TECHNICAL REPORT

ISO/TR 15658

First edition
2009-08-01

Fire resistance tests — Guidelines for the design and conduct of non-furnace-based large-scale tests and simulation

Essais de résistance au feu — Lignes directrices pour la conception et la conduite d'essais et de simulations à large échelle non basés sur les fours

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Reference number
ISO/TR 15658:2009(E)

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Published in Switzerland

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is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 15658 was prepared by Technical Committee ISO/TC 92, *Fire Safety*, Subcommittee SC 2, *Fire Containment*.

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Introduction

The fire engineering community have often had to resort to non-furnace-based tests in order to establish certain characteristics of the fire behaviour of products, or constructions that cannot be obtained using standard methods. The reasons for these are many, including:

a) size of the test element;

b) interaction between components or elements;

c) fire loads and heating rates;

d) achievement of realistic levels of restraint;

e) realistic oxygen availability.

Fire modelling is also being increasingly used to resolve the complex problems that many modern buildings produce. Currently, modelling is often limited by a lack of data and large-scale “natural” tests are increasingly being used to establish the missing information, and, by using the protocol described in this Technical Report, the quality, comparability and validity of the information/data should be significantly improved.

Unfortunately, the design of such tests is often controlled by the availability of space, equipment, cost, environment, etc. and these sometimes compromise the scientific value of the experiment and make the results hard to compare with other experiments performed in other laboratories or countries. This lack of comparability has in the past prevented the value of the findings from being maximized.

When an experiment has been set-up without adequate consideration of the objectives and the test parameters, it is difficult to apply a scientifically valid field of application to the result. As a consequence, the data of findings are frequently wrongly applied to constructions subsequent to the test.

The objective of this Technical Report is to harmonize the approach to the design, performance and reporting of such experiments, in order to increase the possibility of comparing information and also to develop meaningful fields of application of the results. It is not the objective of this Technical Report to inhibit the development of ad-hoc or natural tests, but more to encourage their development, while at the same time increasing their scientific value.

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CAUTION — The attention of all persons concerned with managing and carrying out this fire resistance test is drawn to the fact that fire testing may be hazardous and that there is a possibility that toxic and/or harmful smoke and gases can be evolved during the test. Mechanical and operational hazards may also arise during the construction of the test elements of structures, their testing and disposal of test residues.

An assessment of all potential hazards and risks to health shall be made and safety precautions shall be identified and provided. Written safety instructions shall be issued. Appropriate training shall be given to relevant personnel. Laboratory personnel shall ensure that they follow written safety instructions at all times.

1 Scope

This Technical Report specifies procedures for the design, performance and reporting of fire tests which are not performed using standardized test equipment, such as furnaces or test chambers, and which are primarily duration- or time-based.

It is applicable to all "natural" fire tests, which set out to evaluate the behaviour of structural frames, rooms (or a suite of rooms forming part of a building), with respect to fully developed fire conditions, regardless of whether or not the heat input is by means of natural sources, e.g. cribs or burners. It is not applicable to "reaction-to-fire" large-scale tests, which are primarily designed to evaluate materials and for which the heating rate is slower and the maximum rate of heat release is lower than that which would occur at full development.

In the context of this Technical Report "large" means tests in which the flame has a width of 1 m or more.

This Technical Report is intended for use by the designers of fire tests (laboratories, regulatory authorities and researchers) and for those responsible for disseminating the information and applying the results in practice.

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, *Fire safety — Vocabulary*

3 Terms and definitions

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

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4 Test design requirements

4.1 General

The difficulties experienced when testing “large” structures, e.g. space, cost, instrumentation and material handling equipment, often cause a desire to scale down the construction being tested. In fire testing, this is difficult because the response of the members forming part of a construction varies considerably as a result of their mass. The thermal inertia of an element is a major influence on its thermal response. Similarly, when direct heating is used in an experiment, such as an item or items of furniture, timber cribs, or even gas burners, the size of the flame and the convective plume cannot meaningfully be scaled down commensurate with any proposed reduction in volume of the test chamber or the elements forming it. Reducing the size of the test assembly is often not an option when performing such tests. Where the experiment has to be scaled down in size and where it can be demonstrated that the influence on the thermal response of the structure can be quantified, the largest influence that a reduction in size has is in respect of the time at which critical events happen. When reducing the size of an enclosure the behaviour is modelled more accurately if the heat losses can be made to reflect the actual conditions relative to the volume/area of the space. Any such change shall be quantified and recorded.

