TECHNICAL REPORT

ISO/TR 13387-2

First edition
1999-10-15

Fire safety engineering —

Part 2:
Design fire scenarios and design fires

Ingénierie de la sécurité contre l'incendie —

Partie 2: Conception des scénarios-incendie et des feux

Reference number
ISO/TR 13387-2:1999(E)

Contents

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Printed in Switzerland

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 main task of ISO technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, 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).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 13387-2, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 4, *Fire safety engineering*.

It is one of eight parts which outlines important aspects which need to be considered in making a fundamental approach to the provision of fire safety in buildings. The approach ignores any constraints which might apply as a consequence of regulations or codes; following the approach will not, therefore, necessarily mean compliance with national regulations.

ISO/TR 13387 consists of the following parts, under the general title *Fire safety engineering:*

— *Part 1: Application of fire performance concepts to design objectives*

— *Part 2: Design fire scenarios and design fires*

— *Part 3: Assessment and verification of mathematical fire models*

— *Part 4: Initiation and development of fire and generation of fire effluents*

— *Part 5: Movement of fire effluents*

— *Part 6: Structural response and fire spread beyond the enclosure of origin*

— *Part 7: Detection, activation and suppression*

— *Part 8: Life safety — Occupant behaviour, location and condition*

Annex A of this part of ISO/TR 13387 is for information only.

Introduction

The specification of appropriate design fire scenarios and design fires are a crucial aspect of fire safety design. The assumptions made with regard to these factors have a major impact on all aspects of the design as they represent the input into most of the quantification processes.

A design fire scenario is the description of the course of a particular fire with respect to time and space. It includes the impact on the fire of building features, occupants, fire safety systems and all other factors. It would typically define the ignition source and process, the growth of fire on the first item ignited, the spread of fire, the interaction of the fire with its environment and its decay and extinction. It also includes the interaction of this fire with the building occupants and the interaction with the features and fire safety systems within the building.

ISO/TR 13387-1 provides a framework for the quantitative fire safety engineering assessment of buildings using time-dependent calculations. Fire scenario analysis forms the basis of the method described.

The basis of these calculations is the design fire. A design fire is an idealisation of real fires that may occur in the building. Design fires are described in terms of the variation with time of variables used in the quantitative analysis. These variables typically include heat release rate, fire size, yield of toxic species and yield of soot.

Where the calculation methods used are not able to predict fire growth and spread to other objects within the compartment of origin or beyond, such growth and spread needs to be specified by the analyst as part of the design fire, satisfying the functions of both SS2 and SS3.

Fire safety engineering —

Part 2:
Design fire scenarios and design fires

1 Scope

This part of ISO/TR 13387 provides guidance on the identification of appropriate design fire scenarios for consideration in fire safety design. It also provides guidance on the specification of design fires for quantitative analysis in fire safety design of buildings. This approach may be applied to other constructions. It is intended for use in conjunction with the methodology outlined in part 1 of this Technical Report.

The document describes a systematic approach to the identification of significant fire scenarios that need to be considered in fire safety design. Once significant fire scenarios have been identified, the document provides guidance on the selection of "design fire scenarios" for quantitative analysis.

The document provides guidance on the specification of "design fires" to reflect the design fire scenarios that have been identified for analysis. Design fires are specified in terms of important characteristics that form the input data into the quantitative analysis of various subsystems of the fire safety system as described in part 1.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO/TR 13387. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO/TR 13387 are encouraged to investigate the possibility of applying the most recent additions of the normative documents indicated below. For undated references, the latest addition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid international standards.

ISO/TR 13387-1, *Fire safety engineering — Part 1: Application of fire performance concepts to design objectives.*

ISO/TR 13387-3, *Fire safety engineering — Part 3: Assessment and verification of mathematical fire models.*

ISO/TR 13387-4, *Fire safety engineering — Part 4: Initiation and development of fire and generation of fire effluents.*

ISO/TR 13387-5, *Fire safety engineering — Part 5: Movement of fire effluents.*

ISO/TR 13387-6, *Fire safety engineering — Part 6: Structural response and fire spread beyond the enclosure of origin.*

ISO/TR 13387-7, *Fire safety engineering — Part 7: Detection, activation and suppression.*

ISO/TR 13387-8, *Fire safety engineering — Part 8: Life safety — Occupant behaviour, location and condition.*

ISO 13943, *Fire safety — Vocabulary.*

3 Terms and definitions

For the purposes of this part of ISO/TR 13387, the terms and definitions given in ISO 13943 and ISO/TR 13387-1 and the following apply:

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

Typically, it is an idealised description of the variation with time of important fire variables such as heat release rate, fire propagation, smoke and toxic species yield and temperature.

