INTERNATIONAL STANDARD

ISO 16732-1

First edition
2012-02-15

Fire safety engineering — Fire risk assessment —

Part 1: General

Ingénierie de la sécurité incendie — Évaluation du risque d'incendie — Partie 1: Généralités

Reference number
ISO 16732-1:2012(E)

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Published in Switzerland

Contents

Page

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 16732-1 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 4, *Fire safety engineering*.

This first edition of ISO 16732-1 cancels and replaces ISO/TS 16732:2005, which has been technically revised.

ISO 16732 consists of the following parts, under the general title *Fire safety engineering — Fire risk assessment*:

— *Part 1: General*

The following parts are under preparation:

— *Part 2: Example of an office building*

— *Part 3: Example of an industrial facility* [Technical Report]

Introduction

This part of ISO 16732 is for use by fire safety practitioners who employ risk assessment based methods. Any fire safety practitioner can have reason to employ such methods. All fire safety decisions involve uncertainty. Probabilities are the mathematical representation of uncertainty, and risk assessment is the form of fire safety analysis that most extensively uses probabilities and so most extensively addresses all types of uncertainty.

Examples of types of such fire safety practitioners include fire safety engineers; authorities having jurisdiction, such as territorial authority officials; fire service personnel; code enforcers; code developers; insurers; fire safety managers; and risk managers. Users of this part of ISO 16732 are to be appropriately qualified and competent in the fields of fire safety engineering and risk assessment. It is particularly important that the user understand the limitations of application of any methodology that is used.

Risk assessment is preceded by two steps: establishment of a context, including the fire safety objectives to be met, the subjects of the fire risk assessment to be performed, and related facts or assumptions; and identification of the various hazards to be assessed. A “hazard” is something with the potential to cause harm.

The subjects of fire risk assessment include the design and control of any part of the built environment, such as buildings or other structures. Fire risk assessment of a design consists of analysis of the risks, e.g. frequency and severity of harm, that are predicted to result if the design is implemented, combined with an evaluation of the acceptability of those risks.

Fire risk assessment can be used to support any decisions about fire prevention or fire protection of new or existing built environments, such as buildings, where probabilistic aspects, such as fire ignition or the reliability of fire precautions, are important. Fire risk assessment can also be used to establish safety equivalent to a code, to assess the balance between the cost and the risk reduction benefit of a proposal, or to examine acceptable risk specifically for severe events. Fire risk assessment can also be used to provide general guidance or to support choices in the selection of scenarios and other elements of a deterministic analysis.

Fire risk assessment can be used as part of compliance with ISO 23932, and all the requirements of ISO 23932 apply to any application of this part of ISO 16732. ISO 23932 identifies different applications of fire risk assessment. One application is for the limited purpose of identifying a manageable number of design fire scenarios for a deterministic analysis. This use of fire risk assessment is cited in ISO 23932:2009, 9.2.2.2 and 9.2.2.3. Additional guidance for this application is contained in ISO/TS 16733.

The other application, cited in ISO 23932:2009, 10.1.1.2, is as a calculation method to assess whether a proposed or existing design plan meets fire safety objectives when the performance criteria for the fire safety objectives are expressed in a probabilistic form. That application is the one for which ISO 16732 is principally designed. In that application the concept of design fire scenario, as described in ISO 23932, is better addressed through the dual concepts of fire scenario cluster and representative fire scenario used in this part of ISO 16732. The user should regard representative fire scenarios as the types of design fire scenarios used in fire risk assessment. The term “representative” and the linkage with fire scenario clusters are necessary to establish that calculations based on the selected scenarios will produce an acceptably accurate estimate of the required performance criteria, expressed as measures of fire risk, in accordance with ISO 23932.

Fire safety engineering — Fire risk assessment —

Part 1: **General**

1 Scope

This part of ISO 16732 provides the conceptual basis for fire risk assessment by stating the principles underlying the quantification and interpretation of fire-related risk. These fire risk principles apply to all fire-related phenomena and all end-use configurations, which means these principles can be applied to all types of fire scenarios. The principles and concepts in this part of ISO 16732 can be applied to any fire safety objectives, including the five typical objectives listed as examples in Clause 1 of ISO 23932:2009:

— safety of life,

— conservation of property,

— continuity of business and safety operations,

— protection of the environment,

— preservation of heritage.