Before commencing the design or construction of a test assembly, it is important for the designers to identify the objectives of the experiment as, in many cases, they define the scale and size of the construction being evaluated. The objectives shall form part of the test report.

When designing and setting up an experiment involving a large-scale fire test, there are a number of test parameters capable of influencing the results of the test significantly. Many of these influences can be avoided if sufficient thought is given to the parameter when planning an experiment. If unavoidable, the influence can be anticipated and hence compensated for when performing the test and analysing the results. Guidance on the possible influence of these factors is given in 4.2 to 4.9.

The outcome of the analysis and the selection of the parameters used shall form part of the test characterization and shall be reported as proposed in 7.2.

4.2 Ambient environmental conditions

4.2.1 Air currents, magnitude and direction

Air movement around the construction, which either contains the fire or is the subject of the analysis, can seriously influence the experiment and the results obtained. Air flow directly onto ventilation apertures can produce a pressure within the cell or room which can influence the rate at which gases may egress through gaps or apertures, possibly having a scouring effect. Air flow across or away from such a ventilation opening can create a vacuum on that face drawing gases out and possibly affecting the rate of burning due to a shortage in the supply of oxygen.

Whilst still air produces the most neutral conditions, it is not easy to provide this for large-scale experiments due to the lack of buildings able to house fire tests of this size. Equally, still air conditions are not representative of the in-use conditions, where winds or draughts exist 90 % of the time.

The ambient air movement conditions used in the test should be justified, whether still or moving, and if moving, the velocity and direction shall form part of that analysis.

4.2.2 Temperature

Ambient temperature affects the time at which any temperature-sensitive material reaches its critical temperature, whether that is an ignition temperature or a phase change. If the ambient temperatures are unusually low, these temperatures are reached after an unrealistically long time, whereas if they are high, they can be reached unexpectedly early. The greater the mass of the temperature-sensitive material, the slower is the thermal response. In an anticipated chain reaction, i.e. spread of fire from one object to another, the influence of temperature is compounded, each phase being influenced independently.

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The ambient temperature, not only at the beginning of the test, but for a period prior to the test, which is related to the thermal inertia of the materials, shall be justified and related to the anticipated in-use conditions. Where in practice a wide range of temperatures can be expected, for instance from −5 °C to +40 °C, it can be necessary to perform separate tests at each end of the anticipated scale, if the influence cannot be readily modelled. If it can, a mean temperature should be used.

4.2.3 Humidity

The humidity of the air affects the moisture content of low-mass hygroscopic materials, which may influence their propensity to ignite and burn, if they form part of the construction being evaluated. Similarly, high moisture content and humidity can directly affect the characteristics of heat transfer and it is important to take the prevailing conditions into account when analysing the results.

When timber (or other forms of cellulosic material) is being used as the fuel source, the moisture content affects the rate of heat release. Guidance on this subject can be found in the Loss Prevention Council Report TE 91338-40 [6]. All fuel timber should be controlled to the required moisture content right up until the time of the test.

4.3 Size of the test assembly

4.3.1 Justification for shape

The shape (numbers of sides forming the enclosures) of a test room influences the response of the structure to fire. If the product is to be used in rectangular spaces only, this is probably the correct way of testing. If other applications exist, i.e. for cylindrical or spherical constructions, the application of the result produced in a rectangular test arrangement should be considered and justified when it is used in areas with a differently shaped boundary. It is common in any heating experiment for boundary layers to become established on surfaces, particularly in the corners of rooms or where there is a change in geometry which influences the heat exchange on these surfaces. This influence should be analysed and allowed for when applying the findings to structures with other shapes, e.g. curvilinear.

4.3.2 Justification for height

The height of a test chamber probably has a greater influence on the fire dynamics and response of the structure than any other parameter. Because fire spread is initially a vertical phenomenon, the inclusion of any ceiling, roof or horizontal closure (lid) causes the fire to spread laterally. Combustion gases rising as a result of convective air currents cool due to the dilution with air, which becomes entrained into the plume and also transfer heat to the environment as the height increases. As a consequence, the position of a horizontal membrane determines the temperature of the gases when they start to spread laterally. This can influence the temperature and depth of boundary layers, which can significantly change the feedback to other items of fuel in the space.

