
**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.

Introduction

Fire resistance tests on building components are necessary to establish their behaviour against pre-determined 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.

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.

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.

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

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.

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.

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.

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.

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 fixing 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.

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.

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.

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.

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

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](#).

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

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.

Infilling the frame with a cementitious material will generally increase the stiffness of the frame [see a)], reduce any bowing and, hence, increase its ability to satisfy the integrity (E) criteria and, by increasing the thermal mass, the insulation (I) criteria on the unexposed face.

It may be possible to change the infill in a frame if it can be demonstrated that the change in infill will not increase the unexposed face temperature to the critical levels and that it will not lead to an unacceptable increase in distortion that cannot be compensated for as described above. See [Table 11](#) for the influence of the density and the thermal inertia of metal frame infill material on the integrity and insulation performance of door assemblies.

d) Rebate depth (or door stop depth) (timber doors)

The rebate, or doorstop, applies a high degree of restraint to movement in one direction as the door leaf is prevented from moving out of the frame by the rebate. Generally, doors are tested in their weakest direction in order to generate the maximum field of application. The depth, and hence strength, of the rebate does not have an influence on the deflection. Therefore, the depth of the rebate is of no consequence, as it has no influence on the integrity (E) performance.

However, the rebate depth on a timber door fitted with intumescent seals can have a negative influence on the activation time of the seal and, hence, the integrity (E) criteria. When seals are not fitted, it may have a minor beneficial influence on the integrity (E) criteria. Its impact on insulation (I) criteria is neutral. For doors opening in specific directions, the rebate can control distortion, i.e. door that bows out in the centre and towards the rebate at its edges. In this case, the rebate contributes to compliance with the integrity (E) criteria but the depth is not an important parameter, unless it affects the strength.

The rebate depth may therefore be reduced if it can be demonstrated, using the methodology given in [Annex A](#), that it provides no significant restraint nor contributes significantly to modifying the flow of hot gases and, hence, maintaining the integrity. See [Table 11](#) for the influence of the timber frame rebate depth on the integrity and insulation performance of door assemblies fitted with intumescent seals.

Table 11 — Summary of possible factor influences for fire door frames

Parameter	Factor	Factor influence
Frame stiffness	Greater stiffness	E Increase I Neutral
	Less stiffness	E Decrease I Neutral
Timber density	Increase	E Increase I Neutral
	Decrease	E Decrease I Neutral/Decrease
Timber frame rebate depth (doors fitted with intumescent seals)	Increase	E Decrease/Neutral I Neutral
	Decrease	E Neutral I Neutral
Metal frame infill material (density and thermal inertia/latent heat)	Increase	E Increase I Decrease
	Decrease	E Decrease I Neutral

6.3.4.4 Expert judgements applied to restraint mechanisms controlling leaf movement

6.3.4.4.1 General

Generally, all fire door assemblies, both those primarily of timber or those made of metal, benefit significantly from the application of restraint to the leaf edges. Because these two types of construction behave differently under fire attack, the restraint needs to vary for both types. This restraint is normally required more in the “hot” case than at ambient temperature.

The builder’s hardware/ironmongery provides the majority of the required restraint but the melting point of such items should be considered when taking the restraint on both timber and metal doors due to the hardware into account, especially when using face fixed overhead closers to restrain a door in lieu of latches. Not only does the melting point need to be taken into account, but so does the influence of heat on the method of fixing the hardware, particularly to timber door assemblies.

Intumescent seals (i.e. those materials of a pressure forming type) can apply restraint to deflection/distortion, particularly on timber door leaves, once they have activated.

It may be possible to use hardware/ironmongery that provides lower levels of restraint to the door if the restraint provided by intumescent seals can be increased. (see 6.3.4.4.3). Similarly, it may be possible to use an intumescent seal which offers less resistance to distortion if the restraint provided by the hardware/ironmongery can be increased, but the influence of both of these would need to be resolved using the methodology given in Annex A and taking the characteristics of the hardware and the intumescent as the critical parameters.

Both of these measures require a thorough understanding of the mechanisms involved and expert guidance should be sought from the manufacturer of the doorset or the hardware used in the construction of the assembly or from components of an acknowledged expert.

6.3.4.4.2 Ironmongery (builders' hardware)

It has been demonstrated that the performance of the doorset can be improved if the distortion at the head of the doorset or down the opening jamb can be restricted. This can be achieved by applying mechanical restraint, such as that provided by ironmongery. For those items listed, if a change to these components is proposed, the influence that they have, as indicated below, should be taken into account.

a) Overhead face fixed closing devices

When overhead closers are fitted on the fire side of an inward opening door, these devices initially apply restraint to opening of the door as well as a positive closing force, which gradually reduces between 10 min to 20 min as the closer degrades/melts under the fire exposure. This type of closer is known as a leading arm closer.

When they are fitted on the non-fire side, these devices apply a constant closing force on the door for the duration of the test, i.e. when fitted to a door that is opening into the furnace. These devices are generally known as parallel arm closers.

When considering a change in intumescent seals, the influence of the closer on the restraint on the leaf should be taken into account. See Table 12 for the influence of overhead door closers on the integrity and insulation performance of door assemblies.

b) Floor springs

These devices tend to be located in the threshold of the frame and hence at the coolest part of the furnace, and will therefore experience less detrimental effects, thus enabling them to provide a closing function for longer than either the leading or parallel arms overhead closing devices. See Table 12 for the influence of floor springs on the integrity and insulation performance of door assemblies.

c) Latches (single and multi-point latches)

Single point latches provide a very positive action in restraining the opening/closing edge of the door leaf, thus reducing the amount by which the top closing corner of the door leaf (generally regarded as the most onerous position) distorts relative to the frame. Multi-point latches provide even more restraint, normally directly to the leaf at the top opening corner. See [Table 12](#) for the influence of latches on the integrity and insulation performance of door assemblies.

6.3.4.4.3 Pressure forming intumescent fire seals

One of the factors affecting the performance of insulating (see note) doorsets is the volume of intumescent seals incorporated in the leaf to frame junction/gap. Without intumescent seals, it is unlikely that an the integrity (E) performance of 20 min would be achieved on a timber-based assembly using a nominal 30 min, 44 mm thick door leaf construction. With a “standard” level of intumescent protection, the performance would be increased to over 30 min as a result of the intumescent material sealing the gaps to resist the flow of gases and often to provide restraint to distortion of the leaf if of a pressure forming type. By further increasing the volume of intumescent to an enhanced level, the integrity (E) performance of the door could be increased to between 35 min and 40 min. Therefore, the correct intumescent seal specification provides two important functions. Firstly, the intumescent will act as a gap filling agent and secondly, by selecting a pressure generating intumescent material, it is possible to provide restraint against the tendency to distort, thereby restricting the likelihood of bowing and prolonging the integrity (E) rating.

NOTE Because only “insulating” door assemblies are evaluated by means of the cotton pad method, only these doors will be guaranteed to have intumescent seals fitted. Other door types can be fitted. See [Table 12](#) for the influence of pressure forming intumescent seals on the integrity and insulation performance of door assemblies.

Table 12 — Summary of possible factor influences for mechanisms designed to control leaf deflection/distortion

Parameter	Factor	Factor influence
Mechanical restraint, e.g latches multi-point latches, overhead closing devices	More	E Increase I Neutral
	Less	E Decrease I Neutral
Intumescent restraint — Timber leaf	More intumescent ^a	E Increase I Neutral
	Less intumescent ^a	E Decrease I Neutral
Intumescent restraint — Metal leaf	More intumescent ^a	E Increase/Neutral I Neutral/Increase
	Less intumescent ^a	E Decrease/Neutral I Neutral

^a Only applies to pressure forming intumescent.

6.3.4.4.4 All door/frame fire seals

6.3.4.4.4.1 Heat-activated seals on latched single acting door assemblies (see note)

It is common for fire resisting door assemblies that are evaluated for compliance with the integrity (E) criteria by means of the cotton pad to incorporate heat-activated seals (normally intumescent in composition) in the leaf edge/frame reveal junction or between adjacent leaves in a double leaf assembly. These seals are critical to restrict the flow of hot combustion gases, including hot smoke,

and if they become exhausted or break down prematurely, then the door assembly will probably not achieve the required integrity level. The quantity and nature of the tested seals will normally have been established by type testing (prototype testing) by the manufacturer or certification body. The volume of intumescent material/heat activated strip will normally reflect the difficulty of satisfying the integrity test procedure, i.e. larger doors or doors with a longer required integrity rating will have a greater volume of seal(s) fitted in the perimeter gap. The “type” of intumescent seal should not be varied from that proven by the “type testing”, i.e. pressure forming, non-pressure forming and even restricting the material to a proprietary type if possible, but there will be occasions, possibly during supply problems, when the products may need to be changed.

The position of the heat-activated seal in the rebate of a door frame can be a significant characteristic controlling the duration for which the joint can be sealed. As a consequence, it is recommended that the position of the seal in the rebate remains in the position(s) used in the type test. However, if, for supply problems or hardware variations, it is imperative that the seal has to be varied in location or face width, then the critical parameters are the distance of the seal edge from the opening face of the frame and the total face width of the seals installed.

A summary of the influence that such changes may have on the integrity (E) and insulation (I) criteria is given in [Table 13](#).

Table 13 — Summary of possible factor influences for changing the quantity/volume of heat activated seals

Parameter	Factor	Factor influence
Cross-sectional area (CSA) of heat activated seals	Greater	E Increase ^a I Neutral
	Decrease	E Decrease I Neutral/Decrease

^a An increase in the volume/cross-section area of pressure forming intumescent seals in jambs and meeting stile joints may force an unlatched door or even a weakly restrained latched door open and result in a decrease in the integrity (E) rating. The opinion of an expert should be sought if there is any doubt.

NOTE Unlatched timber fire door assemblies require intumescent edge seals to expand and apply restraint by means of pressure-forming intumescent seals which help to restrict movement of the door leaf. This function requires the expert application and use of complex seals; the critical characteristics of which are only just becoming capable of being measured. As such, while the general principles of this document can be used to interpolate and extrapolate the influences of changes, the important actions are not yet in a position of being quantified by these principles of unlatched doors.

A summary of the influence that the position and face width of intumescent seals will have on the integrity (E) and insulation (I) criteria is given in [Tables 14](#) and [15](#).

A summary of possible factor influences for changing the position and/or face width of seals is given below (also see [Figures 1](#) and [2](#)).

