INTERNATIONAL STANDARD

ISO 16733-1

First edition
2015-09-01

Fire safety engineering — Selection of design fire scenarios and design fires —

Part 1: Selection of design fire scenarios

Ingénierie de la sécurité incendie — Sélection de scénarios d'incendie et de feux de dimensionnement —

Partie 1: Sélection de scénarios d'incendie de dimensionnement

Reference number
ISO 16733-1:2015(E)

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received. www.iso.org/patents

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 92, *Fire safety*, Subcommittee SC 4, *Fire safety engineering*.

This first edition cancels and replaces ISO/TS 16733:2006, which has been technically revised.

ISO 16733 consists of the following parts, under the general title, *Fire safety engineering — Selection of design fire scenarios and design fires*:

— *Part 1: Selection of design fire scenarios*

Introduction

Selection of the fire scenarios requiring analysis is critical in fire safety engineering. The number of possible fire scenarios in any built environment (a building or other structure) can be very large and it is not possible to quantify them all. It is necessary to reduce this large set of possibilities to a small set of design fire scenarios that is amenable to analysis.

The characterization of a fire scenario involves a description of fire initiation, the growth phase, the fully-developed phase and extinction together with likely smoke and fire spread routes. This includes the interaction with the proposed fire protection features for the built environment. It is necessary to consider the possible consequences of each fire scenario.

This part of ISO 16733 introduces a methodology for the selection of design fire scenarios that is tailored to the fire-safety design objectives. There can be several fire safety objectives being addressed, including safety of life (for occupants and rescue personnel), conservation of property, protection of the environment and preservation of heritage. A different set of design fire scenarios can be required to assess the adequacy of a proposed design for each objective.

Following selection of the design fire scenarios, it is necessary to describe the assumed characteristics of the fire on which the scenario quantification are based. These assumed fire characteristics are referred to as “the design fire”. It is important that the design fire be appropriate to the objectives of the fire-safety engineering analysis and that they result in a design solution that is commensurate with credible worse case scenarios considered.

Users of this part of ISO 16733 should be appropriately qualified and competent in the fields of fire safety engineering and risk assessment. It is important that users understand the parameters within which specific methodologies may be used.

ISO 23932 provides 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 based on knowledge of the consequences of such behaviour on life safety, property, heritage and the environment. ISO 23932 provides the process (necessary steps) and essential elements to design a robust performance-based fire safety programme.

ISO 23932 is supported by a set of ISO fire safety engineering standards available on the methods and data needed for the steps in a fire safety engineering design summarized in ISO 23932:2009, Clause 4 and shown in Figure 1. This system of standards provides an awareness of the interrelationships between fire evaluations when using the set of ISO fire safety engineering standards.

Each International Standard includes language in the introductory material of the standard to tie the standard to the steps in the fire safety engineering design process outlined in ISO 23932. Selection of design fire scenarios form part of compliance with ISO 23932, and all the requirements of ISO 23932 apply to any application of this part of ISO 16733. For example, ISO 23932:2009, 9.2 generally describes the procedure for identifying and selecting fire scenarios (see highlighted box in Figure 1). Clause 6 describes, in detail, the approaches for identifying and selecting design fire scenarios.

Fire safety engineering — Selection of design fire scenarios and design fires —

Part 1: Selection of design fire scenarios

1 Scope

This part of ISO 16733 describes a methodology for the selection of design fire scenarios that are credible but conservative for use in fire safety engineering analyses of any built environment, including buildings, structures or transportation systems. Following the procedures given in this part of ISO 16733, a manageable number of design fire scenarios is selected using a qualitative or semi-quantitative approach. For a full quantitative approach using risk assessment, the reader is directed to ISO 16732-1.

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, *Fire safety — Vocabulary*

ISO 16732-1, *Fire safety engineering — Fire risk assessment — Part 1: General*

ISO 23932:2009, *Fire safety engineering — General principles*

3 Terms and definitions

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

3.1
design fire
quantitative description of assumed fire characteristics within a design fire scenario

Note 1 to entry: Typically an idealized description of the variation with time of important fire variables, such as heat release rate and toxic species yields, along with other important input data for modelling such as the fire load density.

3.2
design fire scenario
specific fire scenario on which a deterministic fire safety engineering analysis will be conducted

Note 1 to entry: As the number of possible fire scenarios can be very large, it is necessary to select the most important scenarios (the design fire scenarios) for analysis. The selection of design fire scenarios is tailored to the fire-safety design objectives, and accounts for the likelihood and consequences of potential scenarios.

3.3
fire scenario
qualitative description of the course of a fire with respect to time, identifying key events that characterize the studied fire and differentiate it from other possible fires

Note 1 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* (3.4) within *fire scenario clusters* (3.5).