It is important that the height of the ceiling/roof/horizontal membrane be considered in the light of the influence it can have on the development of the fire conditions. The height used shall be related to the in-use conditions, in respect of the fire load as well as its size and position. The height from the top of the heat source to the ceiling is important in fire growth models as it influences the plume behaviour and the radiative feedback from the gas layer. The height of the ceiling above the floor is important if flame impingement is anticipated in practice.

4.3.3 Justification for width and depth

While the height of the test assembly is the primary influence on the response of the structure with respect to convection (see 4.3.2), the width and depth of the chamber influence the response of the structure to radiation. The proximity of the walls to the heat source can produce dramatically different findings if they are receiving an unrealistically high flux relative to the hazard being reproduced. Because of the rate at which radiation intensity decays with distance, the horizontal distances between the heat source and heated surfaces is not as critical as the height, because there is no convective component in the heat trawler horizontally. Where the relationship between ignition/fire source and the perimeter of the chamber is known to have an influence, the test assembly should be related to the scenario being evaluated.

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4.4 Construction of the test assembly

4.4.1 Physical characteristics of elements not forming part of the test specimen

The test assembly can consist of an assembly of the elements which are the subject of the test or can consist of a number of fixed elements forming part of a test rig to which are attached the element or elements which are being evaluated. These fixed elements provide the methods of supporting the test specimens or providing fixity and/or restraint. As such their physical characteristics are important, especially at the test temperature. The critical physical characteristics of the testing that shall be justified are:

a) the material type, thickness and density of the fixed elements;

b) hot strength/load-bearing capacity;

c) the effectiveness of the fixings available for the attachment of the test specimens;

d) the quality and nature of the seal which can be provided between the rig and the specimen.

4.4.2 Thermal characteristics of elements not forming part of the test specimen

The thermal characteristics of elements only used to close off the test construction can play an important role in creating the exposure conditions of the specimen. Where the specimen conditions of use are known, e.g. a composite floor on top of an otherwise stone or concrete room structure, non-specimen elements used in the test assembly should replicate these. If they do not replicate the in-use construction, any variation shall be justified. The justification should consider the following parameters:

a) combustibility;

b) thermal diffusivity, α, where $\alpha = k/\rho c$ with k is thermal conductivity, ρ is density and c is specific heat. Thermal diffusity, α, provides a means to measure a material's ability to conduct thermal energy relative to its ability to store thermal energy. Materials with a larger thermal diffusity, α, should respond to thermal changes more quickly than materials with a smaller thermal diffusivity, α;

c) coefficient of expansion;

d) propensity to bow (due to temperature differentials).

Where the in-use conditions are not known, any test report should fully characterize these parameters to aid subsequent analysis.

4.4.3 Attaching the specimen to the test construction

The method of fixing any single element to the adjacent structure can influence its thermal response. If the end use is known, the method of attachment should reflect that as far as is practical. When the end use in practice is not known, the fixing method should be fully characterized, describing:

a) the type of fixing;

b) the materials from which the fixings are made;

c) the frequency of fixings;

d) any measured torque forces, if fixings are screwed;

e) any critical temperatures related to the effectiveness of the fixing material, if non-mechanical fixings are used.

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In the case of load-bearing assemblies, the levels of fixing and restraint should be quantified and where possible related to the actual levels of restraint expected.

4.4.4 Sealing of the specimen into the test structure

The sealing of the specimen into the test structure is normally only critical if the test assembly is being evaluated for its ability to contain fire spread. However, if an edge member is to be evaluated for load-bearing capacity, the seal may influence just how much of that member is heated. When the seal does not represent the in-use condition, the material and method chosen shall be justified and the seal should be fully characterized with respect to the following characteristics:

a) the dimensions, particularly the depth in the case of a linear gap seal;

b) the composition/nature of the material;

c) its physical state, e.g. rigid, flexible or compressible;

d) any known thermal characteristics, e.g. softening temperature, activation temperature and expansion ratio (in the case of heat-activated materials).

4.5 Test specimen

4.5.1 Construction of the test specimen

It is assumed that most of the test specimen is manufactured/constructed as it would be when in use, as this is presumably the subject of the test. However, for purposes of practicality, it may be necessary to introduce additional or non-representative joints. When introducing such joints the influence of the joint on the following parameters shall be considered:

a) heat transfer between elements and through the element;

b) the integrity of the specimen;

c) the thermal expansion and distortion of the specimen;

d) the transfer of load, both applied and thermally induced.

