

Eurocode 1: Basis of design and actions on structures —

**Part 2.2: Actions on structures exposed
to fire —**

**(together with United Kingdom
National Application Document)**

ICS 13.220.50; 91.040

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Committees responsible for this Draft for Development

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- British Constructional Steelwork Association
- British Iron and Steel Producers' Association
- British Masonry Society
- Concrete Society
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Property and Buildings Directorate)
- Highways Agency
- Institution of Structural Engineers
- National House Building Council
- Royal Institute of British Architects
- Steel Construction Institute

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National foreword

This Draft for Development has been prepared by Subcommittee B/525/1 and is the English language version of ENV 1991-2-2:1995 *Eurocode 1: Basis of design and actions on structures — Part 2.2: Actions on structures exposed to fire*, 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 England, Wales and Northern Ireland.

ENV 1991-2-2:1995 results from a programme of work sponsored by the European Commission to make available a common set of rules for the structural and geotechnical design of building and civil engineering works.

This publication is not to 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 individual CEN members so as to meet the requirements of national regulations. These parameters are designated by [] in the ENV.

During the ENV period reference should be made to the supporting documents listed in the National Application Document (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 England, Wales and Northern Ireland. The NAD takes precedence over corresponding provisions in the ENV.

The Building Regulations 1991, Approved Document A 1992, draws attention to the potential use of ENV Eurocodes as an alternative approach to Building Regulation compliance.

Users of this document are invited to comment on its technical content, ease of use and any ambiguities and 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 to an EN.

Comments should be sent in writing to the Secretary of Subcommittee B/525/1, BSI, 389 Chiswick High Road, London W4 4AL, quoting the document reference, the relevant clause and, where possible, a proposed revision, within 2 years of the issue of this document.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to xii, the ENV title page, pages 2 to 32 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

National Application Document for use in the UK with ENV 1991-2-2:1995

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Introduction

This National Application Document (NAD) has been prepared by Subcommittee B/525/1. It has been developed from the following.

- A textual examination of ENV 1991-2-2:1995.
- A calibration against Approved Document B (1992 Edition) of the Building Regulations 1991 (England and Wales).
- Trial calculations.

1 Scope

This NAD provides information to enable ENV 1991-2-2:1995 (EC1: Part 2.2) to be used for the design of buildings to be constructed in England, Wales and Northern Ireland. Its application does not extend to civil engineering works.

2 References

2.1 Normative references

This NAD incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on page (xi). Subsequent amendments to, or revisions of, any of these publications apply to this NAD only when incorporated in it by updating or revision.

2.2 Informative references

This NAD refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page (xi), but reference should be made to the latest editions.

3 Partial safety factors and other values to be used in ENV 1991-2-2

In the referenced clauses, the values given in Table 1 shall be used for the design of buildings in place of the “boxed” values given in the ENV. Further recommendations on the adoption of the approaches outlined in ENV 1991-2-2 are given in clause 5 of this NAD.

4 Reference standards

References in the ENV to national regulations refer to:

- BUILDING AND BUILDINGS. The Building Regulations 1991. (SI 1991 No. 2768) in England and Wales;
- BUILDING REGULATIONS. The Building Regulations (Northern Ireland) 1990. (SRNI 1990 No. 59) in Northern Ireland.

Reference standards cited in ENV 1991-2-2 are listed in Table 2 of this NAD. Full references are provided on Page (x).

Table 1 — Values to be used in referenced clauses in place of ENV boxed values

ENV Clause	Description	“Boxed value”	UK value
4.1 (4)	Configuration factor (φ)	1.0	1.0
4.1 (10)	Convection factor on unexposed face (α_c)	9.0	9.0
4.2.1 (2)	Type of test factor (radiation) ($\gamma_{n,r}$)	1.0	0.45 1.0 ^a
4.2.1 (2)	Type of test factor (convection) ($\gamma_{n,c}$)	1.0	1.0
4.2.1 (3)	Emissivity of fire (ε_p)	0.8	0.8
4.2.1 (3)	Material emissivity (ε_m)	0.7	0.7
4.2.2 (2)	Standard curve: coefficient of heat transfer-convection (α_c)	25 W/m ² °C	25 W/m ² °C
4.2.3 (2)	External curve: coefficient of heat transfer-convection (α_c)	25 W/m ² °C	25 W/m ² °C
4.2.4 (2)	Hydrocarbon curve coefficient of heat transfer-convection (α_c)	50 W/m ² °C	50 W/m ² °C
D.1 (3)	Active fire protection factor	0.6	0.6 0.75 ^a
F.3.1 P (1)	Partial safety factor for permanent actions in accidental situation (γ_{GA})	1.0	1.0

^a Guidance on choice of value given in clause 5 of this NAD.

