

TECHNICAL REPORT

ISO TR 3814

Second edition
1989-12-15

Tests for measuring “reaction-to-fire” of building materials — Their development and application

*Essais de mesurage de la « réaction au feu » des matériaux de bâtiment — Leur
élaboration et leur application*



Reference number
ISO/TR 3814 : 1989 (E)



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Foreword

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The main task of ISO technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a technical report of one of the following types:

- type 1, when the necessary support within the technical committee cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development requiring wider exposure;
- 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 are accepted for publication directly by ISO Council. 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 Technical reports type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.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 3814, which is a technical report of type 3, was prepared by Technical Committee ISO/TC 92, *Fire tests on building materials, components and structures*.

This second edition cancels and replaces the first edition (ISO/TR 3814 : 1975) and ISO/TR 6585 : 1979, which have been technically revised.

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Case postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Introduction

A building fire can constitute a hazard to both the building structure and to its occupants, because of the heat generated and the production of smoke and gaseous products of combustion. Consequently, early building codes and regulations were designed to prevent rapid fire development and spread within individual buildings and also from one building to another. These codes have since developed into more complex laws governing public safety. Formerly, a distinction was made between the protection of persons from fire and the protection of property, with more importance being placed upon the latter. However, this distinction becomes somewhat difficult to make when considering modern, large-area, high-rise structures, where protection of the occupants in-place must substitute for rapid evacuation. Restrictions on the use of combustible materials, compartmentalization, early fire detection and extinguishment are key factors for in-place protection of occupants and are also important for minimizing property loss.

This Technical Report describes the work being carried out by Sub-committee ISO/TC 92/SC 1 on the development of tests for the “reaction-to-fire” of building materials and discusses the role and limitations of these tests in reducing fire danger.

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Tests for measuring “reaction-to-fire” of building materials — Their development and application

1 Development of “reaction-to-fire” tests

Building control authorities in many countries have been concerned over the years about the safe use of materials in the construction of buildings. A number of national test methods have, therefore, been developed to provide the data necessary to identify the important characteristics of building materials or products under fire conditions. These tests, most of which are of laboratory scale, are collectively referred to as “reaction-to-fire” tests and include:

ignitability; surface spread of flame; smoke development and obscuration; rate of heat release; non-combustibility; corner wall/room fire development.

The original “reaction-to-fire” tests were generally developed with particular hazards, or fire situations, in mind. For example, the predecessors of the modern surface spread of flame tests were developed in the 1930s and 1940s using flame or radiative heat exposure to represent a fire burning freely in one corner of a room. Such tests are frequently referred to as “open tests”. Later developments led to tests which included a representation of the room itself, these tests being called “enclosure tests” or “box tests”. In the latter case some, or all of the heat produced by the burning material, is retained in the enclosure and therefore can in turn affect more of the material. Consequently, fire exposures in “enclosure tests” are often more severe than in “open tests”.

Some national tests are designed to measure more than one fire parameter. The individual results can sometimes be used independently, although the importance attached to each can vary, whereas in others the test results can be combined empirically to produce an index, or a range of indices, of performance. Considerable care must be taken when interpreting the results of such combined tests.

Because the various national reaction-to-fire test methods have been developed in different ways, even though they are intended to measure essentially the same fire characteristics, it has proved very difficult, and in some cases impossible, to obtain any meaningful correlations between the test results obtained when using them. This has created major difficulties, both for product manufacturers and for regulatory authorities around the world, when comparing the fire performance of products which have been tested using different national test methods. Additional problems have also arisen concerning international acceptance of fire test data, and in some cases these have created barriers to trade.

In an attempt to resolve this situation, ISO/TC 92 decided in the late 1960s to develop a series of individual test methods, each of them capable of providing information about certain aspects of the fire performance of a range of building products, including those intended for use as wall and ceiling linings, floors and external cladding. It was intended that as the new international test methods were developed and accepted, countries should incorporate them into their regulations, thereby minimizing the problems caused by the use of individual national tests.

Sub-committee 1 was, therefore, established and instructed to devise a “tool kit” of reaction-to-fire tests which could be used either individually, or collectively, to provide the required information on the fire performance of building materials and products.

2 Fire development and growth

Fire statistics show that the majority of fires are started by the ignition of building contents. Nevertheless, during a fire in a building all combustible products present can contribute to the overall fire hazard, whether they are present as contents, or are used to form part of the building itself. The product first involved in a fire will emit energy in the form of hot gases and radiative heat. Under unfavourable conditions this can then cause ignition of other combustibles in the room. If enough fuel and oxygen are available this process will continue progressively with increasing temperature. Building products may therefore become involved at any stage of a developing fire. Consequently, reaction-to-fire tests have to provide different exposure intensities simulating fire situations in the range between fire initiation and a fully-developed fire.

