ASTM's Role in Performance-Based Fire Codes and Standards

John R. Hall, Jr.
editor

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Foreword

This publication, *ASTM's Role in Performance-Based Fire Codes and Standards,* contains papers presented at the symposium of the same name held in Nashville, Tennessee, on 8 December 1998. The symposium was sponsored by ASTM Committee E5 on Fire Standards. The symposium chairman was John R. Hall, Jr., National Fire Protection Association.

Overview

The objective of this symposium was to discuss possible roles that ASTM might play in the move toward greater use of performance-based fire codes and standards in the United States and Canada.

This move is a global phenomenon that has been gathering speed and strength for at least a decade. Performance-based fire codes are now established in use from the United Kingdom to Australia and New Zealand, and from Japan to the Nordic countries of Europe. ASTM is a supplier of standards to the world so even if this movement had not reached North America, and it most certainly has, ASTM would have a strong interest in identifying and responding to the challenge and the opportunity presented by performance-based codes and standards.

Performance-Based Codes and Standards

Performance-based codes and standards are documents that state goals and objectives, together with rules and procedures, usually involving testing and modeling, for determining when performance is achieved. Such documents allow designers greater flexibility, which can be used to achieve cost savings, greater safety, or greater quality. Performance-based codes and standards can be written on anything from products, materials and assemblies, to equipment, to whole buildings and complexes, to procedures and programs.

When poorly executed, performance-based codes and standards permit designers too much flexibility, leading to reduced safety, or require bewildering and unmanageable standards of proof, or inadvertently compromise the delicate balance between science and values or between the legitimate interests of different parts of the community. It is not enough to be interested in performance-based codes and standards and intrigued by their potential. They must be approached with care and knowledge.

Do we have enough knowledge? What is a prudent path forward that still offers us the prospect of success in a timely fashion? These were among the sweeping questions addressed in the symposium, but always with a focus on the role ASTM E5 has played and the roles it could (and should) play in the future.

The intent was to give a diverse audience an awareness of relevant concepts and activities, inside and outside ASTM, in order to provide a sound and comprehensive basis for planning by ASTM E5, possibly by Subcommittee E5.91, which has responsibility for planning; possibly by Subcommittee E5.33, whose scope is most nearly aligned with that of performance-based codes and standards; possibly by Subcommittee E5.90, the executive subcommittee; and possibly by all these and others as well.

The symposium featured 12 papers, organized in three groups of four papers each.

Session I—General Concepts and Principles

The first four papers addressed general concepts and principles.

As the symposium chairman and organizer, I spoke first, offering a set of options for ASTM's role and ideas for planning, with associated pros and cons. ASTM E5 was one of the first organizations to offer standards relevant to performance-based activity, but in many ways, the initiative has moved past ASTM E5 in the last few years. This may have occurred because the stage of development of performance-based fire codes and standards now emphasizes elements for which other organizations

are more appropriate, or it may have occurred because ASTM E5 is not sure where to go next, having completed the tasks its members defined for themselves when they first entered this arena. The first possibility is acceptable and appropriate, while the second possibility is worrisome and could be threatening to the long-term health of ASTM E5. Determining which is true and what course to follow is the essence of planning.

The second paper was by Vincent Brannigan and Steven Spivak of the University of Maryland, who discussed quality standards for the participants in performance-based regulation. Professors Brannigan and Spivak have degrees in both fire protection engineering and law, which give them a unique perspective on the interaction of these two decision-making systems, both of which have relevance to performance-based codes and standards. One of the recurring concerns in developing performance-based codes and standards is how to assure that the individuals designing to these documents are up to the job. This paper proposed concepts and approaches to this issue, while underscoring that this is not an internal matter for the engineering field.

