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BSI Standards Publication

Fire-resistance tests - Guidance on the application and extension of results from tests conducted on fire containment assemblies and products

Part 2: Non-loadbearing elements

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National foreword

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Fire-resistance tests — Guidance on the application and extension of results from tests conducted on fire containment assemblies and products —

Part 2: Non-loadbearing elements

Essais de résistance au feu — Recommandations pour l'application et l'extrapolation des résultats d'essais réalisés sur les produits et assemblages d'endiguement du feu —

Partie 2: Éléments non porteurs

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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 procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 2, *Fire containment*.

A list of all parts in the ISO/TR 12470 series can be found on the ISO website.

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Introduction

Fire resistance tests on building components are necessary to establish their behaviour against predetermined criteria when exposed to a representative fully developed fire and to provide information that may be used in determining the fire safety of buildings. For several decades, people have accepted, by means of test results only, the possibility of grading the components. Now, due to the enhancement of our knowledge and the complexity of buildings, it is necessary to be able to give a more accurate assessment of the components used in buildings, particularly with the growth of the use of functional approaches to designing fire safe structures.

The need to understand how the element will perform at a different size, with different levels of restraint, etc., is vital when applying the results of the fire tests in a life safety situation, especially those where the fire safe solution has been generated using fire safety engineering techniques rather than code compliant solutions. This does not negate the need to predict any changes that may result from changes to the test construction when complying with building code solutions, but these codes may themselves provide solutions that take into account the influence or impact of changes, and indeed, the guidance given in this document may be used by the code writers to produce such guidance.

Even with the knowledge available to assess the behaviour of a given constructional element, whatever its design or its size, we will still be some distance away from establishing the complete behaviour of a building in a real fire.

The philosophy of only grading elements into different fire resistance categories may not give any indication about how the element actually behaves when heated. By studying and assessing the data from fire resistance tests, it will be possible, using the guidance within this document, to obtain a basic understanding of the influence of the main parameters on the element performance during fire resistance tests.

In practice, tests give much useful information which can be used for interpolation and extrapolation of the results.

The original version of ISO/TR 12470 was published by ISO/TC 92 in 1998. This Technical Report provided a methodology in identifying how the results of fire resistance tests carried out in the standard furnaces could be modified to apply to the elements as they may be used in practice. In some cases, the results of the test may need to be reduced to reflect any increases in the degree of difficulty that the final application represents, or alternatively, modifications/enhancements may need to be made to the construction in order to maintain the performance level(s).

In the intervening years since the original Technical Report was prepared, a greater understanding has developed as to what the changes are likely to be and how they may be quantified. Some of the work in CEN (Committee European Normalisation) has aided this process and in particular, the principles given in Annex A remained unpublished by CEN but were developed in one of the technical Work Groups of CEN/TC 127. This revision represents the current state-of-art with respect to the objectives of the original 1998 version of ISO/TR 12470.

In this document, all the assessments of extended application are based, on the one hand, on the standard time/temperature conditions and, on the other hand, on isolated elements with no interaction with the adjacent elements.

Ageing and weathering are not covered here.

This document is divided into two parts.

The first part provides the methodology for defining the field of application for loadbearing members, both separating and non-separating. It also includes a review of the state-of-the-art and possible improvement in the methods of testing which would make it easier to establish the field of application for an element.

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Guidance on direct and extended application of test results for specific non-loadbearing elements used in buildings, and the major parameters, which would be assessed by calculation or by expert judgements based upon the principles and discipline given in Annex A, are discussed

This document suggests expert systems which could take into account the interaction of various factors in an assessment of the fire resistance of doors, glazing, services, service penetrations and linear gap seals

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Fire-resistance tests — Guidance on the application and extension of results from tests conducted on fire containment assemblies and products —

Part 2: Non-loadbearing elements

1 Scope

This document explains a methodology to determine the applicability of the results of fire resistance tests to actual applications.

It is applicable to those non-loadbearing elements for which there is an ISO standard test procedure based upon the ISO 834 series for determining the fire resistance of a representative sample of the construction proposed for use in a specific building or just for general use. These elements are:

— fire resisting door assemblies (excluding lift landing doorsets):

  — timber;

  — steel;

— fire resisting vertical glazing – metal framed:

  NOTE The rheology of glass is such that gravity has a disproportional influence on fire glass when it is heated to high temperatures and as a consequence, it is not possible to provide generic guidance on the extended application of horizontal glazed elements.

