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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

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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.

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 Technical reports type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.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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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

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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 (kρc) 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 it 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.

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Once the decision has been made on what is an acceptable level of risk, then all available techniques should be used to devise the most economical and practicable method of keeping the risk below this critical level.

4 Reducing the risk

Over the years many different techniques have been used to reduce the risks arising from building fires, these include

a) reduction of fire incidents by education of building occupants;

b) control of the types and amounts of hazardous materials permitted in specific areas;

c) isolation and control of potential ignition sources, such as heating devices and electrical appliances;

d) providing separations between easily ignitable materials;

e) restriction of rapid fire spread by the use of flame retardant materials;

f) mitigation of the effects of a fire by providing adequate early detection, easily accessible escape routes, smoke control, and extinguishing equipment;

g) containment of fires within limited areas by the use of fire resistant structural elements such as floors and walls, and the protection of openings by the use of fire doors, shutters, etc.

It is obvious from the foregoing that control of building materials under fire conditions is but one aspect of the complex process of fire risk reduction with respect to building protection and life safety.

5 Current work and future developments

The development work already carried out, or nearing completion, within Sub-committee 1 has resulted in the availability of a number of test methods conforming to the ISO "tool kit" concept. These methods satisfy the required specifications regarding ruggedness and ease of operation of test apparatus and reproducibility of test results. Some test outputs or results directly describe the basic material flammability parameters governing the fire growth process within a compartment. Other parameters are only implicitly given by the test data. A serious deficiency is the lack of suitable procedures to translate fire test data accurately and unambiguously into actual fire performance specifications.

The present situation can best be described by reference to a practical situation. Figure 2 gives the time to ignition for two hypothetical materials, A and B, when tested in the ignitability test. Figures 3a) and 3b) represent two possible outcomes from the rate of heat release (RHR) tests for materials. A reasonable interpretation of the test results if figures 2 and 3a) are combined is that material A is the more hazardous. But if the RHR test follows figure 3b), no obvious ranking of materials is possible. Relative ranking may therefore conceivably depend on the chosen scenario. Ranking cannot, therefore, be based on simple ad hoc examination of test results; more elaborate validation procedures are needed.

The elementary method of validation, i.e. the linking of test output with the room fire growth process, would employ a statistical correlation analysis, with test output quantities as independent variables, and time to significant fire process events, such as room flashover, as dependent variables. Unfortunately, the number of combinations of independent variables and the number of room fire scenarios which need to be included in such a study would make this approach prohibitively expensive and cumbersome.

Validation must therefore be based on a theoretical understanding of the test procedures and of the room fire process. Recent developments in mathematical fire modelling suggest that significant progress is being made towards such an understanding.

Theoretical investigations of some of the test methods have indicated procedures which are suitable for the derivation of relevant material flammability parameters. These include minimum exposure levels for ignition, effective values of thermal inertia, and flame spread parameters. For other tests, such as the rate of heat release test, the results are immediately applicable for mathematical modelling.

Very recent and still continuing research has been able to correlate the parameters mentioned above with selected full-scale room fire scenarios. The number of scenarios need to be increased in order to enlarge the area of applicability and in order to gain more confidence in the validation studies. There are good reasons to believe that within a few years this research will lead to the production of engineering calculation rules and a rational methodology based on data obtained from reaction-to-fire tests.

6 Uses of reaction-to-fire tests in reducing fire risk

The reaction-to-fire tests developed within Sub-committee 1 are intended to form a "tool kit" of tests for use by fire engineers and scientists for the evaluation of the fire performance of a wide range of building materials and products. These tests will be particularly useful for measuring reaction-to-fire phenomena under variable conditions during the pre-flashover phase of a developing fire.

It is intended that the test methods should be widely used by building control authorities, both nationally and internationally, for the production of fire safety regulations and codes and it is recommended that

a) countries currently using reaction-to-fire test methods as a basis for their national fire safety requirements should consider incorporating the ISO test methods into their national classification systems at the earliest opportunity, such as when existing regulations become due for revision;

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b) countries intending, in the future, to introduce new national testing and classification systems for fire safety of building materials and products should, as a first step, quantify the hazards relating to reaction-to-fire, concerned in their own control system, and then choose the appropriate test, or tests, from the ISO "tool kit".

Widespread use of the ISO series of "reaction-to-fire" tests should make a significant contribution to the reduction of fire risks by providing a greater understanding to users of the performance of buiding materials and products under standard fire conditions. With the increasing use of these tests, large data bases will become available for a wide range of materials, which should in turn lead to wider international acceptance of fire test data and possibly lead to a reduction in problems concerning barriers to trade.

Data produced from these tests will also be suitable for use in the mathematical modelling of fire performance. An experimental room test has been developed to provide data for test validation and modelling purposes. This may also be useful for the experimental comparison of the "reaction-to-fire" performances of building products, using different fire scenarios and test conditions.