This part of ISO 16732 is designed as a guide for future standards that provide formal procedures for the implementation of the risk assessment principles for specific applications, e.g. situations in which only certain types of fire scenarios are possible. Those future standards will complete the process of full standardization begun by this part of ISO 16732, which not only specifies the steps to be followed in fire risk assessment but also provides guidance for use in determining whether the specific approach used for quantification falls within an acceptable range.

Principles underlying the quantification of risk are presented in this part of ISO 16732 in terms of the steps to be taken in conducting a fire risk assessment. These quantification steps are initially placed in the context of the overall management of fire risk and then explained within the context of fire safety engineering, as discussed in ISO/TR 13387. The use of scenarios and the characterization of probability (or the closely related measure of frequency) and consequence are then described as steps in fire risk estimation, leading to the quantification of combined fire risk. Guidance is also provided on the use of the information generated, i.e. on the interpretation of fire risk. Finally, there is guidance on methods of uncertainty analysis, in which the uncertainty associated with the fire risk estimates is estimated and the implications of that uncertainty are interpreted and assessed.

This part of ISO 16732 is not structured to conform with any national regulation or other requirement regarding the use of fire risk assessment or the type of analysis that is to be performed under the name of fire risk assessment.

2 Normative references

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

ISO 13943:2008, *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
acceptance criterion
⟨fire risk assessment calculations⟩ qualitative and quantitative criterion which forms an acceptable basis for assessing the safety of a built environment design, defined on particular fire risk measurement scales

Note 1 to entry: Adapted from ISO 13943:2008.

3.2
consequence
outcome or outcomes of an event, expressed positively or negatively, quantitatively or qualitatively

3.3
design load
⟨fire risk assessment calculations⟩ fire scenario with sufficient severity to provide an appropriate basis for assessing whether a design will produce unacceptably large consequences

3.4
engineering judgement
process exercised by a professional who is qualified by way of education, experience and recognized skills to complement, supplement, accept or reject elements of a quantitative analysis

3.5
event tree
depiction of temporal, causal sequences of events, built around a single initiating condition

[SOURCE: ISO 13943:2008, 4.85]

3.6
fault tree
depiction of the logical dependencies of events on one another, built around a critical resulting event, which usually has an unacceptable level of consequence and may be described as a failure

[SOURCE: ISO 13943:2008, 4.95]

3.7
fire risk
⟨scenario⟩ combination of the probability of a fire and a quantified measure of its consequence

Note 1 to entry: Adapted from ISO 13943:2008.

3.8
fire risk
⟨design⟩ combination of the frequencies and consequences of scenarios associated with the design

Note 1 to entry: In definition 3.8, risk is typically expressed as risk per unit time, which is the reason that frequency is used instead of probability in the definition. Frequencies are normally calculated for fire scenario clusters (see 3.16), and consequences are normally calculated for representative fire scenarios (see 3.15).

3.9
fire risk, acceptable
⟨fire risk evaluation calculation⟩ risk that satisfies defined acceptance criteria

3.10
fire risk assessment
⟨built environment fire risk calculation⟩ well-defined procedure for estimation of fire risk for a built environment and evaluation of estimated fire risk in terms of well-defined acceptance criteria

3.11
fire-risk curve
graphical representation of fire risk

Note 1 to entry: It is normally a log/log plot of cumulative probability versus cumulative consequence; when consequences are measured as fatalities, fire-risk curve is also called an fN-curve, where f refers to frequency and N refers to number of deaths.

[SOURCE: ISO 13943:2008, 4.125]

3.12
fire risk evaluation
comparison of estimated risk, based on fire risk analysis, to acceptable risk, based on defined acceptance criteria

3.13
fire risk matrix
matrix display in which (1) rows or columns are defined by ranges of fire scenario cluster frequencies, (2) columns or rows are defined by ranges of fire scenario design loads, and (3) cell entries are specified acceptable consequences for the scenario clusters contained in the cell's row and column

Note 1 to entry: A fire risk matrix implicitly assumes that the design itself has no influence on the size or intensity of the fire challenging the building, but rather treats the fire scenario as an externally imposed load.

3.14
fire scenario
qualitative description of the course of a fire with time, identifying key events that characterize the fire and differentiate it from other possible fires

Note 1 to entry: Adapted from ISO 13943:2008.

Note 2 to entry: The fire scenario description typically includes the ignition and fire growth processes, the fully developed fire stage, the fire decay stage, and the environment and systems that will impact on the course of the fire. Unlike deterministic fire analysis, where fire scenarios are individually selected and used as design fire scenarios, in fire risk assessment, fire scenarios are used as representative fire scenarios within fire scenario clusters.

