PD ISO/TR 15657:2013

BSI Standards Publication

Fire resistance tests — Guidelines for computational structural fire design

This Published Document is the UK implementation of ISO/TR 15657:2013.

The UK participation in its preparation was entrusted to Technical Committee FSH/22/-/2, Fire resistance tests - Interpolation and Extrapolation of Test Results for Loadbearing Elements and Protection Systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

ISBN 978 0 580 69943 6

ICS 13.220.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 July 2013.

Amendments issued since publication

Date	Text affected

TECHNICAL REPORT ISO/TR 15657

First edition
2013-06-15

Fire resistance tests — Guidelines for computational structural fire design

Essais de résistance au feu — Lignes directrices sur la conception statistique des feux de structures

Reference number
ISO/TR 15657:2013(E)

Contents

Page

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. 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. 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.

The committee responsible for this document is ISO/TC 92, *Fire safety*, Subcommittee SC 2, *Fire containment*.

Introduction

In recent years significant advances have been made in the scientific community in understanding the behaviour of fire in building structures and as a result there is an increasing activity in the development of computer models that are capable of describing and predicting many of the different aspects of fire safety engineering.

As a result of this research, design codes have been prepared that enable practising engineers to undertake this type of analysis which can be applied to comply with prescriptive requirements as specified in National Building Regulations, or, to develop performance based fire safety strategies and often involving complex computational analysis.

In particular, analytical procedures and computer models have been developed in the areas of:

— reaction of materials to fire;

— fire growth in a compartment;

— fully developed compartment fire;

— fire spread between buildings;

— fire behaviour of load-bearing and separating elements and building structures;

— smoke filling in enclosures and smoke movement in escape routes and multi-story buildings;

— interaction of sprinklers and fire, including sprinkler and fire venting interaction;

— process of escape; and

— systems approach to the overall fire safety of a building, in its most general form comprising fire development models interacting with human response models.

This progress in fire research has led to consequent changes in the field of codes, specifications, and recommendations for fire engineering. Some characteristic trends in these changes are:

— improved relationship between standard tests and real fire scenarios;

— increased use of fire safety engineering principles to meet functional requirements and performance based criteria;

— development of new test methods, that are, as far as possible, material-independent and related to well-defined phenomena and properties;

— increase in the application of reliability-based analytical design;

— extended use of integrated assessments; and

— introduction of goal-oriented systems of analysis of total, active and passive fire protection for a building.

One of the most rapidly developing trends relates to the structural fire engineering design of load-bearing and separating structures. An analytical determination of the fire resistance of structural elements is being accepted more widely by the Approving Authorities in many countries as an alternative to the internationally prescriptive based approaches based on the results of the standard fire resistance test and connected classification.

A significant contribution to the analysis of building structures in fire has been made by the development of the European Structural Eurocodes which enable practising engineers to follow agreed design procedures for application in individual members states. During the mid 1990s, these Codes which covered; Fire Actions and individual structural materials (Concrete, Steel, Composite Steel and Concrete, Timber, Masonry, Aluminium) were published as ENV's (or pre-standards). These Codes had the status of Draft for Development, and were supplemented with National Applications Documents (NAD's), which permitted member states to ascribe certain factors to many of the calculations and input variables in order to align with National experience.

During the last five years, considerable progress has been made in converting these pre-standards into full European Design Codes for application in the European Community member states. The Codes are now divided into two separate parts:

— **Normative -** in which members states are obliged to follow.

— **Informative -** usually consisting of a series of Annexes in which acceptance is voluntary by individual member states.

In addition, there is still provision to apply individual National Determined Parameters (NDP's) to align more closely with National experience. The interaction of the Eurocodes are summarized in Figure 1.

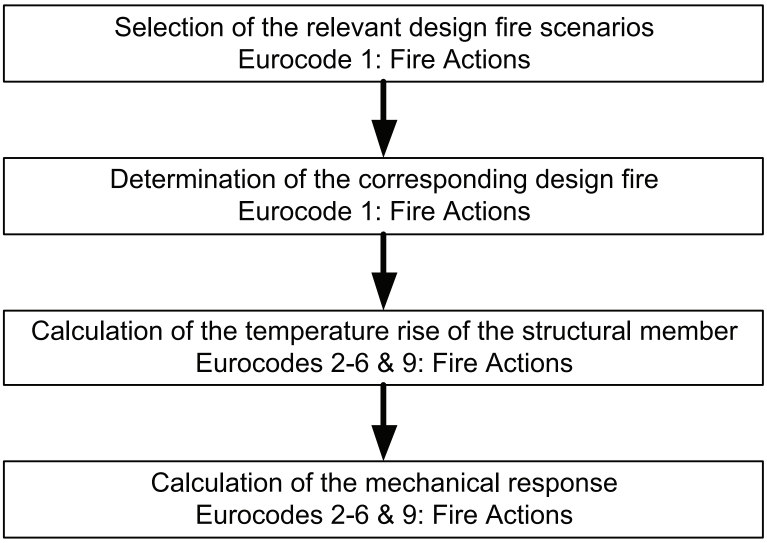

Figure 1 — Interaction of the Structural Eurocodes

The structural Fire Engineering design models have been reviewed in Reference [1] and essentially they can be presented in a simple form as three succinct design steps shown in Figure 2:

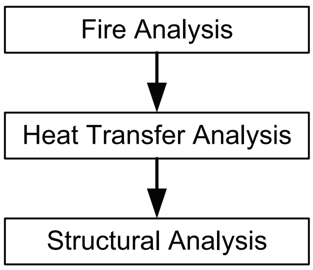

Figure 2 — Three stages to structural fire design

This report examines each of the above under separate headings. In each case, internationally applied methods for a structural fire engineering design are discussed.