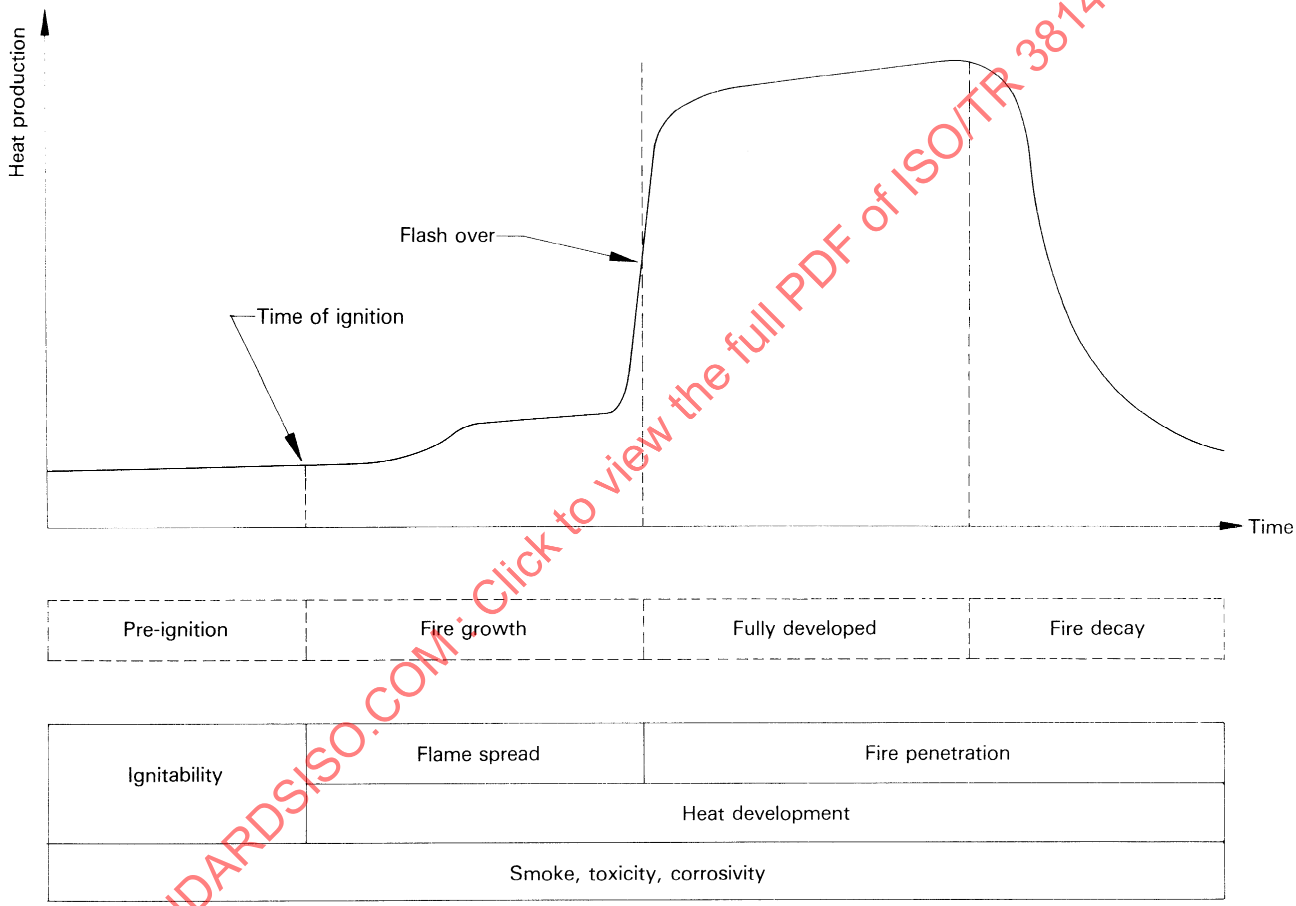

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Figure 1 — Diagram showing the different phases in the development of a fire within an enclosed space

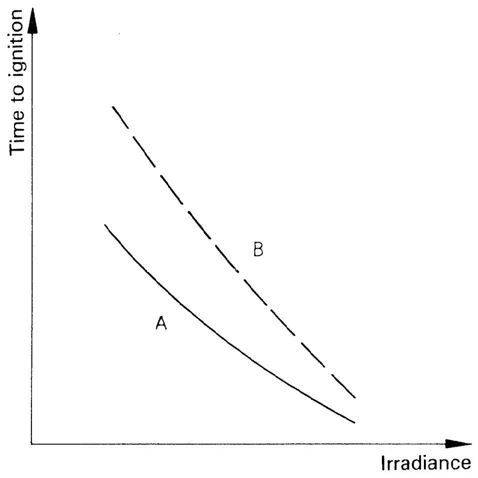

Figure 2 — Time to ignition for materials A and B

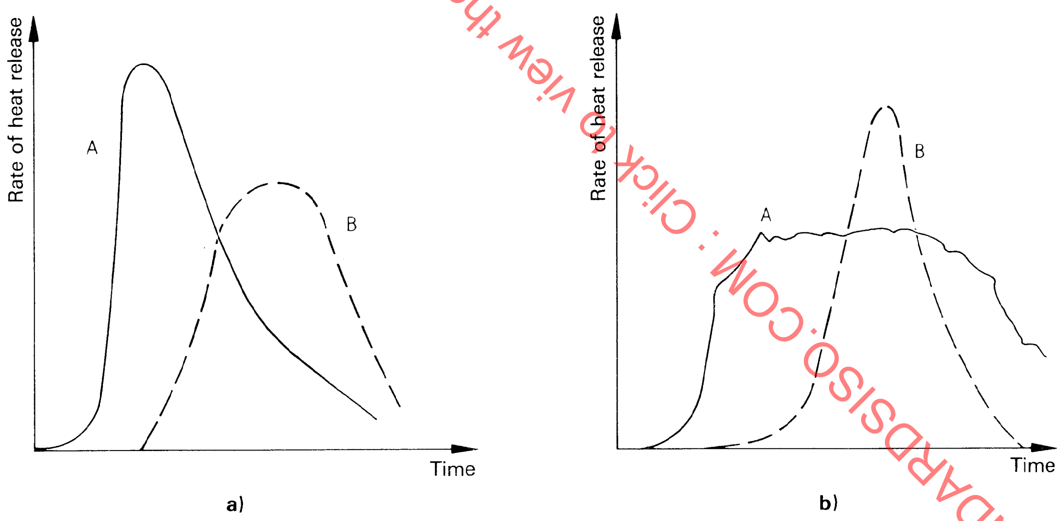

Figure 3 — Two possible sets of data from rate of heat release tests with materials A and B

