BS EN 14509:2013

BSI Standards Publication

Self-supporting double skin metal faced insulating panels — Factory made products — Specifications

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 14509:2013. It supersedes BS EN 14509:2006 which is withdrawn.

EN 14509:2013 is a candidate "harmonized" European Standard and fully takes into account the requirements of the European Commission mandates M/121, Internal and external wall and ceiling finishes, and M/122, Roof coverings, roof lights, roof windows and ancillary products, given under the EU Construction Products Directive (89/106/EEC), and is intended to lead to CE marking. The date of applicability of EN 14509:2013 as a "harmonized" European Standard, i.e. the date after which this Standard may be used for CE marking purposes, is subject to an announcement in the *Official Journal of the European Communities*.

EN 14509:2013 is the subject of transitional arrangements agreed under the European Commission mandate. The Member States have agreed a nominal transition period of twelve months for the co-existence of EN 14509:2013 and its corresponding national standard(s). At the end of this co-existence period, the national standard(s) will be withdrawn.

Additional information: design combination coefficients and safety factors

The UK applies specific design combination coefficients and safety factors to take into account the weather conditions and loadings relevant to the UK. For UK applications, the values for combination coefficients given in Table E.7 may be used as an alternative to Table E.6.

The UK participation in its preparation was entrusted by Technical Committee B/542, Roofing and cladding products for discontinuous laying, to Subcommittee B/542/12, Double skin metal faced sandwich panels for roofing and cladding.

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

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

Published by BSI Standards Limited 2013

ISBN 978 0 580 79607 4

ICS 91.100.60

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

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2013.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 14509

October 2013

ICS 91.100.60

English Version

Self-supporting double skin metal faced insulating panels - Factory made products - Specifications

Panneaux sandwiches autoportants, isolants, double peau à parements métalliques - Produits manufacturés - Spécifications

Selbstragende Sandwich-Elemente mit beidseitigen Metalldeckschichten - Werkmäßig hergestellte Produkte - Spezifikationen

This European Standard was approved by CEN on 18 July 2013.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 14509:2013: E

Foreword

This document (EN 14509:2013) has been prepared by Technical Committee CEN/TC 128 “Roof covering products for discontinuous laying and products for wall cladding”, the secretariat of which is held by NBN.

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 April 2014, and conflicting national standards shall be withdrawn at the latest by October 2014.

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

This document supersedes EN 14509:2006.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

Annex F provides details of significant technical changes between this European Standard and the previous edition.

Data obtained from earlier tests in accordance to EN 14509:2006 may be used without the need for further testing to the revised procedures (6.2.2) providing the declared data does not change significantly.

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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Contents

Page

1 Scope 9
2 Normative references 9
3 Terms and definitions 12
4 Symbols and abbreviations 13
5 Requirements, properties and test methods 17
5.1 Requirements for component materials 17
5.1.1 General 17
5.1.2 Metal facings 17
5.1.3 Core materials 19
5.1.4 Adhesives and bonding 19
5.2 Properties of panels 19
5.2.1 Mechanical resistance of the panel 19
5.2.2 Thermal transmittance 21
5.2.3 Durability and other long-term effects 21
5.2.4 Fire characteristics 23
5.2.5 Dimensional tolerances for sandwich panels 24
5.2.6 Water permeability 24
5.2.7 Air permeability 25
5.2.8 Water vapour permeability 25
5.2.9 Airborne sound insulation ($R_w(C;C_{tr})$) 25
5.2.10 Sound absorption (α_w) 25
5.2.11 Dangerous substances 25
5.3 Actions and safety level requirements 25
5.3.1 Mechanical resistance to design loads 25
5.3.2 Actions and combinations of actions 26
6 Evaluation of conformity, testing, assessment and sampling methods 26
6.1 General 26
6.2 Initial type testing – ITT 26
6.2.1 Initial type evaluation 26
6.2.2 Existing ITT test data 27
6.2.3 Sampling for ITT and audit testing purposes 27
6.2.4 Testing and compliance criteria – ITT 28
6.2.5 Shortened testing programme – ITT (product change) 28
6.3 Factory Production Control (FPC) 33
6.3.1 General 33
6.3.2 Results of FPC tests 33
6.3.3 Equipment 34
6.3.4 Raw materials and components 34
6.3.5 Product testing and assessment – FPC 35
6.3.6 Conformity of Factory Production Control – supplier purchases 37
6.4 Characteristic values from families of tests 38
7 Classification and designation 39
8 Marking, labelling and packaging 40
8.1 Marking and labelling 40
8.2 Packaging, transport, storage and handling 41

Annex A (normative) **Testing procedures for material properties** 42
A.1 Cross panel tensile test 42
A.1.1 Principle 42
A.1.2 Apparatus 42
A.1.3 Test specimens 42
A.1.4 Procedure 43
A.1.5 Calculations and results 43
A.1.6 Cross panel tensile modulus at elevated temperature 44
A.2 Compressive strength and modulus of the core material 45
A.2.1 Principle 45
A.2.2 Apparatus 45
A.2.3 Test specimens 45
A.2.4 Procedure 45
A.2.5 Calculations and results 45
A.3 Shear test on the core material 46
A.3.1 Principle 46
A.3.2 Apparatus 46
A.3.3 Test specimens 47
A.3.4 Procedure 48
A.3.5 Calculations and results – short-term loading 48
A.3.6 Test procedures, calculations and results – long term loading 51
A.4 Test to determine the shear properties of a complete panel 52
A.4.1 Principle 52
A.4.2 Apparatus 52
A.4.3 Test specimens 53
A.4.4 Procedure 54
A.4.5 Calculations and results 54
A.5 Test to determine the bending moment capacity of a simply supported panel 57
A.5.1 Principle 57
A.5.2 Apparatus 57
A.5.3 Test specimens 60
A.5.4 Procedure 60
A.5.5 Calculations and results 61
A.6 Determination of the creep coefficient (φ_t) 66
A.6.1 Principle 66
A.6.2 Apparatus 66
A.6.3 Test specimens 66
A.6.4 Procedure 66
A.6.5 Calculations and results 67
A.7 Interaction between bending moment and support force 68
A.7.1 Principle 68
A.7.2 Apparatus 69
A.7.3 Test specimens 70
A.7.4 Procedure 70
A.7.5 Calculations and results 70
A.8 Determination of apparent core density and mass of panel 71
A.8.1 Determination of apparent core density 71
A.8.2 Determination of mass of a panel 72
A.9 Test for resistance to point loads and repeated loads 72
A.9.1 Panels subject to point loads 72
A.9.2 Panels subject to repeated loads 73
A.10 Calculation method for the determination of the thermal transmittance of a panel (*U*) 75

A.10.1 General ... 75
A.10.2 Determination of the thermal conductivity of component materials ... 75
A.10.3 Calculation of the thermal transmittance of a panel (U) ... 76
A.10.4 Simplified method for the calculation of the thermal transmittance of a panel ($U_{d,S}$) ... 79

A.11 Water permeability – resistance to driving rain under pulsating pressure ... 81
A.11.1 Principle ... 81
A.11.2 Apparatus ... 81
A.11.3 Test specimens ... 81
A.11.4 Procedure ... 82
A.11.5 Calculations and results ... 82

A.12 Air permeability ... 82
A.12.1 Principle ... 82
A.12.2 Apparatus ... 82
A.12.3 Test specimens ... 82
A.12.4 Procedure ... 82
A.12.5 Calculations and results ... 82

A.13 Airborne sound insulation ... 83
A.13.1 Principle ... 83
A.13.2 Apparatus ... 83
A.13.3 Test specimens ... 83
A.13.4 Procedure ... 83
A.13.5 Calculations and results ... 83

A.14 Sound absorption ... 83
A.14.1 Principle ... 83
A.14.2 Apparatus ... 83
A.14.3 Test specimens ... 83
A.14.4 Procedure ... 83
A.14.5 Calculations and results ... 83

A.15 Support reaction capacity at the end of a panel ... 84
A.15.1 Principle ... 84
A.15.2 Apparatus ... 84
A.15.3 Test specimens ... 84
A.15.4 Procedure ... 85
A.15.5 Calculation and results ... 85

A.16 Recording and interpretation of test results ... 86
A.16.1 ITT tests ... 86
A.16.2 FPC tests ... 87
A.16.3 Determination of characteristic values from tests ... 87
A.16.4 Interpolation and extrapolation of test results ... 88

Annex B (normative) Durability testing method for sandwich panels ... 89

B.1 General ... 89

B.2 Test DUR1 ... 89
B.2.1 Principle ... 89
B.2.2 Apparatus ... 89
B.2.3 Test specimens ... 89
B.2.4 Procedure ... 90
B.2.5 Test results and acceptance criteria – DUR1 ... 91

B.3 Test DUR2 ... 91
B.3.1 Principle ... 91
B.3.2 Apparatus ... 91
B.3.3 Test specimens ... 92
B.3.4 Procedure ... 93

B.3.5 Test results and acceptance criteria – DUR2 94
B.4 Test report on durability tests 94
B.5 Adhesive bond between faces and prefabricated core material (wedge test) 95
B.5.1 Principle 95
B.5.2 Apparatus 95
B.5.3 Test specimens 96
B.5.4 Procedure 96
B.5.5 Test results and acceptance criteria 97
B.6 Repeated loading test 98
B.6.1 Principle 98
B.6.2 Apparatus 98
B.6.3 Test specimens 98
B.6.4 Procedure 98
B.6.5 Calculations and results 98
B.7 Thermal shock test 98
B.7.1 Principle 98
B.7.2 Apparatus 99
B.7.3 Test specimens 99
B.7.4 Procedure 99
B.7.5 Calculations and results 100
Annex C (normative) Fire performance tests – additional instructions and direct field of application 101
C.1 Reaction to fire 101
C.1.1 Fire test EN 13823 (SBI) – specimens and mounting and fixing 101
C.1.2 Fire test EN ISO 11925-2 (ignitability test) 104
C.1.3 Direct field of application of reaction to fire test results 105
C.2 Fire resistance 108
C.2.1 General 108
C.2.2 Fire resistance test EN 1364-1 — Walls 109
C.2.3 Fire resistance test EN 1365-2 — Roofs 112
C.2.4 Field of application of fire resistance test results 113
C.3 Fire tests CEN/TS 1187 - external fire performance for roofs 114
C.3.1 Classification without further testing (CWFT) 114
C.3.2 CEN/TS 1187 Method 1 test 115
C.3.3 CEN/TS 1187 Method 2 test 115
C.3.4 CEN/TS 1187 Method 3 test 115
C.3.5 CEN/TS 1187 Method 4 test 116
C.4 Determination of the amount and thickness of the adhesive layer 116
C.4.1 General 116
C.4.2 Measurements on a manufactured panel 116
C.4.3 Measurements during production 117
Annex D (normative) Dimensional tolerances 119
D.1 General 119
D.2 Dimensional tolerances 119
D.2.1 Thickness of panel and joint conformity 119
D.2.2 Deviation from flatness 120
D.2.3 Depth of metal profile 121
D.2.4 Depth of stiffeners on lightly profiled facings 121
D.2.5 Length 122
D.2.6 Cover width 122
D.2.7 Deviation from squareness 124

D.2.8 Deviation from straightness 125
D.2.9 Bowing 125
D.2.10 Pitch of profile 126
D.2.11 Widths of rib and valley 127

Annex E (normative) **Design procedures** 128

E.1 Definitions and symbols 128
E.1.1 Properties of a sandwich panel 128
E.1.2 Symbols used in Annex E 129
E.1.3 Sign convention used in Annex E 131

E.2 General 131

E.3 Actions 132
E.3.1 General 132
E.3.2 Permanent actions 132
E.3.3 Variable actions 132
E.3.4 Actions due to long term effects 133

E.4 Resistance 133
E.4.1 General 133
E.4.2 Residual (rest) bending resistance at an intermediate support 134
E.4.3 End support reaction capacity 135

E.5 Combination rules 136
E.5.1 General 136
E.5.2 Ultimate limit state 136
E.5.3 Combination of the effects of actions for the ultimate limit state 137
E.5.4 Serviceability limit state 137
E.5.5 Combination of the effects of actions for the serviceability limit states 138

E.6 Combination coefficients and safety factors 139
E.6.1 Combination coefficients 139
E.6.2 Load factors 139
E.6.3 Material factors 140

E.7 Calculation of the effects of actions 141
E.7.1 General 141
E.7.2 Methods of analysis 141
E.7.3 Static system, geometry and thickness 146
E.7.4 Sandwich panels with plane or lightly profiled faces 146
E.7.5 Sandwich panels with strongly profiled faces 147
E.7.6 The influence of time on shear deformations of the core 147

E.8 Panels with special profiles 148
E.8.1 General 148
E.8.2 Determination of the effective properties of the faces and the core 148
E.8.3 Design of panels with special profiles 148

Annex F (informative) **Significant technical changes between this European Standard and the previous edition** 152

Annex ZA (informative) **Clauses of this European Standard addressing the provisions of the EU Construction Products Directive** 156

ZA.1 Scope and relevant characteristics 156

ZA.2 Procedures for the attestation of conformity of sandwich panels 158
ZA.2.1 Systems of attestation of conformity 158
ZA.2.2 Certificate and Declaration of Conformity 161

ZA.3 CE Marking and labelling 163
ZA.3.1 General 163

ZA.3.2 Information accompanying CE Marking symbol – Internal walls and ceilings 163
ZA.3.3 Information accompanying CE Marking symbol – External walls 164
ZA.3.4 Information accompanying CE Marking symbol – Roofs 166
ZA.3.5 Example of CE Marking and descriptive information 168

Bibliography 175

1 Scope

This European Standard specifies requirements for factory made, self-supporting, double skin metal faced insulating sandwich panels, which are intended for discontinuous laying in the following applications:

a) roofs and roof cladding;

b) external walls and wall cladding;

c) walls (including partitions) and ceilings within the building envelope.

The insulating core materials covered by this European Standard are rigid polyurethane, expanded polystyrene, extruded polystyrene foam, phenolic foam, cellular glass and mineral wool.

NOTE Polyurethane (PUR) includes polyisocyanurate (PIR).

Panels with edge details that utilise different materials from the main insulating core are included in this European Standard.

Panels used in cold store applications are included in this European Standard. Panels, put on the market as a component of a cold storage room, building and/or building envelope kit are covered by ETA-Guideline 021 “Cold storage premises kits”.

This European Standard does not cover the following:

i. sandwich panels with a declared thermal conductivity for the insulating core greater than 0,06 W/m·K at 10 °C;

ii. products consisting of two or more clearly defined layers of different insulating core materials (multi-layered);

iii. panels with perforated facing(s);

iv. curved panels.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 485-2, *Aluminium and aluminium alloys - Sheet, strip and plate - Part 2: Mechanical properties*

EN 485-4, *Aluminium and aluminium alloys - Sheet, strip and plate - Part 4: Tolerances on shape and dimensions for cold-rolled products*

EN 508-1, *Roofing products from metal sheet - Specification for self-supporting products of steel, aluminium or stainless steel sheet - Part 1: Steel*

EN 826, *Thermal insulating products for building applications - Determination of compression behaviour*

EN 1172, *Copper and copper alloys - Sheet and strip for building purposes*

CEN/TS 1187, *Test methods for external fire exposure to roofs*

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

EN 1364-1, *Fire resistance tests for non-loadbearing elements - Part 1: Walls*

EN 1364-2, *Fire resistance tests for non-loadbearing elements - Part 2: Ceilings*

EN 1365-2, *Fire resistance tests for loadbearing elements - Part 2: Floors and roofs*

EN 1396, *Aluminium and aluminium alloys - Coil coated sheet and strip for general applications - Specifications*

EN 1602, *Thermal insulating products for building applications - Determination of the apparent density*

EN 1607, *Thermal insulating products for building applications - Determination of tensile strength perpendicular to faces*

EN 1990, *Eurocode - Basis of structural design*

EN 10088-1, *Stainless steels - Part 1: List of stainless steels*

EN 10143, *Continuously hot-dip coated steel sheet and strip - Tolerances on dimensions and shape*

EN 10169, *Continuously organic coated (coil coated) steel flat products — Technical delivery conditions*

EN 10204, *Metallic products - Types of inspection documents*

EN 10346:2009, *Continuously hot-dip coated steel flat products - Technical delivery conditions*

EN 12085, *Thermal insulating products for building applications - Determination of linear dimensions of test specimens*

EN 12114, *Thermal performance of buildings - Air permeability of building components and building elements - Laboratory test method*

EN 12865, *Hygrothermal performance of building components and building elements - Determination of the resistance of external wall systems to driving rain under pulsating air pressure*

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

EN 13163, *Thermal insulation products for buildings - Factory made expanded polystyrene (EPS) products - Specification*

EN 13164, *Thermal insulation products for buildings - Factory made extruded polystyrene foam (XPS) products - Specification*

EN 13165, *Thermal insulation products for buildings - Factory made rigid polyurethane foam (PU) products - Specification*

EN 13166, *Thermal insulation products for buildings - Factory made phenolic foam (PF) products - Specification*

EN 13167, *Thermal insulation products for buildings - Factory made cellular glass (CG) products - Specification*

CEN/TS 13381-1, *Test methods for determining the contribution to the fire resistance of structural members - Part 1: Horizontal protective membranes*

ENV 13381-2, *Test methods for determining the contribution to the fire resistance of structural members - Part 2: Vertical protective membranes*

EN 13501-1, *Fire classification of construction products and building elements - Part 1: Classification using test data from reaction to fire tests*

EN 13501-2, *Fire classification of construction products and building elements - Part 2: Classification using data from fire resistance tests, excluding ventilation services*

EN 13501-5, *Fire classification of construction products and building elements - Part 5: Classification using data from external fire exposure to roofs tests*

EN 13823, *Reaction to fire tests for building products - Building products excluding floorings exposed to the thermal attack by a single burning item*

EN 14135, *Coverings - Determination of fire protection ability*

EN 15254-5, *Extended application of results from fire resistance tests - Non-loadbearing walls - Part 5: Metal sandwich panel construction*

EN ISO 354:2003, *Acoustics - Measurement of sound absorption in a reverberation room (ISO 354)*

EN ISO 717-1, *Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation (ISO 717-1)*

EN ISO 1182, *Reaction to fire tests for products - Non-combustibility test (ISO 1182)*

EN ISO 1716, *Reaction to fire tests for products - Determination of the gross heat of combustion (calorific value) (ISO 1716)*

EN ISO 6270-1, *Paints and varnishes - Determination of resistance to humidity - Part 1: Continuous condensation (ISO 6270-1)*

EN ISO 6892-1, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1)*

EN ISO 6946, *Building components and building elements - Thermal resistance and thermal transmittance - Calculation method (ISO 6946)*

EN ISO 9445 (all parts), *Continuously cold-rolled stainless steel - Tolerances on dimensions and form (ISO 9445)*

EN ISO 10140 (all parts), *Acoustics - Laboratory measurement of sound insulation of building elements (ISO 10140)*

EN ISO 10211, *Thermal bridges in building construction - Heat flows and surface temperatures - Part 1: Detailed calculations (ISO 10211)*

EN ISO 10456, *Building materials and products - Hygrothermal properties -Tabulated design values and procedures for determining declared and design thermal values (ISO 10456)*

EN ISO 11654, *Acoustics - Sound absorbers for use in buildings - Rating of sound absorption (ISO 11654)*

EN ISO 11925-2, *Reaction to fire tests - Ignitability of products subjected to direct impingement of flame – Part 2: Single-flame source test (ISO 11925-2)*

ISO 12491, *Statistical methods for quality control of building materials and components*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
auto-adhesion
self adhesion of the core to the face(s) occurring automatically without the use of an adhesive

3.2
bending moment capacity
maximum bending moment recorded during a test on an individual panel

3.3
bending resistance
characteristic value of bending moment capacity determined on the basis of a test series

3.4
bond, bonding
adhesion between the face(s) and the core normally provided by an adhesive

3.5
ceiling
covering over an internal area

3.6
core
layer of material, having thermal insulating properties, which is bonded between two metal faces

3.7
durability
ability of the panel to withstand the environmental effects and accommodate the consequent decrease in mechanical strength with time caused by factors such as temperature, humidity, freeze-thaw cycles and their various combinations

3.8
edge, longitudinal edge
side of the panel where adjacent panels join together in the same plane

3.9
face, facing
flat, lightly profiled or profiled thin metal sheet firmly bonded to the core

3.10
flat facing
facing without any rolled or pressed profile, or raised strengthening rib

3.11
incompletely bonded face
metal face whose bond to the core is adequate for sandwich action but does not include the entire surface of the core

Note 1 to entry: An example is a trapezoidally profiled face that has voids between the raised profiles and the core.

3.12
incompletely bonded panel
panel in which one or both faces is incompletely bonded

3.13
joint
interface between two panels where the meeting edges have been designed to allow the panels to join together in the same plane

Note 1 to entry: The joint may incorporate interlocking parts that enhance the mechanical properties of the system as well as improving the thermal, acoustic and fire performance and restricting air movement.

Note 2 to entry: The term 'joint' does not refer to a junction between cut panels or a junction where the panels are not installed in the same plane.

3.14
lamella
core material consisting of mineral wool that has been cut and orientated with the fibres perpendicular to the facings prior to bonding

3.15
lightly profiled facing
facing with a rolled or pressed profile not exceeding 5 mm in depth

3.16
pre-manufactured, pre-formed
component or material that is supplied to the manufacturer ready for direct incorporation into the sandwich panel

3.17
sandwich panel
building product consisting of two metal faces positioned on either side of a core that is a thermally insulating material, which is firmly bonded to both faces so that the three components act compositely when under load

3.18
self-supporting panel
panel capable of supporting, by virtue of its materials and shape, its self-weight and in the case of panels fixed to spaced structural supports all applied loadings (e.g. snow, wind, internal air pressure), and transmitting these loadings to the supports

3.19
shift
period of production during a working day, normally 6 h to 8 h but can be less

3.20
side lap
folded area of one or both of the facing materials along the longitudinal edge of the panel which engages with the adjacent panel to form an interlocking or overlapping joint

3.21
wrinkling strength
characteristic value of wrinkling stress

3.22
wrinkling stress
stress in the compressed face of a panel undergoing failure in bending where the failure mode takes the form of a “wrinkle” extending over the full width of the panel near the section of maximum bending moment

4 Symbols and abbreviations

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

A cross-sectional area (may be full width of panel or per unit width)

B flexural rigidity (may be full width of panel or per unit width), overall width of the panel/specimen,

C ratio

D overall depth of the panel

E modulus of elasticity

F force, load, support reaction

G shear modulus, permanent action

I moment of inertia

L span, distance, width of support (L_s)

M bending moment

N axial compressive force

Q variable action

R resistance, sound reduction index (R_w), reflectivity (R_G), tensile strength (R_{DUR}, R_{24})

S shear rigidity, value of a load effect, effect of an action

T temperature

U thermal transmittance, thermal transmittance including the influence of the joints $U_{d,s}$

V shear force

a distance apart of clips (A.10.4)

b width of test specimen, width of plate, width of ribs/valleys, bowing

d depth of face profile or stiffeners, depth of core (d_c)

e distance between centroids of faces, base of natural logarithms (e = 2,718 282)

f strength, yield stress, thermal transmittance contribution factor (f_{joint})

h height of profile, thickness (e.g. glue)

k parameter (E.4.3.2 support reaction capacity), correction factor

l length, deviation

m mass

n number of tests, number of screws, number of webs

p pitch of profile

q live load

r radius

s length of web (s_{w1})

t thickness of face sheet

v variance factor

w deflection, displacement, compression, cover width

x, y, z coordinates

α parameter (A.5.5.4), coefficient of thermal expansion, sound absorption (α_w), ratio (A.4.5.3)

β parameter (A.5.5.4 and Table E.10.2 design formulae)

δ deviation

ϕ angle

γ shear strain, partial safety factor

λ thermal conductivity, λ_{Design} (design value), ratio (A.4.5.3)

φ creep coefficient

θ parameter (Table E.10.1 design formulae)

σ stress, compressive strength σ_m, standard deviation

τ shear stress

ψ combination coefficient (Annex E), linear thermal transmittance of joints (A.10.3)

ρ coefficient, density

Subscripts

C core

D declared value (R_D)

F face, action (γ_F)

G self-weight, degree

M material (γ_M)

Q variable action

S sandwich part of the cross-section

adj adjusted

b bending, elastic extension

c compression, core, carrier (C.4.3.2), clip ($f_{joint,c}$)

d design

e external, additional thickness of main profiles (Δe)

eff effective

f load, facing (λ_{fi})

i internal (λ_{fi})

i, j index

k characteristic value

lin linear

m material

n nominal

nc without clip ($f_{joint,nc}$)

obs observed (e.g. result)

q uniform load

s support (L_s = support width), stiffeners, surface (R_{s1})

t tension, time

tol tolerance (normal or special)

tr traffic (C_{tr})

u ultimate (F_u)

v shear, variance

w wind, web, wrinkling (σ_w), weighted (R_w)

y yield

0 basic value, unit width, time (e.g. t = 0)

1 external face, upper face

2 internal face, lower face

<u>Abbreviations</u>

CG cellular glass

CWFT classified without further testing

EPS expanded polystyrene

FPC factory production control

ITT initial type test

MW mineral wool

NPD no performance determined

PCS gross calorific potential

PUR rigid polyurethane foam (the abbreviation PUR includes polyisocyanurate foam (PIR))

PF phenolic foam

XPS extruded polystyrene foam

5 Requirements, properties and test methods

5.1 Requirements for component materials

5.1.1 General

The product shall be manufactured with materials and components conforming to 5.1.2 to 5.1.4.

5.1.2 Metal facings

5.1.2.1 Steel

5.1.2.1.1 Steel faces

Steel faces (other than stainless steel) shall be a construction steel according to EN 10346:2009, Table 1 and have a minimum yield strength of 220 N/mm^2 and shall conform to the requirements of the appropriate standard given in Table 1.

For steels according to EN 10346:2009, Table 1, the steel grade, nominal thickness and tolerance system of each face shall be declared. Tolerances on thickness shall be according to the “special” or “normal” tolerances as described in the relevant standards.

Table 1 – Standards for steel with metallic coating

Metallic coating	European Standard
Zinc, 5 % Al-Zn, 55 % Al-Zn and Aluminium-silicon	EN 10346
The minimum nominal metallic coating masses shall be as specified in EN 508–1. Differential zinc coating shall be permitted for the external face of a panel exposed to the climate for all core materials.	

Organic protective coatings shall be selected according to their durability in the application environment. Organic coated steel sheets shall conform to the requirements of EN 10169. Multi-layer coatings shall conform to EN 508-1.

The panel manufacturer shall state the metal grade, thickness and tolerance system of each face. Tolerances on thickness shall be according to “special” or “normal” tolerances as described in the relevant standards. The thickness of steel facing sheets shall be determined in accordance with EN 10143.

NOTE Not all steels in Table 1 are suitable for sandwich panels in all the intended end uses.

5.1.2.1.2 Backface coating

If the metal face is bonded over its whole area to a rigid foam core with a closed cell structure, the reverse side metallic coating mass shall be a minimum of 50 g/m^2.

When relevant to intended end use application, resistance of metallic protective coatings and organic back face coat (duplex coating) against corrosion shall be ensured by laboratory tests. Minimum resistance of backing coat shall be CPI2 according to EN 10169. Additionally to the requirements in EN 10169 only slight colour change (DE < = 2,0) shall be acceptable in the condensation-water test (EN ISO 6270-1) over 1 000 h.

NOTE The requirements in 5.1.2.1.2 are only applicable to back face coatings.

5.1.2.2 Stainless steel faces

Stainless steel facings shall have a minimum yield strength of 220 N/mm^2. The chemical composition of stainless steel faces and their physical properties shall conform to EN 10088-1.

The panel manufacturer shall state the metal grade, thickness and tolerance system of each face. Tolerances on thickness shall be according to “special” or “normal” tolerances as described in the relevant standards. The thickness of stainless steel facing sheets shall be determined in accordance with EN ISO 9445

NOTE Not all stainless steels in EN 10088–1 are suitable for sandwich panels in all the intended end uses. Reference can be made to EN 508–3, grades suitable for roofing.

5.1.2.3 Aluminium faces

Aluminium facings shall have a minimum design value of the stress at the 0,2 %-strainlimit (for simplification called “yield strength“) of 140 N/mm^2. The chemical composition, temper and mechanical properties of aluminium shall conform to EN 485-2 or EN 1396.

Organic coated aluminium sheets shall conform to the requirements of EN 1396.

The panel manufacturer shall state the metal grade, thickness and tolerance system of each face. Tolerances on thickness shall be according to “special” or “normal” tolerances as described in the relevant standards. The thickness of aluminium facing sheets shall be determined in accordance with EN 485-4 or EN 1396.

NOTE Not all aluminium alloys covered by EN 485–2 or EN 1396 are suitable for sandwich panels in all the intended end uses. Reference can be made to EN 508–2.

5.1.2.4 Copper faces

Copper facings shall have a minimum design value of the stress at the 0,2 %-strainlimit (for simplification called “yield strength“) of 180 N/mm^2. The chemical composition, temper, mechanical properties and thickness tolerances of copper faces shall conform to EN 1172.

The panel manufacturer shall state the metal grade, thickness and tolerance system of each face. Tolerances on thickness shall be according to “special” or “normal” tolerances as described in the relevant standards. The thickness of copper facing sheets shall be determined in accordance with EN 1172.

Not all copper facings in EN 1172 are suitable for sandwich panels in all the intended end uses. Reference should be made to EN 506.

NOTE Only R240 and R290 grades satisfy the requirement of 180 N/mm^2.

5.1.3 Core materials

5.1.3.1 Thermal performance

The declared and design thermal conductivity of core materials shall be determined in accordance with 5.2.2.

5.1.3.2 Thermal stability of core materials

The thermal stability of the core materials in a sandwich panel shall be evaluated through the durability testing in accordance with 5.2.3.

5.1.4 Adhesives and bonding

Adhesives and bonding shall conform to 5.2.1.6 and 5.2.3.1.

The adhesion between the core and the faces of the panel has a fundamental role in the satisfactory performance of the panel. The surface preparation of the facing material shall be appropriate for the adhesive or the method of adhesion.

5.2 Properties of panels

5.2.1 Mechanical resistance of the panel

5.2.1.1 General

For mechanical properties, unless stated otherwise, the mean value and the characteristic value (5 % fractile value assuming a confidence level of 75 % for each population of test results) shall be determined according to ISO 12491.

Declared values shall be given to either two or three significant figures as specified in Annex ZA.

5.2.1.2 Shear strength (f_{Cv}) and shear modulus (Gc)

The declared values of the shear strength and shear modulus of the core shall be determined using the appropriate test procedures from A.3 or A.4 in accordance with Table 2. The same test procedure shall be used to determine both the shear strength and shear modulus of a panel. In principle, each test method is suitable for panels with flat, lightly profiled or profiled facings.

The declared value of the shear strength shall be less than or equal to the characteristic value and shall be declared by the manufacturer in megapascals (MPa).

Only the mean value of the shear modulus obtained from the available test results shall be declared. The 5 %-fractile value shall be recorded for FPC purposes in accordance with A.3 or A.4.

Table 2 – Alternative shear test methods

Test procedure	Core and face materials	Formula for evaluation		Comments
		Shear strength	Shear modulus	
A.3 – 2 load points (on small sample)	All core and face materials	A.5	A.7	Basic procedure. May be used in all situations unless practical requirements dictate otherwise.
A.4 – 2 load points (on full panel)	All core materials. Flat or lightly profiled faces	A.10	A.7	Alternative to A.3. For panels with one or two profiled faces wrinkling of the faces may occur
	One or both faces profiled	A.12	A.11	
A.4 – Vacuum chamber or air bag loading	All core materials. Flat or lightly profiled faces	A.10	A.13	Alternative to the use of 2 load points.
	One or both faces profiled	A.15	A.14	

5.2.1.3 Creep coefficient (φ_t)

The creep coefficient shall be determined according to A.6 and expressed as a number.

The creep coefficient shall be determined for all panels used as a roof or ceiling designed to carry long term or permanent loads e.g. snow and self-weight.

5.2.1.4 Compressive strength (σ_m) or compressive stress (σ_{10})

The compressive strength of the core σ_m or its compressive stress at 10 % deformation σ_{10} (whichever is reached first) shall be determined in accordance with the method given in A.2 and shall be declared by the manufacturer in megapascals (MPa).

5.2.1.5 Shear strength after long-term loading (f_{Cv} long-term)

Where required, the shear strength after long term loading shall be determined in accordance with A.3.6.

This value shall be determined for all panels used as a roof or ceiling designed to carry long term or permanent loads e.g. snow and self-weight. The declared value shall be less than or equal to the characteristic value (f_{Cv}) and shall be declared by the manufacturer in megapascals (MPa).

NOTE The reduction obtained from the small scale long-term test can be applied to panels where the shear strength has been determined on the basis of large scale tests to A.4 or calculated on the basis of A.3.5.3.

5.2.1.6 Cross panel tensile strength (f_{Ct})

The characteristic value for tensile strength and cross panel tensile strength perpendicular to the panel faces shall be greater than 0,018 MPa when tested in accordance with A.1 and shall be declared by the manufacturer in megapascals (MPa).

The declared values shall be less than or equal to the characteristic value.

NOTE Low tensile strength can reduce the wrinkling strength and increase its variability. Account is taken of this in A.5.5.5 (k_2 factor).

5.2.1.7 Bending moment capacity (M_u) and wrinkling stress (σ_w)

The bending moment capacity shall be obtained by testing according to A.5.

For panels with flat, lightly profiled or profiled faces, the wrinkling stress shall be calculated in accordance with A.5.5 and the wrinkling strength shall be declared by the manufacturer in megapascals (MPa).

The declared wrinkling stress should generally be determined on the basis of the results of bending tests. However, A.5.5.3 also allows a conservative value of the wrinkling stress to be calculated according to Formula (A.20) and declared.

Wrinkling stress is related to bending moment by a simple mathematical relationship so that it is not necessary to declare both the bending resistance and the wrinkling strength.

For a panel with a profiled face in compression, the bending resistance shall be declared together with the span of the test specimen. Optionally the wrinkling stress can be declared.

If it is intended that design shall be carried out on the basis of calculations in accordance with Annex E, it is preferable to declare the wrinkling strength wherever possible.

NOTE Declaration of the bending moment is essential for design on the basis of testing.

