TECHNICAL REPORT

ISO/TR 16732-2

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Fire Safety Engineering — Fire risk assessment —

Part 2: Example of an office building

Ingénierie de la sécurité incendie — Évaluation du risque d'incendie —

Partie 2: Exemple d'un immeuble de bureaux

Reference number
ISO/TR 16732-2:2012(E)

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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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 16732-2 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 4, *Fire safety engineering*.

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

— *Part 1: General*

— *Part 2: Example of an office building* [Technical Report]

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

Introduction

This part of ISO/TR 16732 is an example of the application of ISO 16732-1, prepared in the format of ISO 16732-1. It includes only those sections of ISO 16732-1 that describe steps in the fire risk assessment procedure. It preserves the numbering of sections in ISO 16732-1 and so omits numbered sections for which there is no text or information for this example.

This part of ISO/TR 16732 is intended to illustrate the implementation of the steps of fire risk assessment, as defined in ISO 16732-1. Some steps are well illustrated by the example, and others are not well illustrated. The text of this part of ISO/TR 16732 indicates where the example is strongest.

Fire Safety Engineering — Fire risk assessment —

Part 2: Example of an office building

1 Scope

This part of ISO/TR 16732 is an example of the application of ISO 16732-1, prepared in the format of ISO 16732-1. It is intended to illustrate the implementation of the steps of fire risk assessment, as defined in 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 16732-1:2012, *Fire safety engineering — Fire risk assessment — Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16732-1 apply.

4 Applicability of fire risk assessment

This example was conducted to support a policy analysis of alternative national courses of action for fire safety for a class of properties. This situation qualified under several of the circumstances cited in Clause 4 of ISO 16732-1:2012. A wide range of scenarios was deemed to be necessary. There were multiple fire safety goals which made it inappropriate to use a short list of scenarios to represent all scenarios. The objectives were stated in risk terms such as expected annual losses.

5 Overview of fire risk management

Clause 5 of ISO 16732-1:2012, including Figure 1, is not reproduced here; it is not part of the calculations.

6 Steps in fire risk estimation

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.

6.1 Overview of fire risk estimation

Figure 1 describes the sequence of steps involved in fire risk estimation.

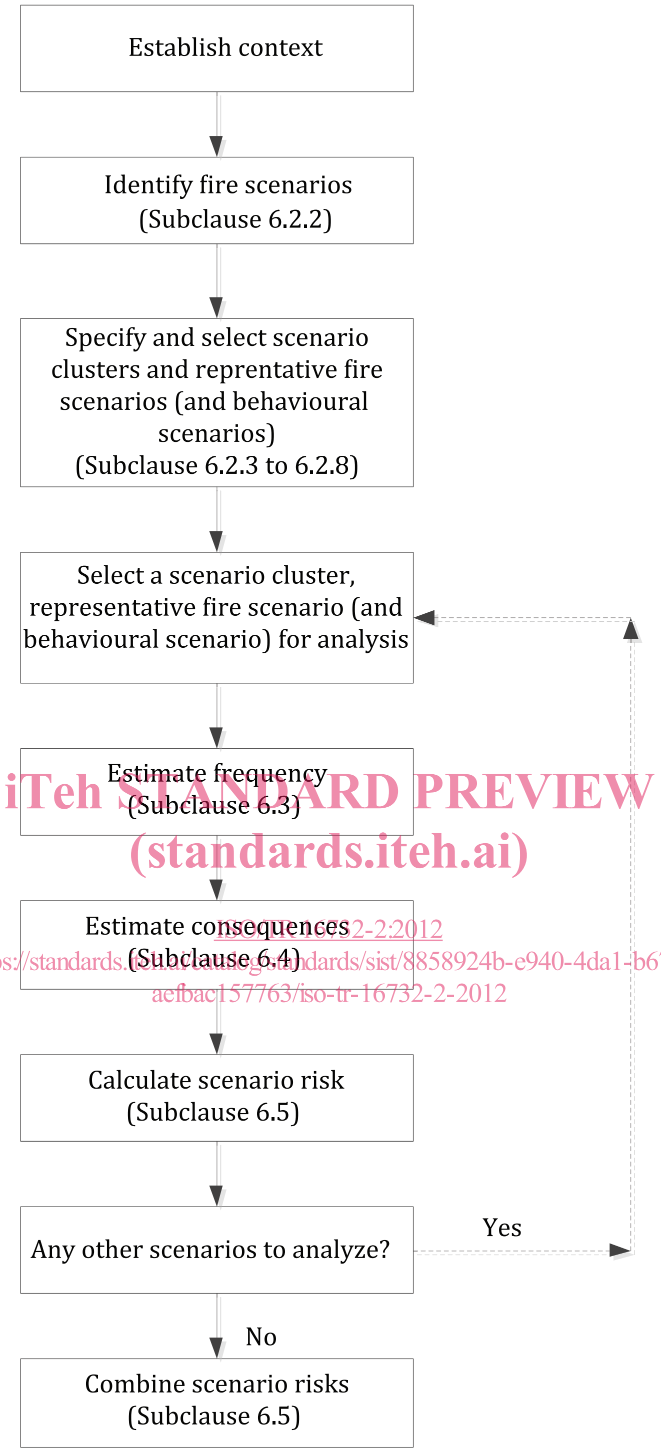


Figure 1 — Fire Risk Estimation Flow Chart

Fire risk estimation begins with the establishment of a context. The context provides a number of quantitative assumptions, which are required with the objectives and the design specifications to perform the estimation calculations.