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Annex A
(informative)

Reaction-to-fire tests

A.1 General

A.1.1 "Tool kit" of tests

The behaviour of building products under fire conditions is very complex and depends upon a range of different factors. Consequently, it is not possible for any currently available single test method to provide information for a complete range of fire scenarios. The test methods described in the following sections have been developed in order to provide a "tool kit" of tests for building products, each of which is intended to measure a different reaction-to-fire parameter. Users can then select whichever test, or combination of tests, they feel will best suit their needs.

A.1.2 Selection of test samples

It is important to ensure that any fire test is carried out on a representative sample of the product to be evaluated. If the product is in any way irregular in its physical dimensions, or composition, e.g., if it has uneven surfaces, different faces, or is formed of asymmetric laminations, then more than one test, or series of tests, may have to be carried out in order to evaluate the overall performance of the product. Each test method should include instructions as to how samples of the product are to be selected for test and also the number required for each test.

A.1.3 Conditioning of test samples

The moisture content of some building materials can have a significant effect on how they perform under fire conditions. This particularly applies to those which are cellulose based and also to cementitious materials. It is important, therefore, that wherever practical, all specimens shall be conditioned to constant mass prior to test, under standard conditions of temperature and humidity. In addition, certain other materials which undergo prolonged curing or setting mechanisms after manufacture may also need to be pre-conditioned before test. The standard conditioning environments for reaction-to-fire test samples are normally in the range 21 °C to 25 °C and 40 % to 60 % relative humidity.

A.1.4 Abnormal behaviour

The instructions for most reaction-to-fire tests require that note shall be made in the test report of any abnormal, or unusual behaviour shown by any of the samples during a test. This is particularly important if it could in any way affect the final result, or otherwise interfere with the satisfactory conduct of the test. Such behaviour can include, for example — melting, slumping or dripping of thermoplastic materials, violent disintegration of the test sample when heated, intumescence, extinguishment of pilot flames caused by flame retardant additives in the test sample, etc. In some cases such behaviour may invalidate the results of the test and thereby render the material unsuitable for testing by that particular method. In some circumstances it may be possible to test additional samples in order to compensate for the abnormal behaviour. Such behaviour during a specific reaction-to-fire test does not necessarily mean that the particular product will be hazardous in a real fire situation.

A.1.5 Validation

To validate each test method fully, the results need to be compared with data obtained on the same materials wheen tested in full-scale fire tests, preferably those which are representative of real fire scenarios. Since the majority of the test methods described in this annex are still under development, such information is not generally available. Nevertheless, before the proposed test methods are accepted for general use, appropriate comparative test data must be provided. Sufficient interlaboratory testing should also be carried out to ensure that the apparatus and the test method are capable of producing results with acceptable levels of repeatability and reproducibility.

A.1.6 Correlation with other fire tests

As far as possible, attempts should be made to correlate the results of these tests with other "reaction-to-fire" tests and also with other fire tests.

A.1.7 Ageing of building products

The fire performance of many building products can change with time. Such changes can occur either very rapidly, or quite slowly, depending upon a number of factors. These factors, which can include exposure to moisture, sunlight, heat, ventilation, mechanical or physical damage, etc., may result in obvious physical changes in the product such as cracking, embrittlement or shrinkage. In addition, other less visible changes may occur including the degradation or migration of chemical constituents. Consequently, it is important to recognize that initial compliance of a material or product with prescribed test criteria is not a guarantee of continued performance. Care should therefore be taken when using test results obtained on building products to make due allowance for the effects of ageing. In some critical situations it may be necessary to re-test products periodically to ensure that an adequate level of performance is being maintained.

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A.2 Ignitability test [1] (see figure A.1)

A.2.1 This test method is designed to measure the ignitability of a horizontally-mounted, essentially flat product when its upper surface is exposed to thermal radiation in the presence of a small pilot flame.

A.2.2 Test samples, 165 mm × 165 mm, are each placed on an inert baseboard for support with thermal protection to the rear, and then wrapped in aluminium foil from which a 140 mm diameter aperture has been cut to allow radiation to fall on the upper surface. They are then exposed to thermal irradiances of up to 50 kW/m^2 from a cone-shaped heating element.

A.2.3 A pilot flame is applied every 4 s to a position close to the centre of the upper surface of the test sample and remains in position for 1 s. If sustained surface ignition occurs, i.e., the inception of a flame on the surface of the sample which is still present at the next application of the pilot flame, then the test is immediately stopped and the time is noted. A test is also discontinued after 15 min if sustained surface ignition on the test sample has not occurred. If ignition does not occur with any of the five replicate samples employed at one irradiance, then it is not considered necessary to test at lower irradiances.