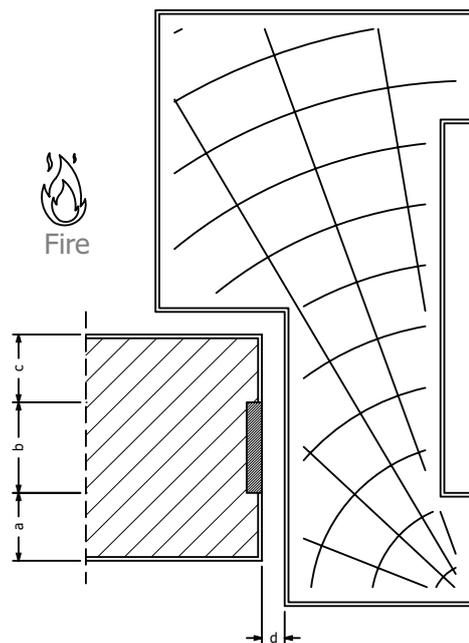


Figure 1 — Position of seal in door leaf edge, door opening away from the fire

Table 14 — Factor influence for door leaves opening away from the fire (see Figure 1)

Parameter	Factor	Factor influence
Edge distance between seal and face of the door leaf (distance a)	Greater	E: Neutral I: Neutral
	Decrease	E: Neutral I: Neutral
Total face width of the seal with same seal thickness in the door leaf edge (distance b)	Greater	E: Increase I: Neutral
	Decrease	E: Decrease I: Decrease
Edge distance between seal and face of the door leaf (distance c)	Greater	E: Neutral I: Neutral
	Decrease	E: Neutral I: Neutral
Gap between the frame and the leaf edge (distance d)	Greater	E: Decrease I: Decrease/Neutral
	Decrease	E: Neutral/Increase I: Neutral

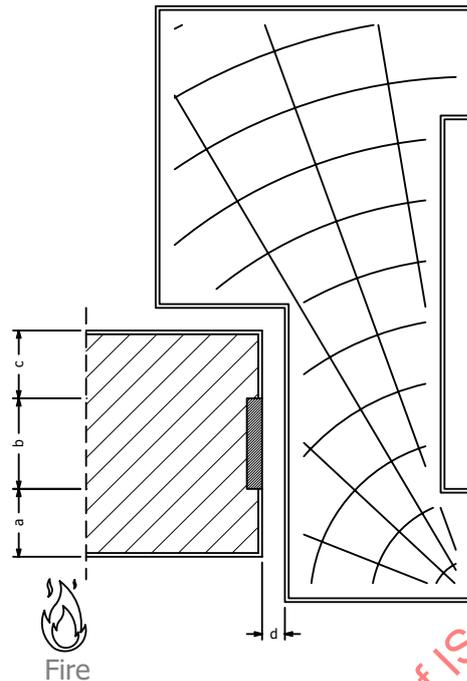


Figure 2 — Position of seal in door leaf edge, door opening towards the fire

Table 15 — Factor influence for door leaves opening towards the fire (see Figure 2)

Parameter	Factor	Factor influence
Edge distance between seal and face of the door leaf (distance a)	Greater	E: Neutral I: Neutral
	Decrease	E: Decrease I: Neutral/Decrease
Total face width of the seal with same seal thickness in the door leaf edge (distance b)	Greater	E: Increase I: Neutral
	Decrease	E: Decrease I: Decrease
Edge distance between seal and face of the door leaf (distance c)	Greater	E: Decrease I: Neutral/Decrease
	Decrease	E: Neutral I: Neutral
Gap between the frame and the leaf edge (distance d) ^{a)}	Greater	E: Decrease I: Decrease/Neutral
	Decrease	E: Neutral/Increase I: Neutral

a) Assuming that door leaf is not consumed from underneath seal during the target duration.

6.3.4.4.4.2 Smoke restricting seals

Many fire resisting doors have a secondary function of restricting the flow of ambient or warm smoke through the gap between the frame and the leaf edge. This is required when the doorsets have to satisfy the smoke leakage criteria given in ISO 5925-1. The seals should have demonstrated their ability to restrict the flow of smoke to the levels identified in the appropriate criteria when fitted to

a door of a similar configuration, action, mode, thermal characteristics and size. Such seals may be added to a different door, subject to the constraints listed above, and be expected to reduce the flow of smoke (ambient or warm/hot) to similar levels. On a “timber” door assembly, the natural insulation (I) characteristics of the timber prevents such seals from compromising the integrity criteria, but when added to a metal door/frame joint, the extra heat flow may cause the seal to ignite and reduce the integrity level. A seal that has ignited or melted will obviously not satisfy the criteria for smoke leakage. Careful consideration needs to be made before fitting smoke seals to metal doors or frames.

Removal of any smoke seals will cause an increase in the passage of ambient or warm smoke.

A summary of the factor influences in relation to the fitting or removal of smoke seals is given in [Table 16](#).

Table 16 — Summary of possible factor influences for adding or removing smoke seals

Parameter	Factor	Factor influence
Smoke restricting seals	Adding a seal (to timber door)	E Increase I Neutral S Lower leakage
	Adding a seal (to metal leaf/frame)	E Neutral/Increase I Neutral S Lower leakage
	Removing a seal (timber or metal leaf/frame)	E Neutral/Decrease I Neutral S Higher leakage

6.3.5 Opening in the leaf or leaves

6.3.5.1 General

It is not permissible to predict the influence of making an opening in a leaf unless there is fire test evidence available from “type testing” (prototype testing) which demonstrates that an opening can be made in a leaf without causing increased deflection/distortion that could compromise the ability to satisfy the integrity (E) criteria for the assembly. Where evidence exists to demonstrate that the leaf can accept “openings”, it may be possible to extend the dimensions/area of the opening or to change the components fitted into the opening as long as they do not have a negative influence on the relevant criteria. The only openings considered in this section are openings for the purpose of installing glass or accommodating air transfer grilles.

6.3.5.2 Dimensions of any opening(s)

In flush “timber” doors in particular and probably in metal faced “pan and lid” construction flush doors, the stiffness and strength of the unexposed face facing can make a significant contribution to the resistance to thermal bowing. Any opening made in this facing, and also to the exposed face, will probably permit the door to bow more than the flush door without openings. Similarly, any increase in the size of the opening will also probably allow the door to distort more. In the case of multiple openings, it is the total area, excluding any intermediate mullions/transoms that do not provide enhanced stiffness between apertures. If the intermediate members do provide stiffness then each aperture may be considered separately. The full analysis of this contribution may require a fire door specialist to be consulted. Generally, an increase in the size of the opening will have the effect of generating greater distortion and, hence, a reduction in the integrity (E) rating.

Apertures in fully framed leaves such as timber “joinery” doors consisting of substantial stiles and rails or metal door leaves formed by making a frame around the periphery and facing with metal sheets are less likely to be affected by the influence of openings or increases in the size of openings than flush

doors. It is recommended that the summary in [Table 17](#) be used for joinery doors, assuming that the framing is not cut away (see note).

NOTE Where either the timber door or the metal door incorporates a structural frame of timber or metal, then any change in the size of the openings is likely to be neutral with respect to integrity (E) or insulation (I), unless the structural frame is reduced in section locally, in which case a timber and/or metal door specialist with in depth fire knowledge will need to be consulted.

Table 17 — Summary of possible factor influences for openings in fire doors leafs

Parameter	Factor	Factor influence
Change in the dimensions of openings in flush timber leaves	Increase	E Decrease I Neutral
	Decrease	E Increase/Neutral I Neutral
Change in dimensions of openings in flush metal leaves	Increase	E Neutral/Decrease I Neutral
	Decrease	E Increase/Neutral I Neutral

6.3.5.3 Position of openings

As with the dimensions of openings in flush doors, both timber and metal, the closer the openings to the leaf edges, either the horizontal or vertical edges, the greater will be the likely influence on the ability of the leaf to resist thermal deflection and, hence, compliance with the integrity (E) criteria. The influence on the insulation (I) criteria will be neutral, assuming that the construction of the insert that is set in the opening is of the same construction as in the type test (prototype test). See [Table 18](#).

Similar considerations apply when multiple openings are installed closer to each other, thereby removing the amount of material between openings.

Table 18 — Summary of possible factor increases for position of openings

Parameter	Factor	Factor influence
Distance between leaf edge and opening edge, or between individual openings	Greater	E Increase/Neutral
	Less	E Decrease
		I Neutral

Special consideration should be given to the situation where the opening dimensions are significantly greater and the edge distances are significantly reduced. Both may not be permitted even though neither causes a critical influence in isolation.

6.3.5.4 Glazing openings in fire door leaves

It is difficult to give general guidance with respect to glazed openings because of the complexity of glass types and the plethora of proprietary glass types. The guidance given below is restricted to a number of robust families of glass, where there may be some restricted interchangeability of products within the same family and where other parameters may also be interchanged. These families are

- a) integral wired soda/lime composition clear glass (nominally 6 mm thick),
- b) borosilicate composition glass,

- c) intumescent interlayer/multi-layer glasses, and
- d) ceramic “glass”.

The following products are considered too sensitive to installation and to glazing practice to be the subject of general guidance:

- a) any clear (non-wired) monolithic soda/lime composition glass (i.e. glasses with a coefficient of expansion of $5,9 \times 10^{-6}$ m/mK;
- b) any clear, non-intumescent resin interlayered multi-layered glasses, with or without wire;
- c) clear, “gel” filled multi-layer glasses;
- d) any other glass type including double glazed units;
- e) non-integral wired soda/lime composition glass.

This family of glasses is frequently used for applications up to 45 min integrity ratings and the only major difference between proprietary types is the shape of the wire mesh and possibly the thickness of the wire. Up to the 45 min integrity rating, these glasses can be interchanged with each other as their glazing requirements are similar.

For 15, 20 and 30 min integrity applications, the size of the exposed pane does not have an impact on the integrity rating and as a consequence, the dimensions and the exposed area of any such glazed aperture may be changed and the influence of the change or the relevant criteria of integrity (E), insulation (I) and radiation (W) may be analysed using the methodology given in [Annex A](#). At integrity ratings of 45 min and above, the natural softening/transition temperature of the glass will also have to be considered as part of this evaluation. The maximum glass size will never exceed the maximum opening size evaluated.

In the case of substitution of glasses within this “family” and changes in the dimensions or area of the exposed pane size, it is critical that the glazing systems are identical to those used in the initial type testing (prototype testing).

Table 19 — Summary of possible factor influence with respect to changes in pane dimensions for exposed glass area

Parameter	Factor	Factor influence
Glass dimensions for integrity ratings 15, 20, 30 min	Increased dimensions	E Neutral I Neutral W Increase in proportion to size changes
	Decreased dimensions	E Neutral I Neutral W Decrease in proportion to size change
Glass dimensions for integrity ratings greater than 30 min ^a	Increased dimensions	E Decrease/Neutral I Neutral W Decrease in proportion to size change
	Decreased dimensions	E Increased I Neutral W Decrease in proportion to size change

^a Integrity (E) ratings of more than 45 min will normally only be achieved with these glasses if the glazing systems provide a significant cool edge or applies pressure to the edge of the glass throughout the fire exposure.

- a) Borosilicate composition glasses (low expansion glasses with a coefficient of expansion of $3,3 \times 10^{-6}$ m/mk

These glasses contain no wires but are manufactured from a chemical composition of glass that exhibits low thermal expansion when heated, making it more robust and hence able to accept greater edge cover, possibly allowing higher levels of restraint and/or clamping, [and will generally have a slightly higher transition temperature(/)], making it more able to satisfy extended integrity durations.

This family of glasses comes in a variety of thicknesses and each thickness should be considered to be a separate product for the purpose of interpolation and extrapolation and be produced separately for each thickness assuming that there is “prototype” test evidence for each variation.

As for integral wired glass, the glazing system should be returned to that used in the type/prototype tested assembly. Depending upon the characteristics of the glazing system, the integrity rating may extend to 90 min. No changes are permitted for low expansion glass with integrity rating in excess of 90 min.