6.1.1 Objectives

The main objectives and requirements of the building owner are to

a) provide the occupants with a level of fire safety that meets the building code requirements,

b) provide a safe area for occupants with disabilities,

c) minimize the potential for fire and smoke damage so as to minimize business losses to tenants, and

d) minimize the cost of fire protection and expected fire losses.

In the case study[1], the objectives were defined as (a) equivalent life-safety performance to that provided by a reference, code-compliant design, and (b) equivalent or better net cost over monetary benefits as compared to the reference design (i.e. cost effective design for property protection). Equivalence is to be established through engineering analysis using a fire risk estimation modelling package developed by the analysts for use on cases like this one.

6.1.2 Design Specifications

Several alternative designs were considered, differing in the use or non-use of automatic sprinkler protection, the use of different fire resistance ratings, and the use or non-use of a refuge area in addition to sprinklers.

a) Option 1, the reference option, is the code-compliant option: with a fire resistance rating (FRR) of 2 h, sprinkler protection (with an assumed 95 % reliability), without a refuge area, and with a central alarm with voice communication, as described in the NBCC requirements[2].

b) Option 2 is the same as Option 1 but with a slightly lower FRR of 90 min. This option is used to check the reduction in protection cost and the corresponding increase in risk.

c) Option 3 is the same as Option 2 but with a refuge area to help reduce risk. There was no consideration of an option with a refuge area but with no sprinklers; this analysis is not intended to comment on the attractiveness such an option would have had if it had been considered.

d) Option 4 is the same as Option 2 but with a 99 % reliability of the sprinkler system to help reduce risk.

e) Option 5 is the same as Option 2 but without sprinkler protection to check the risk without sprinklers.

Table 1 — Fire protection design options considered[1]

Design Option	Fire Resistance Rating	Refuge Area	Sprinklers
	(min)		(% Reliability)
1 (Reference)	120	No	95
2	90	No	95
3	90	Yes	95
4	90	No	99
5	90	No	No

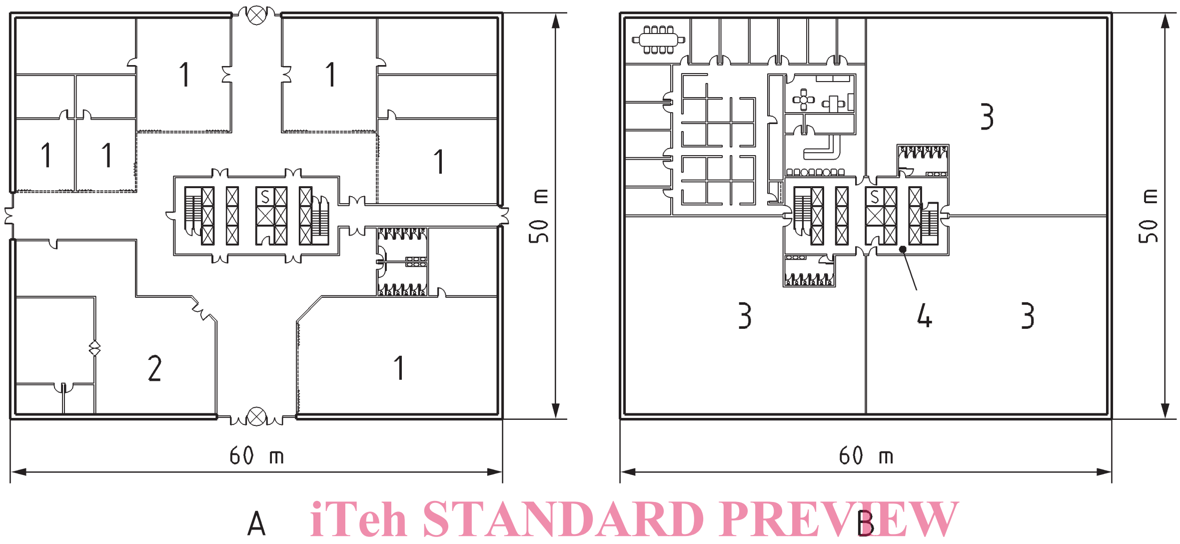
The building is a 40-storey, steel-framed, office building 60 m long by 50 m wide, with no basement. The layout of the floors is shown in Figure 2. The centre core contains the elevator, stair and service shafts, which provides

a) a profitable use of the perimeter and window area of the building for office space,

b) a simple floor layout that can be easily compartmented and fire separated, and

c) a refuge area that may act as a temporary safe place for occupants with disabilities and those who cannot evacuate during an emergency.

