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**Fire safety engineering —  
Requirements governing algebraic  
formulae —**

**Part 4:  
Smoke layers**

*Ingénierie de la sécurité incendie — Exigences régissant les formules  
algébriques —*

*Partie 4: Couches de fumée*





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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.

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 document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at [www.iso.org/patents](http://www.iso.org/patents). ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 4, *Fire safety engineering*.

This first edition cancels and replaces ISO 16735:2006, which has been technically revised.

The main changes are as follows:

- the main body has been simplified by making reference to ISO 24678-1;
- the arrival time of smoke front has been introduced in the calculations of smoke filling time in [Annex A](#);
- comparisons with experimental data have been added in [Annex A](#).

A list of all parts in the ISO 24678 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

The ISO 24678 series is intended to be used by fire safety practitioners involved with fire safety engineering calculation methods. It is expected that the users of this document are appropriately qualified and competent in the field of fire safety engineering. It is particularly important that users understand the parameters within which particular methodologies may be used.

Algebraic formulae conforming to the requirements of this document are used with other engineering calculation methods during a fire safety design. Such a design is preceded by the establishment of a context, including the fire safety goals and objectives to be met, as well as performance criteria when a trial fire safety design is subjected to specified design fire scenarios. Engineering calculation methods are used to determine if these performance criteria are met by a particular design and if not, how the design needs to be modified.

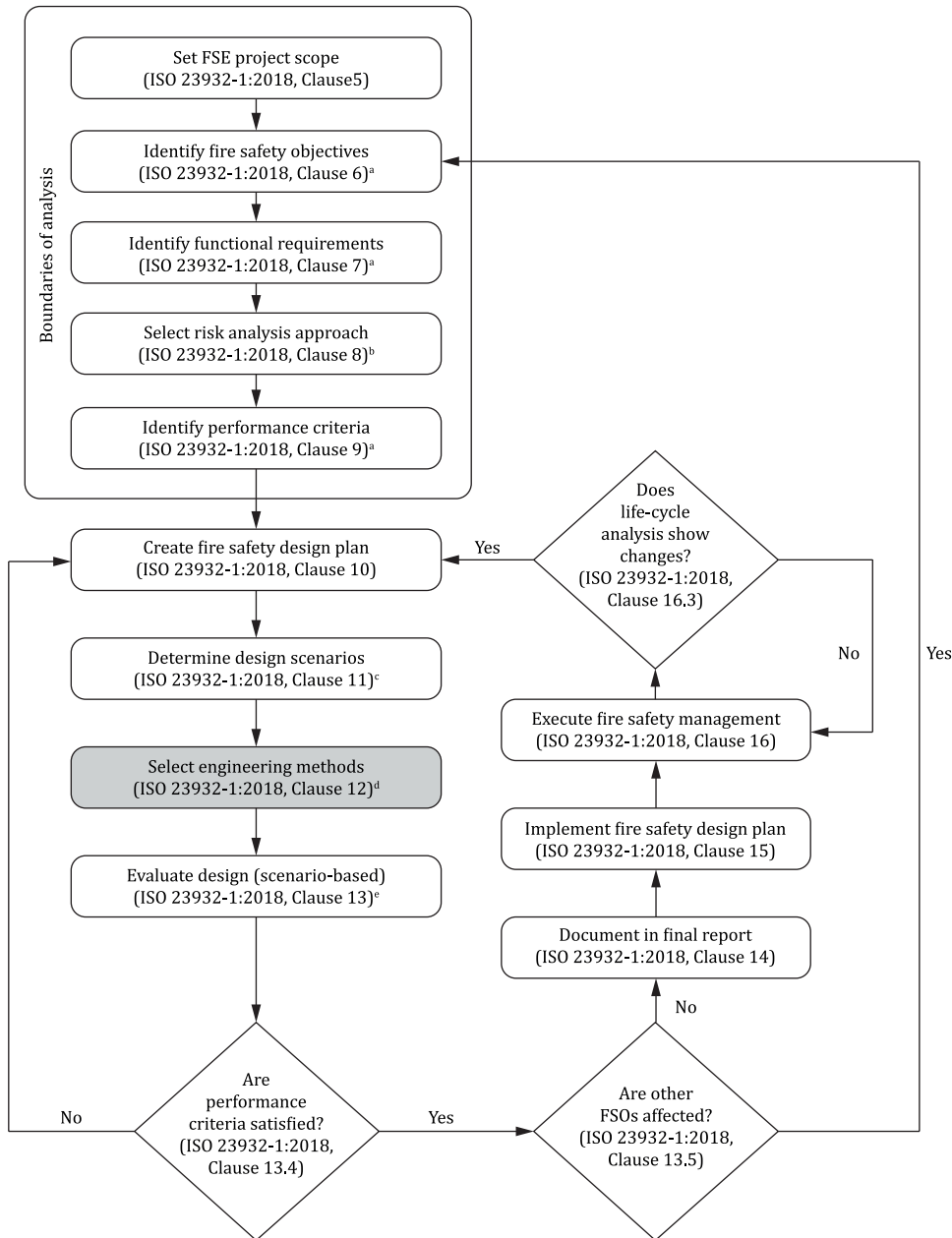
The subjects of engineering calculations include the fire-safe design of entirely new built environments, such as buildings, ships or vehicles, as well as the assessment of the fire safety of existing built environments.

