TECHNICAL REPORT

ISO/TR 12470-1

First edition
2017-11

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

Part 1: Loadbearing elements and vertical and horizontal separating 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 1: Éléments porteurs et éléments horizontaux et verticaux de séparation

Reference number
ISO/TR 12470-1:2017(E)

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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 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 using a code compliant solution. 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 analysing 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 do 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/SC 2 in 1998. This Technical Report provided a methodology 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 Comité Européen de Normalisation (CEN) 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 in respect of the objectives of the original 1998 version of ISO/TR 12470.

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

Also, ageing and weathering are not covered.

The ISO/TR 12470 series is published in two parts:

Part 1: Loadbearing elements and vertical and horizontal separating elements;

Part 2: Fire resistant door assemblies, glazing, services and service penetration.

This document is divided into two sections:

— Guidance on direct and extended application of test results for various elements used in buildings, the major parameters of which would be assessed by calculation or expert judgements based upon the methodology and discipline given in Annex A.

— Current state-of-art and possible evolution:

  — improvement of testing methodologies to give a better prediction of the performance of various sizes and designs of a given element;

  — mathematical modelling which can be used by experts to give their judgement;

  — expert systems which could take into account the interaction of various factors in an assessment.

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

Part 1: Loadbearing elements and vertical and horizontal separating 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 loadbearing and simple vertical and horizontal separating 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:

- loadbearing elements;
- non-loadbearing elements:
  - partitions:
    - stud construction partitions;
    - composite panel/SIPS partitions;
  - ceiling membranes (horizontal partitions):
    - jointed ceilings;
    - composite panel ceilings.

Direct and extended applications of test results are the two possible ways to ensure that a modified element has 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.

One of the most common variations is in respect of the size of the element in use. Fire resistance testing furnaces have size restrictions 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.

This document does not provide guidance on the application and extension of results arising from testing carried out on door and window assemblies, linear gaps or service penetration seals, which is covered in ISO/TR 12470-2.

For some, but not all of the critical parameters, a summary of the possible influences is incorporated in the given examples.

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 13943, *Fire safety — Vocabulary*

3 Terms and definitions

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

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

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

— ISO Online browsing platform: available at http://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 the ISO 834 series. 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 or improved 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 generally requires an assessment by a fire expert either in developing *rules* (3.4) of application for more general application by others, or evaluating the results of fire engineering calculations, or for making a judgement in specific cases

Note 1 to entry: In every case, it should 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 2 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 ISO 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* (3.6). 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 its application does 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 element

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

The field of application from the result of a fire resistance test has at least three possible components: (1) direct application, (2) extended application and (3) 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 the ISO 834 series 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;

— 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: (1) direct application, (2) extended application and (3) 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.

4.1 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.

4.2 Extended application

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;

— 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.

4.2.1 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 un-quantified 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.

4.2.2 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;

— loadbearing elements: in addition to the properties permitted for non-loaded elements, calculation at elevated temperature could be permitted for the loadbearing capacity for well documented materials (steel, concrete, etc.) and for statically determined 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.

4.2.3 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 explained by the body or person responsible for making such judgements. 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. If the fire resistance obtained in a fire test is greater than the fire resistance time aimed at in the assessment, there is an overrun in fire resistance performance. If this overrun, obtained in the fire resistance test, is substantial, then it can be used as a trade-off, i.e. if a significant overrun has been achieved, it will generally be possible to allow for a greater change in the construction than if the claimed fire resistance time has only just been met in the fire resistance test.

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

4.3 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