When the jointing incorporates seals, these should be characterized as proposed in 4.4.4.

4.5.2 Materials for the test specimen

The selection of the materials used for the test specimen shall replicate those in the element to be used. However, when constructing specimens for the test it shall be recognized that some of the materials are out of balance with those used in practice as a result of the time they have to age or condition. Time should be allowed for them to achieve equilibrium with the environment and unless impossible, also to achieve the same state of cure as in practice. If it is impractical to achieve either, the difference between the tested condition and the actual condition should be determined. Non-homogeneous materials should be made in as similar a manner as possible to those being duplicated. The factors that shall be justified are:

a) the moisture content (for hygroscopic materials);

b) the curing for hydraulic-based materials;

c) the chemical reaction for compounds;

d) the strength of any bonding materials/adhesives.

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4.6 Selection of heating conditions

4.6.1 Fire exposure

This is the most critical of the test parameters as the selection of the wrong heating conditions can effectively render the experiment/test valueless. It shall be recognized that in most cases, the conditions used in the test can only represent one scenario of all those possible and therefore the heating conditions shall be correctly specified and reproduced. If more than one common scenario is likely, multiple testing can be necessary.

As a result, the selection of the heating conditions shall be fully justified in respect of the following:

a) the total heat release;

b) the ratio of convective and radiant heat;

c) the heat release rate.

4.6.2 Method of heating

Many constructions vary in their response, depending upon the nature of the received heat flux. The method of heating used in an experiment shall be related to the scale of the elements forming the test assembly. The proportion of the convective and radiative heating, especially in the early stages, shall be justified, especially if artificial forms of heating are utilized, because burners exhibit a different nature of heating compared to a real fire. Many factors can influence the heat output and the ratio of convection and radiation. For timber-based fuels, the moisture content can make a significant difference to the rate of heat output [6]. When cribs are used, the volume of the wood/plastic controls the fire load, the size of the sections controls the duration and the spacing controls the rate of burning. The selection of the conditions used in the design of the crib shall be justified. The following possible methods of heating shall be considered.

a) Cribs of combustible materials:

   1) timber;

   2) plastic;

   3) others.

b) Gas burner:

   1) direct (flame);

   2) diffused (sand bed).

c) Oil burner:

   1) forced air;

   2) natural.

d) Actual materials (e.g. furniture, stored material and liquid fuels).

4.6.3 Position of heating source

The proximity of the source of heating relative to the test specimen can influence its response particularly in the pre-flashover conditions. The amount of heat applied directly to the critical surface influences its initial response. The nature of the heating (see 4.6.2) influences this; however, the distance from these surfaces should be related to the scenario being modelled.

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Where the heat source is close to a wall, or worse, close to a corner, the plume is denied any entrainment of air which affects its temperature, diameter, height and the plume cross-section. The justification should address the following dimensions:

a) the proximity of walls and corners to the fire source in practice (temperature);

b) the height of the element above the heat source (convection and radiation);

c) the distance of walls from the heat source (radiation).

4.7 Selection of ventilation conditions

The amount of available input air affects the rate of heat release for all solid fuel heat sources. Where the test is performed using a burner, it is a normal requirement for the air supply to be provided, either via a fan or by a low-pressure air supply and the valves to these supplies are used to control the heat output of the burner. With a solid fuel such as a timber crib, the air shall be introduced into the test construction via dedicated openings, which often incorporate some type of sliding blade to enable the variation of their size. Too little air causes the fuel to be restricted, while too much air can cause an excessive rise in temperature. A detailed analysis shall be undertaken to ascertain the level of ventilation/make up air available in practice and this level shall be used in the test, albeit it shall be reduced accordingly if the test volume is different.

The relationships between test and in practice shall be made in respect of Equation (1):

$$\frac{A_\mathrm{v}\sqrt{h}}{A_\mathrm{t}} \tag{1}$$

where

A_v is the total area of the openings for ventilation (e.g. windows);

h is the weighted mean height of the openings;

A_t is the total area of the bounding surfaces (walls, floor and ceiling).