Ronald Alpert of Factory Mutual Research Corporation, the current chair of Subcommittee E5.33 on Fire Safety Engineering, provided the third paper, which reviewed the history, activities, and plans of this subcommittee. Subcommittee E5.33 and its two predecessors, Subcommittee E5.35 on Fire Risk and Hazard Assessment and Subcommittee E5.39 on Fire Modeling, have been the home for most of ASTM E5's work related to performance-based codes and standards to this point. Subcommittee E5.33 now faces a number of choices. They can maintain their guides. They can take an active role in educating constituents in the use of those guides. They can play a part in applying the guides to the development of fire risk and hazard assessments for particular products or to the review of particular fire models. Or they can defer to relative newcomers like the Society of Fire Protection Engineers, or seek to partner with them.

Completing the session on general concepts and principles was Marcelo Hirschler of GBH International, who provided a highly personal (at the organizer's request) review—but with very general implications—of his efforts to write ASTM E5 fire hazard assessment standards and guides. Probably no one has spent more time and effort attempting to define, in detail, what a performance-based, fire-hazard-analysis-based product standard would look like in the ASTM E5 system. Dr. Hirschler's review of these efforts and of the thinking behind them is an invaluable starting point for anyone else seeking the same objective, no matter how much they may differ on the particulars.

Session II—Specific Methods and Tools

From general concepts and principles, the symposium next moved to four papers on specific methods and tools.

The first of these papers was given by Daniel Gemeny of Rolf Jensen & Associates, who spoke on the preparation of fire test data for use in specifying design fires. This essential step links traditional fire testing and the many associated standards with which ASTM has made its reputation and its contribution over the years with the often-different needs of models and calculation methods for input data on product performance in a wide variety of fire environments. Having conducted a number of performance-based design projects for a company that is among the world's leaders in this area, Mr. Gemeny was able to provide substantial insight into the steps required for this interface and the issues that arise along the way.

The second of these papers is also the only paper not included in this proceedings. Gordon Hartzell of Hartzell Consulting spoke on recent proposals for new approaches to smoke toxicity assessment, currently under consideration in both ASTM E5 and the International Standardization Organization

(ISO), as an example of a new type of ASTM E5 standard, illustrating the incorporation of fire hazard analysis concepts. Because Dr. Hartzell's work in this area is of far-ranging interest, he presented the same paper to the First International Symposium on Human Behavior in Fire, held in Ulster, Northern Ireland, earlier in 1998. ASTM's policies rightly preclude publication of a paper already published, and Dr. Hartzell's paper is available in the proceedings of that conference. Readers of this volume are encouraged to seek this paper out, because it is a rare and important example of the evolution of fire test methods to support more comprehensive fire hazard assessments rather than to produce evaluative data by themselves.

The third of the specific method and tool papers was by Brian Lattimer of Hughes Associates. A project of his required the adaptation of fire test data from the cone calorimeter (ASTM E 1354) for use in a performance-based fire protection analysis. As with the other two papers, the conversion process tends to be anything but straightforward or simple, but it is essential if the calculations supporting performance-based design are to be based on valid data appropriate to the structures and assumptions of the models.

Completing the session on specific methods and tools was Marc Janssens of Southwest Research Institute, who spoke on computer fire model selection and data sources. Dr. Janssens' paper drew on both his own work and the work of ASTM E5.39, for which Dr. Janssens was the last chairman. The four modeling-related guides produced by ASTM E5.39 include some of the first guidance in print on the selection of data for computer fire models.

Session III—Alliances and Activities of Other Groups

The last session of the symposium broadened out from methods and tools to kindred organizations and their activities, with emphasis on opportunities for alliances and partnerships that would advance the cause of performance-based codes and standards and the interests of ASTM.

The first two of these papers addressed initiatives of the Society of Fire Protection Engineers. Morgan J. Hurley of the Society of Fire Protection Engineers spoke on SFPE's task groups to evaluate specific types of fire models, and Eric Rosenbaum of Hughes Associates spoke on SFPE's project to develop a design guide for performance-based design, the latter due to be published late in 1999. Both authors noted the value of ASTM's guides related to fire modeling as starting points for the SFPE exercises.

