A UNIFIED FRAMEWORK THAT COVERS REGULATION OF PRESCRIPTIVE AND PERFORMANCE-BASED FIRE SAFETY DESIGN

Monideep Dey, Deytec, Inc. USA

General principles and outline

Summary

This paper presents the general principles and outline of a framework for fire safety regulation that covers both prescriptive and performance-based fire safety. The immediate benefit of this framework is to allow development of a systematic top-down or global approach to fire safety, as opposed to piecemeal, that can be used to develop schemes for use with existing ISO conformity assessment standards. The framework can also eventually be used to make improvements to fire codes to unify prescriptive and performance-based requirements.

Background

Presently, most countries have a prescriptive framework for the requirements for fire safety. Countries that have developed a Performance-Based Code (PBC) for fire safety, e.g. New Zealand, still had to maintain many prescriptive requirements that cannot be replaced using performance-based approaches.

Several countries now allow the use of performance-based fire safety design within the framework of its prescriptive fire safety requirements, but in many cases demonstrating the equivalence of the performance-based design with the prescriptive requirements is difficult. A framework and methodology for a unified approach to fire safety requirements, that will allow the use of both sets of requirements in a fire safety program, including an exchange of one set with the other, does not exist at the present. This paper presents the general principles and outline of such a framework.

ISO CASCO has published a wide variety of conformity assessment standards that can be used and beneficial for conformity assessment of fire safety designs based on FSE. These include standards for product and person certification. Currently, ISO/IEC 17025, 17020, and 17065 are already used for the fire certification of building product assemblies (see Intertek webinar). The same product certification standards can be used for certifying a fire safety design based on FSE, a product, with a scheme developed based on the framework presented here.

General principles and outline

This section presents the structure of the framework to accomplish the objectives as set forth above.

Fire phenomena is grouped according to the phenomenology of fire growth and transport in the following functional groups identified in the initial technical reports[1] on fire safety engineering published by ISO that outlined the *global approach* to fire safety:

- **Initiation and development of fire and fire effluent**
- **Movement of fire effluent**
- **Structural response and fire spread beyond enclosure of origin**
- **Detection activation and suppression**

[1] ISO/TR 13387 series of documents in 8 parts (presently withdrawn by ISO).

Other concepts proposed in the past[2] that promote a global and risk approach, as opposed to piecemeal, is also used in the framework.

Performance-based design and prescriptive requirements both address safety objectives and functional requirements for the above phenomena. Performance-based design and standards explicitly address these phenomena and functional groups, whereas prescriptive requirements in national building codes address the phenomena implicitly through prescriptive test standards. The implicit consideration is done through expert engineering judgement in the standard development process. Attachment A is an example of the prescriptive requirements in a national building code, the USA. The attachment discusses how such a prescriptive set of requirements can be grouped along the above functional groups.

This framework allows existing prescriptive requirements in a national building code to be grouped in a systematic, top-down, and global manner. The use of performance-based designs, including specifics of the methods and criteria needed to demonstrate the equivalency between the prescriptive and performance-based designs, is established in a scheme to be used with an ISO conformity assessment standard such as ISO/IEC 17025.

Conclusion and Benefits

This framework provides a methodic means to allow modern fire safety design methods to be used within prescriptive fire safety codes. Builders and owners of the built environment will see benefits from the assurance that their innovative fire programs will be approved by the authorities in a cost-effective manner.

[2] GSA "Systems Concept," Decision Tree, Use of Risk Analysis for the Integrated Design of Fire Safety – See SFPE webinar, July 25, 2016, Carl F Baldassara, Wiss, Janney, Elstner Associates Inc.

Attachment A

Review of the regulatory framework of fire safety requirements in the USA

Introduction

Fire safety requirements for the built environment in the USA are established mainly in the International Building Code (IBC), developed by the International Code Council (ICC). The IBC serves as a model building code that state and regional building authorities codify, as is or in modified form, in the building codes. The International Existing Building Code (IEBC) and the International Residential Code (IRC) also specify fire safety requirements for specific applications. The International Fire Code (IFC) and the International Mechanical Code (IMC) also specify requirements for fire safety, many of which duplicate the requirements in the IBC.

Discussion

The requirements in the IBC, IFC, and IMC are all prescriptive in nature. The ICC has also developed a performance code (ICCPC). The ICCPC requires the establishment of safety objectives, functional requirements, and performance criteria for each category of prescriptive requirements in the IBC. However, the connection from the ICCPC to the prescriptive requirements is by Chapters in the IBC, and not through an approach based on the phenomenology of fires as described in the main text and used in a performance-based approach. This has limited the practicality of the ICCPC and its use in the USA.

The prescriptive requirements in the IBC can however be group in accordance to the phenomenology of fires as will be established in the proposed international standard.

The testing requirements for fire safety in the IBC[3] are mainly in the following Chapters:

Chapter 7: Fire and Smoke Protection Features

Chapter 8: Interior Finishes

Chapter 14: Exterior Walls

Chapter 15: Roofs Assemblies and Roof Top Structures

Chapter 26: Plastic

The fire tests required in the IBC may be grouped in the following functional categories[4]:

1. Fire resistance – to safeguard against the spread of fire and smoke within a building and the spread of fire to or from buildings - *Movement of fire effluent*
    a) ASTM E119/UL 263: walls, floors, ceilings, columns
    b) ASTM E814/UL 1479 – through penetrations

[3] All references are to the 2009 edition of the IBC.