For fire models or thermal actions the report considers:

Furnace tests:

— according to ISO 834: cellulosic, hydrocarbon, external and smouldering curves.

— tunnel heating curves according to RWS and the French National curve.

Natural fires:

— single zone or parametric fires in so far as they may be used in a standardised way to provide characteristic occupancy related standard tests. This also includes time equivalent relationships for quantifying real fires into an equivalent period of heating in the standard ISO 834 test.

For heat transfer models the report considers:

— Heat transfer for uniform temperature distribution

— Non-uniform temperature distribution for

  — one dimension

  — two dimensions

  — three dimensions

For structural models the report considers:

— Single member analysis

  — Sub-frame assembly analysis (sub-frames and assembly of members)

  — Global structural analysis in which load redistribution occurs.

The report also considers **Combination Models** for thermal and structural analysis and the performance of structural glass, plastics and resins.

In addressing structural models relevant thermo-physical and mechanical properties are presented for each loadbearing material. While these are presented for use in calculating the thermal response under standard furnace heating conditions for the most part the same properties will invariably be appropriate for natural fires.

This Technical Report is one of a series of Technical Reports being developed that provide guidance on important aspects of calculation methods for fire resistance of structures. Related documents include

— ISO/TR 15655, *Fire resistance — Tests for thermo-physical and mechanical properties of structural materials at elevated temperatures for fire engineering design*,

— ISO/TR 15656, *Fire resistance — Guidelines for evaluating the predictive capability of calculation models for structural fire behaviour*, and

— ISO/TR 15658, *Fire resistance tests — Guidelines for the design and conduct of non-furnace-based large-scale tests and simulation*.

Other documents, which have been produced in ISO/TC92/SC2, provide data and information on the determination of fire resistance. In particular, these include

— ISO 834 (all parts), *Fire resistance tests — Elements of Building Construction*,

— ISO/TR 12470, *Fire resistance tests — Guidance on the application and extension of results*,

— ISO/TR 12471, *Computational structural fire design — Review of calculation models, fire tests for determining input material data and needs for further development*, and

— ISO/TR 10158:1991[1)], *Principles and rationale underlying calculation methods in relation to fire resistance of structural elements*.

1) Withdrawn.

Fire resistance tests — Guidelines for computational structural fire design

1 Scope

This Technical Report provides an overview of the advances that have been made in understanding how structures respond to fire. This is reviewed in terms of heat transfer to the structural elements from primarily nominal (furnace) fires changes in the elevated temperature, physical and mechanical characteristics of structural materials, and how the information is used in the analysis of structural elements for the fire limit state. In reviewing the fire scenarios the report concentrates primarily on standardized heating curves but includes the basis of characteristic curves, which may at some time in the future be adopted in a standardized way. Reference is made to time equivalent as a recognized methodology in relating a natural or characteristic fire, to an equivalent period of heating in the ISO 834 furnace test.

This Technical Report is the result of the development of European Structural Eurocodes for application by member states in the European Community. These Codes enable practising engineers to follow agreed design procedures for application in individual members states irrespective of whether these are for building projects either inside or outside their own National boundaries.

The current UK national structural codes and the European (Eurocodes) are listed in Annex A.

2 Basic principles

2.1 Primary objectives of fire safety design

The primary objectives for fire safety design are

— Life safety - Regulatory requirements for the occupants, fire fighters and rescue services

— Property protection - Regulatory, societal, economic and insurance requirements

— Environmental protection - Regulatory, societal and insurance requirements

— Heritage - Regulatory and societal requirements

In order to limit the impact of fire risk accepted levels are reflected in national fire safety codes, which are generally expressed in terms of requirements and recommended measures. These set out to control the risk of ignition, fire growth and flashover, as well as their consequences and encompass the following strategies:

a) reducing the risk of occurrence,

b) control of fire (heat, flames, smoke and toxic gases) at an early stage,

c) ensuring a safe evacuation of people (and possibly of property), or safe areas of refuge,

d) preventing fire spread (heat, flames, smoke and toxic gases) beyond a certain area (compartmentation),

e) providing for safe and efficient operating conditions for the fire brigades and rescue services,

f) avoiding premature structural failure or limiting structural damage with respect to reinstatement,

g) minimising business interruption and financial losses,

h) minimising the impact upon the environment.

