



BSI Standards Publication

Eurocode 5 — Design of timber structures

Part 1-2: Structural fire design

National foreword

This British Standard is the UK implementation of EN 1995-1-2:2025. It supersedes BS EN 1995-1-2:2004, which will be withdrawn on 31 March 2028.

The UK participation in its preparation was entrusted to Technical Committee B/525/5, Structural use of timber.

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

National choice is allowed in this standard where explicitly stated within notes. The National Annex to this standard contains the national choices to be used for buildings and civil engineering works constructed in the UK.

The first generation of EN Eurocodes was published between 2002 and 2007, with conflicting British Standards withdrawn in 2010. This document forms part of the second generation of EN Eurocodes.

The second generation of EN Eurocodes is expected to be published between 2023 and 2026. These documents are being published as soon as they are available. This is being done to enable users to prepare for the transition from the first generation to second generation of EN Eurocodes.

UK adoptions of the first generation of EN Eurocodes will be withdrawn by BSI on 30 March 2028. Until that date, the first generation documents should be considered as the applicable standards for buildings and civil engineering works constructed in the UK unless otherwise specified by the relevant authority or in the specification for a particular project.

This standard is intended to be used with its National Annex and other referenced documents, including other second generation Eurocodes, as an interdependent suite of documents.

While the use of provisions in this standard in conjunction with first generation Eurocodes is not precluded, it should be undertaken with care and should only be done when users are satisfied that it will not result in a lower level of reliability than the minimum level set in the first generation Eurocodes and associated UK National Annexes.

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Date

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Eurocode 5 - Calcul des structures en bois - Partie 1-2 :
Calcul du comportement au feu

Eurocode 5 - Bemessung und Konstruktion von
Holzbauten - Teil 1-2: Tragwerksbemessung für den
Brandfall

This European Standard was approved by CEN on 20 July 2025.

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European foreword

This document (EN 1995-1-2:2025) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2027, and conflicting national standards shall be withdrawn at the latest by March 2028.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1995-1-2:2004.

The main changes compared to the previous edition are listed below:

- inclusion of provisions for the effective cross-section method;
- inclusion of provisions for design model for the verification of the separating function of wall and floor assemblies;
- inclusion of provisions for failure time of the fire protection system;
- improved provisions for charring;
- improved provisions for timber-frame assemblies;
- improved provisions for connections;
- improved provisions for detailing;
- improved provisions for timber structures exposed to physically based design fires.

The first generation of EN Eurocodes was published between 2002 and 2007. This document forms part of the second generation of the Eurocodes, which have been prepared under Mandate M/515 issued to CEN by the European Commission and the European Free Trade Association.

The Eurocodes have been drafted to be used in conjunction with relevant execution, material, product and test standards, and to identify requirements for execution, materials, products and testing that are relied upon by the Eurocodes.

The Eurocodes recognise the responsibility of each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level through the use of National Annexes.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal,

EN 1995-1-2:2025 (E)

Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

0 Introduction

0.1 Introduction to the Eurocodes

The Structural Eurocodes comprise the following standards generally consisting of a number of Parts:

- EN 1990 Eurocode — Basis of structural and geotechnical design
- EN 1991 Eurocode 1 — 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 of structures for earthquake resistance
- EN 1999 Eurocode 9 — Design of aluminium structures
- EN 19100 Eurocode 10 — Design of glass structures
- New parts are under development, e.g. Eurocode for design of fibre-polymer composite structures and design of tensioned membrane structures.

The Eurocodes are intended for use by designers, clients, manufacturers, constructors, relevant authorities (in exercising their duties in accordance with national or international regulations), educators, software developers, and committees drafting standards for related product, testing and execution standards.

NOTE Some aspects of design are most appropriately specified by relevant authorities or, where not specified, can be agreed on a project-specific basis between relevant parties such as designers and clients. The Eurocodes identify such aspects making explicit reference to relevant authorities and relevant parties.

0.2 Introduction to EN 1995 (all parts)

EN 1995 (all parts) applies to the design of timber structures and gives specific design rules for buildings and civil engineering timber works.

EN 1995 is subdivided in various parts:

EN 1995-1 in itself not exist as a physical document but comprises the following three separate documents, the basic part being EN 1995-1-1:

- EN 1995-1-1, *Eurocode 5 — Design of timber structures — Part 1-1: General rules and rules for buildings*
- EN 1995-1-2, *Eurocode 5 — Design of timber structures — Part 1-2: Structural fire design*
- CEN/TS 19103, *Design of timber structures — Structural design of timber-concrete composite structures – Common rules and rules for buildings* (foreseen to be published as EN 1995-1-3)

- EN 1995-2, *Eurocode 5 — Design of timber structures — Part 2: Bridges*
- EN 1995-3, *Eurocode 5 — Design of timber structures — Part 3: Execution*

EN 1995-2 “Bridges” refers to the common rules in EN 1995-1-1. The Clauses in EN 1995-2 supplement, modify or supersede them, where relevant.

EN 1995-3 “Execution” refers to the common rules in EN 1995-1-1. The Clauses in EN 1995-3 supplement the Clauses in EN 1995-1 and 1995-2.

0.3 Introduction to EN 1995-1-2

This document provides rules for the structural fire design of timber structures and civil engineering timber works.

0.4 Verbal forms used in the Eurocodes

The verb “shall” expresses a requirement strictly to be followed and from which no deviation is permitted in order to comply with the Eurocodes.

The verb “should” expresses a highly recommended choice or course of action. Subject to national regulation and/or any relevant contractual provisions, alternative approaches could be used/adopted where technically justified.

The verb “may” expresses a course of action permissible within the limits of the Eurocodes.

The verb “can” expresses possibility and capability; it is used for statements of fact and clarification of concepts.

0.5 National Annex for EN 1995-1-2

National choice is allowed in this document where explicitly stated within notes. National choice includes the selection of values for Nationally Determined Parameters (NDPs).

The national standard implementing EN 1995-1-2 can have a National Annex containing all national choices to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

When no national choice is given, the default choice given in this document is to be used.

When no national choice is made and no default is given in this document, the choice can be specified by a relevant authority or, where not specified, agreed for a specific project by appropriate parties.

National choice is allowed in EN 1995-1-2 through notes to the following clauses:

4.5(1)	4.7(2)	5.4.2.2(2)	6.1(1)
9.2.3(1)			

National choice is allowed in EN 1995-1-2 on the application of the following informative annexes:

Annex A	Annex E	Annex F	Annex T
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The National Annex can contain, directly or by reference, non-contradictory complementary information for ease of implementation, provided it does not alter any provisions of the Eurocodes.

1 Scope

1.1 Scope of EN 1995-1-2

(1) This document deals with the design of timber structures for the accidental situation of fire exposure and it is intended to be used in conjunction with EN 1995-1-1 and EN 1991-1-2.

This document only identifies differences from, or supplements to, normal temperature design.

(2) This document applies to timber structures required to fulfil a loadbearing function, separating function or both.

(3) This document gives principles and application rules for the design of structures for specified requirements in respect of the aforementioned functions and the levels of performance.

(4) This document applies to structures, or parts of structures, that are within the scope of EN 1995-1-1 and are designed accordingly.

(5) The methods given in this document are applicable to all products covered by European technical product specifications made reference to in this document.

1.2 Assumptions

(1) In addition to the general assumptions of EN 1990, the following assumptions apply:

- the choice of the relevant design fire scenario is made by appropriate qualified and experienced personnel, or is given by the relevant national regulation;
- any fire protection measure taken into account in the design will be adequately maintained.

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.

NOTE See the Bibliography for a list of other documents cited that are not normative references, including those referenced as recommendations (i.e. in 'should' clauses), permissions ('may' clauses), possibilities ('can' clauses), and in notes.

EN 300, *Oriented strand boards (OSB) — Definitions, classification and specifications*

EN 301, *Adhesives, phenolic and aminoplastic, for load-bearing timber structures — Classification and performance requirements*

EN 312, *Particleboards — Specifications*

EN 520, *Gypsum plasterboards — Definitions, requirements and test methods*

EN 622-2, *Fibreboards — Specifications — Part 2: Requirements for hardboards*

EN 622-3, *Fibreboards — Specifications — Part 3: Requirements for medium boards*

EN 622-4, *Fibreboards — Specifications — Part 4: Requirements for softboards*

EN 622-5, *Fibreboards — Specifications — Part 5: Requirements for dry process boards (MDF)*

EN 636, *Plywood — Specifications*

EN 1995-1-2:2025 (E)

EN 998-1, *Specification for mortar for masonry — Part 1: Rendering and plastering mortar*

EN 1363-1, *Fire resistance tests — Part 1: General requirements*

EN 1990:2023,¹ *Eurocode — Basis of structural and geotechnical design*

EN 1991 (all parts), *Eurocode 1 — Actions on structures*

EN 1991-1-2:2024, *Eurocode 1 — Actions on structures — Part 1-2: Actions on structures exposed to fire*

EN 1992-1-2, *Eurocode 2 — Design of concrete structures — Part 1-2: Structural fire design*

EN 1993-1-2, *Eurocode 3 — Design of steel structures — Part 1-2: Structural fire design*

EN 1995-1-1, *Eurocode 5 — Design of timber structures — Part 1-1: General rules and rules for buildings*

ISO 5660-1, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement)*

EN 13162, *Thermal insulation products for buildings — Factory made mineral wool (MW) products — Specification*

EN 13171, *Thermal insulation products for buildings — Factory made wood fibre (WF) products — Specification*