5.2.1.8 Bending moment capacity and wrinkling stress over a central support

Where required, the bending moment capacity over a central support shall be determined in accordance with A.7. For panels with flat or lightly profiled faces, the wrinkling stress shall then be calculated in accordance with A.5.5.

The bending moment capacity over a central support is required when panels which are continuous over two or more spans are to be designed by calculation in accordance with Annex E. In such cases, the comparison of the design values of resistance according to E.2 is usually carried out in terms of stresses. If the panel has one or more profiled faces, the determination of the ultimate compressive (wrinkling) stress from the bending moment capacity requires calculation in accordance with E.7.5. It is recommended that this calculation is carried out at the time of testing.

5.2.2 Thermal transmittance

The thermal transmittance value for the panel (U), incorporating the declared thermal conductivity for the core material ($\lambda_{Declared}$) and the joints and any profiled facings, shall be determined in accordance with A.10.

Both $\lambda_{Declared}$ and the $U_{d,s}$-value shall be declared.

5.2.3 Durability and other long-term effects

5.2.3.1 Reduction of tensile strength with time as a consequence of ageing (durability)

Panels shall satisfy the criteria for reduction in tensile strength in accordance with the relevant test method DUR1 and DUR2 (see Table 3) as described in Annex B.

Durability tests shall be applied to panels designed for external applications. They are based on the accelerated ageing effect of temperature or humidity, which from long-term experience are critical for each core material.

Where required, the durability tests may be used to assess the performance of internal sandwich panels.

NOTE 1 These tests evaluate the reduction of tensile strength as a result of temperature or humidity on a pass/fail basis.

NOTE 2 The durability requirement covers the performance of all essential structural components of the panel, for example backface coatings, adhesion layers and core material.

PUR panels manufactured using the blowing agents covered within EN 13165 and a combination of these blowing agents, but excluding CO_2 blown foams shall be considered to satisfy the durability requirements without testing. PUR panels manufactured with other blowing agents shall be tested according to test DUR1 and the colour reflectivity levels shall be declared (B.2.5).

Table 3 – Durability tests and deemed to satisfy criteria

Insulating core material	Test method (Annex B)	Note
Mineral wool (MW)	DUR2	DUR2 including the wedge test (B.5)
Polystyrene (EPS or XPS)	DUR1	DUR1 including wedge test (B.5)
Polyurethane (PUR), – auto-adhesive bond	DUR1	No test required for panels manufactured using the blowing agents covered within EN 13165 and combinations of these agents, but excluding foams blown solely by CO_2. Other blowing agents shall be tested to DUR1.
Polyurethane (PUR), – adhesive bond	DUR1	No test required for panels manufactured using the blowing agents covered within EN 13165 and combinations of these agents, but excluding CO_2 blown foams. Other blowing agents shall be tested to DUR1 including the wedge test (B.5). The wedge test (B.5) shall be carried out.
Phenolic (PF)	DUR1, thermal shock B.7 and repeated loading B.6	PF panels with an adhesive bond shall be tested to DUR1 including the wedge test (B.5).
Cellular glass (CG)	DUR1, thermal shock B.7 and repeated loading B.6	Including the wedge test (B.5).

5.2.3.2 Resistance to point loads and access loads – ceiling panels and roofs

Where required, the ability of a sandwich panel to resist point loads and access loads shall be determined in accordance with A.9.1. For applications where there will be more frequent access than occasional foot traffic (see Note), the procedure described in A.9.2 shall also be carried out.

NOTE 1 Point loads are loads resulting from a single person walking on the panel, for occasional access both during and after erection.

The span capabilities of a ceiling panel and its supporting system should be checked before access is allowed.

NOTE 2 Ceiling panels are generally unsuitable for regular foot traffic.

Ceiling panels should be protected when used on regular walking routes or working areas both during installation and in end use.

Panels should allow a wide and safe support for a foot and should not be subject to permanent deformations under occasional foot traffic for access or maintenance. For maintenance purposes, only one person at a time should be allowed to walk on a panel.

5.2.4 Fire characteristics

5.2.4.1 Reaction to fire

The reaction to fire classification of the product shall be determined according to EN 13501-1. The classification shall apply to panel applications defined in Clause 1 (Scope) of this European Standard.

Test arrangements for reaction to fire tests shall be in accordance with the following, as appropriate for the intended class:

— EN ISO 1182;

— EN ISO 1716 including determination of adhesives set out in C.4;

— EN 13823 and EN ISO 11925-2 together with the additions set out in C.1.

NOTE The European Commission has made the following statement after consultation of the Committee referred to in Article 19 of the Directive 89/106/EEC. The reaction to fire classification derived from the provisions in this standard provides regulators and other users with an essential parameter concerning fire performance of sandwich panels. Exclusively based on fire safety needs and with explicit justification, regulators may, for specific intended uses, set additional requirements for ensuring the fire safety of the construction works, in accordance with EN 13501–1. Other classifications, such as fire resistance, may also be required to achieve the intended fire safety objectives. In addition, in exceptional cases, other instruments, such as fire safety engineering, specific to the building incorporating the products and associated assembly characteristics, may be used to assess the fire safety of the building.

5.2.4.2 Fire resistance

Where required, the fire resistance classification of the product shall be determined according to EN 13501-2.

The test methods for sandwich panels shall be in accordance with the following standards:

— EN 1364-1 (non-load bearing walls) together with the additions set out in C.2.3;

— EN 1364-2 (ceilings);

— CEN/TS 13381-1 (ceilings – horizontal protection);

— ENV 13381-2 (walls)

— EN 1365-2 (load bearing roofs) together with the additions set out in and C.2.3;

— EN 14135 (fire protection ability).

5.2.4.3 External fire performance – roofs

Where the manufacturer wishes to declare external fire performance (e.g. when subject to regulatory requirements), the product shall be tested and classified in accordance with EN 13501-5.

Sandwich panels that satisfy the criteria set out in C.3.1 shall be considered to satisfy the requirements for the characteristic external fire performance without the need for further testing in accordance with Decision 2006/600/EC. These products shall be given a $B_{ROOF\ (t1,\ t2\ and\ t3)}$ classification as satisfying CEN/TS 1187 Test Methods 1, 2 and 3.

Test arrangements for external fire performance tests shall be in accordance CEN/TS 1187 together with the additions set out in C.3.2 to C.3.5.

5.2.5 Dimensional tolerances for sandwich panels

The dimensional tolerances for sandwich panels shall be in accordance with Table 4.

Table 4 – Dimensional tolerances for panels

Dimension	Tolerance (maximum permissible)	Measurement method
Thickness of the panel [a]	$D \leq 100$ mm ± 2 mm $D > 100$ mm ± 2 %	D.2.1
Deviation from flatness (according to the length of measurement L)	For $L = 200$ mm – Deviation from flatness 0,6 mm For $L = 400$ mm – Deviation from flatness 1,0 mm For $L > 700$ mm – Deviation from flatness 1,5 mm	D.2.2
Depth of metal profile (ribs) (mm)	$5 < h \leq 50$ mm ± 1 mm $50 < h \leq 100$ mm ± 2,5 mm	D.2.3
Depth of stiffeners and light profiling	$d_s \leq 1$ mm ± 30 % of d_s 1 mm $< d_s \leq 3$ mm ± 0,3 mm 3 mm $< d_s \leq 5$ mm ± 10 % of d_s	D.2.4
Length of the panel	$L \leq 3$ m ± 5 mm $L > 3$ m ± 10 mm	D.2.5
Cover width of the panel	w ± 2 mm	D.2.6
Deviation from squareness	0,006 $\times$ w (nominal cover width)	D.2.7
Deviation from straightness (on length)	1 mm per metre, maximum 5 mm	D.2.8
Bowing	2 mm per metre length, maximum 20 mm 8,5 mm per metre width for flat or lightly profiled – $h \leq 10$ mm 10 mm per metre width for profiles – $h > 10$ mm	D.2.9
Pitch of the profile (p)	If $h \leq 50$ mm p: ± 2 mm If $h > 50$ mm p: ± 3 mm	D.2.10
Width of the ribs (b_1) and width of the valleys (b_2)	For b_1 ± 1 mm For b_2 ± 2 mm	D.2.11
[a] For calculation of the thickness of panels with profiled facings, see Figure D.1.		

5.2.6 Water permeability

Where required, the water permeability (resistance to driving rain) of a complete assembly of sandwich panels shall be assessed, i.e. the assembly that is to be installed in a building, including the product and its coatings, factory applied seals, standard joints, site applied seals, representative flashings, and a method of fixing as appropriate to the test.

The resistance classification of a sandwich panel assembly to driving rain under pulsating air pressure shall be determined according to A.11. The test method shall be used for both external wall and roof applications.

Sandwich panels covered by this European Standard are metal faced. When correctly manufactured and if satisfying an appropriate visual inspection they may be deemed to be impermeable to water. The water tightness of the assembly is a function of its installation. Water permeability is only relevant to the joints and fixings.

5.2.7 Air permeability

Where required, the air permeability of a complete assembly of sandwich panels shall be assessed, i.e. the assembly that is to be installed in a building, including the product and its coatings; factory applied seals, standard joints, site applied seals, representative flashings and a method of fixing as appropriate to the test.

The measurement of air permeability of a sandwich panel assembly shall conform to A.12. The test method shall be used for both external wall and roof applications.

Sandwich panels covered by this European Standard are metal faced. When correctly manufactured and if satisfying an appropriate visual inspection they may be deemed to be impermeable to air. The air tightness of the assembly is a function of its installation. Air permeability is only relevant to the joints and fixings.

5.2.8 Water vapour permeability

For the purposes of this European Standard, the water vapour transmission coefficient for the metal facings used is considered to be infinity. Metal faced sandwich panels are therefore considered to be impermeable to water vapour.

5.2.9 Airborne sound insulation ($R_w(C;C_{tr})$)

Where required, the airborne sound insulation of a sandwich panel assembly shall be determined according to A.13. The result shall be declared as a R_w (C;C_{tr}) rating to EN ISO 717-1.

C is a spectrum adaptation term calculated with A-weighted pink noise. C_{tr} is a spectrum adaptation term calculated with A-weighted urban traffic noise.

5.2.10 Sound absorption (α_w)

Where required, the sound absorption of a sandwich panel assembly shall be determined according to A.14. The result shall be declared as single number rating to EN ISO 11654.

5.2.11 Dangerous substances

National regulations on dangerous substances may require verification and declaration on release, and sometimes content, when construction products covered by this European Standard are placed on those markets.

In the absence of European harmonised test methods, verification and declaration on release/content should be done taking into account national provisions in the place of use.

NOTE An informative database covering European and national provisions on dangerous substances is available at the Construction website on EUROPA accessed through: http://ec.europa.eu/enterprise/construction/cpd-ds/

5.3 Actions and safety level requirements

5.3.1 Mechanical resistance to design loads

The product shall have sufficient mechanical resistance to the design loads arising from the actions of self-weight, snow, wind, temperature and pressure gradients and access, where these loads shall be factored such that, either alone or in combination, they do not impair the performance of the product in service.

The safety of the product shall be verified by design procedures based on the limit state concept. This requires that the ‘design value of the resistance’ shall be greater than the ‘design value of the effect of the actions’ and shall be satisfied at both the serviceability limit state and the ultimate limit state. Verification shall be by calculation in accordance with Annex E.

Information shall be produced which gives all values necessary for both mechanical design and the production of load tables together with the corresponding characteristic values obtained during initial type testing and factory production control. For the purpose of this European Standard provision of this information shall be regarded as part of the product.

5.3.2 Actions and combinations of actions

In design for mechanical resistance the following actions: permanent actions, variable actions and actions due to long-term effects, shall be taken into account in the calculations. They shall be considered either individually or in combination using the combination factors in Annex E.

6 Evaluation of conformity, testing, assessment and sampling methods

6.1 General

The conformity of a sandwich panel to the requirements of this European Standard and to the stated values including classes shall be demonstrated by:

— initial type testing (ITT);

— factory production control (FPC) by the manufacturer, including product assessment;

— where required, initial inspection (FPC);

— where required, continuous surveillance (FPC).

The principle of grouping products into families may be used in order to obtain more uniform characteristic values and material safety factors as the parameters within a range of similar products are varied, or to reduce testing costs.

Where the manufacturer produces products that have the same physical and chemical characteristics on more than one production line or in more than one factory there shall be no need to repeat ITT for the different production lines.

If there is a difference between the characteristic values for products from two different lines, the worst values shall be used.

6.2 Initial type testing – ITT

6.2.1 Initial type evaluation

Initial type testing shall be conducted to show conformity to this European Standard in accordance with Table 4.

Whenever a change occurs in the product, raw material or supplier of the components, or the production process (subject to the definition of a family), which would change significantly one or more characteristics, the type tests shall be repeated for the appropriate characteristic(s).

In addition, initial type testing shall be performed at the beginning of the production of a new panel type (unless a member of the same family) or at the beginning of a new method of production where this may affect the declared properties or conformity of the product.

Characteristics which are required for specific applications, e.g. permeabilities or acoustics, shall be tested on a ‘where required’ basis.

6.2.2 Existing ITT test data

In general, it is not required to repeat ITT tests previously performed in accordance with the provisions of EN 14509:2006 (same product, same characteristics, test method, sampling procedure, system of attestation of conformity etc.). Data obtained from earlier tests may be used without the need for further testing to the revised procedures providing the declared data does not change significantly. There are two exceptions as follows.

a) Reaction to fire test EN ISO 11925-2. In cases where the edge was protected in the original test and is unprotected in the new test (See C.1.2) the product shall be retested.

b) Where the thermal transmittance was calculated using the tabulated values in A.10, the thermal transmittance shall be recalculated.

6.2.3 Sampling for ITT and audit testing purposes

6.2.3.1 General

Samples shall be representative of the product to be placed on the market and the manufacturer shall keep satisfactory records as part of his factory production control.

All samples shall preferably be from the same batch or, if this is not practicable, the manufacturer shall ensure availability of sufficient proof allowing comparison of the ITT or audit test results with those for samples from other batches.

The number of test specimens (for ITT) shall be in accordance with the test methods in Table 5. The sample taken, i.e. panel, shall be a simple random sample, drawn from a finite panel population.

Where test specimens are obtained from a single panel, the specimens shall be taken from a range of positions covering the width of the panel. At least one specimen shall be taken from the middle of the panel and at least one specimen from close to the edge of the panel, with the first cut edge not greater than 10 % of the cover width of the panel from an outside edge.

Conditioning of the test specimens, before or after the test, shall not be carried out unless otherwise specified in the test method.

The minimum age of specimens for initial type tests shall be at least 24 h. The date and time of production shall be recorded at the time of sampling.

Test specimens are very sensitive to the process of cutting and the accuracy of testing, in particular for tensile test measurements. Considerable care is required in the cutting process, especially if the core material is relatively weak or has brittle tendencies. The cutting can be carried out with a band saw with a fine-toothed blade. It may be advantageous to sandwich the specimen between two pieces of plywood or similar material in order to reduce vibration during the cutting process. It is suggested that specimens should be carefully inspected after cutting. Specimens that show evidence of delamination caused by the cutting process should be rejected (up to a maximum of 30 % of those cut for any family of tests).

6.2.3.2 Sampling marking and records

All samples intended for ITT purposes shall be marked as follows:

— date and time of sampling;

— production line or unit;

— identification mark.

The sampling records shall provide at least the following information:

— manufacturing plant;

— place of sampling;

— stock or batch quantity (from which the samples have been taken);

— quantity of samples;

— reference to this European Standard, i.e. EN 14509;

— marking of the product by the manufacturer;

— identification mark of the samples;

— properties to be tested;

— place and date;

— signature(-s) of the person(-s) responsible for sampling.

If a third party is responsible for sampling, the sampling records of that third party may be used.

6.2.4 Testing and compliance criteria – ITT

All characteristics in Table 5, where relevant, shall be subject to ITT tests with the exception of external fire performance when using the CWFT option, where measurement in accordance with C.3.1 is required to ensure that the product meets the definition required for CWFT.

Unless the test method requires otherwise, all testing shall be carried out under ambient laboratory conditions, without any special conditions.

For mechanical properties, unless stated otherwise, the mean value and the characteristic value (5 % fractile value assuming a confidence level of 75 %) for each population of the test results shall be determined according to ISO 12491 using the formula and fractile factors in A.16.3.

The results of all type tests shall be recorded and held by the manufacturer for at least 10 years after the last date of production of the product(s) to which they belong.

6.2.5 Shortened testing programme – ITT (product change)

6.2.5.1 General

If there is only a change of the core material or the adhesive for a panel family, a shortened test programme (not the whole range of ITT) – see Table 6 may be used to compare the values of shear strength and modulus; tensile strength and modulus; compression strength and modulus of the core; and creep against the values from the original ITT.

Provided that all of these characteristic material values for the new core material are better than or equal to the values declared as a result of the original ITT test, the existing declared values for the mechanical properties of the panel may be retained without further ITT.

If there is only a change in the grade of the facing material a shortened test programme to compare the bending moment capacity values shall be used (see Table 6).

6.2.5.2 Calculation and comparison criteria – mechanical properties

The shortened test programme requires that the following characteristics are tested in accordance with Table 6:

— shear strength f_{cv} (see Formula (A.5)) and shear modulus of the core G_c (see Formula (A.7));

— tensile strength f_{ct} (see Formula (A.1)) and tensile modulus of the core E_{ct} (see Formula (A.2));

— compression strength f_{cc} (see Formula (A.3)) and compression modulus of the core E_{cc} (see Formula (A.4));

— creep coefficient;

— bending moment capacity and wrinkling stress (see 6.2.5.1).

If the performance of the above 6 characteristics are better than or equal to the values from the existing ITT but there is a reduced performance with respect to creep, where relevant, then the existing values of tensile, shear and compression strength may be retained but the creep test shall be repeated and a new creep coefficient shall be declared.

6.2.5.3 No shortened programme - Other characteristics

Where there is a change of the core material or the adhesive for a panel family, there is no shortened test programme for the remaining characteristics listed in Table 5 – density, thermal transmittance, durability, fire, permeability and sound. New ITT tests shall be carried out where applicable.

In the case of the fire characteristics any requirement for a retest shall be in accordance with the direct application rules, C.1.3 – reaction to fire and C.2.4 – fire resistance.

Table 5 – Test methods, test specimens, type of the test and conditions for ITT

Characteristic	Test method	Type of test	Tested panel thickness	Min. number of ITT specimens	Compliance criteria and specific conditions	
5.1.2 Mechanical properties of a face	EN ISO 6892–1 [a]			3 [a]		
Technical properties of a panel and its core material						
5.2.1.2 Shear strength and modulus	A.3 or A.4	ITT	Minimum, maximum and intermediate (Max,Min,I)	3	Statement of declared values	
5.2.1.4 Compressive strength and modulus	A.2	ITT		6		
5.2.1.5 Reduced shear strength [c]	A.3.2	ITT		1/10 [d]		
5.2.1.6 Cross panel tensile strength: (and modulus [b])	A.1	ITT		6		
5.2.1.7 Bending moment capacity and wrinkling stress	A.5	ITT		3		
5.2.1.8 Bending moment capacity and wrinkling stress over a central support	A.7	ITT	(Max,Min,I)	3	-	
5.2.1.3 Creep coefficient [c]	A.6	ITT	Max	1	[Number]	
Cross panel tensile modulus at elevated temperatures [b f]	A.1.6	ITT	(Max,Min,I)	3		
Density	A.8	ITT record	(Max,Min,I)		The average value shall be declared	
5.2.2 Thermal transmittance	A.10	ITT	(Max,Min,I)[g]	See A.10	Limit value according to A.10	
5.2.3 Durability [e]	Annex B	ITT	Max, Min		Pass (see 5.2.3 and Annex B)	
5.2.4.1 Reaction to fire	EN ISO 1716, EN ISO 1182	ITT		As specified in EN 13501–1	Classification in accordance with EN 13501–1	
	EN 13823 (SBI)		Min, Max –			Specific

	EN ISO 11925-2		seeTable C.1			conditions see C.1
5.2.4.2 Fire resistance [e]	EN 1364–1 or 1364–2	ITT	Manufacturer choice	1	Classification in accordance with EN 13501–2 Specific conditions see C.2	
	EN 1365–2 or CEN/TS 13381–1		Manufacturer choice	1		
	EN 14135		Manufacturer choice	1		
5.2.4.3 External fire performance-roofs [e]	CEN/TS 1187	CWFT or ITT	Manufacturer choice	see CEN/TS 1187	Classification in accordance with EN 13501–5 Specific conditions see C.3	
5.2.6 Water permeability [e]	EN 12865	ITT	Manufacturer choice	1	EN 12865 and in accordance with A.11	
5.2.7 Air permeability [e]	EN 12114	ITT	Manufacturer choice	1	EN 12114 and in accordance with A.12	
5.2.9 Airborne sound insulation [e]	EN ISO 10140	ITT	Manufacturer choice	1	Declaration $R_w(C{:}C_{tr})$ (see A.13)	
5.2.10 Sound absorption [e]	EN ISO 354	ITT	Manufacturer choice	1	EN ISO 11654 (see A.14)	
5.2.5 Dimensional tolerances	Annex D	ITT	Manufacturer choice	1	-	

[a] These values are required to adjust test results in accordance with A.5.5.4.
[b] Required for design purposes only – not declared.
[c] Roof/ceiling applications only.
[d] 1/10 = a single test series with 10 specimens.
[e] Where required.
[f] Not declared. Required to calculate the wrinkling stress at elevated temperatures.
[g] Alternatively use manufacturers' declared values. Values shall be in the same orientation as in the panel).

Table 6 – Shortened testing programme, test specimens, type of the test and conditions for ITT

Characteristic	Test method	Type of test	Tested panel thickness	Min. number of ITT specimens	Compliance criteria
5.2.1.2 Shear strength and modulus	A.3 or A.4	ITT	Maximum	3	G_C and f_{Cv} ≥ original value
5.2.1.3 Creep coefficient [c]	A.6	ITT	Maximum	1	[Number ≤ original value]
5.2.1.4 Compressive strength and modulus	A.2	ITT	Maximum	6	E_{Cc} and f_{Cc} ≥ original value
5.2.1.6 Cross panel tensile strength: (and modulus [b])	A.1	ITT	Maximum	3	E_{Ct} and f_{Ct} ≥ original value
5.2.1.6 Cross panel tensile strength at elevated temperatures (f_{Ct})	A.1.6	ITT	Maximum	1	E_{Ct} and f_{Ct} ≥ original value
5.2.1.7 Bending moment capacity (Mu) and wrinkling stress	A.5	ITT	Maximum	1	[Number ≥ original value]

6.3 Factory Production Control (FPC)

6.3.1 General

The manufacturer shall establish, document and maintain an FPC system to ensure that the products placed on the market conform to the stated performance characteristics. The FPC system shall consist of procedures, regular inspections and tests and/or assessments and the use of the results to control raw and other incoming materials or components, equipment, the production process and the product.

An FPC system conforming to the requirements of EN ISO 9001, and made specific to the requirements of this European Standard, shall be considered to satisfy the above requirements.

Where this European Standard permits alternative test procedures to be used, all FPC tests shall be carried out using the test procedure that was used for the corresponding ITT tests.

Where CE marking is based on the use of existing ITT test data in accordance with 6.2.2, and where a subsequent change in the required test speed results in a significant change in the FPC results, it is permissible to use the same test speed for FPC tests that was used for the original ITT tests.

The results of inspections, tests or assessments requiring action shall be recorded, as shall any action taken. The procedure and action to be taken in cases of non-conformity shall be clearly stated.

When products of the same family (see 6.1) are produced using the same process equipment, the manufacturer may use common ITT results providing conformity can be shown, in which case factory production control procedures shall be the same.

Where a manufacturer operates different production lines or units in the same factory or production lines or units in different factories and these are covered by a single overall FPC system, the manufacturer shall keep control records for each separate production line or unit.

In addition to the test results, the following minimum information shall also be recorded:

— date and time of manufacture;

— type of product;

— product specification, including materials and components.

6.3.2 Results of FPC tests

Each individual value of a declared mechanical property determined by FPC shall be equal to or higher than the value declared as a result of ITT. If one or more values are lower, a statistical evaluation of this property shall either be carried out over the previous year and the 5 % fractile value determined or, if FPC of this property has been carried out for less than one year, all available results shall be included in the evaluation. This 5 % fractile value shall be equal to or higher than the declared value.

For each declared value, if the fractile value is lower than the declared value, additional FPC tests shall be carried out on material from the same batch and a corrected 5 % fractile value determined. If this value is lower than the declared value, the batch shall be rejected.

If sustained FPC results indicate that the declared value cannot be attained, either the declared value shall be reduced on the basis of the existing ITT tests, or a new set of ITT tests shall be carried out and a new value for the relevant property shall be declared.

Where values shall be reduced, any related characteristics that are not subject to FPC shall be adjusted.

NOTE The number of additional tests required is at the discretion of the manufacturer.

Where the results of FPC consistently exceed the declared value these results may be used to determine a 5 % fractile value which may be used as the basis for an increase in the declared value.

6.3.3 Equipment

Tests to demonstrate conformity of the finished product to this European Standard shall be carried out using equipment described in the relevant test methods referred to in this European Standard.

All weighing, measuring and testing equipment necessary to achieve, or produce evidence of, conformity shall be calibrated or verified and regularly inspected according to documented procedures, frequencies and criteria. Calibration and/or checking shall be against equipment or test specimens traceable to relevant international or nationally recognised reference test specimens (standards). Where no such reference test specimens exist, the basis used for internal checks and calibration shall be documented.

All equipment used in the manufacturing process shall be regularly inspected and maintained to ensure use, wear or failure does not cause inconsistency in the manufacturing process.

Inspections and maintenance shall be carried out and recorded in accordance with the manufacturer’s written procedures and the records retained for the period defined in the manufacturer's FPC procedures.

The manufacturer shall ensure that handling, preservation and storage of test equipment is such that its accuracy and fitness for purpose is maintained.

When production is intermittent, the manufacturer shall ensure that any test equipment which may be affected by the interruption is suitably checked and/or calibrated before use.

The calibration of all test equipment shall be repeated if any repair or failure occurs which could upset the calibration of the test equipment.

6.3.4 Raw materials and components

6.3.4.1 General

The specifications of all incoming raw materials and components shall be documented, as shall the inspection scheme for verifying their conformity.

The manufacturer shall have written procedures which specify how non-conforming raw materials and components shall be dealt with. Any such events shall be recorded as they occur and these records shall be kept for the period defined in the manufacturer’s written procedures.

Conformity for metal facings shall be in accordance with 6.3.4.2, pre-manufactured core components with 6.3.4.3 and adhesives with 6.3.4.4.

6.3.4.2 Metal facings

Where provided by the facing manufacturer, declarations shall be according to EN 10204, document Type 3.1,and shall be provided for every 50 t of coil material. For all metals that do not have a guaranteed yield stress, material certification shall be provided for every batch.

6.3.4.3 Prefabricated lamella and preformed core material

Pre-formed material for the cores of sandwich panels shall undergo factory production control testing (see Table 7). The panel manufacturer shall determine or obtain a manufacturer’s declaration for the following properties in accordance with the relevant insulation product standard (EN 13162 to EN 13167):

— tolerances (particularly consistency of thickness);

— thermal conductivity.

NOTE In the context of this European Standard, declaration means the supplier's formal declaration of the properties.

6.3.4.4 Adhesives

The panel manufacturer shall obtain the supplier's declaration for the following:

— description and specification;

— viscosity/speed;

— shelf life.

6.3.5 Product testing and assessment – FPC

6.3.5.1 General

The manufacturer shall establish procedures to ensure that the stated values of all of the characteristics are maintained in accordance with 6.3.5.2 and 6.3.5.3.

The factory production control procedures shall be organised so that every product type appears in the statistical control in approximate proportion to the volume of production.

Suppliers who purchase the product from a manufacturer whose production plant is outside the EEA shall establish procedures to ensure that the stated values of all of the characteristics are maintained in accordance with 6.3.6.

6.3.5.2 FPC procedures for panels

The minimum factory production control procedure for the manufacture of panels shall include testing according to Table 7.

Factory production control tests shall be carried out either on aged specimens or on specimens taken immediately after production.

The number of test specimens for FPC shall be in accordance with the test methods in Table 7.

The specimens shall be taken from a range of positions covering the width of the panel. At least one specimen shall be taken from the middle of the panel and at least one specimen from close to the edge of the panel, with the first cut edge not greater than 10 % of the cover width of the panel from an outside edge.

NOTE 1 Test specimens are very sensitive to the process of cutting and the accuracy of testing in particular for tensile test measurements. Considerable care is required in the cutting process, especially if the core material is relatively weak or has brittle tendencies. The cutting can be carried out with a band saw with a fine-toothed blade. It may be advantageous to sandwich the specimen between two pieces of plywood or similar material in order to reduce vibration during the cutting process. It is suggested that specimens should be carefully inspected after cutting. Those that show evidence of delamination caused by the cutting process may be rejected (up to a maximum of 30 % of those cut for any family of tests).

For panels without joints in the core, if Formula (A.20) (A.5.5.3) is used or if the wrinkling strength and the bending resistance are determined by calculation on the basis of A.5, it is not necessary to carry out the wrinkling stress tests. Then the FPC control of the tension and compression modulii shall be carried out in accordance with Table 7.

If the ultimate bending moment is controlled at least once per week then there is no requirement to control the tension and compression modulii.

Table 7 – FPC procedures for panels

Type of test	Test method	Minimum number of specimens	Minimum frequency
Density of core material	A.8	3	1 per shift/6 or 8h [a]
Cross-panel tensile strength and modulus (with faces)	A.1	3	1 per shift/6 or 8h [a]
Compressive strength and modulus of core material	A.2	3	1 per week [a]
Shear strength and modulus of core material [e]	A.3	3	1 per week [a]
Tensile strength of face material (or declaration – 6.3.4.2)	-	3	All deliveries
Thickness of face material (or declaration – 6.3.4.2)	-	3	All deliveries
Shear strength and modulus of the core material based on the testing of a complete panel [b]	A.4	1	1 per 2 weeks [a]
Wrinkling stress (optional see text above)	A.5	1	1 per week [a]
Dimensional control:	-	1	1 per shift/6 h or 8 h
— Panel thickness	D.2.1		
— Deviation from flatness	D.2.2		
— Depth of profile	D.2.3		
— Depth of stiffeners	D.2.4		
— Length of panel	D.2.5		
— Cover width	D.2.6		
— Deviation from squareness	D.2.7		
— Deviation from straightness	D.2.8		
— Bowing (curvature)	D.2.9		
— Pitch of profile	D.2.10		
— Width of valleys/ribs	D.2.11		
Reaction to fire – (6.3.5.3) [c]	-	-	Specification Record
Resistance to fire – (6.3.5.3) [c]			
External fire performance – (6.3.5.3) [c] or CWFT			
Thermal insulation performance	A.10.2.1.1 [d]	1	1 per month
Water permeability – 5.2.6 Air permeability – 5.2.7 Water vapour permeability – 5.2.8	Visual inspection [a]	-	-

[a] Where production volumes are below 2 000 m^2 per shift, the manufacturer shall only test every 2 000 m^2 or at least every three months. Dimensional control tests and permeability inspections, however, shall be carried out every shift.

[b] This can be an alternative for panels with MW lamella core material and other panels with joints in the core, see A.4.1

[c] Manufacturer's specification record (see 6.3.5.3) or supplier's statement of fire performance of components.

[d] Procedure tests λ_i (single test result of thermal conductivity) in accordance with the appropriate product standard for the core material (A.10.2.1.1) and shall be representative of the material at the time of manufacture of the panel.

[e] Where a complete shear panel test has been used in ITT to measure the shear strength and modulus it shall also be used in FPC.

NOTE 1 The control of the thickness of pre-formed core material or lamellas and the positioning of the joints between individual slabs are of fundamental importance and is frequently checked (e.g. every 2 h).

NOTE 2 Typical allowable difference in cutting thickness between adjacent pre-manufactured pieces for fabrication with stiff platens is ± 0,5 mm.

6.3.5.3 FPC controls for fire characteristics

FPC controls for fire characteristics shall be carried out as follows:

a) Panels with insulation created by foaming (chemical action) during the manufacturing process shall be controlled by recording the precise specification of all chemical components, fire retardants etc. for each production batch including origin of supply; proportions used etc. In the case of chemical systems supplied by an external manufacturer, a sufficient statement of the specification shall be provided. The panel design/type shall be recorded to confirm the panel to panel joint detail.

b) Panels with pre-formed or lamella insulation produced by bonding shall be controlled by recording the precise specification of all pre-formed or lamella components for each production batch including as applicable the full chemical specification; density; fire retardants; binders; adhesives; or other organic material, including backing coats etc. In the case of pre-formed or lamella and other components (i.e. adhesives) supplied by an external manufacturer a sufficient statement of the specification shall be provided. The panel design/type shall be recorded to confirm the panel to panel joint detail.

Indirect tests on components shall be carried out according to Table 8.

Table 8 – Minimum testing frequencies for components for reaction to fire characteristics

Component	Test method	Frequency
Core material	Check of raw material or chemical formulation, and density (A.8)	1 per shift/6 or 8h
Adhesive	Check for maximum amount and thickness of adhesive layer (C.4)	1 per shift/6 or 8h
Facings	Manufacturer’s declaration	1 per week

6.3.6 Conformity of Factory Production Control – supplier purchases

6.3.6.1 General

Where a supplier purchases the product from a manufacturer whose production plant is outside the EEA, the supplier shall take full responsibility for demonstrating conformity for the product in accordance with 6.3.6.2.

Where a supplier purchases the product from a manufacturer who does not operate an FPC system as described in 6.3, either the manufacturer shall be obliged to operate such a system or the supplier shall take full responsibility for the product in accordance with 6.3.6.2.

6.3.6.2 FPC procedures – products purchased by suppliers

Where a product is purchased by a supplier under the conditions given in 6.3.6.1, the supplier shall take full responsibility for demonstrating the conformity of the product and shall operate an FPC system, including test equipment and non-compliance procedures, to ensure that conformity is maintained with the same degree of certainty as if a full FPC system in accordance with 6.3 had been operated.

Conformity shall be based on product testing of the whole panel or specimens taken from a panel in accordance with Table 9.

Values of the following characteristics shall also be provided in accordance with 6.3.4.2 and 6.3.4.3:

— compressive strength and modulus of the core material;

— shear strength and modulus of the core material;

— tensile strength of the face material (or declaration – 6.3.4.2);

— thickness of face material (or declaration – 6.3.4.2).