Table 2 — Reference in ENV 1991-2-2 to other publications

Document referenced in ENV	Title	Status	UK Document
CPD 89/106/EEC	Construction products directive	EC Directive	CPD 89/106/EEC
ID “ <i>Safety in the case of fire</i> ”	Interpretative document	Published in Official Journal of European Communities ref. 94(c)62/01	
ENV 1991-1	Basis of design	ENV	DD ENV 1991-1
ENV 1992-1.2	Design of concrete structures — Structural fire design	ENV	ENV 1992-1-2 (BS 8110-2) ^a
ENV 1993-1.2	Design of steel structures — Structural fire design	ENV	ENV 1993-1-2 (BS 5950-8) ^a
ENV 1994-1.2	Design of composite structures — Structural fire design	ENV	ENV 1994-1-2
ENV 1995-1.2	Design of timber Structures — Structural fire design	ENV	ENV 1995-1-2
ENV 1996-1.2	Design of masonry structures — Structural fire design	ENV	ENV 1996-1-2 (BS 5628-3) ^a
ENV 1999-1.2	Design of aluminium structures — Structural fire design	In Draft	BS 8118-1
ISO 3898	Bases for design of structures — Notations — general symbols	ISO Standard	ISO 3898
ISO 1716	Building materials — Determination of calorific potential	ISO Standard	ISO 1716
^a To be used until DD ENV is published			

5 Additional recommendations

NOTE 5.1 to 5.7 should be followed when designing in accordance with ENV 1991-2-2.

5.1 Section 1. General

Clause 1.1.2 (1) P

ENV 1991-2-2 is intended for use in conjunction with the fire design parts of ENV 1992 to ENV 1996 and ENV 1999 which give rules for designing structures for fire resistance. Fire resistance in this context is confined to load bearing function, i.e. the ability of the structure to sustain actions during the relevant fire exposure, according to defined criteria.

5.2 Section 4. Thermal actions

a) Clause 4.2.1 (1)

The nominal temperature-time curve considered as appropriate for buildings is the standard temperature-time curve as defined in 4.2.2 of the ENV.

b) Clause 4.2.1 (2)

The net heat fluxes due to radiation and convection are calculated in equations (4.1) and (4.2) in a simplistic manner. Accordingly, to correlate the results of the approach given in equations (4.1) and (4.2) with data from fire resistance tests, a factor is applied to each of the net heat flux components, as given in Table 3.

The fire test factor is applicable only to the calculation of heat flux for use with the appropriate material thermal models, detailed in ENV 1992 to ENV 1996 and ENV 1999. The factor shall not be used with other numerical models of heat transfer.

Table 3 — Fire test correlation factor

Mode of heat transfer	Fire test factor	National value	Construction material
Convection	$\gamma_{n,c}$	1.0	All
Radiation	$\gamma_{n,r}$	0.45	Steel
Radiation	$\gamma_{n,r}$	1.0	Concrete

5.3 Annex A

Parametric fire exposure (informative)

Clause A.2 (2)

An approved extinguishing system may be considered in place when the building is fitted throughout with an automatic sprinkler system meeting the relevant recommendations of BS 5306-2, i.e. the relevant occupancy rating together with the additional requirements for life safety.

5.4 Annex B

Parametric time-temperature curves (informative)

Annex B (1)

The use of parametric temperature-time curves is the subject of current research. At this stage, there has not been sufficient validation of the approach given in equations (B.1) and (B.2). In addition, correlation needs to be established between material temperature response (as calculated in section 4) and recorded experimental data, so that the resulting emissivity and coefficient of convection (in accordance with 4.2.1 and 4.2.2) may be established. Accordingly, the parametric approach detailed in Annex B of ENV 199-2-2 is not yet considered sufficiently proven for adoption in this NAD.

5.5 Annex C

Thermal actions for external members (informative)

Clause C.1 (1)

Calculations of the maximum temperatures reached in a fire compartment shall not be used for compartments whose construction is of a highly insulating nature with respect to fire conditions. Accordingly, the calculation method shall not be used for compartments with lining materials having thermal inertias (i.e. the parameter b in Table E.1 of Annex E) less than $720 \text{ J/m}^2 \text{ S}^{1/2} \text{ K}$.

5.6 Annex D

Fire load densities (informative)

a) Clause D.1 (3)

The safety factor γ_q is considered to be dependent on both the risk of a fully developed fire occurring and the consequences of structural failure. Thus, γ_q values vary with building type and height. Building types are distinguished by the nature of occupancy. Full details of occupancies are given in Annex A to this NAD. Building height refers to the height of the top storey floor level above ground, as described in Figure 1.