Figure 1 shows the different phases occurring during the development of a fire within a room. Reaction-to-fire properties such as ignitability, spread of flame and heat release produced by fire effluents are primarily related to the phases of a developing fire before “flashover”.

The fire performance of a building product is generally highly complex and is not usually solely dependent on the chemical composition of the material itself, but is affected by many other factors. These can include its shape, surface area, mass, thermal inertia, its orientation and position in relation to the potential ignition source and also its combination with other materials. In addition, the environmental and service conditions to which the product has been exposed prior to ignition, the

intensity and duration of the thermal exposure and also the ventilation conditions during exposure can influence its fire performance.

These factors, provided by the product and its environment, should be taken into consideration as far as possible when designing test methods and using the results for estimating potential fire risks. It is important in the assessment of such risks to pay particular attention to all of these, since a variation in one or more of them can significantly influence the product's contribution to a fire. It must, therefore, be stressed that the fire performance of a building product cannot be deemed to be a "specific material property" to which a specific fire risk can be related.

3 Fire risk assessment

Building control authorities, fire protection engineers, and scientists have been developing and using fire risk assessment procedures for many years, even though they have not been thought of as such. These procedures, which have formed the basis for the development of fire protection codes and standards, have of necessity been primarily based on experience, since until recently very little effort has been made to refine the state-of-the-art knowledge to provide a technical basis for them.

Fire risk assessment procedures usually include an evaluation of the following.

3.1 A determination that a particular product may be potentially hazardous in a fire

The possibility that a particular product will create a hazard in a fire has generally been based on the assumption that combustible materials can contribute actively to a fire, whereas non-combustible materials will not. Consequently, most regulations are based on the concept that combustible materials, as defined by a specified test method, may be considered to be potentially "harmful" and non-combustible materials are, therefore, conversely considered to be "safe". Whereas this may be considered to be a reasonable general approach it must not be assumed to be applicable in all cases, since the presence of non-combustible materials can influence fire performance to some degree, particularly in the context of fire growth and spread in a compartment. For example, when making a hazard assessment of a product intended for use in a particular situation, account has to be taken of

- the thermal inertia (kpc) of products in surrounding structures;
- the reflecting properties of those products;
- organic compounds both inside or outside the products, e.g. binders, adhesives, coverings, etc.;
- the influence of air gaps between non-combustible and combustible products.

3.2 An estimate of the probability of the product being ignited under particular conditions

The probability of a fire occurring is a most important consideration in the fire risk assessment process, and this can be

very difficult to estimate. Currently, much reliance is placed on experience and fire records to determine this probability.

The traditional approach was based on the so-called "fire triangle" which required that three components, viz. heat, fuel and oxygen, must be available in appropriate quantities for a fire to start and to be sustained. However, even this was not a simple concept to apply since it was found that factors other than just the quantities of the various components needed to be taken into account. For instance, the total quantity of fuel available may not be a critical factor for determining ignitability since the physical form in which the fuel is presented to the ignition source can also have a significant effect. In general, a material in a finely divided form with a relatively large surface area such as thin strips, shavings, etc., will be more easily ignited and permit more rapid flame spread across its surface and consequently be potentially more hazardous than an equivalent quantity of the same material in a solid form. Indeed, when some materials are used in the form of a fine powder, the ignition process can occur explosively under certain conditions.

Other considerations also need to be taken into account during the assessment procedure, such as whether any heat generated is likely to be retained in close proximity to the fire source, e.g., from a fire in a closed compartment.

3.3 A knowledge of the reaction of the product in various fire situations

Fire tests developed by ISO/TC 92 and similar organizations may provide the necessary information on the reactions of products to different fire situations. However, such tests are most useful when a range of ignition sources and heating conditions can be used. Results based only on a restricted range of test conditions should therefore be used with caution. For example, a product may react entirely differently when exposed to a high heat flux than when tested with a relatively low heat flux.

Although desirable, it is not possible at this time for any one test method to simulate every possible fire scenario. However, every effort should be made to use a thermal exposure in each test which relates to some real fire situation, preferably one that will also give results which can be used for fire modelling calculations.

3.4 Recognition of the degree of risk which is economically and socially acceptable in a given situation

This is a most important aspect of the fire risk assessment process which many believe should be the responsibility of sociologists and/or politicians. However, although such persons may be required to make the final decision, the total responsibility should not rest solely with them. They should be advised by technical experts who have studied the problems in depth and who have a thorough understanding of the significance of all relevant factors.

An important stage in the risk analysis process entails defining the relative hazard represented by the occupancy of the building. An occupancy which consists of alert, mobile people should be able to accept a higher degree of risk than one where the occupants are non-ambulatory or asleep. Careful consideration should also be given to the site location, the nature of the surrounding terrain, the availability of assistance, etc., which can all play major roles.