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Fire safety engineering — Examples of fire safety objectives, functional requirements and safety criteria

Ingénierie de la sécurité incendie — Exemples d'objectifs de sécurité incendie, d'exigences fonctionnelles et de critères de sécurité

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Foreword

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This document 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. ISO 23932 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.

The difference between prescriptive and performance-based approaches to fire safety design is highlighted in ISO 23932 by emphasizing the development of quantifiable fire safety design objectives and related functional requirements as the first step in a performance-based analysis. According to ISO 23932, the fire safety objectives include, for example, safety of life, conservation of property, continuity of operations, protection of the environment and preservation of heritage.

In ISO 23932, it is also mentioned that explicit performance criteria should be developed for each functional requirement. Performance criteria are engineering metrics that are expressed in deterministic or probabilistic (e.g. measures of fire risk) form to determine if each functional requirement has been satisfied by the fire safety design.

As a preliminary work prior to producing ISO standardized documents for fire safety objectives, functional requirements and safety criteria, ISO/TC 92/SC 4 decides to collect the examples of those from the existing documents that have been developed in different countries in the course of moving towards performance-based fire safety design. So far, three countries have responded to the solicitation for such documents, i.e. Japan, France and New Zealand. The development of these documents, as summarized below, was motivated by the attempts to rationalize the existing fire safety design practices based on prescriptive building by making use of fire safety engineering methods.

Japan: First developed by the Building Research Institute during the Ministry of Construction's project for developing a performance-based fire safety design method, 1981 to 1986, and subsequently improved by the committee on fire safety design in Architectural Institute of Japan, of which the report was published in 2000.

France: Developed in the collaborative research project to establish the bases to introduce fire safety engineering into fire safety design, which was conducted with the sponsorship of French ministry for construction and home office from 2005 to 2011, involving research institutes, fire brigades, practitioners, designers and owners.

New Zealand: Developed by a working group made up of external fire experts and staff from the regulatory agency. The group was set up to research and develop a suitable fire safety design framework, in the course of amending the New Zealand Building Codes corresponding to the introduction of the Building Act 2004.

Fire safety engineering — Examples of fire safety objectives, functional requirements and safety criteria

1 Scope

This document compiles examples of fire safety design objectives, functional requirements and safety criteria from Japan, France and New Zealand.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
functional requirements
statement of the means to achieve specified fire safety objectives, taking into account the features of a built environment

Note 1 to entry: Mandatory functional requirements are required by building codes or national regulations; voluntary functional requirements are expressed by other interested/affected parties.

3.2
mandatory objectives
fire safety objectives, such as life safety and protection of the environment, which are required by building codes or national regulations

3.3
performance criteria
quantitative engineering specifications, which form an agreed basis for assessing the safety of a built environment design

3.4
safety factor
multiplicative adjustment applied to calculated values to compensate for uncertainty in methods, calculations, input data and assumptions

3.5
verification
process of determining that a fire safety design complies with the fire safety requirements by examining the design in the light of safety criteria

3.6
voluntary objectives
fire safety objectives, which are requirements expressed by interested/affected parties, beyond mandatory objectives

4 Examples from France, New Zealand and Japan

Annexes A to D contain examples of fire safety objectives, functional requirements and safety criteria from France, New Zealand and Japan.

Annex A
(informative)

Example of fire safety design objectives and functional requirements in France

A.1 Introduction

Fire safety design in France for life safety and property protection is mainly prescriptive and managed by regulation. Even if there are already partial openings to fire safety engineering, since only some years ago it has become increasingly obvious that more involvement in fire safety engineering need to be made in French fire safety regulations.

In mid-2005, a collaborative research project was set up, with the sponsorship of French ministry for construction and home office, involving different partners including research institutes, fire brigades, practitioners, designers and owners. The research project, which ended by mid-2011, was divided into 18 main items, clustered in three main parts:

— Development of general principles for FSE assessment:
  — FSE methodology;
  — objectives and performance criteria;
  — fire risk assessment;
  — design fire and behavioural scenarios;
  — verification of the methodology by examples;
  — validation by reconstructions of fire incidents.
— State-of-the-art and research projects regarding:
  — statistical analysis of fuel load density;
  — characterization of burning items;
  — fire development and spread;
  — structural behaviour calculations;
  — fire containment;
  — behaviour at elevated temperature of regular glazing;
  — fire protection;
  — human behaviour.
— Communication and dissemination:
  — teaching of FSE in universities or high schools for engineers;
  — information and awareness of actors involved in FSE;
  — publication of outcomes;

— proposals for regulation improvements.

