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Fire safety engineering — General principles

Ingénierie de la sécurité incendie — Principes généraux

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 23932 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 4, *Fire safety engineering*.

Introduction

The vast majority of fire safety designs rely on prescriptive specifications written into regional, national or local regulations. Currently, various engineering approaches are also allowed by these regulations, although information needed for an engineering approach is still generally obtained from conventional test methods. Fire Safety Engineering (FSE) is a discipline increasingly being used throughout the world in support of performance-based design, i.e. the reliance on engineering methods to determine whether a given design meets stated performance objectives. An example of such a concept already in use in the current regulatory environment is the “equivalency concept”, where FSE supplements prescriptive design by being applied in a performance-based analysis to specific aspects of a design to obtain “equivalent” performance. The eight parts to ISO/TR 13387 developed by ISO/TC 92/SC 4 have already outlined the fundamental methodologies of FSE.

The difference between prescriptive and performance-based approaches to fire-safety design is highlighted in this International Standard by emphasizing the development of quantifiable fire-safety objectives as the first step in a performance-based analysis. Such objectives can be completely deterministic in nature or contain both deterministic and probabilistic aspects as used in a fire-risk assessment approach.

The new infrastructure of International Standards supporting performance-based fire-safety design consists of two basic types of fire-safety standards:

a) conceptual standards that describe the underlying concepts and contain general requirements for both engineering and test methods to support performance-based design; these correspond to principle and phenomenon standards in the ISO/TC 92 framework report;

b) standards that adapt the conceptual standards to specific configurations of the built environment, e.g. structural systems, transportation systems and manufacturing processes; these correspond to configuration standards in the ISO/TC 92 framework report. Conceptual standards have the advantage of broad applicability as guides for local/regional adoption and for new types of situations, while configuration standards are more specific and detailed.

This International Standard on general design principles and design philosophy for fire-safety engineering contains a comprehensive overview of the performance-based design process for fire safety and thus represents the type of principle standard discussed in the ISO/TC 92 framework report. As such, it is also a template guiding the development of other standards applicable to a wide range of generic and specific fire-safety design situations. Hence, it is important that this International Standard be viewed as an outline of the fire-safety engineering design process, not as a detailed design methodology.

Fire safety engineering — General principles

1 Scope

This International Standard provides general principles for a performance-based methodology for engineers to assess the level of fire safety for new or existing built environments. Fire safety is evaluated through an engineered approach based on the quantification of the behaviour of fire and people and based on knowledge of the consequences of such behaviour on life safety, property and the environment.

This International Standard is not intended as a detailed technical design guide, but does contain the key elements needed by practicing fire safety engineers and peer reviewers (those entities who can be required to review the work of fire-safety engineers) for addressing the different steps and their linkages in a design process. The information contained in this International Standard is intended not only to be useful to engineers directly but also to serve as a template to guide the development of a consistent set of fire-safety engineering documents covering the role of engineering methods and test methods in performance-based design and assessment.

The basic principles of fire-safety design and related fire-safety objectives in this International Standard can be applied in any other document addressing phenomena associated with fire (e.g. fire growth, hot gases and effluents movement, structural and compartmentalization behaviour). Related fire-safety objectives include, for example,

— safety of life;

— conservation of property;

— continuity of operations;

— protection of the environment;

— preservation of heritage.

Furthermore, these basic principles can be applied to all configurations of the built environment (e.g. buildings, transportation systems and industrial installations).

Because prescriptive regulations covering fire-safety design will co-exist for some time with performance-based design, this International Standard takes into account that fire-safety designs conforming to prescriptive regulations can become the basis for comparison of engineered designs of new built environments.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13943, *Fire safety — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943 and the following apply.