3.4
fire scenario, representative
specific *fire scenario* (3.3) selected from a *fire scenario cluster* (3.5) 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

3.5
fire scenario cluster
subset of *fire scenarios* (3.3), usually defined as part of a complete partitioning of the universe of possible fire scenarios

Note 1 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* (3.4) consequence does not impose an undue calculation burden.

3.6
target
person, object or environment intended to be protected from the effects of fire and its effluents (smoke, corrosive gas, etc.) and/or fire suppression effluents

4 Symbols and abbreviated terms

A area of an opening, m^2

h height of an opening, m

$\dot{m}_f$ rate of mass loss of fuel, kg/s

$\dot{m}_{air}$ rate of entry of air into the enclosure, kg/s

$\dot{Q}$ rate of heat release, kW

$\dot{Q}_0$ reference rate of heat release, kW

r stoichiometric air requirement for complete combustion of fuel, expressed as the mass ratio of air to fuel

t time, s

t_g time required to reach the reference rate of heat release, $\dot{Q}_0$ s

5 Fire safety engineering applications

5.1 Fire safety engineering process

ISO 23932 provides 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 based on knowledge of the consequences of such behaviour on life safety, property, heritage and the environment. ISO 23932 provides the process (necessary steps) and essential elements to design a robust performance-based fire safety programme.

This part of ISO 16733 provides guidance for developing design fire scenarios in ISO 23932:2009, 9.2. This step in the fire safety engineering process is shown as a highlighted box in Figure 1.

