TECHNICAL SPECIFICATION

ISO/TS 16312-1

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Guidance for assessing the validity of physical fire models for obtaining fire effluent toxicity data for fire hazard and risk assessment —

Part 1: Criteria

Lignes directrices pour évaluer la validité des modèles de feu physiques pour l'obtention de données sur les effluents du feu en vue de l'évaluation des risques et dangers —

Partie 1: Critères

Reference number
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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.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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/TS 16312-1 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 3, *Fire threat to people and environment*.

ISO/TS 16312 consists of the following parts, under the general title *Guidance for assessing the validity of physical fire models for obtaining fire effluent toxicity data for fire hazard and risk assessment*:

- *Part 1: Criteria* [Technical Specification]

The following part is under preparation:

- *Part 2: Evaluation of individual physical fire models*

Introduction

Providing the desired degree of life safety for an occupancy increasingly involves an explicit fire hazard or risk assessment. This assessment includes such components as:

- information on the room/building properties,
- the nature of the occupancy,
- the nature of the occupants,
- the types of potential fires,
- the outcomes to be avoided, etc.

This type of determination also requires information on the potential for harm due to the effluent produced in the fire. Because of the prohibitive cost of real-scale product testing under the wide range of fire conditions, most estimates of the potential harm from the fire effluent will depend on data generated from a physical fire model, a reduced-scale test apparatus and procedure for its use.

The role of a physical fire model for generating accurate toxic effluent composition is to recreate the essential features of the complex thermal and reactive chemical environment in full-scale fires. These environments vary with the physical characteristics of the fire scenario and with time during the course of the fire, and close representation of some phenomena occurring in full-scale fires may be difficult or even not possible at the small-scale. The accuracy of the physical fire model, then, depends on two features.

a) The degree to which the combustion conditions in the bench-scale apparatus mirror those in the fire stage being replicated.

b) The degree to which the yields of the important combustion products obtained from burning of the commercial product at full scale are replicated by the yields from burning specimens of the product in the small-scale model. This measure is generally performed for a small set of products, and the derived accuracy is then presumed to extend to other test subjects. At least one methodology for effecting this comparison has been developed[1].

This part of ISO 16312 provides guidance for accuracy assessment with and without the use of laboratory animals. Generally, accurate estimation of the toxic potency of the effluent can be obtained from analysis of a small number of gases (the N-gas hypothesis), as described in ISO/TS 13571. This is especially true for product formulations similar to those for which the N-gas model has been confirmed. There are, however, cases where unusual toxicants have been generated in bench-scale apparatus. Thus, for novel commercial product formulations, confidence in the accuracy of the toxic potency measurement in the bench-scale device may be improved by a confirming bioassay and correlation with real-scale fire tests.

Guidance for assessing the validity of physical fire models for obtaining fire effluent toxicity data for fire hazard and risk assessment —

Part 1:
Criteria

1 Scope

This part of ISO 16312 provides technical criteria and guidance for evaluating physical fire models (i.e. laboratory combustion devices and operating protocols) used in effluent toxicity studies for obtaining data on the effluent from products and materials under fire conditions relevant to life safety[2]. Reference should be made to ISO 19701[3], ISO 19702[4], ISO 19703[5], ISO 19706[6], ISO 13344[7], and ISO/TS 13571[8] for presentation of relevant analytical methods, calculation methods, bioassay procedures and prediction of the toxic effects of fire effluents.

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 13943:2000, *Fire safety — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943:2000 and the following apply.

3.1
EC_{50}
concentration of a toxic gas or fire effluent statistically calculated from concentration-response data to produce an effect in 50 % of test animals within a specified exposure and post-exposure time

3.2
fuel/air equivalence ratio
ϕ
ratio of the fuel concentration to oxygen concentration in the fire zone divided by the stoichiometric fuel-to-oxygen ratio for the fuel

NOTE For $\phi < 1$, as in small or well-ventilated fires, the fuel/air mixture is said to be fuel lean; complete combustion (e.g. to CO_2 and H_2O) will dominate. For $\phi = 1$, the mixture is stoichiometric. For $\phi > 1$, as in ventilation-controlled fires, the mixture is fuel rich; relatively high concentrations of pyrolysis and incomplete combustion gases will result.

3.3

global equivalence ratio

⟨compartment fire tests⟩ ratio of the mass lost from the combustible(s) divided by the mass of air introduced into the compartment, normalised by the stoichiometric fuel/air ratio

NOTE Either global equivalence ratio (3.3 or 3.4) can be determined continuously or as a test average, depending on the instrumentation in place.

