cycle quality and performance. For fire safety, this means engineering fire safety into products and buildings and providing means to assure that a facility is safe in use. This can not be done using traditional regulatory methods, nor accomplished by national edict. Rather, creative partnerships between industry, government and academe are needed to devise new strategies and engineering tools; and international scale research and cooperation are needed for development and implementation of global standards and conformity assessment systems.

After briefly describing the context for building and fire safety regulation in the USA, the status of development and implementation of performance-based fire safety engineering practices is discussed. The paper concludes with some observations about critical conditions for success of fire safety engineering and its application to building fire safety regulation.

BACKGROUND

To appreciate the status of "performance fire codes" in the USA, one needs to understand a little about our fire and building safety regulatory "system". As you know, the USA is a union of 50 sovereign states, and responsibility for fire safety rests at the state or local level. This means there is no central national authority for building or fire safety regulation. Regulatory decision-making is by the local "Authority Having Jurisdiction," or AHJ's as we call them. A growing number of states, now 38, have statewide building and fire codes and authority for modification of requirements is retained at the state level. Authority for interpretation remains with the AHJ. These people are central figures in our system. Collectively, they form the membership of three not-for-profit private sector model code organizations - the International Conference of Building Officials (ICBO) located on the west coast, the Building Officials and Code Administrators International, Inc. (BOCA) in the midwest, and the Southern Building Code Congress International (SBCCI) in the southeast - which develop three model building and fire codes. In recent years, these codes groups have agreed to a common format and their codes have become quite similar in content except for mostly regional variations and preferences. The model building and fire codes are adopted in state or local laws or regulations but are often modified

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in the process to meet local preferences. The NFPA also publishes a Life Safety Code, NFPA 101, much of which has been embraced in the model building and fire codes and adopted directly by a number of jurisdictions and government agencies. The model codes cite numerous national standards developed by private not-for-profit voluntary consensus standards organizations. Those related to fire safety are produced primarily by the National Fire Protection Association (NFPA) and the American Society for Testing and Materials (ASTM). The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) and American Society of Civil Engineers (ASCE) also produce some fire safety standards.

There are several routes for change in this system. One is through the consensus standards process. For example, the Fire Safety Evaluation Systems developed at NIST by Bud Nelson and his co-workers years ago became part of the NFPA Life Safety Code, NFPA 101M Alternative Approaches to Life Safety, much of which is now recognized by the national model building codes[1]. Similarly, a method for determination of rate of heat release of materials using the cone calorimeter is now an ASTM standard and applications of it to building materials, contents and furnishings are in development[2]. Once new requirements are adopted into the model codes, their acceptance in state or local regulations accelerates. Another route for change is through acceptance by a state level board in most of those states with state-wide codes, or an individual AHJ using the alternate method or "equivalence" provisions of the code. This approach is often used by developers of new products who mount campaigns to get trial applications of innovative products approved jurisdiction by jurisdiction until they gain enough successful experience in use to achieve broader code or standard approval. Alternatively, the model code organizations themselves offer a "National Evaluation Service" designed to short cut the process of gaining acceptance one local jurisdiction at a time by using modern evaluation methods and panels of experts to determine whether a proposed product or procedure meets the intent of the model codes, again using the "equivalence" provisions of the code[3].

PERFORMANCE CODE MOVEMENT IN THE USA: PAST AND PRESENT

A performance fire code is a code which sets fire safety goals, i.e., says what is required, but leaves to the designer how those goals will be met. To be meaningful, a performance fire code must include objective and practical criteria and measurement methods for determining the extent to which a particular design meets the goals. This is in marked contrast to traditional prescriptive codes which typically specify how safety goals are to be achieved and often leave implicit therein the desired levels of safety. Bukowski and Tanaka have suggested a strategy for a performance fire code[4] and Bukowski has reviewed fire risk prediction methods that would be central to such a code[5].

