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Life-threatening components of fire — Guidelines for the estimation of time available for escape using fire data

Composants dangereux du feu — Lignes directrices pour l'estimation du temps disponible pour l'évacuation, utilisant les caractéristiques du feu

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 13571 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 3, *Fire threat to people and environment*.

This first edition of ISO 13571 cancels and replaces ISO/TS 13571:2002 which has been technically revised.

Introduction

When evaluating the consequences to human life, the crucial criterion for life safety in fires is that the time available for escape be greater than the time required for escape. (Within the context of this International Standard, escape can be to a place of safe refuge.) The sole purpose of the methodology described here is to provide a framework for use in estimating the time available for escape.

The time available for escape is the interval between the time of ignition and the time after which conditions become untenable, such that occupants can no longer take effective action to accomplish their own escape. Untenable conditions during fires result from

a) exposure to radiant and convected heat;

b) inhalation of asphyxiant gases;

c) exposure to sensory/upper-respiratory irritants;

d) visual obscuration due to smoke.

The time available for escape is the calculated time interval between the time of ignition and the time at which conditions become such that an occupant is unable to take effective action to escape to a safe refuge or place of safety. As occupants are exposed to heat and fire effluents, their escape behaviour, movement speed and choice of exit route are also affected, reducing the efficiency of their actions and delaying escape; see ISO/TR 13387-8. These factors affect the time required for escape and are, therefore, not considered in this International Standard.

The methodology described here cannot be used *alone* to evaluate the overall fire safety performance of specific materials or products and cannot, therefore, constitute a test method. Rather, the equations in this International Standard are used as input to a fire hazard or risk analysis; see ISO 13387 (all parts). In such an analysis, the calculated time available for escape depends on many characteristics of the fire, the enclosure and the occupants themselves. The nature both of the fire (e.g. heat release rate, quantity and types of combustibles, fuel chemistry) and of the enclosure (e.g. dimensions, ventilation) determine the toxic-gas concentrations, the gas and wall temperatures and the density of smoke throughout the enclosure as a function of time. The characteristics of the occupants (e.g. age, state of health, location relative to the fire, activity at the time of exposure) also affect the impact of their exposure to the heat and smoke. The interrelationship of all these factors is shown schematically in Figure A.1. Furthermore, estimation of exposure is determined in part by assumptions regarding the position of the occupants' heads relative to the hot smoke layer that forms near ceilings and descends as the fire grows. As a result of all these factors, each occupant is likely to have a different estimated time available for escape (see also Clause A.5).

Annex A describes the context and mechanisms of the fire-effluent toxicity component of life threat. Effects such as those of the asphyxiant toxicants, carbon monoxide and hydrogen cyanide (Clause A.3), as well as the effects of both sensory/upper-respiratory irritants (A.4.2) and pulmonary irritants (A.4.3) are considered.

The heat component of life threat encompasses exposure both to radiant and to convective heat.

The initial impact of visual obscuration due to smoke is on factors affecting the time required for occupants to escape (see Clause A.2). This aspect of smoke obscuration is, therefore, not considered here. However, smoke obscuration of such severity that occupants become disoriented to a degree that prevents effective action to accomplish their own escape also places a limitation on the time available for escape and is considered in this International Standard.

Based upon available human and animal data, but in the absence of definitive, quantifiable human data, the effects of asphyxiant toxicants, sensory irritants, heat and visual obscuration are each considered as acting

independently. Some degree of interactions between these components are known to occur (Clause A.6), but are considered secondary in this International Standard.

The toxic effects of aerosols and particulates and any interactions with gaseous fire-effluent components are not considered in this International Standard. Based upon available human and animal data, it is known that the physical form of toxic effluents does have some influencing effects on acute incapacitation, but they are considered secondary to the direct effects of vapour-phase effluents and are not readily quantifiable.

Adverse health effects following exposure to fire atmospheres are not considered in this International Standard, although they are acknowledged to occur. Pre-existing health conditions may be exacerbated and potentially life-threatening sequelae may develop from exposure both to asphyxiants and to pulmonary irritants (A.3 and A.4.3).

The equations in this methodology enable estimation of the status of exposed occupants at discrete time intervals throughout the progress of a fire scenario, up to the time at which such exposure can prevent occupants from taking effective action to accomplish their own escape. Comparison of this time with the time required for occupants' escape to a place of safety (determined independently, using other methodology), serves to evaluate the effectiveness of a building's fire safety design. Should such comparison reveal insufficient available escape time, a variety of protection strategies then require consideration by the fire safety engineer.

The guidance in this International Standard is based on the best available scientific judgment in using a state-of-the-art but less-than-complete knowledge base of the consequences of human exposure to fire effluents. In particular, the methodology might not be protective of human health after escape, as the interactions of all potential life threats and the short- or long-term consequences of heat and fire-effluent exposure have not been completely characterized and validated.

This International Standard includes an indication of uncertainty for each procedure. The user is encouraged to determine the significance of these and all other uncertainties in the estimation of the outcome of a given fire scenario.

Annex A is for information only.

Life-threatening components of fire — Guidelines for the estimation of time available for escape using fire data

1 Scope

This International Standard is only one of many tools available for use in fire safety engineering. It is intended to be used in conjunction with models for analysis of the initiation and development of fire, fire spread, smoke formation and movement, chemical species generation, transport and decay and people movement, as well as fire detection and suppression. This International Standard is to be used only within this context.

This International Standard is intended to address the consequences of human exposure to the life threat components of fire as occupants move through an enclosed structure. The time-dependent concentrations of fire effluents and the thermal environment of a fire are determined by the rate of fire growth, the yields of the various fire gases produced from the involved fuels, the decay characteristics of those fire gases and the ventilation pattern within the structure (see Clause A.1). Once these are determined, the methodology presented in this International Standard can be used for the estimation of the available escape time.

This International Standard provides guidance on establishing the procedures to evaluate the life threat components of fire hazard analysis in terms of the status of exposed human subjects at discrete time intervals. It makes possible the determination of a tenability endpoint, at which time it is estimated that occupants are no longer able to take effective action to accomplish their own escape (see Clause A.2). The life threat components addressed include fire-effluent toxicity, heat and visual obscuration due to smoke. Two methods are presented for assessment of fire-effluent toxicity: the toxic-gas model and the mass-loss model.

Aspects such as the initial impact of visual obscuration due to smoke on factors affecting the time required for occupants to escape, the toxic effects of aerosols and particulates and any interactions with gaseous fire-effluent components and adverse health effects following exposure to fire atmospheres are not considered in this International Standard (see the Introduction).

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*

3 Terms and definitions

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

3.1
asphyxiant
toxicant causing loss of consciousness and ultimately death resulting from hypoxic effects, particularly on the central nervous and/or cardiovascular systems