4.8 Selection of exhaust conditions

Exhaust is interactive with ventilation as it controls the rate of removing the products of combustion. Too low a rate impacts the amount of air coming in (ventilation), which in turn impacts upon the temperatures able to be achieved. For most fire scenarios, it is possible to estimate the likely pressure regime and this is also controlled by the rate at which products of combustion can escape or not. As a consequence, the amount of ventilation achievable is not a gratuitous item and the amount of ventilation should be controlled and validated against the conditions likely to exist in practice. The following design factors should be justified:

a) the position of exhausts, if used;

b) the size of exhausts;

c) control of exhaust velocity.

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4.9 Selection of decay conditions (if controlled)

Some large-scale structural tests can require the analysis to include the cooling or decay behaviour. The method and rate of cooling, natural or forced cooling, extinguishing, etc., can change the rate at which materials are prevented from ongoing burning in the case of combustible elements, or spall or crack as a result of thermal impact on non-combustible constructions. When justifying the cooling regime specified in the test, the following should be pertinent:

a) air cooling, whether forced or natural;

b) the choice of extinguishing mechanism, if artificially induced;

c) the distribution of extinguishing equipment.

5 Test conditions

The following instrumentation is preferred in order to improve the reproducibility and comparability of results. Other instrumentation may be used, but the sensitivity, time constants, measuring range and accuracy should be related to the recommended apparatus where practical.

During the recording of any data, the validity of the output shall be continually monitored to avoid recording spurious data. This is because it is obviously better to correct any instrumentation error during the course of the test, preferably as early as possible, rather than to discover the error during the analysis of the results.

A typical problem often encountered in experiments involving hygroscopic materials, especially when measuring internal temperatures, is the development of water pockets around the bead of internal thermocouples. Casting-in thermocouples, rather than drilling and installing, can help to reduce this source of error, but if any temperature measuring point exhibits very long temperature plateaus, especially at between 100 °C and 120 °C, the possible cause should be investigated and corrected.

5.1 Ambient conditions

5.1.1 Temperature of the environment surrounding the experiment

The measuring device shall be protected from draughts, preferably by mounting the measuring point in the centre of a large diameter tube, nominally 150 mm in diameter and 250 mm in length. A type T thermocouple is recommended, although a type K can be used if that is what is used to establish the thermal exposure conditions and for which the recording apparatus is calibrated. An ungrounded sheathed thermocouple with a diameter of $(03 \pm 0{,}5)$ mm should have the correct time constant. The use of glass thermometers is deprecated, as they are not able to be automatically monitored.

5.1.2 Air flow

Air flow within a test chamber may be monitored by measuring the flow of exhaust gases, inlet air gases or if practical, the air flow adjacent to critical elements/surfaces within the chamber. The ambient conditions and the measuring point normally designate the appropriate device. Pitot tubes or vein anemometers should be used, but the McCaffry bidirectional low-velocity probe [5] may also be used.

5.1.3 Humidity

The humidity can influence certain characteristics, such as the moisture content of the test specimen, and therefore the humidity should be measured by means of a horse hair hygrometer continuous reading or by a whirling hygrometer reading, at least at the beginning of the test and possibly afterwards.

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5.2 Test conditions — Thermal

5.2.1 Temperature

All temperatures shall be recorded in degrees Celsius.

The thermocouples used should be appropriate to the range of temperatures being measured and the time constant should be known. Selection of the thermocouples should be in conformity with EN 60584-1 [2], EN 60584-2 [3] and EN 60584-3 [4]. Unless it is unavoidable, temperature measurements should not be made within any flaming gas zone and should preferably be made adjacent to, and close to any flames, if the thermal conditions are to be recorded with any accuracy. Consideration should be made of using the “plate” thermometer.

When measuring temperatures within elements forming the test specimen by means of thermocouples, all thermocouple wires and compensating leads shall be taken away from the point of measurement following the isothermal plane. When possible, the thermocouple should be cast into the specimen, rather than inserted into pre-drilled holes as the contact might not be very good and moisture collection in the hole as a result of heating (i.e. condensation of steam) produces a prolonged latent heat plateau.

5.2.2 Radiation — Type of device

The method of measuring the heat flux shall be clearly stated, as heat flux metres can be used with or without a window. When a “windowed” unit is used, all convection currents shall be excluded and a more accurate value of the radiation component should be obtained. The amount of heat received should be measured at a distance of 1 m from the heat source, or measured at a convenient distance and corrected and reported at a distance that reflects the hazard. This involves:

a) total heat release (calorimetry);

b) oxygen concentration;

c) gas velocities (for air flow in hot state);

d) temperatures within the construction being tested.