EN 13353, *Solid wood panels (SWP) — Requirements*

EN 13813, *Screed material and floor screeds — Screed material — Properties and requirements*

EN 13914-2, *Design, preparation and application of external rendering and internal plastering — Part 2: Internal plastering*

EN 13986, *Wood-based panels for use in construction — Characteristics, evaluation of conformity and marking*

EN 14080, *Timber structures — Glued laminated timber and glued solid timber — Requirements*

EN 14081-1, *Timber structures — Strength graded structural timber with rectangular cross section — Part 1: General requirements*

EN 14279, *Laminated Veneer Lumber (LVL) — Definitions, classification and specifications*

EN 14374, *Timber structures — Structural laminated veneer lumber — Requirements*

EN 14915, *Solid wood panelling and cladding — Characteristics, requirements and marking*

EN 15101-1, *Thermal insulation products for buildings — In-situ formed loose fill cellulose (LFCI) products — Part 1: Specification for the products before installation*

EN 15283-2, *Gypsum boards with fibrous reinforcement — Definitions, requirements and test methods — Part 2: Gypsum fibre boards*

¹ As impacted by EN 1990:2023/prA1:2024

EN 15425, *Adhesives — One component polyurethane (PUR) for load-bearing timber structures — Classification and performance requirements*

EN 15497, *Structural finger jointed solid timber — Performance requirements and minimum production requirements*

EN 16254, *Adhesives — Emulsion polymer isocyanate (EPI) for load-bearing timber structures — Classification and performance requirements*

EN 16351, *Timber structures — Cross laminated timber — Requirements*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1990, EN 1991-1-2 and EN 1995-1-1 and the following apply.

3.1.1

assembly

composition of elements

3.1.2

basic design charring rate

charring rate (3.1.7) of initially unprotected timber members or panels exposed to fire from one side without considering effects of *gaps* (3.1.17), joints, etc.

3.1.3

bond line integrity in fire

ability of the bond line for face bonds to maintain stickability between layers in the fire situation

3.1.4

char-line

border-line between the char layer and the *residual cross-section* (3.1.27), assumed to be equal with the position of the 300 °C isotherm

3.1.5

charring depth

distance from the original surface of the timber member to the *char-line* (3.1.4)

3.1.6

charring phase

initially unprotected, protected, post-protected or consolidated phase within the European charring model, defined as a time period

3.1.7

charring rate

relationship between two consecutive in-depth positions of the *char-line* and corresponding time period

3.1.8

cladding

external or internal covering formed by panels

Note 1 to entry: Another term used is lining.

3.1.9

coating

surface treatment applied on timber member

3.1.10

component

part of an *assembly* (3.1.1) or element

3.1.11

effective cross-section

cross-section of the original timber member reduced by the *charring depth* (3.1.5) and the *zero-strength layer* (3.1.35) at heated sides of the timber member

3.1.12

failure time of fire protection system

time at which the fall-off of the *fire protection system* (3.1.14) occurs

3.1.13

fire protection material

material applied for the purpose of increasing fire resistance

3.1.14

fire protection system

kit of *fire protection material(s)* (3.1.13) together with a defined method of fixing and mounting

3.1.15

foil

thin layer applied on and in an *assembly* (3.1.1) or element, e.g. a vapour barrier

3.1.16

fully developed char layer

layer of charred material insulating the substrate

3.1.17

gap

distance between or within adjacent assemblies, elements or *components* (3.1.10) in a joint

3.1.18

I-shaped member

glued thin-webbed beam or stud consisting of wood-based flanges and symmetrically placed thin web between the flanges, e.g. I-joist or I-stud

3.1.19

insulation

material with a thermal conductivity less than 0,1 W/mK used as cavity insulation or panel

3.1.20

insulation time

time from the start of fire to reach the temperature rise of 140 K on the unexposed side of the *assembly* (3.1.1) used for the separating function method

3.1.21**notional charring depth**

charring depth (3.1.5) considering *notional design charring rates* (3.1.22) for all relevant *charring phases* (3.1.6)

3.1.22**notional design charring rate**

charring rate within one *charring phase* (3.1.6) considering effects of dimensions, *gaps* (3.1.17), joints, etc. according to the European charring model

3.1.23**normal temperature design**

design for ambient temperature according to Part 1-1 of EN 1992 to EN 1996 or EN 1999

3.1.24**protected member**

member with applied *fire protection systems* (3.1.14)

3.1.25**protection time**

time to reach the charring of entire thickness or temperature rise of 250 K behind the considered material or product

3.1.26**protection level (PL)**

level describing the ability of cavity insulation to protect timber members in case of fire

3.1.27**residual cross-section**

cross-section of the original timber member reduced by the *charring depth* (3.1.5) at heated sides of the timber member

3.1.28**start time of charring**

time at the beginning of the fire exposure for initially unprotected sides of timber members, or time when the surface temperature for initially protected sides of timber members reaches 300 °C

3.1.29**span direction**

direction of the member between two supports

3.1.30**spacing**

centre to centre distance

3.1.31**tongue-groove joint**

joint between *wood-based panels* (3.1.33) or panelling which have edges profiled to tongue and groove geometry

3.1.32**vertical member**

member not deviating more than 15° from the vertical

3.1.33

wood-based panel

panel according to EN 13986

3.1.34

solid wood panelling

layers of solid wood boards according to EN 14915

3.1.35

zero strength layer

depth of cross-section taking into account the stiffness or strength reduction of timber member when exposed to fire and the uncertainty of charring rate

3.2 Symbols and abbreviations

For the purposes of this document, the following symbols apply.

3.2.1 Latin upper case letters

A_{fi}	maximum area of the fire
A_{st}	combusting surface of timber members
A_t	surface area of the design fire compartment
E	integrity criterion
$E_{d,fi}$	design value of effect of actions for the fire situation
E_f	modulus of elasticity of the flange
E_r	cumulative radiant energy
E_{web}	modulus of elasticity of the web
I	insulation criterion
K	slip modulus at normal temperature
K_{fi}	slip modulus in the fire situation
L_p	span of the panel
$L_{z,ef}$	effective length for flexural buckling about z-axis (in plane buckling)
O	opening factor of the fire compartment
$Q_{ext,ef}$	effective external time dependent rate of heat release
$Q_{f,ef}$	effective time dependent rate of heat release by the movable fire load
$Q_{int,ef}$	effective internal time dependent rate of heat release
$Q_{st,ef}$	effective time dependent rate of heat release by the structural fire load
$Q_{tot,ef}$	effective total time dependent rate of heat release
R	loadbearing criterion

R_k	characteristic loadbearing capacity of the timber member or the connection at normal temperature
$R_{k,fi}$	characteristic loadbearing capacity of the connection at the required fire resistance time
$R_{d,fi,t}$	design resistance in the fire situation
RHR_f	time dependent rate of heat release by the movable fire load
RHR_{st}	time dependent rate of heat release by the structural fire load
T	temperature
$T_{mean,45}$	temperature after 45 minutes of fire exposure
$T_{mean,60}$	temperature after 60 minutes of fire exposure
$X_{d,fi}$	design value of a strength or stiffness property for fire temperature design
X_k	characteristic value of a strength or stiffness property for normal temperature design

3.2.2 Latin lower case letters

a	distance
a_3	minimum end distance
a_4	minimum edge distance
a_{edge}	distance of the panel edge
a_{fi}	increase of end or edge distance required for the fire situation
$a_{fi,t1}$	increase of the thickness of the timber side member required for the fire situation
a_{min}	minimum end or edge distance
a_p	minimum distance from the exposed side
$a_{p,i}$	distance from the exposed side i
b	width of the initial cross-section
b_{ef}	width of the effective cross-section
b_{fi}	width of the cross-section of the timber member required for fire situation
b_f	initial cross-section width of the flange
$b_{f,ef}$	effective cross-section width of the flange
b_w	initial cross-section width of the web
$b_{w,ef}$	effective cross-section width of the web
c	specific heat capacity; minimum initial bearing width

c_i	coefficient i
d	thickness
d_0	zero-strength layer depth
$d_{\text{char},i,j}$	measured charring depth at the cross-section i at the point j
$d_{\text{char},n}$	notional charring depth
$d_{\text{char},n,1}$	notional charring depth for the fire-exposed side
$d_{\text{char},n,2}$	notional charring depth for the lateral side
$d_{\text{char},n,i}$	notional charring depth of the layer i
$d_{\text{char},n,w}$	notional charring depth of the web
$d_{\text{char},t}$	design charring depth, charring depth to determine the structural fire load
d_{ef}	effective charring depth
d_i	depth at measurement point i from the initial fire exposed surface of the timber member
d_{i+1}	depth of the subsequent measurement point $i+1$ from initial fire exposed surface of the timber member
f	joint width
h	depth of the initial cross-section
h_{ef}	depth of the effective cross-section
h_{fi}	depth of the cross-section of the timber member required for the fire situation
h_i	thickness of the layer i
h_{ins}	thickness of the cavity insulation
h_{f}	initial cross-section depth of the flange
$h_{\text{f,ef}}$	effective cross-section depth of the flange
h_n	thickness of the last layer n
h_p	panel thickness
$h_{p,j}$	average initial thickness of the wooden panel j under investigation
$h_{p,\text{min}}$	minimum thickness of the panel
$h_{\text{res},i}$	uncharred thickness of the layer i
i	number of the layer i or number of the cross-section i
j	number of the measurement point j in the cross-section i
k	coefficient for connections; web stiffness
k_2	protection factor for Phase 2