3.1
engineering judgement
process exercised by a professional or a team of professionals who is qualified by way of education, experience and recognized skills to complement, supplement, accept or reject elements of an engineering analysis

3.2
fire-safety manual
fire-safety information system
document or computer system detailing the fire-safety management procedures intended for implementation on a continuing basis

3.3
fire-safety strategy
specification of design functions used in achieving fire-safety objectives that, when fully elaborated and specified, forms the basis for a trial design

3.4
functional requirement
statement of the means to achieve specified fire-safety objectives, taking into account the features of a built environment

NOTE Mandatory functional requirements are required by building codes or national regulations; voluntary functional requirements are expressed by other interested/affected parties.

3.5
interested/affected party
party that is impacted by a fire safety design, including property owners and other property stakeholders, or authority having jurisdiction in charge of the public health and welfare

3.6
mandatory objective
fire-safety objective, such as life safety and protection of the environment, which is required by building codes or national regulations

3.7
performance criteria
quantitative engineering specifications that form an agreed basis for assessing the safety of a built-environment design

3.8
safety factor
multiplicative adjustment applied to calculated values to compensate for uncertainty in methods, calculations, input data and assumptions

3.9
trial design
design chosen for the purpose of making a fire-safety engineering analysis

3.10
uncertainty
quantification of the systematic and random error in data, variables, parameters or mathematical relationships, or of a failure to include a relevant element

3.11
validation
⟨fire calculation model⟩ process of determining the degree to which a calculation method is an accurate representation of the real world from the perspective of the intended uses of the calculation method, such as confirming the correct assumptions and governing equations implemented in a model when applied to the entire class of problems addressed by the model

3.12
verification
⟨fire calculation model⟩ process of determining that a calculation method implementation accurately represents the developer's conceptual description of the calculation method and the solution to the calculation method

NOTE The fundamental strategy of verification of computational models is the identification and quantification of error in the computational model and its solution.

3.13
voluntary objective
fire safety objectives that are requirements expressed by interested/affected parties beyond mandatory objectives

4 Overview of the fire-safety engineering process

Fire is a complex phenomenon that imposes fluid-dynamic, thermal, mechanical and chemical actions (loads) on a built environment, on occupants or users of a built environment and on fire services. Therefore, it is essential that the fire-safety design process outlined in this International Standard be an integral part of all construction projects involving aspects that cannot be adequately accommodated by prescriptive requirements. The fact that fire actions (loads) can lead to changes that alter subsequent fire behaviour, with a resulting modification of the fire action (load), makes the interaction of fire-safety design with all other component design features essential during the life of a project. For example, boundaries can rupture in response to a fire, which can allow the introduction of additional ventilation causing an increase in fire intensity. The actions of building occupants can also influence the fire development by opening or closing doors/windows or by attempting to fight the fire.

The chart in Figure 1 is an outline of the fire-safety engineering process (design, implementation and maintenance) of a built environment, with reference to clause numbers where the process is explained in more detail.

Figure 1 shows the various steps required for the development of a fire-safety engineering process that fully meets the objectives of all interested/affected parties. After having defined accurately the scope of the project (Clause 5), the first step (Clause 6) involves the development of fire-safety objectives, related functional requirements and quantitative performance criteria for the various design functions (e.g. fire protection) that are required to achieve the fire-safety objectives. A specific fire-safety design plan is then developed (Clause 8), containing trial design elements that can potentially satisfy the quantitative performance criteria according to a preliminary hazards identification (Clause 7). It is necessary to agree on a set of design fire scenarios that can be used to challenge the performance of these design functions (Clause 9). Whether the performance criteria are, in fact, satisfied is determined by an engineering analysis of the trial design, as described in Clause 11, making use of engineering methods selected as indicated in Clause 10. If the performance criteria are not satisfied by the trial design, modifications are required until a final design plan in line with requirements is achieved. The final project report, including the necessary documentation, is produced and validated (Clause 12). The implementation of this final design plan leading to the erection of the built environment is discussed in Clause 13. Even after implementation is complete, the fire-safety engineering process continues with periodic inspections and ongoing fire-safety management procedures as described in Clause 14.