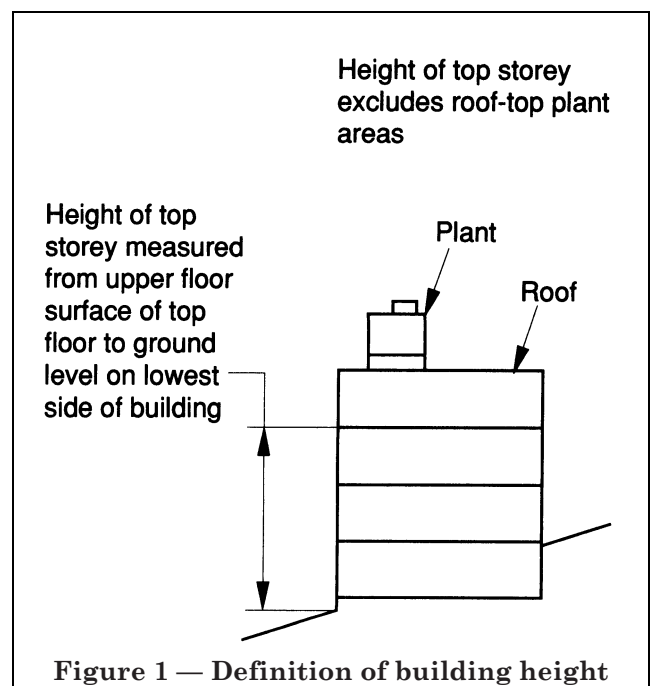


Figure 1 — Definition of building height

γ_q as defined in equation (D.1) is to be given by:

$$\gamma_q = \gamma_{q1} \cdot \gamma_{q2} \quad (1)$$

where

γ_{q1} and γ_{q2} are factors quantifying the risk and consequence of failure and are defined in Table 4 and Table 5.

Table 4 — Factors quantifying consequences of failure (γ_{q1}) to be used in equation (1)

Occupancy	Building Height (see Figure 1)			
	≤ 5 m	≤ 20 m	≤ 30 m	> 30 m
		Depth of lowest basement		
		≤ 10 m	> 10 m	
Flats, dwellings, institutional, residential, offices	0.8	1.1	1.6	2.2
Assembly, shops		0.8	1.1	
Industrial	0.6			1.6
Car parks	0.4			

Table 5 — Factors quantifying risk of failure (γ_{q2}) factor to be used in equation (1)

Occupancy	γ_{q2}
Flats, dwellings, institutional, offices	1.2
Shops, assembly & recreation, industrial, storage, car parks	0.8
Open car parks (as defined in Annex A of this NAD)	0.4

The differentiation factor accounting for active protection measures, defined by γ_n in equation (D.1), shall have the values given in Table 6. The active protection factor is dependent on the safety factor γ_q in equation (1).

Table 6 — Active protection factor

Active Protection Measures	National values for γ_n	
	$\gamma_q \leq 1.6$	$\gamma_q > 1.6$
Approved sprinkler system (as defined 5.2)	0.60	0.75
Other	1.0	1.0

For certain building types, additional considerations that are beyond the scope of this NAD may demand that an approved sprinkler system is installed. Further details may be found in the appropriate national regulations.

b) *Clause D.2.3 (2)*

The protected fire load factor, given as Ψ_i in equation (D.2) shall have the value 1.0.

c) *Clause D.2.5 (2)*

The combustion factor, given as m_i in equation (D.2) shall have the value 1.0.

d) *Clause D.3 (2)*

Table 7 gives the fire load densities (related to the floor area of the compartment). These variable fire loads depend on the nature of the compartment's occupancy, information on which is given in Annex A of this NAD.

Where a single fire compartment contains several different occupancies, e.g. a single compartment multi-storey building, the design fire load shall be calculated based on the occupancy with the highest characteristic fire load density.

Table 7 — Characteristic variable fire load densities

Variable fire load density ($q_{f,k}$) MJ/m ²	Occupancy
500	Flats, dwellings, institutional, car parks, offices
750	Shops, assembly & recreation
1 000	Storage, industrial

5.7 Annex E

Equivalent time of fire exposure (informative)

a) *Annex E (1)*

The equivalent time of fire exposure approach should not be used for design of compartments with very low ventilation, i.e. where the ventilation factor w_f , defined in equation (E.3), has a value greater than 3.0. The approach has only been validated up to a limiting time equivalent duration of 120 min (without any factoring of fire load density) and should not be used beyond this limit.

The provision of sprinklers and other fire protection measures is recommended for certain building types and sizes. Detailed recommendations are given in the relevant national guidance, as referenced in clause 6 of this NAD.

b) *Annex E (4)*

Where no detailed assessment of the thermal properties of the enclosure is made, the conversion factor, defined as k_b in equation (E.2), to be used is 0.09. Guidance on the thermal properties of a range of typical construction materials is given in Annex B of this NAD.

The values assigned to the conversion factors in ENV 1991-2.2 shall be replaced nationally by the values given in Table 8.