  — timber framed;

— linear gap sealing;

— service penetration sealing.

Fire resistance testing furnaces have fairly restricted size limitations and as a consequence, there is little confidence that the result obtained on an element of construction tested in accordance with the standard methods will behave in a similar manner when installed in the final building.

Direct and extended applications of test results are the two possible ways to ensure that an element that is not identical to the tested construction will have an acceptable probability of obtaining the same fire rating as that of the original tested specimen. In both cases, these applications generally refer only to the fire rating that the building element can expect to reach if it, or a representative sample of it, were to be tested in a furnace according to the standard fire test conditions used in the reference test.

The criteria and methodology used in evaluating ductwork and dampers is significantly different from those used to evaluate conventional separating elements and for this reason, these forms of construction are not included in the scope of this document. It is planned that a subsequent part of this document may include guidance on these elements.

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2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 834 (all parts), *Fire-resistance tests — Elements of building construction*

ISO/TR 10295 (all parts), *Fire tests for building elements and components — Fire testing of service installations*

ISO 13943, *Fire safety — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 834 (all parts), ISO/TR 10295 (all parts) and ISO 13943 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
direct application
application that identifies the modifications that can be made to the design of the tested element without reducing its fire rating

Note 1 to entry: These possible modifications are based on obvious knowledge and do not need further evaluation. In every case it is, at least, assumed that the basic material(s) used for the construction of the tested sample will not be changed.

Note 2 to entry: Direct application defines the variation(s) in the construction and the limits of use for the element which, without further analysis, are covered by the result of a test in accordance with ISO 834 (all parts). Direct application is arrived at by the application of simple *rules* (3.4) that are known, or considered by the fire community, to give equal fire resistance performance by the users. The rules can be applied by non- fire experts.

Note 3 to entry: Only results from one test report can be used when considering a change of an element. Any combination and use of two or more tests reports or other technical sources should be regarded as *extended application* (3.2) and hence dealt with accordingly.

3.2
extended application
application that is arrived at by the application of calculation or assessment *rules* (3.4) that are known, or considered by the fire community, to give equal or improved fire resistance performance by the users

Note 1 to entry: The rules are applied by fire experts.

Note 2 to entry: This will generally require an assessment by a fire expert either in developing rules of application for more general application by others or evaluating the results of fire engineering calculations or for making a judgement in specific cases. In every case, it will be taken into consideration that extended application may take into account the difference between the result of the original test and the fire resistance required for the untested element.

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Note 3 to entry: Extended application defines and specifies the variations in the construction and establishes the limits of use for an element that has been tested according to the appropriate EN standard based upon an analysis by fire experts. The extended application can use the results from one or more test reports and can be based upon rules, calculations and expert judgement. As a result of the extended application, the fire resistance classification of an element with respect to defined performance characteristics may be maintained, increased or decreased when used in practice.

3.3
project specific application
application that uses a mixture of established validated calculations/computer models (if they exist and are appropriate) together with judgements made by suitably qualified persons (normally a professional badged engineer or a corporate member of a learned professional body)

Note 1 to entry: Because the application will, in these circumstances, require an understanding of both the structural response and the fire dynamics of the building in question, it is inevitable that the solution will involve an element of fire safety engineering.

3.4
rule
quantitative *factor* (3.9) that can be applied to the result of tests when defining the limits of application for which justification exists as a result of research and testing

Note 1 to entry: Rules are primarily used in determining the *direct application* (3.1) of the result as their application do not generally require specialist knowledge.

Note 2 to entry: It is anticipated that these rules be established by the specialist (or ad-hoc) groups preparing the specific standards based upon public domain knowledge and developed by industry consortia or trade associations for specific elements for which the members have appropriate interest and knowledge, particularly in Europe initially. After some experience, the results of calculations and judgements may become rules.

3.5
calculation in support of extended application
calculation method that can be applied to one or more parameters of a tested construction and which are based on existing physical laws or which have been empirically validated and which form part of the process of defining the *extended application* (3.2)

Note 1 to entry: If this term has a definition elsewhere, then it should be used but possibly modified to include this specific use.