A.2.4 The irradiance in the plane of the sample surface is set prior to commencement of the test using a radiometer. During the test period the temperature of the heater is controlled to a value which the calibration shows gives the required irradiance.

A.2.5 The test can be used for a wide range of building and other products. For products which are normally used backed

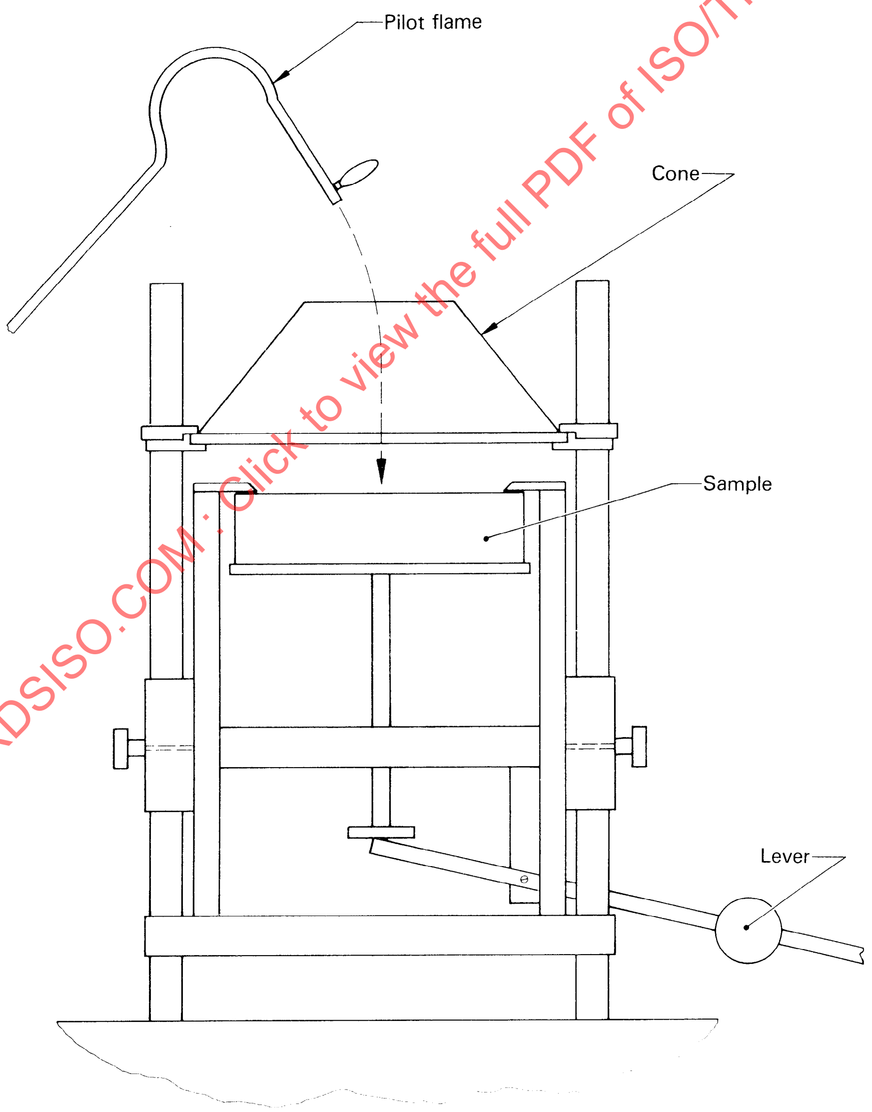

Figure A.1 — ISO ignitability test

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1) See ISO 5657 : 1986, *Fire tests — Reaction to fire — Ignitability of building products.*

by an air gap, an appropriate air gap can be provided between the sample and baseboard. Problems may be encountered when testing some products which have a reflective surface finish, e.g., metal foil.

A.2.6 A supplementary test is under consideration which uses a flame impinging on the test sample without additional imposed radiation.

A.3 Surface spread of flame test[1] (see figure A.2)

A.3.1 This test method is used principally to measure the rate of travel of a flame front in a horizontal direction over the surface of an essentially flat building product exposed to thermal radiation. The product may be tested in any of three orientations, viz. vertical, horizontal face-upwards or horizontal face-downwards. The irradiances will differ somewhat in each case, but the principle of the test remains the same. Development work has been concentrated on the vertical orientation test.

A.3.2 A test specimen, 800 mm × 155 mm, is positioned so that its surface is exposed to thermal radiation from a vertically-mounted gas-fired radiator, the irradiance decreasing fairly uniformly along the length of the specimen. A pilot flame to initiate flaming is applied to the end of the specimen receiving the maximum irradiance.

A.3.3 If a flame front develops, its lateral progress is assessed visually in relation to distance markers, and is expressed as a function of time. Also, the time to flame initiation, the time to flame front extinguishment, and the maximum distance of flame travel are recorded.

A.3.4 The test is continued for a minimum period of 10 min and until 6 min after all flaming has ceased, or when the flame front reaches the end of the test sample. During the test, observations are made of the general behaviour of the sample, e.g., glowing, charring, production of flaming droplets.

A.3.5 Before each series of tests a calibration procedure is carried out with a dummy sample, incorporating radiometers, mounted in the specimen holder. The temperature of the radiator and the precise angle at which the specimen holder is presented to it are adjusted to give specified irradiances at a number of positions along the sample.