For years, the potential benefits of such performance codes have been touted, primary among them being freedom of design and motivation for the designer to achieve potential savings in cost or improvements in function or safety or both. Opponents argue that the implementation of such codes is likely to be more difficult or costly than simple prescriptive specifications. The easy answer to such claims is that once a performance code is established, manuals of accepted practice can be compiled for those who prefer to copy previously proven solutions while preserving the benefits of performance for those who choose to innovate. A more complete response must acknowledge that education and training requirements for performance codes typically will be higher than with prescriptive codes, but so will the benefits. Modern advances in computing, telecommunications, simulation, and expert systems offer exciting mechanisms with which to address these issues. Deming and others have shown that inspection-based quality control of manufacturing is inferior to and more costly than strategies which assure quality throughout the design and manufacturing processes[6]. Well-founded performance codes and modern quality management practices offer the same potential benefits in construction.

An inescapable issue with performance fire codes is that building contents and occupant activities must be addressed explicitly[7]. Thus, traditional approaches such as review of plans and specifications and pre-occupancy inspection are not necessarily relevant to affirming the conformance of a building in use to its performance-based design. Rather, performance simulations and other quality engineering measures applied throughout a facility's life cycle and built-in diagnostic systems appear to be the way for the future.

The desire to shift from prescriptive to performance requirements in codes and standards has been present in the USA for many decades[8]. A number of major efforts to develop credible performance criteria and measurement methods for fire safety in buildings have been undertaken by various Federal Agencies in the last four decades. These include the "Operation Breakthrough" program run by the U.S Department of Housing and Urban Development in the early 1970's, the Goal Oriented Systems Approach concept fostered by the General Services Administration in the 1970's, and the adoption of the Fire Safety Evaluation Systems by the Department of Health and Human Services (HHS) in their health care facility financing requirements in the 1980's[9,10,11]. Although each of these efforts achieved some success, a major stumbling block for all of them has been the lack of a sound technical basis for the needed quantitative performance criteria and measurement methods.

There are many other reasons for resistance to such changes, with human nature perhaps heading the list. Also, AHJ's, as noted before, play a pivotal decision-making role in our system. Few of them have the time or inclination to gain the technical background necessary to become comfortable with the use of these tools. Many industries, for example those happily selling to current markets using traditional methods and standards, oppose changes which they fear may erode their market share or profits. Others fear the potential liability exposure of shifting to new methods until they have been well proven, by others. Most consumers of products and owners of buildings care only to get the most building for their money and in the shortest time possible and are unwilling to pay more time or money for "experimental" projects. Until recently, there has not been a broad enough basis of support for such change and only a few could afford to invest in the long term for improvements the benefits of which they themselves could not capture.

That situation is now changing. The Centers for Building Technology and Fire Research, now the Building and Fire Research Laboratory, at NIST, have the mission to develop such tools and have been working towards this objective since the 1970's but have such modest resources that progress has been slow. However, now NIST has made considerable progress in the development and demonstration of scientifically-based fire safety performance criteria and measurement tools. Well known examples of scientifically-based measurement methods are the cone calorimeter (ASTM E-1354 and ISO DIS 5660) and the LIFT method (ASTM E-1321) for heat release, ignition, smoke and flame spread data. Also, a smoke toxicity protocol has finally been developed that is likely to gain consensus approval nationally[12]. Decades of effort to develop fire and smoke movement models have opened the door for a series of highly sophisticated fire hazard and risk prediction methods and systems such as the HAZARD, FPETOOL, and FRAMEWORKS the National Fire Protection Research Foundation (NFPRF) risk method[13,14,15].

These tools are now gaining acceptance and use. For example, in 1982, the first fire protection engineering firm dedicated to the use of such tools opened its doors in the USA. That was Benjamin/Clarke Associates formed by two former NIST scientists. Now, all of the major fire protection engineering firms in the nation use these tools; some routinely, others still only infrequently. The Underwriters Laboratories has a staff scientist devoted to fire modeling and its application to their work. At least one of the model code organizations, ICBO, has trained its staff in the use of these models for use internally and in the National Evaluation Service. Fire models are now widely used in the USA in fire safety litigation, product development, and to a much lesser extent in code approvals. Some technical committees of NFPA now rely on such analyses in their decision-making. But, the process is far from complete and the supply of appropriately educated fire protection engineers still inadequate. Towards responding to this need, academic fire protection engineering curricula have been strengthened and expanded so that now the University of Maryland offers BSE and MSE degrees, Worcester Polytechnic Institute offers MSE and PhD, and University of California at Berkeley offers a PhD all in fire protection engineering. Also, some of these schools and others have expanded their in-service/continuing education offerings in fire science and the use of modern fire protection engineering tools.