Changes in dimensions may be permitted by reference to the methodology given in [Annex A](#).

Table 20 — Summary of possible factor influences with respect to changes in pane dimensions for any specific thickness of low expansion glass exposed glass areas

Parameter	Factor	Factor influence
Dimension of low expansion glass	Increase	E decrease I neutral W decrease
	Decrease	E increase I neutral W increase in proportion to size change

b) Intumescent interlayer multi-layer glasses

These glasses consist of two or more layers of nominally 3 mm thick clear soda/lime composition glass separated by interlayers of intumescent material (normally of sodium silicate composition). When heated, the interlayers react and initially turn opaque, blocking out radiation, and then expand, layer upon layer, reducing the unexposed face temperature while maintaining integrity. Such glasses can be used as insulating glasses for various durations of fire resistance where the integrity (E) and insulation (I) ratings are identical, used as partially insulating glass, whereby the insulation (I) criteria is satisfied for a lesser duration than integrity (E), or where the radiation (W) criteria is satisfied for the same duration as integrity (E) or for a reduced duration. Glasses in this category require similar glazing systems and methods of glazing to satisfy the integrity and insulation criteria for durations up to 60 (90) min.

Subject to the test evidence for the glass being able to demonstrate that the type tested/(prototype tested) glass that is proposed to be substituted by, or with has at least a 10 % factor of safety on a size for size comparison, then the glasses may be interchanged.

The size of the glass in any leaf opening may be changed and the influence of that change should be analysed using the methodology described in [Annex A](#), assuming that the method of glazing and the glazing system is not modified from that proven in the type test (prototype test).

Table 21 — Summary of possible factor influences with respect to changes in the pane dimensions of intumescent interlayer multi-layered glasses

Parameter	Factor	Factor influence
Dimensions of intumescent interlayer exposed glass	Increase	E decrease I neutral W neutral
	Decrease	E increase I neutral W neutral

c) Zero thermal expansion clear “ceramic” glass

These glazing materials are not really glass but consist of transparent ceramic materials. As such, they do not exhibit the same rheology as glass and have no transition temperature and an extremely high “melting” temperature, well in excess of that reached in a fire resistance test of up to 240 min duration. As a consequence of these materials exhibiting zero expansion, they are very easy and simple to glaze and require no special techniques and, as they have no effective softening temperature, the size of the pane can be increased or decreased without restriction and without reducing the integrity rating, other than the restrictions imposed by the maximum size of opening. Radiation (W) will increase/decrease according to the size of the pane of glass.

NOTE Where material regulations impose requirements for glass to break safely in the event of an impact by persons, clear ceramics/zero expansion “glass” cannot satisfy such requirements without laminating directly to tempered or laminated glass(es). In this case, the laminated glass becomes a special glass not covered by this guidance as ignition of the interlayer can cause a loss of integrity in some applications.

6.3.5.5 Air transfer grilles in openings in timber fire door leaves

Air transfer grilles are generally a proprietary product and the ability to satisfy the relevant criteria of integrity (E) and insulation (I) for the prescribed duration generally lies with the grille manufacturer. The direct and extended application for the grille also lies within the responsibilities of the manufacturer, but the extended application for the grille *in situ*, i.e. set in an opening in the fire door leaf, may form part of the responsibility of a third party, who is either the manufacturer/supplier of the door leaf or a tradesman employed to install the device. The air transfer grille under consideration should, therefore, have been “type tested” to demonstrate that the device has the capability of satisfying the integrity (E) and, if appropriate, the insulation (I) criteria when correctly installed. The third party selecting/installing the product in the door leaf (supporting/associated construction) should ensure that the direct and extended application of the *in situ* product is correct by adopting the following guidance. The critical parameters when installing an air transfer grille into a timber fire door leaf are the thickness of the leaf (relative to the thickness of the grille), the density of the timber and the method of fixing/retaining the grille. This assumes that any gaskets, sealants and intumescent sealing strips used in the installation of the prototype test are used in the final installation.

A summary of the possible factor influences with respect to changes in the supporting construction for the air transfer grille is given in [Table 22](#).

Table 22 — Summary of possible factor influence with respect to changes in a timber based door leaf construction

Parameter	Factor	Factor influence
Density of timber used in the construction of the door leaf adjacent to the grille	Increase	E Increase I Neutral/Increase
	Decrease	E Decrease I Neutral
Thickness of timber in the door leaf containing the opening	Increase	E Increase I Increase
	Decrease	E Decrease/Neutral I Decrease/Neutral
Effectiveness of fixings, screw lengths, angle sizes, etc.	Increase	E Neutral/Increase I Neutral
	Decrease	E Decrease I Neutral

6.3.5.6 Air transfer grilles in openings in metal fire door leaves

The guidance given in this part is primarily related to fire resisting air transfer grilles. Recent development into the design have resulted in the manufacture of smoke restricting air transfer grilles. The guidance given herein for fire resisting grilles will generally apply to both types.

It is assumed that any air transfer grille installed in metal fire door leaf will form part of the original manufacture and form part of the responsibility of the door manufacturer to characterize their product and provide an appropriate field of application for the door assembly and all of its components. As a consequence, no guidance is given in this part relating to the separate determination of the extended application of air transfer grilles when mounted in metal door assemblies. However, the metal door manufacturer may need to engage the services of a professional fire engineer with knowledge and experience of metal fire doors in order to make the expert judgements necessary to define the field of application in the first place.

7 Fixed vertical fire resisting glazed elements

7.1 General

Fixed glazed screens are a form of non-loadbearing separating element, e.g. a partition, and much of the guidance given for partitions in ISO/TR 12470-1 is applicable to this clause. However, there are many different types of fire resisting glass, most of which require their unique installation considerations which should be accommodated by the design and manufacture of the components incorporated in the assembly and this is often the critical aspect to be considered when defining the extended field of application for glazed elements. Almost all of the fire resisting glasses are proprietary in nature and as a consequence, the amount of generic information available for establishing the extended field of application is restricted. However, because there is generally an obligation on the glass manufacturer to provide direct test evidence in support of any product that is being subjected to approval by building authorities and, therefore, it is not normally difficult to obtain the necessary evidence of performance required to generate the extended application of the product

7.2 Direct application

7.2.1 General

The results of a fire resistance test on a fixed glazed element are deemed to be applicable to a similar type of untested construction manufactured from similar/identical components provided that all of the following are satisfied.

7.2.2 Common parameters of all forms of fixed glazed elements

- a) The height of the glazed partition is not increased.
- b) The edge conditions are unchanged and for a glazed element tested with all edges restrained; no increase in width is permitted.
- c) For glazed elements only fixed at the top and bottom and tested at least with one edge free, wider elements are allowed.
- d) Openings in walls should be controlled such that their size and number of any equivalent area is not increased, the method of protecting the opening is unchanged and their position relevant to any critical component of the construction (if there are any) is not decreased.

7.2.3 Framing members (timber)

- a) The number of vertical framing members are not decreased in number.
- b) The cross-sectional area and second moment of area of these framing members are not reduced.

- c) The distance between those vertical framing members is not increased.
- d) The method of jointing these members to be head and sole plates is not any weaker with respect to in-plane loads and “racking” forces.
- e) The density and the inherent charring rates of these timber members is not reduced.
- f) Any horizontal framing members used to create glazing apertures should have a cross-sectional area and second moment of area not less than that tested.
- g) The method of forming joints between the vertical and horizontal members should be no less effective than the joints as were tested.

7.2.4 Framing members (metal)

- a) The metal used for the manufacture of the framing members should be nominally the same composition, i.e. have similar melting points, coefficients of expansion and “temper”.
- b) The number of vertical framing members are not decreased in number.
- c) The section moduli of these metal vertical framing members is not reduced.
- d) The distance between these vertical framing members should not be greater than what was tested.
- e) The methods of jointing framing members to each other; e.g. welding, bolting, spigotting, is likely to be a critical characteristic of the system’s ability to provide fire resistance and this should not be varied.

7.2.5 Glass retention system

The glass should be installed into openings between framing members by means of a glass retention system normally consisting of fixed or removable section of compatible material which may be used to create a rebate or bead that can retain the glass in position together with any gaskets or sealants necessary to satisfy the fire function together with other possible functions, i.e. acoustics, gas tightness. These are critical components which generally cannot be modified to produce a modified design of element using direct field of application rules with the possible exception of the following:

- the fixings used to retain removable glazing beads can be increased in number, but not reduced, assuming that they have an equal or stronger retention strength.

7.2.6 Glass

- a) The glass cannot be replaced by another glass (even glasses with similar sounding names) as the glasses invariably achieved their fire resistance capabilities using different mechanisms.
- b) The size of any pane of glass can be reduced in area by up to 50 %, subject to the restrictions on changes in aspect ratio as laid down in c).
- c) The aspect ratio of the height to width dimensions of the glass panes designed to provide fire resistance periods in excess of 30 min (E30) should not vary by more than 30 %.
- d) The surface of the glass should not be modified by etching, applications of films or other manifestations.

This is the limit of design changes permitted by the application of direct application rules.

7.3 Extended application

7.3.1 General

Greater variations in the design and construction of a vertical glazed separating element may be achieved by the use of the extended application process, based upon the application of rules, fire engineering calculations or expert judgements. Unfortunately, there are very few validated rules and only a limited number of design parameters that lend themselves to a calculation process. However, by using the methodology given in [Annex A](#), the expert judgement approach, more generous and accurate extended applications, may be established.

Guidance on the extended application rules for a fixed glazed vertical separating element is given below.

7.3.2 Rules

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 fixed glazed element by the application of pre-determined rules.

7.3.3 Fire engineering calculations

Fire engineering calculations may be generated and applied for the following.

a) Temperature profile of framing members

Heat transfer through members where the thickness of the framing has been changed may be calculated by using an accepted temperature analysis model that is appropriate to the form of construction e.g. tubular hollow sections. 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 framing components. For composite members, it is probably necessary to estimate, using relevant test results, the duration of exposure at which destruction or detachment of the composite parts of the element, i.e. facings, insulation, etc., will occur, as these will change the mechanical and thermal response, i.e. the behaviour of the profiles when exposed to further heating.

b) Insulation performance

Compliance with the maximum insulation criterion may be calculated using appropriate temperature profiles for the members as above. Compliance with the mean temperature rise should require calculating the temperature rise through the glazed components for which there may not be adequate knowledge in the public domain, albeit it may be possible with the glass manufacturers.

c) Deflection due to thermal gradient and its potential impact on the glass performance

Deflections of the framing may be calculated for glazed elements where the physical properties and the relationships between stress and strain including, if necessary, creep effect are known as a function of temperature and where the temperature profile over the cross-section of the element is known and its effect on the glass can be quantified.

7.3.4 Expert judgements

7.3.4.1 General

Changes may be made to the following construction parameters of a fixed glazed element provided that expert judgement, based upon the methodology given in [Annex A](#), is adopted.

7.3.4.2 General parameters relating to fixed glazed elements

a) Height

The height of the fixed glazed element may be increased provided the behaviour of any fire protection applied to any framing members can be demonstrated (by using the method given in [Annex A](#)) not to compromise the integrity, or in the case of unprotected framing members, that the variation in slenderness ratio does not generate increased deflection that could damage the glass or glazing interface.

b) Width

The width of any construction tested with a free edge is covered by the direct application [see [7.2.2, c\)](#)], but when the partition was tested with four edges restrained, the width may still be increased subject to the behaviour being evaluated in accordance with the method of [Annex A](#).

c) Services

Services may be installed both in and passing through vertical glazed elements provided that the ability of the construction to satisfy the insulation (I) and integrity (E) criteria is not reduced.

