

**THE BENEFITS OF INNOVATIVE, LESS FLAMMABLE PRODUCTS
IN AN ERA OF PERFORMANCE-BASED
BUILDING AND FIRE CODES**

by

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The Benefits of Innovative, Less Flammable Products in an Era of Performance-Based Building and Fire Codes

ABSTRACT

Within the next decade, there will be great opportunities for the marketing of products whose fire performance exceeds current prescriptive standards. Constructed facilities will be allowed to meet broad safety objectives **by** a diverse array of approaches. Within this new paradigm, it will become feasible to utilize novel products whose functions transcend traditional categories if their contribution to **fire** hazard can be incorporated within determinations of overall fire safety design. Thus there will **be** a premium on **NIST** research into and **FRCA** members' development of advanced techniques for providing building products of low flammability and high functionality

BACKGROUND

Compliance with regulations in prescriptive building and fire codes drives most fire safety decisions, both in the United States and globally. While there are a few examples of regulations that cover products exclusive of where they are used (e.g., "pill test" requirements for carpet and cigarette ignition test requirements for mattresses) most apply only to materials and products found in critical locations or occupancies. Examples are critical **flux** or flame spread limits on finish materials found in exit access corridors and Cal TB133 limits on HRR of most furniture found in high **risk** occupancies. In Europe some materials (e.g., polyurethane foam in furniture) and even entire chemical families (e.g., the French ban on halogen compounds) constrain the marketing of products regardless of the quantity, application, or **any** compensating features of the building design.

While these approaches have led to a reasonable level of fire safety in regulated buildings they are often blamed for being arbitrary, increasing costs, **and** limiting choices for designers and owners of buildings. Additionally these approaches can create problems in marketing and distribution of products in the global marketplace. For example if halogen-containing fire retardants are used to meet the fire performance requirements in one area those same products could not be marketed in areas that ban halogens. Additives used to meet fire performance levels also may limit the ability to meet recycling objectives that are increasingly being adopted.

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Another issue with the traditional approach of prescriptive regulation is that there is no incentive for designers or owners to utilize materials or products that exceed the minimum levels typically incorporated in regulation. Without such credit it is difficult to differentiate more costly, high performance products that may have the potential to reduce fire losses even further. A global example is high performance steel. High performance steel has higher strength and retains this strength to higher temperatures. But the ASTM E 119 and **IS0834** tests specify assembly failure on the basis of surface temperature on the structural steel using a value established for normal steel. Thus an assembly incorporating (more costly) high performance steel receives no additional credit in fire resistance time. Absent an effective marketing mechanism it is even difficult for manufacturers to justify the cost of development of improved products for regulation driven markets.

PERFORMANCE-BASED CODES

These issues are at least partially driving a global transition to performance-based codes (regulations). Rather than prescribing specific solutions, performance-based codes embody the set of desired outcomes that reflect society's expectations for the built environment. These required outcomes can be achieved in any way that can be demonstrated to the satisfaction of the regulatory officials. Such demonstration might take the form of engineering analysis using accepted methods and data, demonstrative testing, or experience with similar products or systems in similar applications (expert judgement).

Performance-based codes have been developed and placed in practice in several countries (U.K., Australia, New Zealand, Sweden) and are currently being developed in the **U.S.** and Canada (where they are called Objective-based codes). They typically follow a hierarchical structure of objectives, functional statements, and performance requirements that provide an increasing level of detail of what is meant by the next higher level. The final level of acceptable methods may be part of the regulation or advisory material depending on the regulatory philosophy of the regulatory system. **An** advantage of limiting the regulation to the top levels is that society's expectations evolve slowly while more rapidly advancing technology often determines the options available for meeting those objectives. Thus, keeping the lower levels as advisory result in less frequent legislative or administrative changes to the regulations. For continuity most performance-based regulatory systems recognize the provisions of the prescriptive code as acceptable (or deemed-to-satisfy) solutions to associated performance objectives.

