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Fire safety engineering — Requirements governing algebraic formulas — Flashover Related Phenomena

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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.

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 24678 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 4, *Fire safety engineering*.

Introduction

This standard is intended to be used by fire safety practitioners involved with fire safety engineering calculation methods. Examples include fire safety engineers; authorities having jurisdiction such as: territorial authority officials, fire service personnel, code enforcers and code developers. It is expected that users of this draft Standard 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 formulas conforming to the requirements of this standard are used with other engineering calculation methods during fire safety design. Such 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 tentative fire safety design is subject to specified design fire scenarios. Engineering calculation methods are used to determine if these performance criteria will be met by a particular design and if not, how the design must 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 formulas discussed in this standard are very useful for estimating the consequences of design fire scenarios. Such formulas are particularly valuable for allowing the practitioner to quickly determine how a proposed fire safety design should be modified to meet performance criteria. Thus, detailed numerical calculations can be delayed until final design documentation. Examples of areas where algebraic formulas have been applicable include determination of heat transfer, both convective and radiant, 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.

With respect to flashover phenomena, algebraic formulas are often used to estimate the threshold (minimum) heat release rate required to produce flashover in the space under consideration. These estimates can suggest restrictions on flammable contents or an appropriate fire detection and suppression package to limit the maximum expected heat release rate to below that expected to produce flashover. These formulas are empirically developed from experiments done in relatively small – rectilinear – enclosures of similar size and with walls and ceilings of similar thermal properties. Thus, the calculated threshold – flash over - heat release rates do not incorporate the many variables that complicate enclosure fires. Consequently, these calculated values should be considered as preliminary estimates. Ultimately, these estimates can be useful for checking the results of zone – and the more comprehensive numerical – models that calculate fire growth and its consequences.

Fire safety engineering — Requirements governing algebraic equations — Flashover Related Phenomena

1 Scope

1.1 The requirements in this standard govern the application of explicit algebraic formula sets to the calculation of flashover-related phenomena.

1.2 This standard is an implementation of the general requirements provided in ISO 16730-1 for the case of fire dynamics calculations involving sets of explicit algebraic formulas.

1.3 This standard is arranged in the form of a template, where specific information relevant to algebraic flashover formulas are provided to satisfy the following types of general requirements:

a) description of physical phenomena addressed by the calculation method;

b) documentation of the calculation procedure and its scientific basis;

c) limitations of the calculation method;

d) input parameters for the calculation method;

e) domain of applicability of the calculation method.

1.4 Examples of sets of algebraic formulas meeting the requirements of this standard will be provided in separate Annexes to this standard. Currently, there is one informative annex containing a set of algebraic equations each of which calculate the minimum heat release rate to cause flashover in residential size enclosures.

2 Normative references

The following referenced documents are indispensable for the application 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 16730-1 *Fire safety engineering — Assessment, verification and validation of calculation methods*

ISO 16733-1 *Fire safety engineering — Selection of design fire scenarios and design fires — Part 1: Selection of design fire scenarios*

ISO 16735 *Fire safety engineering — Requirements governing algebraic equations — Smoke* layers

ISO 16737 *Fire safety engineering — Requirements governing algebraic equations — Vent flows*

ISO 5725, all parts, *Precision of test methods – determination of repeatability and reproducibility for a standard test method by inter-laboratory tests*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943 shall apply. See annex for the terms and definitions specific to that annex.

4 Requirements governing description of physical phenomena

4.1 The onset of flashover is a complex thermo-physical phenomenon that can be highly transient. As a result of burning in an enclosure, hot smoke layer develops in the upper part as stated in ISO 16735. Heat and mass transfer in enclosure takes place. Radiative and convective heat transfer to fuel surface may increase the heat release rate. To calculate the onset of flashover, interactions between phenomena should be considered.

4.2 Flashover phenomena to be calculated and their useful ranges shall be clearly identified, including those characteristics inferred by association with calculated quantities.