The last two papers addressed performance-based code initiatives of the National Fire Protection Association and the International Code Council. John Watts of the Fire Safety Institute described NFPA's proposal for a performance-based option within the Life Safety Code, and Beth Tubbs of the International Conference of Building Officials described ICC's proposal for a performance-based version of their building and fire codes. By focusing on codes, as distinct from the standards ASTM publishes, the two authors offered two initiatives that could create demand for supporting standards from ASTM.

Closing Thoughts Amidst the Opening Remarks

After you have read these papers, you may be frustrated that you cannot immediately do a specific job better or identify a new skill you have acquired. The benefit and relevance of these papers is in another form.

If you are an active volunteer within ASTM E5, you should learn a great deal about new ways in which the standards you write will be used. You may even have some new thoughts on whether you are working on the most important issues in the most appropriate way.

If your interest is more in performance-based design, codes, or standards, and only secondarily in ASTM's role, you may discover a resource in ASTM that you had not previously recognized.

You may wish to explore the ability of ASTM E5 standards, existing and prospective, to support your interests.

No matter how you came to this volume, these papers should give you a better sense of context and of possibility, and a lot to think about. But a passive reaction to this material is not what we are looking for.

This volume is meant to motivate even more than educate. It is meant to galvanize even more than inform. We are in the midst of a defining moment for the ways in which we make decisions about the fire safety of everything. If you have any thoughts or any preferences for how this ought to proceed, you owe it to yourself and to your colleagues and progeny to become a part of the debate and contribute a part of the solution.

Whenever you find this volume, it is likely that every author represented here is still working on the subject and would like to hear from you. It is certain that ASTM, especially Committee E5, is still working on this subject and would like to hear from you. So get involved and get in touch.

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Symposium Chairman and Editor

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General Concepts and Principles

John R. Hall, Jr.[1]

Options for ASTM's Role — Ideas for Planning

Reference: Hall, J. R., Jr., **"Options for ASTM's Role — Ideas for Planning,"** *ASTM's Role in Performance-Based Fire Codes and Standards, ASTM STP 1377,* J. R. Hall, Jr., Ed., American Society for Testing and Materials, West Conshohocken, PA, 1999.

Abstract: Performance-based codes and standards are a growing reality around the world. With state-of-the-art guides for fire modeling and guides to the writing of fire hazard assessment standards and fire risk assessment standards, ASTM E-5 has played an essential role and has been one of the earliest major players in this activity. But now the landscape has changed. Groups from SFPE to NFPA to ICC, from ISO to IEC to CIB, and others are all active, and each brings a special focus and a special skill to the activity. ASTM E-5 needs to decide what its special role can and should be. This paper will discuss some of the options, based on the traditional scope and areas of traditional strength and emphasis for ASTM.

Keywords: fire risk, fire hazard, fire performance, fire test method, performance-based fire standard, fire scenario, index.

Five years ago, ASTM's E-5 Committee on Fire Standards was arguably the most advanced and the most visible source of materials related to performance-based fire safety design in the U.S.A.

The ASTM Guide for Development of Fire-Hazard-Assessment Standards (E 1546) provided a complete guide to the steps required to write a fire-performance-based product standard using fire hazard analysis as the measure of performance, and a companion guide, the ASTM Guide for Development of Fire-Risk-Assessment Standards (E 1776), based on fire risk analysis was fast nearing final approval. ASTM's Subcommittee E-5.39 had constructed a comprehensive set of complementary guides for fire model users who wished to make sure their model usage met the most demanding criteria for proper and appropriate model usage. These guides addressed validation and verification, uses and limitations, data, and documentation.

That was then, but what about now? At the end of 1998, ASTM's position is virtually unchanged from five years ago. But several other U.S. organizations that

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arguably had little of substance to offer back then have since moved strongly and effectively to put their stamp on the subject of performance-based fire codes and standards.