A translation of the general principles developed within the scope of this collaborative research is given in this document. The performance-based structure consists of the three following levels:

— fire safety objectives;

— functional requirements;

— performance criteria.

Fire safety objectives which are explicitly or implicitly mentioned in French regulations (for public buildings, tall buildings, work places, warehouses, industrial plants, etc.) were identified. Functional requirements were selected mainly by brain storming among the members who joined this research project.

A few examples of vulnerability criteria have been given, involving life safety objectives and requirements, and focusing on what should be “adequate tenability conditions”. Performance criteria proposed were derived from some national or international research works or standards.

A.2 General

A.2.1 Purpose

This document provides examples of fire safety objectives, functional requirements and performance criteria for interested parties involved in a performance-based approach to assess the level of fire safety of a built environment. The development of quantifiable fire safety objectives is the first step in a performance-based analysis. This is an alternative to prescribed regulatory requirements, giving more freedom in the design of built environments, a better cost/benefit within sustainability development, while retaining equal or higher level of safety performance compared with the prescribed approach.

A.2.2 Scope

The examples developed in this document can apply when performing the fire safety engineering process for a whole built environment or part of it, and for new or existing buildings. They can be used when the performance-based approach is considered as an alternative to a prescriptive acceptable solution (in this case, performance criteria are not defined but relative to the performance reached by the acceptable solution when considering the selected fire safety objectives and functional requirements).

These objectives can be used as either mandatory or voluntary fire design objectives, depending on the regulatory requirements which need to be fulfilled.

It is necessary to have an agreement on any assumptions taken for objectives, functional requirements and performance criteria (when they are not explicitly given in the regulation) from authorities having jurisdiction, prior to performing the assessment work as such.

A.2.3 Terms and definitions

A.2.3.1

compartment

enclosed space, which may be subdivided, separated from adjoining spaces by fire barriers

A.2.3.2

media impact

qualitative value of exposure through a given medium

A.2.3.3

safe refuge

temporary location that is free from immediate danger from effects of fire

A.2.3.4

strategic function

capacity or resource of an entity or an organization that maintains its ability to achieve future outcomes and determines its long-term performance

A.2.3.5

sudden change

transition within a few seconds

A.2.3.6

untenable condition

condition such that people are unable to take effective action to accomplish their own escape to a place of safe refuge

A.2.4 Symbols and abbreviated terms

Shown below are the abbreviated terms that are used in this document.

FNR	functional requirement
FSE	fire safety engineering
OBJ	objective

A.3 Fire safety objectives

The fire safety objectives which need to be addressed in design of a building can be related to the safety of life, property, environment, continuity of operations, or cultural heritage. The different categories of objectives are summarized below.

OBJ 1: Health and life safety

Life safety is often the most important objective of fire safety design. It first involves occupants of the building and may extend to firefighters who are expected to assist in evacuation or prevent extensive uncontrolled spread of fire, and finally to third parties. Thus, three sub-objectives are defined.

OBJ 1-1: Health and life safety of occupants

OBJ 1-2: Health and life safety of firefighters

OBJ 1-3: Health and life safety of third parties

OBJ 2: Environment protection

Avoiding long-term consequences of the environmental impact of fires is becoming a more apparent goal. The objectives of environmental protection in case of fire may be divided into two main groups as follows:

OBJ 2-1: Ground and water

OBJ 2-2: Atmosphere

OBJ 3: Property protection

Protection of property from fire damage aims generally at limiting any damage to the contents of the building, to the building itself, or to the vicinity of the building.

In the modern world, the cost of business interruption is also of interest because it may be much higher than the cost of direct damage to the contents and the building itself. In the same way, preservation of the strategic functions may be essential, especially when involving, for example, transportation, power, and other infrastructures necessary to the functioning of a community.

Besides, some buildings with architectural, historical or cultural importance may have values which cannot be measured on a monetary scale. Their protection against the damage caused by fire is considered to be one of the basic moral duties of the society.

