

Eurocode 3: Design of steel structures —

Part 1.2: General rules — Structural fire design

(together with United Kingdom
National Application Document)

ICS 13.220.20; 91.010.30; 91.080.10

Committees responsible for this Draft for Development

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British Constructional Steelwork Association
Cold Rolled Sections Association
Confederation of British Forgers
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Department of the Environment, Transport and the Regions —
Construction Directorate
Department of the Environment, Transport and the Regions —
Highways Agency
Health and Safety Executive
Institution of Civil Engineers
Institution of Structural Engineers
Steel Construction Institute
UK Steel Association
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National foreword

This publication has been prepared by Subcommittee B/525/31 in cooperation with B/525/4 and is the English language version of ENV 1993-1-2:1995, *Eurocode 3: Design of steel structures — Part 1.2: General rules — Structural fire design*, as published by the European Committee for Standardization (CEN). This Draft for Development also includes the United Kingdom (UK) National Application Document (NAD) to be used with the ENV in the design of buildings to be constructed in the UK.

ENV 1993-1-2:1995 results from a programme of work sponsored by the European Commission to make available a common set of rules for the design of building and civil engineering works.

This publication should not be regarded as a British Standard.

An ENV is made available for provisional application, but does not have the status of a European Standard. The aim is to use the experience gained to modify the ENV so that it can be adopted as a European Standard.

The values for certain parameters in the ENV Eurocodes may be set by CEN Members so as to meet the requirements of national regulations. These parameters are designated by □ (boxed values) in the ENV.

During the ENV period of validity, reference should be made to the supporting documents listed in the NAD.

The purpose of the NAD is to provide essential information, particularly in relation to safety, to enable the ENV to be used for buildings constructed in the UK. The NAD takes precedence over corresponding provisions in the ENV.

The Building Regulations 1991, Approved Document A 1992 (published December 1991)¹⁾, draws designers' attention to the potential use of ENV Eurocodes as an alternative approach to Building Regulation compliance. ENV 1993-1-2:1995 has been thoroughly examined over a period of several years and is considered to offer such an alternative approach, when used in conjunction with this NAD.

Compliance with DD ENV 1993-1-2:2001 does not of itself confer immunity from legal obligations.

Users of this document are invited to comment on its technical content, ease of use and any ambiguities or anomalies. These comments will be taken into account when preparing the UK national response to CEN on the question of whether the ENV can be converted into an EN.

Comments should be sent in writing to BSI, 389 Chiswick High Road, London W4 4AL, quoting the document reference, the relevant clause and, where possible, proposed revised wording.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to xi, the ENV title page, pages 2 to 64 and a back cover.

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¹⁾ Available from The Stationery Office, PO Box 29, St Crispins House, Duke Street, Norwich NR3 1GN.

National Application Document

**for use in the UK with
ENV 1993-1-2:1995**

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Introduction

This National Application Document (NAD) has been prepared by Subcommittee B/525/31. It has been developed from:

- a) a textual examination of ENV 1993-1-2:1995;
- b) a parametric calibration against BS 5950-8, supporting standards and test data;
- c) trial calculations.

It should be noted that this NAD, in common with ENV 1993-1-2 and supporting CEN standards, uses a comma (,) where a decimal point (.) would be traditionally used in the UK.

1 Scope

This NAD provides information required to enable ENV 1993-1-2:1995 *Eurocode 3 — Design of steel structures — Part 1.2: General rules — Structural fire design*, to be used for the fire resistant design of buildings to be constructed in the UK. ENV 1993-1-2:1995 is intended to be used in conjunction with DD ENV 1991-2-2:1996 and DD ENV 1993-1-1:1992, which refer to British Standards for the values of mechanical and thermal loads (actions).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this NAD. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 476-20:1987, *Fire tests on building materials and structures — Part 20: Method for determination of the fire resistance of elements of construction (general principles)*.

BS 476-21:1987, *Fire tests on building materials and structures — Part 21: Methods for determination of the fire resistance of loadbearing elements of construction*.

BS 5555:1993, *Specification for SI units and recommendations for the use of their multiples and certain other units*.

DD ENV 1991-2-2:1996, *Basis of design and actions on structures — Part 2-2: Actions on structures exposed to fire (together with United Kingdom National Application Document)*.