The frequency of testing for these characteristics shall be every 2 000 m^2 and at least once per delivery.

Table 9 – Supplier purchases: FPC system requirements for panels

Type of test	Test method	Minimum number of specimens	Minimum frequency
Density of core material	A.8	3	
Cross-panel tensile strength and modulus (with faces)	A.1	3	All deliveries
Shear strength of complete panel[a]	A.4	1	
Dimensional control:	-	-	-
— Panel thickness	D.2.1		
— Deviation from flatness	D.2.2		
— Depth of profile	D.2.3		
— Depth of stiffeners	D.2.4		
— Length of panel	D.2.5		
— Cover width	D.2.6	1	All deliveries
— Deviation from squareness	D.2.7		
— Deviation from straightness	D.2.8		
— Bowing (curvature)	D.2.9		
— Pitch of profile	D.2.10		
— Width of valleys/ribs	D.2.11		
Reaction to fire – (6.3.5.3) [b]	-	-	
Resistance to fire – (6.3.5.3) [b]	-	-	Specification Record
External fire performance – (6.3.5.3) [b] or CWFT	-	-	
Thermal insulation performance – 5.2.2	A.10		Every 3 months
Water permeability – 5.2.6			
Air permeability – 5.2.7	Visual inspection	-	All deliveries
Water vapour permeability – 5.2.8			

[a] Panels with MW lamella insulating cores and incompletely bonded panels only.

[b] Manufacturer's specification record (see 6.3.5.3) or supplier's statement of fire performance of components.

6.4 Characteristic values from families of tests

The concept of families is described in 6.1. This concept is generally applied to mechanical characteristics and the parameters, which may vary within a family, include core depth, geometry of the faces, span and face material characteristics.

The evaluation of families of test results shall follow the principles given in EN 1990:2002, Annex D. The procedure that follows is a simplified version of the more general procedure given in EN 1990, which is deemed to be adequate for the purposes of this European Standard.

The characteristic resistances of the members of the family shall be determined on the basis of a suitable design expression 'x_{des}' that relates the test results to all of the relevant parameters. This design expression may either be based on the appropriate formulae of structural mechanics or determined on an empirical basis.

The design expression shall be modified to predict the measured resistance as accurately as possible by adjusting the coefficients in order to optimise the correlation.

NOTE 1 An optimum design expression may be determined on the basis of a regression analysis but this is not essential. A limited amount of trial and error is sufficient to meet the requirements of this clause.

Where possible, design expressions with a linear variation between the varying parameter(s) and the required values should be preferred.

NOTE 2 This method remains valid if the required "design expression" is a constant value.

In order to calculate the standard deviation, each test result '*x*' should first be normalised by dividing it by the corresponding value predicted by the design expression.

$$x_n = \frac{x}{x_{des}}$$

The number of tests '*n*' should be taken as the total number of tests in the complete family. For a family of at least four tests, the characteristic resistance R_k shall then be obtained using the following formula:

$$R_k = x_p = x_{des} e^{(\bar{y}_n - k\sigma_{yn})}$$

Where

x_p is the 5 % fractile value of population *x*;

$y_n = L_n(x_n)$;

$\bar{y}_n$ is the mean value of y_n;

k is the fractile value given in Table A.5;

σ_{yn} is the standard deviation of y_n.

$$\bar{y}_n = \frac{1}{n}\sum_{i=1}^{n} L_n\left(x_{n.i}\right)$$

7 Classification and designation

A sandwich panel shall be classified and designated in accordance with Table 10 where required, for example when subject to regulatory requirements. Declared values shall be rounded to two or three significant figures.

Table 10 – Classification and designation

Clause	Designation	Units or class
5.2.1	Mechanical properties: — metal grade / thickness / tolerance system — cross panel tensile strength — shear strength (core) — shear modulus (core) — creep coefficient [a] — compressive strength (core) — long term shear strength [a] — wrinkling strength [c] or bending resistance [c] —	 Statement MPa MPa MPa (number) MPa Mpa MPa kNm/m
	Density	Kg/m^3
5.2.2	Thermal transmittance and thermal conductivity	W/m^2·K and W/m·k
5.2.3	Long term mechanical properties – Durability	Pass (colours-see Annex B) / Fail
5.2.4.1	Reaction to fire	See EN 13501–1
5.2.4.2	Fire resistance	See EN 13501–2 [b]
5.2.4.3	External fire performance for roofs	$B_{ROOF(t1, t2, t3)}$(CWFT) or EN 13501–5 [b]
5.2.6	Water permeability	Class: e.g. A (1 200 Pa): B (600 Pa): C (300 Pa). [b]
5.2.7	Air permeability	C and n values[b]
5.2.9	Airborne sound insulation	Rating: $R_w(C:C_{tr})$ [b]
5.2.10	Sound absorption	Single value rating: α_w [b]

[a] Characteristic only required for panels used as roofs and ceilings.

[b] These characteristics may be designated NPD (No Performance Determined, see ZA.3) where the intended use is not subject to regulatory requirements.

[c] Either the wrinkling strength or bending resistance shall be declared. The wrinkling strength or bending resistance shall be declared for both positive and negative bending. Where one or both faces are flat or lightly profiled, the wrinkling strength shall be declared for such faces (A.5.5.3).

8 Marking, labelling and packaging

8.1 Marking and labelling

The following information shall be supplied by the manufacturer with or attached to every pack, or bundle of sandwich panels or supplied with the commercial documentation:

a) name or registered identification of the manufacturer and address of production plant or identification, where applicable, of his agent within the EEA;

b) number of this European Standard, i.e. EN 14509;

c) information on the type of product including product reference/name;

d) mass of the product in kg/m^2;

e) thickness of the product;

f) description of the metal faces including grade of metal, and coatings where applicable;

g) description of the core material including material identification, thickness, density etc.;

h) values of the characteristics in Table 10.

NOTE Where ZA.3 covers the same information as in 8.1, the requirements of this subclause are met.

Manufacturers may wish to supply additional information with the product as appropriate.

8.2 Packaging, transport, storage and handling

Any instructions regarding transport, storage and handling shall be clearly visible on the package or in the accompanying documentation.

If severe service conditions are expected during transportation, storage or processing, the product may be supplied with an additional protection of a temporary, strippable film, wax or oil.

The type, thickness, adhesion properties, formability, tear strength and light fastness should be taken into consideration when choosing protective films. All protective films can be exposed to outdoor weathering for only a limited period without deterioration.

Annex A
(normative)

Testing procedures for material properties

A.1 Cross panel tensile test

A.1.1 Principle

This test measures the cross panel tensile strength and the E-modulus of the core material.

The characteristic value of the cross panel tensile strength shall be determined in accordance with EN 1607 and the following subclauses.

A.1.2 Apparatus

The tensile test apparatus shall be in accordance with EN 1607.

A.1.3 Test specimens

Sampling and conditioning of the test specimens shall comply with 6.2.2 and 6.2.3.

The test shall be performed with the faces of the panel intact (in place) in order to include the tensile bond strength between the faces and the core or to demonstrate adequate bond.

For panels with profiled faces the specimens shall be cut from the predominant thickness (see examples in Figure A.1).

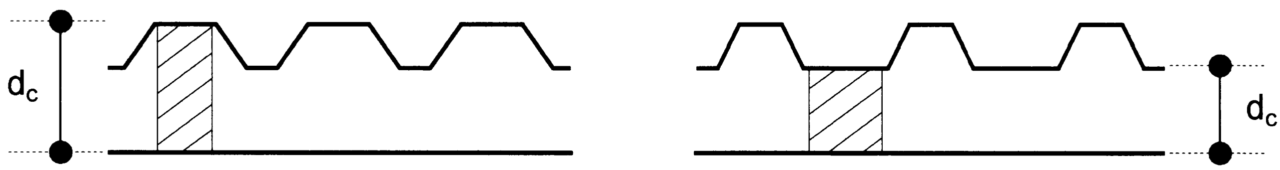


Figure A.1 – Cutting of specimens

Test specimens shall be of square cross-section having side dimensions between 100 mm and 300 mm. Where applicable the test specimen shall include the full width of lamellas.

For incompletely bonded panels, the specimens shall be cut from the fully-bonded part of the cross-section (see the right hand example in Figure A.1).

The dimensions of the specimen shall be measured in accordance with EN 12085. The tolerance on side dimension shall be ± 3 mm.

Test specimens are very sensitive to the process of cutting and the accuracy of testing in particular for tensile test measurements. Considerable care is required in the cutting process, especially if the core material is relatively weak or has brittle tendencies. The cutting can be carried out with a band saw with a fine toothed blade. It may be advantageous to sandwich the specimen between two pieces of plywood or similar material in order to reduce vibration during the cutting process. It is suggested that specimens should be carefully inspected after cutting. Those that show evidence of delamination caused by the cutting process shall be rejected (up to a maximum of 30 % of those cut for any family of tests).

Where it is not possible to cut a specimen with two plain faces, due to the profile of the faces, the specimen shall be prepared with an appropriately shaped filling piece, which is glued to the profiled face (see examples in Figure A.2).

Additional thin layers may be adhered to the faces in order to ensure that the loading platens of the testing machine are parallel at the commencement of the tensile test.

NOTE As an alternative to the use of shaped filling pieces and if the shape of the profiled face is suitable, it may be possible to glue two specimens together in such a way that the profiled faces mate.

Figure A.2 – Examples of specimens with shaped filling pieces

A.1.4 Procedure

The test shall be carried out by loading the specimen continuously, or in at least 10 increments, using a tensile testing machine. The deflection rate shall have a minimum value of 1 % of d_c per minute and shall not exceed 3 % of d_c per minute. During the test the extension shall be measured with a precision of 0,01 mm.

The test shall be continued until the ultimate load (F_u) is reached (Figure A.3). If the specimen does not exhibit a clearly defined ultimate load the test shall be discontinued when the relative deformation exceeds 20 %.

The tests shall be performed under normal laboratory conditions of temperature and humidity except when carrying out the test at elevated temperature (A.1.6).

A.1.5 Calculations and results

A.1.5.1 Cross panel tensile strength (f_{Ct})

A load-deflection curve shall be drawn (see Figure A.3) and the tensile strength shall be calculated as follows.

The tensile strength f_{Ct} is given by Formula (A.1):

$$f_{Ct} = \frac{F_u}{A} \tag{A.1}$$

Where

F_u is the ultimate load;

A is the cross-sectional area of the specimen determined from the measured dimensions.

NOTE For specimens that do not exhibit a well-defined ultimate load, F_u may alternatively be defined as the load at a specified relative deformation. For polyurethane foams, 10 % relative deformation (0,1 d_c) may be an appropriate limit. For materials with a more rigid cell structure or of non-cellular structure, a lower value may be used.

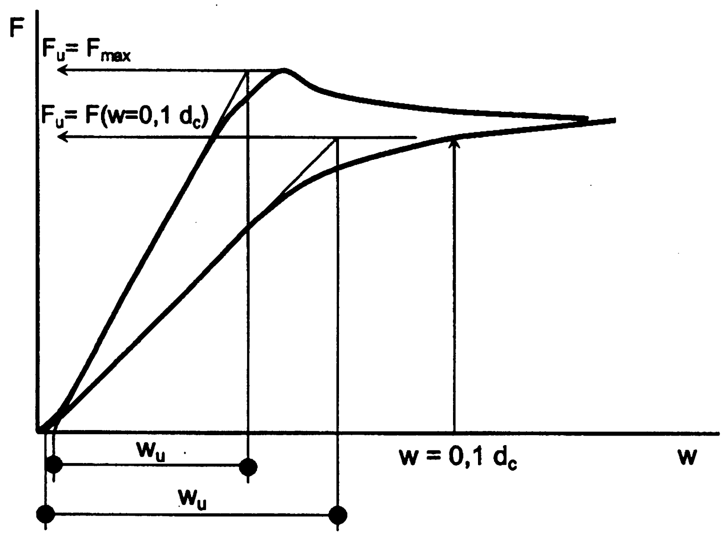


Figure A.3 – Load against deflection curve (F_U against displacement '*w*')

Recording and interpretation of test results shall comply with A.16.

The test report shall state the characteristic value (6.2.3) for tensile strength and shall state the failure mode, i.e. whether failure was in the adhesion layer or in the core.

Special attention should be given in cases where the failure is close to the adhesion layer to determine the location of the failure.

A.1.5.2 Tensile E-modulus of the core (E_{Ct})

The test report shall also give the characteristic E-modulus for the core material.

The tensile modulus E_{Ct} is given by Formula (A.2):

$$E_{Ct} = \frac{F_u \, d_C}{w_u \, A} \qquad \text{(A.2)}$$

where

F_u *is the* ultimate load;

d_c is the thickness;

w_u is the ideal displacement at ultimate load based on the linear part of the curve as shown in Figure A.3;

A is the cross-sectional area of the specimen determined from the measured dimensions.

A.1.6 Cross panel tensile modulus at elevated temperature

Where required for design and ITT but not for FPC procedures of external panels, the test described in A.1.1 to A.1.5 shall also be carried out on specimens which have been heated for 20 h to 24 h in a heating chamber at a temperature of 80^{+3}_{-1} °C. The tensile test shall be carried out immediately, before the specimen has cooled.

The test may be carried out by heating the specimens together with the load distributing platens to a temperature a little above 80 °C and then carrying out the tensile test before the specimen has cooled below 80 °C (limits 80^{+3}_{-1} °C).

The characteristic value for the E-modulus at elevated temperature shall be added to the test report.

A.2 Compressive strength and modulus of the core material

A.2.1 Principle

This test measures the compressive strength and E-modulus in compression of the core material.

The characteristic value of the compressive strength of the core material shall be determined in accordance with EN 826 and the following subclauses.

A.2.2 Apparatus

The apparatus shall be in accordance with EN 826.

A.2.3 Test specimens

Sampling and conditioning of the test specimens shall comply with 6.2.2 and 6.2.3.

Test specimens shall be prepared as described in A.1.3. If the profile of the face(s) requires the use of filling pieces then these shall not be glued to the loading platen.

A.2.4 Procedure

The specimen shall be placed between the two parallel stiff loading plates of a compression testing machine. The deflection rate shall have a minimum value of 1 % of d_c per minute and shall not exceed 3 % of d_c per minute. During the test the displacement shall be measured with a precision of 0,01mm and a load-deflection curve drawn (see Figure A.3).

The tests shall be performed under normal laboratory conditions of temperature and humidity.

A.2.5 Calculations and results

A.2.5.1 Compressive strength (f_{Cc})

The compressive strength f_{Cc} of the core material shall be calculated using Formula (A.3):

$$f_{Cc} = \frac{F_u}{A} \qquad \text{(A.3)}$$

where

F_u is the ultimate load;

A is the cross-sectional area of the specimen determined from the measured dimensions.

NOTE For specimens which do not exhibit a well-defined ultimate load, F_u may alternatively be defined as the load at a specified relative deformation. For polyurethane foams, 10 % relative deformation (0,1 d_c) may be an appropriate limit (see Figure A.3). For materials with a more rigid cell structure or of non-cellular structure, a lower value may be used.

A.2.5.2 Compressive E-modulus of the core (E_{Cc})

The test report shall also give the characteristic E-modulus for the core material.

The compressive modulus E_{Cc} of the core material shall be calculated using Formula (A.4):

$$E_{Cc} = \frac{F_u \, d_C}{w_u \, A} \tag{A.4}$$

Where

F_u is the ultimate load;

d_c is the thickness;

w_u is the ideal displacement at ultimate load based on the linear part of the curve as shown in Figure A.3;

A the cross-sectional area of the specimen determined from the measured dimensions.

Recording and interpretation of test results shall comply with A.16.

The test report shall state the characteristic value (6.2.3) for compressive strength and modulus of the core material.

A.3 Shear test on the core material

A.3.1 Principle

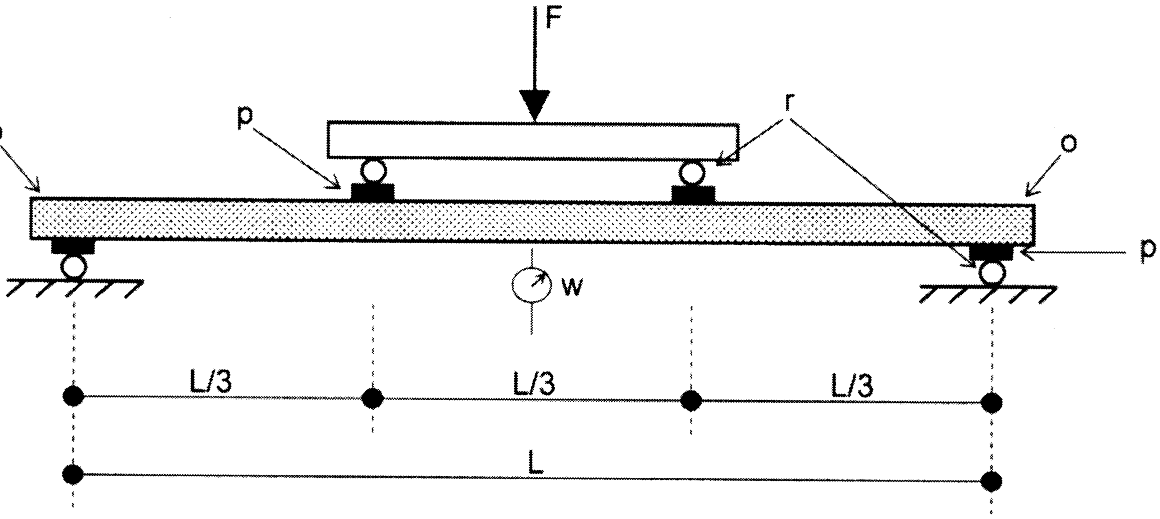
This test determines the shear strength and shear modulus of the core material. The ultimate load carried by the specimen failing in shear shall be measured and the shear modulus calculated from the load deflection curve.

A.3.2 Apparatus

The test apparatus is illustrated in Figure A.4.

Steel load spreading plates (p) are required below the load points and over the supports. The thickness of the load spreading plates shall be between 8 mm and 12 mm.

The width L_s of the load spreading plates at the support and load points shall be a minimum of 60 mm. This value shall be increased as necessary, in order to avoid local crushing of the core and to achieve the maximum possible shear stress at failure. The clear distance between the load plate and support plate shall not be less than 1,2 d_c.



Key

F applied load

r rollers, radius 15 mm

w measured deflection

p metal load spreading plates of width L_s

o overhang not exceeding 50 mm

Figure A.4 – Test with two load points

A.3.3 Test specimens

Conditioning of the test specimens shall comply with 6.2.2 and 6.2.3.

The specimens shall be cut in the lengthwise direction of the panel. The position shall be chosen so that the faces of the specimen are flat and parallel.

NOTE 1 Faces may incorporate light profiling.

For all core materials except MW lamellas, the width of the specimen shall be 100 mm ± 2 mm. For MW lamellas the width to be used shall be ≥ 100 mm and shall be chosen to incorporate at least one full width of lamellas. There shall be no cut ends of lamellas or pre-formed core material within the length of the test specimen.

NOTE 2 With thicker panels and panels with lamella cores, it may be preferable to use the test described in A.4 to determine the shear strength and modulus of panels.

Span *L* shall be chosen so that a shear failure is obtained. The recommended span is 1 000 mm. If the recommended span does not result in a shear failure similar to that illustrated in Figure A.5, the span shall be reduced in increments of 100 mm until a shear failure is obtained. Subsequent tests shall then be carried out at the reduced span.

NOTE 3 With thicker panels it may be advantageous to use spans greater than 1 000 mm.

If the test does not result in shear failure, the results may be used for ITT and FPC as the outcome will be safe.

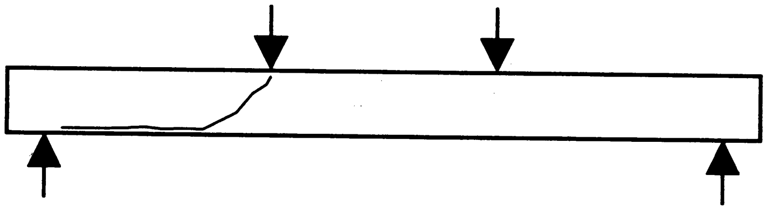


Figure A.5 – Typical shear failure

A.3.4 Procedure

The specimen shall be loaded as shown in Figure A.4. The loading rate shall be uniform and such as to result in failure between 1 min and 5 min after the commencement of the test. During the test the deflection shall be measured with a precision of 0,01mm. The loading shall be continued until failure and a load-deflection curve shall be drawn.

In the case of thick panels, test procedures using four point loads may be used to achieve shear failure.

The tests shall be performed under normal laboratory conditions of temperature and humidity.

The metal thickness, excluding all protective coatings, of both faces of each test specimen shall be measured and recorded.

A.3.5 Calculations and results – short-term loading

A.3.5.1 Shear strength of the core material (f_{Cv})

The ultimate shear strength f_{Cv} of the core material shall be calculated from the maximum load attained in a specimen failing in shear as follows (A.5):

$$f_{Cv} = k_v \frac{F_u}{2Be} \quad \text{(A.5)}$$

Where

F_u is the ultimate load carried by the specimen failing in shear;

B is the measured width of the specimen;

e is the measured depth between the centroids of the faces;

k_v is the reduction factor for cut ends in pre-formed or lamella cores.

The shear strength for panels with offset pre-formed or lamella cores shall be reduced to take account of the fact that the cut ends of the core materials have little or no shear strength. For non-lamella panels with pre-formed cores, no reduction in shear strength shall be considered when the joints are adhered.

If no reduction is taken into account it is important that the joints between the ends of the lamellas are completely adhered, usually by adhesion. The manufacturer should demonstrate adequate performance.

For panels with the core material foamed *in situ* or pre-formed in a single piece, or for panels with cut ends which are adhered, k_v = 1,0. For other panels with pre-formed or lamella cores, unless a better result can be justified by testing a full cover width of panel to A.4, k_v shall be calculated by Formula (A.6):

$$k_v = \frac{\textit{the minimum width of uncut core material across a line of cut ends}}{\textit{the full width of the panel}} \qquad \text{(A.6)}$$

Where the cut ends are closer to each other than 5 cm in the longitudinal direction, they shall be treated as one cut end.

Recording and interpretation of test results shall comply with A.16.

The test report shall state the characteristic value (6.2.3) for the shear strength in megapascals (MPa). The span shall be declared in the test report.

A.3.5.2 Shear modulus of the core material (G_C)

For each test specimen, the shear modulus G_C shall be calculated from the slope of the straight part of the load-deflection curve $\left[\frac{\Delta F}{\Delta w}\right]$ as follows (A.7):

Flexural rigidity $$B_S = \frac{E_{F1} \cdot A_{F1} \cdot E_{F2} \cdot A_{F2}}{E_{F1} \cdot A_{F1} + E_{F2} \cdot A_{F2}} e^2$$

Bending deflection $$\Delta w_B = \frac{\Delta F\, L^3}{56{,}34\, B_S}$$

Shear deflection $$\Delta w_S = \Delta w - \Delta w_B$$

Shear modulus $$G_C = \frac{\Delta F\, L}{6\, A_C\, \Delta w_S} \qquad \text{(A.7)}$$

Where

E_{F1} is the E-modulus of the top face;

E_{F2} is the E-modulus of the bottom face;

A_{F1} is the measured area of cross-section of the top face based on measured steel thickness;

A_{F2} is the measured area of cross-section of the bottom face based on measured steel thickness;

e is the measured depth between the centroids of the faces;

Δw is the deflection at mid-span for a load increment ΔF taken from the slope of the linear part of the load-deflection curve;

d_C is the depth of the core material (see D.2.1 where $d_c = D - (t_1 + t_2)$ i.e. the thickness of the two facings);

A_c is the cross sectional area of the core based on measured depth d_c;

L is the span of test specimen at shear failure.

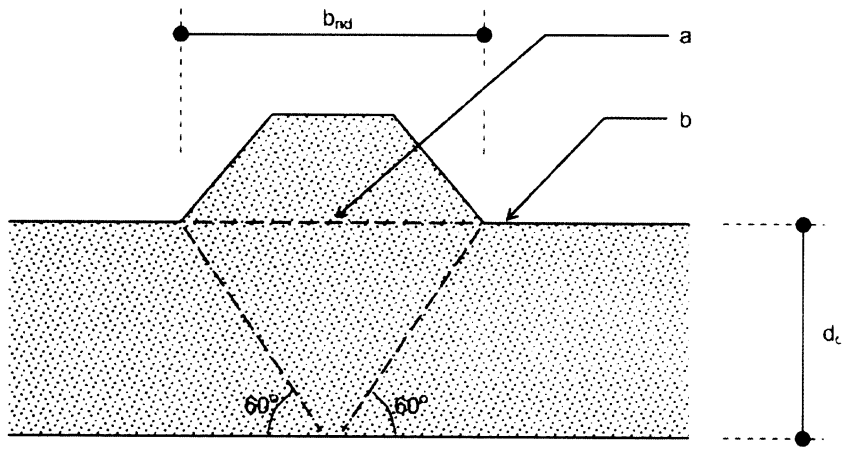
Recording and interpretation of test results shall comply with A.16.

The test report shall state both the mean and characteristic values (6.2.3) of the shear modulus in megapascals (MPa). The span shall be declared in the test report.

A.3.5.3 Incompletely bonded panels

If the core is not completely bonded with the faces the declared values shall be calculated using the following procedures based on the dimensions illustrated in Figure A.6.

It is important that the unbonded area on the full modular width of panel is not too large and that bonded areas have a safe minimum dimension. Manufacturer should test to ensure there is a safe functional dimension between unbonded areas.



Key

a unbonded area (b_{nd} = unbonded width)

b bonded area

d_c continuous depth of core

Figure A.6 Incompletely bonded panel

Where $b_{nd} \leq 2 \cdot d_c \cdot 0{,}58$ the unbonded area has only a small influence on the recorded values.

The declared value of the shear strength f_{Cv} shall be determined using Formula (A.5) and the shear modulus G_C using Formula (A.7).

Where $b_{nd} > 2 \cdot d_c \cdot 0{,}58$ the declared values shall be reduced in accordance with Formulae (A.8) and (A.9).

$$f_{Cv,red} = f_{Cv}\left(1-\frac{b_{nd}-1.16\,d_c}{p}\right) \tag{A.8}$$

$$G_{C,red} = G_C\left(1-\frac{b_{nd}-1.16\,d_c}{p}\right) \tag{A.9}$$

Where

f_{Cv} and G_C are determined using Formula (A.5) and Formula (A.7)

p is the pitch in accordance with Figure A.18.

Alternatively, the shear strength f_{Cv} and the shear modulus G_C shall be determined in accordance with A.4.

A.3.6 Test procedures, calculations and results – long term loading

A.3.6.1 Principle

Where required for design purposes for roof and ceiling applications, and if no tests are available, the long term shear strength at 2 000 h and 100 000 h shall be calculated as:

40 % of the short term value, if the φ_t is less or equal than 2,4 at 2 000 h

30 % of the short term value, if the φ_t is higher than 2,4 at 2 000 h.

Where φ_t is the creep coefficient according to A.6.5.

A.3.6.2 Procedure

Using the apparatus described in Figure A.4 at least 10 long term loading tests shall be carried out. These tests shall be carried out on nominally identical specimens subject to a range of loads, which shall be held constant after initial application. The loads shall be chosen such that the failures of $n \geq 10$ specimens are spread over the time interval 6 min $\leq t \leq$ 1 000 h. Specimens failing after $t >$ 1 000 h may also be incorporated into the analysis.

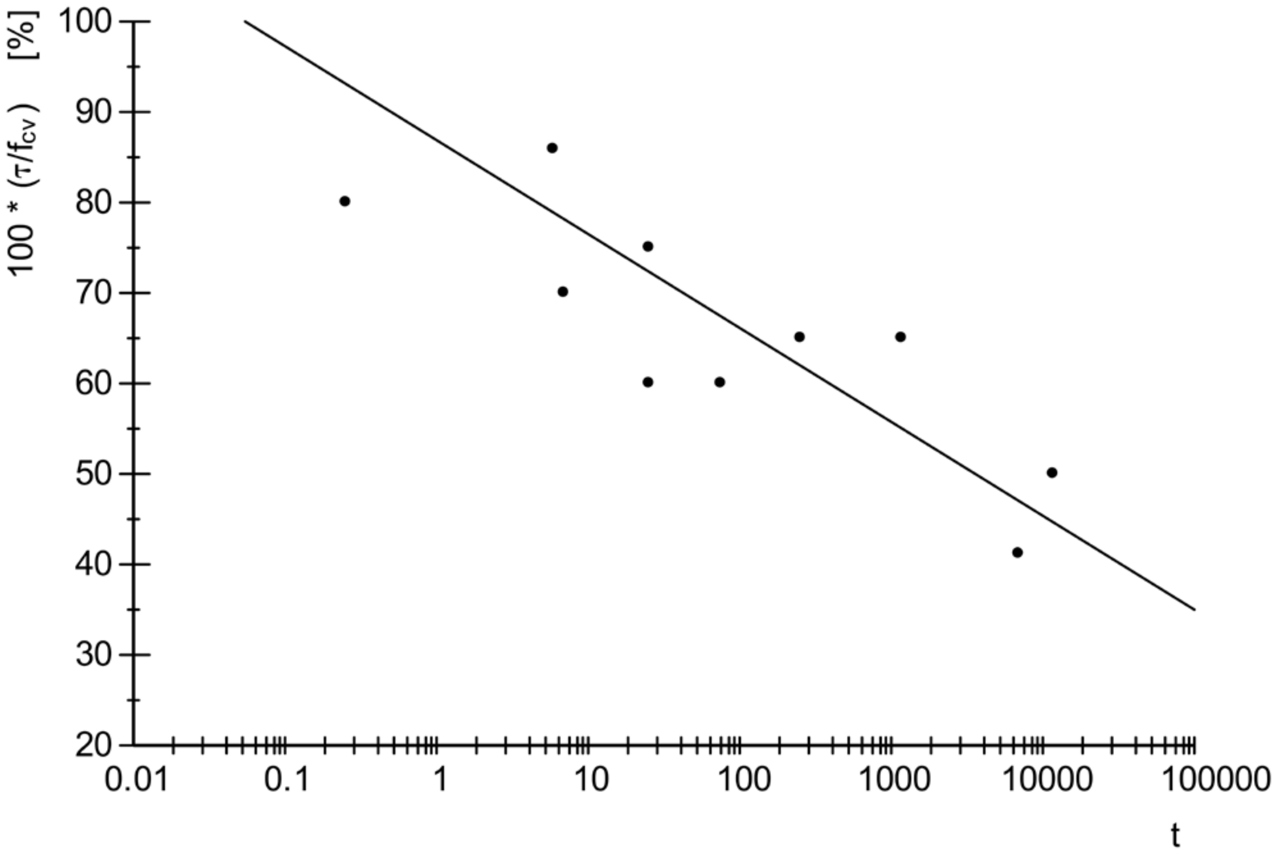
Deformation measurements are not required.

The tests shall be performed under normal laboratory conditions of temperature and humidity.

A.3.6.3 Results and calculations

Based on the test results for the failure loads, a straight regression line shall be drawn (see Figure A.7), in order to show the relationship of the mean long-term shear strength to the initial shear strength (short-term strength) as a function of the loading time plotted on a logarithmic scale.

The long-term shear strength at 2 000 h or 100 000 h shall be determined by extrapolation using the mean-value regression line.



Key

t time (hours)

τ shear stress in specimen

f_{Cv} shear strength (short-term)

Figure A.7 – Regression line showing long-term shear strength

A.4 Test to determine the shear properties of a complete panel

A.4.1 Principle

This test is an alternative to A.3 and offers a more reliable method of determining the shear strength and shear modulus of panels with lamella and pre-formed cores where joints between the core elements may affect the shear properties. The value determined by the test takes account of the influence of the end joint on the shear modulus.

NOTE 1 When this test is used for panels with profiled faces there may be a primary failure due to wrinkling in the profiled face and only a secondary failure due to the shear of the core. The achieved value can be used as the shear strength.

NOTE 2 The expressions to determine the shear properties of panels with profiled faces (see A.4.5.3 and A.4.5.5) become relatively complicated and require the use of design charts or computer software to find numerical solutions. Additional information on the formulae for sandwich panels of all types is given in 'Lightweight sandwich construction' [3].

A.4.2 Apparatus

The test load shall be applied using either line loads extending across the full width of the panel, as illustrated in Figure A.4 or in the form of a uniformly distributed load using either air pressure or a partial vacuum. When using a uniformly distribute load, the applied load shall be measured by means of load cells, not air pressure.

Steel load spreading plates are required below the load points and over the supports. When testing samples with profiled faces and line loads are used the load shall be applied through timber or steel transverse loading beams together with timber loading platens (see Figure A.12).

The width L_s of the load spreading plates shall not be less than 60 mm. This width may be increased as necessary in order to avoid local crushing of the core. The clear distance between the load plates and the support plates shall not be less than 1,2 dc. The thickness of the load spreading plates shall be between 8 mm and 12 mm.

The support conditions shall be such as to apply no restraint to the rotation of the panel about the lines of support.

A.4.3 Test specimens

Sampling and conditioning of the test specimens shall comply with 6.2.2 and 6.2.3.

The span *L* shall be chosen so that a shear failure is obtained.

For panels with discontinuous core material, tests shall be carried out on the full cover width of the panel with joints in the core material in the worst arrangement that may arise in practice but not at a distance from the support less than half the panel thickness.

The span should be chosen to be close to but less than the largest span that gives rise to a reliable shear failure recognised by the failure mode shown in Figure A.5. The recommended span for general use is 1 000 mm but for deep panels (dc > 100 mm) a larger span may be more appropriate. If the recommended chosen span does not result in a shear failure similar to that illustrated in Figure A.5, the span should be reduced in increments of 100 mm until a shear failure is obtained. Subsequent tests should then be carried out at the reduced span.

NOTE Joints in the core material near the support are more critical than joints near mid span.

At the discretion of the manufacturer, visible compressive deflection of the core material at the supports may be taken into account in the calculation of the shear modulus. If this is the case, visible deflections ws1 and ws2 over the supports shall be measured during the tests. The deflection w at mid span shall then be modified by subtracting

$\left(\frac{w_{s1} + w_{s2}}{2}\right)$ from the measured deflection *w*

where

w_{s1} and w_{s2} are the measured deflections of the top face of the specimen over the left and right hand supports respectively.