3.2
design fire scenario
a specific fire scenario on which an analysis will be conducted

3.3
engineering judgement
the process exercised by a professional who is qualified by way of education, experience and recognised skills to complement, supplement, accept or reject elements of a quantitative analysis

3.4
fire scenario
a qualitative description of the course of a fire with time, identifying key events that characterise the fire and differentiate it from other possible fires

It typically defines the ignition and fire growth process, the fully developed stage and the decay stage, together with the building environment and systems that will impact on the course of the fire.

3.5
relative risk
the relative potential for realisation of an unwanted event

It is the product of the probability of occurrence of a consequence and the magnitude of the consequence based on numbers that are only internally consistent within the set being compared and does not represent the actual risk in absolute values.

4 Symbols and abbreviated terms

A_w Area of window opening, expressed in m^2

g Acceleration due to gravity, expressed in m/s^2

h_w Height of window, expressed in m

$\dot{Q}$ Heat release rate, expressed in MW

$\dot{m}_{air}$ Rate of inflow of air, expressed in kg/s

$\dot{m}_f$ Rate of volatilisation of fuel, expressed in kg/s

R Burning rate (wood equivalent) , expressed in kg/s

r Stoichiometric air/fuel ratio

ρ Density, expressed in kg/m^3

t Time, expressed in s, min or h

T_a Ambient temperature, expressed in °C

T_g Fire gas temperature, expressed in °C

T_w Temperature of fire at window, expressed in °C

T_z Flame temperature along the vertical axis, expressed in °C

w Aggregate window width of enclosure, expressed in m

X Flame length along axis of flame, expressed in m

z Vertical distance, expressed in m

z_f Flame height, expressed in m

5 Design fire scenarios

5.1 Role of design fire scenarios in fire safety design

Design fire scenarios are at the core of the fire safety engineering methodology described in all parts of ISO/TR 13387. The methodology is based on analysing particular design fire scenarios and then drawing inferences from the results with regard to the adequacy of the proposed fire safety system to meet the performance criteria that have been set. Identification of the appropriate scenarios requiring analysis is crucial to the attainment of a building that fulfils the fire safety performance objectives.

In reality, the number of possible fire scenarios in most buildings approaches infinity. It would be impossible to analyse all scenarios even with the aid of the most sophisticated computing resources. This infinite set of possibilities needs to be reduced to a finite set of design fire scenarios that are amenable to analysis and the results of which represent an acceptable upper limit to the fire risk. That is to say that more onerous fire scenarios have an acceptable probability of occurring and that the consequences of those scenarios would need to be borne by society. The outcome of these extreme scenarios may be mitigated by additional factors that are often outside the scope of the analysis. Regulatory authority input into, and concurrence with, the selection of the design fire scenarios is most desirable.

The characterisation of a design fire scenario for analysis purposes should involve a description of such things as fire initiation, growth and extinction of fire, together with the likely smoke and fire spread routes under a defined set of conditions. This may include consideration of such conditions as different combinations of outcomes or events of each of the fire safety subsystems, different internal ventilation conditions and different external environmental conditions. The possible consequences of each design fire scenario need to be considered.

Important design fire scenarios need to be identified during the qualitative design review (QDR) stage. During this process, it is possible to eliminate scenarios that are of low consequence or have a very low probability of occurrence from further consideration (see 5.2.4). It is important to remember that smouldering fires may have the potential to cause a large number of fatalities in certain occupancies such as residential buildings.

Each design fire scenario is represented by a unique occurrence of events and is the result of a particular set of circumstances associated with the fire safety measures. Accordingly, a design fire scenario represents a particular combination of outcomes or events associated with factors such as:

— type of fire;

— internal ventilation conditions;

— external environmental conditions;

— performance of each of the fire safety measures;

— type, size and location of ignition source;

— distribution and type of fuel;

— fire load density;

— fire suppression;

— state of doors;

— breakage of windows;

— building air-handling system.

Design fires may be needed for a wide range of design fire scenarios. These may be internal or external fire scenarios. Examples of typical design fire scenarios include:

a) Internal

- — room fire (corner, ceiling, floor, wall);
- — fire in stairwells;
- — single burning item fire (furniture, wastepaper basket, fittings);
- — developing fire (smoke extraction);
- — cable tray or duct fire;
- — roof fires (under roof);
- — cavity fire (wall cavity, facade, plenum).

b) External

- — fire in neighbouring building;
- — fires in external fuel packages;
- — fires on roofs;
- — fires on facades.