7.3.4.3 Expert judgement applied to the specific components of a vertical fixed glazed element

Expert judgement in accordance with the [Annex A](#) principles can be applied to the following construction parameters:

a) Width of vertical framing members (mullions)

The width of a vertical framing member may be varied for architectural or functional reasons. Increases in the width of these mullions would generally be neutral, whether they are metal or timber, but decreases in mullion width; timber mullions, in particular, may lead to a more rapid consumption of the cross-section and a possibly resultant reduction in integrity. See [Table 23](#).

Table 23 — Summary of possible factor influences for width variations of mullions

Parameter	Factor	Factor influence
Width of mullion (timber)	Increase	E Neutral I Neutral
	Decrease	E Decrease I Neutral
Width of mullion (metal)	Increase	E Neutral I Neutral/Decrease
	Decrease	E Neutral I Neutral

b) Depth of vertical framing members (mullions)

The depth of a vertical framing member may be varied for aesthetic/functional purposes. Increases in the depth of these members will have different influences depending upon whether the member is metal or timber. As a consequence, the summaries of possible influences on the fire resistance of fixed glazed elements as a result of changes in the depth of mullions are given in [Tables 24](#) and [25](#) for timber and metal members, respectively. The influence of changes in depth of these mullions will generally influence integrity mostly for timber and insulation/deflection for metal members.

Table 24 — Summary of possible factor influences for depth of timber mullions

Parameter	Factor	Factor influence
Depth of mullion	Increase	E Increase I Increase
	Decrease	E Decrease I Neutral/Decrease

Table 25 — Summary of possible factor influences for depth of metal mullions

Parameter	Factor	Factor influence
Depth of mullion	Increase	E Increase I Increase
	Decrease	E Decrease I Decrease

c) Applied facings to metal framing members (mullions)

Metal framing members sometimes incorporate applied facings for decorative or functional purposes. Varying the thickness of these facings may need to take place on occasions for performance, supply or aesthetic reasons. Increasing the thickness of these facings will generally have a beneficial influence on the performance of a fixed vertical glazed element, but there is a difference between facings that are non-combustible fire protective facings and decorative, possibly combustible, facings. These influences are summarized in [Table 26](#).

Table 26 — Summary of possible factor influences for facings applied to mullions

Parameter	Factor	Factor influence
Thickness of applied non-combustible fire protection board facings	Increase	E Increase I Increase
	Decrease	E Neutral I Decrease
Thickness of applied decorative combustible facings	Increase	E Increase I Increase
	Decrease	E Decrease I Decrease

d) Width between vertical framing members (mullions)

The width between framing members may be subject to variation in order to generate glass pane “aspect-ratios” required for aesthetic reasons or to accommodate a symmetrical sub-division of a space, into which the glazed element is to be installed, that is not a multiple of the 3,0 m test specimen size. The summary of the influence of variations in mullion centres is restricted solely to the influence of the variation on the mullions and any incidental changes in the area of the glass is to be considered using the guidance on variations in glass sizes (see [7.3.4.3](#))

Table 27 — Summary of possible factor influences for variation in the fixing centres of vertical framing member

Parameter	Factor	Factor influence
Distance between vertical framing members	Increase	E Decrease I Neutral
	Decrease	E Neutral/Increase I Neutral

e) Height of vertical framing members (mullion)

An increase in the overall height of a vertical fixed glazed element, as permitted by 7.3.4.2 b) has a resultant influence on the vertical framing members (mullions) to which the glass panes are fixed. Variations in the height of these members will invariably influence the degree of bowing of these components and this may have an impact on the performance of the glass pane and/or the glass retention system. The influence will generally be the same for framing members regardless of whether the mullions are constructed from hollow metal sections or solid timber. See Table 28.

Table 28 — Summary of possible factor influences for variations in the height of vertical members (mullions)

Parameter	Factor	Factor influence
Height of vertical framing members	Increase	E Decrease I Neutral
	Decrease	E Increase I Neutral

f) Variations in the size of the glass panes installed in fixed vertical glazed elements

The fixed vertical glazed elements will often incorporate glazed areas which are different in size from that tested as a direct consequence of adopting some of the variations in the design of the construction as identified in 7.3.4.3, a) to e). There are many different types of fire resisting glass and as stated in 6.3.5.4, they are generally proprietary in nature and the maximum glass pane sizes for each type at the various fire resisting durations will be as specified by the manufacturer and should never be exceeded. Variations to the pane sizes can be made within this maximum approved size, including variations to the aspect ratio of the pane subject to it being evaluated by means of an expert judgement analysis, in accordance with the process given in Annex A. Guidance on the possible factor influences for the glass pane element of a vertical fixed glazed element can be found in principle in 6.3.5.4 where the factor influences for glass installed in fire resisting doorsets is discussed.

g) Variations in the glass retention system

The glass retention system for fire resisting glass is bespoke to each individual type of glass and no variation to this can be made, even when adopting the Annex A expert judgement principles. All variations made to the glass retention system should be evaluated by a new test performed in accordance with the appropriate test method, i.e. ISO 3009.

8 Linear gap sealing systems

8.1 General

See Figure 3 for the position of a typical aperture in a horizontal element and the position of a typical aperture in a vertical element. In a building, there will be a number of linear gaps, gaps which are longer than their width by a factor of not less 10:1. These gaps may have been caused by imperfections of fit generated during the construction process or may have been designed-in for functional purposes,

i.e. to provide movement joints which accommodate mechanically or thermally induced movements, for acoustic purposes or to make assembly simpler. Where these linear gaps occur in or around the perimeter of a wall or floor that has to provide fire separation or smoke containment, it is important that they are sealed in a manner that maintains these qualities. The seals used for this purpose are known as linear gap seals and the objective of this section is to define how these seals may be varied and still maintain their fire/smoke sealing capabilities.

NOTE Sometimes the seals are known as fire stopping, but this term fails to identify the primary function of these seals and as such, the term is deprecated.

Linear gap seals are evaluated against the criteria of integrity (E) and insulation (I), if applicable, and the seal should satisfy these criteria for a period equal to that of the element being penetrated. Where the fire resistance is different for the two elements forming the gap, the seal should satisfy the criteria for the longer duration of the two.

8.2 Direct application

8.2.1 General

The results of a fire resistance test on a linear gap seal/sealing system are deemed to be applicable to a similar type of untested seal manufactured from identical materials and installed in a similar manner provided the following are satisfied.

8.2.2 Common parameters for all applications

8.2.2.1 General

- a) The width of the gap is not increased.
- b) The depth of the seal in the gap is not less than in the characterization test.
- c) The orientation of the gap has not changed.
- d) The supporting/associated construction forming the two faces/edges of the gap are constructed from materials with similar thermal and mechanical responses to standard fire test conditions and the surface(s) of the gap edges provide identical levels of adhesion or “stickability”, subject to other parameters complying with the following direct application conditions.

8.2.2.2 Common parameters relating to supporting construction

- a) Parameters related to solid concrete/masonry associated construction:
 - 1) the density of the element should not be varied by more than 20 %;
 - 2) the thickness of the construction being penetrated should not be reduced.
- b) Parameters related to the timber studded/joisted associated constructions with fire “resisting” facings applied to the fire exposed face:
 - 1) the timber structural members should have had a face width and/or a depth not less than that tested in the characterization test;
 - 2) the structural members should not be fixed farther apart from each other (i.e. with a wider gap) than that tested and the fixings used to join members together should not provide any less fixity to the studs;
 - 3) the fire exposed linings protecting the studs forming the gap should not be thinner than that tested;

- 4) the material used for the linings (exposed and unexposed faces) should not be varied from that tested;
 - 5) any infill between the lining of a timber studded construction to support the linear gap seal should not be varied with respect to density, combustibility, high temperature characteristics and fixing method.
- c) Parameters related to steel studded/joisted associated constructions with fire “resisting” facings applied to the fire exposed face:
- 1) the rolled steel framing members should not be varied in profile, dimensions or methods of fixings;
 - 2) the structural members should not be fixed farther apart from each other than as was tested and methods of jointing framing members to each other should not be varied, i.e. welding, riveting, screw fixing, etc.;
 - 3) the material used for the linings (exposed and unexposed faces) should not be varied from that tested;
 - 4) any infill provided between the faces of the steel studded/joisted element bounding a gap to support the linear gap seal should not be varied with respect to density, combustibility, high temperature characteristics and fixing methods.

The above represent the limit of design variations permitted by the application of direct application rules.

8.3 Extended applications

8.3.1 General

Greater variations in the design and application of a linear gap sealing system may be achieved by the use of the extended application process, based upon the application of rules, fire engineering calculations or expert judgements. Unfortunately, there are very few validated rules and only a limited number of design parameters that lend themselves to a calculation process. However, by using the methodology given in [Annex A](#), with the expert judgement approach, more generous and accurate extended applications may be established.

Guidance on the extended application rules for a linear gap sealing system installed into a fire separating element is given below.

8.3.2 Rules

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 linear gap sealing system by the application of pre-determined rules.

8.3.3 Fire engineering calculations

Fire engineering calculations may be generated and applied for the following variations.

- a) Unexposed face temperature of seal (insulation)

Heat transfer through a seal consisting of only one homogenous material where the thickness of the seal has been changed may be calculated by using an accepted temperature analysis model that is appropriate to the sealing material. Input data should be based on values for actual specific heat capacity and thermal conductivity as a function of temperature for that material. Composite seals, where more than one material is used to form the seal, are not appropriate for calculation techniques.

- b) Deflection of associated supporting construction due to thermal gradient and its potential impact on the seal performance

Deflections of the supporting construction may be calculated for a linear gap seal where the physical properties and the relationships between stress and strain are known as a function of temperature and where the temperature profile over the cross-section of the element(s) in which the gap is formed are also known. This information is not directly of value but may be used in conjunction with expert judgement to assist in the prediction of integrity failure using the technique described in [8.3.4](#).

8.3.4 Expert judgement

8.3.4.1 General

Changes may be made to the following construction parameters of a linear gap seal/sealing system provided that expert judgement, based upon the methodology given in [Annex A](#), is adopted.

8.3.4.2 Length of gap to be sealed

8.3.4.2.1 General

In practice, a linear gap can be longer or shorter than was tested. The response of the sealant to such changes will depend to a large extent on the physical nature of the sealing material. A non-setting sealant may be more prone to slumping with extended gap lengths in vertical side entry gaps, but would be unaffected by extended horizontal side entry gaps. Rigid sealants may respond badly to extensions in the gap lengths due to shrinkage of the sealant or expansion of the associated construction, especially for those sealants that do not rely on intumescent technology. The extrapolation process relating to changes in the gap length should, therefore, differentiate between sealants with different characteristics and gaps with different orientations.