DD ENV 1993-1-1:1992, *Eurocode 3: Design of steel structures — Part 1-1: General rules and rules for buildings (together with United Kingdom National Application Document)*.

DD ENV 1993-1-3, *Eurocode 3: Design of steel structures — Part 1-3: General rules — Supplementary rules for cold formed thin gauge members and sheeting (together with United Kingdom National Application Document)*.

DD ENV 1994-1-2, *Eurocode 4: Design of composite steel and concrete structures — Part 1-2: General rules — Structural fire design (together with United Kingdom National Application Document)*.

3 Mechanical loading, partial factors, combination factors and other values

- a) Pending the issue of EN 1993-1-1, the mechanical actions, partial factors, combination factors and other values should be determined from clauses 3 and 4 of the NAD for ENV 1993-1-1:1992.
- b) The partial factors for the fire situation should be taken from Table 1 and the combination factors should be taken from Table 2.

4 Thermal loading, partial factors, combination factors and other values

- a) The thermal actions should be obtained from the NAD of ENV 1991-2-2.
- b) The value of $h_{\text{net,d}}$ referred to in ENV 1993-1-2:1995, 4.2.5.1(2) should be obtained from ENV 1991-2-2, 4.2.1 making the following modifications:
- 1) a value of 0,45 should be used in ENV 1991-2-2:1996, 4.2.1(2) for the factor $\gamma_{\text{n,r}}$ in accordance with the NAD of DD ENV 1991-2-2;
 - 2) a value of 0,8 should be used in ENV 1991-2-2:1996, 4.2.1(3) for the emissivity of steel ε_{m} , giving a value of 0,64 for ε_{res} .
- c) The values for the adaptation factors κ_1 and κ_2 should be taken from Table 3

Table 1 — Partial factors (γ factors) for the fire situation

Reference in ENV 1993-1-2	Description	Symbol	Condition	Value	
				Boxed ENV value	Value for UK use
2.3(2)P	Partial factor for the fire situation	$\gamma_{\text{M,fi}}$	For thermal properties	1,0	1,0
2.3(3)P	Partial factor for the fire situation	$\gamma_{\text{M,fi}}$	For mechanical properties	1,0	1,0
2.4.3(4)	Partial factor for permanent action in accidental design situation	γ_{GA}	Fire	1,0	1,0 ^a

^a This value of γ_{GA} is different from the value in the NAD of DD ENV 1993-1-1:1992.

5 Reference standards

Where ENs are referred to, appropriate BS ENs should be used. The remaining supporting standards which should be used are listed in Table 4.

Table 2 — Combination factors for the fire situation

Action	$\psi_{1,1}$
Imposed floor loads in buildings:	
— storage;	0,9
— escape stairs and lobbies;	0,9
— all other areas.	0,7
Imposed roof loads (including snow loads)	0
Wind loads:	
— height to eaves up to 8 m;	0
— height to eaves greater than 8 m.	0,3

NOTE Plant load should be taken as a permanent load.

6 Additional recommendations

Table 3 — Adaptation factors

Reference in ENV 1993-1-2	Description	Symbol	Condition	Value	
				ENV value	Value for UK use
4.2.3.3(8)	The adaptation factor for non-uniform temperature distribution across a cross-section	κ_1	For a beam exposed on all four sides	1,0	1,0
4.2.3.3(8)	The adaptation factor for non-uniform temperature distribution across a cross-section	κ_1	For a beam exposed on three sides with a composite or concrete slab on side four	0,7	0,7
4.2.3.3(9)	The adaptation factor for non-uniform temperature distribution along a beam	κ_2	At the supports of a statically indeterminate beam	0,85	0,85
			In all other cases	1,0	1,0

Table 4 — Directly referenced supporting standards

Reference in ENV 1993-1-2	UK supporting standards
PrEN ISO 834	BS 476-20:1987
PrENV yyy 5-1	BS 476-20:1987 BS 476-21:1987 ^a
PrENV yyy 5-2	
PrENV yyy 5-3	
ENV 1991-2-2	DD ENV 1991-2-2
ENV 1993-1-1	DD ENV 1993-1-1
ENV 1993-1-3	DD ENV 1993-1-3
ENV 1994-1-2	DD ENV 1994-1-2
ISO 1000	BS 5555:1993
^a Further information can be obtained from <i>Fire protection for structural steel in buildings</i> [1].	