In EN 14509:2006, the deduction for visible compression at the supports was mandatory. However, subsequent detailed finite element analyses have suggested that making this deduction may not always result in the most accurate value of the shear modulus. For this reason, pending further research, making this deduction is now to be regarded as optional. There is no 'safe' procedure because introducing a low value of the shear modulus into the design calculations will generally result in more critical deflections together with less critical stresses in the faces, and vice versa. The manufacturer's decision should reflect which of these is considered to be the most critical factor in the design.

The net metal thickness, excluding all protective coatings, of both faces of each test specimen (t_{f1}, t_{f2}) shall be measured and recorded. The joint arrangement used in the tests shall be described in the test report.

A.4.4 Procedure

The test shall be carried out by subjecting a simply supported panel of full cover width to either two equally spaced line loads, or to a uniformly distributed load.

A uniformly distributed load may by applied using air pressure caused by either a partial vacuum chamber test apparatus or air bags (A.5).

Other load positions may be used and the properties calculated accordingly.

The loading rate shall be uniform and such as to result in failure between 1 min and 5 min after the commencement of the test. During the test the deflection shall be measured with a precision of 0,01 mm. The loading shall be continued until failure and a load-deflection curve shall be drawn.

The tests shall be performed under normal laboratory conditions of temperature and humidity.

A.4.5 Calculations and results

A.4.5.1 General

The load F_u at failure gives the shear strength of the complete panel including the contribution of both the core and faces.

A.4.5.2 Panels with flat or lightly profiled faces loaded using line loads

For panels with flat or lightly profiled faces subject to two line loads applied at the third points of the span the shear strength f_{Cv} shall be calculated as follows (A.10):

$$f_{Cv} = \frac{F_u}{2Be} \tag{A.10}$$

Where

F_u is the ultimate load carried by the specimen failing in shear including the self-weight and the weight of any loading equipment;

B is the width of the core of the specimen;

e is the measured depth between the centroids of the faces.

and the shear modulus G_C shall be as given in A.3.5.2 (Formula (A.7).

In cases where a vacuum box is used and the support area is not protected and therefore affected by air pressure, the measured support reaction shall be reduced by multiplying the measured total load by the ratio

$$\left(\frac{L - L_s}{L + L_s}\right)$$

Where

L_s is width of the support plate

A.4.5.3 Panels with one or two profiled faces using line loads

For panels with either one or two profiled faces subject to two load points applied at the third points of the span, the shear modulus G_C shall be calculated from the slope of the straight part of the load deflection curve $\left[\frac{\Delta F}{\Delta w}\right]$ using Formula (A.11):

NOTE This calculation is iterative as λ depends on the shear modulus which is initially unknown

Shear modulus $$G_C = \frac{\left(\frac{\Delta F}{\Delta w_s}\right) B_S L d_C^2}{6 A_C e^2 (B_S + B_D)(1+\alpha)} \quad \text{(A.11)}$$

Where

Shear deflection $\Delta w_s = \Delta w - \Delta w_B$

Δw is the deflection at mid-span for a load increment ΔF taken from the slope of the linear part of the load-deflection curve;

Bending deflection = $$\Delta w_B = \frac{\Delta F L^3}{B_S + B_D}\left[\frac{23}{1296} + \frac{1}{6\alpha\lambda^2} - \frac{\sinh\left(\frac{\lambda}{3}\right)\sinh\left(\frac{\lambda}{2}\right)}{\alpha\lambda^3 \sinh(\lambda)}\right]$$

A_c is the cross sectional area of the core;

d_C is the depth of the core

$\alpha = \frac{B_D}{B_S}$

$B_D = E_{F1} I_{F1} + E_{F2} I_{F2}$

$B_S = \frac{E_{F1} A_{F1} E_{F2} A_{F2} e^2}{E_{F1} A_{F1} + E_{F2} A_{F2}}$

$\beta = \frac{B_S d_C}{B e^2 G_C L^2}$

$\lambda = \sqrt{\frac{1+\alpha}{\alpha\beta}}$

and where the assumed geometry and the remaining symbols are given in E.1.

The shear strength f_{Cv} shall then be calculated as follows using Formula (A.12)):

$$f_{Cv} = \frac{F_u}{2(1+\alpha)A_C}\left[1-\frac{\sinh\left(\frac{\lambda}{3}\right)+\sinh\left(\frac{2\lambda}{3}\right)}{\sinh(\lambda)}\right] \quad \text{(A.12)}$$

A.4.5.4 Panels with flat or lightly profiled faces subject to vacuum chamber or air bag loading

For panels subject to a uniformly distributed load, the shear strength f_{Cv} shall be calculated using A.10.

The shear modulus shall be calculated from the slope of the straight part of the load deflection curve $\left[\frac{\Delta F}{\Delta w}\right]$ as follows (A.13)

Bending deflection $\Delta w_B = \dfrac{\Delta F\, L^3}{76{,}8\, B_S}$

Shear deflection $\Delta w_S = \Delta w - \Delta w_B$

Shear modulus $G_C = \dfrac{\left(\frac{\Delta F}{\Delta w_s}\right) B_S\, L\, d_C^2}{8\, A_C\, e^2 \left(B_S + B_D\right)(1+\alpha)}$ (A.13)

A.4.5.5 Panels with one or two profiled faces subject to vacuum chamber or air bag loading

For panels subjected to a uniformly distributed load, the shear modulus shall be calculated from the slope of the straight part of the load deflection curve $\left[\frac{\Delta F}{\Delta w}\right]$ using Formula (A.14), where the assumed geometry and symbols are given in E.1:

NOTE This calculation is iterative as it depends on the shear modulus which is initially unknown

Shear modulus $G_C = \dfrac{\left(\frac{\Delta F}{\Delta w_s}\right) B_S L d_C}{8Be^2\left(B_S + B_D\right)(1+\alpha)}$ (A.14)

Where

Bending deflection $\Delta w_B = \dfrac{\Delta F\, L^3}{\left(B_S + B_D\right)}\left[\dfrac{5}{384} - \dfrac{\cosh\left(\frac{\lambda}{2}\right)-1}{\alpha\lambda^4\cosh\left(\frac{\lambda}{2}\right)}\right]$

Shear deflection $\Delta w_s = \Delta w - \Delta w_B$

The shear strength f_{Cv} shall be calculated using Formula (A.15)

$$f_{Cv} = \frac{F_u}{(1+\alpha)\,A_C}\left[\frac{1}{2}-\frac{\sinh\left(\frac{\lambda}{2}\right)}{\lambda\cosh\left(\frac{\lambda}{2}\right)}\right] \quad \text{(A.15)}$$

For panels with other loading systems, the shear strength and modulus of the core material shall be determined by calculation. Where relevant, this calculation shall take account of the profiled faces.

Recording and interpretation of test results shall comply with A.16. The test report shall state both the mean and characteristic values (6.2.3) of the shear modulus and shear strength in megapascals (MPa). Only the mean value of the shear modulus obtained from the available test results shall be declared. The 5 %-fractile value shall be recorded for FPC purposes.

A.5 Test to determine the bending moment capacity of a simply supported panel

A.5.1 Principle

This test is used to determine the bending moment capacity of a panel in which the span *L* is sufficiently large to ensure a bending failure i.e. wrinkling, yielding or face buckling. The wrinkling stress for flat or lightly profiled faces, or the buckling or yield stress for profiled faces, shall then be determined by calculation.

NOTE There are a number of alternative load systems which simulate a uniformly distributed load on a panel. These all give similar results for the bending strength of the panel.

A.5.2 Apparatus

A.5.2.1 Loading arrangement

The test shall be carried out by subjecting a simply supported panel to four line loads (see Figure A.8 or Figure A.9) extending across the full width of the panel, or to air pressure caused by either a partial vacuum chamber test apparatus or air bags (see Figure A.10).

NOTE Each of these load systems gives rise to the same maximum bending moment.

$$M_u = \frac{F_u\,L}{8},$$

Where

F_u is the total ultimate load on the panel including the self weight of the panel itself and the weight of the loading equipment.

In general the load shall be measured by load cells located below the supports. Alternatively, if the load is applied by a jack and loading beams, it may be measured by a load cell at the point of application of the load.

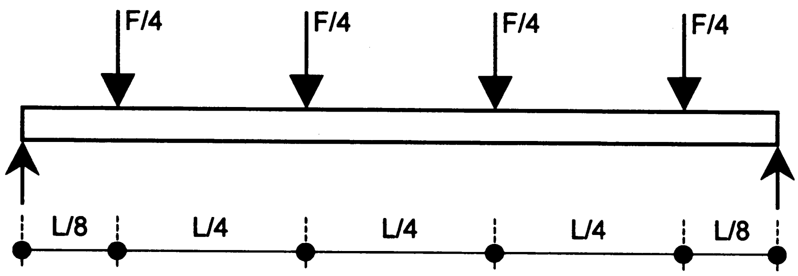


Figure A.8 – Simply supported panel: 4 line loads

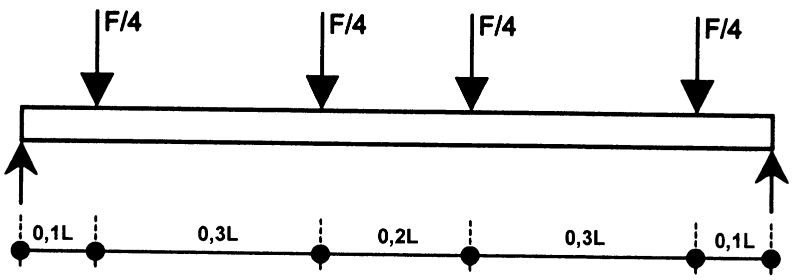
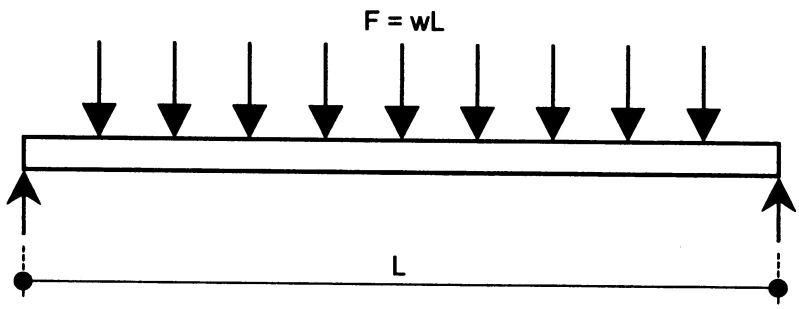


Figure A.9 – Simply supported panel: 4 line loads (alternative)



Key

w load per unit length

Figure A.10 – Simply supported panel: Air pressure

A.5.2.2 Support conditions

The support conditions shall be such as to apply no restraint to the rotation of the panel about the lines of support.

A suitable panel support detail is shown in Figure A.11. The width of the supports shall be sufficiently large to prevent local crushing of the core.

Timber blocks may be used to avoid deformation of a side rib which does not contain core material.

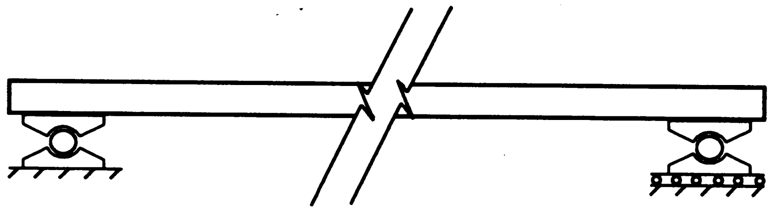


Figure A.11 – Panel support detail

A.5.2.3 Application of load to panel facings

Where line loads are applied to panels with lightly profiled faces, they shall be applied through loading platens (see Figure A.4).

Steel load spreading plates are required below the load points and over the supports. The width L_s of the load spreading plates at the support and load points shall be a minimum of 60 mm. This value shall be increased up to 200 mm, if necessary, in order to avoid local crushing of the core. The thickness of the load spreading plates shall be between 8 mm and 12 mm.

Where line loads are applied to a profiled face, they shall be applied through timber or steel transverse loading beams together with timber loading platens placed in the troughs of the profile (see Figure A.12). The width of the loading platens shall be sufficient to avoid compressive failure of the core below the platens.

A layer of felt, rubber or other similar material may be placed between the loading platens and the panel in order to reduce the possibility of local damage.

Line loads should not be applied directly to an incompletely bonded profiled face, i.e. a face where there are voids below the profile.

The loads shall be maintained perpendicular to the panel throughout the test.

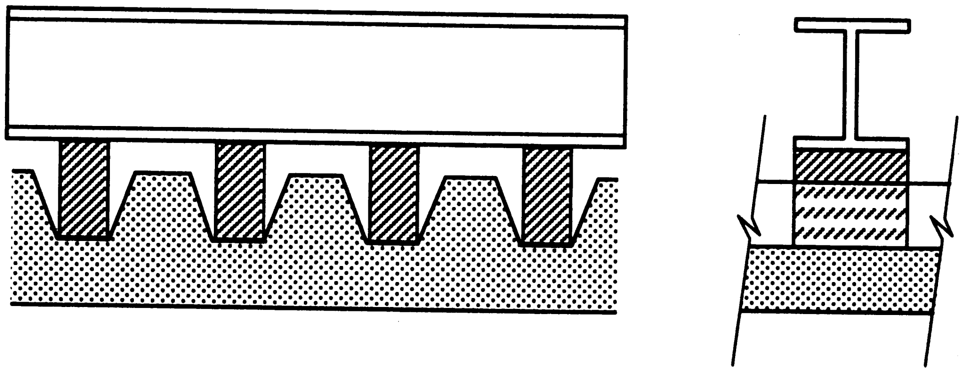


Figure A.12 – Loading platens for profiled facings

If the trough of the profile includes rolled-in stiffeners, the loading platens shall be shaped appropriately (see Figure A.13).

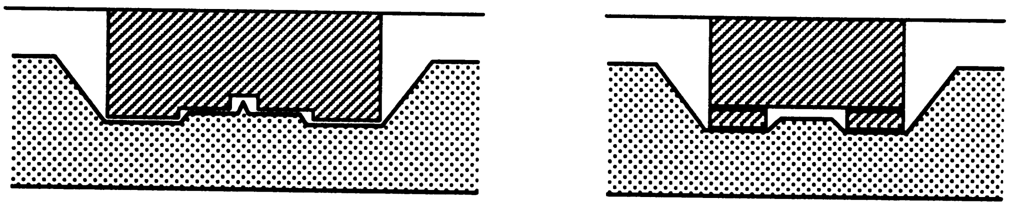


Figure A.13 – Loading platens for facings with stiffeners

A.5.3 Test specimens

The necessary span is dependent on several factors including the overall depth d_c of the panel and shall be chosen to give a bending failure.

NOTE 1 The values in Table A.1 are offered for guidance.

Table A.1 – Indicative span criteria to obtain bending failure

Overall depth of panel (d_c)	Indicative span (L)
d_c < 40mm	3,0 m
40 mm ≤ d_c < 60 mm	4,0 m
60 mm ≤ d_c < 100 mm	5,0 m
d_c ≥ 100 mm	≥ 6,0 m

If the span values in Table A.1 are found to give rise to a shear failure, they shall be increased in increments of 1,0 m until a bending failure is obtained.

In the case of panels of the same type but with different face-thickness, at least panels with the thinnest face shall be tested.

NOTE 2 There may be an advantage in testing more than one face thickness to obtain improved wrinkling stress values.

A.5.4 Procedure

For all panels, including those with similar upper and lower faces, this test shall be carried out on both orientations of the panel because the wrinkling stress may be greatly influenced by whether the face was at the top or bottom of the panel during manufacture.

Prior to the test a small load, which shall be not greater than 10 % of the failure load, shall be applied for no more than 5 min and then removed.

The tests shall be performed under normal laboratory conditions of temperature and humidity.

The panel shall be loaded steadily in at least 10 increments until failure occurs. The loading rate shall be such as to result in failure between 5 min and 15 min after the commencement of the test. Both the load and the central deflection shall be recorded. Displacement transducers shall have an accuracy of 0,1 mm.

After completion of the test, the net metal thickness excluding all protective coatings and yield stress of each face shall also be determined from a minimum of three specimens per panel and recorded.

A.5.5 Calculations and results

A.5.5.1 General

Recording and interpretation of test results shall comply with A.16.

The failure load and the nature and location of the failure shall be recorded. A load-deflection curve shall be drawn for the central displacement.

A.5.5.2 Determination of the bending moment capacity (M_u)

The bending moment capacity M_u shall be given by Formula (A.16):

$$M_u = \frac{F_u L}{8} \tag{A.16}$$

Where

M_u is the ultimate bending moment recorded in the test including the effect of the self-weight of the specimen and the mass of the loading equipment;

F_u is the total load recorded in the test including an allowance for the self weight of the panel and the weight of the loading equipment.

The bending moment values determined from the tests shall additionally be corrected by the correction factors set out in A.5.5.4 and A.5.5.5 prior to obtaining the characteristic values to be declared.

A.5.5.3 Determination of the wrinkling stress (σ_w) of a flat or lightly profiled face or the local buckling stress of a profiled face

The wrinkling stress σ_w is only directly relevant for panels where the face in compression is fully bonded and either flat or lightly profiled. However, for the purposes of this European Standard, the term 'wrinkling stress σ_w' is also taken to include local buckling of a profiled face in compression, whether fully or incompletely bonded to the core.

The wrinkling stress of a panel shall be obtained by first determining the ultimate bending moment. The face stress at failure shall then be determined by calculation.

For panels of nominally identical inner and outer faces, the wrinkling stress for design purposes shall be based on the least favourable wrinkling stress.

NOTE 1 Due to the way that the foam or adhesive is laid down during manufacture, it is possible for nominally identical upper and lower faces to have significantly different wrinkling stresses. This requirement recognises that it may not be possible to identify which face was uppermost during manufacture once the product has left the factory.

If the face under tension is flat or lightly profiled the wrinkling stress σ_w shall be determined from the bending moment in accordance with Formula (A.17):

$$\sigma_w = \frac{M_u}{e\, A_{F1}} \tag{A.17}$$

where

e is the depth between centroids of the faces;

A_{F1} is the cross-sectional area of the face in compression.

If the face under tension is profiled, the wrinkling stress σ_w shall be determined from the ultimate test load in accordance with Formula (A.18):

$$\sigma_w = \frac{F_u L}{(1+\alpha) e A_{F1}} \left[\frac{1}{8} - \frac{\cosh\left(\frac{\lambda}{2}\right) - 1}{\lambda^2 \cosh\left(\frac{\lambda}{2}\right)} \right] \tag{A.18}$$

Where the assumed geometry is given in E.1 and the symbols are as defined with Formula (A.11).

NOTE 2 λ is dependant upon the shear modulus (see A.3 or A.4).

The wrinkling stress calculated in this way shall not exceed the yield stress of the face material.

The wrinkling stress values determined from the tests shall additionally be corrected by the correction factors set out in A.5.5.4 and A.5.5.5 prior to obtaining the characteristic values to be declared.

In the case of panels of the same type but with different face-thickness, where only panels with the thinnest face have been tested the wrinkling stresses for thicker faces shall be determined using Formula (A.19):

$$\sigma_{w,t_2} = f \cdot \sigma_{w,t_1} \tag{A.19}$$

where

$\sigma_{w,t2}$ is the wrinkling stress of a thicker face, t_2;

$\sigma_{w,t1}$ is the wrinkling stress of the thinnest face, t_1;

f is the reduction factor = $\frac{A_1 \times \sqrt[3]{I_2}}{A_2 \times \sqrt[3]{I_1}}$

A_1, I_1 is the cross-sectional area and moment of inertia of the face with t_1;

A_2, I_2 is the cross-sectional area and moment of inertia of the face with t_2.

For panels without joints in the core the wrinkling stress σ_w may be determined, as an alternative to testing, by Formula (A.20):

$$\sigma_w = \alpha \sqrt[3]{G_C E_C E_F} \tag{A.20}$$

Where

E_C is the mean of the mean values of the tensile and compressive moduli of the core material, Formula (A.21).

$$E_C = \frac{E_{Ct} + E_{Cc}}{2} \tag{A.21}$$

G_C is the mean shear modulus of the core material;

E_F is the modulus of elasticity of the face material in compression.

α is a numerical value which is generally greater than 0,5. In the absence of large scale tests, σ_w may be determined by calculation with α = 0,5.

NOTE 3 Although, in most cases, the design value of the wrinkling stress may be calculated, more favourable values of the wrinkling stress will generally be obtained by testing.

NOTE 4 Local buckling of a profiled face in compression generally causes a non-uniform stress distribution in the elements of the profile and this in turn causes an apparent reduction in the yield stress. This effect is resisted by the core material and is, therefore, more significant when the profile is not filled with fully-bonded core material as in an incompletely bonded panel. For the purposes of this European Standard, the wrinkling stress σ_{yr} is the apparent yield stress when this effect is taken into account.

If the face in compression is profiled and the other face is either flat or lightly profiled, the wrinkling stress σ_{yr} shall be determined from the bending moment in accordance with Formula (A.22):

$$\sigma_{yr} = \frac{M_{Su}}{e\,A_{F1}} + \frac{M_{Du}\,E_{F1}\,d_{11}}{B_F}, \qquad \text{(A.22)}$$

Where

$$M_{Su} = \frac{F_u\,L}{1+\alpha}\left[\frac{1}{8} - \frac{\cosh\left(\frac{\lambda}{2}\right)-1}{\lambda^2\cosh\left(\frac{\lambda}{2}\right)}\right]$$

$$M_{Du} = \frac{F_u\,L\,\alpha}{1+\alpha}\left[\frac{1}{8} + \frac{\cosh\left(\frac{\lambda}{2}\right)-1}{\alpha\,\lambda^2\cosh\left(\frac{\lambda}{2}\right)}\right]$$

If both faces are fully profiled, Formula (A.22) shall be replaced by the appropriate formulae from E.7.2.5.

A.5.5.4 Correction factors to be applied to test results for bending moment capacity and wrinkling stress

The following correction factors shall be used within the range of tolerance whenever the measured thickness t_{obs} is less than the design value t and/or the measured yield stress $f_{y,obs}$ is greater than the design yield strength.

For the failure of the profiled metal face in compression [wrinkling] the individual test results shall be adjusted according to the following Formulae (A.23a) and (A.23b):

$$R_{adj,i} = R_{obs,i}\left(\frac{f_y}{f_{y,obs}}\right)^{\alpha}\left(\frac{t}{t_{obs}}\right)^{\beta} \quad \text{[wrinkling stress calculation.]} \qquad \text{(A.23a)}$$

NOTE 1 Formula (A.23a) is also applicable to all tests intended solely for design by testing.

$$R_{adj,i} = R_{obs,i}\left(\frac{f_y}{f_{y,obs}}\right)^{\alpha}\left(\frac{B}{B_{obs}}\right)^{\beta} \quad \text{[bending moment capacity calculations]} \qquad \text{(A.23b)}$$

Where

$R_{obs,i}$ is the result of test number *i*;

$R_{adj,i}$ is the test result modified to correspond to the design values of metal thickness and yield stress;

f_y is the design yield stress;

$f_{y,obs}$ is the yield stress measured in the test specimen;

$B = B_F + B_S$ Bending stiffness with t and e;

$B_{obs} = B_{F,obs} + B_{S,obs}$ Bending stiffness with t_{obs} and e_{obs}.

Where

$$B_F = E_{F1}\, I_{F1} + E_{F2}\, I_{F2}$$

$$B_{F,obs} = E_{F1}\, I_{F1}\, \frac{t_{1,obs}}{t_1} + E_{F2}\, I_{F2}\, \frac{t_{2,obs}}{t_2}$$

$$B_S = \frac{E_{F1}\, A_{F1}\, E_{F2}\, A_{F2}\, e^2}{\left(E_{F1}\, A_{F1} + E_{F2}\, A_{F2}\right)}$$

$$B_{S,obs} = \frac{E_{F1}\, A_{F1}\, \frac{t_{1,obs}}{t_1}\, E_{F2}\, A_{F2}\, \frac{t_{2,obs}}{t_2}\, e_{obs}^2}{\left(E_{F1}\, A_{F1}\, \frac{t_{1,obs}}{t_1} + E_{F2}\, A_{F2}\, \frac{t_{2,obs}}{t_2}\right)}$$

And all A_F and I_F are calculated with nominal geometry

t is the design metal thickness;

t_{obs} is the metal thickness measured in the test specimen;

e is the design distance between centroids of the faces;

e_{obs} is the distance between the faces on the basis of the measured geometry;

$\alpha = 0$ if $f_{y,obs} \le f_y$ and for flat and lightly profiled faces.

$\alpha = 1$ if $f_{y,obs} > f_y$

except that, for the compression failure mode of a profiled face:

$\alpha = 0{,}5$ if $f_{y,obs} > f_y$ and $\frac{b}{t} > 1{,}27\sqrt{\frac{E_F}{f_y}}$

In general:

β = 0 when calculating the wrinkling stress from test results, or

β = 1,0

except that, for the compression failure mode of a profiled face:

$\beta = 1{,}0$ if $t_{obs} \le t$

β = 1,0 if $t_{obs} > t$ and $\frac{b}{t} \leq 1{,}27\sqrt{\frac{E_F}{f_y}}$

β = 2,0 if $t_{obs} > t$ and $\frac{b}{t} > 1{,}27\sqrt{\frac{E_F}{f_y}}$

where

$\frac{b}{t}$ is the width to thickness ratio of the widest part of the profiled face

and

b is the width of top of profiled face (rib) (see Figure D.15);

t is the thickness of flange material.

The values $R_{adj,i}$ shall be used to represent the individual test results in the evaluation of characteristic strengths and resistances.

NOTE 2 For steel faces the design value for the wrinkling strength σ_w may be chosen equal to the nominal yield strength f_y if each individual tested value for the wrinkling strength $\sigma_{w,obs,i}$ exceeds the measured yield strength of the face material.

A.5.5.5 Correction factors for bending moment capacity and wrinkling stress

The wrinkling stress or the bending moment capacity obtained from original tests shall be corrected with the following correction factor k in order to obtain the value to be declared.

NOTE This factor takes account of the reduction in the wrinkling stress caused by higher temperatures (k_1) and the additional variability in the case of low cross-panel tensile strength (k_2).

$$k = k_1 \cdot k_2$$

For panels in external end use applications with a lightly profiled or flat face in compression (wrinkling) and with a face temperature higher than +20 °C according to the design procedure (E.3), the individual test results shall be reduced according to Formula (A.24):

$$k_1 = \sqrt[3]{\left(\frac{E_{Ct,+80^o C}}{E_{Ct,+20^o C}}\right)^2} \quad \text{(A.24)}$$

Where

$E_{Ct,+20\,°C}$ is the tensile characteristic cross panel E-modulus at 20 °C;

$E_{Ct,+80\,°C}$ is the tensile characteristic cross panel E-modulus at 80 °C.

In all other cases k_1 = 1,0.

For the failure of the lightly profiled or flat face in compression (wrinkling) the individual test results shall be adjusted additionally according to the following procedure:

$$k_2 = (6{,}10 \times f_{Ct} + 0{,}39)$$

and $k_2 \leq 1{,}0$

where

f_{Ct} is the characteristic cross panel tensile strength (MPa);

k_2 shall only be used in the case of a uniformly distributed load i.e. vacuum chamber, air bag or similar.

A.6 Determination of the creep coefficient (φ_t)

A.6.1 Principle

Where required for the design of roof or ceiling panels, a single test on a simply supported panel with a constant uniform load shall be sufficient to determine the creep coefficient for a particular core material.

A.6.2 Apparatus

The test shall be carried out by subjecting a simply-supported panel (Figure A.10) to a uniformly distributed dead load.

NOTE The creep test is usually carried out by loading the panel with weights because of the difficulty of maintaining any other form of loading constant for the required length of time.

A.6.3 Test specimens

The test shall be carried out on a complete panel of span ‘L’ equal to that used for the bending test in A.5.

Where the range of thickness is up to 200 mm the thickest panel shall be tested. If the thickest panel exceeds 200 mm, it is sufficient to test a panel of 200 mm thickness. However, it is permissible to test greater thicknesses.

A.6.4 Procedure

The test shall be carried out by subjecting a simply-supported panel to uniformly distributed dead load. The panel shall be supported on two lines of support distance ‘L’ apart with the exterior face upwards. The load used for the creep test shall be chosen to give rise to a maximum shear stress in the core not less than 30 % of the shear strength to be declared. After application, this load shall remain constant for a minimum of 1 000 h. Deflections at mid span shall be measured at two locations close to the longitudinal edges of the panel using dial gauges or equivalent transducers capable of a resolution of 1 % of the static deflection anticipated.

NOTE 1 The load used for creep tests is not unduly critical.

Deflection measuring devices shall be set to zero with the panel freely supported under its own weight. Prior to the placing of the load, the panel shall be propped from below on a minimum of two lines located at the third points of the span in such a way that the propping can be removed quickly and smoothly in order to initiate the test. Hydraulic or pneumatic prop removal is to be preferred. The props shall be located at levels that retain the unloaded shape of the panel as the load is applied. The static self-weight deflections may then be calculated and the props may then be positioned to raise the panel by the calculated amount. Alternatively, the initial deflections may be corrected for the calculated self-weight deflection at the conclusion of the test. Deflection measurements at mid span shall commence as soon as the full load is applied and the props removed and shall be recorded regularly for the duration of the test. As a minimum, deflections shall be recorded at 30 s, 1 h and 24 h after removal of the props and then at intervals of 24 h for the first week and 48 h thereafter. The final deflection shall be recorded just before removal of the load. The graph of deflection versus time should be smoothly continuous for the duration of the test otherwise the test shall be repeated.

The initial deflection ‘w_0‘ at time $t = 0$ shall be determined by extrapolating the deflection versus time curve back to the starting time. Alternatively, this value may be determined by calculation.

NOTE 2 It is preferable to use both methods of determining w_0 and to check one against the other.

A.6.5 Calculations and results

A.6.5.1 Recording and interpretation

Recording and interpretation of test results shall comply with A.16.

On the basis of the results of the tests within the time range 0 > t ≥ 1 000 h, the creep coefficients required for design shall be determined by extrapolation using a linear approximation to the deflection versus time curve on a semi-logarithmic diagram.

NOTE 1 Creep behaviour and its treatment for the purposes of design is described in Annex E.

NOTE 2 The creep coefficient is generally required at t = 2 000 h for snow load and t = 100 000 h for permanent actions (self-weight), see E.7.6.

A.6.5.2 Creep coefficient (core) for lightly profiled panels (φ_t)

The creep coefficient for the core of a lightly profiled sandwich panel shall be determined using Formula (A.25):

$$\varphi_t = \frac{w_t - w_0}{w_0 - w_b} \tag{A.25}$$

Where

w_t is the deflection measured at time t,

w_0 is the initial deflection at the time t = 0 and

w_b is the deflection caused by the elastic extension of the faces (without shear deformation).

If, prior to the commencement of the test, at zero deflection, the panel is supported in such a way that its self weight is carried by the support system, w_0 shall be multiplied by the factor (1 + g/q) where g is the self weight of the panel and q is the applied load.

NOTE If the deflections are determined from the graph of deflection versus time at t_1 = 200 h and t_2 = 1 000 h, the required creep coefficients may be determined as follows:

$$\varphi_{2000} = 1{,}2(1{,}43\varphi_{1000} - 0{,}43\varphi_{200}) = 1{,}7(\varphi_{1000} - 0{,}3\varphi_{200})$$

$$\varphi_{100000} = 3{,}86\varphi_{1000} - 2{,}86\varphi_{200}$$

A.6.5.3 Creep coefficient (core) for deeply profiled panels (φ_t)

The deflections caused by the bending and shear deformations of a sandwich panel with strongly profiled faces cannot be separated in the expression for the deflection because the distribution of the bending moment into the sandwich component M_S and the facing components M_{Fl}, M_{F2} depends on the shear stiffness of the core (see E.7.2.4). The creep coefficient shall be evaluated on the basis of the measured deflections as a function of the time.

If one or both faces of a sandwich panel are profiled, the creep coefficient shall be evaluated from Formula (A.26).

$$\varphi_t = \frac{\beta(C_D - 1)}{\beta_1(1 - \beta - \beta\rho(C_D - 1))} \tag{A.26}$$

Where

$C_D = \frac{w_t}{w_0}$ is the relationship between the deflection after a loading time of *t* and the initial deflection;

$\rho = 0{,}5$ is a relaxation coefficient, having here the value of 0,5.

$$\beta = \frac{I_F}{I_W}$$

$$I_W = I_F + \frac{I_S}{1+k}$$

Where

I_F is the moment of inertia of the profiled face(s) (sum if both faces are profiled);

I_S is the moment of inertia of the sandwich part (see Annex E);

$$k = \frac{\pi^2 \times E_{F2} \times A_{F2}\, e^2}{\left(\frac{A_{F2}}{A_{F1}} + 1\right) \times G_C \times A_C \times L^2}$$

$$\beta_1 = \frac{k\,\beta}{1+k}$$

Where

e is the measured depth between centroids of the faces;

L is the span of panel used in creep test.

NOTE If the deflections are determined from the graph of deflection versus time at t_1 = 200 h and t_2 = 1 000 h, the required creep coefficients may be determined with the formulae given in A.6.5.2, Note.

For declaration, φ_{2000} shall be declared for applications where snow lies for significant periods and φ_{100000} shall be declared for general roof and ceiling applications.

A.7 Interaction between bending moment and support force

A.7.1 Principle

This test is used to determine the interaction between bending moment and support force at the serviceability limit state. It simulates the conditions at an internal support of a panel which is continuous over two or more spans. The bending strength shall be first determined and the corresponding wrinkling stress for flat or lightly profiled faces or the buckling or yield stress for profiled faces shall then be determined by calculation.