Both the National Fire Protection Association (NFPA) and the International Code Commission (ICC) have produced major proposals for performance-based fire codes that are likely to be available by the year 2000. Canada's National Research Council is producing a Canadian counterpart, covering everything from objectives and criteria to what is arguably the world's most comprehensive risk-based fire performance analysis modeling package. The Society of Fire Protection Engineers (SFPE), having already produced two editions of a detailed handbook on engineering methods and tools, has recently sponsored an introductory book on performance-based concepts and will soon produce a design guide for use in performance-based design. [1,2] SFPE has even taken the old ASTM E5.39 guides and begun applying them to the evaluation of particular fire-related models.

All of these organizations have made use of ASTM E-5's materials and have publicly acknowledged the value of these materials. But with every passing year, the approaches used by these organizations are increasingly their own, reflecting the ideas and concepts they added to the ASTM E-5 materials more than they reflect those source materials themselves.

What Next for ASTM E-5?

And what about ASTM E-5? That pioneering body remains committed, in writing in its strategic plan, to the pursuit of fire hazard assessment and fire risk assessment as next-generation approaches to the fire standards that have been a source of value and visibility for ASTM for so many decades. The active membership of ASTM E-5 includes nearly all of the same people who produced those original materials. And yet, there seems to be little consensus on what should come next.

I believe ASTM E-5 is at a crossroads in its history, a defining moment that will dictate what role it will play and what contribution it will make to the shape of performance-based codes and standards that will, I also believe, define fire safety design in the U.S. for the next millennium. There are a number of individuals in ASTM E-5 who have ideas to propose on what that role should be. Many of them are on today's program, and others are in today's audience. So are representatives of the groundbreaking work being done by kindred organizations like NFPA, ICC, and SFPE.

If this symposium is successful, it will initiate a substantive dialogue on alternative philosophies and principles by which ASTM E-5 can define its role. Those on today's program who are active in the performance-based fire code and standard activities of kindred organizations may have additional ideas on roles ASTM could play. They will at least provide a clear picture of how the future will be defined if ASTM is not involved, because it will be these other organizations that then will invent the future for America.

I can imagine a number of different roles ASTM could play and — given ASTM's historic strengths and proven capabilities — could play well and effectively. I will try to

describe the principal alternatives I see in this paper. Some alternatives I find exciting, while others seem more risky and require more luck for success.

I can even imagine ASTM E-5 making a prudent decision to play no larger or continuing role, based on an explicit and widely shared calculation that ASTM's interests do not require its active involvement and that the needs of performance-based fire codes and standards in the U.S. are being met by other organizations better equipped than ASTM to address each aspect. I would be surprised by such a judgment, but I could imagine a spirited and well-thought-out planning discussion ending in such a determination.

The only outcome I could not respect — and that no one in this room should respect — would be a sideline role for ASTM E-5 resulting solely from ASTM's inability or unwillingness to decide what role to pursue. Irrelevance based on indecision or the inertia of the status quo is not a reasoned or respectable choice. And yet, one could look at the landscape at ASTM E-5 today and listen to the discussions surrounding this topic, and one could well conclude that this one unacceptable outcome is today the most likely outcome of all.

That is why I regard this as a defining moment for ASTM E-5. Performance-based fire codes and standards are on the move worldwide, and the pace in the U.S. is accelerating at an often dizzying speed. Having played a critical role in starting the car forward, ASTM E-5 has yielded the driver's seat to other groups — largely without an explicit choice — and is in danger of losing all influence and communication with those groups entirely. If ASTM E-5 does not care where the car it started ends up — or when and whether it reaches its goal — then this shift is of no importance. But if this is not the case, then now, today, is the time to begin redefining and reasserting ASTM E-5's ideas about this future we will all share.