Perhaps as importantly, are the forces driving us to improve the vitality of our domestic economy, and of international competitiveness and global standardization. These pressures are increasing interest in developments which offer industry and designers more options, that reduce costs on a life cycle basis, help stimulate innovation, and reduce the costs and time burdens of regulation. For example, in recent years, the National Bureau of Standards has become NIST, a change not only in name but also in mission. We have gone from being a basic measurement technology lab to one dedicated to serving U.S. industry by also helping industry improve quality and international competitiveness. Specific new programs include the Advanced Technology Program which over the next decade will provide hundreds of millions of dollars in financial support to industry for innovative research, and the growing number of Federally supported Manufacturing Technology Centers which function to help small and medium sized firms learn and adopt modern manufacturing and business practices[16]. Within the next few years, these new programs will become larger than the traditional lab based programs of the Institute. The implications of all this for fire safety are profound, especially for those who believe, as do we, that advances in fire safety engineering are enabling fire safety to be engineered reliably into products and buildings. This portends a revolution in fire safety practice with very significant economic impacts.

Finally, and to some extent stimulated by developments elsewhere in the world, attention to performance fire codes is increasing. In May of 1991, Worcester Polytechnic Institute (WPI) and the Society of Fire Protection Engineers (SFPE) co-sponsored a conference funded by the National Science Foundation on Fire Safety Design in the 21st Century[17,18]. The premise of this conference was that application of new fire safety engineering tools in the United States is lagging advances in fire research and the development of these tools. Prominent in the program of this conference was testimonial on the status of performance fire code development and use in Australia, U.K. and Sweden. This gave rise to a strong sentiment among many of the participants, "this should happen in the USA." Consequently, a major conclusion of this conference was the proposed national goal,

> "By the year 2000 the first generation of an entirely new concept in performance-based building codes be made available to engineers, architects, and authorities having jurisdiction . . . in a credible and useful form."

The conference suggested five strategies for achieving this goal:

1. establishment of university/industry/government center(s) of excellence to champion the new concepts;

2. an intensive short term effort to develop a "strawman" performance building code;

3. engineering tools to achieve the goal must be made readily available and functional;

4. the usefulness, assumptions and limitations of engineering tools must be established;

5. efforts should be strengthened to provide necessary educational programs.

WPI, SFPE, NIST and others are working together to find ways to support and implement these strategies. Already, some activity is underway on each of them.

THE WAY FORWARD

As we take on these challenges, it is important to consider concurrent threads of change in construction generally and in other aspects of fire safety since both of these will heavily influence how and in what form performance-based fire safety codes will evolve.

In construction, cost and efficiency are gaining increasing attention. These forces are building support for advances in computer-integration of design and construction which can greatly reduce losses and improve quality of product[19]. For example, architects and engineers in the U.S. increasingly are delivering designs in electronic form as well as on paper. Innovations in manufacturing practice such as "just in time" and concurrent engineering have great appeal in construction as well. Simulation of design and of design in use can reduce the amount of rework, waste, and redesign by an order of magnitude. However, much of the potential gains would be lost if traditional approaches to design approval, site inspection, and pre-occupancy certification do not likewise give way to reliance on similar new technologies and tools.

A parallel and related shift is towards increased interest in life cycle cost and performance of constructed facilities. Also, new technologies being introduced to respond to environmental concerns are resulting in changes in product performance that had not been anticipated. New metrics are needed for service life and reliability prediction of buildings in use as well as for life cycle costing.