8.3.4.2.2 Non-rigid gunnable sealants

- a) Side entry vertical gaps

The position of a side entry vertical gap is presented in [Figure 4](#). A reduction in the length of such a gap should not result in any reduction in performance because there would naturally be less of a tendency to slump as the weight of sealant would generally be less than in the situation of a long gap. However, an increase in the length of the gap to be sealed may have a detrimental influence on the ability of the seal to maintain the integrity of the gap as the potential for slumping is increased by the increased mass/weight of the sealant, albeit this tendency will be governed by the viscosity/thixotropy of the sealant material at higher temperatures.

The sealant may be applied to the exposed or unexposed face of the gap or, alternatively, on both faces and any backing rod material will also influence any propensity to slump, again modified significantly by the position of the backing material in the gap relative to the fire exposed face. With many sealing systems, mineral rock fibre is used as the backing rods/gaskets, and these can make a significant contribution to the integrity of the seal and the expert judgement should take this contribution into account when resolving the performance. The summary given in [Table 29](#) for side entry vertical gaps sealed with a non-setting gunnable seal (intumescent or non-intumescent) assumes that the backing material does not make a major contribution to the integrity (E) rating, (i.e. is either not used or is formed of a low melting temperature plastic composite) and that the seal is applied to the gap from the fire exposed face.

Table 29 — Summary of possible factor influences for side entry vertical linear gaps sealed with non-rigid gunnable sealants

Parameter	Factor	Factor influence
Gap length	Decrease	E Neutral/increase I Neutral
	Increase	E Decrease/Neutral I Decrease/Neutral
Depth of seal in the gap/thickness of associated construction (assuming the seal is fitted full depth)	Decrease	E Decrease/Neutral I Decrease/Neutral
	Increase	E Increase/Neutral I Increase

b) Side entry horizontal gaps

The position of a side entry horizontal gap is presented in [Figure 4](#). The tendency to slump is unaffected by the length of the gap as gravity is only having an influence on the cross-section/width of the gap. The length of the gap would have a neutral influence on integrity (E) and insulation (I). The width of the gap can be decreased but an increase in the gap width may possibly result in a reduction in the integrity and the insulation criteria. See [Table 30](#).

Table 30 — Summary of possible factor influences for horizontal side entry linear gaps sealed with non-rigid gunnable sealants

Parameter	Factor	Factor influence
Gap length	Decrease	E Neutral I Neutral
	Increase	E Neutral I Neutral
Width of gap	Decrease	E Neutral/Increase I Neutral
	Increase	E Decrease I Decrease/Neutral
Depth of seal in the gap/thickness of associated construction (assuming the seal is fitted full depth)	Decrease	E Decrease I Decrease
	Increase	E Increase I Neutral

c) Horizontal vertical entry linear gap(s)

The position of a horizontal vertical entry linear gap is presented in [Figure 4](#). An example of a horizontal vertical entry gap is to be found in [Figure 1](#). Such gaps may be filled from above or below and seals applied from below are prone to earlier losses of integrity due to the influence of gravity and the onerousness of the exposure.

The sealant may be applied to the exposed (bottom) or unexposed (top) face of the gap or, alternatively, to both faces and any “backing rod” material used will also influence any propensity to slump, again modified significantly by the position of the backing material in the gap relative to the soffit. With many sealing systems, mineral rock fibre is used as the backing rods/gaskets and these can make a significant contribution to the integrity of the seal and the expert judgement should take this contribution into account when resolving the performance.

The summaries of factor influences given in [Table 31](#) and [Table 32](#) below for top/bottom entry horizontal gaps sealed with a non-setting gunnable seal (intumescent or non-intumescent) assumes that the backing material does not make a major contribution to the integrity (E) rating, (i.e. is either not used or is formed of a low melting temperature plastic composite) and that the seal is applied to the gap from the fire exposed face, or does make a contribution because it is made of a high temperature resistant material and the gap is sealed from above. Other combinations are possible and should be adjudged by analogy.

The length of the gap may influence the integrity (E) and insulation (I) characteristics of the seal as the potential to slump in this orientation may be influenced by a change in the gap length, i.e. a greater weight of sealing system, unless the sealant exhibits a change in state when heated, in which case, the possibility of extending the performance without further testing is limited. See [Table 31](#) and [Table 32](#) for the influence of the gap length on the integrity and insulation performance of the linear gap seal.

An increase in the gap width can result in a reduction in the friction/stickability of the sealant and or backing rod, which may, depending upon the materials' characteristics, result in a reduction in integrity and insulation. A decrease in width is most likely to be beneficial unless excess pressure is generated with respect to an intumescent sealant which could cause the seal to "pop-out" prematurely. See [Table 31](#) and [Table 32](#) for the influence of the gap width on the integrity and insulation performance the linear gap seal.

An increase in the seal depth or the thickness of the associated construction is likely to be beneficial, albeit a reduction in depth/thickness could result in a decrease in integrity (E) and insulation (I). See [Table 31](#) and [Table 32](#) for the influence of the seal depth on the integrity and insulation performance the linear gap seal.

Table 31 — Summary of possible factor influences for horizontal vertical entry gaps sealed with non-rigid gunnable sealants — Non-contributory backing rod

Parameter	Factor	Factor influence
Gap length	Decrease	E Neutral I Neutral
	Increase	E Neutral I Neutral
Width of gap	Decrease	E Increase/Neutral I Neutral
	Increase	E Decrease I Decrease
Depth of seal in the gap/thickness of associated construction (assuming the seal is fitted full depth)	Decrease	E Decrease I Decrease
	Increase	E Increase I Increase/Neutral

Table 32 — Summary of possible factor influences for horizontal vertical entry gaps sealed with non-rigid gunnable sealants — Contributory backing rod

Parameter	Factor	Factor influence
Gap length	Decrease	E Neutral I Neutral
	Increase	E Neutral I Neutral
Width of gap	Decrease	E Increase/Neutral I Neutral
	Increase	E Neutral/Decrease I Neutral/Decrease
Depth of seal in the gap/thickness of associated construction (assuming the seal is fitted full depth)	Decrease	E Decrease/Neutral I Neutral
	Increase	E Increase I Increase

8.3.4.2.3 Rigid sealing systems (mortar, intumescent plaster, etc.)

a) Side entry vertical gaps

A reduction in the length of such a gap should not result in any reduction in integrity performance, as any shrinkage, the most likely cause of a loss of integrity, would be decreased by a reduction in the length of the gap, especially as a percentage of the total length. Similarly, an extension in the gap length should not result in a decrease in the integrity performance of the seal, unless the material becomes non-rigid during heating, in which case, no EXAP is possible.

The width of the gap can generally be reduced without any reduction in integrity (E) and insulation (I), but an increase in gap width could produce a reduction in these criteria as the sealant has a more difficult task to perform.

An increase in the thickness of the associated construction/depth of seal would be beneficial, but a reduction in thickness could cause a reduction in the integrity (E) and insulation (I). See [Table 33](#)

Table 33 — Summary of possible factor influences for vertical side entry linear gaps sealed with rigid sealing systems

Parameter	Factor	Factor influence
Gap length	Decrease	E Neutral/increase I Neutral
	Increase	E Decrease/Neutral I Decrease/Neutral
Width of gap	Decrease	E Increase/Neutral I Neutral
	Increase	E Decrease I Decrease/Neutral
Depth of gap/thickness of seal or thickness of associated construction	Decrease	E Decrease I Decrease/Neutral
	Increase	E Increase/Neutral I Increase

b) Side entry horizontal gap(s)

Any change in the length of gap will generate the same as for side entry vertical gaps [see 8.3.4.2.3 a)]. An increase in the width of the gap would not be expected to result in a reduction in the integrity (E) and/or insulation (I), assuming that the thickness of the seal is either increased proportionally or some form of reinforcement is incorporated. A decrease in the width of the seal would not be expected to reduce either the integrity (E) or the insulation (I) performance.

As with vertical side entry gaps, any reduction in the depth of a rigid sealant or the thickness of the associated construction (assuming that the rigid sealant is full depth) would be expected to lead to decrease in both the integrity (E) and insulation (I) rating. See Table 34.

Table 34 — Summary of possible factor influences for side entry horizontal linear gaps sealed with rigid sealing systems

Parameter	Factor	Factor influence
Gap length	Decrease	E Neutral/Increase I Neutral
	Increase	E Neutral/Decrease I Neutral/Decrease
Width of gap	Decrease	E Neutral/Increase I Neutral
	Increase	E Decrease/Neutral I Neutral
Depth of gap/thickness of seal or thickness of associated construction (assuming seal is installed to full depth)	Decrease	E Decrease I Decrease
	Increase	E Increase I Increase

c) Horizontal linear gaps(s) with top or bottom entry

All horizontal seals are assumed to be exposed from below, as in the relevant fire resistance to fire exposure from above is not considered in this document. Horizontal/Vertical entry seals can be installed from above the gap or from below. For gaps in excess of 10 mm, normally both techniques incorporate a backing rod which can take the form of a “plastic rod” or a pre-formed section of a mineral rock fibre, both of which are pushed into the gap prior to the application of the sealant. This rod either supports the sealant when it is applied from above or controls the depth of the sealant when installed from below and, in addition, possibly reduces the permeability of the sealed gap, especially as the seal breaks down under fire attack. The presence of these backing rods will influence the way the seal works which, in turn, will affect the field of application of the test results. The following guidance addresses the three alternative installations:

- 1) narrow gaps ≤10 mm, without backing rods;
 - 2) gaps >10 mm, with backing rods — bottom entry;
 - 3) gaps 10 mm, with backing rods — top entry.
- i) Length of gap — Common to all three

A decrease in the length of any linear gap sealed with a rigid sealing system should not result in an increase or decrease in the integrity and insulation performance of the seal.

An increase in the length of such a gap may result in a decrease in integrity if there is a differential expansion between the associated construction and the rigid sealing system which was accommodated at test scale, but possibly not in use. Such a differential could also be accompanied by a reduction in the insulation performance in the vicinity

of any integrity (E) failure. This is, however, uncommon for most forms of associated construction; the influence will be minimal. See [Table 35](#) for the influence of the gap length on the integrity and insulation performance of the linear gap seal.

ii) Increased gap width; small gaps ≤ 10 mm in width

A rigid sealant material may exhibit a reduction in the integrity (E) and insulation (I) performance if the gap width is increased, particularly as gravity is acting against the seal in the configuration, and any shrinkage or erosion may reduce the effectiveness of the seal. A reduction in gap width would generally have a neutral effect. See [Table 35](#) for the influence of the gap width on the integrity and insulation performance of the linear gap seal.

iii) Increased gap width; gaps >10 mm with backing rods — Bottom entry

Because bottom entry seals are subject to direct fire exposure, gravity would be expected to lead to premature failure if the gap width is increased. It should be noted that the backing rod will make very little contribution to the integrity (E) rating. As a consequence, an increase in the width is likely to have either a neutral influence or a reduction in the integrity (E) or insulation (I) rating, depending upon the behaviour of the rigid sealant. See [Table 35](#) for the influence of the gap width on the integrity and insulation performance of the linear gap seal.

iv) Increased gap width; gaps >10 mm with backing rods — Top entry

If the linear gap is sealed from the top using a “backing rod” and no seal is installed from the bottom, then the backing rod is going to be attacked by the fire first. Therefore, the nature of the backing rod will have a major influence on the life of the seal when attacked by fire. A mineral rock fibre seal will protect the sealant longer than a “plastic” backer rod. However, a wider gap will possibly result in either an earlier loss of the support/protection as well as of the rigid sealant resulting in a reduction in the integrity (E) rating and probably an associated decrease in the insulation capability, or a neutral influence, assuming no increase in the volume of either the rod or the seal. See [Table 35](#) for the influence of the gap/thickness of the seal on the integrity and insulation performance of the linear gap seal.