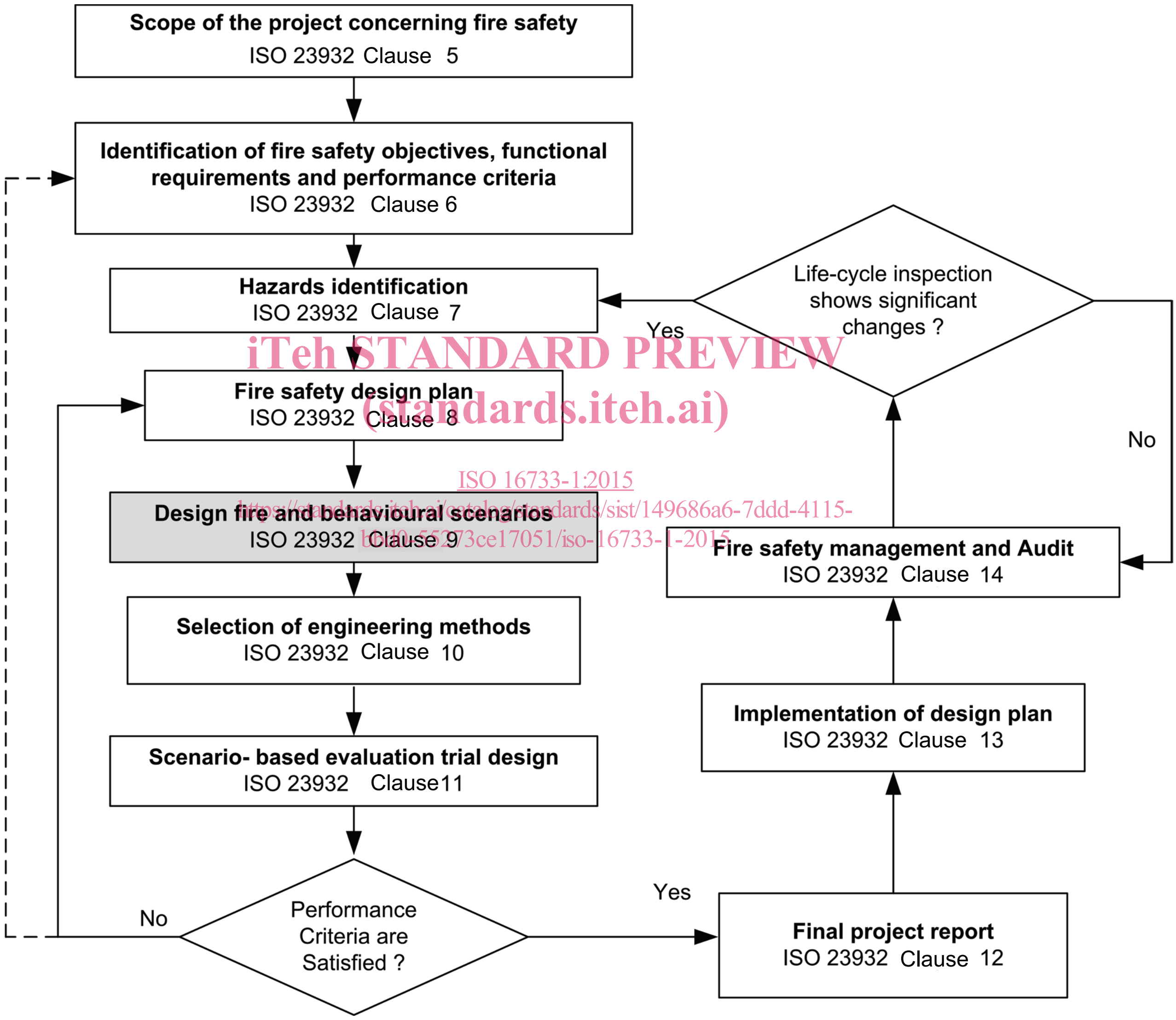

Figure 1 — Flow chart illustrating the fire safety design process and selection of design fire scenarios (Source: ISO 23932:2009)

5.1.1 Establish project scope

A preliminary plan shall contain information describing the purpose and function of each part of the design, and its intended fixtures, furnishings, decorations, equipment and combustible products that are planned to be installed, stored or used in the built environment. When this type of detailed information is not available, assumptions shall be made, the validity of which shall be checked and confirmed during and again at the end of the project. The contractual and organisational context of the design work must be clearly defined including the extent to which a FSE approach will be applied. See ISO 23932:2009, Clause 5.

5.1.2 Identify fire safety objectives

It shall be noted that there may be several fire safety objectives including safety of life (for occupants and rescue personnel), conservation of property, protection of the environment and preservation of heritage and that a different set of design fire scenarios can be required to assess the adequacy of the proposed design for each objective.

See ISO 23932:2009, 6.3 for a more detailed discussion.

5.1.3 Determine functional requirements

A functional requirement is a statement of a condition necessary to achieve the fire safety objective (e.g. harmful fire effects in spaces used for evacuation shall be avoided). It is necessary that these are identified and described in order that the potential of possible fire scenarios to threaten the fulfilment of the functional requirement can be assessed. If a fire scenario does not threaten the achievement of a functional requirement, then it is not relevant. An example of a functional requirement for life safety could be “avoid failure of the structure and protect the paths of egress from harmful fire effects until evacuation is completed”.

See also ISO 23932:2009, 6.4.

5.1.4 Identify performance criteria

The level of analysis (deterministic, probabilistic) and the performance criteria shall be agreed. Performance criteria are the 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. For a life safety functional requirement, performance criteria shall be developed. An example is setting the maximum concentration or dose of carbon monoxide that an occupant may be exposed to.

See ISO 23932:2009, 6.5.

5.1.5 Hazard identification

Hazard identification comprises both internal and external hazards that could have an impact on the built environment, hazards unique to the use of the property and hazards common to many properties, combustible materials or products, equipment and other heat sources, natural hazards and activities.

See ISO 23932:2009, Clause 7.

5.1.6 Fire safety design plan

The fire safety strategy shall be elaborated in a trial fire safety design plan and documented in a fire design report presenting enough detailed information to allow its evaluation in terms of meeting the fire safety objectives when assessed against the design fire scenarios. The fire safety design plan shall describe the functions of different parts of the built environment and their contribution to satisfying the fire safety strategy. Figure 1 illustrates the fire safety design process as described in ISO 23932.

5.2 The role of design fire scenarios in fire safety design

Design fire scenarios are the foundation of fire safety engineering assessments. Such assessments entail analysing design fire scenarios and drawing inferences from the results with regard to the adequacy of the proposed design to meet the performance criteria that have been set. Identification of the appropriate scenarios requiring analysis is crucial to the attainment of a built environment that fulfils the fire safety objectives.

In reality, the number of possible fire scenarios in most built environments approaches infinity. It is impossible to analyse all scenarios even with the aid of the most sophisticated computing resources. It is necessary to reduce this infinite set of possibilities to a manageable set of design fire scenarios that is amenable to analysis and that represents the range of fires that can challenge the engineering design that is the subject of the analysis.

Each design fire scenario is selected to represent a risk-significant cluster of fire scenarios. The risk associated with a cluster is characterized in terms of the combination of probability (or likelihood) of occurrence of the cluster and the resultant consequence. For the purposes of this International Standard, when a deterministic assessment is envisioned, a qualitative estimation of the likelihood and consequence suffices. For a full risk assessment, such as that outlined in ISO 16732-1, a quantitative estimation is undertaken.

Once design fire scenarios are selected, the design of the built environment is modified until the analysis demonstrates the performance criteria associated with the relevant fire safety objective(s) is met and the risk associated with the design is acceptably low.