A.3.6 The critical irradiance at extinguishment is under consideration as being a significant parameter for certain classes of

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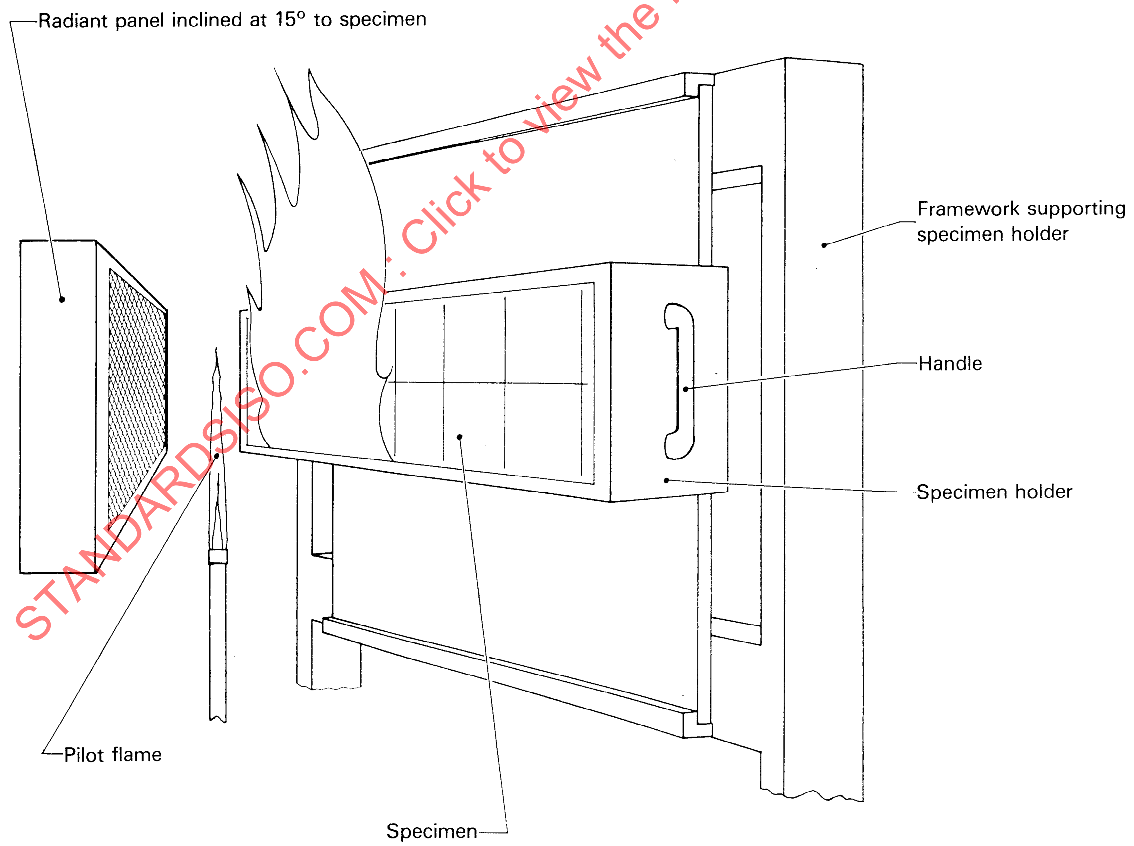

Figure A.2 — Apparatus for surface spread of flame test.

1) See ISO/TR 5658, *Reaction to fire tests — Spread of flame test.* (To be published.)

building products. The time from pilot application to flame initiation may be considered to give a measure of the ignitability of the product at the particular irradiance imposed. A theoretical understanding of flame spread over surfaces is currently being developed for this test.

A.4 Rate of heat release test[1] (see figure A.3)

A.4.1 This test method is primarily intended to be used for determining the rate at which heat is evolved from a fire involving the test material. The test apparatus is basically an oxygen consumption calorimeter which measures the responses of materials when exposed to different thermal irradiances. Materials can be tested in both horizontal and vertical orientations. The method is based on the principle that for a range of materials the net heat of combustion is proportional to the amount of oxygen required for combustion.

A.4.2 A 100 mm × 100 mm sample of the material to be tested is exposed to irradiance from a cone-shaped heater. The pyrolysis gases produced are ignited by a spark generated by a spark plug and the resulting combustion gases are extracted through an exhaust system.

A.4.3 Continuous measurements of oxygen concentration and exhaust gas flow rate permit the determination of heat release as a function of time. Possible exposure conditions range from 10 kW/m^2 to 100 kW/m^2. During the tests, the heat flux from the heater is maintained at a preset level by means of a temperature controller. In both test orientations, the specimen holder is mounted on a sensitive load cell so that measurements of mass loss rates can be made. Smoke obscuration may also be monitored as an additional parameter to the primary measurements of oxygen concentration and exhaust gas flow rate.

A.4.4 The gas sampling system and the oxygen analyser are calibrated at regular intervals using a methane burner giving a heat output of 10 kW. The temperature controller is also regularly calibrated by means of a radiometer, using a procedure similar to that used for the ignitability test apparatus.

A.4.5 The test is not applicable to products which do not have essentially flat surfaces, nor is it suitable for testing very thin materials or some types of composites.

A.5 Smoke development and obscuration test[2] (see figure A.4)

A.5.1 This test method is designed to measure the smoke production behaviour of essentially flat materials whose surfaces are exposed to specified thermal irradiances.