k_3	post-protection factor for Phase 3
$k_{3,1}$	post-protection factor for Phase 3 for the fire exposed side
$k_{3,2}$	post-protection factor for Phase 3 for the lateral side
k_4	consolidation factor for Phase 4
k_{con}	connection factor
k_{ef}	modification factor accounting for the loading condition
k_{fi}	modification factor for a strength or stiffness property for the fire situation
k_g	gap factor
k_{gd}	grain direction factor
k_h	thickness factor
k_i	modification factors for charring
k_j	joint coefficient
$k_{j,i}$	joint coefficient of the layer i
$k_{j,n}$	joint coefficient of the last layer n
k_{mod}	modification factor
k_n	conversion factor
$k_{\text{pos,exp},i}$	position coefficient for the fire exposed side of the layer i
$k_{\text{pos,exp},n}$	position coefficient for the fire exposed side of the last layer n
$k_{\text{pos,exp,sim}}$	position coefficient for the fire exposed side from simulation
$k_{\text{pos,unexp},i}$	position coefficient for the unexposed side of the layer i
$k_{\text{pos,unexp,sim}}$	position coefficient for the unexposed side from simulation
$k_{\text{s},n,1}$	combined section and conversion factor for the fire exposed side
$k_{\text{s},n,2}$	combined section and conversion factor for the lateral side
k_{side}	number of respective sides exposed to fire
k_w	factor taking into account the stiffness and geometry
k_θ	temperature-dependent reduction factor for a strength or stiffness property
k_ρ	density factor
l	distance between lateral supports
$l_{\text{a,min}}$	minimum anchorage length of the fastener into the uncharred timber member

l_s	depth of the residual bearing area required for loadbearing in the case of fire
$l_{z,f,ef,fi}$	effective length for flexural buckling about z-axis for the unbraced flange on the fire exposed side
l_x	penetration length of the fastener
$l_{x,min}$	minimum penetration length of the fastener
m	combustion factor
n	number; number of the last layer; number of the measurement points
p	projection of steel dowels above the timber surface
$q_{d,fi,t}$	design compartment fire load density related to the surface area A_t
$q_{d,st,t}$	structural fire load density related to the surface area A_t
$q_{d,tot,t}$	design total fire load density related to the surface area A_t
s_{10}	the rate of heat release of timber members per unit area related to the charring rate
t	time
t_0	time until a constant charring rate is assumed
$t_{300,furnace}$	time when the temperature of 300 °C in the furnace is reached
$t_{300,i}$	time when the temperature of 300 °C in measurement point i is reached
$t_{300,p,j}$	time when the temperature of 300 °C behind the wooden panel j is reached
$t_{300,i+1}$	time when the temperature of 300 °C in the subsequent measurement point $i+1$ is reached
$t_{1,fi}$	thickness of the timber side member required for the fire situation
$t_{1,sim}$	time from simulation until the temperature between the preceding layer and the investigated layer reaches 270 °C
t_2	thickness of the timber internal member
$t_{2,sim}$	time from simulation until the temperature behind the investigated layer reaches 270 °C
$t_{3,sim}$	time from simulation until the temperature behind the investigated layer which is baked by mineral wool reaches 270 °C
t_a	consolidation time
$t_{a,i}$	consolidation time of layer i
t_{ch}	start time of charring on the fire exposed side
$t_{ch,2}$	start time of charring for the lateral side
$t_{ch,w}$	start time of charring of the web
t_{end}	time when the parametric fire temperature reaches 20 °C

t_f	failure time of panels initially exposed to fire
t_{fi}	fire resistance time
$t_{fi,min}$	minimum fire resistance time
$t_{f,i}$	failure time of layer i
$t_{f,pr}$	failure time of the fire protection system
$t_{f,test}$	failure time of the fire protection system determined from the tests
$t_{f,test,i}$	failure time of the fire protection system determined from the test i
t_g	thickness of the slot
t_{ins}	insulation time of the assembly
$t_{ins,0}$	basic insulation time
$t_{ins,0,n}$	basic insulation time of the last layer n
$t_{ins,0,sim}$	basic insulation time from simulation
$t_{ins,n}$	insulation time of the last layer n
$t_{ins,max,n}$	maximum insulation time of the last layer n
t_j	time until the mean value of the temperature measurements reaches 270 °C
t_{max}	time when the maximum temperature is reached
$t_{mean,100}$	average time when the char-line has reached the depth of 100 mm on the surface of the timber member
t_{peak}	time for maximum values of zero-strength layer depths
$t_{prot,0}$	basic protection time
$t_{prot,0,i}$	basic protection time of the layer i
$t_{prot,0,sim}$	basic protection time from simulation
$t_{prot,i}$	protection time of the layer i
$t_{prot,max,i}$	maximum protection time of the layer i
$t_{prot,n}$	protection time of the last layer n
t_{req}	required fire resistance time
$v_{fi,c}$	absolute value of the time dependent cooling rate
v_{rec}	recession speed
w	dimension as width / length
x	scaling factor
y	distance from the fire exposed side in y-direction

z distance from the fire exposed side in x-direction

3.2.3 Greek upper case letters

Γ factor accounting for the thermal properties of the boundaries of the enclosure of the compartment given

Δt_i correction time of the layer i

$\Delta t_{i,c}$ time difference in the cooling phase

$\Delta t_{\max,i}$ maximum correction time of the layer i

$\Delta t_{\max,n}$ maximum correction time of the last layer n

Δt_n correction time for the last layer n

$\Delta T_{i,c}$ temperature difference in the cooling phase

θ time dependent temperature

$\theta_{\max}$ maximum temperature in the fire compartment

Πk_i product of applicable modification factors for charring

$\sum t_{\text{prot}}$ sum of protection times

$\sum t_{\text{prot},i}$ sum of the protection times of the layer i and the layers preceding the layer i

$\sum t_{\text{prot},i-1}$ sum of the protection times of the layers preceding the layer i

$\sum t_{\text{prot},n-1}$ sum of the protection times of the layers preceding the last layer n

3.2.4 Greek lower case letters

α time dependent parameter

α_{fi} modification factor for the zero-strength layer depth

α_i coefficient i

α_{st} time dependent modification factor

β_0 basic design charring rate

$\beta_{0,t,j}$ time dependent charring rate at an individual measurement station j

$\beta_{0,t,\text{mean}}$ mean time dependent charring rate

β_{ij} charring rate between two consecutive in depth measurement points i and $i+1$ at an individual measurement station j ; charring rate at the individual measurement points i of panel j

$\beta_{ij,\text{aver}}$ average charring rate in a specific depth at point i considering the preceding measurement points in a measurement station j

$\beta_{\text{mean,specimen}}$ mean charring rate of the test specimen

$\beta_{\text{mean,reference}}$ mean charring rate of the reference specimen

β_n	notional design charring rate within one charring phase
$\beta_{n,Phase2}$	notional design charring rate during Phase 2
$\beta_{n,Phase3}$	notional design charring rate during Phase 3
β_{par}	design charring rate for the parametric fire
β_{st}	time dependent design charring rate
$\gamma_{M,fi}$	partial factor for the relevant mechanical material property for the fire situation
ε	emissivity
μ_f	factor for effective length between the lateral supports
η_{fi}	reduction factor; ratio between the design value of effect of actions for the fire situation and the characteristic loadbearing capacity of the connection at normal temperature
$\eta_{K,fi}$	modification factor for the slip modulus for the fire situation
$\eta_{R,fi}$	modification factor for the strength for connections for fire situation
λ	thermal conductivity
λ_p	density dependent conductivity
ρ	density
ρ_{20}	density at normal temperature of 20 °C
ρ_i	density of the layer i
ρ_k	characteristic density
σ	Stefan-Boltzmann constant

3.2.5 Abbreviations

(1) For the purposes of this document, the abbreviations given in EN 1995-1-1 and the following apply.

BGL	Block glued glulam
CB	Clay board
CLT	Cross laminated timber
CP	Clay plaster
EPI	Emulsion polymer isocyanate adhesive
EPS	Expanded polystyrene insulation
FJ	Finger joint performance level
FS	Floor screed (cement, anhydride)
FST	Structural finger jointed solid timber
GFB	Gypsum fibreboard

GL	Glued laminated timber
GLVL	Glued laminated LVL
GPB	Gypsum plasterboard
GST	Glued solid timber
HB	Fibre board, hard
LCF	Loose-fill cellulose fibre cavity insulation made from paper
LP	Lime plaster
LVL	Laminated veneer lumber
LWF	Loose-fill wood fibre cavity insulation
MB	Fibre board, medium
MDF	Dry process fibre board
MWB	Mineral wool insulation board
MW	Mineral wool insulation
OSB	Oriented strand board
PIR	Polyisocyanurate insulation
PL	Protection level
PUR	Polyurethane insulation, polyurethane adhesive
PW	Plywood
RPB	Resinoid-bonded particleboard
ST	Structural timber
SWP	Solid wood panel
WFB	Wood fibre insulation board
WF	Wood fibre insulation
XPS	Extruded polystyrene foam insulation

4 Basis of design

4.1 General

(1) The structural fire design shall be in accordance with the general rules given in EN 1990 and EN 1991 (all parts) and the specific design provisions for timber structures given in EN 1995-1-1.

(2) Where mechanical resistance in the case of fire is required, timber structures shall be designed and constructed in such a way that they maintain their loadbearing function during the relevant fire exposure.

(3) Where compartmentation is required, the elements forming the boundaries of the fire compartment, including joints, shall be designed and constructed in such a way that they maintain their separating function during the relevant fire exposure to ensure that integrity and insulation failures do not occur.