6.1 Chapter 1 General

a) 1.1 Scope

ENV 1993-1-2:1995 may be used to determine the resistance of stainless steel members subjected to the accidental situation of exposure to fire.

NOTE The performance of stainless steel in fire is usually significantly better than that of mild steel.

6.2 Chapter 2 Basic Principles and Rules

a) 2.1(2)P

Provided fire protection materials satisfy the recommendations given in ENV 1993-1-2:1995, 3.3.2 the reduction factor k_y given in ENV 1993-1-2:1995, Table 3.1 may be used to calculate the member resistance. In other cases, the reduction factor k_x in ENV 1993-1-2:1995, Table 3.1 should be used.

NOTE Information on fire protection materials that satisfy the recommendations in ENV 1993-1-2:1995, 3.3.2 can be found in the publication *Fire protection for structural steel in buildings* [1].

b) 2.4.4(4)

In general, the effects of thermal expansion may be neglected. However, consideration should be given to the effect of thermal expansion on bracing members. Further guidance is given in 6.4b).

6.3 Chapter 4 Structural Fire Design

a) 4.2.1(5)P

Alternatively, for the design of bolts and welds in the fire situation, the strength reduction factor may conservatively be taken as 80 % of the temperature-dependent value of $k_{x,\theta}$ given in ENV 1993-1-2:1995, Table 3.1.

b) 4.2.2(4)

Contrary to ENV 1993-1-2:1995, 4.2.2(4) in a fire design situation all members should be classified as for normal temperature design using the following expression for ε :

$$\varepsilon = [(235/f_y)]^{0,5}$$

where

f_y is the steel yield strength given in ENV 1993-1-1:1992, 3.2.2.1.

c) 4.2.3.1

For tension members, $k_{y,\theta}$ should be replaced in the expression by the temperature-dependent value of $k_{x,\theta}$ given in Table 3.1 of ENV 1993-1-2:1995.

d) 4.2.3.2(2)

As an alternative to expression (4.6) in ENV 1993-1-2:1995, $\bar{\lambda}_{\theta,\max}$ may be conservatively calculated as:

$$\bar{\lambda}_{\theta,\max} = 1.2 \bar{\lambda}$$

where

$\bar{\lambda}$ is the relative slenderness for a normal temperature design.

e) 4.2.3.2(4)

For a column in a steel frame in which each storey comprises a separate fire compartment with sufficient fire resistance, the buckling length ℓ_{fi} should be taken as $0,7L$ where the column is continuous at both ends. Where the column is continuous at one end only, the buckling length should be taken as $0,85L$. ENV 1993-1-2:1995, Figure 4.1 as modified by 6.3f) gives the buckling lengths of columns in braced frames.

f) Figure 4.1 Buckling lengths ℓ_{fi} of columns in braced frames

The buckling length $\ell_{fi,2}$ of the column in the intermediate storey should be taken as $0,7L_2$ and the buckling length $\ell_{fi,4}$ of the top storey column should be taken as $0,85L_4$.

g) 4.2.3.3(5)

The constant 1,2 in expression (4.11) of ENV 1993-1-2:1995 should be replaced by the parameter K whose value is given by the following expression:

$$K = \frac{\lambda_{L,T,\theta,\text{com}}}{3} + 0,87$$

where

$\lambda_{L,T,\theta,\text{com}}$ is given in ENV 1993-1-2:1995, 4.2.3.3(6) as modified by 6.3h).

h) 4.2.3.3(6)

Contrary to ENV 1993-1-2:1995, 4.2.3.3(6) the value of the non-dimensional slenderness $\bar{\lambda}_{L,T,\theta,\text{com}}$ for the temperature $\theta_{a,\text{com}}$ should be taken as the value of the normal temperature non-dimensional slenderness $\bar{\lambda}_{LT}$.

i) 4.2.4

The critical temperature method is an alternative to that given in ENV 1993-1-2:1995, 4.2.3 but cannot be used for the following cases:

- columns;
- tension members;
- unrestrained beams with $\bar{\lambda}_{L,T,fi} > 0,4$.

It can only be used for fully restrained beams, unrestrained beams where $\bar{\lambda}_{L,T,\text{fi}}$ is not greater than 0,4 and members with Class 4 cross-sections.