A.5.2 Smoke is generated in one compartment of a box, the decomposition chamber, using a modified ignitability test apparatus with the pilot flame attachment removed.

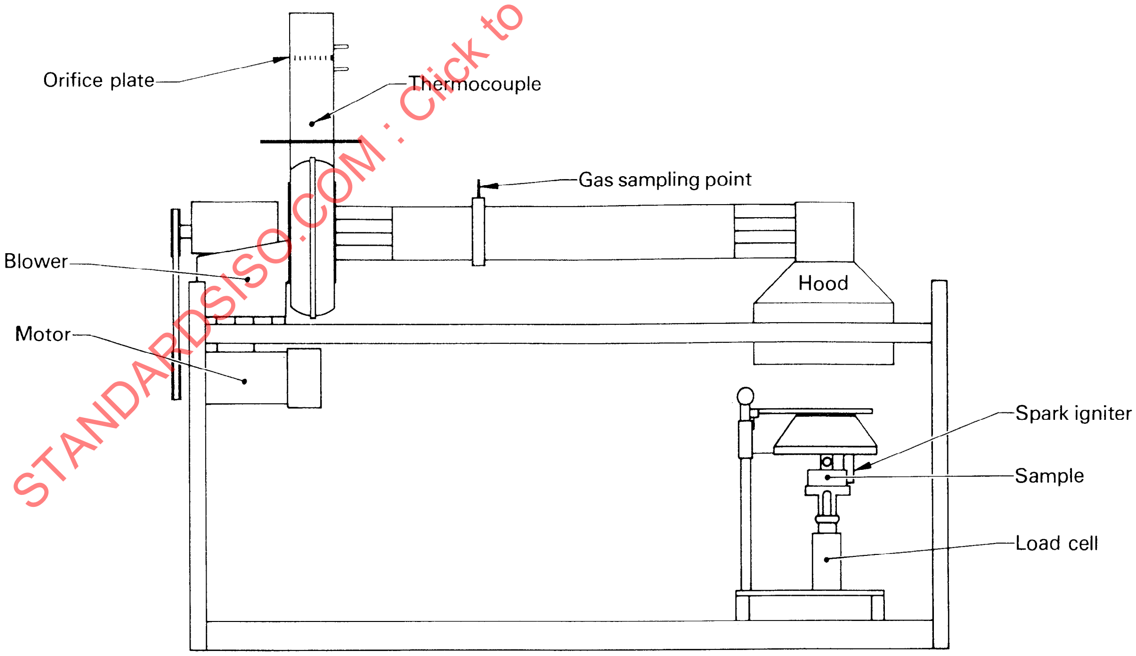

Figure A.3 — ISO heat release test

1) See ISO 5660, *Reaction to fire tests — Rate of heat release.* (To be published.)

2) See ISO/TR 5924, *Fire tests — Reaction to fire — Smoke generated by building products (Dual chamber test).* (To be published.)

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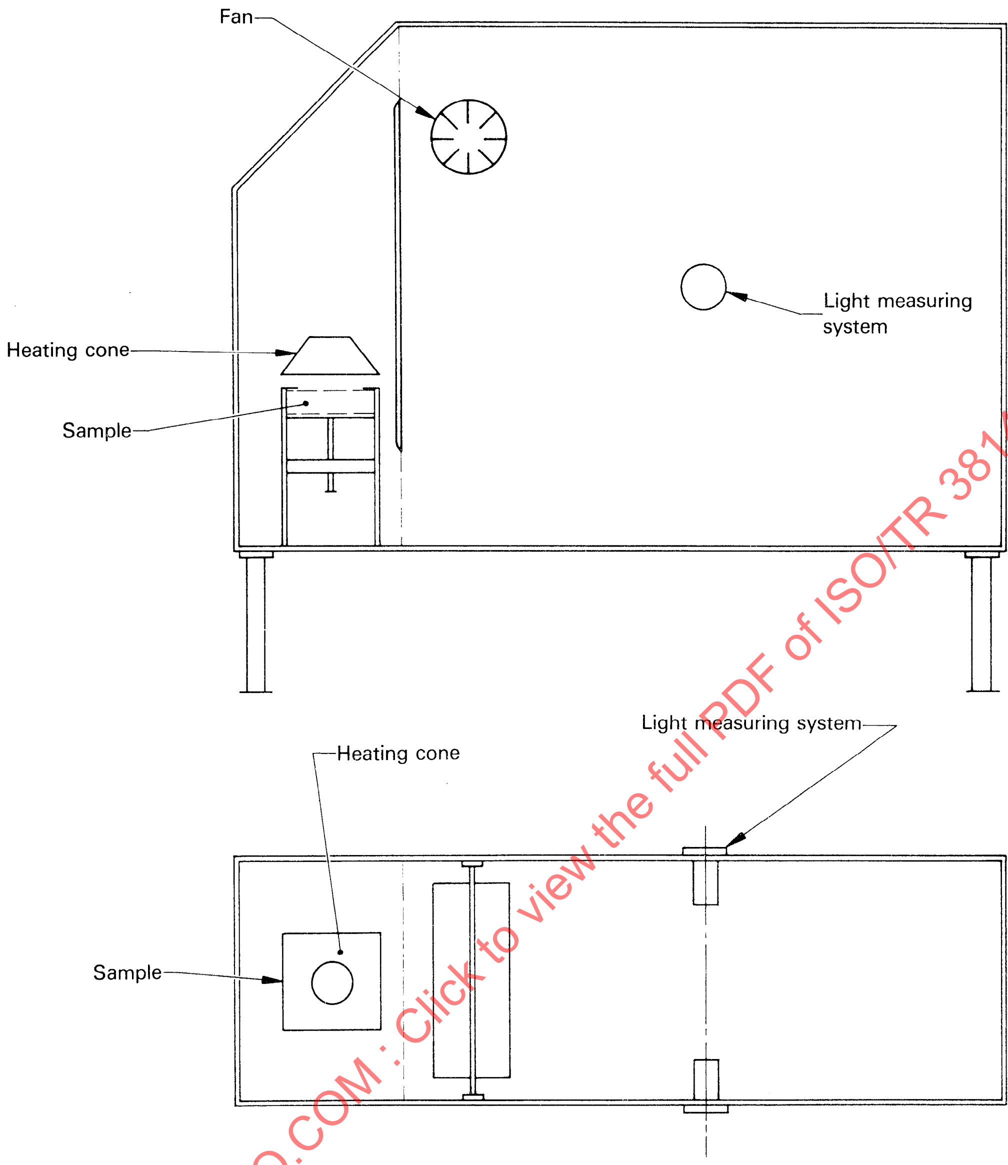