The algebraic formulae discussed in this document can be useful for estimating the consequences of design fire scenarios. Such formulae are valuable for allowing the practitioner to quickly determine how a proposed fire safety design needs to be modified to meet performance criteria and to compare among multiple trial designs. Detailed numerical calculations can be carried out up until the final design documentation. Examples of areas where algebraic formulae have been applicable include determination of convective and radiative heat transfer from fire plumes, prediction of ceiling jet flow properties governing detector response times, calculation of smoke transport through vent openings, and analysis of compartment fire hazards such as smoke filling and flashover. However, the simple models often have stringent limitations and are less likely to include the effects of multiple phenomena occurring simultaneously in the design scenarios.

The general principles of fire safety engineering are described in ISO 23932-1, which 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 and the environment. ISO 23932-1 provides the process (i.e. necessary steps) and essential elements for conducting a robust performance-based fire safety design.

ISO 23932-1 is supported by a set of fire safety engineering documents on the methods and data needed for all the steps in a fire safety engineering design as summarized in [Figure 1](#) (taken from ISO 23932-1:2018, Clause 4). This set of documents is referred to as the Global fire safety engineering analysis and information system. This global approach and system of standards provides an awareness of the interrelationships between fire evaluations when using the set of fire safety engineering documents. The set of documents includes ISO/TS 13447, ISO 16730-1, ISO 16732-1, ISO 16733-1, ISO/TS 16733-2, ISO/TR 16738, ISO 24678-1, ISO 24679-1, ISO/TS 29761 and other supporting Technical Reports that provide examples of and guidance on the application of these documents.

Each document supporting the global fire safety engineering analysis and information system includes language in the introduction to tie that document to the steps in the fire safety engineering design process outlined in ISO 23932-1. ISO 23932-1 requires that engineering methods be selected properly to predict the fire consequences of specific scenarios and scenario elements (ISO 23932-1:2018, Clause 12). Pursuant to the requirements of ISO 23932-1, this document provides the requirements governing algebraic formulae for fire safety engineering. This step in the fire safety engineering process is shown as a highlighted box in [Figure 1](#) and described in ISO 23932-1.



a See also ISO/TR 16576 (Examples).

b See also ISO 16732-1, ISO 16733-1, ISO/TS 16733-2, ISO/TS 29761.

c See also ISO 16732-1, ISO 16733-1, ISO/TS 16733-2, ISO/TS 29761.

d See also ISO/TS 13447, ISO 16730-1, ISO/TR 16730-2 to ISO/TR 16730-5 (Examples), ISO/TR 16738, ISO 24678-1, ISO 24678-2, ISO 24678-3, ISO 24678-4 (this document), ISO 24678-5, ISO 24678-6, ISO 24678-7 and ISO 24678-9.

e See also ISO/TR 16738, ISO 16733-1, ISO/TS 16733-2.

NOTE Documents linked to large parts of the fire safety engineering design process: ISO 16732-1, ISO 16733-1, ISO 24678-1, ISO 24679-1, ISO/TS 29761, ISO/TR 16732-2 and ISO/TR 16732-3 (Examples), ISO/TR 24679-2 to ISO/TR 24679-4, ISO/TR 24679-6, ISO/TR 24679-8 (Examples).

**Figure 1 — Flow chart illustrating the fire safety engineering (FSE) design process (adapted from ISO 23932-1:2018)**

# Fire safety engineering — Requirements governing algebraic formulae —

## Part 4: Smoke layers

### 1 Scope

This document specifies the requirements governing the application of a set of explicit algebraic formulae for the calculation of specific characteristics of smoke layers.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. 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 24678-1, *Fire safety engineering — Requirements governing algebraic formulae — Part 1: General requirements*

### 3 Terms and definitions

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

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

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/>

#### 3.1

##### **boundary**

surface that defines the extent of an enclosure

#### 3.2

##### **enclosure**

room, space or volume that is bounded by surfaces

#### 3.3

##### **fire plume**

upward turbulent fluid motion generated by a source of buoyancy that exists by virtue of combustion and often includes an initial flaming region

#### 3.4

##### **fire source diameter**

effective diameter of the fire source, equal to the actual diameter for a circular source or the diameter of a circle having an area equal to the plan area of a non-circular source

#### 3.5

##### **flow coefficient**

fraction of effective flow area over total area of a vent