NOTE For non-loadbearing elements, the loadbearing function under self-weight is expected to be maintained in order to fulfil the separating function.

(4) Deformation criteria shall be applied where the means of protection require consideration of the deformation of the loadbearing structure.

(5) Consideration of the deformation of the loadbearing structure may be omitted, when the efficiency of the means of protection has been evaluated according to 5.4.2.3 or 7.3.

(6) Deformation criteria shall be applied where the design criteria for separating elements require taking into account the deformation of the loadbearing structure.

(7) Consideration of the deformation of the loadbearing structure may be omitted when the separating elements fulfil requirements of a nominal fire exposure.

(8) Timber structures designed in accordance with EN 1995-1-1 should be considered to have sufficient minimum robustness for the accidental fire design case.

4.2 Nominal fire exposure

(1) For standard fire exposure, elements shall comply with one of the following functions or combinations of function during the required time of fire exposure:

- loadbearing function: loadbearing capacity (R);
- separating function: integrity (E) and, when requested, insulation (I);
- separating and loadbearing functions: (R, E) and, when requested, insulation (I).

NOTE 1 The loadbearing function (R) is assumed to be satisfied when loadbearing capacity is maintained.

NOTE 2 The separating function is assumed to be satisfied when integrity (E) and, when requested, insulation (I) are maintained.

NOTE 3 Integrity (E) is assumed to be maintained when a separating element of building construction, exposed to fire on one side, prevents the passage through it of flames and hot gases and the occurrence of flames on the unexposed side.

NOTE 4 Insulation (I) is assumed to be maintained when the average temperature rise over the whole of the unexposed surface is limited to 140 K, and the maximum temperature rise at any point of that surface does not exceed 180 K.

(2) With the external fire exposure curve the same functions (R, E, I) shall apply. However, the reference to this specific curve shall be identified by the letters "ef".

(3) With the hydrocarbon fire exposure curve the same functions (R , E , I) shall apply. However, the reference to this specific curve shall be identified by the letters "HC".

4.3 Physically based fire exposure

(1) The loadbearing function shall be maintained during the complete duration of the fire, including the cooling phase or during a required period of time according to EN 1991-1-2:2024, 4.4(4).

NOTE 1 A method for the design of timber structures exposed to physically based design fires is given in Annex A.

NOTE 2 A method for the assessment of external flaming of fire compartments with exposed structural timber is given in Annex E.

(2) For the verification of the separating function the following applies, assuming that the normal temperature is 20 °C:

- the average temperature rise of the unexposed side of the construction should be limited to 140 K and the maximum temperature rise of the unexposed side should not exceed 180 K during the heating phase until the maximum temperature in the fire compartment is reached;
- the average temperature rise of the unexposed side of the construction should be limited to 200 K and the maximum temperature rise of the unexposed side should not exceed 240 K during the cooling phase.

4.4 Actions

(1) Thermal and mechanical actions shall be taken from EN 1991-1-2.

4.5 Design values of material properties

(1) Design values of mechanical (strength and stiffness) properties for the fire situation $X_{d,fi}$ should be determined as follows:

$$X_{d,fi} = k_{\theta} k_{fi} X_k / \gamma_{M,fi} \quad (4.1)$$

where

- $X_{d,fi}$ is the design value of a strength or stiffness property (generally f_k or E_k) for fire temperature design;
- k_{θ} is the temperature-dependent reduction factor for a strength or stiffness property according to 7.2 or 8.6;
- k_{fi} is the modification factor for a strength or stiffness property for the fire situation according to Table 4.1;
- X_k is the characteristic value of a strength or stiffness property (generally f_k or E_k) for normal temperature design according to EN 1995-1-1;
- $\gamma_{M,fi}$ is the partial factor for the relevant mechanical property for the fire situation.

NOTE The value of $\gamma_{M,fi}$ is 1,0 unless the National Annex gives a different value.

(2) The modification factor k_{fi} for a strength or stiffness property for the fire situation should be taken from Table 4.1.

Table 4.1 — Modification factor k_{fi} for strength and stiffness property for the fire situation

Material	k_{fi}
ST, FST, GST	1,25
GL, BGL, CLT, Wood-based panels	1,15
LVL, GLVL	1,10

(3) For products not included in Table 4.1, the modification factor k_{fi} should be taken equal to 1,0.

(4) The modification factor k_{mod} according to EN 1995-1-1 shall be taken equal to 1,0.

(5) The design values of thermal properties for the fire situation should be taken equal to their characteristic values.

NOTE The characteristic values of thermal properties correspond to the mean values.

4.6 Verification methods

(1) The model of the structural system adopted for design shall reflect the performance of the structure in the fire situation.

(2) Mechanical resistance shall be verified for the required duration of fire exposure t as follows:

$$E_{d,fi} \leq R_{d,fi,t} \quad (4.2)$$

where

$E_{d,fi}$ is the design value of effect of actions for the fire situation, determined in accordance with EN 1991-1-2, including effects of thermal expansions of materials and deformations;

$R_{d,fi,t}$ is the corresponding design resistance in the fire situation.

(3) The thermal expansion of timber may be neglected.

(4) The structural analysis for the fire situation should be carried out according to EN 1990:2023, 7.1.5.

NOTE For verifying resistance requirements based on the standard fire curve, unless otherwise specified, a member analysis is typically undertaken.

(5) If not specified in the relevant clauses, the verification methods given in this document may be applied for all types of fire exposure.

(6) The following design methods may be used in order to satisfy 4.6(2):

- use of tabulated design data for specific types of members, see Clause 6;
- use of simplified design methods for specific types of members, see Clause 7 and Clause 10;
- use of advanced design methods for the analysis of members and connections, parts of the structure or the entire structure, see Clause 8.

(7) As an alternative to design by calculation, fire design may be based on the results of fire tests, or on fire tests in combination with calculations.

(8) Fire resistance calculated according to design methods given in this document may be used as an alternative to the classification according to EN 13501-2.

NOTE EN 13501-2 classifies results only based on testing.

4.7 Member analysis

(1) The design value of effect of actions should be determined for time $t = 0$ using combination factors according to EN 1991-1-2:2024, 6.3.

(2) When $E_{d,fi}$ is obtained according to EN 1991-1-2:2024, 6.3.2(4) the safe-sided values of η_{fi} should be used.

NOTE The value of η_{fi} is 0,6, except for imposed loads according to category E as given in EN 1990 (areas susceptible to accumulation of goods, including access areas) where the value of η_{fi} is 0,7, unless the National Annex gives different values.

(3) The effects of thermal deformations resulting from thermal gradients across the cross-section of materials other than timber shall be considered in the design.

(4) The effects of axial or in-plane thermal expansions may be neglected.

(5) The kinematic boundary conditions at supports and ends of members, applicable at time $t = 0$, may be assumed to remain unchanged throughout the fire exposure.

(6) Tabulated design data (given in Clause 6), simplified design methods (given in Clause 7) or advanced design methods (given in Clause 8) may be used for verifying members under fire conditions.

4.8 Analysis of parts of the structure

(1) The effect of actions should be determined for time $t = 0$ using combination factors according to EN 1991-1-2:2024, 6.3.

(2) As an alternative to 4.8(1), the reactions at supports and internal forces and moments at boundaries of part of the structure may be obtained from structural analysis for normal temperature design as given in 4.7.

(3) Within the part of the structure to be analysed, the relevant failure mode in fire, the temperature-dependent material properties and member stiffness, and the effects of thermal expansions of materials other than timber and deformations (indirect fire actions) shall be taken into account.

(4) The part of the structure to be analysed should be specified on the basis of the potential thermal expansions of materials other than timber and deformations such that their interaction with other parts of the structure can be approximated by time-independent support and boundary conditions during fire exposure.

4.9 Global structural analysis

(1) A global structural analysis for the fire situation shall take into account:

- the relevant failure mode in fire exposure;
- the temperature-dependent material properties and member stiffness;
- effects of thermal expansions of materials other than timber and deformations (indirect fire actions).

5 Material properties

5.1 General

(1) Products used for the design according to this document shall fulfil the minimum requirements given in:

- Table 5.1 for timber members;
- Table 5.2 for panels;
- Table 5.3 for screed;
- Table 5.4 for cavity insulation.

Table 5.1 — Minimum requirements for timber member products

Timber members	Abbreviation	EN	EAD ^a	Requirements
Structural timber	ST	EN 14081-1	—	$\rho_k \geq 290 \text{ kg/m}^3$
Structural finger jointed solid timber	FST	EN 15497	—	$\rho_k \geq 290 \text{ kg/m}^3$
Glued solid timber	GST	EN 14080	—	$\rho_k \geq 290 \text{ kg/m}^3$
Glued laminated timber	GL	EN 14080	—	$\rho_k \geq 290 \text{ kg/m}^3$
		—	EAD 130320	$\rho_k \geq 600 \text{ kg/m}^3$
Block glued glulam	BGL	EN 14080		$\rho_k \geq 290 \text{ kg/m}^3$
Cross laminated timber	CLT	EN 16351	EAD 130005	$\rho_k \geq 290 \text{ kg/m}^3$
Laminated veneer lumber	LVL	EN 14374	—	$\rho_k \geq 480 \text{ kg/m}^3$
Glued laminated LVL	GLVL	—	EAD 130337 or EAD 130010	$\rho_k \geq 480 \text{ kg/m}^3$
where ρ_k is the characteristic density, in kg/m^3 .				
^a The column has the status of a NOTE (informative) and is not exhaustive.				