Figure A.4 — ISO smoke test

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The smoke then passes into a second (measuring) chamber, where its optical density is measured. The total volume of the two chambers is approximately 1,3 m^3.

A.5.3 Test samples, 165 mm × 165 mm, are mounted on baseboards and wrapped in aluminium foil as for the ignitability test (see A.2). They are then exposed to thermal irradiances of up to 50 kW/m^2 from the cone-shaped heating element.

A.5.4 The smoke produced then passes into the measuring chamber where it is mixed with the air in the chamber using a fan. The optical density of the diluted smoke in the chamber is continuously measured over a specified horizontal path length using a light beam/photocell assembly. The results are reported in terms of the maximum optical density measured during the test.

A.5.5 The optical density measuring system is equipped with a standardized lamp and lens system producing a parallel light beam. The transmitted light is focused on a light receiver which responds to wavelength characteristics similar to the human eye.

A.5.6 The methods used for calibrating the decomposition apparatus and for controlling the thermal irradiance levels during the tests are the same as for the ignitability test. The optical system is calibrated by means of standard grey filters.

A.5.7 This test can be used for a wide range of building and other products. However, problems may arise when testing some products having a reflective surface finish, e.g., metal foil.

A.6 Non-combustibility test[1] (see figure A.5)

A.6.1 This test method is designed to ascertain whether a material will, or will not, contribute directly to fire development.

A.6.2 The test apparatus consists essentially of a vertical tubular refractory furnace with a cone-shaped air-flow stabilizer attached to the base and a draught shield attached to the top. A specimen holder and insertion device is provided.

A.6.3 The test requires a heating environment of approximately 750 °C inside the furnace tube with an ample natural air-flow passing through it, i.e., without using forced ventilation. The specimen is heated by radiation from the interior wall of the furnace which is adjusted to a constant temperature of approximately 835 °C over a prescribed area prior to the start of the test.

A.6.4 Three thermocouples are specified for the test, each being located at a height corresponding to the mid-point of the furnace tube. The "furnace thermocouple" is placed between the furnace wall and the test sample. The "sample centre thermocouple" and the "sample surface thermocouple" are placed at the centre and on the vertical surfaces, respectively, of the test sample.

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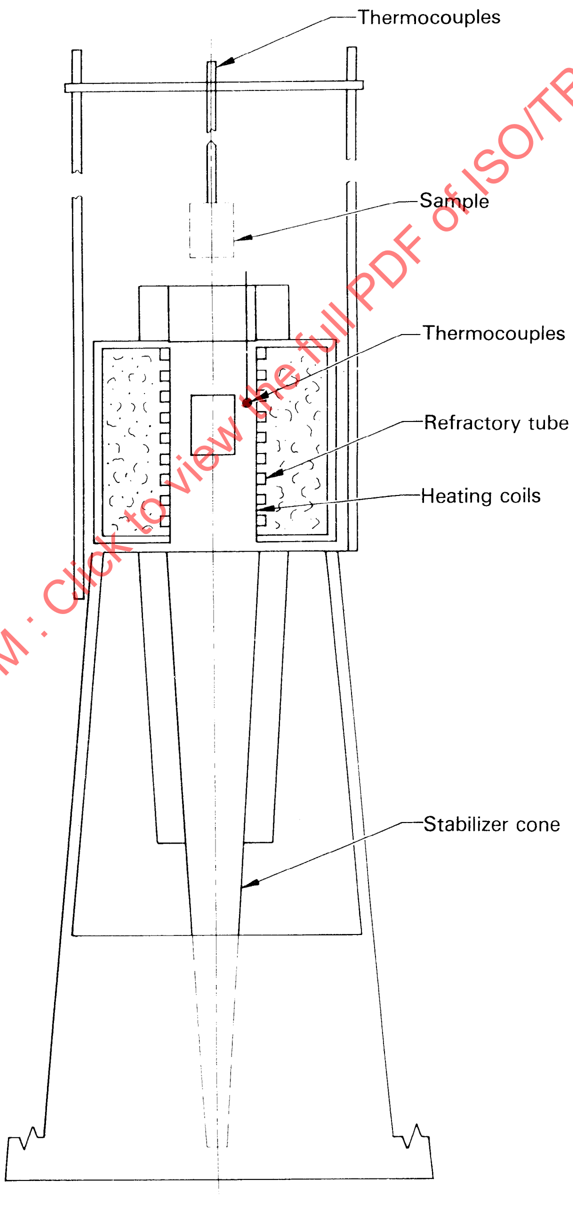

Figure A.5 — ISO non-combustibility test

1) See ISO 1182 : 1983, *Fire tests — Building materials — Non-combustibility test.*

A.6.5 The test sample is inserted into the pre-heated furnace and the test is normally continued for a period of 30 min, although in certain circumstances this time can be extended. Maximum temperature rises are noted in relation to the final equilibrium temperature indicated by each thermocouple. Observations are made of the duration of any flaming from the test sample and also of any mass loss.