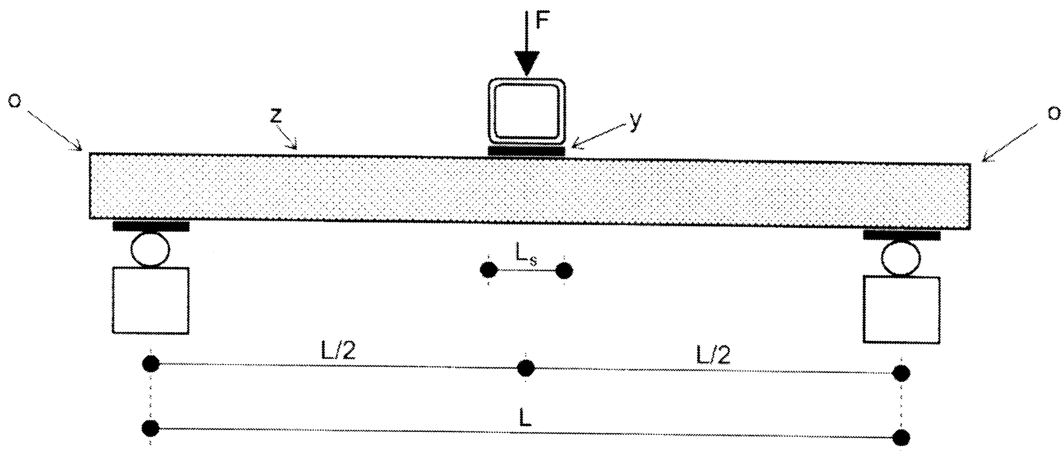
The interaction between bending moment and support reaction force shall be determined from a single span panel subject to a line load.

NOTE 1 This is often referred to as the “simulated central support test” because it simulates the conditions in the central support of a two-span beam (see Figures A.14 and A.15).

NOTE 2 The ultimate limit state is determined for zero bending moment at an internal support, see E.4.3.2.

A.7.2 Apparatus

The test arrangement for the interaction between bending moment and support reaction force shall be a single span panel subject to a line load.



Key

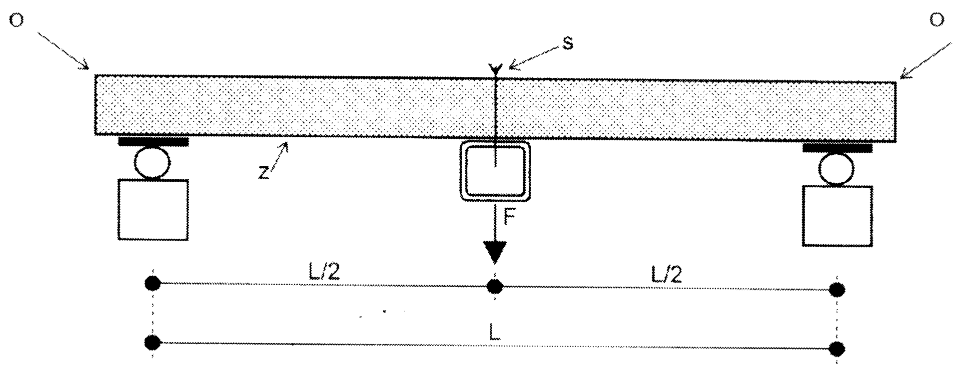
z face against support in practice

y sheet metal strip approximately 60 mm × 4 mm

L span

o overhang beyond the end of the support plate not exceeding 50 mm

Figure A.14 – Simulated central support test – downward load



Key

z face against support in practice

s screws

L span

o overhang beyond the end of the support plate not exceeding 50 mm

Figure A.15 – Simulated central support test – uplift load

A.7.3 Test specimens

The tests shall be carried out on a full panel width and span according to A.7.4.

For the uplift load test the fixing detail and the number and type of screws and washers shall conform to those used in practice.

A.7.4 Procedure

In order to determine the wrinkling stress at an intermediate support two types of test shall be carried out:

a) tests which simulate downward load (see Figure A.14);

b) tests which simulate uplift load (see Figure A.15).

It is important that the span shall be sufficient to ensure that:

— for test a), the compressive force between the panel and the support (under the line load) at the time of wrinkling failure shall be less than the support reaction capacity of the panel. For the purposes of this test, the support reaction capacity shall be determined as the product of the characteristic compressive strength of the core material and the contact surface area of the loading platen simulating the support;

— and for test b), the forces in the fasteners at wrinkling failure of the panel are less than their design values.

NOTE 1 This ensures that all failure modes (wrinkling of the face, compressive failure of the core and tensile failure of the connection) are designed for approximately equal levels of safety.

NOTE 2 If the test is carried out on a shorter specimen than that described, the failure mode is likely to be dominated by core crushing and a conservative value of the wrinkling stress will be obtained.

A.7.5 Calculations and results

Recording and interpretation of test results shall comply with A.16.

The failure load and the nature and location of the failure shall be recorded. A load-deflection curve shall be drawn for the displacement at the load position.

The bending moment capacity shall be given by Formula (A.27):

$$M_u = \left[\frac{F_u}{4} + \frac{F_G}{8}\right] L \tag{A.27}$$

Where

F_u is the ultimate load including the weight of the loading system;

F_G is the self-weight of the panel.

The bending moment capacity determined in this way shall be corrected using the procedures given in A.5.5.4 and A.5.5.5 prior to the determination of the characteristic values to be used in design (see E.4.2). The wrinkling stress shall then be determined from the characteristic ultimate moment using the procedure given in A.5.5.3.

For a panel with one or both faces fully profiled, the test shall be evaluated as follows:

The sandwich component of bending moment M_S shall be evaluated as follows:

$$M_s = \frac{F_u L}{1+\alpha}\left(\frac{1}{4} - \frac{\sinh\left(\frac{\lambda}{2}\right)^2}{\lambda \sinh(\lambda)}\right) + \frac{F_G L}{1+\alpha}\left(\frac{1}{8} - \frac{\cosh\left(\frac{\lambda}{2}\right) - 1}{\lambda^2 \cosh\left(\frac{\lambda}{2}\right)}\right)$$

The face component of bending moment M_D shall be evaluated as follows:

$$M_D = \frac{F_u L\alpha}{1+\alpha}\left(\frac{1}{4} + \frac{\sinh\left(\frac{\lambda}{2}\right)^2}{\alpha\lambda \sinh(\lambda)}\right) + \frac{F_G L\alpha}{1+\alpha}\left(\frac{1}{8} + \frac{\cosh\left(\frac{\lambda}{2}\right) - 1}{\alpha\lambda^2 \cosh\left(\frac{\lambda}{2}\right)}\right)$$

The components of bending moment capacity determined in this way shall be corrected using the procedures given in A.5.5.4 and A.5.5.5 prior to the determination of the characteristic values to be used in design (see E.4.2). The wrinkling stress of the face in compression shall then be determined from the components of ultimate moment using the formulae given in E.7.2.5.

A.8 Determination of apparent core density and mass of panel

A.8.1 Determination of apparent core density

A.8.1.1 Principle

The apparent density ρ_c shall be determined according to EN 1602.

A.8.1.2 Apparatus

The apparatus shall be as defined in EN 1602.

A.8.1.3 Test specimens

Specimens shall be taken during the production of the sandwich panels as follows:

(a) Panels with core material from slabstock or lamella bonded to faces:

Three specimens of the core material with the dimensions 100 mm x 100 mm x thickness shall be taken before bonding.

(b) Panels with auto-adhesive bonded PUR core:

Three specimens including the faces with the dimensions 100 mm x 100 mm x thickness shall be cut from positions covering the width of the panel (see Figure A.16).

Dimensions in millimetres

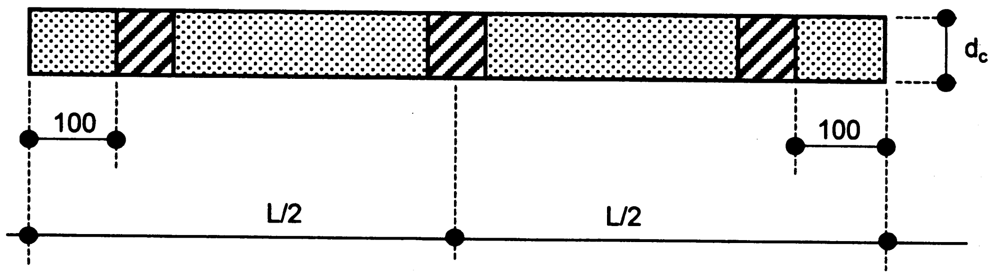


Figure A.16 – Location of test specimens – density test

The faces shall be removed carefully (e.g. by cutting) with the remaining core specimens to be orthogonal. The thickness of the cut off core material shall not exceed 3 mm at each face.

For panels with profiled faces specimens shall be cut from the predominant thickness (see examples in Figure A.1).

A.8.1.4 Procedure

The procedure shall be as defined in EN 1602.

A.8.1.5 Calculations and results

Calculations shall be as defined in EN 1602. Recording and interpretation of test results shall comply with A.16.

A.8.2 Determination of mass of a panel

The mass of the panel shall be determined by calculation based on the nominal dimensions and nominal densities of the core material and faces.

The mass of the panel is required for the design of roofs and ceilings and also seismic calculations for certain applications. It is also useful for handling purposes and shall be recorded on the accompanying documentation.

A.9 Test for resistance to point loads and repeated loads

A.9.1 Panels subject to point loads

A.9.1.1 Principle

This test checks the safety and serviceability of roof or ceiling panels e.g. with respect to a single person walking on the panel, for occasional access both during and after erection.

A.9.1.2 Apparatus

Simply supported panel with central load.

A.9.1.3 Test specimens

The test specimen shall be a single panel of full width. The length (span) shall be the largest envisaged in practice.

A.9.1.4 Procedure

The tests shall be carried out on single span panels of full width.

A load of 1,2 kN shall be applied unless required otherwise by national regulatory requirements. The load shall be applied at mid-span on the edge rib or on the edge of a flat panel through a timber block measuring 100 mm x 100 mm. In order to avoid local stresses, a 10 mm thick layer of rubber or felt shall be placed between the timber block and the metal skin of the panel.

A.9.1.5 Observations and recommendations

Panels shall sustain a point load giving rise to three possible outcomes:

a) if the panel carries the applied load without permanent visible damage, there are no restrictions for occasional access onto the roof or ceiling either during or after erection;

b) if the panel supports the load but with permanent visible damage, measures shall be taken to avoid damage during erection (e.g. walking boards). Furthermore, there shall be no provision for access to the roof after building work is completed;

c) if the panel fails to support the load it shall be used only on roofs or ceilings where no walking access is possible/permitted. This limitation shall be clearly indicated on the panel (or elsewhere).

NOTE This is mainly a problem for panels with a flat upper face.

Recording and interpretation of test results shall comply with A.16.

A.9.2 Panels subject to repeated loads

A.9.2.1 Principle

This test checks the safety and serviceability of roof or ceiling panels e.g. with respect to a single person walking on the panel, for repeated access both during and after erection.

NOTE In the absence of a small-scale test which can satisfactorily replicate the effect of repeated heel impacts at varying locations within a panel, this test aims to reproduce the actual behaviour over a small area of a full sized panel.

A.9.2.2 Specimen

A single panel of length approximately 5,7 m and full cover width. This panel shall be conditioned for at least 24 h under normal laboratory conditions prior to the test.

A line shall be drawn down the centre line of the panel and eight squares, each measuring 100 mm × 100 mm, shall be clearly marked on the upper face of the panel at 600 mm centres as shown in Figure A.17. Rigid lines of support, each providing a bearing width of 75 mm ± 5 mm shall be provided at 1 200 mm centres as shown. Sufficient restraint shall be provide to ensure that the panel cannot move with respect to the points of support as a person walks on the panel.

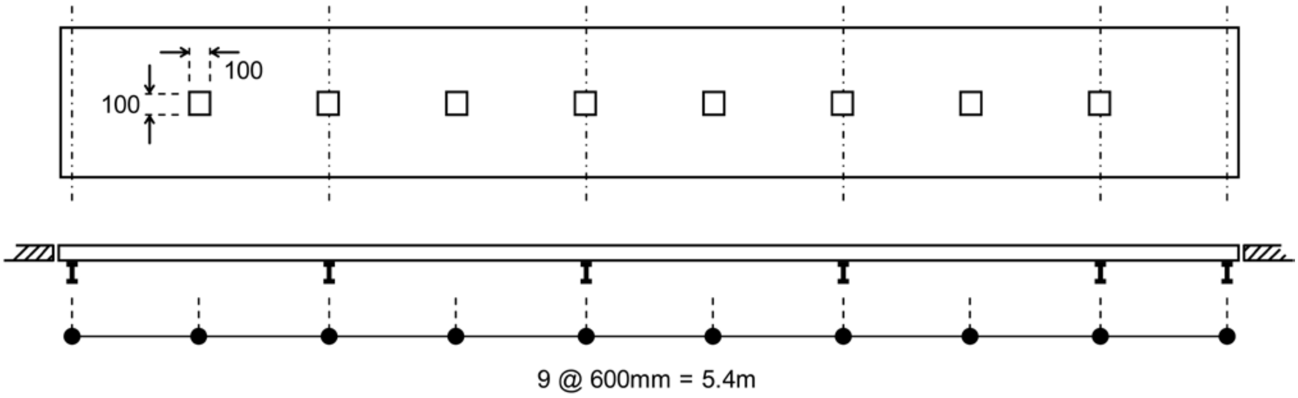


Figure A.17 – General arrangement of panel for repeated loading tests

A.9.2.3 Repeated loading procedure

The test shall be carried out by a person carrying a toolbox (if required). The total weight of the person plus toolbox shall be at least 90 kg and the person shall wear standard protective footwear with no significant wear at the heel where it impacts the panel when walking. The person shall walk backwards and forwards across the panel turning at each end on a platform that is clear of the panel. During each passage of the panel, care shall be taken to ensure that a heel impact takes place within each of the squares drawn on the surface of the panel. The actual location of these impacts within the squares should be random, i.e. it is important that the heel does not impact the same points on each passage.

After 500 passages, a plywood sheet of minimum thickness 12 mm shall be placed over two of the squares, one in a span and the other over a support, so that these are protected from any further direct heel impact. After a total of 1 000 passages, a further two such squares shall be similarly protected. This part of the test shall be terminated after a total of 2 000 passages across the specimen. The eight marked squares shall then be carefully cut out from the panel. Three similar squares shall also be cut out from random parts of the panel remote from the line of walking.

The metal faces of the 11 panel samples shall be bonded to tensile plates with an adhesive and they shall be tested to determine their cross-panel tensile strength in accordance with A.1.4.

A.9.2.4 Calculations and results

For each specimen, the cross panel tensile strength (f_{Ct}) shall be calculated as in A.1.5.1 using $f_{Ct} = \frac{F_u}{A}$

The average tensile strength shall be calculated ($f_{Ct,0}$) for the three specimens taken from points remote from the walking route.

The test results shall be plotted on a graph of tensile strength versus number of heel impacts including $f_{Ct,0}$. The test series is valid in there is a progressive deterioration of the tensile strength with number of cycles.

NOTE In the nature of this test, a significant scatter of test results is to be expected. The results may also be influenced by the care taken to cut test specimens, which may have already been weakened by repeated impacts, from the complete panels. It would, therefore, be optimistic to expect the test results to give rise to smooth curves, a generally decreasing trend with number of cycles is all that is required.

The test shall be interpreted on the basis of the four results for specimens subjected to 2 000 cycles of load. If these form a compact block of results, the characteristic value of the reduced tensile strength, $f_{Ct,2000}$, shall be taken as the mean of the four relevant values of f_{Ct} minus 2,68 standard deviations. If the results for specimens from over a support are significantly different from those for specimens in the span, $f_{Ct,2000}$ shall be taken as the lowest of the four values of f_{Ct}. If the pattern of results does not allow a rational interpretation, then the complete test series shall be repeated with a different panel.

If $f_{Ct,2000} > 0.8\ f_{Ct,0}$, Then the panel shall be deemed to be suitable for occasional foot traffic for access or maintenance without additional protection.

A.10 Calculation method for the determination of the thermal transmittance of a panel (*U*)

A.10.1 General

The thermal transmittance (*U*) of metal faced insulating sandwich panels shall be determined in accordance with the procedures in A.10.2, A.10.3 and A.10.4.

A.10.2 Determination of the thermal conductivity of component materials

A.10.2.1 Core material

A.10.2.1.1 Declared thermal conductivity

The declared thermal conductivity ($\lambda_{\text{Declared}}$) shall be determined in accordance with the procedures described in the appropriate product standard for the core material:

— EN 13162 for MW;

— EN 13163 for EPS;

— EN 13164 for XPS;

— EN 13165 for PUR;

— EN 13166 for PF;

— EN 13167 for CG.

The following variations from the conditions described in the product standard procedures shall be taken into account:

— the core material surface shall have the same orientation, relative to the direction of heat flow, that it would have in the panel;

— the core material surface shall be normal to the direction of heat flow in the test equipment.

A.10.2.1.2 Design thermal conductivity

The design thermal conductivity (λ_{design}) shall be determined according to EN ISO 10456, except in the case where the declared value is the aged value, when it is not necessary to use the ageing calculations in EN ISO 10456.

The value of the declared thermal conductivity value ($\lambda_{\text{Declared}}$) for the core, determined in the correct orientation, shall be used in determining the design thermal conductivity value (λ_{design}).

For panels created by adhesive bonding of metal faces to preformed cores, which are subject to thermal conductivity ageing in the absence of the metal faces, the 90/90 declared values shall be determined using the measured thermal conductivity of the preformed core at time of bonding as initial value and adding ageing increments in accordance with EN 13164 for XPS, EN 13165 for PUR and EN 13166 for PF (ageing increments for products with diffusion tight facings). Alternatively the 90/90 declared aged value quoted by the manufacturer for the preformed core product shall be used.

For auto-adhesively bonded PUR cores the aged core thermal conductivity value shall be derived from EN 13165, either by applying the ageing procedure given in EN 13165, C.4.2, or the fixed increment procedure given in EN 13165, C.5.

A.10.2.2 Facing, sealant and fixing materials

For materials, other than the core material, for which no design thermal conductivity is given, tabulated values in accordance with EN ISO 10456 shall be used.

A.10.3 Calculation of the thermal transmittance of a panel (*U*)

When determining the thermal transmittance for the panel the following conditions apply:

— tests and calculations shall take account of the thermal effect of the profiles of the external and internal faces;

— calculations shall take account of the panel-to-panel edge joints (A.10.4).

The thermal transmittance ($U_{d,S}$) of the panel shall take account of the profile geometry of the panel and the thermal influence of the longitudinal joint and shall either be determined by calculation (Formula (A.28)), or using a computer programme in accordance with EN ISO 10211 (Finite Element Method).

$$U_{d,S} = U_{n,S} + \Delta U_j \tag{A.28}$$

where

$U_{n,S}$, the thermal transmittance of the panel including the profile geometry of the panel

$$U_{n,S} = \frac{1}{R_{si} + \frac{t_{ni}}{\lambda_{fi}} + \frac{d_c + \Delta e}{\lambda_c} + \frac{t_{ne}}{\lambda_{fe}} + R_{se}}$$

and

ΔU_j , the thermal influence of the longitudinal joint

$$\Delta U_j = \frac{\psi_j}{B}$$

where

d_c is the nominal thickness of the core (ignoring the thickness of the facings (m) and the geometry of the main profiles), see Figure A.18 and Figure A.19;

t_{ni} is the nominal thickness of the internal facing (m);

t_{ne} is the nominal thickness of the external facing (m);

λ_c is the declared thermal conductivity of the core (W/m·K);

λ_{fi} is the declared thermal conductivity of the internal facing (W/m·K);

λ_{fe} is the declared thermal conductivity of the external facing (W/m·K);

Δe is the additional thickness due to the profiles of both faces (m) (see Tables A.2 and A.3);

Where

$\Delta e = \Delta e_i + \Delta e_e$

Ψ_j is the linear thermal transmittance of the joints per metre length of panel (W/m·K) according to EN ISO 10211;

B is the overall width of the panel (m);

R_{si} is the internal surface resistance (m^2K/W);

R_{se} is the external surface resistance (m^2K/W).

Subscriptes:

S sandwich panel;

d design value;

n nominal value;

j joint;

The declared thermal conductivity (λ_c) for the core material shall be determined according to A.10.2.1.2.

The declared thermal conductivity for the facing, sealant and fixing materials shall be determined according to A.10.2.2.

The linear thermal transmittance of the joints (ψ_j) shall be determined according to EN ISO 10211.

The internal surface resistance (R_{si}) and the external surface resistance (R_{se}) shall be determined according to EN ISO 6946.

For profiled panels the additional thickness due to the main profiles ($\Delta e_{i,e}$) shall be calculated according to EN ISO 10211. Examples are given in Table A.2 and A.3.

NOTE For flat and lightly profiled (profile height less than 10 mm) panels ($\Delta e_{i,e}$)is zero.

Table A.2 –Examples of additional thickness due to the main profiles ($\Delta e_{i,e}$), mm for trapezoidal geometry

Geometry of trapezoidal sheet					Numerical calculation
h [mm]	b_1 [mm]	b_2 [mm]	*p* [mm]	*r* [%]	$\Delta e_{i,e}$ [mm]
42	48	25	333	11	1
35	63	31	333	14	2
38	72	23	333	14	2
39	72	23	333	14	2
37	55	20	250	15	2
35	86	40	334	19	2
39	88	39	333	19	2
40	88	40	334	19	2
18	64	36	100	50	4
35	160	114	200	69	15
25	160	116	200	69	12

Where *r* in Table A.2 is defined by Formula (A.29)

$$r = \frac{0,5 \times (b_1 + b_2)}{p} \tag{A.29}$$

Table A.3 – Examples of additional thickness due to the main profiles ($\Delta e_{i,e}$), mm for sinusoidal geometry

Geometry of sinusoidal sheet		Numerical calculation
h [mm]	*b* [mm]	Δe [mm]
20	77	6
20	125	7
25	125	8
27	125	9

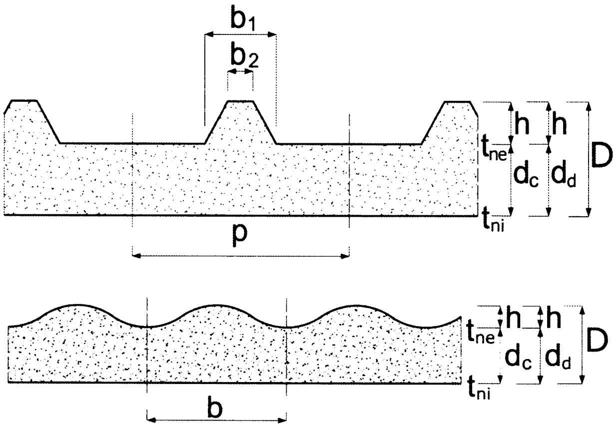


Figure A.18 – Definition of symbols in Table A.2 and A.3

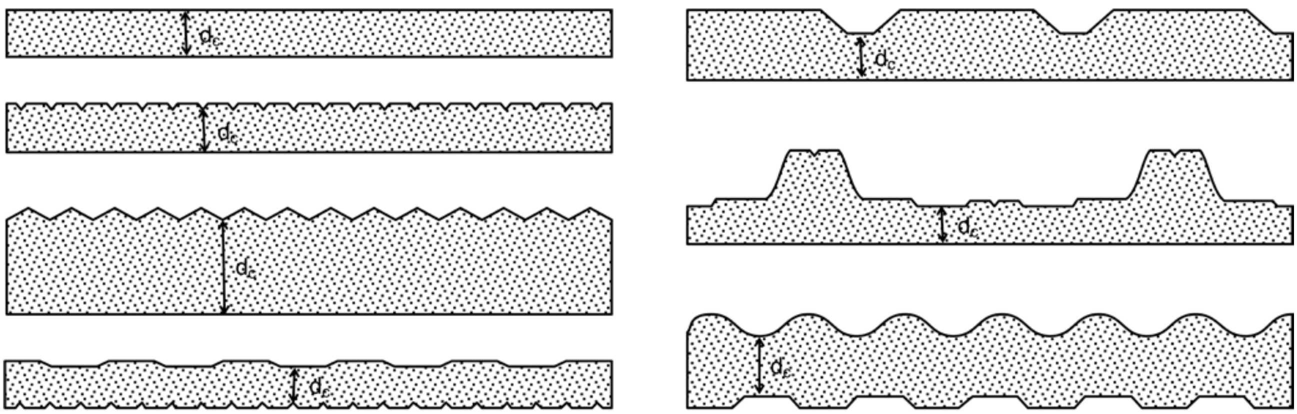


Figure A.19 – Definition of the nominal thickness d_c

A.10.4 Simplified method for the calculation of the thermal transmittance of a panel ($U_{d,S}$)

Alternatively the thermal transmittance of a panel $U_{d,S}$ can be calculated with a simplified method by using Formula (A.30) neglecting the influence of the profiled faces and using the linear thermal transmittance contribution factor of the joints (f_{joint}) obtained from Table A.4 for steel faces according to the generic type of joint (see Figure A.20).

$$U_{d,S} = \frac{1}{R_{si} + \frac{d_c}{\lambda_c} + R_{se}} \cdot \left(1 + f_{joint} \cdot \frac{1,0}{B}\right) \quad \text{(A.30)}$$

Where

f_{joint} the linear thermal transmittance contribution factor of the joints calculated for a joint distance of 1,0 m (see Table A.4).

The design thickness d_d (see Table A.4), to determine the thermal-bridge effect of the longitudinal joint is given by Formula (A.31):

$$d_d = t_{ni} + d_c + t_{ne} \quad \text{(A.31)}$$

Table A.4 –Thermal transmittance contribution factor (f_{joint}) for steel faces

f_{joint}									
d_d [mm]	Type I	Type II		Type III	Type IV	Type V	Type VI	Type VII	Type VIII
		no clip ($f_{joint,nc}$)	clip ($f_{joint,c}$)						
30	-	-	-	-	0,057	-	-	-	0,061
40	0,160	-	-	-	0,045	0,144	-	0,098	0,044
60	0,083	0,111	0,818	0,244	0,031	0,072	0,227	0,049	0,030
80	0,052	0,063	1,016	0,105	0,024	0,044	0,094	0,036	0,024
100	0,039	0,047	1,184	0,072	0,021	0,032	0,064	0,029	0,020
120	0,032	0,039	1,325	0,057	0,019	0,026	0,049	-	-
160	0,025	0,030	1,555	0,041	0,015	0,019	0,034	-	-
200	0,020	0,025	1,733	0,033	0,013	0,015	0,026	-	-

NOTE 1 Joint type I, II, III, IV, VII, VIII are calculated with sealant strips with λ_s = 0,05 W/m·K, the design thermal conductivity of the sealant. Joint type V and VI are calculated without sealant strips.

NOTE 2 Formula (A.32) for determination of f_{joint} of joint type II (see Table A.4):

$$f_{joint} = f_{joint,nc} \frac{a - b_c}{a} + f_{joint,c} \frac{b_c}{a} \tag{A.32}$$

Where

$f_{joint,nc}$ is the thermal transmittance contribution factor of the joints with no clips;

$f_{joint,c}$ is the thermal transmittance contribution factor of the joints with clips;

a is the distance of the clips (if no other information is available, a = 2 500 mm shall be used);

b_c is the width of the clips (if no other information is available, b_c = 120 mm shall be used).

NOTE 3 It is allowed to interpolate between the thicknesses d_d in Table A.4.

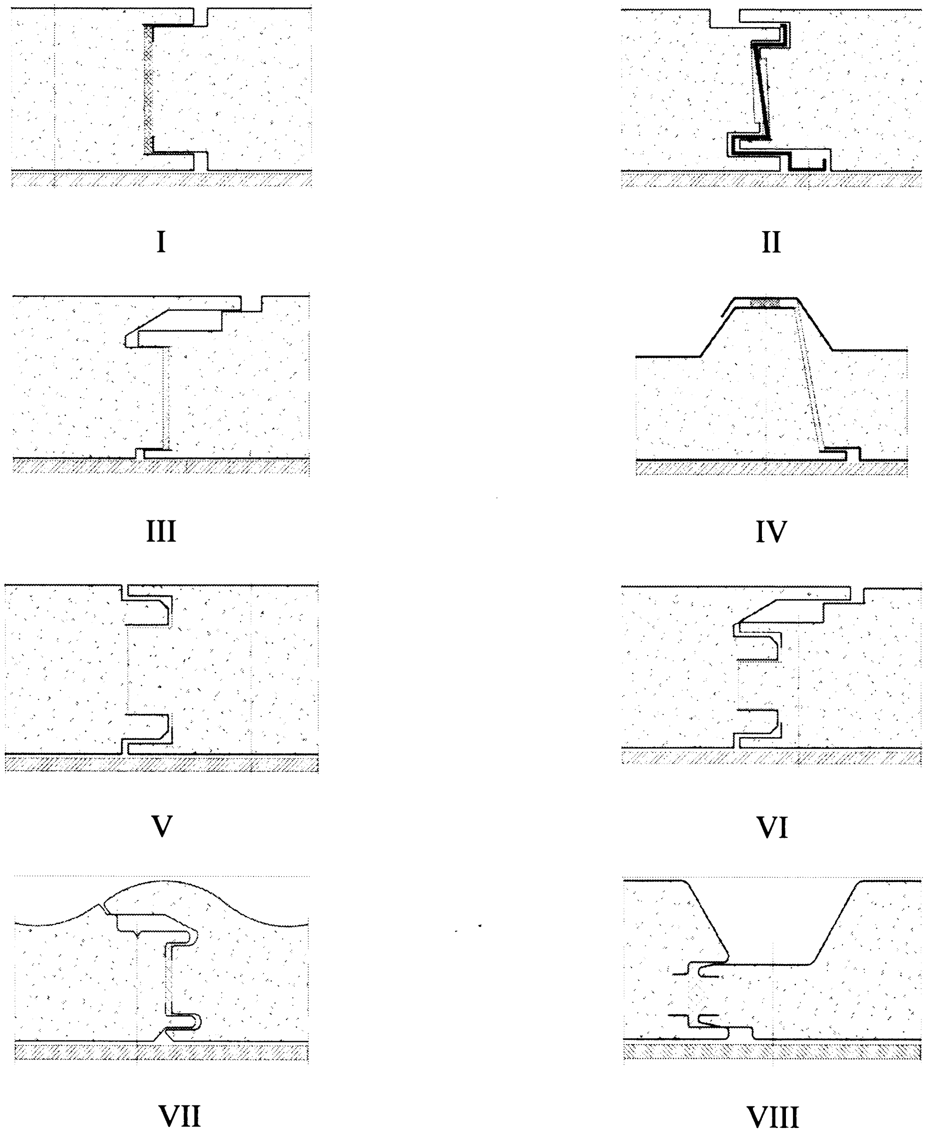


Figure A.20 – Generic types of longitudinal joints

A.11 Water permeability – resistance to driving rain under pulsating pressure

A.11.1 Principle

Where required, the resistance of a sandwich panel assembly to driving rain under pulsating air pressure shall be tested according to EN 12865.

A.11.2 Apparatus

The test apparatus shall be in accordance with EN 12865.

A.11.3 Test specimens

The dimensions of the test specimen shall be as specified in EN 12865. Both horizontal and vertical joints shall be incorporated where these are an intrinsic part of the panel assembly.

A.11.4 Procedure

The test shall be carried out in accordance with EN 12865 — Procedure A.

A.11.5 Calculations and results

The following criteria shall be used to define water tightness:

— no water penetrates through the panel assembly to the inside of the building, which would continuously or repeatedly wet the inside face of the assembly or any part of the specimen intended to remain dry;

— any water penetrating through the joint system or fixings is of the order of a few small drops and is estimated to dry out.

One of the following three test classes shall be used:

— Class A: Demanding applications with heavy rain and wind. The assembly shall be watertight up to 1 200 Pa;

— Class B: Normal applications. The assembly shall be watertight up to 600 Pa;

— Class C: Low requirement applications. The assembly shall be watertight up to 300 Pa.

A.12 Air permeability

A.12.1 Principle

Where required, the air tightness of a sandwich panel assembly shall be tested according to EN 12114 including the following additional requirements.

A.12.2 Apparatus

The test apparatus shall be in accordance with EN 12114.

A.12.3 Test specimens

The dimensions of the test assembly shall be as large as necessary to be representative of the intended use. The assembly shall not be less than 1 200 mm x 2 400 mm.

The joints of the modules comprising the test assembly shall be representative, i.e. the same length per m^2 as in end use. Both horizontal and vertical joints shall be incorporated where these are an intrinsic part of the panel assembly.

A.12.4 Procedure

The test shall be carried out in accordance with EN 12114.

A.12.5 Calculations and results

The air permeability (air loss) shall be determined in accordance with EN 12114.

The air permeability test should begin with a pressure difference Δp_{max} of at least 200 Pa between the inside and outside of the test assembly.

The values n and C shall be declared on the basis of the test results (according to EN 12114, app. B, Formula (B.8). The air loss $\dot{V}$ can be calculated using

C = exp(α) and $\dot{V}$ = C·Δp^n (EN 12114, app. B, Formula (B.1)

A.13 Airborne sound insulation

A.13.1 Principle

Where required, the airborne sound insulation of a sandwich panel assembly shall be tested in accordance with EN ISO 10140 including the following additional requirements.

A.13.2 Apparatus

The test apparatus shall be in accordance with EN ISO 10140.

A.13.3 Test specimens

The mounting of the test specimens in the test opening shall conform to the normal assembly in a building with the same connections and seals between the elements.

The specimen shall be mounted in accordance with EN ISO 140-3, Clause 5.2.1 Partitions.

A.13.4 Procedure

The sound reduction indices *R* in each one-third octave band in the range from 100 Hz to 3 150 Hz shall be determined using the method described in EN ISO 10140.

A.13.5 Calculations and results

The following single number rating shall be declared in accordance with EN ISO 717-1: $R_w(C;C_{tr})$.

A.14 Sound absorption

A.14.1 Principle

Where required, sound absorption shall be determined in accordance with EN ISO 354.

A.14.2 Apparatus

The test apparatus shall be in accordance with EN ISO 354.

A.14.3 Test specimens

The mounting of the test specimens shall conform to the normal assembly in a building with the same connections and seals between the elements. The test specimen shall be placed directly against one of the internal surfaces (wall, ceiling or floor) of the chamber in accordance with EN ISO 354:2003, Annex B Type A. A reflective frame shall be installed round the test specimen.

A.14.4 Procedure

The test shall be carried out in accordance with EN ISO 354.

A.14.5 Calculations and results

The result shall be declared as a single number rating (α_w) in accordance with EN ISO 11654.