Table 5.2 — Minimum requirements for panel products

Panels	Abbreviation	EN	Requirements
Solid wood panelling and claddings	—	EN 14915	$\rho_k \geq 290 \text{ kg/m}^3$
Solid wood panels	SWP	EN 13353 and EN 13986	$\rho_k \geq 290 \text{ kg/m}^3$
Oriented strand boards	OSB	EN 300 and EN 13986 ^a	$\rho_k \geq 550 \text{ kg/m}^3$
Resinoid-bonded particleboards	RPB	EN 312 and EN 13986 ^a	$\rho_k \geq 500 \text{ kg/m}^3$
Fibreboards	HB MB MDF	EN 622-2, EN 622-3 or EN 622-5 and EN 13986 ^a	$\rho_k \geq 500 \text{ kg/m}^3$
LVL panels	—	EN 14374 and EN 14279	$\rho_k \geq 480 \text{ kg/m}^3$
Plywood	PW	EN 636 and EN 13986 ^a	$\rho_k \geq 400 \text{ kg/m}^3$
Gypsum plasterboards Type A, H and F	GPB	EN 520	$\rho \geq 680 \text{ kg/m}^3$
Gypsum fibreboards	GFB	EN 15283-2	$\rho \geq 1000 \text{ kg/m}^3$
Clay plaster	CP	EN 13914-2	$\rho \geq 1600 \text{ kg/m}^3$
Clay boards	CB	—	$\rho \geq 1600 \text{ kg/m}^3$
Lime plaster	LP	EN 998-1 and EN 13914-2	$\rho \geq 1600 \text{ kg/m}^3$
Mineral wool insulation boards	MWB	EN 13162	$\rho \geq 100 \text{ kg/m}^3$ for protection level PL1
Wood fibre insulation boards	WFB	EN 13171 or EN 622-4 and EN 13986 ^a	$110 \leq \rho \leq 270 \text{ kg/m}^3$
where ρ_k is the characteristic density, in kg/m^3; ρ is the density, in kg/m^3.			
^a EN 13986 in conjunction with the indicated material standard.			

Table 5.3 — Minimum requirements for screed

Screed	Abbreviation	EN	Requirements
Floor screed (cement, anhydride)	FS	EN 13813	$\rho \geq 1500 \text{ kg/m}^3$
where ρ is the density, in kg/m^3 .			

Table 5.4 — Minimum requirements for cavity insulation products

Cavity insulation	Abbreviation	EN	EAD ^a	Requirements
Mineral wool insulation	MW	EN 13162	–	$\rho \geq 20 \text{ kg/m}^3$ for protection level PL1
				$\rho \geq 14 \text{ kg/m}^3$ for protection level PL2
Wood fibre cavity insulation	WF	EN 13171	–	$\rho \geq 50 \text{ kg/m}^3$
Loose-fill cellulose fibre cavity insulation made from paper	LCF	EN 15101-1	EAD 040138	$\rho \geq 50 \text{ kg/m}^3$
Loose-fill wood fibre cavity insulation	LWF			$\rho \geq 35 \text{ kg/m}^3$
where ρ is the density, in kg/m ³ .				
^a The column has the status of a NOTE (informative) and is not exhaustive.				

(2) The protection level PL shall be assessed as specified in Annex D or shall be taken from Table 5.5.

Table 5.5 — Protection level PL for cavity insulation materials

Protection level PL	Insulation material	Requirement
PL1	Stone wool	$\rho \geq 26 \text{ kg/m}^3$
PL2	Glass wool	$\rho \geq 14 \text{ kg/m}^3$
	Wood fibre	$\rho \geq 50 \text{ kg/m}^3$
	Loose-fill cellulose fibre	$\rho \geq 50 \text{ kg/m}^3$
	Loose-fill wood fibre	$\rho \geq 35 \text{ kg/m}^3$
PL3	Expanded polystyrene (EPS) Extruded polystyrene (XPS) foam Polyurethane (PUR) foam Polyisocyanurate (PIR) foam	-
	Not assessed insulation materials	-
where ρ is the density, in kg/m^3 .		

5.2 Thermal properties

(1) Thermal properties should be taken as given in 8.5.

NOTE Thermal properties are used for advanced design methods (Clause 8). For simplified design methods (Clause 7 and Clause 9) thermal properties are already considered in the methods.

(2) The values of thermal properties given in 8.5 shall be treated as characteristic values.

NOTE The characteristic values of thermal properties correspond to mean values.

5.3 Mechanical properties

(1) The influence of temperature on the mechanical properties should be taken as given in 8.6.

NOTE Temperature-dependent mechanical properties are used for advanced design methods (Clause 8). For simplified design methods (Clause 7 and Clause 9) the influence of temperature on the mechanical properties is considered in the methods.

5.4 Charring

5.4.1 General

(1) Charring shall be taken into account for all sides of timber members directly exposed to fire, and, where relevant, for initially protected sides, where charring occurs during the relevant time of fire exposure.

(2) The position of the char-line in timber members should be assumed as the position of the 300 °C isotherm.

NOTE Determination of temperature in timber members for specific situations (e.g. glued composite timber members or connections with bonded-in rods) can be calculated using Annex T.

(3) The charring depth should be calculated using appropriate charring rate(s).

(4) It should be taken into account that the charring rates are normally different for:

- initially unprotected sides of timber members;
- initially protected sides of timber members prior to failure of the fire protection system;
- sides of timber members directly exposed to fire after failure of the fire protection system.

(5) The calculation of the residual cross-section should consider the geometrical and material characteristics of the member or the assembly, and, where appropriate, the overlay of heat flux into the residual cross-section.

NOTE 1 Components with deviating heat conduction compared to wood (e.g. steel plates or fasteners) can influence the charring rate.

NOTE 2 The overlay of heat flux can result from e.g. fire exposure from several sides or the influence of steel plates or fasteners.

(6) The radius of the corner roundings of the residual cross-section due to the overlay of heat flux may be taken equal to the charring depth.

(7) The residual cross-section shall be calculated using either the European charring model (see 5.4.2) or advanced calculations (see Clause 8).

NOTE The European charring model is a simplified model for the calculation of the residual cross-section of a timber member assuming linear charring rates during different charring phases.

5.4.2 The European charring model

5.4.2.1 General

(1) The European charring model should be applied to standard fire exposure.

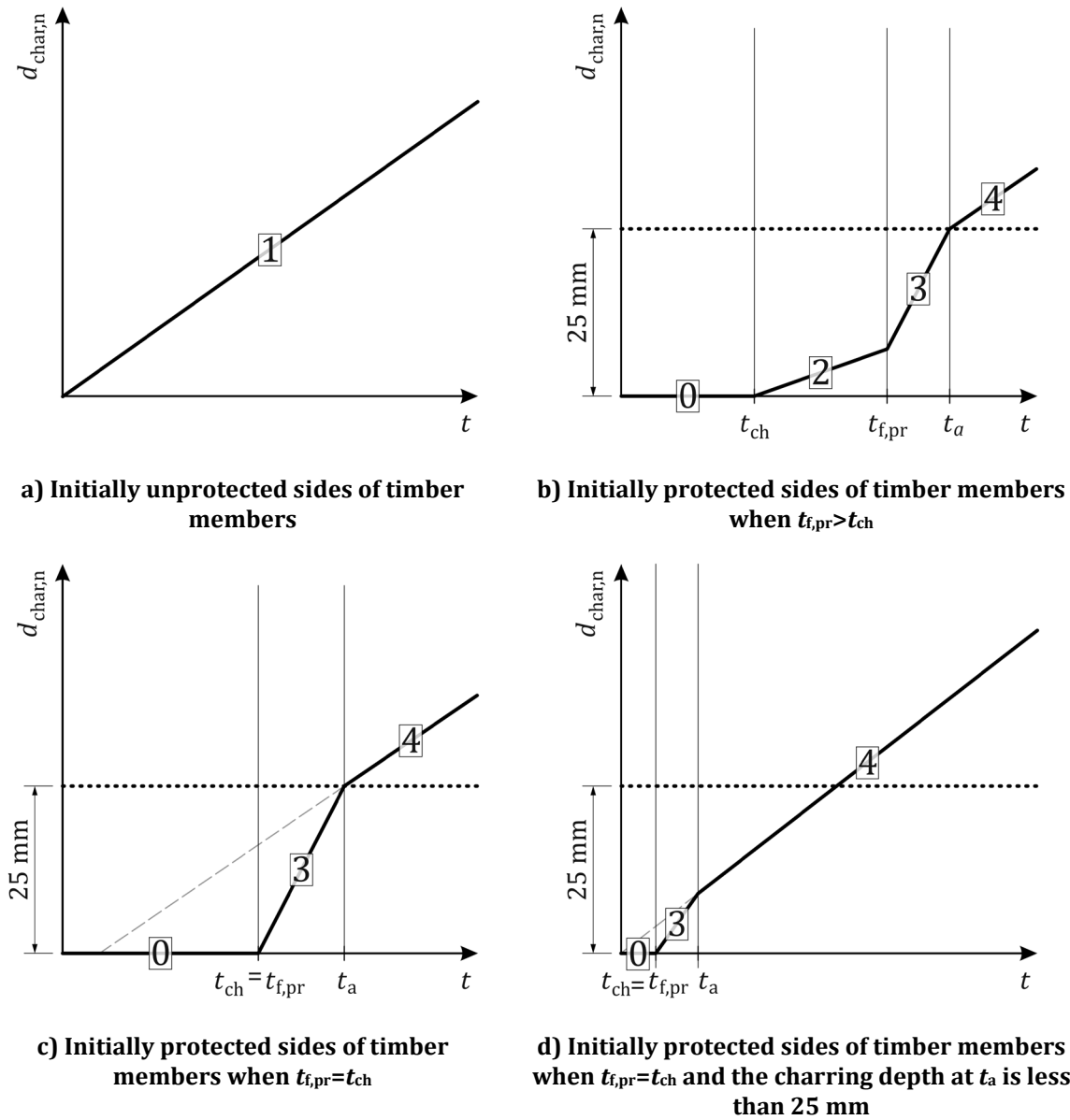
(2) The following phases should be taken into account where relevant (see Figure 5.1 and Figure 5.2):

For initially unprotected sides of timber members:

- **Normal charring phase (Phase 1).**

For initially protected sides of timber members:

- **Encapsulated phase (Phase 0)** is the phase when no charring occurs behind the fire protection system;
- **Protected charring phase (Phase 2)** is the phase when charring occurs behind the fire protection system while this system is still in place;
- **Post-protected charring phase (Phase 3)** is the phase after the failure of the fire protection system before a fully developed char layer has been formed;
- **Consolidated charring phase (Phase 4)** is the phase with fully developed char layer.