Other design fire scenarios may be agreed upon during the QDR for special situations.

5.2 Identification of important design fire scenarios

5.2.1 General

A systematic approach to the identification of fire scenarios for analysis is desirable in order to identify all important scenarios and to provide a consistent approach by different analysts.

Generally, several design fire scenarios must be applied to the building under consideration to meet different requirements. At least one fire scenario should be considered for structural hazards and one for life safety hazards.

A risk-ranking process is recommended as the most appropriate basis for the selection of design fire scenarios. Such a process takes into account both the consequences and likelihood of the scenario.

Key aspects of the risk-ranking process, explained in the detailed steps below, are:

— identification of a comprehensive set of possible fire scenarios;

— estimation of the probability of occurrence of the scenario using available data and engineering judgement;

— estimation of the consequence of the scenario using engineering judgement;

— estimation of the relative risk of the scenarios (product of consequence and probability of occurrence);

— ranking of the fire scenarios according to the relative risk.

Design fire scenarios may need to consider not only the impact of all of the fire safety provisions on the chosen design fire but also the partial or complete failure of fire safety provisions.

Generally, fire scenarios involving simultaneous failure of a number of reliable fire safety systems properly maintained need not be considered as the combined probability of such scenarios are very low. However, if they are associated with very severe consequences, where the resultant risk is significant, then they need to be considered.

Fire incident statistics provide an appropriate basis for identification of the initial set of possible design fire scenarios. Fire statistics can be used to identify both the most common types of fire as well as the most hazardous type of fire for a particular occupancy.

The following systematic approach towards identifying possible design fire scenarios is recommended. It is recognised that alternative means of identifying design fire scenarios may be used.

5.2.2 Step 1 — Type of fire

From fire incident statistics appropriate for the building and occupancy under consideration, identify:

a) the most likely type of fire scenario;

b) the most likely severe-consequence fire scenario.

The most likely type of fire scenario can be determined from consideration of the items most commonly ignited, the ignition source and location of the fire from relevant fire incident statistics.

The most likely severe-consequence fire scenario can be determined by consideration of a subset of the fire incident statistics based upon an appropriate measure of the consequences, such as life loss or property loss. From this subset of severe-consequence incidents, appropriate for the building and occupancy under consideration, the most likely severe-consequence fire scenario can be identified.

If appropriate national statistics are not available, then information from other countries with similar fire experience may be utilised. Care needs to be exercised in applying fire incident statistics to ensure that the data is appropriate for the building under consideration.

5.2.3 Step 2 — Location of fire

For each of the scenarios identified in step 1, select a specific location or locations in the building that would produce the most adverse fire scenario(s).

5.2.4 Step 3 — Potential fire hazards

Consider the fire scenarios that could arise from the potential fire hazards identified during the qualitative design review phase.

Identify other critical severe-consequence scenarios for consideration. These scenarios typically involve:

— fires in assembly areas;

— fires within the egress system;

— fires blocking entry into the egress system;

— fires leading to structural collapse;

— fires involving high-hazard materials;

— fires exhibiting rapid growth.

If any of these scenarios is likely to have more severe consequences than those identified previously, they need to be included in the set for analysis. They may replace less hazardous scenarios that are similar in nature.

5.2.5 Step 4 — Systems impacting on fire

Identify the building and fire safety system features which are likely to have a significant impact on the course of the fire or the development of untenable conditions. Typical factors for consideration and their states include:

— type of fire (smouldering or flaming);

— wind (calm or representative of the location);

— doors and other openings in the enclosure of fire origin (open or closed);

— active suppression system (successful or unsuccessful in controlling fire);

— smoke management system (performed as expected or reduced performance);

— windows (glass intact or glass breaks);

— fire detection system (functions as designed or reduced performance);

— materials control (effective in limiting fire growth or not);

— warning and communication system (functions as designed or reduced performance);

— compartmentation (functions as designed or reduced performance);

— egress system (capacity and facility as designed or reduced);

— structural members (perform as designed or reduced performance).

5.2.6 Step 5 — Occupant response

Identify occupant characteristic and response features which are likely to have a significant impact on the course of the fire. Typical factors for consideration are:

— occupant response to alarm system (normal or delayed response);

— occupant intervention (successful or unsuccessful intervention).