Further, major changes are taking place in technology generally that will significantly influence the scope and content of performance-based fire safety codes in the near future. These include advances in computing and telecommunications, in sensor technology and materials, and in manufacturing/production quality and reliability control. These changes should make it possible to completely rethink assumptions underlying traditional rating and ranking methods, and inspection and plan-checking approaches that form the basis for much of current code technology.

Likewise, performance-based codes must be sufficiently basic and broad to anticipate or accommodate advances in fire safety technologies themselves. Fire safety is rarely viewed as an absolute or in a vacuum. Rather, fire safety of necessity involves trade-offs in safety, cost and function, and this includes tradeoffs among alternative strategies for fire safety. For example, in the U.S. there are interests pursuing each of the following avenues of change:

- Legislate or regulate fire safety.
- Make products, materials, etc., that are so safe that fire is no longer an issue. This thrust by some material developers is driven by concerns over liability exposure of traditional materials and the prospects of new global markets for such products.
- Develop "panacea" fire protection technologies. At present, some sprinkler advocates sound like this. Also, the search for Halon alternatives is leading to the prospect of entirely new suppressants and extinguishment technologies.
- Educate people so that they do not do the foolish things that result in fires.
- Provide the resources to fight whatever fires occur.
- Conduct research needed to make engineering fire safety into constructed facilities practicable.

Each has some merit. Advocates of each of these tend to push their cause to the exclusion of others. For example, some argue, why develop materials that do not burn if sprinklers are required, etc. Obviously, no one of these thrusts by itself will fully succeed nor be sufficient. Rather, some combination of all of them is essential. The critical trick for performance fire code methodology is to provide means to answer such sticky questions to everyone's satisfaction. This is a hard trick for anyone. In the U.S., it has been estimated that fire safety is a $128 billion "industry." This figure includes estimates of the costs of built-in fire protection in buildings, the fire services, and direct and indirect fire losses[20]. This estimate does not include any estimate of the costs of the building and fire safety regulatory system in the U.S. nor what Federal agencies spend on fire safety. With that much at stake, unfortunately, there are more people interested in keeping things as they have been than there are who want change. Indeed, our inability to pinpoint the costs of fire safety regulation make it difficult to address the potential added value of performance based fire codes, or assess the benefits of applying modern quality manufacturing concepts to building life cycle performance.

At NIST, our strength is in the last of the strategies listed above, basic and applied fire research. However, we work with others in the fire safety community on all of them. We have devoted a major share of our resources over the last two decades to development of fire science and predictive models of fire hazard and risk, measurement methods and new understanding for the development of fire safe materials, and developing the technical basis for next generation fire sensing and suppression technologies. In the next decade, we expect to continue these efforts. Also, we will invest more in the validation, demonstration and user acceptance of fire safety engineering tools and encouraging open systems design of the technologies. Consistent with developments in computer-integration of construction, we anticipate development of expert system-based user friendly interactive computer systems for fire safety evaluations, approvals, and inspections. This should provide the strongest possible footing for performance fire codes.

Critical to the successful deployment of these new technologies is demand pull from the user industries be they product manufacturers, architectural engineering firms, building owners, or whomever. Likewise, fire and building officials must become confident that these tools meet their needs and concerns. Also, critical to our success is provision of needed changes in the infrastructure on which these groups depend. Topping the list of needs here are education and training, databases, trial applications, assistance in achieving acceptance of the new methods, and transition to widespread use of international standards in fire safety[21].

SUMMARY

The USA has long advocated performance based codes and standards and to the extent of our technological capability such are in use and/or being developed.

A centrally mandated performance fire code is highly unlikely in the USA. Rather, we foresee an evolving consensus on use of performance-based fire safety engineering methods that will emerge to supplement then replace traditional prescriptive codes. This will occur when we have demonstrated that these new tools and methods outperform traditional methods.

A number of essential needs must be met before performance based fire codes are a reality in the U.S. Some of these needs are technical, some educational, and some political.

High on the list of technical needs is a metric in terms of which the costs and value to society of building regulatory machinery can be assessed and the value-added of performance-based measures, codes and standards weighted.

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