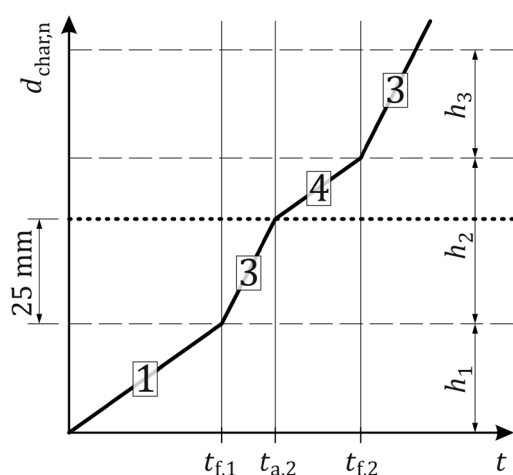
Key

0	encapsulated phase (Phase 0)	$d_{\text{char},n}$	notional charring depth, in mm
1	normal charring phase (Phase 1)	t	time
2	protected charring phase (Phase 2)	t_a	consolidation time; see 5.4.2.3(1)
3	post-protected charring phase (Phase 3)	t_{ch}	start time of charring; see 5.4.2.3(3)
4	consolidated charring phase (Phase 4)	$t_{\text{f,pr}}$	failure time of the fire protection system; see 5.4.2.3(4) to (10)

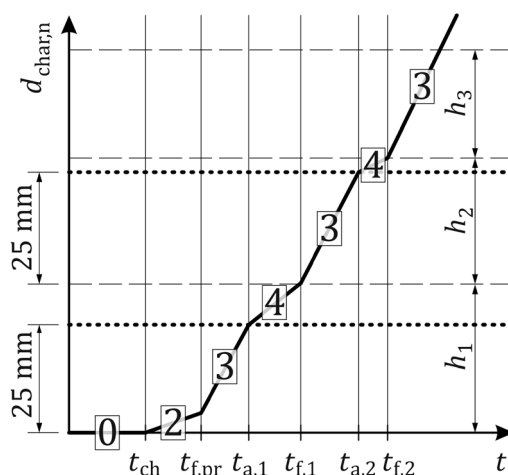
NOTE 1 In Figure 5.1 b) and c), the Phase 4 illustrates that a char layer of 25 mm gives sufficient protection to reduce the charring rate to the value for initially unprotected sides of timber members (Phase 1).

NOTE 2 Information on bond line integrity in fire of face bonds is given in 5.5.

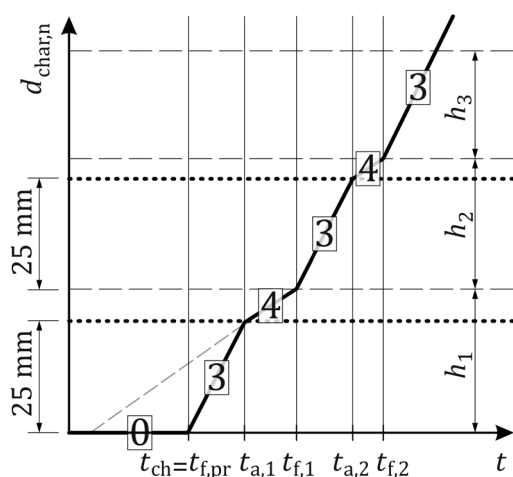
Figure 5.1 — Phases for sides of timber members when the bond line integrity of face bonds is maintained during the fire exposure



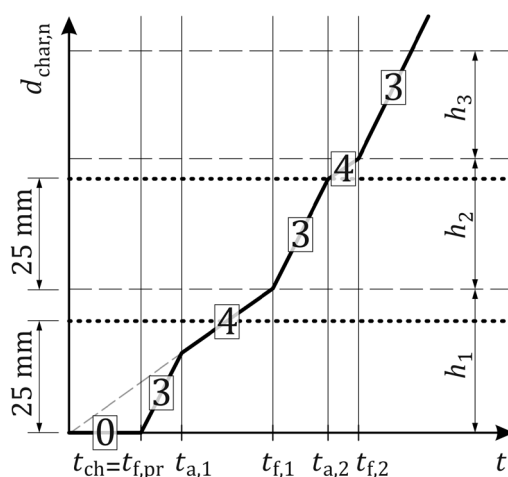
a) Initially unprotected sides of timber members



b) Initially protected sides of timber members when $t_{f,pr} > t_{ch}$



c) Initially protected sides of timber members when $t_{f,pr} = t_{ch}$



d) Initially protected sides of timber members when $t_{f,pr} = t_{ch}$ and the charring depth at t_a is less than 25 mm

Key

- 0 encapsulated phase (Phase 0)
- 1 normal charring phase (Phase 1)
- 2 protected charring phase (Phase 2)
- 3 post-protected charring phase (Phase 3)
- 4 consolidated charring phase (Phase 4)

- $d_{char,n}$ notional charring depth, in mm
- h_1, h_2, h_3 thickness of layers $i = 1, i = 2$ and $i = 3$, in mm
- t time
- $t_{f,i}$ failure time of layer i
- $t_{a,i}$ consolidation time of layer i

NOTE 1 Figure 5.2 illustrates a combination of sequenced charring phases for each layer using individual notional design charring rates.

NOTE 2 In Figure 5.2 Phase 3 illustrates that fall-off of the charring layer occurs when the charring depth reaches the bond line leading to an increased charring rate for the following layer.

NOTE 3 In Figure 5.2 a), b) and c), Phase 4 illustrates that a char layer of 25 mm gives sufficient protection to reduce the charring rate to the value for initially unprotected sides of timber members (Phase 1).

NOTE 4 Information on bond line integrity in fire of face bonds is given in 5.5.

Figure 5.2 — Phases for sides of timber members when the bond line integrity of face bonds is not maintained during the fire exposure

(3) If the timber member undergoes charring in different charring phases, the European charring model shall be individually applied for the individual charring phases (see Figure 5.1 and Figure 5.2).

(4) The notional charring depth $d_{\text{char},n}$ (see Figure 5.3) should be calculated as follows:

$$d_{\text{char},n} = \sum_{\text{Phases}} (\beta_n t) \quad (5.1)$$

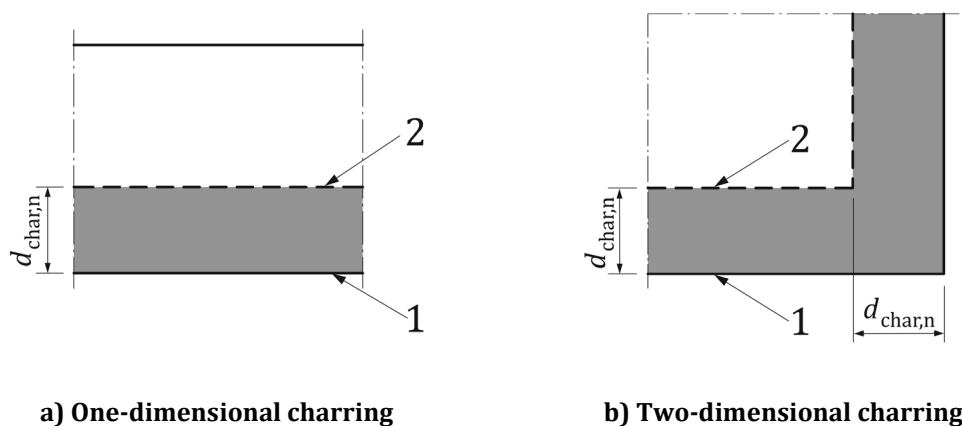
where

$d_{\text{char},n}$ is the notional charring depth, in mm;

β_n is the notional design charring rate within one charring phase, in mm/min (see 5.4.2.2);

t is the time for the charring phase considered, in min (see Figure 5.1 and Figure 5.2).

NOTE The notional charring depth is the sum of the charring depths considering the individual charring phases where relevant.



Key

- 1 fire exposed side
- 2 border-line of the residual cross-section
- $d_{\text{char},n}$ notional charring depth in mm

Figure 5.3 — Notional charring depth $d_{\text{char},n}$

5.4.2.2 Notional design charring rate

(1) The notional design charring rate β_n should be calculated in accordance with Formula (5.2) using the applicable modification factors for charring k_i given in Table 5.6 and the basic design charring rate β_0 given in Table 5.7:

$$\beta_n = \prod k_i \beta_0 \quad (5.2)$$

where

β_n is the notional design charring rate within one charring phase, in mm/min;

β_0 is the basic design charring rate, in mm/min given in Table 5.7;

$\prod k_i$ is the product of applicable modification factors for charring k_i given in Table 5.6.