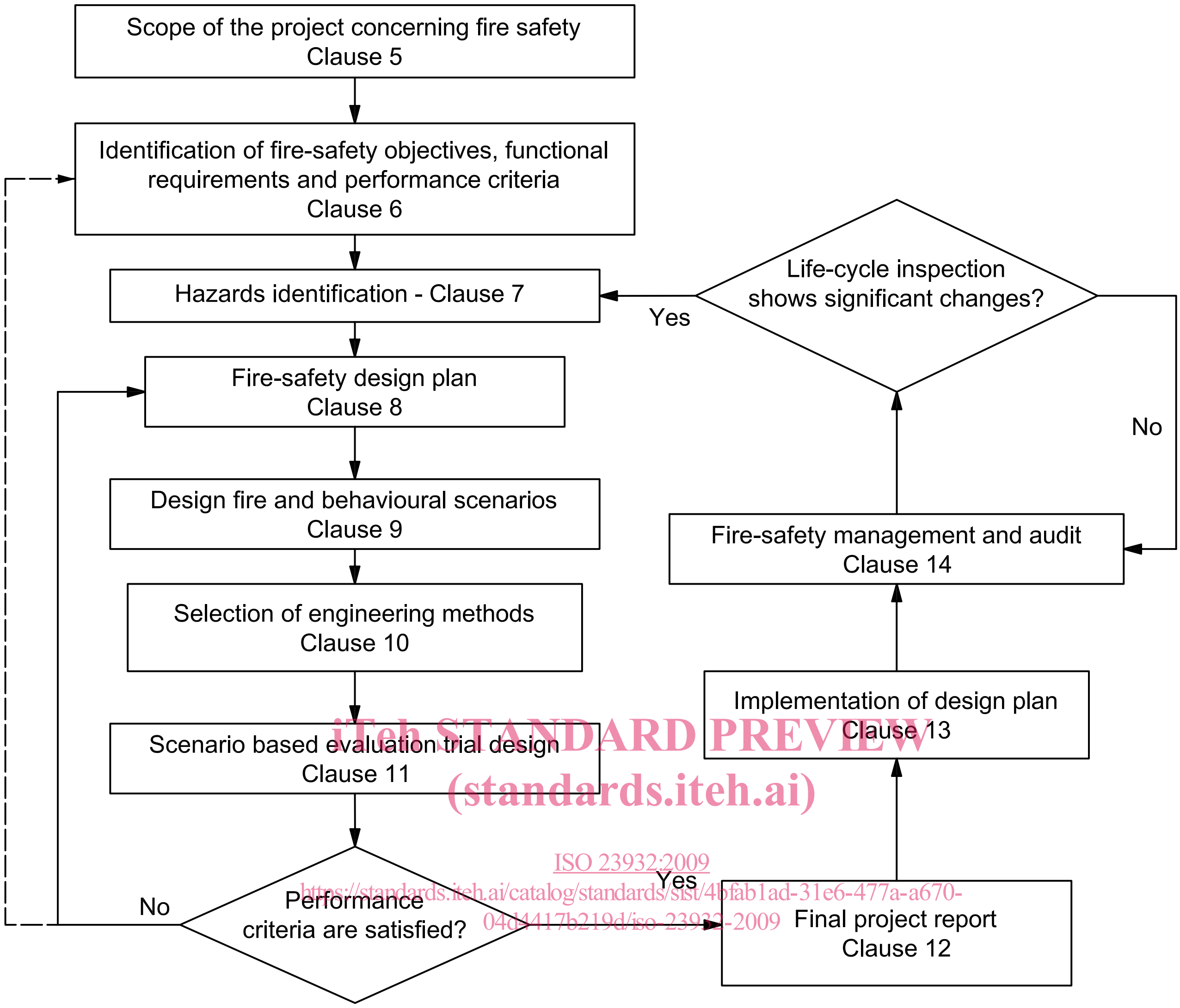

Figure 1 — Flowchart illustrating the fire-safety engineering process — Design, implementation and maintenance