It is necessary to identify relevant design fire scenarios in the preliminary qualitative report described in ISO 23932:2009, 10.2 and for them to be collectively reviewed by the stakeholders. During this process, it is possible to eliminate scenarios that are of such low risk that they cannot, individually or collectively, affect the overall evaluation of the design. It is important to remember that low consequence combined with high likelihood or high consequence combined with low likelihood can be high or low risk, depending on whether consequence or probability dominates. Neither probability nor consequence can be used completely in isolation for risk screening.

The characterization of a design fire scenario for analysis purposes involves a description of such things as the initiation, growth and extinction of fire, together with likely smoke and fire spread routes under a defined set of conditions. The impacts of smoke and fire on people, property, structure and environment are all part of potentially relevant consequences of a design fire scenario and are part of the characterization of that scenario when those consequences are relevant to the specified fire safety objectives. The characterization of fire growth, fire and smoke spread, fire extinction and fire and smoke impact involving temporal sequences of events belong to the “design fire”. Some later events are predictable from earlier events through the use of fire safety science and it is important that the characterization of the event sequence in the scenario be consistent with such science.

5.3 The role of design fires in fire safety design

Following identification of the design fire scenarios, it is necessary to describe the assumed characteristics of the fire on which the scenario quantification will be based. These assumed fire characteristics and the further associated fire development are referred to as the “design fire”.

A complete description of the design fire from ignition to decay is estimated using specified initial conditions and a series of simple calculations to estimate parameters such as the sprinkler activation time, transition to flashover and duration of fully developed burning. Alternatively, the design fire can be a combination of quantified initial conditions and subsequent fire development determined iteratively or by calculation using more complex models that account for phenomena such as transient effects of changing ventilation on smoke production or thermal feedback effects from a hot layer to the fuel surface.

As with the design fire scenario, it is important that the design fire be appropriate to the relevant fire-safety objectives. For example, if safety of life is an objective, a design fire could be selected that affects the means of escape. If the severity of the design fire is underestimated, then the application of engineering methods to predict the effects of the fire elsewhere can produce results that do not accurately reflect the true impact of fires and can underestimate the hazard. Conversely, if the severity is overestimated, unnecessary expense can result.

Guidance on characterizing design fires is given in Annex C.

6 Design fire scenarios

6.1 Characteristics of fire scenarios

Each fire scenario is represented by a unique occurrence of events and circumstances associated with the nature of the facility and the sources of fire, as well as a particular set of circumstances associated with the fire-safety measures. The latter are defined by the fire safety design, while the former is required to be specified to characterize the scenario. Accordingly, a fire scenario may be characterized with factors such as the following:

In relation to the nature of the facility or built environment:

— ventilation conditions including location and size of potential openings that could provide a source of air/oxygen during the course of the fire;

— ambient environmental conditions;

— interconnections between spaces or compartments providing potential routes of fire and smoke spread;

— materials and methods of construction and the size of the compartments;

— status and performance of each of the fire safety measures, including active systems and passive features;

— detection, alarm and suppression of fire by automatic or non-automatic (human) means;

— self-closing doors or other discretionary elements of compartmentalization;

— building air handling system or smoke management system;

— reliability of each of the fire safety measures.

In relation to the sources of fires:

— location of initial ignition (where the categories of location might be set to highlight occupied versus unoccupied spaces, spaces filled with valuable contents versus mostly empty spaces, or areas close enough to expose structural elements versus areas not so close. Each of these binary sorts could instead be made into a matter of degree, e.g. densely occupied, lightly occupied, occasionally occupied, inherently unoccupied);

— initial state is smouldering or flaming (which will be based firstly on the first item ignited and secondly on the igniting heat source);

— combustion environment of the initial ignition and availability of fuel is or is not sufficient to support fire growth to flashover (where the more detailed specifications of contents and furnishings, of room linings and such, or of fuel load per unit area, might be derived from field surveys that provide probabilities of high-density vs. low-density, high-combustibility vs. low-combustibility spaces directly. Alternatively, these might be set up as one of a few rooms designed and selected to represent all spaces that are or are not capable of going to flashover, where the probabilities are taken from fire statistics based on what percentage of fires in the design properties historically have gone to flashover or not).

6.2 Identification of fire scenarios

6.2.1 General

A systematic approach to the identification of design fire scenarios for analysis is required in order to identify important scenarios and to provide a consistent approach. The number of possible fire scenarios in any built environment can be very large and it is not possible to quantify them all. It is necessary to reduce this large set of possibilities to a manageable set of design fire scenarios that is amenable to