Table 5.6 — Modification factors k_i for charring

Modification factor	Designation	Description	Reference
k_{con}	connection factor	It considers the effect of increased charring due to the fasteners.	5.4.2.2(3) and (4)
k_{gd}	grain direction factor	It considers the effect of the increased charring parallel to the grain.	5.4.2.2(5) and (6)
k_{g}	gap factor	For plane timber members, it considers the effect of increased charring of the member with the gap.	7.2.3(2) and (3)
k_{h}	thickness factor	For solid wood panelling and claddings, LVL panels and wood-based panels, it considers the effect of the limited thickness.	5.4.2.2(7)
k_{n}	conversion factor	For linear timber members, it considers the effect of corner roundings and the effect of cracks and fissures on the surface, and allows the conversion into a rectangular residual cross-section.	7.2.2(2) and (3)
$k_{\text{s,n,1}}$	combined section and conversion factor for the fire exposed side	For timber frame assemblies, they consider the effect of corner roundings as well as the superposition of heat flux, and allow the conversion into a rectangular residual cross-section.	7.2.4(14)
$k_{\text{s,n,2}}$	combined section and conversion factor for the lateral side		7.2.4(14)
k_{ρ}	density factor	For wood-based panels, it considers the effect of the density.	5.4.2.2(8)
k_2	protection factor	They consider the different phases of the European charring model according to 5.4.2.1(2).	5.4.2.2(9) and (10)
k_3	post-protection factor		5.4.2.2(11)
$k_{3,1}$	post-protection factor		7.2.4 Table 7.6
$k_{3,2}$	post-protection factor		7.2.4 Table 7.6
k_4	consolidation factor		5.4.2.2(12)

Table 5.7 — Basic design charring rate β_0

Timber member or panel	β_0 [mm/min]
Timber member made of softwood ^{a, c, d}	0,65
Timber member made of hardwood ^a	
Beech ^e	0,70
Beech ^e LVL	0,65
Ash ^f	0,60
Oak ^g	0,50
Panel ^b	
Solid wood panelling and cladding, solid wood panel with only one layer	0,65
LVL panel ^c	0,65
Particleboard, fibreboard	0,72
OSB, solid wood panel with multiple layers	0,9
Plywood	1,0
^a Timber members according to 5.1(1), subgroup timber members ^b Panels according to 5.1(1), subgroup panels ^c LVL and GLVL with a characteristic density $\rho_k \geq 480 \text{ kg/m}^3$ ^d Table B.2 in EN 14081-1 ^e FASY in EN 14081-1 ^f FXEX in EN 14081-1 ^g QCXA, QCXE, QCXR in EN 14081-1	

(2) For products made of materials not included in Table 5.7, the basic design charring rate shall be determined by testing as specified in Annex C.

NOTE The National Annex can give the basic design charring rate for products made of materials not included in Table 5.7.

(3) The connection factor k_{con} should be taken from Table 9.6 for connections with dowels or bolts and from Table 9.11 for connections with nails or screws.

(4) For internal dowel-type reinforcement the connection factor k_{con} may be:

$$k_{\text{con}} = 1$$

(5) The grain direction factor k_{gd} should be:

$$k_{\text{gd}} = \begin{cases} 1 & \text{for charring perpendicular to the grain} \\ 2 & \text{for charring parallel to the grain} \end{cases}$$

Linear interpolation should be used for charring between perpendicular and parallel to the grain.

(6) For sides of members exposed to charring both perpendicular and parallel to the grain (e.g. narrow face of CLT), a weighted average for the grain direction factor may be used.

(7) For solid wood panelling and claddings, LVL panels and wood-based panels the thickness factor k_h should be calculated as follows:

$$k_h = \begin{cases} 1 & \text{for } h_p \geq 20 \text{ mm} \\ \sqrt{\frac{20}{h_p}} & \text{for } h_p < 20 \text{ mm} \end{cases} \quad (5.3)$$

where

h_p is the panel thickness in mm.

(8) For OSB, PW, RPB, HB, MB and MDF the density factor k_ρ should be calculated as follows:

$$k_\rho = \sqrt{\frac{450}{\rho_k}} \quad (5.4)$$

where

ρ_k is the characteristic density in kg/m³.

NOTE For wood-based panels characteristic densities can be found in the declaration of performance of the product (DoP).

(9) The protection factor k_2 for Phase 2 should be taken as given in Table 5.8.

Table 5.8 — Protection factor k_2 for Phase 2

Panel	Protection factor k_2	
GPB, GFB	$k_2 = 1 - \frac{h_p}{55}$	for $h_p \leq 50$ mm
CP, CB, LP	$k_2 = 1 - \frac{h_p}{100}$	for $h_p \leq 40$ mm
MWB ^a	$k_2 = \begin{cases} 1 \\ 0,6 \end{cases}$	for $h_p < 20$ mm
		for $h_p \geq 45$ mm

where

h_p is the thickness of the single panel or the total thickness of multiple panels of the same material, in mm;

^a Linear interpolation may apply.

(10) For other products not listed in Table 5.8, the protection factor k_2 for Phase 2 should be determined by testing according to EN 13381-7.

(11) Unless other rules are given in this document, the post-protection factor k_3 for Phase 3 should be as follows:

$$k_3 = 2$$

(12) Unless other rules are given in this document, the consolidation factor k_4 for Phase 4 should be as follows:

$$k_4 = 1$$

5.4.2.3 Time limits for charring phases

(1) The consolidation time t_a should be calculated as follows:

$$t_a = \min \left\{ t_{f,pr} + \frac{25 - (t_{f,pr} - t_{ch}) \beta_{n,Phase2}}{\beta_{n,Phase3}}; 2t_{f,pr} \right\} \quad (5.5)$$

where

- t_a is the consolidation time, in min;
- $t_{f,pr}$ is the failure time of the fire protection system, in min;
- t_{ch} is the start time of charring, in min;
- $\beta_{n,Phase2}$ is the notional design charring rate during Phase 2, in mm/min;
- $\beta_{n,Phase3}$ is the notional design charring rate during Phase 3, in mm/min.

(2) The following time limits (see Figure 5.1 and Figure 5.2) should be assessed on the basis of tests according to EN 13381-7 or taken from this document:

- the start time of charring t_{ch} ;
- the failure time $t_{f,pr}$ of the fire protection system.

NOTE A procedure for the assessment of the failure time of fire protection systems based on reported results of full-scale fire tests other than EN 13381-7 is given in Annex F.

(3) The start time of charring t_{ch} behind the fire protection system should be calculated as follows:

$$t_{ch} = \sum t_{prot} \quad \text{for the fire protection system consisting only of timber and wood – based materials} \quad (5.6)$$

$$t_{ch} = \min \{ \sum t_{prot}; t_{f,pr} \} \quad \text{for other fire protection systems} \quad (5.7)$$

where

- t_{ch} is the start time of charring behind the fire protection system, in min;
- $\sum t_{prot}$ is the sum of protection times of the fire protection system according to 7.3.2, in min;
- $t_{f,pr}$ is the failure time of the fire protection system, in min.

NOTE In general, the calculation procedure of the start time of charring of initially protected timber members is as follows:

- 1) calculation of the sum of protection times of the fire protection system;
- 2) calculation of the failure time of the fire protection system protecting the timber member;
- 3) calculation of the start time of charring of the timber member.

(4) The failure time $t_{f,pr}$ of the fire protection system should be calculated as follows:

$$t_{f,pr} = \sum t_{prot} \quad \text{for the fire protection system consisting only of timber and wood – based materials} \quad (5.8)$$

$$t_{f,pr} = t_f \quad \text{for the fire protection system consisting only of panels according to Table 5.9} \quad (5.9)$$

$$t_{f,pr} = \max \{ \sum t_{prot}; t_f \} \quad \text{for all other fire protection systems consisting of combinations of panels according to Table 5.9 with other panels} \quad (5.10)$$

where

t_f is the failure time of panels initially exposed to fire according to Table 5.9, in min;

$\sum t_{\text{prot}}$ is the sum of protection times of the fire protection system according to 7.3.2, in min.

NOTE In general, the failure time of the fire protection system is dependent on material degradation of the fire protection system or anchorage failure of the fasteners. Detailing rules for fasteners are given in 10.2.2.

(5) The failure time $t_{f,\text{pr}}$ of the fire protection system for linear timber members and walls may be calculated as follows:

$$t_{f,\text{pr}} = \sum t_{\text{prot}} \quad (5.11)$$

where

$t_{f,\text{pr}}$ is the failure time of the fire protection system, in min;

$\sum t_{\text{prot}}$ is the sum of protection times of the fire protection system according to 7.3.2, in min.

NOTE In general, failure due to material degradation is dependent on temperature and size of the panels and their orientation. Normally, vertical orientation of the assembly e.g. walls is more favourable than horizontal orientation of the assembly, e.g. ceilings.

(6) The failure time t_f of panels initially exposed to fire should be taken from Table 5.9.