Finally, in many fields of industry, a good public image is essential to success in business. A fire loss may damage public image and lead to detrimental long-term consequences.

As a result, the property protection objectives may be divided into the following sub-objectives:

OBJ 3-1: Moveable properties and real estate within the premises

OBJ 3-2: Moveable properties and real estate of third parties

OBJ 3-3: Continuity of operations

OBJ 3-4: Strategic matters

OBJ 3-5: Preservation of heritage

OBJ 3-6: Media impact

A.4 Functional requirements

Functional requirements are necessary to take into account specific conditions related to the built environment to enable the link between fire safety objectives and performance criteria.

OBJ 1-1: Health and life safety of occupants

FNR 1-1-1: No sudden change in the tenability conditions before every occupant left the room of origin

In the room of fire origin, the different factors influencing fire development and spread of fire effluents shall be such that sudden changes in the exposure conditions, which can catch the occupants before they have become aware of the hazard and have left the room, should be prevented. The underlying idea is to delay the occurrence of a flashover in this room, for example, by distancing the different combustible materials present in the room, or by using safety systems such as automatic detection or sprinkler system.

FNR 1-1-2: Adequate tenability conditions in the egress route up to any occupant left

The occupants must be able to totally evacuate the building without being subject to untenable conditions.

FNR 1-1-3: Adequate tenability conditions in space within the building, outside the room of origin, where people are waiting for rescue

The occupants must be able to remain in a safe refuge, waiting to get rescued, without being subject to untenable conditions.

FNR 1-1-4: Adequate tenability conditions for the whole duration of the fire, in space within the building where people have found refuge

The occupants must be able to remain in a safe refuge for the whole duration of the fire without being subjected to untenable conditions. This is the same as the previous functional requirement, except that the possibility to get rescued is not considered. It could lead, for example, to a fire resistance rating for the walls of the refuge more important that in the previous case.

OBJ 1-2: Health and life safety of firefighters

FNR 1-2-1: Adequate tenability conditions during the necessary time for the reconnaissance of the fire area

This mainly concerns the access paths for firefighting vehicles and the egress routes to search for the origin of the fire or to identify specific risks such as storage of gas cylinders.

FNR 1-2-2: Adequate tenability conditions during the necessary time for evacuating people

The firefighters must be able to evacuate people without being subjected to untenable conditions.

FNR 1-2-3: No sudden change in the tenability conditions when fighting the fire

Sufficient time must be available for the firefighters to get out from the room, the floor or the building before conditions have become untenable. They should not be trapped by an extremely rapid fire progress or other flashover-related phenomena that may happen in a room with combustible partition walls.

OBJ 1-3: Health and life safety of third parties

FNR 1-3-1: Adequate tenability conditions within a neighbouring built environment during the whole duration of the fire

The health and life safety of third parties must be ensured during the whole duration of the fire without forcing them to leave the premises.

FNR 1-3-2: Adequate tenability conditions in the surrounding spaces, during the necessary time, as a function of the mobility conditions of the third parties (including traffic roads)

Third parties in surrounding spaces must be able to move away from the fire zone without being subjected to the effects of the fire. Surrounding spaces include sidewalks, public or private areas, and roads for which visibility conditions may be essential.

OBJ 2-1: Ground and water protection

FNR 2-1-1: Reduction of hazardous solid or liquid fire residues

When fighting and extinguishing the fire, there are often serious releases of hazardous solid or liquid fire residues to the ground or to the waste water system, which may consequently damage the ground water or nearby lakes or rivers. Necessary measures such as containment basins must be in place to limit or contain these combustion residues.

FNR 2-1-2: Control of hazardous fire effluent released

Necessary measures must be in place to contain the hazardous, polluting or toxic products released during the fire. Highly hazardous products could be, for example, placed in specifically designated areas with a particular protection and sectioned off from other areas.

OBJ 2-2: Atmosphere protection

FNR 2-2-1: Fire effluent containment

Necessary measures must be in place to contain the smoke and combustion products released during the fire, in order to limit emissions into the atmosphere.

FNR 2-2-2: Control of hazardous fire effluent released and dispersed into the atmosphere

Necessary measures must be in place to limit the hazardous, polluting or toxic products released during the fire and dispersed into the atmosphere.