5.2.7 Step 6 — Event tree

Construct an event tree that represents the possible states of the factors that have been identified as significant. A path through this tree represents a fire scenario for consideration.

Event trees are constructed by starting with an initial state, such as ignition, and then a fork is constructed and branches added to reflect each possible state of the next factor. This process is repeated until all possible states have been linked. Each fork is constructed on the basis of occurrence of the preceding state. An example of an event tree is illustrated in Figure 1 (not all scenarios need to be quantified).

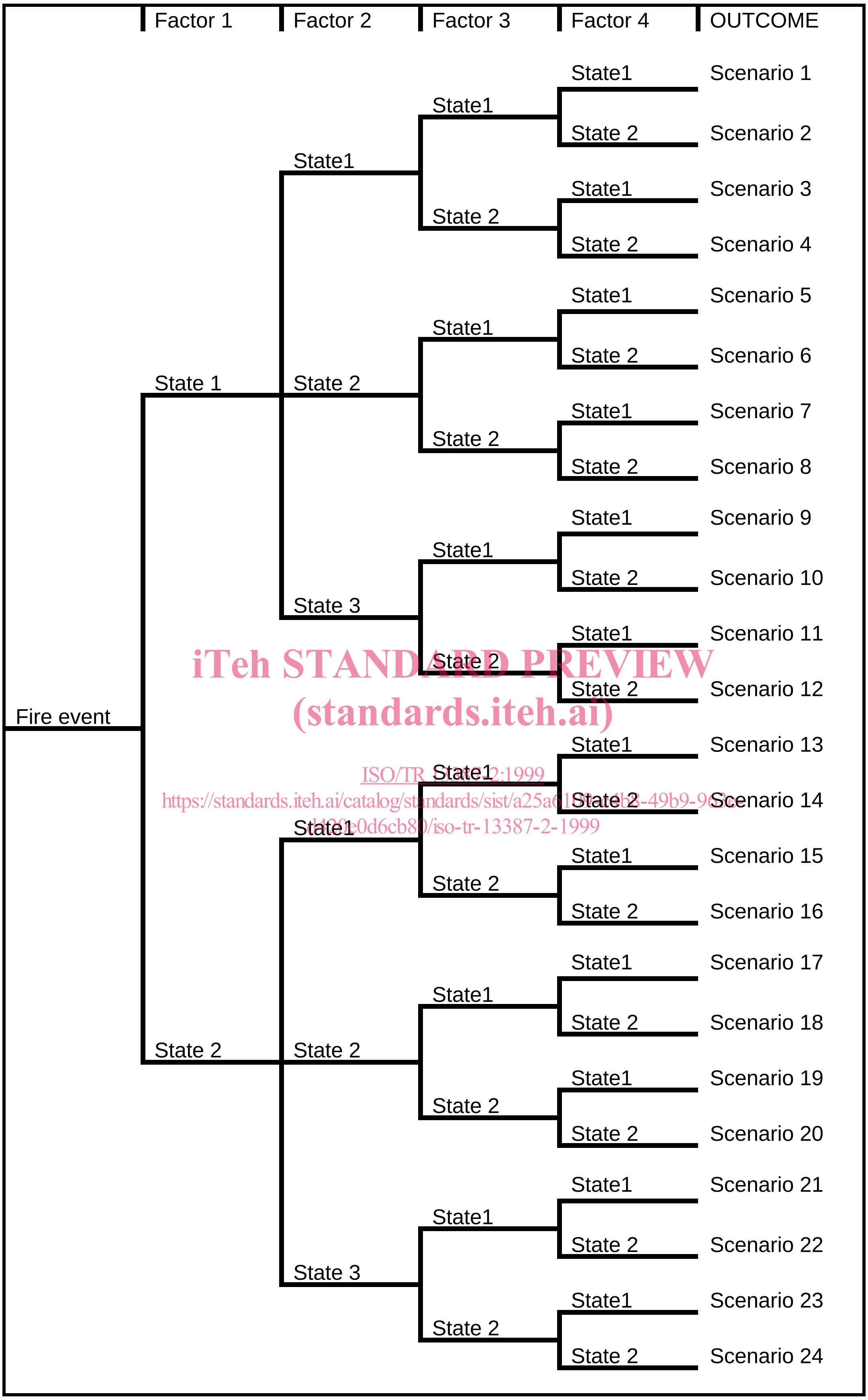

Figure 1 — Example of an event tree