Table 5.9 — Failure time t_f of panels initially exposed to fire

Panels	Vertical		Horizontal	
	t_f [min]	h_p [mm]	t_f [min]	h_p [mm]
GPB Type F, one layer	$t_f = 4,6 h_p - 25$	$9 \leq h_p \leq 18$	$t_f = 1,3 h_p + 9$	$9 \leq h_p \leq 18$
GPB Type F, two layers or GPB Type F ^a + A	$t_f = 4,4 h_p - 50$	$25 \leq h_p \leq 36$	$t_f = 1,5 h_p + 15$	$25 \leq h_p \leq 36$
GPB Type A, one layer	$t_f = 2,1 h_p - 6$	$9 \leq h_p \leq 18$	$t_f = 2,1 h_p - 9$	$9 \leq h_p \leq 18$
GPB Type A, two layers	$t_f = 1,8 h_p - 4$	$25 \leq h_p \leq 36$	$t_f = 1,7 h_p - 13$	$25 \leq h_p \leq 36$
GFB, one layer	$t_f = 3,8 h_p - 21$	$9 \leq h_p \leq 18$	$t_f = 1,3 h_p + 7$	$9 \leq h_p \leq 18$
GFB, two layers	$t_f = 3,7 h_p - 42$	$25 \leq h_p \leq 36$	$t_f = 1,3 h_p + 14$	$25 \leq h_p \leq 36$
where				
h_p is the thickness of the single panel or the total thickness of multiple panels, in mm.				
^a Type F directly exposed to fire.				

(7) For fire protection systems with horizontal orientation (e.g. floors) and exposed to fire from above, the values according to Table 5.9 for vertical application may be used.

(8) For linear timber members (e.g. beams and columns, see 7.2.2) the values according to Table 5.9 for the vertical orientation may be used and the values may be increased by 10 %.

(9) For timber frame assemblies with void cavities the values according to Table 5.9 may be increased by 10 %.

(10) The failure time t_f according to Table 5.9 may be increased by 10 % when the fire protection system is applied to plane timber members (see 7.2.3) or panels, which are vertically oriented (e.g. walls).

(11) The failure time t_f according to Table 5.9 may be increased by 20 % when the fire protection system is applied to plane timber members (see 7.2.3) or panels, which are horizontally oriented (e.g. ceilings).

(12) The failure time $t_{f,pr}$ of the fire protection system made of clay plaster and clay boards on walls may be calculated as follows:

$$t_{f,pr} = \sum t_{prot} + \frac{(l_x - 10)}{\beta_{n,Phase2}} \quad (5.12)$$

where

- $t_{f,pr}$ is the failure time of fire protection system, in min;
- $\sum t_{prot}$ is the sum of protection times of the fire protection system according to 7.3.2, in min;
- l_x is the penetration length of the fastener, see Figure 10.4, in mm;
- $\beta_{n,Phase2}$ is the notional design charring rate during Phase 2, in mm/min.

5.5 Adhesives

5.5.1 General

(1) For structural glued members and glued connections the fire performance for the required time of fire resistance t_{req} shall be considered in the design.

(2) The design methods given in this document should be used to satisfy 5.5.1(1) assuming the following types of adhesives:

For structural glued members (bonds of wood to wood, wood to wood-based materials or wood-based materials to wood-based materials):

- phenolic Type I adhesives according to EN 301;
- aminoplastic Type I adhesives according to EN 301;
- polyurethane (PUR) Type I adhesives according to EN 15425;
- emulsion polymer isocyanate (EPI) Type I adhesives according to EN 16254;
- adhesives for structural LVL according to EN 14374 and plywood according to EN 636;
- adhesives for structural solid wood panels according to EN 13353.

For glued connections:

- 2-component polyurethane (PUR) adhesives according to EN 17334;
- epoxy adhesives according to EN 17334.

(3) As an alternative to 5.5.1(2), the fire performance for the required time of fire resistance t_{req} for the particular member or connection may be assessed by testing.

NOTE The loadbearing capacity in fire of the particular member can be assessed by testing according to EN 1365 (all relevant parts).

5.5.2 Bond line integrity in fire of face bonds

(1) For structural members with face bonds, the bond line integrity in fire for the required time of fire resistance t_{req} shall be considered in the design.

NOTE The bond line integrity in fire can depend on the particular member, e.g. layup of the cross-section, thickness of the lamellae, etc.

(2) The European charring model given in 5.4.2 should be used to satisfy 5.5.2(1) when the bond line integrity in fire is maintained (see Figure 5.1) or not maintained (see Figure 5.2).

(3) Unless other rules are given in this document, the bond line integrity in fire of face bonds shall be verified using the test method given in Annex B.

(4) The bond line integrity in fire may be assumed as maintained for the following adhesives:

- phenolic Type I adhesives according to EN 301;
- phenolic adhesives for structural LVL according to EN 14374 and plywood according to EN 636.

6 Tabulated design data

6.1 General

(1) The tabulated design data refer to member analysis according to 4.7. They shall be used only for the standard fire exposure and without extrapolation outside their range of application.

NOTE 1 Tabulated data are derived from tests, calculation models or a combination of the two and are presented either in the form of a table or a formula.

NOTE 2 Tabulated design data give safe-sided results compared to relevant tests or simplified or advanced design methods.

NOTE 3 Additional tabulated design data can be given in the National Annex.

(2) The temperature distribution should be assumed to be the same along the length of the structural members.

(3) Tabulated design data given in Clause 6 may be used with materials and products according to 5.1(1).

6.2 Time limits for charring phases

(1) For common fire protection systems, the start time of charring t_{ch} and the failure time of the fire protection systems $t_{f,pr}$ may be taken from Table 6.1 and Table 6.2 when:

- material and product requirements in 5.1(1) are satisfied;
- detailing requirements in 10.2 are satisfied;
- joint coefficient $k_{j,i} = 1,0$ is considered.

NOTE The values given in Table 6.1 and Table 6.2 were calculated based on the rules in 5.4.2 using the minimal density requirements given in Table 5.1 to Table 5.4.

(2) For fire protection systems $t_{f,pr}$ with horizontal orientation (e.g. floors) and exposed to fire from above, values given in Table 6.1 may be used.

Table 6.1 — Start time of charring t_{ch} and failure time of the fire protection systems $t_{f,pr}$ on linear timber members, vertical plane timber members or vertical timber frame assemblies

Panels	Thickness of the fire protection system [mm] ^a		Fire protection system backed by insulation ^b		Fire protection system backed by panel ^{b, c}	
	layer 1 h_1	layer 2 h_2	t_{ch} [min]	$t_{f,pr}$ [min]	t_{ch} [min]	$t_{f,pr}$ [min]
GPB Type A	12,5	-	15	20	21	22
	15	-	21	25	28	28
	18	-	28	32	35	35
	12,5	12,5	28	41	38	45
	15	15	37	50	49	55
	18	18	47	61	61	67
GPB Type F	12,5	-	15	32	21	35
	15	-	21	44	28	48
	18	-	28	58	36	63
	12,5	12,5	39	60	49	66
	15	15	50	82	61	90
	18	18	64	108	76	119
GPB Type F + Type A (Type F is layer 1)	12,5	12,5	39	60	49	66
	15	12,5	45	71	56	78
GFB	12,5	-	15	26	21	29
	15	-	21	36	28	39
	18	-	28	47	36	52
	12,5	12,5	39	50	49	55
	15	15	50	69	61	76
	18	18	63	91	76	100
RPB	18	-	19	19	27	27
OSB	18	-	16	16	21	21
PW	18	-	12	12	16	16
GPB Type A + PW	12,5	18	29	29	30	30
GPB Type F + PW	15	18	49	49	49	49
SWP	18	-	17	17	26	26
LVL panel	27	-	29	29	41	41
^a Layer 1 is at the fire exposed side. ^b When the layers are backed by a void cavity with a thickness of 40 mm or more, the following values should be used: — start time of charring for layers backed by insulation; — failure time for layers backed by panel. ^c When the layers are backed by a vertically or horizontally oriented linear member, the values for layers backed by a panel should be used.						

Table 6.2 — Start time of charring t_{ch} and failure time of the fire protection systems $t_{f,pr}$ on horizontal plane timber members or horizontal timber frame assemblies exposed to fire from below

Panels	Thickness of the fire protection system [mm] ^a		Fire protection system backed by insulation ^b		Fire protection system backed by panel	
	layer 1 h_1	layer 2 h_2	t_{ch} [min]	$t_{f,pr}$ [min]	t_{ch} [min]	$t_{f,pr}$ [min]
GPB Type A	12,5	-	15	17	20	20
	15	-	21	22	27	27
	18	-	28	29	34	34
	12,5	12,5	28	29	35	35
	15	15	37	38	45	45
	18	18	47	48	58	58
GPB Type F	12,5	-	15	25	21	30
	15	-	21	28	28	34
	18	-	28	32	36	39
	12,5	12,5	39	52	49	63
	15	15	50	60	61	72
	18	18	64	69	76	83
GPB Type F + Type A (Type F is layer 1)	12,5	12,5	39	52	49	63
	15	12,5	45	56	56	67
GFB	12,5	-	15	23	21	28
	15	-	21	26	28	32
	18	-	28	30	36	36
	12,5	12,5	39	46	49	55
	15	15	50	53	61	63
	18	18	61	61	73	73
RPB	18	-	19	19	27	27
OSB	18	-	16	16	21	21
PW	18	-	12	12	16	16
GPB Type A + PW	12,5	18	28	28	28	28
GPB Type F + PW	15	18	40	40	42	42
SWP	18	-	17	17	26	26
LVL panel	27	-	29	29	41	41
^a Layer 1 is at the fire exposed side. ^b When the layers are backed by a void cavity with a thickness of 40 mm or more, the following values should be used: — start time of charring for layers backed by insulation; — failure time for layers backed by insulation increased by 10 %.						