A.15 Support reaction capacity at the end of a panel

A.15.1 Principle

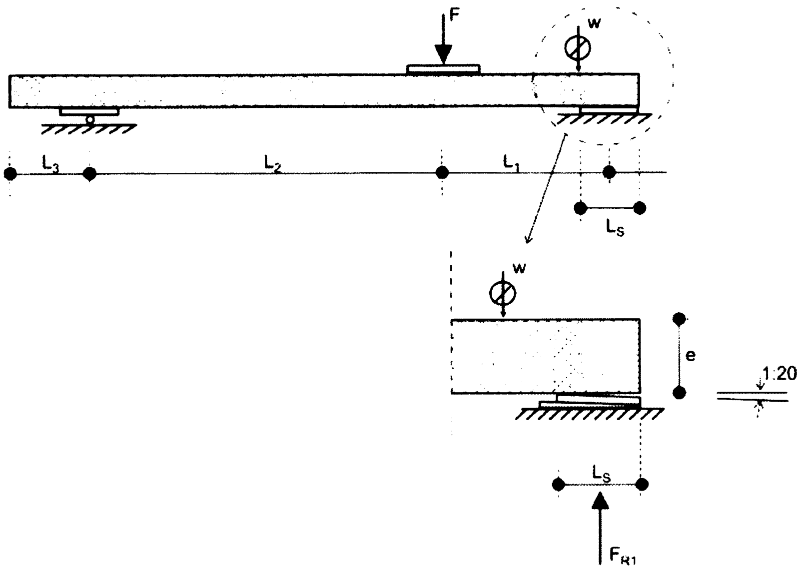
Where required for design purposes and as an alternative to calculation in accordance with E.4.3.2, the reaction capacity at the end of a panel where the contact face is either plain or lightly profiled shall be determined by tests on full width panels according to A.15.5.

NOTE This test may also be used to determine an experimental value of the factor 'k' in order to improve the calculation of the reaction capacity at an internal support.

A.15.2 Apparatus

The test apparatus shall be as shown in Figure A.21.

The right hand support shall be a 10 mm thick steel plate held firmly at an inclination of 1:20. The right hand end of the specimen shall be aligned vertically with the right hand end of the support, i.e. there shall be no overhang. The support width L_S shall either be the minimum used in practice or tests shall be carried out for each support width used in practice. The dimensions L_1, L_2 and L_3 shall either be chosen so that the test specimen fails in compression at the right hand support, or, if the failure mode is a shear failure between the loading platen (F) and the support platen (F_{R1}), the reaction capacity shall be taken to be the support reaction force at the time of shear failure. L_1 shall be > 1,5 e.



Key

w compressive deflection

L_s support width

e distance between centroids of the faces

Figure A.21 – Test arrangement for the determination of the resistance for the end support reaction

A.15.3 Test specimens

Sampling and conditioning of the test specimens shall comply with 6.2.2 and 6.2.3.

The test shall be carried out on test specimens of length *L*, where the length is as specified in A.15.2. Three tests are carried out for each support width.

Where a test series is intended to cover a range of core depths, it is sufficient to test one core depth at each end of the range and one near the middle and to use interpolation and/or extrapolation. Characteristic values of the support reaction capacity F_{R1} shall then be calculated by treating the test results as a family according to 6.4.

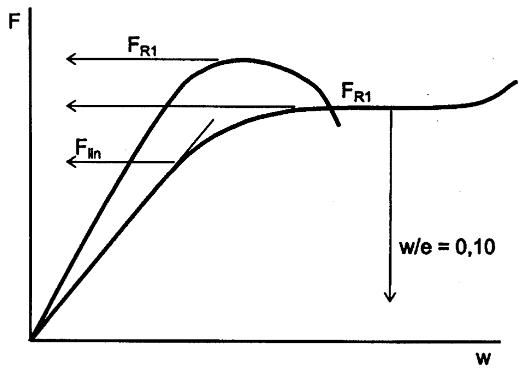
A.15.4 Procedure

The rate of loading shall be such that the ratio w/e rises by between 1 % and 3 % per minute. A minimum of three tests shall be carried out at each support width. The compressive strength f_{Cc} of the core material of the test specimen shall be determined according to A.2.

The test value of the reaction capacity, F_{R1}, shall either be measured by a load cell placed below the support or calculated using Formula (A.33):

$$F_{R1} = \frac{L_2}{L_1 + L_2} F_u \tag{A.33}$$

where F_u is the maximum load measured in the test or the load corresponding to a compressive deflection of $w = 0,1\ e$ (where e is the depth between the centroids of the faces) if this deflection is attained on the rising part of the load-deflection curve and is less than the maximum load (see Figure A.22).



Key

F support reaction

F_{lin} load at the end of the linear part of the curve

w compression

Figure A.22 – Definition of the ultimate load from the load-deflection curve in an end support reaction test

A.15.5 Calculation and results

The test results shall be adjusted by multiplying them by the ratio f_{Cc}/f_C.

The adjusted characteristic value of F_{R1} shall be the value to be used in design (see E.4.3).

Where required for use in E.4.3, the distribution parameter k may be determined using Formula (A.34).

$$k = \frac{2\left(F_{R1} - f_c\, B\, L_s\right)}{f_c\, B\, e} \tag{A.34}$$

Where

B is the width of panel;

L_s is the width of support;

e is the distance between centroids of the faces;

f_c is the mean compressive strength

f_{Cc} is the relevant characteristic value of the compressive strength of the core following initial type testing;

Where the values of F_{R1} at three or more core depths have been treated as a family, the corresponding values of f_c should be treated in a similar way.

A.16 Recording and interpretation of test results

A.16.1 ITT tests

For each ITT test series, formal documentation shall be prepared giving all the relevant data so that the test series can be accurately reproduced. In particular, in addition to the results of the tests, the specimens shall be fully and accurately described in terms of dimensions and material properties. Any observations made during the tests shall also be recorded.

The following information shall be recorded in all ITT test reports:

a) date and time of manufacture;

b) method of manufacture and orientation of panel during manufacture (e.g. which face was uppermost, which was the leading edge during continuous foaming);

c) date of testing;

d) conditions during testing (temperature and humidity);

e) method of loading and details of instrumentation;

f) support conditions (number and length of spans, width and details of supports, number and details of connections to supporting structure etc.);

g) orientation of panel during testing;

h) type and properties of face material (thickness, yield stress, geometry etc.);

i) type and properties of core material (density, strength, moduli etc.);

j) type and details of adhesive;

k) measurements made during testing (load, deflection readings, temperature etc.);

l) mode of failure.

The analysis of the results of a test shall be based on the measured dimensions and material properties of the test specimens rather than the nominal values assumed in the design.

A.16.2 FPC tests

The following information shall be recorded in all FPC test reports:

a) date of manufacture;

b) method of manufacture and orientation of panel during manufacture;

c) date of testing;

d) orientation of panel during testing;

e) type and properties of face material (thickness, yield stress, geometry etc.);

f) type and properties of core material (density, strength, moduli etc.);

g) type and details of adhesive;

h) measurements made during testing (load, deflection readings, temperature etc.);

i) mode of failure.

The analysis of the results of a test shall be based on the measured dimensions and material properties of the test specimens rather than the nominal values assumed in the design.

A.16.3 Determination of characteristic values from tests

Unless otherwise required by a horizontal standard, for each of the test procedures that result in quantified design parameters, the characteristic values of the relevant properties shall be determined in accordance with the following statistical procedure.

For each population ‘x’of test results, the mean value and the 5 % fractile value shall be determined using a confidence limit of 75 % in accordance with ISO 12491.

The 5 % fractile value shall be determined according to Formula (A. 35) and used as the characteristic value R_k:

$$R_k = x_p = e^{\left(\bar{y} - k\sigma_y\right)} \quad \text{(A.35)}$$

Where

x_p is the 5 % fractile value of population x

y = L_n(x)

$\bar{y}$ is the mean value of y (A. 36)

k is the fractile value given in Table A. 5

σ_y is the standard deviation of y (A. 37)

$$\overline{y} = \frac{1}{n}\sum_{i=1}^{n} L_n\left(x_i\right) \tag{A.36}$$

$$\sigma_y = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(L_n\left(x_i\right) - \overline{y}\right)^2} \tag{A.37}$$

Table A.5 – Fractile factor *k* assuming a confidence level of 75 %

Number of specimens (*n*)	3	4	5	6	7	8	9	10	15	20	30	60	100
k_σ	3,15	2,68	2,46	2,34	2,25	2,19	2,14	2,10	1,99	1,93	1,87	1,80	1,76

A.16.4 Interpolation and extrapolation of test results

In the case of panels of the same type the minimum requirement is that the greatest and least thickness shall be tested together with a panel from the middle of the range. If only three thicknesses are tested, the values for products of intermediate thickness and of greater thickness up to 20 % but not more than 30 mm higher may be interpolated or extrapolated linearly.

However, it is recommended that interpolation and extrapolation should be carried out by treating the results as a family according to 6.4. If more than three thicknesses are tested, the same extrapolation limits apply but interpolation and extrapolation shall be carried out by treating the results as a family.

Annex B
(normative)

Durability testing method for sandwich panels

B.1 General

The influence of ageing on sandwich panels or their constituent materials is tested by measuring changes in the tensile strength across the depth of the panel. The durability is defined by the change in the tensile strength of a test specimen that is subjected to climatic test cycles denoted as DUR1 and DUR2. The cycle DUR1 is defined in B.2 and cycle DUR2 in B.3.

B.2 Test DUR1

B.2.1 Principle

The effect of ageing (durability) shall be measured by determining the change in tensile strength in accordance with EN 1607, performed on panel samples that have been subject to durability test cycle DUR1.

The test shall be used on panel types where the effect of temperature is known to be the main cause of ageing (see 5.2.3.1, Table 2).

The test shall be carried out at one of the three temperature levels (*T*) that reflect the maximum temperatures that may be reached in end use, according to the colour of the exposed facing:

— test temperature 90 °C for dark colours;

— test temperature 75 °C for light colours;

— test temperature 65 °C for very light colours.

The reflectivity definition of the three colour ranges is listed in the note in E.3.3.

B.2.2 Apparatus

1) Test apparatus for the durability test in accordance DUR1 comprising a test chamber with constant temperature of (T ± 2) °C (see B.2.1) and dry conditions (relative humidity not greater than 15 %).

2) Test apparatus for the tensile strength test in accordance with EN 1607.

B.2.3 Test specimens

B.2.3.1 Dimensions of test specimens

The thickness of the specimens shall be the full product thickness including, where applicable, any irregular profile.

The specimens of 100 mm x 100 mm shall be cut from the centre of the sandwich panel and not closer to the edge than 250 mm. The samples shall be taken four weeks after production but immediately before artificial ageing. All test specimens for the test programme shall be cut from the same panel in accordance with A.1.3.

B.2.3.2 Number of test specimens

Six test specimens shall be used for the determination of the initial tensile strength (initial test) and a minimum of five test specimens shall be used for each subsequent part of the test sequence:

DUR1 specimens: Set 1 (initial set) + two sets of five specimens.

NOTE Where there is a wide scatter in the tensile strength results in the initial test, it may be necessary to test more than five specimens.

If panels are produced in more than one thickness, the tests shall be conducted with samples from panels of both maximum and minimum thickness. The worst result shall apply to panels of all intermediate thickness.

B.2.3.3 Preparation of test specimens

Before commencing the tests, the specimens shall be stored for at least 24 h under normal laboratory conditions.

B.2.4 Procedure

B.2.4.1 General

The dimensions of all test specimens shall be measured before and after the tests and shall be according to EN 12085.

The tensile strength of the product shall be determined in accordance with A.1 using the initial set of the test specimens (see B.2.4.2). The strength value obtained shall be denoted f_{Ct0} and shall be determined as the mean strength of the tested specimens.

After testing, the specimens shall be visually inspected, paying special attention to the failure type (cohesive failure of the core, adhesive bond failure in any of the bonded surfaces, proportional area of the adhesive failure etc.). A description of the results of these observations shall be included in the test report.

If the metal faces of any of the specimens have suffered from general edge corrosion during exposure, and if the corrosion has propagated deeper than 10 mm into the joint between the surface sheet and the core over an edge length longer than 50 % of the specimen perimeter, the specimen shall be rejected and its results shall not be included in the calculation of the test results. A note on this rejection shall be included in the test report.

Tensile strength statistics shall refer to mean values.

B.2.4.2 DUR1 Temperature test

The test shall be carried out at the selected temperature level, T = 90 °C, 75 °C, or 65 °C, as defined in B.2.1.

The test programme shall be as follows:

Set 1 (initial set): Condition for 1 day in normal laboratory conditions followed by tensile test;

Set 2: Condition for 42 days at T °C followed by tensile test;

Set 3: Condition for 84 days at T °C followed by tensile test;

Where

T is the selected test temperature.

B.2.4.3 Tensile strength test

The tensile strength tests shall be conducted under normal laboratory conditions. The tensile strength shall be determined with both metal faces intact.

B.2.5 Test results and acceptance criteria – DUR1

If panels are produced in more than one thickness, the tests shall be conducted with samples from panels of both maximum and minimum thickness. The worst result shall apply to panels of all intermediate thickness.

The durability criteria shall be satisfied providing the following conditions are met:

— f_{Ct42} or f_{Ct84}, whichever is lowest, shall not be less than 50 % of the initial tensile strength value $f_{Ct\,0}$;

— the mean value of tensile strength f_{Ct42} or f_{Ct84}, whichever is lowest, shall be not less than 0,02 MPa;

— the dimensional change of the specimen width in all three directions of the sections at T °C in test procedure DUR1 for all samples tested shall not be greater than 5 %, in the most affected area.

The test report shall state the temperature at which the specimen passed the DUR1 test. The colour limitation and reflectivity range shall be declared according to the following acceptance criteria:

— Durability pass: suitable for all colours (T = 90 °C test);

— Durability pass: suitable for light and very light colours. Reflectivity 40-90. (T = 75 °C test);

— Durability pass: suitable for very light colours only. Reflectivity 75-90. (T = 65 °C test).

B.3 Test DUR2

B.3.1 Principle

The test shall be used on panel types where the effect of humidity is known to be the main cause of ageing (see 5.2.3.1, Table 2).

When evaluating the effect on the core material the effect of ageing (durability) shall be measured by determining the change in tensile strength in accordance with A.1, performed on panel samples that have been subject to durability test cycle DUR2.

NOTE 1 The DUR 2 test covers both, testing of the core material as such, the adhesion layer and the back face coating.

NOTE 2 For core materials tested according to both DUR 1 and DUR 2 (see 5.2.3.1, Table 3) the DUR 2 test is used to check the corrosion risk of the back face coating.

B.3.2 Apparatus

B.3.2.1 Test apparatus for the humidity test

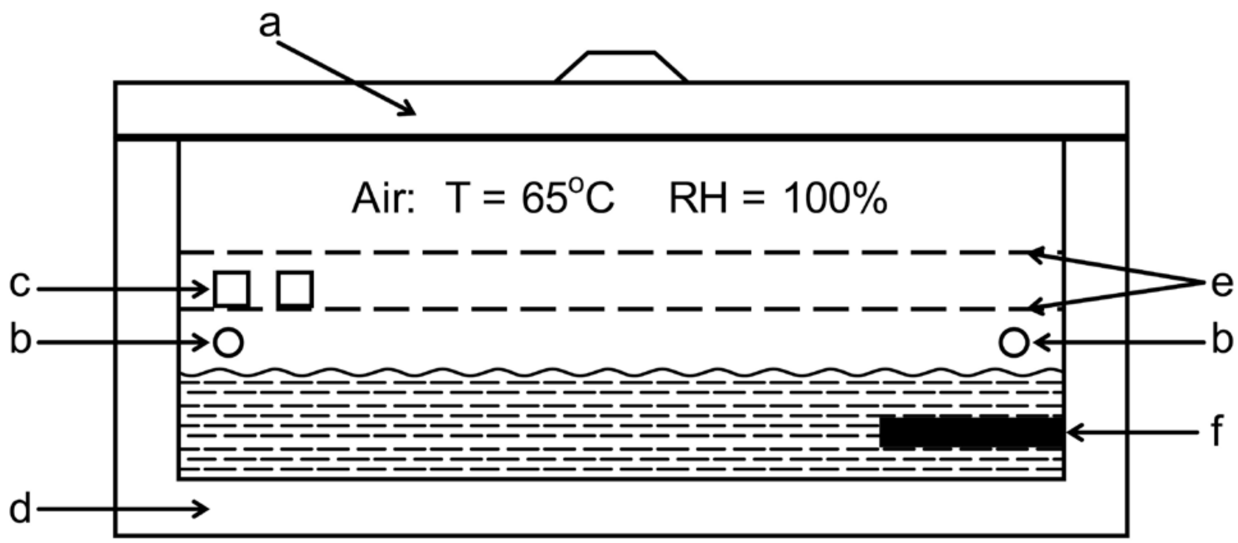
The humidity test shall be carried out using the DUR2 test chamber.

B.3.2.1.1 DUR2 test chamber

Test apparatus for the humidity test in accordance with DUR2 comprises a test chamber with constant conditions: air temperature of (65 ± 3) °C and moisture saturated air (app. 100 % relative humidity) is achieved by heating up water at the bottom of the chamber.

The test chamber shall consist of a box in which the water is heated up to roughly +70 °C, (see Figure B.1). Uniform air temperature shall be achieved before starting the test.

NOTE Normally it is not necessary to provide any accelerated thermal exchange by means of fans in the test chamber. By putting the heating element to one side circulation of the water is ensured.



Key

a sealed cover – insulated

b air temperature thermometers - (25 ± 10) mm above water level

c specimens

d insulated box (0,9 < R < 1,1 where R is the thermal resistance of the box)

e grid for specimens - above water level

f heating element

Figure B.1 – Test chamber for durability test DUR2

B.3.2.2 Test apparatus for the tensile strength test

Test apparatus for the tensile strength test shall be in accordance with EN 1607.

B.3.3 Test specimens

B.3.3.1 Dimensions of test specimens

All test specimens shall be cut from the same panel and shall be in accordance with A.1.3.

The thickness of the specimens shall be the full product thickness including, where applicable, any irregular profile.

Specimens taken from panels with core materials other than mineral wool shall have a square plan form with squarely cut edges in accordance with EN 12085 having sides of 100 mm and an accuracy of 0,5 %.

B.3.3.2 Number of test specimens

At least five test specimens shall be used for the determination of the tensile strength in each series:

DUR2 specimens: Set 1(initial set) + three sets of minimum five specimens.

If panels are produced in more than one thickness, the tests shall be conducted with samples from panels of both maximum and minimum thickness. The worst result shall apply to panels of all intermediate thickness.

B.3.3.3 Preparation of test specimens

The cut edges of the metal facing sheets in the samples shall be protected from the effects of corrosion by the application of a layer of water resistant sealant.

Before commencing the tests, the specimens shall be stored for at least 24 h under normal laboratory conditions.

B.3.4 Procedure

B.3.4.1 General

The exact dimensions of all test specimens shall be measured before and after the tests and the dimensional changes for all three directions shall be according to EN 12085.

The tensile strength of the product shall be determined in accordance with A.1 using the initial set of the test specimens (see B.3.4.2). The mean strength value obtained shall be denoted f_{Ct0} and shall be determined as the average strength of the tested specimens.

After testing, the specimens shall be visually inspected, paying special attention to the failure type (cohesive failure of the core, adhesive bond failure in any of the bonded surfaces, proportional area of the adhesive failure etc.). A description of the results of these observations shall be included in the test report.

If the metal faces of any of the specimens have suffered from general edge corrosion during exposure, and if the corrosion has propagated deeper than 10 mm into the joint between the surface sheet and the core over an edge length longer than 50 % of the specimen perimeter, the specimen shall be rejected and its results shall not be included in the calculation of the test results. A note on this rejection shall be included in the test report.

Tensile strength statistics shall refer to mean values.

B.3.4.2 DUR2 Humidity test

Set 1 (initial set):	Condition for 1 week in normal laboratory conditions followed by tensile test.
Set 2:	Maintain under constant conditions for 7 d at (65 ± 3) °C and moisture saturated air (B.3.2.1) followed by tensile test.
Set 3:	Maintain under constant conditions for 28 d at (65 ± 3) °C and moisture saturated air (B.3.2.1) followed by tensile test.

If required (see B.3.4.3):

Set 4:	Maintain under constant conditions for 56 d at (65 ± 3) °C and moisture saturated air (B.3.2.1) followed by tensile test.

B.3.4.3 Tensile strength (f_{Ct}) test – DUR2

The tensile strength tests shall be conducted under normal laboratory conditions. The tensile strength shall be determined with both metal faces intact.

The tensile strength test after the 7, 28 and 56 day exposure time shall be carried out on stabilised samples. After the ageing test, the samples shall be stored until the mass has stabilised under ambient laboratory conditions. Constant mass shall be fulfilled when the change in mass between two subsequent weighings with a 24 h interval is smaller than 1 % of the total mass. The ambient laboratory conditions shall be included in the test report.

The mean tensile strength values obtained from the initial samples shall be denoted as f_{Ct0}; after conditioning for seven days as f_{Ct7}; and after 28 days as f_{Ct28}.

If the test results illustrate a continuing decline in tensile strength with time a further set of test specimens that have been exposed to the DUR2 test cycle for 56 days shall be tested. The strength value obtained shall be denoted as f_{Ct56}.

B.3.5 Test results and acceptance criteria – DUR2

The durability criteria shall be satisfied providing the following conditions are met:

— $f_{Ct7} – f_{Ct28}$ shall be equal to or smaller than 3 (f_{Ct0} - f_{Ct7});

— f_{Ct28} shall not be less than 40 % of f_{Ct0}.

— the dimensional change of the specimen for all three directions after exposure to each condition in test procedure DUR2 for all samples tested shall not be greater than 5 %, in the most affected area.

If this is not fulfilled, specimens shall be exposed to the DUR2 test for 56 days. The criteria for acceptance shall be that:

$f_{Ct28} – f_{Ct56}$ shall be less than $f_{Ct7} – f_{Ct28}$

and

f_{Ct56} shall not be less than 40 % of f_{Ct0}.

B.4 Test report on durability tests

The test report shall include the following information:

a) reference to this European Standard, i.e. EN 14509;

b) product identification:

1) product name, factory, manufacturer and supplier;

2) type of product;

3) packaging;

4) the form in which the product arrived at the laboratory;

5) presence of facing or coating;

6) type of adhesive;

7) type of core material;

8) other information as appropriate, e.g. nominal thickness, nominal density, the conditions under which the product was stored and transported before arriving at the laboratory;

c) test procedure:

1) conditioning;

2) any deviations from this European Standard (B.2 and B.3);

3) date of testing;

4) general information related to the testing:

   i) the basic test cycle used;

   ii) use, where applicable, of the additional 56 days exposure;

5) factors which may have affected the results:

   i) corrosion of the exposed samples;

   ii) interruptions in the cycling test programme and the treatment of specimens during these;

   iii) rejection of individual test specimens due to the failure of the edge corrosion protection.

Information about the apparatus and identity of the technician shall be available in the laboratory, but does not need to be recorded in the test report,

d) results:

1) all individual and mean values;

2) any visual observations of the specimens after testing:

   i) type of failure of the specimens in tensile testing (cohesive failure of the core, adhesive failure between the surface sheet and core, failure between the surface sheet and its coating etc.);

   ii) any corrosion of the test specimens;

3) a statement as to whether the product has passed or failed the acceptance criteria.

B.5 Adhesive bond between faces and prefabricated core material (wedge test)

B.5.1 Principle

The wedge test shall be used to control the adhesion between the adhesives and the back face coating of the facings.

B.5.2 Apparatus

Test apparatus for the wedge test comprises a small aluminium or stainless steel wedge as shown in Figure B.2.

Dimensions in millimetres

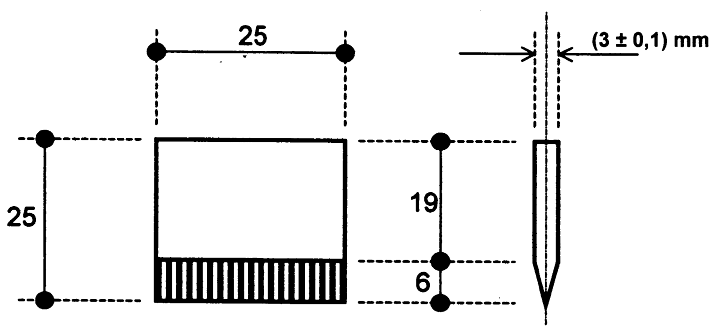


Figure B.2 – Wedge test – aluminium or stainless steel wedge

B.5.3 Test specimens

Five specimens shall be used for the wedge test. The test specimens shall be fabricated from two strips of the face material with a width of 20 mm and a length of at least 100 mm. The face tested shall be between 0,5 mm and 0,6 mm. If the manufacturer is using thicker faces only, the thinnest available face shall be used.

These strips shall either be cut from the coil material to be used in the manufacturing process or, alternatively, the strips shall be cut from the manufactured panels. When cutting from completed panels, the core material shall be carefully removed without damaging the back face coating of the metal face.

The strips of face material shall then be bonded together.

Samples for the wedge test may be produced the following ways:

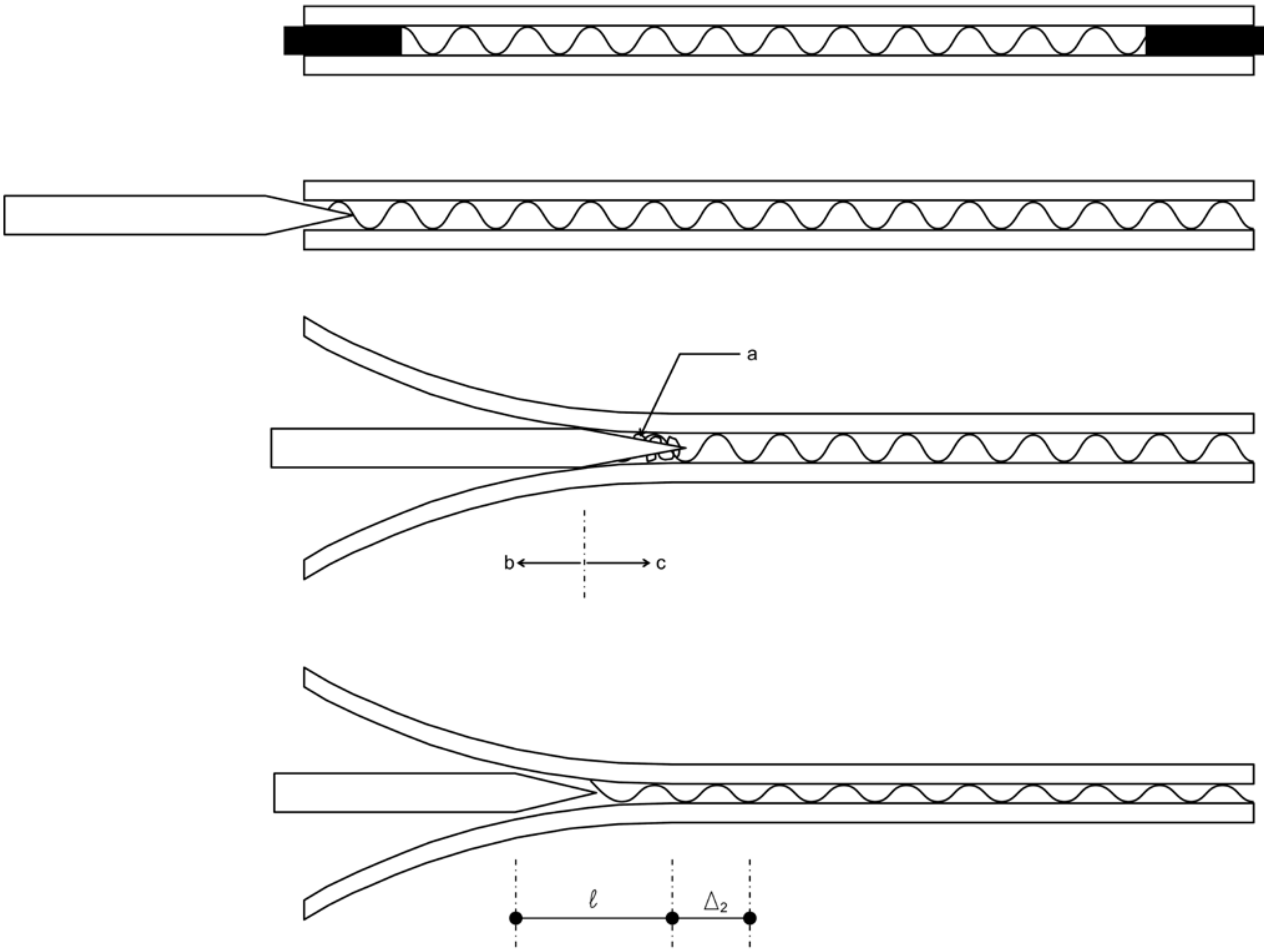
A piece of face material may be adhered to the core material during normal production of the panels. After production this area may be removed and the test specimen cut out. Before applying the wedge, a portion of the glue should be removed to facilitate penetration.

Alternatively the required strips of material may be cut directly from the coil. The glue should then be applied directly onto the strips which may then be assembled with the help of an additional spacer. The glue should be similar to that used in production but without any expansive properties The amount of glue used is not critical for the test.

B.5.4 Procedure

The wedge shall be pressed between the two faces, thus causing an initial crack whose length shall be measured (Figure B.3). The wedge shall then be loaded with a force of approximately 3 N. The specimen shall then be immersed for 24 h in water heated to 70 °C.

NOTE The load of 3 N can either be applied by means of a simple rubber band of suitable size or by holding the test specimens vertically using small weights.



Key

a initial crack in glue layer

b glue free zone

c glued zone

ℓ initial crack length (mm)

Δ_2 crack growth after exposure (mm)

Figure B.3 – Wedge test using aluminium or stainless steel wedge

B.5.5 Test results and acceptance criteria

The initial crack shall not extend for more than approximately 30 mm and shall not grow by more than a further 20 mm to 25 mm after immersion for 24 h in heated water in order to ensure a reasonable stress level in the glue layer. Test results are only valid if these criteria are fulfilled.

The test shall be passed when the crack only extends within the adhesive layer. The test shall fail if the crack reaches the back face coating.

NOTE It is acceptable for a ‘pass’ if four out of five specimens fulfil the acceptance criteria.

B.6 Repeated loading test

B.6.1 Principle

The repeated loading test is part of the durability assessment procedure for sandwich panels identified in 5.2.3.1 (Table 3). The requirement is that the wrinkling stress shall not be reduced by more than the allowed limit in B.6.5.

B.6.2 Apparatus

The loading arrangements and support conditions for subjecting a simply supported panel to four line loads shall be in accordance with A.5.2.

B.6.3 Test specimens

A single test shall be carried out for each product family.

Sampling and conditioning of the test specimens shall comply with 6.2.2 and 6.2.3.

The specimens shall be in accordance with A.5.3. The test shall be carried out on the thickest panel of the product family.

B.6.4 Procedure

The applied load shall be applied cyclically between upper and lower limits. The lower limit shall be not more than the weight of the panel + 0,5 kN. The upper limit shall be the load determined according to A.5 (5 % fractile value) to reach the wrinkling stress at the serviceability limit state, i.e. the characteristic value divided by γ_F γ_M, where γ_F is the load factor for variable actions and γ_M is the material safety factor for wrinkling failure. This upper limit shall be applied with a tolerance of ± 5 %.

The load shall be applied for 5 000 cycles with a load frequency not less than (1 ± 0,25) Hz.

If the frequency coincides with the natural frequency of the specimen, the load frequency shall be reduced until no effect takes place.

After cyclic loading, the load shall be increased statically until failure occurs.

The deflection at the centre of the specimen shall be continuously measured by means of a suitable transducer during both cyclic loading and static loading to failure.

The tests shall be performed under normal laboratory conditions of temperature and humidity.

B.6.5 Calculations and results

Panels shall satisfy the test providing that the reduction in the characteristic wrinkling strength of the panel after repeated loading is less than the initial characteristic value divided by γ_M.

The increase in the maximum deflection as a result of cyclic loading shall be less than 5 % of the maximum deflection observed during the first cycle.

B.7 Thermal shock test

B.7.1 Principle

The thermal shock test is part of the durability assessment procedure for sandwich panels identified in 5.2.3.1 (Table 3). The requirement is that shear failure, blistering or delamination does not occur.

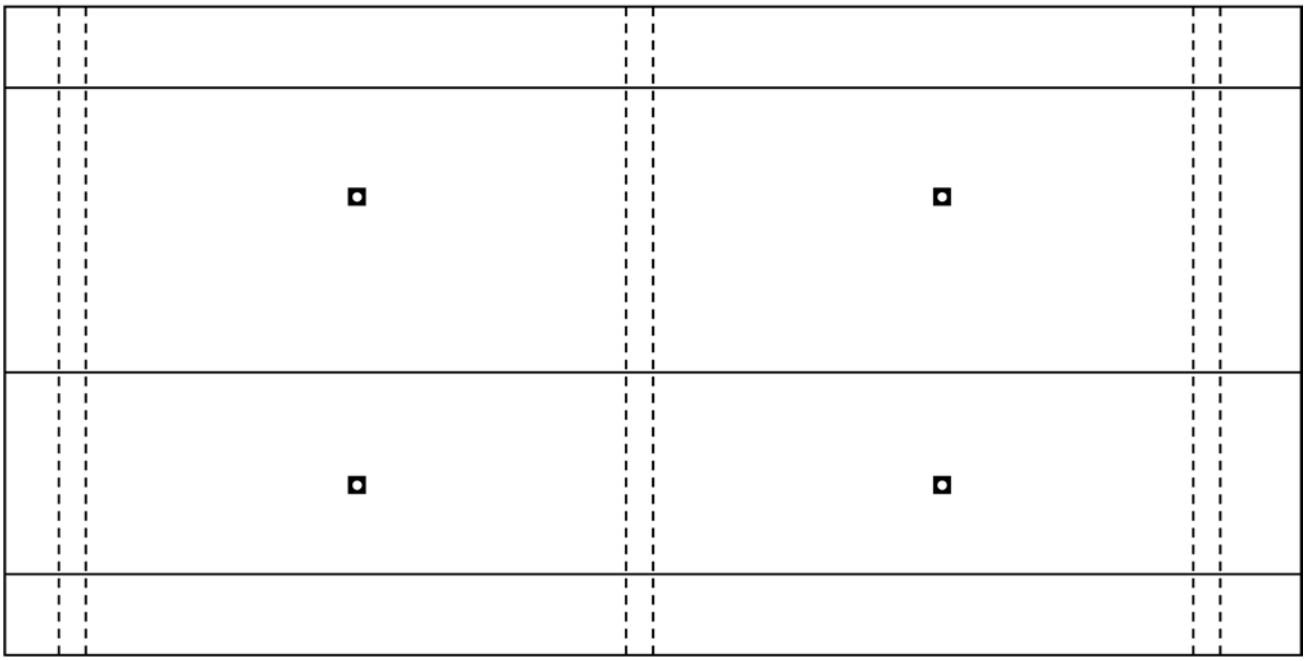
B.7.2 Apparatus

The framework designed to support an assembly of two full-width panels with half-width panels at the top and bottom to complete the assembly is shown in Figure B.4.