4.3 Scenarios elements (e.g. two layers environment) to which specific formulas apply shall be clearly identified.

4.4 Because different formulas describe different flashover characteristics (4.2) or apply to different scenarios (4.3), it shall be shown that if there is more than one method to calculate a given quantity, guidance shall be given on the selection of appropriate methods. An example of description is given in Annex A.

5 Requirements governing documentation

5.1 The procedure to be followed in performing calculations shall be described through a set of algebraic formulas.

5.2 Each formula shall be presented in a separate clause containing a phrase that describes the output of the formula, as well as explanatory notes and limitations unique to the formula being presented.

5.3 Each variable in the formula set shall be clearly defined, along with appropriate SI units, although formula versions with dimensionless coefficients are preferred.

5.4 The scientific basis for the formula set shall be provided through reference to recognised handbooks, the peer-reviewed scientific literature or through derivations, as appropriate.

5.5 Examples shall demonstrate how the formula set is evaluated using values for all input parameters consistent with the requirements in Clause 5.

6 Requirements governing limitations

6.1 Quantitative limits on direct application of the algebraic-formula set to calculate output parameters, consistent with the scenarios described in Clause 5, shall be provided.

6.2 Cautions on the use of the algebraic-formula set within a more general calculation method shall be provided, which shall include checks of consistency with the other relations used in the calculation method and the numerical procedures employed.

7 Requirements governing input parameters

7.1 Input parameters for the set of algebraic-formulas shall be identified clearly, such as; geometric dimensions of enclosure surfaces and vents, special location of vents, special location of fire source, physical properties of boundaries, combustion properties and so on.

7.2 Sources of data for input parameters shall be identified or provided explicitly within the standard.

7.3 The valid ranges for input parameters shall be listed as specified in ISO 16730-1.

8 Requirements governing domain of applicability

8.1 One or more collections of measurement data shall be identified to establish the domain of applicability of the formula-set. These data shall have certain level of quality (e.g., repeatability, reproducibility – see ISO 5725) assessed through a documented/standardised procedure.

8.2 The domain of applicability of the algebraic formulas shall be determined through comparison with the measurement data of 8.1.

8.3 Potential sources of error that limit the set of algebraic formulas to the specific scenarios given in Clause 5 shall be identified, for example, the assumption of uniform gas layers in an enclosed space.

Annex A
(informative)

Algebraic Equations for Calculating the Minimum Heat Release Rate to Cause Flashover in Residential Size Enclosures

A.1 Terms and definitions used in Annex A

The terms and definitions given in ISO 13943 shall apply, in addition to the following:

A.1.1
critical heat release rate for flashover
The minimum heat release rate of a fire in an enclosure to cause flashover in that enclosure

A.2 Normative reference

The following referenced documents are indispensable for the application of this Annex. 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 9705, *Fire Tests — Full-scale room test for surface products*

ISO 16733-1, *Fire safety engineering — Selection of design fire scenarios and design fires – Part 1: Selection of design fire scenarios*

ISO 16735, *Fire safety engineering — Requirements governing algebraic equations — Smoke layers*

ISO 16737, *Fire safety engineering – Requirements governing explicit algebraic equations – Vent flows*

A.3 Symbols and abbreviated terms used in Annex A

A	Area of ventilation opening (m^2)
A_f	Area of floor (m^2)
A_T	total interior area of the enclosure excluding opening area (m^2)
A_{wc}	Area of walls and ceiling (m^2)
h_T	effective heat transfer coefficient ($kW \cdot m^{-2} \cdot K^{-1}$)
$(k\rho c)_f$	thermal inertia of floor lining ($kJ^2 \cdot m^{-4} \cdot K^{-2} \cdot s^{-1}$)
$(k\rho c)_{wc}$	thermal inertia of wall and ceiling linings ($kJ^2 \cdot m^{-4} \cdot K^{-2} \cdot s^{-1}$)
H	height of ventilation opening (m)
$\dot{m}$	mechanical ventilation rate ($kg \cdot s^{-1}$)
$\dot{Q}_{fo}$	critical (minimum) heat release rate to cause flashover (kW)
$\dot{Q}$	heat release rate in an enclosure (kW)
$\dot{Q}_0$	reference heat release rate (=1,000 kW)