An increase in the depth or thickness would result in an increase in fire resistance performance with respect to both criteria.

Table 35 — Summary of possible factor influences for horizontal linear gaps (general)

Parameter	Factor	Factor influence
Gap length	Decrease	E Neutral I Neutral
	Increase	E Neutral I Neutral
Width of gap	Decrease	E Increase I Neutral
	Increase	E Decrease I Decrease/Neutral
Depth of gap/thickness of seal or thickness of associated construction (assuming seal is installed to full depth)	Decrease	E Decrease I Decrease
	Increase	E Increase I Increase/Neutral

8.3.4.2.4 Compressible open or closed cell polymeric foam sandwiched between intumescent strips

This form of seal is proprietary in nature, but as most fire sealing companies supply a seal of this type, it is thought to be common enough to warrant having general guidance as to how the performance of the seal can be assessed using expert judgement.

a) Vertical side entry gaps

Only pressure generating seals can be used in the manufacture of these “sandwich” construction seals as the intumescent has to expand and compress the core polymeric foam as it is degraded/consumed by the fire. The intumescent used on the face of these composite seals can either be of a uni-directional or multi-directional expansion type and this will be the major characteristic in deciding how the seal will behave with respect to changing the gap parameters.

The standard method of installing these seals is to subject them to a modest level of compression which ensures that in normal use, the outer surfaces of the seal are positively pressed against the surface(s) of the gap to be sealed. It is important that the two edges/surfaces bounding the gap to be sealed are nominally parallel with each other because, if the gap is tapered in practice, then any expansion under heating will not be in the plane of the seal/element being sealed.

A reduction in the length of gap should not result in any reduction in the integrity (E) and/or insulation (I) of the sealed gap as a shorter length of seal would result in less mass and a reduced tendency to slump or fall out, if everything else is equal. An increase in the length of the gap, especially a significant increase, could result in the associated construction extending when heated, possibly resulting in differential expansion between the element and the seal. If the intumescent seal material exhibits multi-directional expansion properties, any differential extension in the length of the gap should be filled by the expanding intumescent. Where the intumescent is mono-directional, it is possible that the seal will not fully fill the gap even when it expands and as a consequence, a decrease in integrity (E) and/or insulation (I) is likely. See [Table 36](#) for the influence of the gap length on the integrity and insulation performance of the linear gap seal.

A reduction in the width of the gap to be sealed would normally be beneficial for most form of seals, but with these intumescent/foamed polymeric composites, if the gap is reduced too much, then excessive expansion pressures may be generated forcing the intumescent to “pop-out” of the gap. This would cause an immediate decrease in the integrity (E) and insulation (I) ratings. See [Table 36](#) for the influence of the gap width on the integrity and insulation performance of the linear gap seal.

An increase in the width of the gap will reduce the compression on the seal, such that it reduces eventually to zero and will fall out. Increases in the width of the gap less than that which would result in the seal falling out will mean that the active intumescent material has a larger gap to seal and this would probably lead to a reduction in both the integrity (E) and insulation (I) rating. See [Table 36](#) for the influence of the gap width on the integrity and insulation performance of the linear gap seal.

An increase in the depth of the seal or the thickness of the associated construction will, in general, always be beneficial as it will take longer to erode away the seal. A decrease in the thickness/depth of the seal will invariably result in a reduction in the integrity (E) and insulation (I) ratings, as there will inevitably be less thickness of activated material to maintain the seal against the fire attack. See [Table 36](#) for the influence of the depth of the seal on the integrity and insulation performance of the linear gap seal.

Table 36 — Summary of possible factor influences for vertical side entry gaps sealed with compressible open or closed cell polymeric foam interlayered between intumescent strips

Parameter	Factor	Factor influence
Gap length	Decrease	E Neutral I Neutral
	Increase	E Neutral/Decrease I Neutral
Width of gap	Decrease	E Decrease ^a /Increase I Decrease ^a /Neutral
	Increase	E Decrease/Neutral I Neutral/Decrease
Depth of seal ^b	Decrease	E Decrease I Decrease
	Increase	E Increase I Increase
<p>^a As stated in 8.3.4.2.3, a), when pressure forming intumescent is used, then there is likely to be a critical gap width below which excessive pressure may cause the seal to “pop-out”.</p> <p>^b Assumes that the composite strip can be varied in width without changing concept/proportions but generally a wider strip may be considered to be a separate product and will require to be the subject of additional testing.</p>		

b) Horizontal side entry gap(s)

With polymeric foam cored interlayered intumescent seals, the difference between side entry vertical gaps and side entry horizontal gaps is very small and, as a consequence, the same guidance with respect to the length, width and depth of the seals is the same for both orientations.

c) Horizontal linear gaps with top or bottom vertical entry

As with the gunnable sealants, the action of gravity has a significant influence on the performance of polymeric foam cored interlayered intumescent seals. The influence is both with respect to the need to maintain an element of compression on the seal during the early stages of heating and to compensate for erosion of the foam during the later stages of heating. The length of the gap should not have an influence that is different from the horizontal entry applications for these seal types. Polymeric foam cored seals in the vertical entry horizontal applications are adversely influenced by the gap width, both with respect to the gap being made too narrow and causing the seal to “pop-out” and being too wide, thereby allowing an inadequately compressed seal falling out.

Any reduction in the seal depth will invariably result in a decrease in the integrity and insulation, as will a reduction in the thickness of the associated construction, which could increase the thermal bowing of the slab containing the seal and resulting in a reduction in integrity.

Summary of vertical entry gaps in horizontal constructions sealed with compressible open or closed cell polymeric foam interlayered between intumescent strips.

There is currently inadequate public domain information against the ISO test procedures to produce a tabular summary of factor influences.

8.3.4.2.5 Mineral rock fibre sealing system

Mineral rock fibre does not include glass fibre, which is not recommended for fire stopping except for low duration/small gap applications which are not covered by this document. Rock fibre has been used and will continue to be used for linear gap sealing, relying on its compressibility both as semi-rigid slab(s) and quilt(s) to stay in place in the cold state. This compressibility is generally lost or severely compromised by the application of high temperatures, as this consumes the binders which are required to give the material its natural “springiness”. Because of the loss of friction that accompanies the loss

of springiness, mineral rock fibre seals are not recommended for use in horizontal vertical entry applications without special measures to retain the fibre in place, in which case this document cannot give judgmental guidance for such bespoke measures.

a) Vertical side entry gaps

There is an element of gravitational influence with vertical linear gaps because the seal will have a tendency to vibrate down the gap in daily use, especially if the penetrated element is subjected to heating/cooling cycles in normal use or is subject to regular vibrations (railways/trunk roads) or impacts from repeated opening cycles of an adjacent door or shutter. However, these are likely to occur in the pre-fire use of the product and such fibre based seals should be regularly inspected to establish their condition. Under fire attack, there is a possibility of the seal “slumping” down the gap once the product loses its springiness, but this would normally be restricted to wide, high density, mineral fibre strips and the guidance given in this document is restricted to linear gap seals with a face width not exceeding 75 mm.

Extending the length of the gap beyond that used in the characterization test would not be expected to result in a decrease in the integrity (E) and associated insulation (I) due to the lack of continuity between the individual fibres making up the seal, assuming the seal is fitted to the same density as in the initial test. A reduction in the length of the gap would also be expected to have a neutral influence on these criteria. See [Table 37](#) for the influence of the gap length on the integrity and insulation performance of the linear gap seal with mineral rock fibre infill.

An increase in the gap width would be expected to decrease the integrity (E) or insulation (I) rating of the seal, as the total volume of binder to be consumed/burnt away is larger and this may be expected to have a greater influence on the compression and associated ability to remain in place, even if the material is installed at an identical density. A reduction in the gap width would be expected to have a neutral or beneficial influence on integrity and insulation. See [Table 37](#) for the influence of the gap width on the integrity and insulation performance of the linear gap seal with mineral rock fibre infill.

An increase in the seal depth or the thickness of the associated construction in which the gap is formed, would be likely to produce an increase in the integrity (E) or insulation (I) rating. A reduction in either is potentially likely to result in a decrease in both criteria. See [Table 37](#) for the influence of the depth of the seal on the integrity and insulation performance of the linear gap seal with mineral rock fibre infill.

Table 37 — Summary of horizontal entry gaps in vertical constructions sealed with mineral rock fibre seals

Parameter	Factor	Factor influence
Gap length	Decrease	E Neutral I Neutral
	Increase	E Decrease ^a /Neutral I Decrease ^a /Neutral
Width of gap	Decrease	E Neutral I Neutral
	Increase	E Decrease I Decrease
Depth of seal	Decrease	E Decrease I Decrease
	Increase	E Increase I Increase

^a Prone to slumping due to gravity when binders are lost.

b) Horizontal side entry gaps

This is probably the preferred orientation for the use of mineral rock fibre linear gap gaskets as they are likely to remain in place even if they experience a loss of “springiness” and any associated loss of compression.

An increase in the length of any gap will have a neutral factor influence and a reduction in the length of the gap would be expected to have a neutral or beneficial influence on the two criteria. See [Table 38](#) for the influence of the gap length on the integrity and insulation performance of the linear gap seal with mineral rock fibre infill.

An increase or decrease in the gap width would not produce an increase or decrease in the integrity (E) and insulation (I) performance in this orientation. See [Table 38](#) for the influence of the gap width on the integrity and insulation performance of the linear gap seal with mineral rock fibre infill.

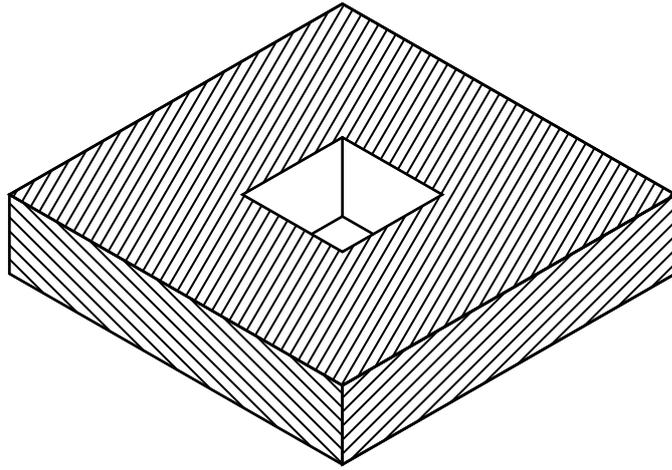
A decrease in the depth of the seal or in the thickness of the associated construction would generate a corresponding decrease in the integrity (E) and insulation (I) rating of a horizontal side entry gap sealed with a mineral rock fibre seal. An increase in either or both of these parameters would produce an increase in the integrity (E) and insulation (I) performance. See [Table 38](#) for the influence of the depth of the seal on the integrity and insulation performance of the linear gap seal with mineral rock fibre infill.