5.3 Test conditions — Pressure

5.3.1 Pressure differential

When measuring the pressure differential between a heated chamber representing the construction under test and the unheated area around it, i.e. the laboratory, the tube attached to the pressure sampling head shall exit from the chamber at the same height as the measuring head until the gas temperature is in equilibrium with the outer atmosphere. The pressure head should be designed such that it effectively measures static pressure and all of its positions should be selected so as to avoid dynamic pressure changes, unless they form part of the experimental data output.

5.3.2 Pressure gradient

As gases warm-up they become buoyant and this generally results in a pressure gradient. In still air and with adequate temperature measurements, the change in pressure over the height can be calculated. Dynamic conditions can influence this gradient and the inclusion of additional pressure measuring devices at the different heights can help to establish the presence and magnitude of any gradients. Any such gradient should be fully justified.

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5.4 Test conditions — Mechanical

5.4.1 Load measurements

Whilst hydraulic pressure, or air pressure, may be used to monitor load, the forces should be confirmed by the use of load cells to eliminate any error caused by frictional losses. The magnitude and distribution of the load should be justified and should be representative of the in-service condition, or at least its relationship to these conditions should be stated. When the test is scaled down, the induced stresses shall not only be of the correct magnitude, but of the same nature, e.g. shear or bending.

5.4.2 Deflection measurement

Deflections provide valuable information on the behaviour of constructions as they provide indirect information on restrained expansion temperature differentials, etc. However, a single point of measurement is unlikely to reveal sufficient information to generate a full movement history of the construction. The use of multiple deflection measurements is therefore recommended.

All deflection measurements should, where possible, be undertaken using calibrated linear electrical transducers with an adequate range to cover the anticipated levels of deflection. Care should be undertaken to ensure that the transducer is following the element throughout the test.

5.4.3 Restraint measurement

Restraint, in all of its modes, e.g. rotational and elongational, can have a major influence on the behaviour of elements and structures exposed to high temperatures. Gratuitous, non-justified restraint should be avoided, but where restraint is known to exist in practice, this should be reproduced and where possible, measured.

5.5 Timing of the test

5.5.1 Time recording

Time shall be recorded by means of a chronometer which measures in minutes and seconds and all time shall be recorded in respect of the last elapsed minute or second, if appropriate. Measurements shall be made to an accuracy of not less than ± 0,5 %.

5.6 Output measurements

Output from the test invariably relates to the test objectives, e.g. if the objective is to establish the route of heat release, this is the primary output and is expressed in terms of the watts/m^3. However, during the experiment the opportunity to measure other important characteristics can present itself and the following should be considered:

a) smoke density;

b) smoke composition;

c) spread of flame;

d) maximum temperature;

e) radiation intensity.

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5.7 Data recording and storage

The use of Microsoft Office Excel[1)] spread sheets is almost universal as a way of presenting and tabulating data. Data should be recorded and stored as (delimited) easy-to-read strings, separated by commas.

6 Test procedure

6.1 Ignition

6.1.1 Method of ignition

The method of ignition can influence the early rate of fire development. The excessive use of hydrocarbon fuels or multiple ignition points can cause the fire to grow unjustifiably quickly. The nature of the ignition source shall be fully described and its selection shall be justified.

6.1.2 Timing

One of the most difficult aspects to standardize in ad-hoc testing is when ignition takes place and what constitutes ignition. A recommended method is to identify a particular temperature measuring device and start the test when this measures a pre-determined temperature. Where this is not practical, the event considered to represent ignition shall be clearly stated.

6.2 Safety procedures

6.2.1 Emergency provisions

Fire is by its very nature dangerous and, in the experimental context, often unpredictable. Before performing any test a risk assessment should be undertaken to identify all potential hazards. Measures should be introduced to counter any perceived risk. Such provisions shall be reported.

6.3 Monitoring

6.3.1 Duration

The time recorded is always with respect to a readily identifiable event, i.e. the start of ignition, attainment of a certain temperature, etc. The basis of the commencement of measurement shall be given. The use of a fixed temperature as measured by a designated thermocouple is the preferred method because it is repeatable.

6.3.2 Time presentation

If time is to be incorporated visually in any record (e.g. videotape or photograph), the timing device shall always start from time 00,00 and show the elapsed time. The timing device shall not use “real” time which may be confusing if the record is used out of context.

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