OBJ 3-1: Moveable properties and real estate within the premises

FNR 3-1-1: Preservation of a specific component within the room of origin

A specific content of the building can be considered of great interest, like a safety-deposit box or a work of art, and specific protection (automatic detection, sprinkler system, etc.) should be used to prevent any degradation.

FNR 3-1-2: Fire restricted to the room of origin

Necessary measures must be in place to avoid the spread of fire outside the room of origin.

FNR 3-1-3: Damages restricted to the room of origin

Even if the fire is restricted to the room of fire origin, the effects of the fire may cause damages to adjacent rooms. It may be necessary to avoid damages outside the room of origin.

FNR 3-1-4: Damages restricted to the compartment of origin/to the floor of origin

It is the same approach as the previous requirement, except that damages are accepted to all the rooms of the compartment or floor of origin.

OBJ 3-2: Moveable properties and real estate of third parties

FNR 3-2-1: No spread of fire to neighbouring constructions

Necessary measures must be taken to avoid the spread of fire to neighbouring constructions. For example, to avoid the spread of fire between adjacent multi-storey buildings, a classical approach is to limit the use of combustible materials in facades.

FNR 3-2-2: No damages to neighbouring constructions

Necessary measures must be in place to avoid damages to neighbouring constructions. It could be by imposing distance between buildings.

OBJ 3-3: Continuity of operations

FNR 3-3-1: Preservation of a given activity

In a company, an organization, or an association, an activity of critical importance might be subjected to specific provisions in case of fire.

FNR 3-3-2: Protection of the production capability

Necessary measures must be in place to maintain the production capability intact in case of fire.

FNR 3-3-3: Preservation of a specific device (and its supplying fittings)

Within a building, a specific device can be deemed to be essential for the good functioning of the building. Necessary measures must be in place to protect the device and its supplying fittings in case of fire.

OBJ 3-4: Strategic matters

FNR 3-4-1: Preservation of the strategic functions

Necessary measures must be in place to ensure the continuity of the strategic functions in case of fire.

FNR 3-4-2: Protection of any devices involved in strategic functions

Necessary measures must be in place to protect from the effects of the fire any devices involved in strategic functions.

OBJ 3-5: Preservation of heritage

FNR 3-5: Protection from attack to any object or construction which could not be replaced

Necessary measures must be in place to protect from the effects of the fire any objects or buildings with architectural, historical or cultural importance. Any alterations which are unavoidable should be reversible, allowing the objects or building affected to be returned to its original condition. Consequently, in some cases, fire detection would be more appropriate than fire suppression.

OBJ 3-6: Media impact

FNR 3-6: Preservation of the image from any media action

This is a global rather than an individual protection, and necessary measures must be in place to minimize the visible consequences that may damage public image and lead to detrimental long-term consequences.

A.5 Performance criteria

A few examples of criteria are proposed in this clause, focusing on what should be "adequate tenability conditions". These criteria, based on both discrete values (which are sometimes associated with a discrete time period) and dose methods (which consider time-dependent exposures and thresholds), are not exhaustive.

OBJ 1-1 and 1-3: Health and life safety of occupants and third parties

FNR 1-1-2, 1-1-3, 1-1-4, 1-3-1 and 1-3-2

Criteria 1: Maximum gas temperature of 60 °C[1][2]

Criteria 2: Maximum incident heat flux of 2 kW/m^2 (for an exposure time >10 s) or 2,5 kW/m^2 (for an exposure time <10 s)[2]

Criteria 3: Maximum radiative dose of 300 kW$^{4/3}$m$^{-8/3}$s (for an exposure time <2 min)[3]

Criteria 4: Maximum fractional effective dose (FED) of 0,3[4]

Criteria 5: Minimum visibility of 10 m (as calculated in ISO 13571)[4]

OBJ 1-2: Health and life safety of firefighters

FNR 1-2-1 and 1-2-2

Criteria 6: Maximum incident heat flux of 5 kW/m^2[5]

A.6 Bibliography

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[3] MINISTRY OF ENVIRONMENT. "Guide technique relatif aux valeurs de références de seuils d'effets des phénomènes accidentels des installations classées" (October 2004)