3.6
expert judgement
qualitative process performed by fire experts when the complexity of the influence is beyond the scope of *rules* (3.4), to establish the resultant effect of a variation in one or more parameters, on the classification awarded

3.7
construction parameter
aspect of the design and construction of an element that may be varied and which may result in a change in the fire resistance performance, e.g. a change in one or more of the dimensions of a stud in a stud-framed separating elements

3.8
thermal and mechanical parameter
aspect of the conditions of a test that may vary in practice and influence the classification system given, e.g. the pressure differential that will exist at the top of a larger element than existed at the top of the specimen when tested

3.9
factor
one of the possible variations that may be applied to a parameter, e.g. a change in the stiffness as a result of a dimensional change in the member or a component within the element

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3.10
factor influence
one of the potential causes of a change in the fire resistance recorded by test, with respect to one or more of the criteria, when a *factor* (3.9) is changed, e.g. an increase in the loadbearing capacity, *R*, as a result of an increase in stiffness

4 Principles of the field of application

4.1 General

The field of application from the result of a fire resistance test has at least 3 possible components: a) direct application, b) extended application and c) project specific application.

The process of determining the Direct Application and Extended Application of the fire resistance rating of a tested construction normally assumes that the performance is evaluated against the temperature/time and differential pressure conditions given in the appropriate ISO fire resistance testing standard [based upon ISO 834 (all parts) or the national, regional equivalent], as this is generally what is referenced in national prescriptive legislation. The variations between the tested specimen and the "as-built" construction will therefore be restricted to

— variations in the size of the construction,

— variations in the materials and methods of construction,

— variations in the restraint and fixity, and

— variations in the load carried (if any).

In this situation, only the constructional parameters given in A.2.2 need to be taken into account.

In practice there will be a need to predict the performance of a structure when it is exposed to different fire exposure conditions, in terms of the temperatures reached after certain durations and with greater, or lesser pressure differentials. Generally, the parameters will be analysed by means of a fire engineering analysis which is outside of the scope of this document, but the parameters listed in A.2.1 may be appropriate for use in an expert judgement analysis of these characteristics.

For each type of element of construction, the application of test results will be considered under three conditions: a) direct application, b) extended application and c) project specific fields of application.

Changes in materials and methods of construction can have significant influences on the fire resistance. Because the advice and recommendations are common to all elements, those aspects are dealt with separately under 5.1 to avoid repetition. The user of this document should consider these aspects in all applications of results whether direct applications, extended applications, or project specific applications.

4.2 Direct application

The direct application will normally involve the application of "rules" that are given as part of the test standard or in a document directly associated with the test standard. It requires no knowledge of the process of determining the fire resistance other than an understanding of the criteria and the general terminology.

Where there is more than one change in any proposed construction/installation, two "direct application" rules should not be applied automatically and the two should be compared as part of an extended application.

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4.3 Extended application

4.3.1 General

Determining the extended application of the fire resistance is a more complex matter and will generally need to be undertaken by “experts” who understand the mode of failure and the factors that lead to such a failure. There are three common methods used by practitioners to establish the extended application of the fire resistance of elements of construction and these are

— application of locally validated rules, especially within Europe,

— use of established validated calculations/computer models, where they exist, and

— use of technical judgement by suitably qualified persons.

NOTE In Europe, as part of the application of products within the context of the Construction Products Regulations (CPR), the extended application is determined by means of Extended Application (EXAP) standards, for use in the process of classification of products to enable CE marking. These EXAP standards cannot be used in the context of generating a fire safe environment without further analysis.

4.3.2 Rules of extended application

These would be applied universally even by persons without expertise in fire as part of the direct field of application of the test result for a given family or products. These rules may require cold state calculation. The quantification of these rules would be agreed universally based upon validated experience related to generic constructions or components. This could cover size changes, number of joints, size of glazing, etc.

Throughout this document, the clauses covering rules frequently express the acceptable change in terms of unquantified percentages indicated by the letter “X” and an appropriate suffix.

This allows national regulatory authorities to insert their own acceptable limits which will relate to their established fire safety philosophy.

Authorities are encouraged to support the necessary research towards internationally harmonized validated values.

4.3.3 Calculations and computer programs used in extended applications

These would be used by an expert in determining the field of application but will mainly be restricted to the properties indicated below:

— non-loaded elements: this would be restricted to the calculation of temperature rise and deflection of "simple" components and elements.

In every case, the calculations and/or models used by the experts, whatever their source (purchased from software manufacturers or developed by the assessing body), have to be fully validated by comparison with existing test results and by sensitivity analysis of the various parameters.