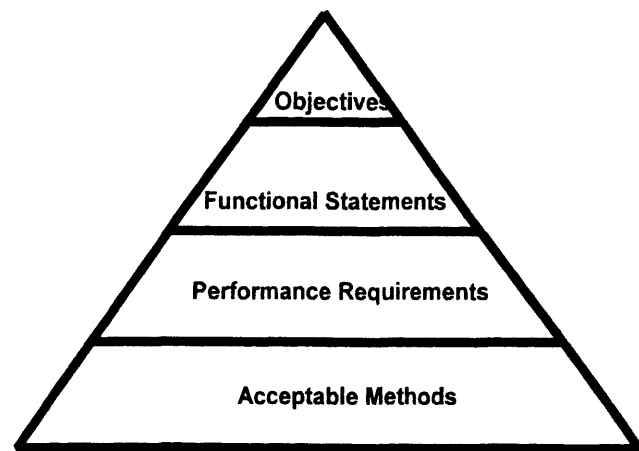


Figure 1 Hierarchical structure of Performance Codes

DEVELOPMENTS IN U.S. PERFORMANCE-BASED CODES

ICC Performance Code for Buildings and Facilities'

In 1994 the three U.S. Model Code organizations jointly formed the International Code Council to develop a coordinated family of codes including a prescriptive building code, the International Building Code (2000) and an unique performance (building and fire) code titled ICC performance Code for Buildings and Facilities. Released as a draft into the ICC code development process in August 2000, this code includes a number of unique features, including a **risk** management matrix that specifies multiple levels of performance for varying size (and frequency) events such as wind, seismic, and fire.

The table below summarizes the required performance of buildings to events of increasing level of impact. Performance groups replace the traditional building code concept of occupancies or use groups. In prescriptive codes there is an implicit assumption that buildings in the same occupancy class involve similar **risks** and require similar mitigation strategies. Thus, bringing an existing building up to current code is only required on a change in occupancy.

The performance code recognizes that changes to an existing building may result in a change in risk even within the same occupancy, and that changes on occupancy do not necessarily result in changes in **risk**. Performance groups attempt to classify building uses by **risk** to occupants, property, community interests and the environment. Performance Group I is exemplified by agricultural buildings that are only occasionally occupied and represent a low risk to human life in the event of failure. Performance Group II covers most buildings. Performance Group III includes most educational, small health care, assembly, detentional, and public utility as well as industrial facilities that contain hazardous materials capable of producing threats generally contained to the facility boundaries. Performance Group IV includes major facilities that need to continue in operation following an event, such as major hospitals, police and fire stations, buildings designated as shelters, and facilities where significant damage could lead to additional risk to life by explosion or release of toxic materials into the community.

Another unique concept shown in the table is the requirement that small and presumably more frequent events do not significantly effect the functionality of the building. Thus, a small fire (or earthquake or natural event) cannot damage the building infrastructure (e.g., power, communications, emergency systems) such that the building can continue in normal use immediately following the event. These requirements have major implications for the protection philosophy needed in most buildings.

**Table 1 MAXIMUM LEVEL OF DAMAGE TO BE TOLERATED BASED ON
PERFORMANCE GROUPS AND DESIGN EVENT MAGNITUDES**

		INCREASING LEVEL OF PERFORMANCE → → → → → → → → → → → → → → → → PERFORMANCE GROUPS				
		Performance Group I		Performance Group II		
		Performance Group I	Performance Group II	Performance Group III	Performance Group IV	
MAGNITUDE OF DESIGN EVENT	INCREASING MAGNITUDE OF EVENT	VERY LARGE (Very Rare)	SEVERE	SEVERE	HIGH	MODERATE
	LARGE (Rare)	SEVERE	HIGH	MODERATE	MILD	
	MEDIUM (Less Frequent)	HIGH	MODERATE	MILD	MILD	
	SMALL (Frequent)	MODERATE	MILD	MILD	MILD	

NFPA Life Safety Code (2000 edition)²

The current edition of **NFPA 101** also includes a performance-based design option that describes an optional method for assessing the fire performance of a building against performance objectives. This method includes the concept of “retained prescriptive requirements” that represent a minimum performance level for certain building features that are considered essential, such as the provision of two, independent means of egress. The method further provides for a series of eight generic design fire scenarios that represent the Occupancy Committees’ ideas of the most important challenges for which

any building should be able to perform. Additional design fire scenarios unique to the building and its use are also encouraged.

Additional guidance in the development of fire hazard analyses and performance-based design that is compatible with the Life Safety Code performance design option is found in the SFPE Engineering Guide to Performance-based Fire Protection³. Chapter 9 on Developing Trial Designs discusses material control as an one of the important strategies to consider in the prevention of ignition, control of fire development, and the spread, control, and management of smoke.