5 Scope of the project concerning fire-safety engineering process

The fire-safety engineering process should be initiated at the earliest stage of a project (that may include, for example, architectural concept design, structural, ventilation, plumbing, electrical designs) for a new built environment, to modify or refurbish an existing built environment or to evaluate compliance with updated regulations. Fire-safety design should be integrated fully with all other engineering design specialties throughout such a project. The requirement for this type of integration is obvious when considering, for example, how the result of acoustic or thermal engineering (introduction of flammable sound/heat absorbing materials) or enhancement of security (limitation of methods of egress) can introduce unintended fire-safety design problems.

To facilitate the determination of actions (loads) on a new built environment due to a fire, it is necessary for a preliminary design plan to be made available to fire-safety designers. This preliminary plan should contain information about the purpose/function of each part of the design, dimensions of each part of the design (including openings) and a description of the anticipated location of all fixtures, furnishings, decorations, equipment and combustible products planned for installation, stored or used in the new built environment, as well as the description and analysis of processes for industrial installations. When dealing with the refurbishment of an existing built environment, it is necessary to provide the same kinds of information. In this case, it is not a preliminary plan but the description of the existing components that provides the basis.

At this stage, it is necessary that the contractual and organizational context of the design work be clearly defined, including the extent to which an FSE approach will be applied (for the whole built environment or part of it) and the functions and duties of each member of the design team.

6 Identification of fire-safety objectives, functional requirements and performance criteria

6.1 General description

Through a process of discussion, negotiation and/or compromise by all interested/affected parties, fire-safety objectives should be identified (including those stated in mandatory regulations), functional requirements that translate these objectives into the required functionality (e.g. fire-protection systems) of the fire-safety design should be developed and quantitative performance criteria should be established for determining whether this functionality results in the achievement of the fire safety objectives.

This process provide answers to the following questions; see 6.3 to 6.5.

— Regarding objectives: What are the required/desired outcomes of all foreseeable fires?

— Regarding functional requirements: How will these outcomes be achieved by design functionality?

— Regarding performance criteria: How will the adequacy of the design be measured in engineering terms?

6.2 Compatibility with prescriptive regulations

Prescriptive regulations generally provide “acceptable solutions” for fire-safety design elements or specific fire-safety design features that are “deemed to satisfy” regulatory requirements. Such regulations may, in some cases, also provide explicit mandatory objectives and/or functional statements concerning the intent of the regulations. When this is the case, additional regulatory information should be used to help prepare the objective statements and to list the functional requirements discussed in 6.3 to 6.5. In the absence of information on the intent of regulations, it is necessary that sets of objectives and functional requirements be developed independently to identify how the impact of fire scenarios is measured by performance criteria.

In addition, when developing an alternative to a prescriptive acceptable solution, it is not necessary that performance criteria be absolute; they can be relative to the performance reached by the acceptable solution. When relative performance criteria are used, it is necessary that the comparison basis be clearly and completely explained.

6.3 Fire safety objectives of interested/affected parties

6.3.1 General

When dealing with performance-based codes or regulations, it is necessary to identify a set of broad objective statements (e.g. desired outcomes) specific to fire safety and in terms understandable to all interested/affected parties. Interested/affected parties can include authorities having jurisdiction, owners, developers, employees and other prospective occupants, emergency responders, insurers and neighbours. Interested parties other than the owner can be represented by authorities having jurisdictions or by third-party professionals.

Since fire safety is a regulatory matter in most countries, there is generally limited scope for modifying these requirements, and it is necessary to provide evidence that the required regulatory objectives are fulfilled. On the other hand, there can be some other objectives that are voluntary, such as minimizing of business interruption or providing a higher level of safety than required by regulatory requirements. In this case, engineering analysis can lead to the modification of objectives, e.g. to the achievement of a balance of safety and cost that is more acceptable to the interested/affected parties.

Objective statements typically address one or more of the areas in 6.3.2 to 6.3.6.