Having, I hope, made the case that the stakes for today's symposium are very high, I would now like to change to the topic stated in the title of my paper, namely defining some of the alternative roles ASTM E-5 might play.

What Are Performance-Based Fire Codes and Standards?

Performance-based fire codes and standards are the means by which a society controls design decisions so as to achieve acceptable safety while also providing greater flexibility on how that safety is achieved.

It is no secret that fire safety — or safety in general — is not the principal consideration in the design and inventive redesign of products. Instead, products are designed for certain functional, aesthetic, or affordability objectives, with safety regarded as a constraint.

With more explicit statements of how much safety in what form the public demands, combined with agreed procedures for measuring and assessing how much safety a product delivers, a designer or manufacturer is in a better position to innovate. Perhaps as important, barriers to international trade may be lowered as manufacturers are able to provide the levels and types of safety demanded by other countries — and prove that

performance in the form demanded by those countries — without being needlessly constrained by local accidents of history regarding how exactly safety is designed into products.

What Does Performance-Based Evaluation Mean for the Kinds of Standards Traditionally Written by ASTM E-5?

How does this intent translate into changes in the form of the kinds of product standards traditionally written by ASTM E-5? Can't we simply say that the results of product tests are measures of product fire performance and let it go at that?

"Performance-based" means rules based on an explicit set of goals and objectives, combined with a defined method of measuring whether the goals and objectives have been met. You can have performance-based evaluation of a product, material, or assembly; a structure, vehicle, or space; a process, program, or activity; an individual or group; or any other subject for which goals and objectives are meaningful. Performance-based fire codes and standards are those for which the goals and objectives relate to fire risk, fire loss, or some other measure of fire safety. If you cannot draw an explicit connection between the measurement of the product's behavior relative to fire and a set of specific goals and objectives that describe a desired level of fire safety, then you do not have performance-based evaluation of that product. You may have measurement relevant to performance, but you do not have performance-based evaluation.

But safety and risk are not inherent characteristics of products. Rather, safety and risk are experienced by people who use products in environments. The characteristics of those people and those environments must be understood and quantified before it is possible to characterize the safety and risk consequences of using particular products.

Mattresses pose little risk of fire loss in normal use. But mattresses in hotels are used by people with significant risk of drinking and smoking, leading to unintentional cigarette exposure. Mattresses in homes have the added risk of exposure to unsupervised children playing with matches or lighters. And mattresses in correctional facilities are used by populations in which vandalism of the product is not just possible but likely. It is unfair, in a philosophical sense, to blame the poor mattress for the fires that result when unsafe behavior or misuse occurs in its vicinity, but as a practical matter, the safety and risk experience of real people with mattresses will be largely defined by the ability of the products to perform well in the face of misbehavior or misuse.

This means we cannot assess the fire performance of a product without making some judgments, not only about what level of performance is considered unacceptably dangerous but also about what level of insult — that is, what types and magnitudes of fire-starting events — must be considered and what other environmental factors may reduce or increase the risk consequences of a mattress fire.

If most homes have smoke alarms, then perhaps we can tolerate more severity in mattress fires, given an increased ability of occupants to react quickly and escape. If most correctional facilities restrict occupant movement — as they do by definition —

then we cannot permit mattress fire severity on the basis of some assumed occupant ability to escape, because no such ability exists.

If you look at ASTM Standards E 1546 and E 1776, on fire hazard and fire risk assessment, you will see that they contain a number of steps to follow to define these occupant characteristics, fire scenarios, and environmental factors. Because they are so important to the resulting risk and safety, these factors must be defined by the affected public, through codes, and not solely by designers and manufacturers. But the net result is that ASTM's two guides to product fire performance standards require the user to describe the whole building on the way to assessing the product.