ENV 1993-1-2 uses the term “degree of utilization”, μ_0 , which allows the applied load on a member to be directly related to the critical temperature and is determined from the following expression:

$$\mu_0 = \frac{E_{\text{fi,d}}}{R_{\text{fi,d},0}}$$

The variables in the above expression are as defined in ENV 1993-1-2:1995, **4.2.3.5**.

For a beam bending with a uniform temperature distribution over its cross-section and along its length, $R_{\text{fi,d},0}$ is the design moment of resistance of the member at ambient temperature.

For a beam bending with a non-uniform temperature distribution over its cross-section and along its length, $R_{\text{fi,d},0}$ is determined by dividing the member's design moment of resistance at ambient temperature by the adaptation factors κ_1 and κ_2 .

j) **4.2.4(4)**

When calculating the degree of utilization, the value of $R_{\text{fi,d},0}$ is determined by dividing the member resistance at normal temperature by both adaptation factors κ_1 and κ_2 .

k) **4.2.4(6)**

The method described in this clause may be used to design members constructed from Class 4 open sections.

6.4 Recommendations on subjects not covered in ENV 1993-1-2:1995

a) *Re-use of steel after a fire*

It may be possible to re-use steel after a fire. The guidance in BS 5950-8:1990, appendix C should be followed.

b) *Bracing members*

Bracing members provided stability to the structure in the fire design situation and should be distributed throughout the building so no substantial portion of the structural frame is solely reliant on a single plane of bracing in each of two directions approximately at right angles. Where the stability of the structure is solely dependent on a single plane of bracing or where the bracing systems are located adjacent to a single fire compartment, the temperature in the columns and compressive members forming part of the bracing system should not exceed 450 °C.

c) *Water-filled structures*

The design of water-filled structures should follow the guidance in BS 5950-8:1990, **4.7**.

NOTE Further information may be found in *Fire and steel construction — Water cooled hollow columns* [2].

d) *Portal frames*

The design of portal frames in the fire situation should follow the guidance in BS 5950-8:1990, **4.5**.

NOTE Further information may be found in *Fire and steel construction: The behaviour of steel portal frames in boundary conditions* [3].

e) *Beams with shelf angles*

The fire resistance for beams with shelf angles should be determined in accordance with the guidance in BS 5950-8:1990, appendix E.

f) *Fire resisting walls*

The guidance in BS 5950-8:1990, **4.10** should be followed for the design of fire resisting walls in the fire situation.

g) *Roofs*

Where a roof spans across a fire resisting compartment wall where it is required that strips of the roof should be fire protected on the underside of both sides of the compartment wall, care should be taken to fire stop any gaps between the top of the wall and the underside of the roof cladding to accommodate differential thermal movement in fire. Where practicable, combustible insulation should also be fire stopped along the line of the wall.

h) *Ceilings*

In addition to ENV 1993-1-2:1995, **4.2.5.3** the guidance in BS 5950-8:1990, **4.12** should also be followed for the design of ceilings in the fire situation

Bibliography

BS 5950-8:1990, *Structural use of steelwork in building — Code of practice for fire resistant design*.

[1] Association of Specialist Fire Protection Contractors and Manufacturers Limited, Steel Construction Institute. *Fire protection for structural steel in buildings* (Revised Second Edition), 1992²⁾.

[2] BOND, G.V.L. *Fire and steel construction — Water cooled hollow columns*. Steel Construction Institute, 1975²⁾.

[3] NEWMAN, G.M. *Fire and steel construction — The behaviour of steel portal frames in boundary conditions* (Second Edition), Steel Construction Institute, 1990²⁾.

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²⁾ Available from The Steel Construction Institute, Silwood Park, Ascot, Berkshire SL5 7QN.

EUROPEAN PRESTANDARD

ENV 1993-1-2

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

September 1995

ICS 13.220.20; 91.040.00; 91.080.10

Descriptors: buildings, steel construction, structural steels, design, safety requirements, accident prevention, fire protection, fire resistance, mechanical properties, thermodynamic properties, computation, mechanical strength

English version

Eurocode 3 - Design of steel structures - Part 1-2: General rules - Structural fire design

Eurocode 3 - Calcul des structures en acier -
Partie 1-2: Règles générales - Calcul du
comportement au feu

Bemessung und Konstruktion von Stahlbauten -
Teil 1-2: Allgemeine Regeln -
Tragwerksbemessung für den Brandfall

This European Prestandard (ENV) was approved by CEN on 1993-11-05 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into an European Standard (EN).