4.3.4 Judgements in extended applications

For a test result to be extrapolated to cover changes outside those for which calculations or written rules are applicable, the result may still apply subject to some expert judgement being made. The section on judgements highlights the matters that need to be considered and to be justified by the body or person(s) responsible for making such judgments. Generally, components of a construction element could be changed, provided it can be shown that this does not reduce the fire resistance. It should be demonstrated that the interaction of a new component with other components will not adversely affect the performance of the tested construction. When resistance time is higher than the required time, it will generally be possible to have a greater change than with only the necessary safety level.

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In order to bring greater consistency to the judgemental process, it is recommended that this process follows the methodology given in Annex A.

4.4 Project specific application

This document has described the manner by which variations in the construction of an element which has been designed to provide fire resistance can be accepted, or rejected, which utilizes the main parameters of the materials and components incorporated in the proving test. However, it may be possible in certain application to provide more generous extensions to the field of application because it has been possible to utilize certain factors relating to the "in-use" application, e.g. significantly enhanced restraint or an uneven distribution of the applied load. In such cases, the derived direct or extended field of application is only valid for the specific project from which these inputs have been derived. Because of the bespoke nature of the inputs, the field of extended application only applies to the use of the element in question within the application for which it was designed. As a consequence, the field of application (FoA) is known as project specific.

5 Common factors which influence the field of application of all elements

5.1 General

The advice in this clause applies to all subsequent elements and groups of elements.

5.2 Manufacture and materials

5.2.1 General

For certain applications, even small changes in either the materials or the methods of manufacturing may result in large changes in fire resistance. For example, flush timber fire resisting door assemblies use significant quantities of adhesives in their construction. If a urea formaldehyde adhesive is replaced by a polyvinyl acetate (pva), the fire resistance is likely to be lower. The results from a fire resistance test may be used to support an evaluation of the performance of a similar untested element or they may be used to justify an element in use without any further calculations, or the application of rules, if the manufacture of the element complies with the guidance given in 5.2.2. Where the construction is not covered by the direct application, then the calculations or application rules need to be applied as indicated.

Additionally, there are quality control and certification schemes in some countries. Control procedures ensure that the untested construction is equivalent to the tested construction. Any relaxation of these procedures may only be undertaken if it can be established that they only influence non-critical aspects of the construction (e.g. colour, texture, etc.). Evidence of the effect should be available if the control of the “critical” processes or materials are involved. Reduced scale fire resistance tests may be used for this purpose subject to the changes not affecting distortion.

The information given for direct applications and extended applications has to be used for every construction element.

5.2.2 Direct application

a) The quality control procedures are not reduced.

b) The manufacturing/construction procedures remain unchanged.

c) Constituent materials, admixtures, preservatives, flame retardants, adhesives, etc. remain unchanged.

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6 Fire resisting door assemblies

6.1 General

Door assemblies achieve their fire resistance as a result of a complex interaction between a number of components; the interrelation between them being too difficult to be the subject of rules, or even calculations. There are also many different configurations and modes of operation which further complicate the analysis.

This clause, therefore, covers only doors with hinged or pivoted leaves. Other types of doors are not covered due to the lack of knowledge in the public domain of their fire behaviour.

Doors made from cellulosic materials, e.g. wood, behave differently from doors made primarily of metal and, therefore, the different guidance is appropriate as the modes of failure vary.

The results from a fire resistance test may be used to support an evaluation of the performance of another door of the same or similar material that has hinged or pivoted leaves without any further calculations or the application of rules or judgements if the construction complies with the guidance given in 6.3.2. Where the construction does not comply with the direct application rules, then the fire engineering calculations or expert judgements need to be applied as indicated in 6.3.4.

The relevant performance criteria are integrity (abbreviation is the letter “E”, measured by gap gauge, sustained flaming or ignition of cotton pad) and insulation (abbreviation is the letter “I”, increase of average or maximum temperature rise).

6.2 Direct application

6.2.1 General

The results of a fire resistance test are deemed to be applicable to a similar type of untested door of the same primary material provided that all of the following are true.

