
Toxicity testing of fire effluents —

Part 4:

The fire model (furnaces and combustion apparatus used in small-scale testing)

Essais de toxicité des effluents du feu —

Partie 4: Modèle feu (fours et appareillages de combustion utilisés dans les essais à petite échelle)



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Contents

	Page
1 Scope	1
2 Characteristics of fire stages	1
3 Criteria for assessment of fire models	2
3.1 Relevance to real fires	2
3.1.1 Oxygen concentration	2
3.1.2 CO ₂ /CO ratio	2
3.1.3 Temperature and heat flux	2
3.2 Validity to toxic hazard assessment	3
3.3 Specimen composition and configuration	3
3.4 Documentation and experience	4
3.5 Exposure dose quantification	4
3.6 Procedural criteria	4
4 Fire models	4
4.1 "Box" furnace models	4
4.1.1 NBS cup furnace	4
4.1.2 UPitt box furnace	5
4.2 Tube furnace models	6
4.2.1 DIN 53436 tube furnace	6
4.3 Radiant heat models	7
4.3.1 US radiant furnace (modified)	7
4.3.2 Cone calorimeter	9
4.3.3 Japanese cone furnaces	10
4.3.3.1 BRI (Building Research Institute) cone furnace	10
4.3.3.2 RIPT (Research Institute for Polymers and Textiles) cone furnace	11

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4.3.4 Japanese Ministry of Construction model 11

5 Selection of a fire model 12

Annex

A Bibliography 13

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 main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, 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).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 9122-4, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 92, *Fire tests on building materials, components and structures*, Sub-Committee SC 3, *Toxic hazards in fire*.

This document is being issued in the type 2 Technical Report series of publications (according to subclause G.4.2.2 of part 1 of the ISO/IEC Directives) as a "prospective standard for provisional application" in the field of toxicity testing of fire effluents because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this type 2 Technical Report will be carried out not later than two years after its publication with the options of: extension for another two years; conversion into an International Standard; or withdrawal.

ISO/TR 9122 consists of the following parts, under the general title *Toxicity testing of fire effluents*:

- *Part 1: General*
- *Part 2: Guidelines for biological assays to determine the acute inhalation toxicity of fire effluents (basic principles, criteria and methodology)*
- *Part 3: Methods for the analysis of gases and vapours in fire effluents*
- *Part 4: The fire model (furnaces and combustion apparatus used in small-scale testing)*
- *Part 5: Prediction of toxic effects of fire effluents*

Annex A of this part of ISO/TR 9122 is for information only.

Introduction

Fire involves a complex and interrelated array of physical and chemical phenomena. As a result, it is essentially impossible to simulate all aspects of a real fire in laboratory-scale apparatus. This problem of fire model validity is perhaps the single most perplexing technical problem associated with all of fire testing.

For fire models used in evaluating fire effluent toxicity, additional restrictions and criteria are necessarily imposed due to the need for the laboratory combustion to be compatible with bioassay procedures using live test animals. For example, reduced oxygen levels and heat must not, in themselves, be unduly compromising to exposed animals. At the same time, sufficiently high concentrations of fire effluents must be produced so as to obtain measurable toxicological effects. As a result of these restrictions, compromises must often be made which can further reduce the apparent validity of the fire model.

Essentially two approaches are used to evaluate the toxicity of fire effluents; i.e. those using full-scale fire models and those using small-scale fire models. In full-scale procedures, fire models consisting of a room, multiple rooms or a complete building are used which are intended to simulate as far as possible the full characteristics of fires including ignition, growth and evolution of toxic fire effluents. Full-scale methods are usually applied in tests of the toxic *hazard* presented by the fire, although some attempts have been made to model the main features of toxic hazard in small-scale tests.

In small-scale fire models, it is considered possible to re-create the reactive chemical environments characteristic of various stages and types of fire conditions in terms of temperature, the presence or absence of flame and oxygen supply. Under these conditions, the relative yields of toxic products in the fire effluents from materials will be similar to those evolved at equivalent stages in full-scale fires. Thus, small-scale fire models are regarded as relevant to the testing of the toxic *potencies* of the chemical products evolved from materials under the defined decomposition conditions. These potency values may then be used as input data in toxic hazard assessments which take into consideration the dynamic characteristics of specific fire scenarios.

Toxicity testing of fire effluents —

Part 4:

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1 Scope

This part of ISO/TR 9122 is restricted to the consideration of fire models (i.e. laboratory combustion devices) used in fire effluent toxicity studies, together with suggestions for the appropriate use of the fire models in standard testing. Reference should be made to other parts of ISO/TR 9122 for discussions of analytical methods, bioassay procedures, toxicity testing and prediction of toxic effects of fire effluents.

This part of ISO/TR 9122 defines the criteria for an acceptable fire model, reviews existing fire models against these criteria, and proposes that fire models

be selected for use through consideration of these criteria which includes a capacity to generate fire conditions characteristic of known stages of fire.

This part of ISO/TR 9122 does not give a detailed analysis of the physics and chemistry of fire.

2 Characteristics of fire stages

For the purposes of a discussion of fire models and their appropriate use, the combustion conditions shown in table 1 are generally accepted as being characteristic of certain stages or phases of fire^[1].

Table 1 — General classification of fire stages

Stage or phase of fire	Oxygen content ¹⁾ (%)	CO ₂ /CO ratio ²⁾	Temperature (°C)	Irradiance ³⁾ (kW/m ²)
Non-flaming decomposition a) Smouldering (self-sustaining) b) Non-flaming (oxidative) c) Non-flaming (pyrolitic)	21 5 to 21 < 5	not applicable not applicable not applicable	< 100 < 500 < 1 000	not applicable < 25 not applicable
Flaming developing fire	10 to 15	100 to 200	400 to 600	20 to 40
Flaming fully-developed fire a) Relatively low ventilation b) Relatively high ventilation	1 to 5 5 to 10	< 10 < 100	600 to 900 600 to 1 200	40 to 70 50 to 150
1) General environmental condition (average) within compartment. 2) Mean value in fire plume near to fire. 3) Incident irradiation on the sample (average).				