Alternatively an assembly of 3 full-width panels can be used depending on the way panels are normally fixed.

The framework shall have a central support beam and two support beams located at the end of the span (Figure B.4) to support the panels. The support beams shall be rigid and free of any movement.

The framework shall be vertical or quasi-horizontal with a slope 0: −10° to facilitate run off of the cooling water.



Key

◘ temperature sensors on the exposed side and on the non-exposed side

Figure B.4 – Test arrangement with temperature sensors

B.7.3 Test specimens

Sampling and conditioning of the test specimens shall comply with 6.2.2 and 6.2.3.

The test shall be carried out on the thickest panel of the product family with the thinnest facing. The test specimens shall be between 4 m and 7 m in length spanning equally either side of the central support (Figure B.4). Fixings shall be as in practice. Where the assembly comprises two full-width and two half-width panels only the full width-panels shall be considered as the testing zone.

B.7.4 Procedure

The panel assembly shall be subject to four cycles of thermal loading which shall be applied in sequence, after which the panels shall be subject to thermal shock.

Cycles 1, 2 and 3: The panels shall be heated in five steps such that the average temperature difference between the two faces is 10 °C ± 2°C, 20 °C ± 2°C, 30 °C ± 2°C, 40 °C ± 2°C and 50 °C ± 2°C respectively. At each step, the temperature shall be kept constant for one hour and the displacements measured.

In the fourth cycle there shall be a sixth step with a temperature difference of 60 °C ± 2°C. The final temperature shall then be maintained for a further 2 h, after which the panels shall immediately be subjected to thermal shock by spraying water until the temperature difference between the facings has reduced to less than 5 °C in less than 10 min.

Panels shall be carefully inspected during each cycle and the location and size of any shear failure, blistering, waves in the facing that disturb the esthetical aspect of the panel, or delamination recorded.

NOTE 1 Blisters are most easily observed when the panel is hot. Delamination can often be detected by tapping the panel with a hard object.

NOTE 2 Optional measurements.

1. The force exerted on the internal support due to a temperature gradient in the panel may be measured. For this purpose, the test rig should incorporate a load-cell under each end support. Results of measurement at the end of each cycle can be tabulated. This information can be useful to the manufacturer for comparison with with calculated data.

2. The average displacements in the middle of every span can also be measured. For this purpose, the displacements are measured at the end of each cycle, either in the middle of the span and the middle of the width of the 2 middle panels, or in case of 3 full panels, in the middle of the span and the middle of each panel width. All data can be tabulated together with a calculation of the average deflection of the panel in each span. If wrinkling occurs during the test, the moment of the wrinkling may be recorded in this table. This information can be useful to the manufacturer to compare with calculated data.

B.7.5 Calculations and results

Panels shall satisfy the test providing that no shear failure, blistering or delamination is observed at the conclusion of the test cycles. Small waves in the facing are normally regarded as an aesthetic problem. They shall be classed as a failure of the tests if the panel no longer satisfies dimensional tolerance requirements of the Standard.

A clearly defined wrinkle at the internal support shall not be classed as a failure.

NOTE 1 Optionally obtained measurements are not part of the thermal shock test.

NOTE 2 Results from tests carried out using more stringent conditions e.g. by using more cycles and higher temperatures, are equally valid.

Annex C
(normative)

Fire performance tests – additional instructions and direct field of application

C.1 Reaction to fire

C.1.1 Fire test EN 13823 (SBI) – specimens and mounting and fixing

C.1.1.1 General

All sandwich panel products, including roof, ceiling and horizontal wall types, shall be tested vertically in the test rig with a vertical panel-to-panel joint on the long wing.

For sandwich panels used in external roof and wall applications, the internal face and/or the external face shall be tested, depending on the end use conditions and the regulatory requirements in the Member State of use.

For internal end use applications, where both faces may be exposed to the internal fire, the following shall apply:

— products with similar facings (e.g. same metal type, profile and coating – see Table C.1) and with symmetrical geometry of the panel to panel joint shall be tested on one side only;

— products with asymmetrical or dissimilar facings (e.g. different types of material, profile geometry, or coating – see Table C.1) shall be tested on both sides. In this case, two options are possible for the declaration:

  — either the worse test result shall be used to declare the reaction to fire class of the panel (valid for both faces exposed);

  — or a declaration of the reaction to fire class of each face shall be made, provided that the identification of the faces is clearly visible in the marking and labelling of the panel.

In the case of a Euroclass F declaration for one of the faces, no test needs to be performed on that face.

C.1.1.2 Specimen

The dimensions of the specimens shall be:

Short wing.	Panel size:	(495 ± 5) mm	x 1,5 m ± 5 mm (height)	
Long wing.	Panel sizes:	a)	(200 + *D* ± 5) mm	x 1,5 m ± 5 mm (height)
		b)	(795 ± 5) mm	x 1,5 m ± 5 mm (height)
	and (a + b) $(1\,000 + D)^{+0}_{-5}$ mm			

where *D* is the thickness of panel.

NOTE The maximum panel thickness that can be accommodated in the rig is 150 mm. This is measured at the thickest point of the panel and allows for a minimum 35 mm gap between specimen and backing board behind the panel.

The test specimen shall always include both panel facings.

In cases where the profile depth of the face to be tested is between 10 mm and 50 mm, the facing shall be cut away to extend over the U-profile – see C.1.1.3.1.4 and Figure C.2.

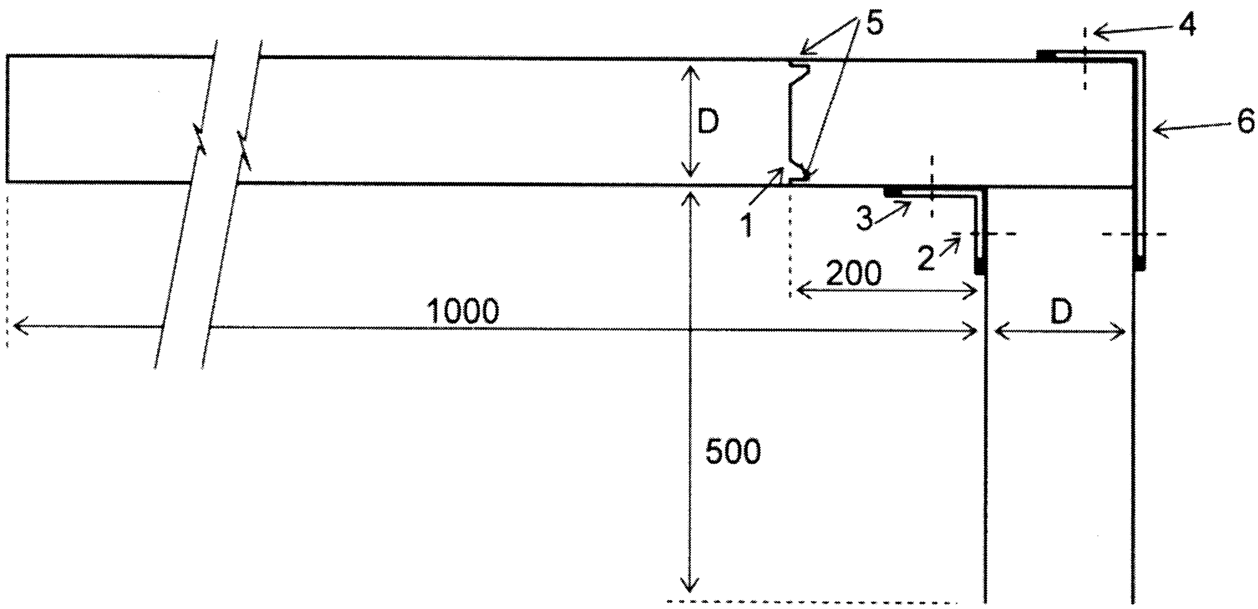
C.1.1.3 Mounting and fixing

C.1.1.3.1 General configuration

C.1.1.3.1.1 General

Sandwich panels shall be installed and fixed as described in EN 13823 in the configuration shown in Figure C.1 and in accordance with C.1.1.3.1 and C.1.1.3.2.

Dimensions in millimetres



Key

D panel thickness
1 panel joint with factory applied seals
2 screws or pop rivets every 400 mm
3 internal corner flashing
4 screws or pop rivets every 400 mm
5 screws, pop rivets or fixing plate
6 external corner flashing

Figure C.1 – Assembly and corner detail for standard assembly, fire test EN 13823

C.1.1.3.1.2 Corner flashings and seals

a) Standard assembly – steel corner flashings:

— the two panels forming the long wing shall be assembled with the joint secured according to C.1.1.3.2;

— the cut edge of the short wing panel shall be placed against the long wing assembly to form an internal corner so that the vertical joint on the long wing is 200 mm from the internal corner. The two wings shall then be secured at 90° to each other using internal and external corner flashings and steel screws or 'pop' type rivets at 400 mm spacing. Positioning of the fixings measured from the bottom of the specimen shall be at the following centres: 50 mm; 450 mm; 850 mm; 1 250 mm and 1 450 mm (see Figure C.1);

— steel corner flashings shall have the following dimensions:

  — internal flashing: 50 mm x 50 mm x 0,5 mm or 0,6 mm thickness;

  — external flashing: 50 mm x (*D* + 50) mm x 0,5 mm or 0,6 mm thickness;

— the internal corner flashing shall have the same coating as the panel specimen;

— the cut panel edges at the top and sides and bottom of the specimen shall not be covered by flashings, foil or other materials;

— panels that are produced and manufactured where the core material is covered by metal facings on all sides and will not be cut or perforated in end use application shall be tested with the edges covered. Panels shall be produced for testing in accordance with the dimensions specified in C.1.1.2.

b) Alternative corner flashings and seals – assembly in end use configuration:

Where required for specific end use applications, alternative corner flashings i.e. aluminium, plastics shall be used in the EN 13823 test. Internal seals, e.g. cold store vapour seals which are normally applied on site, shall also be incorporated into the assembly. The materials used in the tests shall be representative of those used in the end use application.

The type of alternative materials, dimensions, fixing centres, coatings etc. shall be recorded on the test report.

Panels used without corner flashings in end use shall be tested in accordance with EN 13823 without corner flashings. This shall be recorded on the test report.

NOTE The assembly may be prepared and fixed together away from the test chamber. The complete assembly can then be placed on the trolley.

C.1.1.3.1.3 Backing boards and air gap

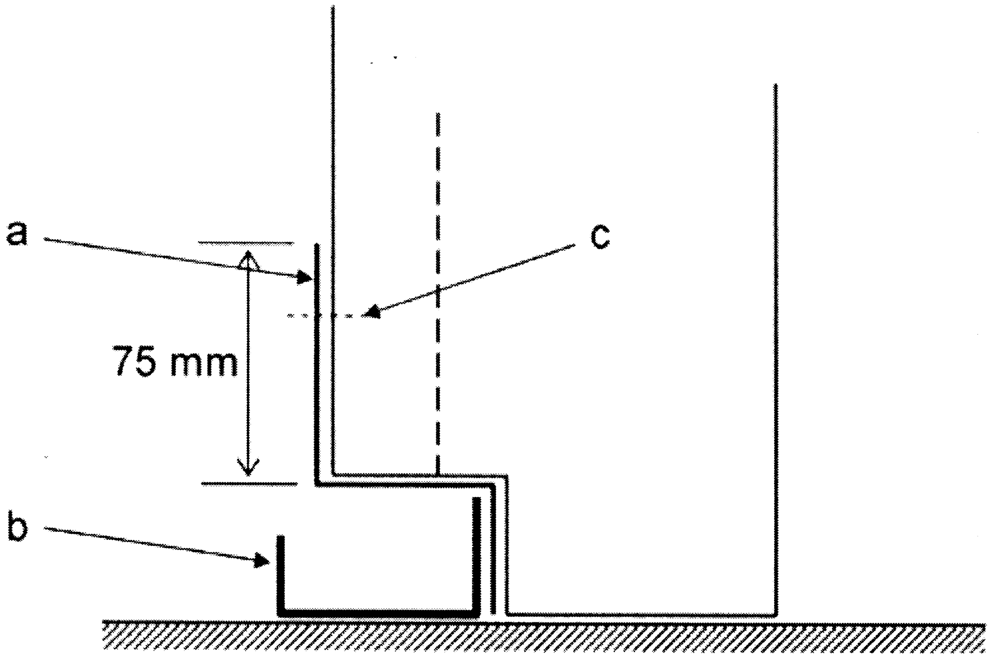
Backing boards shall be placed in accordance with EN 13823 with a minimum 35 mm distance between board and the panel specimen using a spacer bar at top and bottom. The frame between backing board and specimen shall be open to allow ventilation into the gap.

C.1.1.3.1.4 Profiled facings

Non-flat products, where the facing to be tested is profiled, shall be tested in such a way that not more than 30 % of a representative area of 250 mm ”square“ of the facing to be tested, i.e. $B > 0,7 \times A$ in Figure D.1, is more than 10 mm behind the vertical plane through the rear side of the U-profile.

Non-flat products shall be reshaped (cut-back) to partly extend over the U-profile to the side of the burner to fulfil this requirement (see Figure C.2). A product shall not extend over the burner (i.e. maximum extension over the U-profile is 40 mm).

The cut section shall be covered with a flashing (Figure C.2 key a) manufactured from the same material as the face to be tested. The bottom edge of the panel behind this flashing shall not be covered (see Figure C.2).



Key

a cover flashing over tested face

b U-profile

c fixing

Figure C.2 – Cut-back of profiled facing over U-profile

C.1.1.3.2 Securing the panel to panel joint

The following principles shall apply when securing the panel joint on the long wing:

— Panels that are normally fixed to spaced structural supports i.e. in external roof and wall applications, shall be mounted in one of the following ways:

  — by using rivets or screw fixings to hold the panel joint in place. This represents the tight joint achieved in end use. Fixings shall be placed 40 mm from the top and bottom of the specimen (within the aperture dimensions formed by the upper board and lower ‘U’ section). Both internal and external facings shall be secured. The internal face shall be secured first;

  — for panels where the joint design does not allow a screw type of fixing to be used, a thin plate fixing of maximum size 100 mm x 20 mm x 2 mm may be used to hold the joint tightly together.

— Sandwich panels that are normally held together with an internal locking system, i.e. some wall panels in controlled environmental chambers, shall be fixed together using the locking method. Panels shall be cut so that the locking system is positioned symmetrically between the top and bottom of the test sample.

If the locking system does not hold the joint together over the whole length of the specimen, an additional fixing may be used at either the top or bottom of the specimen.

C.1.2 Fire test EN ISO 11925-2 (ignitability test)

C.1.2.1 Specimen

The dimensions of the specimens shall be in accordance with EN ISO 11925-2.

Where the thickness of the sandwich panel is greater than 60 mm, the specimen shall be prepared by reducing the thickness to 60 mm by cutting away the unexposed external face of the panel and some of the insulation. The facing may be replaced with a flat steel sheet adhesively bonded to the 60 mm specimen.

C.1.2.2 Method

Testing shall be in accordance with EN ISO 11925-2.

a) Standard procedure

   In the edge exposure part of the test, the flame shall be applied directly to the insulating core of the sandwich panel without any facing, flashing or covering and shall be carried out on the middle of the thickness of the insulating core (specimen turned 90°). For this European Standard, other layers i.e. adhesive shall be considered non-substantial and shall not be tested individually.

b) Procedure for panels with closed facing

   In the case of panels that are designed and manufactured so that the core material is covered by the facings on all sides and will not be cut or perforated in end use application, only the surface flame attack shall be carried out.

C.1.2.3 Results

a) Results from standard procedure tests

   The results shall be recorded for both surface and edge flame attack test methods.

   The results shall be valid for all end use applications whether the edge of the sandwich panels is either unprotected or protected by a metal facing or separate edge flashing.

b) Results from tests on panels with closed facing

   In the case of panels that are designed and manufactured where the core material is covered by the facings on all sides, the result shall be valid only for that end use application.

C.1.3 Direct field of application of reaction to fire test results

The direct field of application of the reaction to fire tests for the standard parameters for sandwich panels described in Table C.1 shall apply.

Table C.1 – Reaction to fire: Direct field of application of test results

Parameter	Factors	Validity of test
Metal facings	Grade of metal	Valid for all grades of tested metal type
	Thickness of metal facing excluding organic coatings	Valid for all thicknesses between tested thickness and up to +100 % of the tested thickness
	Profile geometry of inside facing a) flat or light profiling up to 5 mm b) profiles greater than 5 mm	 Valid for other types of flat or light profile Valid for any profiles of greater profile depth
	Surface coating – tested face a) PCS value 0 to 4 MJ/m^2 b) PCS value > 4 MJ/m^2 c) colour of coating	 Valid for all coatings in the range 0 to 4 MJ/m^2 Valid for PCS values lower than that tested within manufacturing tolerances Valid for all colours

Parameter	Factors	Validity of test
Joint design	Similar types of joint of the tested face with facings of the same profile – see 'Facings' above and Figure C.3. Joint Types I to VIII Butt joint (Types IX). Worst case scenario	Valid for similar types of overlapping joint where the metal overlapping tongue on the internal face is ≥ 15 mm Valid for all types of joint
Adhesive (where relevant)	Change of tested quantity and/or type: a) Quantity only b) Type only [a] c) Quantity and Type [a]	Valid for lower quantity of tested adhesive (expressed as g/m^2) Valid for an alternative adhesive with calorific value ≤ to that tested (expressed as PCS in MJ/kg) Valid for an alternative adhesive and different quantity, with calorific value ≤ to that tested (expressed as PCS in MJ/m^2)
Seals and gaskets	Seals and gaskets (integral with panel)	Valid only for the types of joint seals and gaskets tested and for those of equal or lower PCS value
MW insulating core	a) density [b] b) orientation of fibres – lamella or slabs c) joints between lamellas d) MW fibres and binders	Valid for ± 15 % of tested density Not valid for change of orientation Valid for change in the number of joints Valid for same type of fibre with same PCS or lower of the tested binder
PUR, XPS, EPS, PF insulating core	a) chemical composition b) density [b]	Valid for the same chemical system and blowing agent Valid for ± 15 % of tested density
Thickness of panel (*D*)	Panels produced in different thicknesses	In the case of a single test, valid for ± 15 % of tested thickness Where the same panels are produced in different thicknesses, both the maximum and minimum thickness shall be tested and the lowest classification declared In cases where the thickest panel is > 150 mm the results from any specimen in the range $100 \leq D \leq 150$ mm in thickness shall be valid for the thickest specimen
Orientation of panels	Vertical or horizontal application of sandwich panels	Test (vertical) is also valid for horizontally installed all panels and ceiling applications
Metal corner flashings [c]		Valid for end use flashings of same material as that tested and of at least the same width and thickness Tests carried out with no corner flashings or steel flashings shall be valid for all types of steel flashings
Plastic corner flashings		Valid for end use flashings of the same material; no flashings; or metal flashings
Fixings for metal flashings	Standard spacing is 400 mm	Valid for fixing spacing of 400 mm or less
Seals [d]	Seals which are applied in end use but not part of the manufactured panel	Valid for seals of the same type as tested or seals with the same or lower PCS

Parameter	Factors	Validity of test
[a] PCS values expressed as PCS in MJ/m^2 shall be calculated using the maximum application rate, as stated in the manufacturing specification. [b] Density: Where the same panels are produced in different densities, the maximum and minimum density shall be tested. The lowest classification or a classification together with its associated density shall be declared. [c] Flashings: The flashing dimensions and metal thickness stated in C.1.1.3.1.2 represent the minimum thickness and dimension in end use. Results are valid for any metal flashing of greater thickness or dimension used in practice. [d] Seals: Where seals are incorporated during the manufacture of the sandwich panel they shall be tested as part of the product in accordance with EN 13823.		

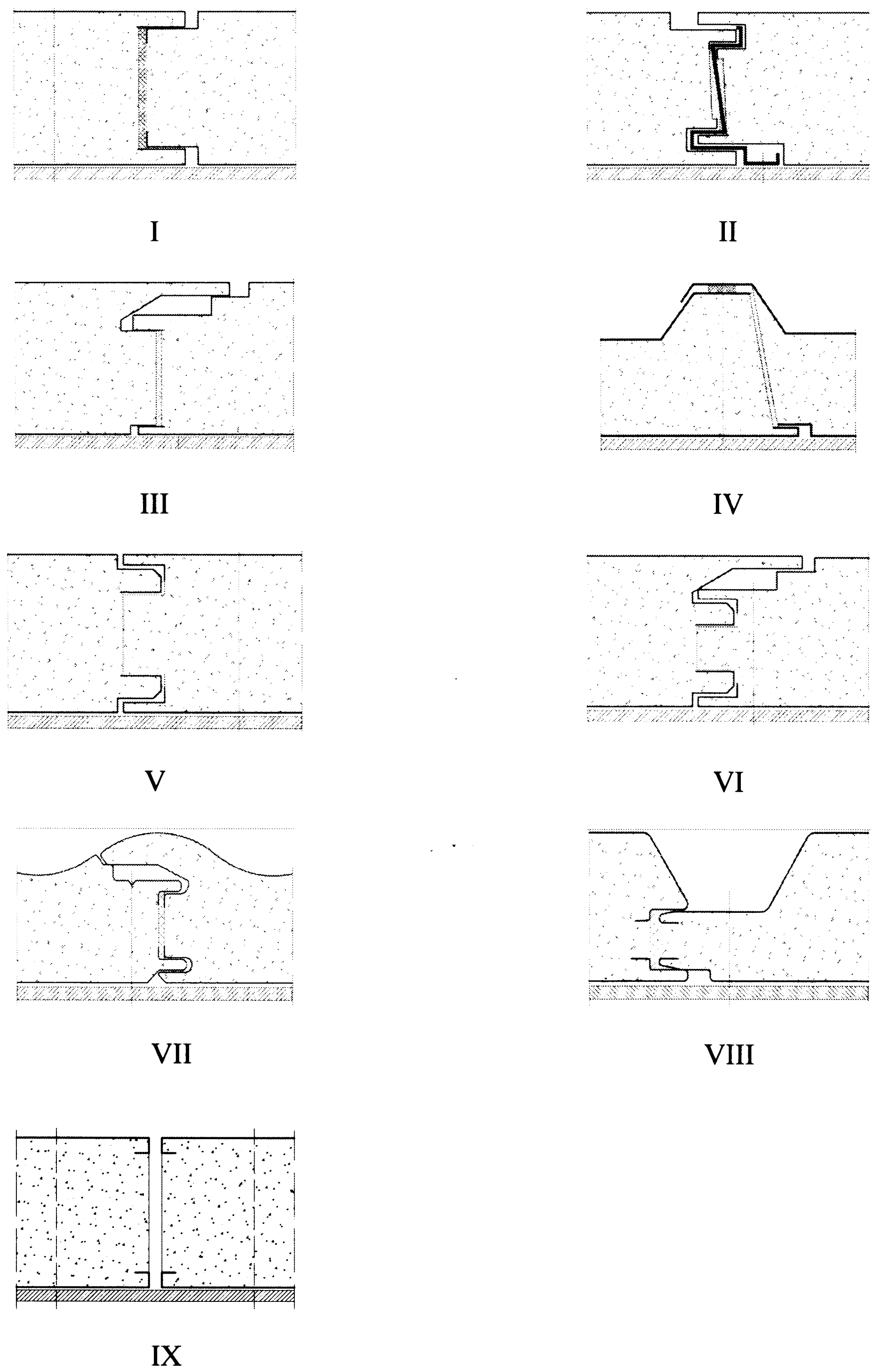


Figure C.3 Illustration of joint types

C.2 Fire resistance

C.2.1 General

This subclause applies to test methods in 5.2.4.2 as applicable.

C.2.2 Fire resistance test EN 1364-1 — Walls

C.2.2.1 General

Supplementary requirements for testing non-loadbearing, self-supporting sandwich panels as external or internal walls supported by vertical structural elements.

C.2.2.2 Size of specimen

The dimensions of the specimen/panel assembly shall be at least 3 m x 3 m and be sufficient fill the opening in the test frame.

C.2.2.3 Mounting and fixing rules

C.2.2.3.1 Exposed face

The exposed face to be tested for sandwich panels used in external and internal roof and wall applications shall depend on the end use conditions and the regulatory requirements in the Member State of use. There may be a requirement to test both faces. However if the faces are symmetrical and have the same composition the test for one side shall be sufficient for classification.

NOTE Where one face is the external face of the building, this face can be tested as the exposed face using the time-temperature curve for external applications [EN 1363–2] where required in accordance with national regulations.

C.2.2.3.2 General Fixing rules

The number of fixings shall not be greater than those used in end use applications. The diameter of the fixings used shall not be larger than fixings used in end use applications.

Fixings may be used independently to secure both the exposed and non-exposed facings (typically for partitions). Alternatively a ‘through-fixing can be used to secure both faces as for external claddings. The through-fixing method represents the worst case and results are valid for the independently secured method.

Fixing between panels (stitching) may be used as in end use conditions but shall be declared in the classification report.

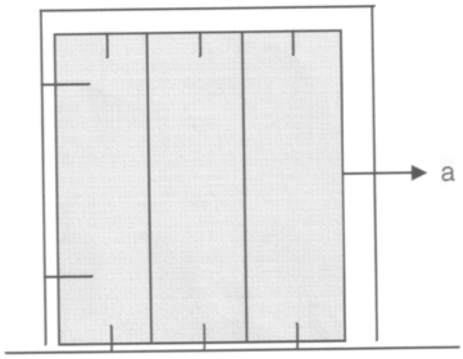
Fixings shall only be protected inside the furnace if the same method is applied in end use.

NOTE It may be necessary to use a method of fire protection for both flashings and fixings to obtain classes of fire resistance greater than 2 h.

C.2.2.3.3 Wall panels in vertical orientation

C.2.2.3.3.1 General

The specimen shall be mounted with one fixed and one free vertical edge (see Figure C.4). This covers the majority of end use applications. However both edges can be unrestrained where this conforms to the end use application but shall be declared in the classification report.



Key

a free edge

Figure C.4 Mounting and fixing of wall panels with vertically orientated joints

C.2.2.3.3.2 Fixing at the top of the specimen – vertical orientation

The method of fixation at the top of the specimen shall be to an angle profile or between angle profiles e.g. where the wall is a partition between a floor and a ceiling. Any gap above the panels shall be firestopped (as in practice in the case of partitions). The method of fixing the angle profile(s) to the concrete test frame shall simulate a rigid supporting structure.

NOTE The gap above the panels does not provide a means for expansion because the movement of the panel is restrained by the fixings and any expansion results in bowing of the panel.

C.2.2.3.3.3 Closure of the vertical free edge – vertical orientation

The vertical free edge is shown in Figure C.4. The free edge (min. 30 mm gap between specimen and frame) shall be filled with a non-combustible insulating material class A2 (e.g. mineral wool). This material shall be held in place with profiles that are fixed to the sandwich panel, not fixed to the concrete test-frame. Alternatively two layers of MW with one side of aluminium foil to provide less friction etc. may be used.

NOTE The free edge is NOT a part of the test- specimen.

C.2.2.3.3.4 Fixing at the bottom of the specimen – vertical orientation

Panels shall be fixed to the bottom of the concrete test frame using at least one angle profile on the exposed side of the panels and using either through-fixings or fixings on the exposed side only. The angle profile shall be sufficient to simulate a rigid construction element of the supporting structure. The manufacturer shall decide and show in test documentation how the horizontal leg of L-profile on bottom of test structure will be positioned according to end use.

NOTE For partitions, installation with the horizontal leg under the panel is the most practical way and represents a worst-case scenario regarding thermal bridging.

Angle profiles on the exterior side or a U-profile can also be used. A U-profile covers all methods of fixation. Panels representing external applications are generally fixed at the bottom with the angle profile turned away from the panel (exposed side). However this is not the worst-case condition if both applications are considered in the test.

A filling with a non-combustible insulating material class A2 may be used under the panels.

C.2.2.3.3.5 Fixing along the fixed vertical edge of the specimen – vertical orientation

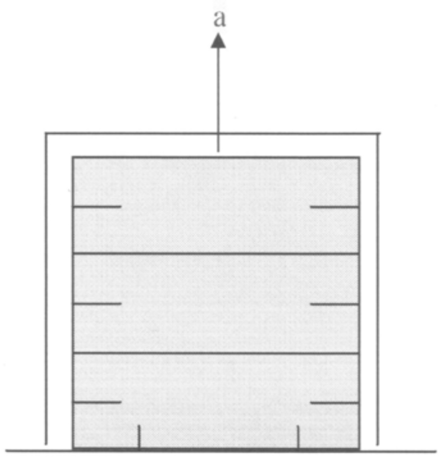
At the fixed vertical edge angle profile(s) shall be fixed to the concrete test-frame to restrain the movement of the panel in the horizontal direction. The panel shall be fixed to the angle profile(s) as in end use condition. This method of fixing of the panel is considered to be equally valid for partition or external wall applications. The angle profile(s) shall not cover the panel facing more than they would in end use conditions.

If a panel shall be cut in width to fit the assembly into the test-frame, the cut panel shall be mounted on the restrained vertical side

C.2.2.3.4 Wall panels in horizontal orientation

C.2.2.3.4.1 General

The specimen shall be mounted with one fixed (bottom) and one free (top) horizontal edge (see Figure C.5). This covers the majority of end use applications. However both edges can be unrestrained where this conforms to end use application.



Key

a free edge

Figure C.5 Mounting and fixing of wall panels with horizontally orientated joints

C.2.2.3.4.2 Fixing along the fixed vertical side of the specimen – horizontal orientation

At the fixed vertical edge angle profile(s) shall be fixed to the concrete test-frame to restrain the movement of the panel in horizontal direction. The panel shall be fixed to the angle profile(s) as in end use condition. This method of fixing of the panel is considered to be equally valid for both partition or external wall applications. The angle profile(s) shall not cover the panel facing more than they would in end use conditions

NOTE 1 The fixing of both the exposed and non-exposed side either independently or using a through-fixing are expected to have the same effect. The first method is used more often in partitions, the second one in external applications.

NOTE 2 Expansion movement in the panels can be expected at both ends between the concrete frame and the panel edge.

C.2.2.3.4.3 Closure at the free top edge of the specimen – horizontal orientation

The top panel shall be either the smallest width panel or the panel with the cut edge. This corresponds with end use applications where the full panel width is always at the bottom. The gap between the top panel and the frame shall be at least 30 mm and shall be filled with a non-combustible insulating material class A2 (e.g.

mineral wool). This material shall be held in place with profiles that are fixed to the sandwich panel, not fixed to the concrete test-frame.

NOTE Expansion movement can be expected between the panel and the frame as experienced in the end use applications (in case of internal partitions against a ceiling or horizontal construction.

C.2.2.3.4.4 Fixing at the bottom of the specimen – horizontal orientation

Panels shall be fixed to the bottom of the concrete test frame using at least one angle profile on the exposed side of the panels and using either through-fixings or fixings on the exposed side only. The angle profile shall be sufficient to simulate a rigid construction element of the supporting structure. The manufacturer shall decide and show in test documentation how the horizontal leg of L-profile on bottom of test structure will be positioned according to end use.

NOTE 1 For partitions, installation with the horizontal leg under the panel is the most practical way and represents a worst-case scenario regarding thermal bridging.

Angle profiles on the exterior side or a U-profile can also be used. A U-profile covers all methods of fixation. Panels representing external applications are generally fixed at the bottom with the angle profile turned away from the panel (exposed side). However, this is not the worst-case condition if both applications are considered in the test.

NOTE 2 A filling with a non-combustible insulating material class A2 may be used under the panels. If in end-use conditions the panel is not fixed to the floor, the filling can be held in place at the bottom by profiles that are not fixed to the concrete test frame.

C.2.2.4 Additional test measurements and test report

Additional measurements covering the bow of panels between joints, and the opening of the joints as described in EN 15254-5 shall be carried out. These measurements shall be reported in the test report in addition to the standard reporting requirements in accordance with EN 1363-1, Clause 12.

C.2.3 Fire resistance test EN 1365-2 — Roofs

C.2.3.1 General

Sandwich panel roofs may be subject to loads. Only in exceptional designs (e.g. acting as diaphragms) do they carry part of the primary load of the building structure.

C.2.3.2 Apparatus

The framework shall be designed to support the panel assembly as in end use.

The specimen shall be tested in the horizontal position.

C.2.3.3 Procedure

The applied load shall be in accordance with national regulations valid in the country of use and determined according to EN 1365-2 for the end use condition.

C.2.3.4 Results and declaration

The load shall be declared with the fire resistance classification.

C.2.4 Field of application of fire resistance test results

C.2.4.1 Wall panels

The field of application of the fire resistance test results for sandwich panels used for wall applications shall be in accordance with EN 15254-5 together with the additional in field of application in Table C.2.

Table C.2 – Fire resistance – Additional direct field of application of test results – wall panels

Parameter	Factors	Validity of test
Metal facings	Surface coating – tested side	Valid for all coatings
	a) colour of coating	Valid for all colours
	b) un-coated facings	Tests on coated facings are not valid for un-coated facings

C.2.4.2 Ceiling panels

The field of application of the fire resistance test results for sandwich panels used for ceiling applications for the standard parameters for sandwich panels described in Table C.3 shall apply.