Table 38 — Summary of horizontal entry gaps in vertical constructions sealed with mineral rock fibre seals

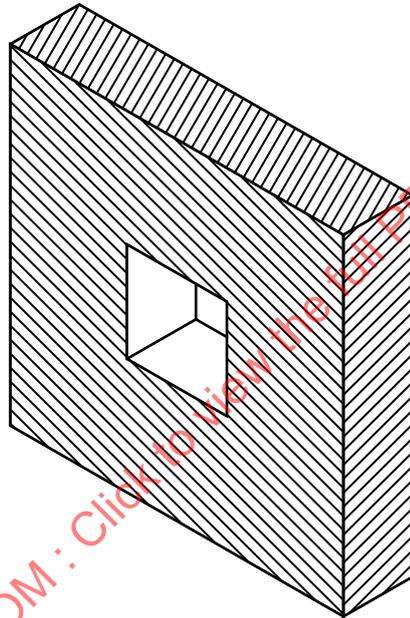
Parameter	Factor	Factor influence
Gap length	Decrease	E Neutral I Neutral
	Increase	E Neutral I Neutral
Width of gap	Decrease	E Neutral I Neutral
	Increase	E Decrease I Decrease
Depth of seal	Decrease	E Decrease I Decrease
	Increase	E Increase I Increase

c) Horizontal vertical entry gaps

As stated in the opening paragraph of [8.3.4.2.5](#), mineral rock fibre gaskets are not recommended for this application and, therefore, no guidance is given with respect to the application of results from tests.

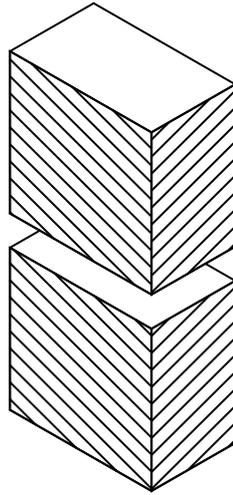


a) Aperture in horizontal element

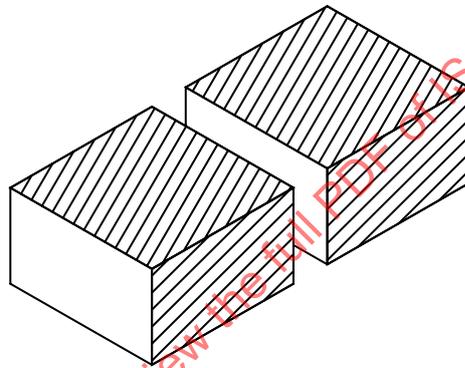


b) Aperture in vertical element

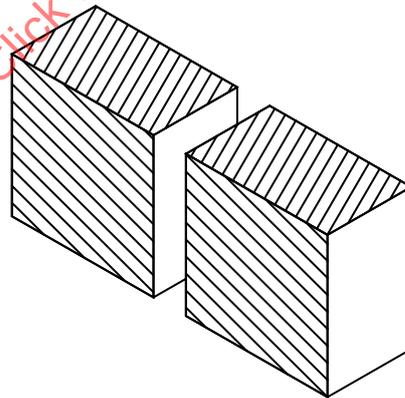
Figure 3 — Nomenclature for gaps and apertures



a) Horizontal linear gap with side entry



b) Horizontal linear gap with vertical entry



c) Vertical linear gap with side entry

Figure 4 — Nomenclature for gaps and apertures

9 Service penetration sealing systems

9.1 General

All buildings are perforated by services, e.g. water, gas, electric and even air, all of which pass through walls and floors, most of which are required to provide fire separation normally expressed in terms of the duration of fire resistance. These services pass through penetrations/apertures either designed

in, or made immediately before or after, the handover of the building and each aperture represents a localized compromise to the fire compartmentation. It is vital that the apertures through which services pass are infilled around the service so that the fire resistance of the penetrated barrier is maintained to the specified level with respect to integrity and, where appropriate, insulation, which may also include restricting the temperature rise on the service itself. The fire resistance is maintained by the application of penetration sealing systems which are bespoke to the service and the nature/construction of the wall/floor being penetrated. Evidence of performance should be available to substantiate the performance of the wall/floor/seal/service combination which will normally take the form of a field of application/extrapolation report because of the difficulty and cost of evaluating each and every combination of parameters (e.g. service type, service size and associated supporting construction). When generating such a field of application report, it should take into account not only the fire behaviour of the sealing system and/or the associated supporting construction, but should also take into account the fire response of the service. Generating the direct and extended application of a service penetration seal is a complex matter and the following guidance will be of assistance in formulating the expert judgement needed to define the performance.

When an aperture is provided for the purpose of permitting the passage of services through a wall or floor that is designed to provide fire resistance, it may be possible to predict the performance of variations in either the service, the seal and/or the construction of the penetrated element without recourse to further testing. This clause provides guidance as to how this may be achieved, but with the present state of knowledge, this can only be carried out when the services penetrating the aperture are similar in nature, i.e. all cables, metal pipes, plastic pipes, etc. The methodology, particularly which associated with expert judgement, is still appropriate for mixed services but the confidence in the prediction will inevitably be less, albeit, for example, any cables are separated from metal pipes to an extent that they can be treated as separate penetrations, then the extended application may be determined independently. In such a situation the service type that produces the lowest fire resistance performance is the determining factor for the seal.

This section is not appropriate for evaluating seals fitted between ductwork and any supporting construction, as these are special seals which are the responsibility of the ductwork/damper manufacturer to specify and are bespoke to the system.

This clause does not consider “live” services i.e. those that are permanently filled with liquids or gases or where cables require to continue carrying current.

NOTE As for linear gap seals (see [Clause 8](#)), these seals are sometimes known as “fire-stopping”, but this term fails to identify the primary function of the seal in normal use and, as such, this term is deprecated.

9.2 Direct application

9.2.1 General

The results of a fire resistance test on a penetration seal/sealing system are deemed to be applicable to a similar type of untested seal, manufactured from identical materials and installed in a similar manner provided the following are satisfied.

9.2.2 Common parameters

- a) Neither the width or height nor the major axis of the hole being penetrated should be increased.
- b) The depth of the seal/sealing system in the aperture is not less than in the characterisation test.
- c) The penetrating services should not be
 - 1) more in number,
 - 2) greater in variety, e.g. ratio of cables/pipes,
 - 3) of larger cross-section,

- 4) closer to each other,
 - 5) less well supported, or
 - 6) of different materials.
- d) The service should not have any lesser level of support or restraint.
 - e) The orientation of the penetrated aperture should not be changed.
 - f) The supporting/associated construction that is penetrated will be of similar materials and method(s) of construction and have similar thermal and mechanical responses to standard fire conditions, e.g. for solid concrete/masonry associated supporting construction, the following parameters are relevant:
 - 1) The density of the material(s) forming the element being penetrated should not vary by more than 20 %;
 - 2) The thickness of the element should not be reduced.

9.3 Extended applications

9.3.1 General

Greater variations in the design and application of a service penetration sealing system may be achieved by the use of the extended application process, based upon either the application of rules, fire engineering calculations or expert judgements. Unfortunately, there are very few validated rules and only a limited number of design parameters that lend themselves to a calculation procedure. However, by using the methodology given in [Annex A](#), the expert judgement approach, more generous and accurate extended applications may be established. The guidance given in this clause on extended application is made with a number of assumptions as follows, which are required due to the complexity of service penetration where there are several variables that need to be taken into account:

- a) The end condition of any metal pipe is the same as was used in the characterization test, e.g. sealed on fire side, sealed on non-fire side, etc.;
- b) The penetrated element is solid throughout, i.e. concrete, masonry or other form of solid, nominally cementitious material, if not throughout then for the full thickness of the element local to the penetration;
- c) The service is adequately, independently supported on both the fire exposed side and on the non-fire exposed side and is not reliant on the sealing system for any support;
- d) When a number of metal pipes or cables pass through the same penetration, there is a gap between individual services of not less than 20 mm or 20 % of the pipe/cable diameter.

Testing in accordance with ISO/TR 10295-3 may be used to derive the values specified in d).

Guidance on the extended application process using rules, engineering calculations or expert judgement for a service penetration sealing system installed into a fire separating element is given below

9.3.2 Rules

Except in the context of product classification within CEN (see EN 13501-2), it is not possible to extend the application of a test result on a service penetration sealing system by the application of pre-determined rules.

9.3.3 Fire engineering calculations

Fire engineering calculations can be generated and applied for the following:

- a) Unexposed face temperature of the seal (insulation).

Heat transfer through a seal consisting of only one homogenous material where the thickness of the seal has been changed may be calculated by using an accepted temperature analysis model that is appropriate to the sealing material. Input data should be based on values for actual specific heat capacity and thermal conductivity as a function of temperature for that material. Composite seals, where more than one material is used to form the seal, are not appropriate for calculation technique

Heat transfer via the service penetrating the element may be calculated by using an accepted temperature analysis model that is appropriate for the material used for the service. As above, the values used should be adjusted as a function of temperature as the conductivity normally varies proportionately with temperature.

- b) Deflection of associated supporting construction due to thermal gradient and its potential impact on the seal performance.

Deflections of the supporting construction may be calculated for service penetration seals where the physical properties and the relationships between stress and strain are known as a function of temperature and where the temperature profile over the cross section of the element(s) in which the penetrated aperture is formed is also known. This information is not directly of value but may be used in conjunction with expert judgement to assist in the prediction of integrity failure using the methodology discussed in [9.3.4](#).

9.3.4 Expert judgement

9.3.4.1 General

Changes may be made to the following construction parameters of a service penetration seal/sealing system provided that expert judgement, based upon the methodology given in [Annex A](#), is adopted.

However, even by using the methodology given in [Annex A](#), there are too many variables to give direct guidance on generating an extended application for service penetration sealing systems, unless the guidance is rationalized as described briefly in [9.3](#). For the purpose of simplifying the process, the guidance given in various service types is limited to single cables, single metal pipes and small (38 mm) and large (160 mm) PVC pipes. Other sizes and/or material variations will need to be resolved by analogy, albeit the principles behind the guidance given in [Annex A](#) will apply to all services. The influence of multiple services of the same type passing through the same penetration can also be resolved using the same logic process.

9.3.4.2 Support and restraint provided to the service

The support and restraint given to the service passing through the aperture to be sealed is often quite critical to the ability to maintain a seal during fire exposure. It should be recognized that the section of the service running through or around the fire exposed area is exposed to heat along the length of the service. This can cause metallic products to expand and deflect, either as a result of uneven exposure to heat or restraint to expansion. Plastic pipes or some forms of plastic coated cables lose stiffness and slump under the influence of exposure to elevated temperatures. These movements influence the quality of the seal where the service passes through a fire resisting wall or floor. While this subclause assumes that the service is “adequately” supported (see [9.3](#)), there is no doubt that if the support/restraint conditions are engineered to provide enhanced support or to accommodate known levels of expansion, the integrity (E) performance should be no worse than as tested and probably enhanced.

9.3.4.3 Metal pipes

9.3.4.3.1 General

Metal pipes come in a variety of materials, diameters and wall thicknesses. These parameters will invariably influence the ability of a sealant/sealing system to maintain integrity (E) and possibly the insulation capabilities of the element being penetrated. The influence of the major parameters related to metal pipes are discussed below.