6.2.2 Leaves

a) The number of leaves is not increased.

b) The mode of operation is unchanged (e.g. single swing/double swing).

c) The height and width of the leaf are not increased.

d) The thickness of the leaf is not reduced.

e) The gap dimension between leaf and frame or leaf and leaf (including a flush overpanel if fitted) are not increased.

f) The restraint on the leaf is not decreased (see ironmongery and intumescent seals).

g) The thickness of any structural facing is not decreased.

h) The stiffness (expressed as the second moment of area) of any structural component in the leaf is not reduced.

i) The number of connectors/spacers per leaf (or per unit area) is not increased.

j) The thermal insulation characteristics of any core, sub-facing or infill material is not decreased in the case of an insulated door, or are unchanged for other door types.

k) The number of joints in the core is not increased.

l) For timber doors, the quality of the wood as indicated by the density and slope of grain is not reduced.

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6.2.3 Openings in the leaf

a) The area of any glazed aperture(s) is not increased.

b) The number of glazed apertures is not increased.

c) The proximity of glazed aperture(s) to any leaf edge is not decreased nor is the distance between them.

d) The re-positioning or change of shape of any aperture does not cause the removal of any structural component.

e) The type and thickness of glass remains unchanged.

f) The glazing system remains unchanged including the type (including gaskets) and number of fixings.

g) Openings made in the leaf for other purposes does not reduce the integrity of the assembly, e.g. air transfer grilles, letter plates.

6.2.4 Frames

a) The generic frame material is not changed, e.g. timber or metal type.

b) The frame stiffness is not decreased.

c) The method of manufacture and construction remain unchanged.

d) For timber frames, the quality of the wood as indicated by its density and screw holding abilities is not reduced.

e) The restraint provided by the method of foxing the frame into the structural opening is not decreased.

f) The wall into which the frame is installed is not less stiff when hot nor has a lower thermal inertia.

6.2.5 Door hardware (ironmongery)

a) The hardware does not apply less restraint to the door leaf or leaves, i.e. the number of hinges or latches is not decreased.

b) The method of attaching the ironmongery to the frame or the leaf remains unchanged and does not require removal of any more of the leaf/frame.

c) The melting point of the ironmongery that contributes to the restraint is not reduced.

d) Any alternative hardware does not require the removal of any part of any fire seal.

6.2.6 Fire seals

a) The position and type of any fire or smoke seal remains unchanged.

b) The cross-sectional area of any intumescent seal fitted to control the spread of fire and/or smoke through the leaf to frame gap is not decreased. In the jambs of unlatched door assemblies, the cross-sectional area of any pressure forming seal is not increased, or when fitted in the head gap is not decreased.

NOTE Certain formulations of intumescent, i.e. sodium silicate and intercalated graphite compounds produce a pressure when expanded, which is often used to provide restraint to thermal movement, either in conjunction with the hardware or sometimes on their own.

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6.3 Extended application

6.3.1 General

Defining the extended field of application, even when restricted to hinged and pivoted doors, is very complex using either rules (of which there are few), fire engineering calculations or expert judgements, particularly when more than one parameter at a time is changed. It is common practice when planning to extend one parameter, e.g. the width of the leaf, to compensate by changing another parameter such as the position and/or size of any intumescent sealing system. There are automatically two influences to consider when making such judgements and it is hard to establish the degree of importance of either. For this reason, it will become increasingly common for "expert systems" to be generated which harmonizes and rationalizes such approaches (see 8.3.). However, by using the methodology given in Annex A, the "judgement" approach will become much more accurate and consistent and should enable more accurate and/or possibly more generous extended applications to be made.

6.3.2 Rules

6.3.2.1 General

Except in the context of classification in CEN (see EN 13501-2), it is not possible to extend the application of a test result on a door assembly by the application of pre-determined rules. While such rules are still being validated in CEN, by the experience gained in the use of EXAP standards, the typical way of expressing this form of "extended" application is as follows.

6.3.2.2 Leaf dimensions and design

a) The leaf can be increased in height by X1 %[1)].

b) The leaf can be increased in width by X2 %[1)].

c) The area of glass can be increased by the following:

— doors with integrity-only performance of up to Y1 %[1)] but not to exceed Y2 %[1)] of the leaf area;

— doors with integrity and radiation performance of up to Y3 %[1)] of leaf area;

— doors with integrity and insulation performance of up to Y4 %[1)] of leaf area.

d) The number of glazed openings may be increased but the combined areas should not exceed the tested area by more than Y5 %[1)] nor exceed the maximum percentages of the leaf areas described above.

6.3.2.3 Frames — Dimensions

Assuming that the associated construction into which the door frames are to be installed has the same hot stiffness and thermal characteristics as the supporting construction used in the test, then:

— the rebate depth can be reduced by Z1 %;

— the face width of the frame can be reduced by Z2 %.