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Foreword

Objectives of the Eurocodes

- (1) The “Structural Eurocodes” comprise a group of standards for the structural and geotechnical design of buildings and civil engineering works.
- (2) They cover execution and control only to the extent that is necessary to indicate the quality of the construction products, and the standard of the workmanship, needed to comply with the assumptions of the design rules.
- (3) Until the necessary set of harmonized technical specifications for products and for methods of testing their performance is available, some of the Structural Eurocodes cover some of these aspects in informative annexes.

Background to the Eurocode programme

- (4) The Commission of the European Communities (CEC) initiated the work of establishing a set of harmonized technical rules for the design of building and civil engineering works which would initially serve as an alternative to the different rules in force in the various member states and would ultimately replace them. These technical rules became known as the “Structural Eurocodes”.
- (5) In 1990, after consulting their respective member states, the CEC transferred the work of further development, issue and updating of the Structural Eurocodes to CEN, and the EFTA Secretariat agreed to support the CEN work.
- (6) CEN Technical Committee CEN/TC 250 is responsible for all Structural Eurocodes.

Eurocode programme

- (7) Work is in hand on the following Structural Eurocodes, each generally consisting of a number of parts:

EN 1991	Eurocode 1	Basis of design and actions on structures;
EN 1992	Eurocode 2	Design of concrete structures;
EN 1993	Eurocode 3	Design of steel structures;
EN 1994	Eurocode 4	Design of composite steel and concrete structures;
EN 1995	Eurocode 5	Design of timber structures;
EN 1996	Eurocode 6	Design of masonry structures;
EN 1997	Eurocode 7	Geotechnical design;
EN 1998	Eurocode 8	Design provisions for earthquake resistance of structures;
EN 1999	Eurocode 9	Design of aluminium alloy structures.
- (8) Separate sub-committees have been formed by CEN/TC 250 for the various Eurocodes listed above.
- (9) This Part 1.2 of Eurocode 3 is published by CEN as a European Prestandard (ENV) with an initial life of three years.
- (10) This Prestandard is intended for experimental application and for the submission of comments.
- (11) After approximately two years CEN members will be invited to submit formal comments to be taken into account in determining future actions.

(12) Meanwhile feedback and comments on this Prestandard should be sent to the secretariat of CEN/TC 250/SC 3 at the following address:

BSI Standards
British Standards House
389 Chiswick High Road
London W4 4AL
England

or to your national standards organization.

National Application Documents (NAD's)

(13) In view of the responsibilities of the authorities in member countries for safety, health and other matters covered by the essential requirements of the Construction Products Directive (CPD), certain safety elements in this ENV have been assigned indicative values which are identified by ☐ ("boxed values"). The authorities in each member country are expected to review the "boxed values" and may substitute alternative definitive values for these safety elements for use in national application.

(14) Some of the supporting European or International Standards might not be available by the time this Prestandard is issued. It is therefore anticipated that a National Application Document (NAD) giving any substitute definitive values for safety elements, referencing compatible supporting standards and providing guidance on the national application of this Prestandard, will be issued by each member country or its Standards Organization.

(15) It is intended that this Prestandard is used in conjunction with the NAD valid in the country where the building or civil engineering works is located.

Matters specific to this Prestandard

(16) Work on those parts of the Structural Eurocodes covering fire resistance was initiated by the CEC and a first draft of this document was issued in 1990 as a draft "Eurocode 3 : Part 10".

(17) With the transfer of work on Structural Eurocodes to CEN, the responsibility for completing this document passed to CEN Technical Committee CEN/TC 250, sub-committee CEN/TC 250/SC 3.

(18) The scope of Eurocode 3 is defined in 1.1.1 of ENV 1993-1-1. Additional Parts of Eurocode 3 that are planned are indicated in 1.1.3 of ENV 1993-1-1.

(19) The general objectives of fire protection are to limit risks with respect to the individual and society, neighbouring property and, where required, directly exposed property, in the case of fire.