RELIABILITY ISSUES

In any engineering analysis in support of a performance design reliability must be explicitly considered. For example, if the reason that the limiting temperature of the steel is not reached is that an automatic sprinkler system is provided, the functional reliability of that sprinkler system is crucial to the success in achieving the regulatory objective. In the Performance-based design option contained in the 2000 edition of the Life Safety Code, the consequences of failure of detection or suppression systems must be evaluated for each of the design fire scenarios. While such failure can cause one or more of the design objectives to be missed, it cannot result in an outcome unacceptable to the regulatory authority, considering the probability of the failure.

This means that passive protection methods have an inherent advantage by their high reliability. In fact, by reliability issues alone it should be possible to justify most cost impacts of combustion modified fuels used in contents and finishes as long as there are no associated, negative impacts. It was previously shown that halving the burning rate outweighs a ten-fold increase in toxic potency, so as long as other issues such as ignitability, smoke yield, or environmental impact do not create problems, chemically retarded fuels should be an effective part of solutions to performance designs.

BENEFITS OF PERFORMANCE-BASED CODES TO PRODUCT MANUFACTURERS

The result is a regulatory system that is much more flexible and able to accommodate innovative products or solutions provided the means exist to demonstrate their performance. Under a performance-based regulatory system no specific products or solutions are mandated and none are prohibited. Further, products and solutions are evaluated in the context of their proposed use using performance metrics for the specific product and making use of any compensating factors that might be present.

This approach allows costs to be optimized while still achieving the required level of performance. This advantage has been the primary driver for performance-based codes in many countries. In Australia for example, the steel interests funded much of the early research as a means of eliminating the need for what they felt to be unnecessary, field

applied fireproofing on steel where the potential exposure could be shown to be incapable of producing temperatures above the limiting value. This resulted in making ordinary (unprotected) steel more cost effective against competing materials and provided a means to justify the additional cost of high performance steel where its higher performance eliminated the need for (and the cost of) additional protection.

But the experience with alternative methods and performance-based designs both in the U.S. and internationally is that it is not typically driven by a desire to save money but rather by the need to overcome constraints and provide the flexibility to create more functional buildings. Building owners are quite willing to spend considerably more money to obtain the building that they feel they need. An example is the Mall of America in Minnesota where the architectural and business plan called for shopping areas open to the central amusement park so that shoppers heard the happy noises and were inspired to spend more money. Prescriptive codes constrained the ability to do this with compartmentation requirements. A performance design involving materials controls and active protection allowed the open design.

RESPONSIBILITIES OF MATERIALS AND PRODUCT PRODUCERS

The regulatory framework and engineering methodologies to allow these performance approaches are currently being put in place in the U.S. and exist in a growing list of other countries. NIST has been working at home and internationally to assure that the performance-based regulations and engineering design methods are based on sound science and thus are globally consistent. This effort has been highly successful and performance building designs that would meet U.S. requirements would also be accepted in most countries with performance-based systems. This virtually eliminates non-tariff barriers to trade and should open markets to companies positioned to provide the necessary material or product performance data.

While it may be some time before the last vestiges of politically-motivated regulations (such as the EU's SBI test and the French ban on halogens) are eliminated, for most structural, finish, and contents materials HRR and species yields, ignitability characteristics, and surface flame spread represent the majority of the needed data. Cone calorimeter (ISO 5660), LIFT, and the ISO Room-Corner Test (ISO 9705) seem to be evolving as the basic set of test methods required. Those who cannot supply these data will be shut out of the performance-design markets.

CONCLUSIONS

The global transition to performance-based codes and building regulatory systems represents an opportunity to rationalize these methods and to place them on a scientific basis of performance against public expectations for the built environment. This further provides the ability to market materials and products globally, based on a consistent set of performance metrics that are universally accepted. To enjoy the benefits of these changes

it is only necessary for material and product manufacturers to understand the system and to assure that they **can** provide the requisite data on demand. Those not prepared will be left behind.

REFERENCES

1. ICC Performance Code for Buildings and Facilities (Final Draft) International Code Council, Alexandria, VA August 2000.
2. Life Safety Code, NFPA 101 **2000** edition, National Fire Protection Association, Quincy, **MA 02269**.
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