That is a lot of work to do in order to evaluate some products. In my discussions with ASTM E-5 members, I know that many believe such a process is needlessly and unacceptably cumbersome. But this is a defining issue. If you establish the whole-building context, then you can legitimately claim to be evaluating products on the basis of the real effect their performance will have on the fire experience of real people. If you attempt to evaluate the products only on the basis of small-scale tests and associated criteria, you simply cannot know how those artificial laboratory measures of product fire performance will translate into real fire experience for real people. Test results are measures *related* to product fire performance, but they are not measures *of* product fire performance.

But if you accept this argument and evaluate products only in the context of their application and environment, then the structure of the analysis inevitably makes it awkward to treat the product as the subject of the analysis. You are not really evaluating the product but rather the building and its occupants including the product. It is the design of the building that is more naturally the focus of the assessment. Does that mean that performance-based evaluation does not make sense at the product level?

ASTM is traditionally a powerhouse source of product standards, but it leaves the specification of codes for whole buildings to other organizations. Committee E-5 is traditionally a step further back within ASTM, defining the measurement tools by which a product may be evaluated but leaving it to others to define the acceptable level of performance.

The focus on products rather than buildings is a major factor complicating ASTM's ability to play a lead role in performance-based fire codes and standards. It is at least hard and possibly impossible to do performance-based evaluation validly and still maintain a focus on products rather than buildings.

The focus on measurement tools rather than complete assessment requirements is a further complication for Committee E-5 within ASTM. It is no small leap for a group that understands fire tests to expand its interests and transform its way of doing business to embrace calculation and the other elements required by more comprehensive evaluation methods.

Option 1: Provide Standard Test Methods That Yield Data Suitable for Performance-Based Evaluation

One possible role for ASTM E-5 is to continue to concentrate on test methods as measurement tools. The existing test methods were designed to be used for direct control of products. They require only an acceptability threshold for this purpose. Therefore, Option 1 may require some work, i.e. developing new standard fire tests that provide quantitative measurements of product fire performance in a form compatible with and valid for use in more comprehensive product and building risk and hazard assessments that would be defined by others. Such a role would make maximum use of ASTM's proven strengths in its universally recognized area of greatest relative expertise.

However, such a role would also be severely constraining. The authors of the larger product and building assessment frameworks would be in the position to dictate their needs for tests in ever greater detail. The small handful of ASTM E-5 customers who will emerge as primary sources and overseers of fire safety engineering methods, including fire hazard and risk assessment packages, would assume disproportionate importance in deciding whether ASTM E-5 standards are used. Their needs might be so detailed and so unavoidable that ASTM E-5 would lose much of its current independence and prominence, becoming instead a specialized consulting group to code writing organizations and engineering societies.

Another problem with this option involves technical expertise. Valid fire safety engineering calculations require scenario-specific data, and it is increasingly recognized that such data may not emerge from a small-scale test with no calculation applied to its output. Full-scale tests are very expensive, but scaling effects are increasingly recognized as important. Most fire loss in the U.S. occurs in severe fires, such as post-flashover fires, that cannot be reproduced in less than full-scale tests and are difficult to measure in reproducible fashion even in full-scale tests. Add to this the recognition that different fire scenarios pose different kinds of challenges to products and different kinds of threats to occupants, so it is increasingly indefensible to select a single scenario as a basis for test specification or assessment. That means multiple tests — even multiple test methods — or another reason to use calculation.

The bottom line is that writing the tests for a new world of performance-based fire safety design would be a natural role for ASTM E-5, but it still might require us to reinvent the way we think of fire tests. If taken seriously, Option 1 is not a recommitment to the status quo; it involves significant change and expertise going beyond traditional areas of strength for ASTM E-5.

Option 2: Provide All the Standard Methods Required for Performance-Based Evaluation

A second role for ASTM E-5 would be to provide guidance on all the tools employed in designing to performance-based fire codes and standards, not just test methods.

For fire tests, ASTM E-5 would define exactly how they should be done. For other tools, like fire models or product fire performance assessment frameworks, ASTM E-5 could provide standards or could limit its role to guides, which would identify questions