A.6.6 This test has been developed for the assessment of construction materials which, while not completely inert, generate only a limited amount of heat and flame when heated to temperatures of approximately 750 °C. Materials of inorganic origin such as aerated concrete, asbestos, mineral fibres with small amounts of resinous binders, exfoliated vermiculite, perlite, and expanded glass are common examples of non-combustible products.

A.6.7 This test method is not suitable for testing composite materials or coated products. Nor can it be used to evaluate the indirect contribution of non-combustible materials to the development of a fire by virtue of their thermal and/or reflecting properties.

A.7 Corner wall/room test[1] (see figure A.6)

A.7.1 This test method is designed primarily to determine the contribution to room flashover of wall or ceiling linings. It is particularly suited to products for which small-scale results are considered unreliable because of problems associated with melting, dripping, cracking or spalling, etc., and with assemblies involving composites or joints.

A.7.2 The method comprises a full-scale room fire test simulating a wall/ceiling fire which starts in a corner of the room, under well-ventilated conditions. The test room is 3,6 m long × 2,4 m wide × 2,4 m high. Ventilation is provided by a single doorway opening, 2 m high × 0,8 m wide in one of the end walls.

An exhaust hood and duct assembly is located above the doorway outside the room to collect the products of combustion. The ignition source is a 170 mm × 170 mm propane gas burner located in a corner of the room remote from the door and in contact with the lining material. The lining to the interior of the fire room is fixed as far as possible as in normal use. If it is necessary to test thin surface coatings, such as paints or varnishes, they are first applied to standard combustible or non-combustible substrates, which are then used to line the fire room.

A.7.3 Fire spread, fire growth and generation of combustion products in the fire room are monitored, together with measurements of gas temperatures and thermal irradiances at floor level. Optional additional measurements can include sample surface temperatures, gas flow rates and thermal irradiances in the doorway. Measurements made in the exhaust duct include gas flow rates, oxygen concentrations (to calculate rate of heat release), carbon monoxide and carbon dioxide concentrations, and optical density of smoke. A video recording of the fire growth process is also required.

A.7.4 Calibration of the rate of heat release measurement system is carried out with the gas burner positioned directly under the hood, for a range of heat output levels and for various gas flow rates through the exhaust duct.

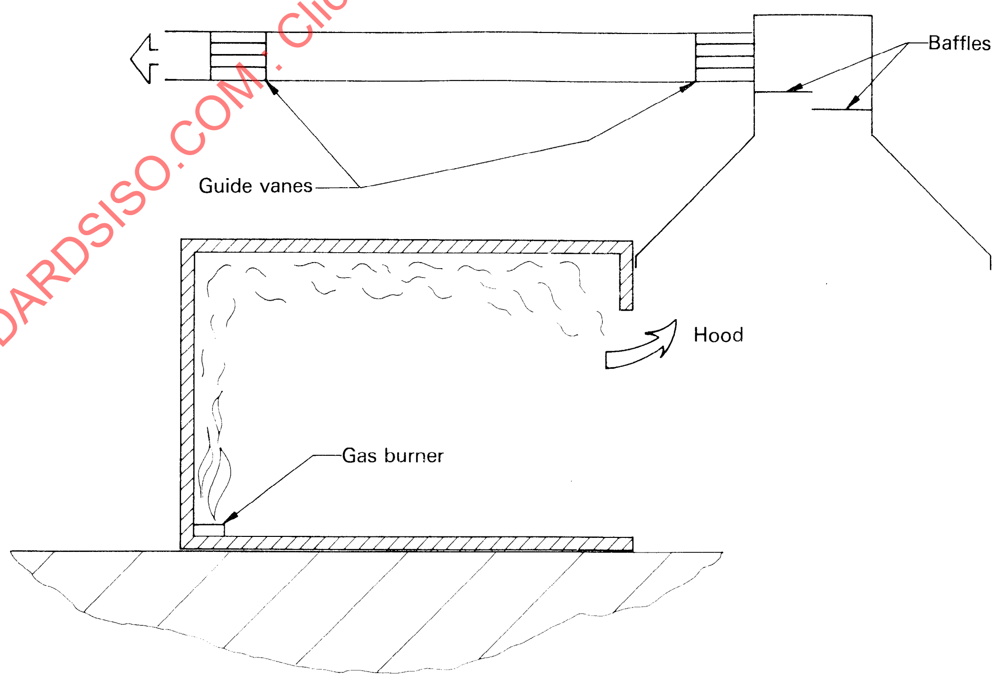

Figure A.6 — ISO room test

1) See ISO 9705, *Fire tests — Full scale room test for surface products.* (To be published.)

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