(20) The Structural Eurocodes deal with specific aspects of passive fire protection in terms of designing structures and parts thereof for adequate load-bearing capacity and for limiting fire spread as relevant.

(21) Required functions and levels of performance are generally specified by national authorities - mostly in terms of standard fire resistance rating. Where fire safety engineering for assessing passive and active measures is accepted, requirements by authorities may be less prescriptive and allow alternative strategies.

(22) This Part 1.2, together with ENV 1991-2-2, gives the supplements to ENV 1993-1-1 that are necessary so that structures designed according to this set of Structural Eurocodes may also comply with structural fire resistance requirements.

(23) Supplementary requirements concerning, for example:

- the possible installation and maintenance of sprinkler systems;
- conditions of occupancy of the building or fire compartment;
- the use of approved insulation and coating materials, including their maintenance;

are not given in this document, because they are subject to specification by national authorities.

(24) A method is included in this ENV for applying deformation criteria to the load-bearing structure where the means of protection, or the design criteria for separating members, require such consideration (see 2.1(2), 3.2.1(6), 4.2.1(6) and 4.2.2(5)). However no specific provisions are given for its application. It is intended that where any such provision is considered necessary, it should be included in the NAD.

(25) A full analytical procedure for structural fire design would take into account the behaviour of the structural system at elevated temperatures, the potential heat exposure and the beneficial effects of active fire protection systems, together with the uncertainties associated with these three features and the importance of the structure (consequences of failure).

(26) At the present time it is possible to undertake a procedure for determining adequate performance that incorporates some, if not all, of these parameters and to demonstrate that the structure, or its components, will give adequate performance in a real building fire. However, the principal current procedure in European countries is one based on results from standard fire resistance tests. The grading systems in national regulations that call for specific periods of fire resistance, take into account (though not explicitly) the features and uncertainties described above.

(27) Due to the limitations of the test method, further tests or analyses may be used. Nevertheless, the results of standard fire tests form the bulk of the input to calculation methods for structural fire design. This Prestandard therefore deals in the main with design for the standard fire resistance.

(28) Simple calculation models for steel structures are given in this document and accordingly tabulated data are not included. It is expected that tables and other design aids based on the calculation methods given in this ENV 1993-1-2 will be prepared by interested external organisations.

1 General

1.1 Scope

- (1)P This Part 1.2 of ENV 1993 deals with the design of steel structures for the accidental situation of fire exposure and is intended to be used in conjunction with ENV 1993-1-1 and ENV 1991-2-2. This Part 1.2 only identifies differences from, or supplements to, normal temperature design.
- (2)P This document deals only with passive methods of fire protection. Active methods are not covered.
- (3)P This Part 1.2 applies to structures that, for reasons of general fire safety, are required to avoid premature collapse of the structure in exposure to fire (load-bearing function).
- (4)P This Part 1.2 gives principles and application rules (see 1.2) for designing structures for specified requirements in respect of the aforementioned function and the levels of performance.
- (5)P This document only applies to structures, or parts of structures, that are within the scope of ENV 1993-1-1 and are designed accordingly.
- (6)P The methods given in this document may also be applied to cold-formed thin gauge steel members and sheeting within the scope of ENV 1993-1-3.
- (7)P For the fire resistance of composite steel and concrete structures see ENV 1994-1-2.
- (8)P The methods given in this document are applicable to any steel grade for which material properties are available.
- (10)P The steel properties given in this document apply to steel grades S 235, S 275 and S 355 of EN 10025 and to all steel grades of EN 10113, EN 10155, EN 10210-1 and EN 10219-1.

1.2 Distinction between principles and application rules

- (1)P Depending on the character of the individual clauses, distinction is made in this Part between principles and application rules.
- (2)P The principles comprise:
- general statements and definitions for which there is no alternative;
 - requirements and analytical models for which no alternative is permitted unless specifically stated.
- (3) The principles are identified by the letter P following the paragraph number.
- (4)P The application rules are generally recognised rules which follow the principles and satisfy their requirements. It is permissible to use alternative design rules different from the application rules given in the Eurocode, provided that it is shown that the alternative rule accords with the relevant principles and have at least the same reliability.
- (5) In this Part the application rules are identified by a number in brackets, as in this paragraph.