The ground floor has a restaurant, various retail stores, a lobby area at the main entrance, and three side exits with one connected directly to the stairs via a protected corridor. Floors 2 to 40 are divided into four spaces, suitable for use by professional companies (e.g. law offices). Each space can have two means of egress to the centre core area.



Key

1 Store
2 Restaurant
3 Office space
4 Refuge area
A Ground floor
B Floors 2 to 40

Figure 2 — Floor plans[1]

Since the building is an office building, the occupants are mainly office workers with the exception of some working in the restaurant and in the retail stores. The occupants on the upper floors with impaired mobility are assumed, in case of a fire emergency, to be helped by coworkers or to wait in the refuge area for rescue by the firefighters when they arrive on scene. The number of occupants per floor is assumed to be 300 (one occupant per 9.3 m^2 usable space, as per NBCC[2]). The refuge area in Figure 2 can accommodate 300 people. The total number of occupants in the building is 12,000. For design options without a refuge area, the layout is the same, but the indicated refuge area is not so extensively protected by fire-rated walls and smoke control systems.

6.2 Use of scenarios in fire risk assessment

6.2.1 Overview of specification and selection of scenarios

This step is just an introduction and does not need to be implemented as a step. The following steps define how the scenarios are selected in this study.

This step could also require a sensitivity analysis to determine the hazards that have the most impact on the probability of failure. This was not done for this example as the statistics used to define the probability of fire start were based on typical fire hazards in office buildings.

6.2.2 Combining scenarios into scenario clusters

This example began with a concise, parametric description of the universe of possible scenarios.

The scenario structure defines three distinct types of fires:

a) smouldering fires, where only smoke is generated;

b) non-flashover flaming fires, where a small amount of heat and smoke is generated; and

c) flashover fires, where significant amounts of heat and smoke are generated with a potential for fire spread to other parts of the building.

At this level of detail, the scenario specifications are not sensitive to detailed differences in the burning properties of initial fuel packages, let alone to the ease of ignition or burning properties of common major secondary fuels, such as large pieces of furniture or room furnishings, including floor, wall or ceiling coverings.

The definition of the type of fire is based on the severity of the fire when it was observed and recorded by the firefighters upon their arrival at the scene of the fire. Of course small fires can develop into fully developed fires (another name for flashover fires) if they are given enough time and the right conditions. However, the fire conditions at the time of fire department arrival are the ones used. They represent the fire conditions that the occupants are exposed to prior to fire department extinguishment and rescue operations.

The three fire types are extended into six scenario clusters by adding consideration of the status (open or closed) of the door to the room of fire origin. When the door is open, this may reflect the absence or failure of self-closing devices or human-caused obstructions that block the door open.

The modelling package used in the example includes a set of standard design fires. The initiating conditions of the fire and the status of the door from the first involved compartment are taken from the scenario cluster specifications. Other parameters are taken from the description of the subject property, which in this example was a 40-storey office building with specified room sizes and other dimensions, as well as standard fuel loads in the rooms and occupant loads and locations in the building. Some of these standard assumptions for an office building are taken from values set in the national building code. For some parameters – such as the location of the ignition point – the case study documentation does not clearly indicate how the parameters were determined. Details on such parameters can be found in the fire growth model.

The representative fire scenarios for the scenario clusters are therefore taken from the library of available design fires based on the best match to the defined characteristics of the subject property.

6.2.3 Exclusion of scenarios with negligible risk

In this example, the use of fire statistics to identify fire scenarios and to assemble the scenarios into scenario clusters made it unnecessary to exclude any scenarios based on negligible risk.

6.2.4 Demonstrating that the scenario structure is appropriate and sufficient

In the example, the scenario structure was comprehensive by definition, in that all types of fires were included in the scenario clusters. Questions could still remain regarding the representativeness of representative scenarios chosen for each scenario cluster, with respect to any conditions not defined by the subject property's specifications, the scenario cluster specifications, or the national building code's standard assumptions for engineering analysis. The location of the ignition point is an example of a condition not defined by any of those sources. The case study did not perform any analysis to demonstrate representativeness of its choices for those conditions.

Many other scenario characteristics, including the timeline of fire growth and spread of fire products, are derived from the modelling package operating on the externally defined initiating conditions. Therefore, the representativeness of those characteristics of the scenarios would depend in large part on the evidence for the validity of the models. That is discussed later.