9.3.4.3.2 Pipe material

There are two major variations in the choice of material used in the manufacture of the metal pipes that are likely to influence the fire resistance performance of the seal installed around the pipe; softening/melting temperature and thermal conductivity. If the metal has a melting/softening temperature lower than the metal used in the pipe that was the subject of the initial “type” test, then integrity is likely to be significantly reduced depending upon the duration for which the seal is to be maintained. Any non-ferrous metal, aluminium or brasses are unlikely to satisfy integrity for 120 min or greater and of these, aluminium is unlikely to satisfy integrity for 60 min applications.

Gunnable intumescent based sealants which can fill voids caused by the loss of melting materials are more likely to maintain the integrity of non-ferrous pipes more than inert rigid sealants or mineral rock fibre based sealing systems.

9.3.4.3.3 Pipe diameter

Pipes with a large circumference will probably put more stress on the sealant than pipes with a smaller diameter and, hence, circumference because the service/sealant interface is extended. This extension can cause more shrinkage of the sealant and, hence, the likelihood of reduced integrity. Similarly, the extended interface can, for some seal types, cause early and excessive activation which may lead to earlier exhaustion and possibly increased temperature rise on the unexposed face of the seal.

The potential for a reduction in the integrity rating is greater in the case of flexible gunnable sealants, especially intumescent containing sealants, than it is for inert rigid sealing materials. The effect of pipe size on mineral rock fibre seals is probably somewhere between the two. Mineral rock fibre loses many of its sealing qualities once the “resin” binder breaks down, which occurs at higher temperatures and, therefore, longer durations. After 90 min, such seals will probably be more prone to integrity loss with larger metal pipes than either the flexible gunnable sealants and/or the rigid, more cementitious sealing materials.

9.3.4.3.4 Pipe wall thickness

The thickness of the wall of metal pipes can vary even for pipes of the same nominal metal composition, e.g. steel/stainless steel. Internal pressure in the pipe or the span between supports may require thicker walls to the pipe. A thick walled pipe will take longer to heat up, but once hot, it will store and probably transmit more heat to the unexposed face than thin walled pipes, especially in cases where the associated supporting construction is thicker.

Generally, regardless of the nature of the sealing system used, thinner pipe walls are more likely to result in integrity failures than thicker walled pipes at fire resistance periods of up to, and including, 60 min but beyond this time, the thicker walled pipes may overactivate intumescent based gunnable sealants and exhaust the binders in a mineral-rock fibre sealing system.

9.3.4.3.5 Orientation of pipe

Seals around metal pipes that pass through a horizontal element, i.e. in a vertical direction, are more prone to drop out under gravity, especially after activation in the case of an intumescent seal, than pipes that pass through in a horizontal manner. As such, a change from the pipe being orientated vertically to horizontally should result in an increase in integrity performance. A change from the

pipe being orientated vertically to horizontally will also have a positive influence on the insulation (I) performance.

9.3.4.3.6 Summaries of the factor influences

For each of the above metal pipe parameters, it will be necessary to develop the factor influence using the “parameter/factor” approach given in [Annex A](#) in both horizontal and vertical orientations for the following sealing systems:

- a) gunnable intumescent sealants ;
- b) gunnable non-intumescent/ablative sealants ;
- c) rigid “cementitious” sealants (intumescent and non-intumescent) ;
- d) mineral rock fibre batts/quilts;
- e) modular systems.

The complexity of the range of metals in conjunction with the pipe parameters given in [9.3.4.3.2](#), [9.3.4.3.3](#) and [9.3.4.3.4](#) when taken in conjunction with the five different sealant options makes it impossible to present summary tables as in the other subclauses in this document. The method is, however, still appropriate.

9.3.4.4 Plastic pipes

9.3.4.4.1 General

Unlike metal pipes, all plastic pipes melt at temperatures of below 300 °C, a temperature reached in the very early stages of a fully developed, “flashover” fire. As a consequence, if a mechanism is not put in place to close up the hole left by a melting pipe, then this would create an open void through the wall or floor through which fire could pass, failing the integrity (E) and insulation (I) criteria. Before intumescent was developed for commercial sealing purposes, a variety of mechanical bladed systems were available, e.g. “guillotines”, but this subclause does not cover mechanical systems.

The seals that are to be considered in this subclause all utilize the sealing capability of pressure forming intumescent material, normally, but not exclusively, based upon the behaviour of sodium silicate or intercalated graphite compounds. The general principle is that as the pipe softens under the influence of the fire exposure, the pressure forming intumescent reaches its activation temperature and either crushes the pipe to form the seal or directly fills the developing void left by the melting plastic. The length of time for which these seals can maintain the integrity of the element depends upon the depth of the material used to create the seal and the resistance to erosion and consumption displayed by the activated materials.

In order for the intumescent to be able to expand forcibly and close-off the opening, it is important that the intumescent is either constrained by the structure of the construction being penetrated or by a metal container fixed onto or into the element in question.

Generally, intumescent material fixed inside the aperture but outside of the pipe is referred to as an “intumescent pipe wrap” or when it is in a metal container, these are known as a “collar”. The effectiveness of either of these devices is dependent upon the type (or nature) of the plastic, the diameter of the plastic pipe and the wall thickness of the pipe.

9.3.4.4.2 Pipe material

Plastic pipes are available in a number of different types or grades of material. These “plastics”, by the nature of their constituents, all soften or melt at slightly different temperature, which affects the time

at which they will melt-out, or soften to a temperature that allows them to be crushed. A list of typical plastic pipe materials and the recognized softening/melting point temperatures is given below:

- a) Polyvinyl chloride (PVC);
- b) Unplasticised PVC (uPVC);
- c) Chlorinated PVC (cPVC);
- d) Polyethylene (PE);
- e) High density polyethylene (HDPE);
- f) Polypropylene (PP);
- g) ABS.

Those that soften early are generally easier to seal than those that remain rigid for longer, albeit this does depend upon the activation temperature of the intumescent sealing material. A low melting point plastic in combination with a high activation temperature intumescent may leave the aperture unsealed.

In practice, this will have been addressed by the initial type test on the sealing system and the compatibility between the temperatures would have been proven. It is only when changing the pipe material on the intumescent material (not recommended) that a subsequent incompatibility may need to be considered. Generally, an increase in the pipe softening temperature may induce a loss of integrity because the pipe will resist crushing for longer.

The guidance on pipe materials is equally valid for pipe collars and pipe wraps, albeit both systems rely on a minimum response from the associated supporting construction, which in the case of collars should provide adequate fixity to the collar throughout the fire exposure and in the other case, provide adequate restraint to the expanding intumescent for the required fire duration.

9.3.4.4.3 Pipe wall thickness

Even when the material of the pipe remains the same as in the initial type test, any increase in the pipe wall thickness for the same diameter of pipe will also make the pipe harder to crush and seal. The pipe obviously has a greater thermal inertia and it will take longer for it to reach its softening temperature. With respect to a potential loss of integrity resulting from the pipe melting-out before it is sealed, the increase in thermal mass will make it more resistant to such a failure and so the localized integrity (E) performance may increase. The mode of failure in the initial type test may be of support when making an expert judgement on the influence of wall thickness on the fire resistance of the whole penetration.

When the increased thickness of the pipe wall is associated with the increase in the pipe diameter, there is likely to be an influence that is governed by the ratio between the perimeter dimensions and the cross sectional area, similar to the H_p/A concept used in the protection of structural steel sections. Such an analysis may inform an expert judgement, but at this stage, there is unlikely to be scientific evidence to support this.

As with the influence of the material, the pipewall thickness parameter will respond similarly for both collars and pipewraps assuming that the associated supporting construction behave as proposed in [9.3.4.5.1](#).

As stated, plastic pipes can only be sealed by active devices such as pipe collars and/or pipewraps, if this methodology is to be applicable. With the practice of passing plastic pipes through steel sleeves penetration, the fire resisting element is not supported by type testing evidence and as such, the guidance in this document is not applicable to such forms of sealing.

9.3.4.4.4 Pipe diameter

The diameter of the pipe, once it has melted out, leaves holes of the original diameter. As a result, this is a critical parameter as it is directly proportional to the volume of the expanded/activated intumescent material. Also, the diameter of that hole has an influence on the characteristic of the expanded intumescent. For larger diameter holes/apertures, the expanded sealing material will need an inherently higher degree of cohesiveness as it has a more demanding role to perform especially under the influence of differential fire pressures and turbulence.

9.3.4.5 Cables penetrating fire separating walls and floors

9.3.4.5.1 General considerations of cable performance

Cables penetrating fire resisting elements can be sealed by all of the materials identified in 9.3, namely, gunnable flexible sealants, rigid cementitious based materials or mineral rock fibre sealing systems. In many aspects, a cable has the same ability to conduct heat through a fire separating element as a metal pipe. The diameter of a cable is generally going to be less than that of a pipe and, of course, it is solid and not hollow. An additional complication is that the conductor is invariably encased in an insulation (for electrical reasons rather than for fire or energy purposes) which may themselves contain combustible constituents, often plastic(s) of one form or another. This subclause is primarily aimed at predicting the potential for the cable and the aperture seal to result in a loss of integrity and/or insulation of the element being penetrated, but the need to suppress the ignition of the insulant should also be a consideration. This will invariably require the unexposed part of the cable to be wrapped in a protection system as proven in any initial type testing and countering this risk of ignition does not form part of this extended application methodology.

This part of the expert judgement approach to the extended application process confines itself to single cable penetration and considers in 9.3.4.5.2 changes to the conductor material and in 9.3.4.5.3 its diameter/cross-sectional area and the influences this may have on seals made from the three seal types listed above. The influence of changes in any supporting frame, e.g. a cable tray or cable ladder with respect to the fire performance of the method of sealing is to be found in 9.3.4.5.4. Again, each of the seal types is considered in turn.

9.3.4.5.2 Area of the aperture that is penetrated by the service which is sealed

The unsupported area of any seal installed between the penetrating cable, with or without cable tray and the supporting construction, can be critical to the performance of the seal. The seal would be expected to be self-supporting, but depending upon the mode of failure, there may well be a maximum area, or a maximum dimension, across which the seal will span and this should be considered in any such judgement. ISO/TR 10295 (all parts), will generally be able to define these maximum dimensions for any generic or proprietary seal, depending upon its thickness and the duration for which it is expected to maintain a seal. Depending upon the nature of the sealant, sealing system used, there will generally be a difference between the acceptable area of a seal formed around a cable in a vertical element, than the permitted area in a horizontal element. Both will need to be evaluated by expert judgement separating, albeit the aperture in a vertical element will normally be expected to be larger than a similar aperture in a horizontal element.

9.3.4.5.3 Conductor material

The conductor within the majority of all cables will either be copper, including copper-based alloys, or aluminium. This subclause does not, at this time, consider the use of glass conductors as may be found in fibre optic cables.

The melting temperature of copper/copper-based alloys will be significantly greater than that reached in fire resistance testing durations of up to 2 h, but can be marginal for durations of more than this, especially 4 h and beyond. Melting of the conductor is only a problem if the length of cable within the wall or the seal is short, i.e. less than 50 mm, in which case it could cause a loss of integrity due to