1.3 Normative references

This European Prestandard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

- EN 10025 *Hot rolled products of non-alloy structural steels: Technical delivery conditions;*
- EN 10113 *Hot rolled products in weldable fine grade structural steels:*
Part 1: *General delivery conditions;*
Part 2: *Delivery conditions for normalized/normalized rolled steels;*
Part 3: *Delivery conditions for thermomechanically rolled steels;*
- EN 10155 *Structural steels with improved atmospheric corrosion resistance - Technical delivery conditions;*
- EN 10210 *Hot finished structural hollow sections of non-alloy and fine grain structural steels:*
Part 1: *Technical delivery conditions;*
- EN 10219 *Cold formed welded structural hollow sections of non-alloy and fine grain structural steels:*
Part 1: *Technical delivery conditions;*
- pr EN ISO 834 *Fire resistance: General requirements;*
- pr ENV yyy5 *Fire tests on elements of building construction:*
Part 1: *Test method for determining the contribution to the fire resistance of structural members: by horizontal protective membranes;*
Part 2 *Test method for determining the contribution to the fire resistance of structural members: by vertical protective membranes;*
Part 4: *Test method for determining the contribution to the fire resistance of structural members: by applied protection to steel structural elements;*
- ENV 1991 *Eurocode 1. Basis of design and actions on structures:*
Part 2.2: *Actions on structures exposed to fire;*
- ENV 1993 *Eurocode 3. Design of steel structures:*
Part 1.1: *General rules : General rules and rules for buildings;*
Part 1.3: *General rules : Supplementary rules for cold formed thin gauge steel members and sheeting;*
- ENV 1994 *Eurocode 4. Design of composite steel and concrete structures:*
Part 1.2: *General rules : Structural fire design;*
- ISO 1000 *SI units.*

1.4 Definitions

For the purposes of this Part 1.2 of ENV 1993, the following definitions apply:

1.4.1 configuration factor: Solid angle within which the radiating environment can be seen from a particular point on the member surface, divided by 2π .

1.4.2 convective heat transfer coefficient: Convective heat flux to the member related to the difference between the bulk temperature of gas bordering the relevant surface of the member and the temperature of that surface.

1.4.3 critical temperature of structural steel: For a given load level, the temperature at which failure is expected to occur in a structural steel element for a uniform temperature distribution.

1.4.4 design fire: A specified fire development assumed for design purposes.

1.4.5 effective yield strength: For a given temperature, the stress level at which the stress-strain relationship of steel is truncated to provide a yield plateau.

1.4.6 external member: Structural member located outside the building, that may be exposed to fire through openings in the building enclosure.

1.4.7 fire compartment: A space within a building, extending over one or several floors, that is enclosed by separating members such that fire spread beyond the compartment is prevented during the relevant fire exposure.

1.4.8 fire protection material: A material that has been shown, by fire resistance tests, to be capable of remaining in position and of providing adequate thermal insulation for the fire resistance period under consideration.

1.4.9 fire resistance: The ability of a structure, a part of a structure or a member to fulfil its required functions (load bearing function and/or separating function) for a specified fire exposure and for a specified period of time.

NOTE: For steel members only the load bearing function applies.

1.4.10 fire wall: A wall separating two spaces (generally two buildings) that is designed for fire resistance and structural stability, including resistance to horizontal loading such that, in case of fire and failure of the structure on one side of the wall, fire spread beyond the wall is avoided.

1.4.11 global structural analysis (for fire): An analysis of the entire structure, when either the entire structure, or only parts of it, are exposed to fire. Indirect fire actions are considered throughout the structure.

1.4.12 indirect fire actions: Thermal expansions, thermal deformations or thermal gradients causing internal forces and moments.

1.4.13 load bearing criterion: A criterion by which the ability of a structure or member to sustain specified actions, during the relevant fire, is assessed.

1.4.14 load bearing function: The ability of a structure or a member to sustain specified actions during the relevant fire, according to defined criteria.

1.4.15 member analysis (for fire): The thermal and mechanical analysis of a structural member exposed to fire in which the member is considered as isolated, with appropriate support and boundary conditions. Indirect fire actions are not considered, except those resulting from thermal gradients.

1.4.16 net heat flux: Energy per unit time and surface area absorbed by members.

1.4.17 normal temperature design: Ultimate limit state design for ambient temperatures according to ENV 1993-1-1 for the fundamental combination according to ENV 1991-1.