The use of these rules will be restricted to the region/country where they have evolved and will have only limited value in the context of life safety. Such rules should be used with caution in regions outside of those where they were generated.

1) These values can be those inserted in regulations as a result of research undertaken by sector groups, in Europe possibly in conjunction with CE marking guidance.

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6.3.3 Fire engineering calculations

6.3.3.1 General

Calculations may be used for the following.

6.3.3.2 Leaves

a) Temperature profile

Heat transfer through door leaves may be calculated to aid thermal deflection modelling using a valid temperature analysis model. Input data should be based on values for specific heat capacity and thermal conductivity as a function of temperature for all materials included in the construction of the leaf. For composite leaves, incorporating internal framing, cores and facings, it is necessary to estimate, using relevant test results, the time of exposure at which the detachment of components of the leaf (i.e. boards, insulation, etc.) will occur and as a consequence composite action may be lost and the heat transfer model will become invalid.

b) Insulation performance

Compliance with the insulation criterion may be calculated using appropriate temperature profiles as determined from a).

c) Thermally induced deformation

In the case of very simple metal leaf constructions, it may be possible to predict distortion due to bowing resulting from thermal differentials that have been established under b).

6.3.3.3 Frames

a) Heat transfer

Because of edge influences at the wall and leaf interfaces calculation of temperature rise on the unexposed face of the frame, heat transfer can only be achieved using accurate models and a knowledge of the relevant heat transfer coefficients.

b) Thermally induced deformation

In the case of simple frames, it may be possible to predict thermal distortion by calculation of differential temperatures between the exposed and unexposed faces, but care and valid data is needed to correlate this directly with an integrity failure.

6.3.4 Expert judgements

6.3.4.1 General

Changes may be made to the following construction parameters of the door assemblies provided that expert judgement, based on the methodology given in Annex A, is adopted. The material from which the assembly is made will dictate the relevance for some of the guidance given below, which is listed on a parameter by parameter basis.

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6.3.4.2 Expert judgement applied to leaf construction (timber and metal)

Expert judgement, in accordance with the Annex A, principles can be applied to the following leaf parameters.

a) Leaf dimensions (height/width)

The leaf width and leaf height both generally have an influence on the thermal deflection of the leaf, which will have an impact on the integrity (E) criteria as the leaf will be prone to bow out of the frame unless other forms of restraint prevent it (see Table 1).

The height and width parameters in a virtually homogenous leaf construction may be increased, providing the construction parameters of the major components (normally a slab core and facings) can be demonstrated by the method given in Annex A, not to compromise the integrity of the assembly, albeit the factors related to these parameters can only be resolved when considered with a particular set of frame/seal/hardware parameters and in many cases, also the influence of the supporting construction.

Table 1 — Summary of possible factor influences for a fire door leaf

Parameter	Factor	Factor influence
Leaf height	Larger	E Decrease I Neutral
	Less[a]	E Increase I Neutral
Leaf width	Larger	E Decrease I Neutral
	Less[a]	E Increase I Neutral

[a] It is probably covered by direct application if performed to EN standards.

For hinge position, it should be noted that if the door leaf height is increased, the hinges should move upwards/downwards in such a way that the distance between the top hinge and the head of the door leaf remains the same as in the fire test; the distance between the bottom hinge and the bottom of the door leaf should also remain the same as in the fire test. Increasing the door leaf height may require the number of hinges to be increased in order to provide sufficient points of restraint to the door leaf.

b) Leaf thickness

1) Timber door leaves

The parameter of leaf thickness influences both the insulation (I) and the integrity (E) criteria of a fire door assembly (see Table 2).

The thickness of a leaf may be increased or reduced but any reduction should demonstrate, by using the methodology given in Annex A, that it does not cause an increase in distortion that could result in a reduction in the integrity criteria below the required level. Additional restraint may be used to control the potential increase in distortion and, thereby, reinstate the required integrity (E) rating.

Any reduction in thickness should not produce a reduction in the ability of the assembly to satisfy the insulation (I) requirements for the leaf as measured on the unexposed face, in the case of a door assembly that is required to satisfy the insulation (I) or radiation (W) criteria.