3.15
fire scenario, representative
specific fire scenario selected from a fire scenario cluster such that the consequence of the representative fire scenario can be used as a reasonable estimate of the average consequence of scenarios in the fire scenario cluster

Note 1 to entry: For additional information, see ISO/TR 13387-1:1999, 8.2.1 a) to f).

3.16
fire scenario cluster
subset of fire scenarios, usually defined as part of a complete partitioning of the universe of possible fire scenarios

Note 1 to entry: For additional information, see ISO/TR 13387-1:1999, 8.2.1 a) to f).

Note 2 to entry: The subset is usually defined so that the calculation of fire risk as the sum over all fire scenario clusters of fire scenario cluster frequency multiplied by representative fire scenario consequence does not impose an undue calculation burden.

3.17
limit state
⟨fire risk assessment calculation⟩ threshold or limiting value on a consequence scale that marks the line between acceptably large consequence and unacceptably large consequence

3.18
reliability
probability that a unit will perform a required function for given conditions and for a given period of time

3.19
individual risk
measure of fire risk limited to consequences experienced by an individual and based on the individual's pattern of life

Note 1 to entry: There is nothing in the definition that implies or requires acceptance.

[SOURCE: ISO 13943:2008, 4.195]

3.20
societal risk
measure of fire risk combining consequences experienced by every affected individual

Note 1 to entry: There is nothing in the definition that implies or requires acceptance.

[SOURCE: ISO 13943:2008, 4.297]

3.21
risk acceptance
decision to accept an estimated level of risk, based on either compliance with acceptance criteria or an explicit decision to modify those criteria

3.22
risk aversion
given two choices for which the product of frequency and consequence are identical, preference for the choice with the lower consequence

3.23
risk communication
exchange or sharing of information about risk between decision-maker and other individuals, groups or organizations who may affect, be affected by, or perceive themselves to be affected by the risk

3.24
risk management
processes, procedures, and supporting culture for ongoing achievement of desired risk criteria

Note 1 to entry: Risk management is a combination of risk assessment, risk treatment, risk acceptance, and risk communication.

3.25
risk treatment
risk modification measure, normally used to refer to changes other than changes to design, and the process used to select and implement the measures

Note 1 to entry: Risk modification measures that are not changes to design include changes to fire safety management procedures.

3.26
sensitivity
measure of degree to which a small perturbation of a system will create a large change in system status

3.27
uncertainty
quantification of systematic and random error in data, variables, parameters, or mathematical relationships or of failure to include a relevant element

3.28
propagation of uncertainty
mathematical analysis of uncertainty of calculated risk as a function of uncertainty in variables, parameters, data, and mathematical relationships used in the calculation

3.29
variability
quantification of probability distribution function for variable, parameter, or condition

4 Applicability of fire risk assessment

4.1 Circumstances where fire risk assessment provides advantages relative to deterministic fire safety engineering analysis

Scenarios with low frequency but high consequence present a challenge. It may be impossible to achieve the fire safety objectives at acceptable cost for such scenarios, but it may be unacceptable to ignore such scenarios entirely. Weighting the consequences of such scenarios by their frequency, as is done in fire risk assessment, incorporates such scenarios into the calculation without making them the only scenarios driving the calculation. Any of the following scenario characteristics can produce low-frequency, high-consequence scenarios:

If there is great diversity in the fire scenarios of concern or if consequences are very sensitive to small changes in input parameters, it may not be possible to produce a short list of design fire scenarios that collectively address and represent all fire scenarios. In such circumstances, fire risk assessment can provide a more flexible framework for analysis using a large number of representative fire scenarios, as well as providing quantitative evidence that the scenarios selected are representative of all scenarios.

Reliability is inherently probabilistic. Fire risk assessment has considerable advantages in analysing any problem where the results are highly sensitive to reliability or where reliability varies substantially from one design specification to another.

5 Overview of fire risk management

Risk management includes risk assessment but also typically includes risk treatment, risk acceptance, and risk communication. Risk acceptance marks the conclusion of risk assessment. If risk is not accepted, another risk assessment is necessary, and risk treatment is an option after each risk assessment. Risk communication is conducted after risk acceptance (see Figure 1). Fire risk assessment can also be used to assess alternative designs prior to selecting a specific design or making changes to that design to achieve compliance with the acceptance criteria.