1.4.18 protected members: Members for which measures are taken to reduce the temperature rise in the member due to fire.

1.4.19 section factor: For a steel member, the ratio between the exposed surface area and the volume of steel; for an enclosed member, the ratio between the internal surface area of the exposed encasement and the volume of steel.

1.4.20 separating member: Structural or non-structural member (wall or floor) forming part of the enclosure of a fire compartment.

1.4.21 standard fire exposure: Exposure to furnace gases with a temperature that varies with time according to the standard temperature-time curve.

1.4.22 standard fire resistance: The ability of a structure or part of it (usually only members) to fulfil required functions (load-bearing function and/or separating function), for the standard fire exposure for a stated period of time.

NOTE: Standard fire resistance requirements are normally expressed in terms of periods of time, such as 30, 60 or more minutes.

1.4.23 standard temperature-time curve: The nominal temperature-time curve given in ENV 1991-2-2.

1.4.24 structural members: The load-bearing members of a structure, including bracings.

1.4.25 sub-assembly analysis (for fire): The structural analysis of parts of the structure exposed to fire, in which the respective part of the structure is considered as isolated, with appropriate support and boundary conditions. Indirect fire actions within the sub-assembly are considered, but no time-dependent interaction with other parts of the structure.

NOTE 1: Where the effects of indirect fire actions within the sub-assembly are negligible, sub-assembly analysis is equivalent to member analysis.

NOTE 2: Where the effects of indirect fire actions between sub-assemblies are negligible, sub-assembly analysis is equivalent to global structural analysis.

1.4.26 support and boundary conditions: Restraint conditions and applied forces and moments assumed at the supports and boundaries of a structure or part of a structure for the purposes of structural analysis.

1.4.27 temperature analysis: The procedure of determining the temperature development in members on the basis of the thermal actions (net heat flux) and the thermal material properties of the members and of protective surfaces, where relevant.

1.4.28 temperature-time curves: Gas temperatures in the environment of member surfaces as a function of time. They may be:

- **nominal:** Conventional curves, adopted for classification or verification of fire resistance, such as the standard time-temperature curve;
- **parametric:** Determined on the basis of fire models and the specific physical parameters defining the conditions in the fire compartment.

1.4.29 thermal actions: Actions on the structure described by the net heat flux to the members.

1.5 Symbols

1.5.1 Supplementary to ENV 1993-1-1, the following symbols are used:

A_m	is	the surface area of a member per unit length;
A_p	is	the area of the inner surface of the fire protection material per unit length of the member;
E_a	is	the modulus of elasticity of steel for normal temperature design;
$E_{a,\theta}$	is	the slope of the linear elastic range for steel at elevated temperature θ_a ;
$E_{fi,d}$	is	the design effect of actions in the fire situation;
$R_{d,\theta}$	is	the design resistance at uniform elevated material temperature θ ;
$R_{fi,d}$	is	the design resistance in the fire situation;
$R_{fi,d,t}$	is	the design value of a resistance in the fire situation, at time t ;
T	is	the temperature [K] (cf θ temperature [°C]);
V	is	the volume of a member per unit length;
$X_{fi,d}$	is	the design material property in the fire situation;
X_k	is	the characteristic value of a material property;
$X_{k,\theta}$	is	the characteristic value of a material property at elevated temperature θ ;
c	is	the specific heat [J/kgK];
d_p	is	the thickness of fire protection material;
$f_{p,\theta}$	is	the proportional limit for steel at elevated temperature θ_a ;
$f_{y,\theta}$	is	the effective yield strength of steel at elevated temperature θ_a ;
$\dot{h}_{net,d}$	is	the design value of the net heat flux per unit area;
k_θ	is	the relative value of a strength or deformation property of steel at elevated temperature θ_a ;
ℓ	is	the length at 20 °C ;
$\Delta\ell$	is	the temperature induced expansion;
t	is	the time in fire exposure [minutes];
Δt	is	the time interval [seconds];
η_{fi}	is	the reduction factor for design load level in the fire situation;
θ	is	the temperature [°C] (cf T temperature [K]);
κ	is	the adaptation factor;
λ	is	the thermal conductivity [W/mK];
μ_0	is	the degree of utilisation at time $t = 0$.