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Table 2 — Summary of possible factor influences for timber leaves

Parameter	Factor	Factor influence
Leaf thickness	Thicker	E Increase I Increase
	Thinner	E Decrease I Decrease

2) Flush faced metal door leaves

This section only considers the behaviour of flush faced steel "pan and lid" leaf constructions with or without an infill of insulation and metal spacers.

The thickness of a metal door leaf will influence the thermal differential and hence the distortion and the performance with respect to the integrity (E) criteria, but if the door contains insulation material, this will have an impact on the performance with respect to the insulation (I) criteria as well (see Tables 3 and 4). The relationship is very complex and it may be more appropriate to use more advanced modelling to evaluate this influence rather than the methods described in Annex A, albeit the modelling route can be fairly time and cost consuming.

Table 3 — Summary of possible factor influences for insulated metal door leaves

Parameter	Factor	Factor influence
Leaf thickness	Thicker[a]	E Increase[b]/Neutral I Increase
	Thinner	E Neutral/Decrease I Decrease

[a] In Europe, it is probably covered by CEN Direct Application rules.

[b] Due to thermally induced bowing as a result of temperature differentials.

Table 4 — Summary of possible factor influences for non-insulating metal door leaves

Parameter	Factor	Factor influence
Leaf thickness	Thicker[a]	E Increase/Neutral I Not applicable
	Thinner	E Neutral/Decrease I Not applicable

[a] In Europe, it is probably covered by CEN Direct Application rules.

3) Change of core or infill (timber and metal)

A core, or an infill material which has a higher thermal diffusivity than that tested, could have a negative influence on insulation (I), but as long as it can be shown using the methods given in Annex A, possibly in combination with a heat transfer model, that this will not cause the unexposed face temperature of the leaf to increase above the insulation (I) criteria, if insulation is appropriate, or that the unexposed face temperature will not rise to a level which may cause a deterioration of the unexposed surface in a timber door leaf, its use may be justified. Extended periods of deterioration could cause ignition of the unexposed face or weaken the external facing to the point that it is not able to provide the required stiffness to resist thermal bowing, either of which will have a significant negative influence on integrity (E).

If the thermal diffusivity were to be reduced significantly, this would produce a beneficial influence on insulation (I), but it could increase the temperature differential between the hot and cold faces particularly on a metal door leaf and with certain door types, these factors may

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lead to more exaggerated distortion. When considering reductions in the thermal diffusivity of these core or infill materials, the effect on distortion and, hence, its negative impact on the integrity criteria should be considered, using the methodology given in Annex A.

In addition to the thermal diffusivity of the insulation/infill material, the combustibility of the material may have a negative influence on the ability to satisfy the integrity (E) criteria due to the risk of continuous flaming that may become associated with the unexposed face temperature. See Tables 5 and 6.

Table 5 — Summary of possible factor influences for cores in "timber" fire door leaves

Parameter	Factor	Factor influence
Core combustibility	More combustible	E Decrease/Neutral I Decrease
	Less combustible	E Increase I Neutral
Thermal diffusivity	Lower	E Neutral I Increase
	Higher	E Neutral I Decrease

Table 6 — Summary of possible factor influences for infills in metal fire door leaves

Parameter	Factor	Factor influence
Infill combustibility	More combustible	E Decrease/Neutral I Neutral/Decrease
	Less combustible	E Increase I Increase
Thermal diffusivity	Lower	E Neutral I Increase
	Higher	E Neutral/Decrease I Decrease

4) Core joints (timber doors) and infill joints (metal doors)

Joints in the core produce positive and negative influences on the fire resistance performance of timber door leaves (see Table 7).

Joints in the make-up of a door leaf have two distinctly separate influences. Joints often allow stresses to be relieved and, therefore, they can be used to limit the distortion created by thermal or moisture imbalances and this would have a positive influence on integrity (E). The number of joints should not therefore be decreased without considering whether this will create larger distortions.

The second influence relates to the permeability of the leaf. If the joints are not made tight or are subject to increase in width due to shrinkage of adjacent components, they can have a negative impact on both integrity (E) and insulation (I). In this case, the number of joints should be severely restricted. It may, however, be possible to increase the number of joints if the quality control or manufacturing processes are improved or if the joints incorporate a gap filling material at the time of manufacture which should remove the negative impact on integrity (E). These influences should be ascertained by using the analysis method given in Annex A.