3.4

global equivalence ratio

⟨bench-scale devices⟩ ratio of the mass lost from the test specimen divided by the mass of air in the system (closed systems) or introduced into the system (open systems) normalised by the stoichiometric fuel/air ratio.

NOTE Either global equivalence ratio (3.3 or 3.4) can be determined continuously or as a test average, depending on the instrumentation in place.

4 General principles

4.1 Physical fire model

A physical fire model is characterized by the requirements placed on the form of the test specimen, the operational combustion conditions, and the capability of analysing the products of combustion.

4.2 Model validity

For use in providing data for effluent toxicity assessment, the validity of a physical fire model is determined by the degree of accuracy with which it reproduces the yields of the principal toxic components in real-scale fires.

4.3 Test specimens

Fire safety engineering requires data on commercial products or product components. In a reduced-scale test, the manner in which a specimen of the product is composed can affect the nature and yields of the combustion products.

4.4 Combustion conditions

The yields of combustion products depend on such apparatus conditions as the fuel/air equivalence ratio, whether the decomposition is flaming or non-flaming, the persistence of flaming of the sample, the temperature of the specimen and the effluent produced, the stability of the decomposition conditions, and the interaction of the apparatus with the decomposition process, with the effluent and the flames.

4.5 Effluent characterization

4.5.1 For the effluent from most common materials the major acute toxic effects have been shown to depend upon a small number of major asphyxiant gases and a somewhat wider range of inorganic and organic irritants. In ISO/TS 13571, a base set of combustion products has been identified for routine analysis. Novel materials may evolve previously unidentified toxic products. Thus a more detailed chemical analysis may be needed in order to provide a full assessment of acute effects and to assess chronic or environmental toxicants. A bioassay can provide guidance on the importance of toxicants not included in the base set. ISO 19706 contains a fuller discussion of the utility of bioassays.

4.5.2 It is essential that the physical fire model enable accurate determinations of chemical effluent composition.

4.5.3 It is desirable that the physical fire model accommodate a bioassay method.

5 Significance and use

5.1 Most computational models of fire hazard and risk require information regarding the potential of fire effluent (gases, heat, and smoke) to cause harm to people and to affect their ability to escape or to seek refuge.

5.2 The quality of the data on fire effluent has a profound effect on the accuracy of the prediction of the degree of life safety offered by an occupancy design.

5.3 Due to the large number of products to be included in fire safety assessments, the high cost of performing real-scale tests of products, and the small number of large-scale test facilities, information on effluent toxicity is most often obtained from physical fire models.

5.4 There are numerous physical fire models cited in national regulations. These apparatus vary in design and operation, as well as in their degree of characterization. This part of ISO 16312 defines what apparatus characteristics should define a physical fire model, identifies the data appropriate for assessing the validity of a physical fire model, and provides technical criteria for evaluating them with regard to the accuracy of their data relevant to life safety.

5.5 This part of ISO 16312 does not address means for combining the effluent component yields to estimate the effects on laboratory animals (see ISO 13344) or for extrapolating the test results to people (see ISO/TS 13571).

6 The ideal fire effluent toxicity test method

6.1 Fire stages

6.1.1 The combustion and/or pyrolysis conditions in the combustor section of the apparatus reproduce the conditions in one or more stages of actual fires, including incipient, growing and fully developed fires.

6.1.2 Specimens are burned under constant, pre-selected conditions of thermal insult and oxygen availability (ventilation). The decomposition conditions and decomposition behaviour of the specimen enable yields to be characterized for specific condition parameters.

6.1.3 For initial and progressive smouldering, the effects of specimen bulk and thermal properties are considered.

6.1.4 For growth and early fire simulations, including oxidative pyrolysis and well ventilated flaming, the in-use exposed surface of a material or product is exposed to the appropriate thermal insult.

6.1.5 For simulation of the developed stages of a fire, full burning of the test specimen is required.

6.2 Applicability

This method tests homogeneous materials (both solid and cellular) and commercial products (especially layered, non-uniform specimens), both melting and non-melting, in relevant form and under simulated fire scenarios. The nature and quantity of the decomposition products is representative of actual fire scenarios.

6.3 Apparatus independence

The apparatus does not impose any significant influence on the results, i.e. the results reflect the burning behaviour of the test specimen and not apparatus effects. Flame quenching on surfaces should not affect the nature of the effluent and the effluent should not be subject to ageing effects. The combustion zone and effluent plume treatment are designed to ensure that these are achieved.

6.4 Operational efficiency

The test equipment is as simple as possible and capable of safe operation.