TECHNICAL **ISO/TR**

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First edition
2009-08-01

# Fire-safety engineering — Technical information on methods for evaluating behaviour and movement of people

*Ingénierie de la sécurité incendie — Informations techniques sur les méthodes d'évaluation du comportement et du mouvement des personnes*

Reference number
ISO/TR 16738:2009(E)

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Published in Switzerland



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## Foreword

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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is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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ISO/TR 16738 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 4, *Fire safety engineering*.


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# Introduction

This Technical Report provides information (sometimes called “advice” or “guidance”, although there is no intention to present mandatory guidance) on engineering methods currently available for the evaluation of life-safety aspects of a fire-safety engineering design for the built environment, including structures such as tunnels, underground complexes, ships and vehicles. Advice is presented on the evaluation and management of occupant behaviour, particularly escape behaviour, during a fire emergency and for the evaluation of occupant condition and capabilities, particularly in relation to the effects of exposure to fire effluent and heat.

The guidance focuses mainly on the evacuation of the occupants, although maintenance in place or relocation to an area of refuge or safety can be appropriate alternatives in some situations. A basic principle of performance-based (fire-safety engineering) design is that the available safe-escape time (ASET) is greater than the required safe-escape time (RSET) by an adequate margin of safety.

Should a fire occur in which occupants can be exposed to fire effluent and/or heat, the objective of the fire safety engineering strategy is usually to ensure that such exposure does not significantly impede or prevent the safe escape (if required) of all of the occupants, without their experiencing or developing serious health effects.

Possible objectives for a fire-safety design can include ensuring that those occupants outside the area of fire origin are able to reach (or remain in) an area of safety without ever coming into contact with, or even being aware of, fire effluent and/or heat, while those inside the enclosure of fire origin are not subjected to life-threatening conditions. These are proposed as the main design criteria for the safety of the majority of occupants in multi-compartment structures.

There are, inevitably, some potential scenarios when some occupants do become aware of, or are exposed to, fire or fire effluent, particularly when the occupants are in the enclosure of fire origin. This can vary between seeing flames or smoke or exposure to slight smoke contamination, common in many fires, to life-threatening exposures. For all scenarios, it is important to be able to assess the likely behavioural responses and the effects of such experiences, either as part of the main design or as part of a fire risk assessment.

In order to achieve these evaluations, detailed input information is required in four main areas:

— building design and emergency life safety management strategy;

— occupant characteristics;

— fire simulation dynamics;

— intervention effects.

The response of occupants to a fire condition is influenced by a whole range of variables in these four categories, related to the characterization of the occupants in terms of their number, distribution within the building at different times, their familiarity with the building, their abilities, behaviours and other attributes; the characterization of the building, including its use, layout and services; the provision for warnings, means of escape and emergency management strategy; and the interaction of all these features with the developing fire scenario and provisions for emergency intervention (fire brigade and rescue facilities).

Guidance is provided on

a) the evaluation of escape and evacuation times from buildings:

   — for occupants not directly affected by fire (for example, in building locations remote from the fire compartment),

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— for occupants whose escape behaviour and, therefore RSET, is influenced by fire effluents and heat;

b) the evaluation of ASET in relation to tenability limits due to fire effluents and heat.

NOTE Reference can be made to ISO 13571 for details of calculation methods used for the evaluation of tenability in relation to exposure to fire effluent and heat.

The time required for escape depends upon a series of processes consisting of

— time from ignition to detection;

— time from detection to the provision of a general evacuation warning to occupants;

— evacuation time, which has two major phases:

  — pre-travel activity time, which consists of the time required to recognize the emergency and then carry out a range of activities before the evacuation travel phase,

  — travel time (the time required for occupants to travel to a safe location).

Time from ignition to detection and from ignition to alarm are covered in ISO/TR 13387-7. In terms of pre-travel activity time recognition and response times, most research (see References [1], [2], [3], [4], 5], [6], [7], [8] and also ISO/TR 13387-8) has been essentially qualitative, describing the psychological, behavioural and physiological factors affecting detection and recognition of fires and the wide range of behaviours engaged in by groups of occupants. There are few methods available for the quantification of these phenomena and the interactions between them, although some data on response time distributions have been obtained from observations of behaviour during real or simulated emergencies; see References [4], [5] and [9]. These studies have shown that the overall times required for these behaviours can comprise the greatest part of the time required for escape.

Travel to and through exits and escape routes involves more physically based processes, which have been relatively well quantified and are amenable to relatively simple calculation methods for design purposes; see References [10], [11], [12] and [13]. Nevertheless, travel times can be affected by behaviours such as way-finding and exit choice. Also, certain physical phenomena, such as merging flows, have not been adequately evaluated; see References [11] and [14].

There are considerable interactions between the various aspects of pre-travel activity time and travel times in the determination of total evacuation times for groups of building occupants. This has considerable implications for design performance evaluations; see References [6], [14], [15] and [16].

It is expected that users of this Technical Report are appropriately qualified and competent in the fields of fire-safety engineering and fire risk assessment. It is particularly important that users understand the parameters within which particular methodologies can be used. Users are cautioned that methods developed for, and assumptions based on observations from, building evacuations might not be directly applicable to different occupancies or to other built environments, such as tunnels or ships.


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