[4] "Fire Performance Testing," SFPE Webinar, December 16, 2015, Michael Beaton, Intertek.

   c) UL 10B, 10C, 555 – opening protectives and dampers
2. Flame spread – propagation of flame over a surface - *Initiation and development of fire and fire effluent*
   a) ASTM E84/UL 723
   b) NFPA 286 - room corner test
   c) NFPA 285 - vertical flame spread
   d) ASTM E108/UL 790 – roofing
3. Radiant panel - *Initiation and development of fire and fire effluent*
   a) NFPA 268 – Ignition properties
   b) ASTM E970 – Ignition properties (attic floors)
4. Small-scale material properties - *Initiation and development of fire and fire effluent*
   a) ASTM E136 – non-combustibility
   b) NFPA 259 – potential heat
   c) ASTM E1354 – cone calorimeter

The above provides an example of how prescriptive testing standards can be grouped and included in the same framework used for performance-based designs. The proposed international standard, which will specify how these groups can be constructed, may be adopted in a revision of the national fire safety regulation.

Fire safety requirements in the USA building codes

The following provides some further details of the USA model building codes resulting from the review. It is included for information for the reader to provide an example of a national building code. The review also indicates the complexity of the organization of prescriptive requirements in a typical building code. This complexity makes it difficult to demonstrate equivalency between prescriptive and performance-based requirements, unless the prescriptive requirements are grouped in the same structure used in a performance-based approach.

The IBC addresses structural strength, means of egress, sanitation, adequate lighting and ventilation, accessibility, energy conservation and life safety in regards to new and existing buildings, facilities and systems.

Content of IBC - Chapters and Subjects

1-2 Administration and definitions

3 Use and occupancy classifications

4,31 Special requirements for specific occupancies or elements

5-6 Height and area limitations based on type of construction

7-9 Fire resistance and protection requirements

10 Requirements for evacuation

11 Specific requirements to allow use and access to a building for persons with disabilities

12-13, 27-30 Building systems, such as lighting, HVAC, plumbing fixtures, elevators

14-26 Structural components-performance and stability

32 Encroachment outside of property lines

33 Safeguards during construction

34 Existing building allowances

35 Referenced standards

Appendices A-K Appendices

Relationship between IBC and IFC

Content of IFC - Chapters and Subjects

The IFC addresses fire prevention, fire protection including for fire services and response, life safety, and safe storage and use of hazardous materials:

- Emergency planning and preparedness
- Fire service features
- Building services and systems
- Fire-resistant-rated construction
- Interior finish, decorative materials, and furnishings
- Fire protection systems
- Means of egress
- Handling of variety of hazardous materials

The IBC requirements for high hazard, fire-resistance-rated construction, interior finish, fire protection systems, means of egress, emergency and standby power, and temporary structures are directly correlated with the requirements of the IFC. The following chapters/sections of the IBC are correlated to the IFC.

IBC Chapter/Section	IFC Chapter/Section	Subject
Sections 307,414,415	Chapters 27-44	High-hazard requirements
Chapter 7	Chapter 7	Fire-resistance-rated construction
Chapter 8	Chapter 8	Interior finish, decorative materials
Chapter 9	Chapter 9	Fire protection systems
Chapter 10	Chapter 10	Means of egress
Chapter 27	Section 604	Standby and emergency power

Section 3103	Chapter 24	Temporary structures

Relationship between IBC and IMC

The IBC requirements for smoke control systems, and smoke and fire dampers are directly correlated to the requirements of the IMC. IBC Chapter 28 is a reference to the IMC and the IFGC for chimney, fireplaces and barbeques, and all aspects of mechanical systems.

The following chapters/sections of the IBC are correlated with the IMC.

IBCChapter/Section	IMC Chapter/Section	Subject
Section 716	Section 607	Smoke and fire dampers
Section 909	Section 513	Smoke control

Content of ICCPC

The ICCPC is intended to provide a performance-based framework to building design. It contains requirements to establish:

1. Objectives. The objectives define what is expected in terms of societal goals or what society "demands" from buildings and facilities. Objectives are topic-specific and deal with particular aspects of performance required in a building, such as safeguarding people during escape and rescue.
2. Functional Statements. The functional statement explains, in general terms, the function that a building must provide to meet the objective or what "supply" must be provided to meet the "demand." For example, a building must be constructed to allow people adequate time to reach a place of safety without exposure to untenable conditions.
3. Performance Requirement. Performance requirements are detailed statements that break down the functional statements into measurable terms. This is where the link is made to the acceptable methods.

The requirements to establish objectives, functional statements, and performance requirements are for each topic in a chapter and section of the IBC, and not in a hierarchical manner used in a typical performance-based approach.

Equivalent materials and Methods

The IBC does allow the use of equivalent materials and methods as follows, however, guidance on how equivalence can be established is presently absent in the fire safety industry.