Table 8 — Conversion factor

Thermal inertia (J/m ² s ^{1/2} K)	k_b given in ENV 1991-2-2	k_b for use in UK
> 2 500	0.04	0.05
2 500 – 720	0.055	0.07
< 720	0.07	0.09

c) *Annex E (5)*

The ventilation factor, defined by w_f in equation (E.3), shall be limited to values between 0.5 and 3.0.

Annex A (normative)

Description of occupancies

Occupancy is a means of describing the use classification of a building or (where the building is sub-divided into compartments) to a compartment. The occupancy description should describe the main use of the compartment. Where a building contains more than one compartment, with differing occupancy, each compartment may be treated individually, with due regard in each compartment of the possible increased risk from adjacent compartments. In all cases, due regard shall be given to the relevant guidance contained in National Building Regulations with regard to provision of the fire-resisting (separating) function.

Occupancy	Description
Flats	Flat, maisonette.
Dwellings	Dwellinghouse.
Institutional	Hospital, nursing home, home for old or children, school with living accommodation, place of detention, where such persons sleep on the premises, hotel, boarding house, residential college, hall of residence.
Offices	Offices or premises used for the purposes of administration, clerical work, handling money, communications, radio, television, audio or visual recording or performance (not open to public).
Shops	Shops or premises used for a retail trade or business (including sale to members of the public food or drink for immediate consumption on the premises), and premises to which the public is invited to deliver or collect goods in connection with their hire, repair or other treatment.
Assembly & recreation	Place of assembly, entertainment and recreation; including bingo halls, broadcasting, recording & film studios open to the public, casinos, dance halls, entertainment—, conference, exhibition & leisure centres, funfairs & amusement arcades, museums & art galleries, non-residential clubs, theatres, cinemas, concert halls, educational, establishments, dancing schools, gymnasia, swimming pool buildings, riding schools, skating rinks, sports pavilions, sports stadia, law courts, churches & other buildings of worship, crematoria, libraries open to the public, non-residential day centres, clinics, health centres & surgeries, passenger stations & termini for air, rail, road and sea travel, public toilets, zoos & menageries.
Industrial	Factories and other premises used for manufacturing, altering, repairing, cleaning, washing, breaking-up, adapting or processing any article, generating power or slaughtering livestock.
Storage	Place of storage or deposit of goods or materials.
Car parks (open)	Car parks designed to admit and accommodate cars, motor cycles and passenger or light goods vehicles weighing no more than 2 500 kg (gross), with no basement storey. Each storey is to be naturally ventilated by permanent openings having an aggregate vent area not less than 5 % of the total floor area, at that level, of which at least 50 % should be on opposing walls.

Annex B (normative)

Thermal properties of typical compartment linings

Nature of Compartment Linings	Thermal Inertia (J/m ² s ^{1/2} K)
Bounding structures of ordinary concrete	2 400
Brickwork	1 500
Bounding structures of lightweight concrete (density = 500 kg/m ³)	700
50 % of bounding structures of ordinary concrete and 50 % lightweight concrete	1 500
Ordinary plasterboard	750
Vermiculite plaster	650
Bounded with 33 % lightweight concrete and 67 % plasterboard (2 × 13 mm thick) stud partition	1 000
50 % bounding structures of lightweight concrete, 33 % ordinary concrete and 17 of plasterboard (13 mm thick) on blockwork	1 200
80 % bounding surfaces of sheet steel and 20 % ordinary concrete	2 000
20 % bounding surfaces ordinary concrete and 80 % double plasterboard (2 × 13 mm thick) stud partition	1 320
Wood	450

List of references (see clause 2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 5306, *Fire extinguishing installations and equipment on premises.*

BS 5306-2:1990, *Specification for sprinkler systems.*

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 4422, *Glossary of terms associated with fire.*

BS 4422-1:1987, *General terms and phenomena of fire.*

BS 4422-2:1990, *Glossary of terms associated with fire — Structural fire protection.*

ISO publications

International Organization for Standardization (ISO), Geneva. (All publications are available from BSI Sales.)

ISO 3938:1987, *Bases for design of structures — Notations — General symbols.*

ISO 1716:1973, *Building materials — Determination of calorific potential.*

Other publications

DoE/WELSH OFFICE. The Building Regulations 1991, Approved Document B, *Fire Safety*; 1992 Edition. London: HMSO.

NORTHERN IRELAND. The Building Regulations (Northern Ireland) 1990. SRNI 1990. No. 59.

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Eurocode 1 — Bases du calcul et actions sur les
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Partie 2-2: Actions sur les structures — Actions
sur les structures exposées au feu

Eurocode 1 — Grundlagen der
Tragwerksplanung und Einwirkungen auf
Tragwerke —
Teil 2-2: Einwirkungen auf Tragwerke —
Einwirkungen im Brandfall

This European Prestandard (ENV) was approved by CEN on 1993-06-30 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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