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In the case of metal door leaves of the "pan and lid" form of construction, the thermal bowing will not be influenced by joints in the infill used in an insulating metal door. Infill joints can, however, increase the risk of insulation (I) failure, especially if the joints are not tight. The metal facings make the major contribution to integrity resistance and gaps in the infill will have no influence on the integrity (E) (see Table 8).

Table 7 — Summary of possible factor influences for core in timber and metal doors

Parameter	Factor	Factor influence
Joints in core (timber door leaves)	More	E Increase/Decrease I Decrease/Neutral
	Less	E Increase/Decrease I Increase

Table 8 — Summary of possible factor influences for infill joints in timber and metal doors

Parameter	Factor	Factor influence
Joints in infill	More	E Neutral I Decrease
	Less	E Neutral I Neutral/Increase

5) Change of facing thickness (flush timber doors)

The facing of a door leaf will have an impact on the insulation (I) criteria (thermal characteristics) and the integrity (E) criteria (stiffness/strength characteristics) due to the stiffness of the unexposed face facing being able to resist thermally induced bowing (see Table 9).

Many facing materials contribute to the stiffness of the leaf and, hence, the compliance with the integrity (E) criteria, and it may be established using the methods described in Annex A whether the facing is making a significant influence to integrity (E) more than the thickness, assuming that the density and material type is unchanged.

It may be possible to reduce the thickness of the facing on a timber door, but this will probably need to be compensated for by an increase in the core material thickness, if the insulation (I) criteria is to remain compliant.

Increasing the thickness of a facing will, therefore, generally be beneficial with respect to integrity (E) and insulation(I), but if the thickness of the core and any framing is proposed to be reduced to accommodate the increased thickness, then the influence of such a change should be analysed using the method given in Annex A for the core thickness.

In the case of steel doors, the thickness of the facing material will have no direct influence on integrity (E) criteria, but the thermal bowing may be increased or reduced by the change which will have an indirect influence on integrity (E). This can, however, cause an unacceptable rise in temperature and cause a failure with respect to the insulation (I) criteria.

Table 9 — Summary of possible factor influences for changing facing thicknesses (timber doors)

Parameter	Factor	Factor influence
Facing thickness	Increase	E Increase I Increase
	Decrease	E Decrease I Decrease

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6) Internal connections (steel doors)

In the case of steel doors of the "pan and lid" construction, any increase in the number of connections between the two faces of the leaf will generally cause an increase in the temperature rise on the unexposed face and, hence, generate a negative impact on the insulation (I) criteria. The increase in temperature of the unexposed face could reduce the thermal differential between the faces, thereby reducing the thermal bow and having a possible beneficial influence on integrity (E) (see Table 10).

Similarly, additional fixings may enhance the composite action making the leaf stiffer.

Table 10 — Summary of possible factor influences for changing the number of internal connections

Parameter	Factor	Factor influence
Internal fixings	More	E Neutral/Increase I Decrease
	Less	E Decrease I Increase

It may be possible to increase the number of connectors but it may be established using the methods described in Annex A, probably in conjunction with heat transfer calculations, that changing this parameter in this way will not cause an unacceptable rise in the unexposed face temperature.

6.3.4.3 Expert judgements applied to door frames

Expert Judgement in accordance with the principles in Annex A can be applied to the following frame parameters.

a) Frame stiffness

Generally, a reduction in the parameter of frame stiffness could have a negative influence on the integrity (E) criteria because it could generate differential movement between the leaf and the frame. However, it may be possible to reduce the frame stiffness if the method of fixing is increased to reduce the potential increase in distortion and, hence, its impact on integrity. Increasing the frame stiffness would normally have a beneficial influence on integrity. See Table 11 for the influence of frame stiffness on the integrity performance of door assemblies.

A change in the frame stiffness would have a neutral impact on insulation as the heat flow would not be significantly altered. See Table 11 for the influence of frame stiffness on the insulation performance of door assemblies.

b) Density (timber frames)

Higher density timbers, e.g. many hardwoods, are both stiffer and generally char at a slower rate.

It may be possible to use wood of a lower density if its section size is increased to compensate for the reduced stiffness and likely increase in the rate of erosion due to charring. The position of fixings may need to be changed to reflect the greater erosion and possibly reduced screw holding capability. See Table 11 for the influence of timber density on the integrity and insulation performance of door assemblies.

c) Frame infill (metal hollow frames) for use with timber or metal door leaves

Hollow metal door frames are sometimes infilled to stiffen them up and/or increase the thermal inertia of the frame.

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