Table C.3 – Fire resistance – Direct field of application of test results – ceiling panels

Parameter	Factors	Validity of test
Metal facings	Grade of metal	Valid for all grades of tested metal type
	Thickness of metal facing	Valid up to ± 50 % of the tested thickness
	Profile geometry of facing	
	a) flat or small profiling up to 5 mm	Valid for any profile change
	b) profiles greater than 5 mm	Valid for variations + 50 % of profile depth
	Surface coating – tested side	Valid for all coatings
	a) colour of coating	Valid for all colours
	b) un-coated facings	Tests on coated facings are not valid for un-coated facings
Joint design		Valid within normal tolerances (see 5.2.5) Not valid for changes of shape or configuration
Adhesive (where relevant)	Amount and type of adhesive	
	a) PCS value 0 to 4 MJ/m^2	Valid for all adhesives ± 50 % of mass tested
	b) PCS value > 4 MJ/m^2	Valid for PCS values lower than the tested adhesive within manufacturing tolerances
	c) PCS > 4MJ/m^2 and > 1,15*PCS	Test results reduced by the same % as the PCS value over the initial tested adhesive
Seals and gaskets (integral with panel)		Valid only for the types of joint seals and gaskets tested and for those of equal or lower PCS value

Parameter	**Factors**	**Validity of test**
MW	a) MW fibres and binders	Not valid if the MW fibres or binders used differ from the original tested materials Valid for increase in binder content + 20 % or for lower quantities of binder
	b) density	Valid for all densities greater than that tested in the density range 50 kg/m^3 to 150 kg/m^3 Valid to down to –10 % of tested density
	c) orientation of fibres – lamella or slabs	Not valid for change of orientation
	d) joints between lamellas	Valid for reduction in the number of joints
PUR	Chemical composition	Valid for the same chemical system and blowing agent Valid for ± 10 % of tested density
PF	Chemical composition	Valid for same chemical composition, density and blowing agent
Thickness of panel	Increase of panel thickness	Valid for any increase in thickness using the same insulating core material
Width	a) decrease in panel width	Test valid (see EN 1364–1)
	b) increase in panel width	Valid for increases not greater than + 20 %
Seals	Seals which are applied in end use but not part of the manufactured panel	Valid for that type of seal only and for those of equal or lower PCS value Valid for the same panels without seals for MW and CG cores. Not valid for other core materials

C.2.4.3 Roof panels

This European Standard does not provide rules for direct field of application of fire resistance test results for roof panels, which are considered loadbearing.

C.3 Fire tests CEN/TS 1187 - external fire performance for roofs

C.3.1 Classification without further testing (CWFT)

The following types of roof panel have been approved for CWFT providing they are designed for external roof applications satisfying the specifications below and are subject to FPC controls for safety in fire characteristics (6.3.5.3).

Panels with a profiled external metal facing and a core material of PUR or MW incorporating:

— minimum thickness 0,4 mm for facings of steel and stainless steel;

— minimum thickness 0,9 mm for facings of aluminium;

— at each longitudinal joint between two panels an overlap of the external metal facing extending across the crown and a minimum 15 mm down the opposite face of the crown,

or a metal cover cap completely covering the joint crown, or a raised standing metal seam along the joint;

— at each transverse joint between two panels an overlap of the external metal facing of at least 75 mm;

— a protective weather coating comprising a liquid applied PVC paint of maximum nominal dry film thickness 0,200 mm, a PCS of not greater than 8,0 MJ/m^2 and a maximum dry mass of 300 g/m^2,

or any thin paint coating less than the above;

— minimum reaction to fire classification of the panel of D-s3,d0 without edge protection in accordance with EN 13501-1;

— a nominal core density > 35 kg/m^3 for PUR insulating cores;

— a nominal core density > 80 kg/m^3 for MW with lamella cores;

— a nominal core density > 110 kg/m^3 for MW with full width board cores.

NOTE The raised profile of the external metal facing may be either trapezoidal or sinusoidal in shape (see Figure A.18). The crown is the upper section or point of the profile. The opposite face of the crown is the reverse face for trapezoidal shapes or measured from the apex of the curve for sinusoidal profiles.

C.3.2 CEN/TS 1187 Method 1 test

C.3.2.1 Specimens and mounting – side lap test

The specimens shall be cut so that the end of the overlap sheet is at least 250 mm from cut edge of panel.

Panels shall be fixed to three support sections (Top-hat or angles) at top, centre and bottom and side laps shall be stitched every 400 mm.

C.3.2.2 Specimens and mounting – end lap test

The specimens shall be cut to create an end lap so that the cut edge of the upper panel is positioned 750 mm from the lower edge of the specimen.

The panel at the end lap shall be fixed in each trough to a support angle with a minimum bearing surface of 75 mm and the overlap sheet shall be stitched in each trough 50 mm from the cut edge.

C.3.3 CEN/TS 1187 Method 2 test

Specimens and their mounting shall be as specified in CEN/TS 1187.

C.3.4 CEN/TS 1187 Method 3 test

C.3.4.1 Specimens

a) Side lap plus end lap test:

The test specimen shall be made up from two part-panels with a central standard side-lap joint. The central line shall be the edge of the overlap not the edge of the panel. The left hand panel shall have a standard end lap situated 500 mm from the bottom edge.

b) Side lap test only:

The test specimen shall be made up from two full-length part-panels with a standard side-lap joint. The dimension to the cut edge of the overlap, not the edge of the panel, shall be 785 mm from the left hand edge.

C.3.4.2 Mounting and fixing

a) Side lap plus end lap test:

The panel at the end lap shall be fixed in each trough to a support angle with a minimum bearing surface of 75 mm and the overlap sheet shall be stitched in each trough 50 mm from the cut edge.

Panels shall be fixed to three support sections (Top-hat or angles) at top, centre and bottom and side laps shall be stitched every 400 mm.

b) Side lap test only:

Panels shall be fixed to three support sections (Top-hat or angles) at top, centre and bottom and side laps shall be stitched every 400 mm.

NOTE For the CEN/TS 1187 tests, the position of the cut edge stated in the test requirements refers to the position of the edge of the overlapping top sheet and not the position of the panel joint underneath.

C.3.5 CEN/TS 1187 Method 4 test

The specimen shall be prepared with a longitudinal panel joint positioned centrally.

Specimens shall be secured to a non combustible framework using standard fixings so that the joint is held rigidly, as in end use.

C.4 Determination of the amount and thickness of the adhesive layer

C.4.1 General

Where required, the amount and thickness of the adhesive layer shall be determined in accordance with C.4.2 for panels after production, or in accordance with C.4.3 for control measurements during production.

C.4.2 Measurements on a manufactured panel

C.4.2.1 Principle

The method to collect and calculate the amount and thickness of adhesive used in the manufacture of sandwich panels shall be determined according to C.4.2.2 to C.4.2.5.

C.4.2.2 Specimen

A 500 mm x 500 mm specimen of the panel facing shall be cut (e.g. by sawing) from the panel. The length and width of the facing sheet shall be measured with 1 mm accuracy at three places in both directions and the area A shall be calculated using the measured mean values. The place of the sample in the panel shall be documented.

C.4.2.3 Procedure

The insulation material shall be removed from the facing. Any wool fluff or insulant shall be carefully removed with a steel brush so that a clean adhesive surface is visible.

The facing sheet shall be weighed with adhesive to an accuracy of 0,1 g.

A paint remover shall be spread over the adhesive and the softened adhesive removed with a steel trowel.

The facing sheet shall be weighed without adhesive, on the same scales.

C.4.2.4 Calculation of results

The amount of adhesive shall be calculated from Formula (C.1):

$$m_{glue} = (m_1 - m_2)/A \quad \text{(C.1)}$$

where

m_{glue} is the amount of adhesive in grams per square metre (g/m^2);

m_1 is the mass of facing + glue in grams (g);

m_2 is the mass of facing in grams (g);

A is the area of facing sheet in square metres (m^2).

The mean thickness of the adhesive layer shall be calculated from:

$$h_{glue} = m_{glue} / \rho$$

where

h_{glue} is the thickness of adhesive in millimetres (mm);

m_{glue} is the amount of glue in grams per square metre (g/m^2),

ρ is the density of used glue in kilograms per cubic metre, i.e. density of uncured glue mixture, (kg/m^3).

C.4.2.5 Reporting

The test report shall contain the following information:

a) date of the test;

b) test method used;

c) panel code or specification;

d) place of the sample in the panel;

e) type of glue, glue batch (if known), density of the glue;

f) dimensions and area of the facing sheet;

g) mass of the facing sheet with and without glue.

C.4.3 Measurements during production

C.4.3.1 Principle

The method to collect and calculate the amount and thickness of adhesive used in the manufacture of sandwich panels shall be determined according to C.4.3.2 to C.4.3.3.

C.4.3.2 Procedure

Weigh a suitable carrier e.g. an A3 size piece of paper (m_c). The length and width of the carrier shall be measured with 1 mm accuracy at three places in both directions and the area shall be calculated using the measured values.

Place the carrier on the lower sheet of the sandwich panel over which the adhesive dispensing head passes. The place of the carrier on the facing sheet shall be documented.

Coat the carrier as part of the normal application process and remove from the line.

Weigh the carrier and adhesive (m_{a+c}).

C.4.3.3 Calculation of results

Calculation of the amount of the adhesive (C.2):

$$m_{(adhesive)} = (m_{a+c} - m_c) / A \quad (C.2)$$

where

m_{a+c} is the mass of the carrier and adhesive;

m_c is the mass of the carrier;

A is the area of the carrier.

Annex D
(normative)

Dimensional tolerances

D.1 General

Tolerances have an impact on the strength of a panel and its safety in use. The tolerances defined in 5.2.5, Table 3 are the maximum permissible.

The following tolerances shall apply to measurements made in the factory, before delivery, on panels that have reached a stable condition. Prior to measurement for ITT only, foamed panels shall be kept fully supported on a flat surface at ambient temperature for at least 24 h. The measurements shall be corrected for temperature variations to 20 °C where appropriate.

Measurements of pitch, crown, valley and cover width shall be carried out at 200 mm from the end of the panel.

When measurements are taken, the panel shall be placed on at least three equally spaced supports, which are on a rigid flat surface.

D.2 Dimensional tolerances

D.2.1 Thickness of panel and joint conformity

The measured thickness (*D*) of the panel shall be the nominal distance between the external flat surfaces of the faces excluding from the measurement any trapezoidal profiles or stiffeners and including the thickness of both metal faces (see Figure D.1).

These measurements shall be taken at each end of the panel on lines 200 mm from the ends of the panel and at a minimum distance of 100 mm from the longitudinal edge. Two of these measurements shall be at the opposite edges of the panel and one at the centre.

In the case of panels that have profiled faces, the measurement shall be made at the position of predominant thickness. FPC records shall indicate where, within the geometry of the panel, this measurement is to be made and a consistent measurement location shall be used.

Tolerances: $D \leq 100$ mm ± 2 mm,

$D > 100$ mm ± 2 %.

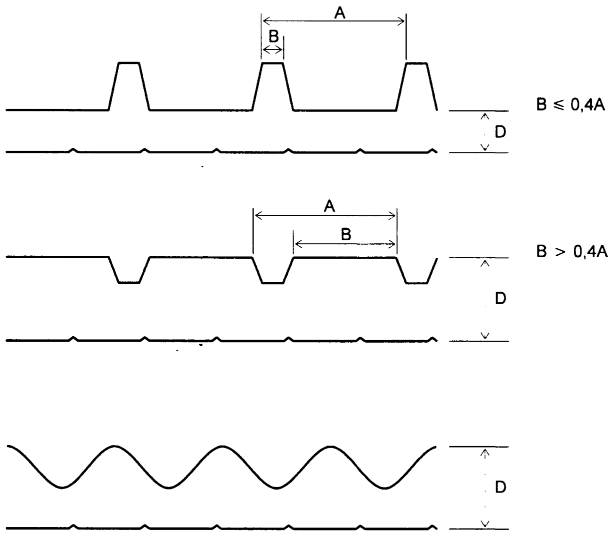


Figure D.1 – Thickness of panels

D.2.2 Deviation from flatness

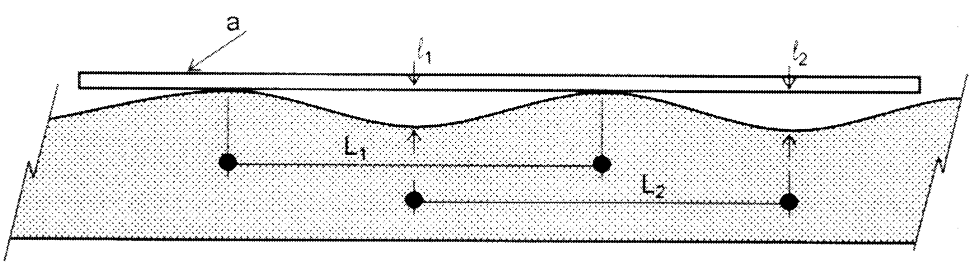
This measurement is only relevant in the case of panels with nominally flat or lightly profiled facings.

Deviation from flatness (*l*) shall be defined as the distance between any point in the surface and the theoretical flat plane as shown in Figure D.2. Flatness shall be measured in both the longitudinal and transverse directions over a minimum distance of *L* = 200 mm.

The location of the measured distance *L* shall be at least 100 mm from the edge of the panel and 200 mm from the end of the panel.

A straight metal bar shall be placed on the surface of the panel and the maximum gap between the bar and the panel measured with a precision gauge.

Tolerance:	For *L* = 200 mm	*l* = 0,6 mm;
	For *L* = 400 mm	*l* = 1,0 mm;
	For *L* > 700 mm	*l* = 1,5 mm.



Key

L measured distance on flat plane

l deviation from flatness

a straight metal bar

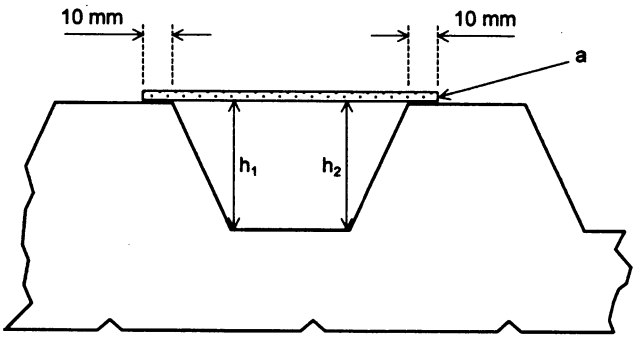
Figure D.2 – Flatness

D.2.3 Depth of metal profile

The depth of the profile (h) shall be the distance between the crown and valley measured on the same side of the sheet (see Figure D.3), at 200 mm from the sheet end. This measurement shall only be taken for panels that have at least one lightly profiled or profiled face.

Tolerances:

5 mm < h ≤ 50 mm	±1 mm;
50 mm < h ≤ 100 mm	±2,5 mm.



Key

a straight metal bar

Figure D.3 – Dimensional check for depth of profile *h*

The depth of each valley across the sheet shall be measured by means of a template or a measuring rule at both sides of the valley (see Figure D.3). The tolerances shall apply to the average value for each valley:

$$h = \frac{h_1 + h_2}{2} mm$$

D.2.4 Depth of stiffeners on lightly profiled facings

The depth of any stiffeners (d_S, see Figure D.4), on crown, valley or web, or the depth of light profiling, shall be measured across the sheet on a line at 200 mm from the end by means of a template or measuring rule and a precision gauge.

The average depth obtained in ITT tests shall be the value used for the depth of stiffeners (d_s).

Tolerances:

d_S ≤ 1 mm	±30 % of d_S,
1 mm < d_S ≤ 3 mm	±0,3 mm,
3 mm < d_S ≤ 5 mm	±10 % of d_S.

Figure D.4 – Depth of stiffeners and light profiling

Where flat faced panel properties are used as the basis of design for mechanical resistance, the tolerance of the stiffeners or light profiling need not be considered.

D.2.5 Length

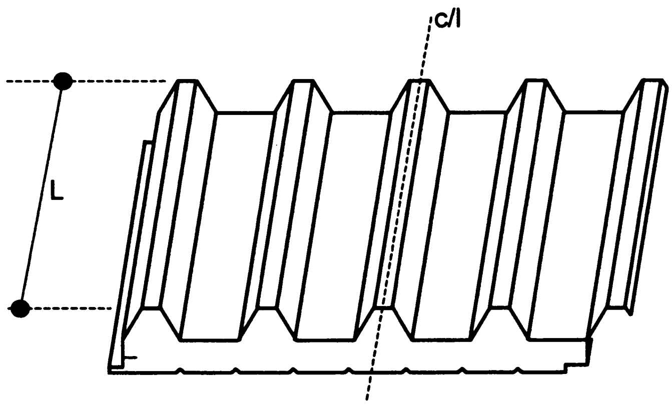
The length (*L*) shall be measured along the centre axis of the panel (see Figure D.5) with the panel continuously supported on a flat surface. The panel length shall be verified at least once during each shift (6 h or 8 h).

If the length over the foam is different from the length over the steel sheet, the tolerance shall be based on the length of the metal sheet. A separate tolerance shall be applied to the overlap.

Tolerances: $L \leq 3\ 000$ mm ±5 mm;
$L > 3\ 000$ mm ±10 mm.

NOTE 1 Specific requirements may be agreed between the manufacturer and the purchaser at the time of ordering.

NOTE 2 Panels for cold store applications generally require tighter tolerances.



Key
c/l centre line of the panel

Figure D.5 – Sheet length

D.2.6 Cover width

The cover width, *w*, shall be stated by the manufacturer. For profiled panels with a side lap, the cover width is the distance between the centre lines of the two outer profiles as shown in Figure D.6.

For flat panels or panels with a male and female joint or panels with a joint built up on site, the cover width is the distance between the axes of the joints. In such cases, the points of measurement depend on the details of the joint. The manufacturer shall clearly define the measurement points and the same points shall be used every time a measurement is made (see examples in Figures D.7 and D.8).

The cover width of the sheet shall be measured across the sheet by means of a purpose-made gauge (see Figure D.9) or as the distance between two plates placed on the side webs (see Figure D.14 for example of method).

Measurements of cover width w_1 and w_2 shall be taken at a distance of 200 mm from the panel ends (see Figure D.6). Both measurements shall be within the specified tolerance.

A third measurement w_3 of cover width shall be made across the centre line of the sheet to determine the contraction or bulging of the panel. This w_3 measurement shall be within the stated tolerance referred to the average value for w_1 and w_2:

$$w_3 = \frac{w_1 + w_2}{2}$$

Tolerances: ± 2 mm for all profiles.

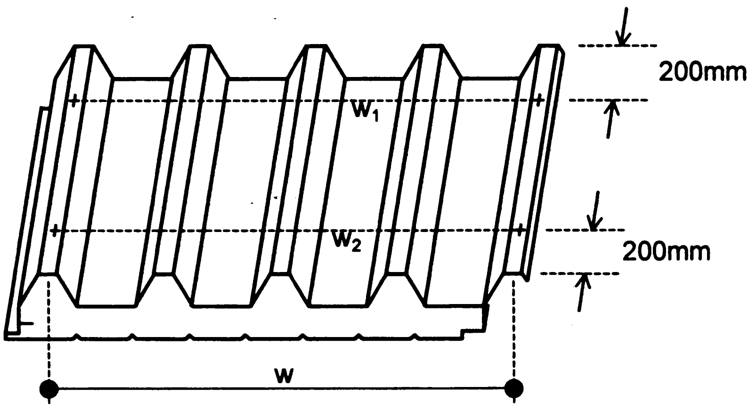


Figure D.6 – Cover width (*w*) of profiled panels

Dimensions in millimetres

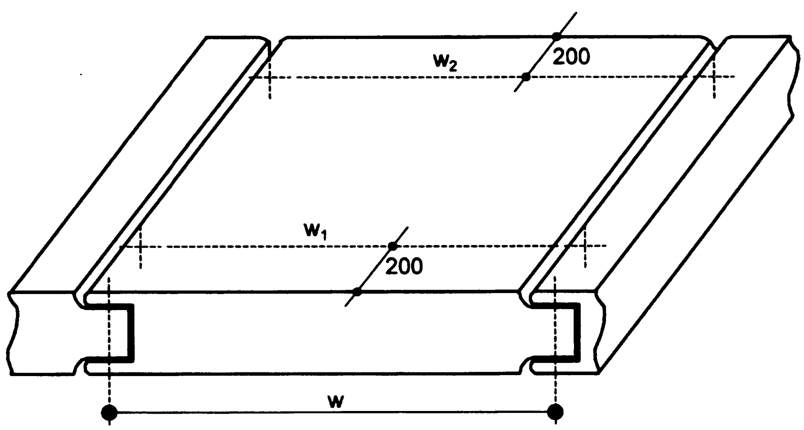


Figure D.7 – Design width (*w*) in the case of a male and female joint

Dimensions in millimetres

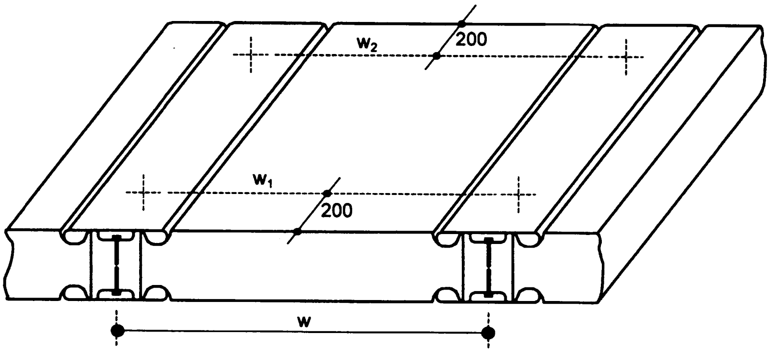
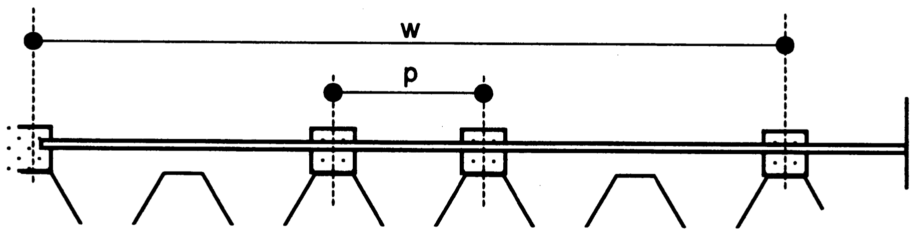


Figure D.8 – Measurement of cover width (*w*)



Key

p pitch

w cover width

Figure D.9 – Dimensional check for cover width *w* and pitch *p* using a calibrated gauge

D.2.7 Deviation from squareness

The deviation from squareness of the profiled sheet end is defined as the dimension *s* in Figure D.10.

Tolerance: *s* ≤ 0,6 % of the nominal cover width *w*.

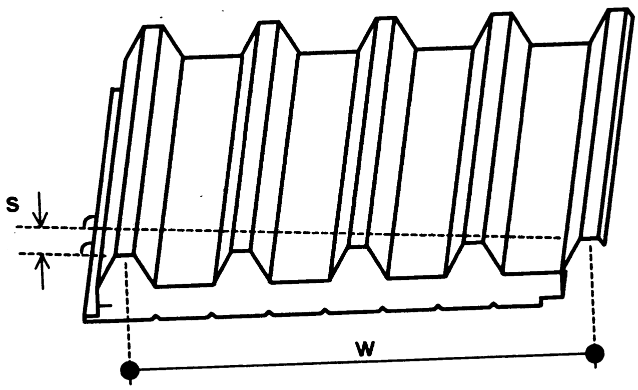


Figure D.10 – Squareness

D.2.8 Deviation from straightness

The deviation of straightness from the theoretical straight line is defined as the dimension δ in Figure D.11.

The straightness of a panel shall be measured from a thin steel wire tightly stretched between two points on the same edge at 200 mm from each end of the panel. The measurement shall be made at the centre of the panel.

Tolerance: 1,0 mm/m, not exceeding 5 mm.

Dimensions in millimetres

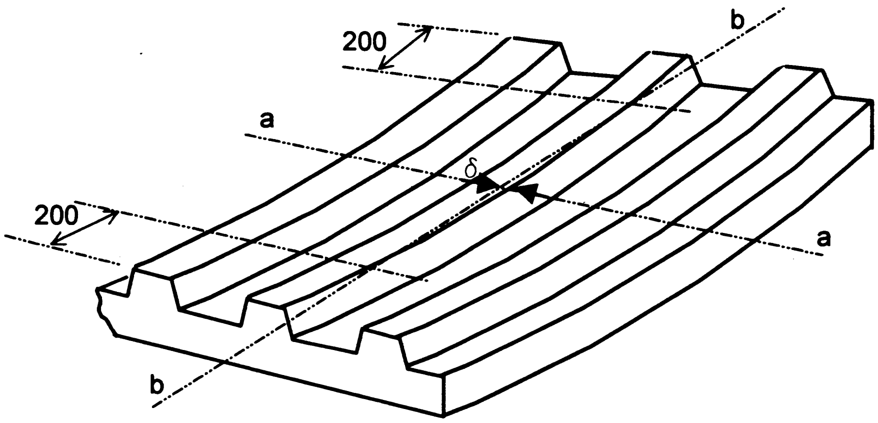


Figure D.11 – Deviation of straightness

D.2.9 Bowing

The bowing of the panel is a measure of the displacement between the surface of the panel and the straight line connecting the two ends (see Figure D.12).

A thin steel wire shall be tightly stretched between two ends of the panel along the longitudinal centre line or across the width. The maximum displacement between the wire and the panel surface shall be measured using a graduated metal scale. Alternatively, the straight line between the two ends of the panel may be defined by means of a laser beam.

The location of the measured tolerance b shall be at least 100 mm from the edge of the panel and 200 mm from the end of the panel.

Care shall be taken that no transverse load is applied to the panel during the measurement. Advantageously, this test may be carried out with the panel on its side in order to eliminate the influence of self-weight.

Tolerance: 2,0 mm for each metre length but not greater than 20 mm;

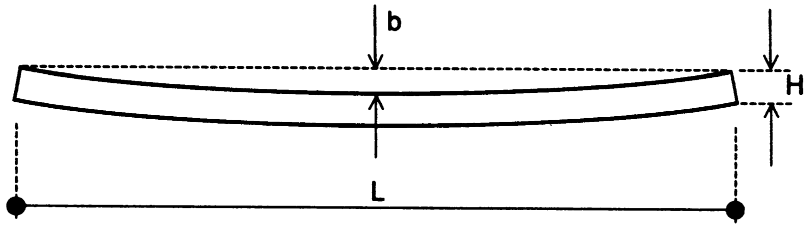
8,5 mm for each metre width for flat or lightly profiled – $h \leq 10$ mm (see D.2.3);

10 mm for each metre width for other depths of profile – $h > 10$ mm (see D.2.3).

Continuously laminated panels may bow in this way during curing. The measurement should not be carried out until the panel is cured to ambient temperature.

A temperature difference between faces should be avoided during testing.

Panels with dissimilar faces e.g. steel/aluminium in particular should be checked for bowing.



Key

b bowing displacement

Figure D.12 – Panel bowing

D.2.10 Pitch of profile

The pitch *p* of the profile (see Figure D.13) shall be the distance between the centres of adjacent ribs, measured at 200 mm from the sheet ends.

The measurements shall be made by one of the following methods, of which a) is preferred:

a) as the distance measured between two plates placed on the webs, as illustrated in Figure D.14;

b) as the deviation from a template;

c) by means of a profile gauge (see Figure D.9).

Tolerances: where $h \leq 50$ mm ± 2 mm;

$h > 50$ mm ± 3 mm.

NOTE This measurement may also be related to D.2.6 cover width. Problems may arise in practice if the relationship of the profile to the edge of the panel is not correct.

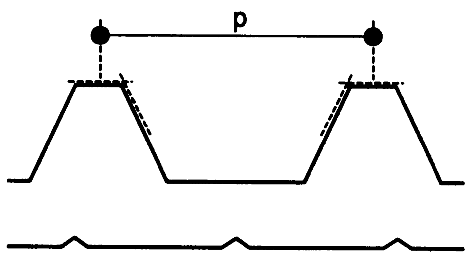


Figure D.13 – Pitch (*p*)

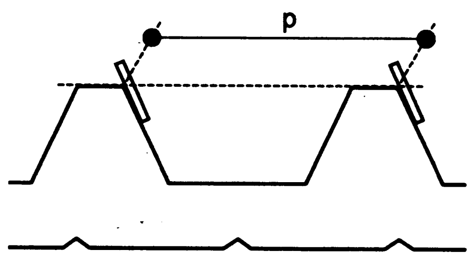


Figure D.14 – Dimensional check for pitch

D.2.11 Widths of rib and valley

The widths of a rib (b_1) and valley (b_2) (see Figure D.15) shall be measured at 200 mm from the sheet ends.

The widths of ribs and valleys shall be measured on a line across the sheet by means of a template.

Tolerances: ribs ± 1 mm, valleys ± 2 mm.

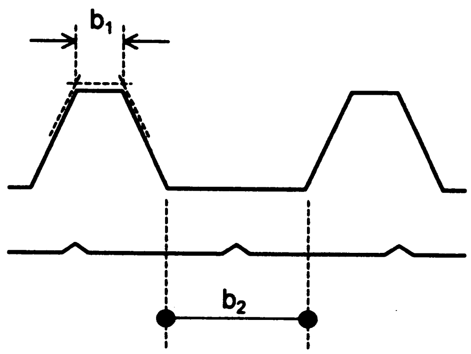


Figure D.15 – Widths of rib and valley

Annex E
(normative)

Design procedures

NOTE This annex supports mechanical resistance characteristics required by the standard and describes the methods required for their calculation. The mechanical resistance characteristics can equally be obtained by testing. E.7.2.8 is an informative guidance for the calculation of additional stresses due to expansion. E.8 gives informative guidance on the design of panels with specific profiles.

E.1 Definitions and symbols

E.1.1 Properties of a sandwich panel

The cross-section and material properties of a sandwich panel shall be as shown in Figures E.1 a) and E.1 b) and Table E.1.

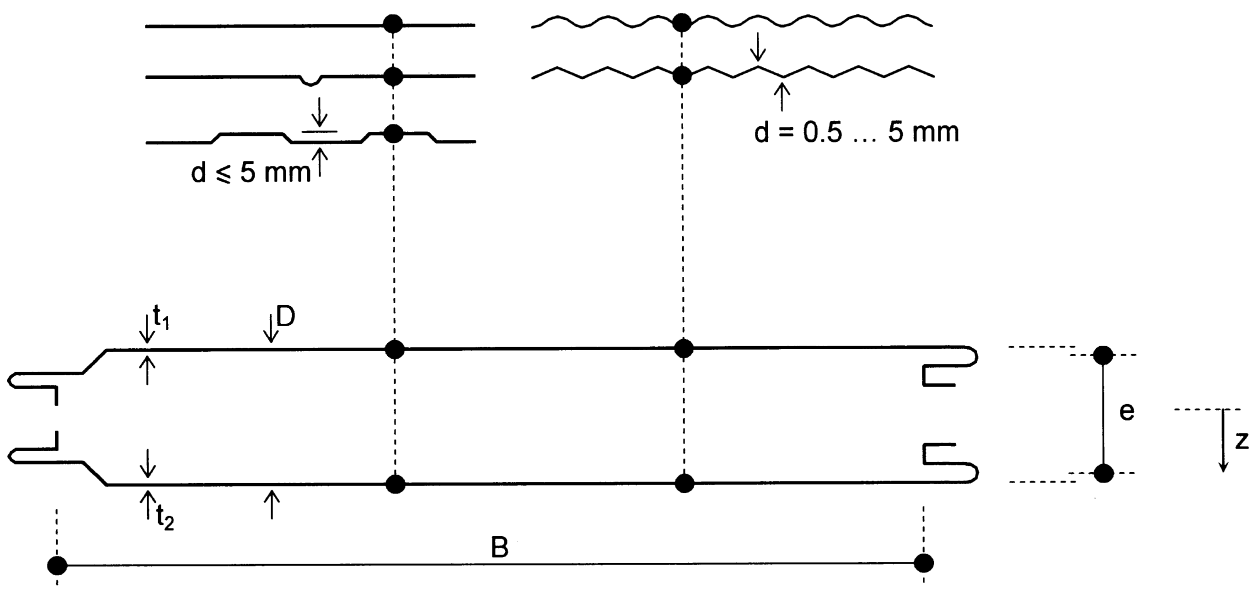


Figure E.1 a) – Panel cross-section, flat, lightly profiled or microprofile face

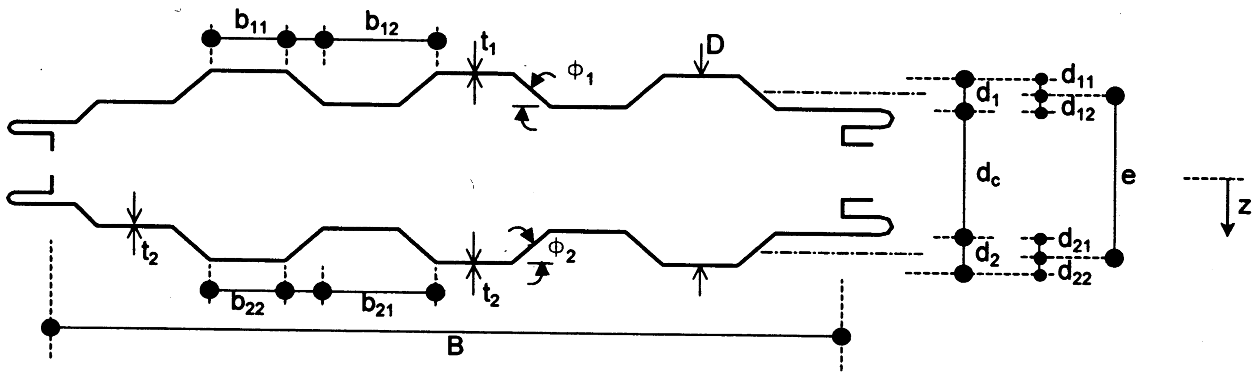


Figure E.1 b) – Panel cross-section, profiled face and material properties of a sandwich panel

Table E.1 – Panel properties

Layer	Geometry	Material properties	Structural properties
Face 1	t_1, d_1, d_{11}, d_{12}, A_{F1}, I_{F1}	E_{F1}, α_{F1}	B_{F1}
Core	d_C	E_C, G_C	S
Face 2	t_2, d_2, d_{21}, d_{22}, A_{F2}, I_{F2}	E_{F2}, α_{F2}	B_{F2}

E.1.2 Symbols used in Annex E

The following symbols apply to this annex.

A cross-sectional area

B overall width of the panel, flexural rigidity

NOTE A, cross sectional area and B, flexural rigidity may apply either to the full width of a panel (e.g. in Annex A when interpreting test results) or to a unit (metre) width of panel when carrying out design calculations or preparing load tables.

C design value of a serviceability criterion

D overall depth of the panel

E modulus of elasticity, design value of the effect of an action

F force, load

G shear modulus, permanent action

I moment of inertia

L span, distance

M bending moment

N axial compressive force

Q variable action

R resistance, reflectivity (R_G)

S shear rigidity, characteristic value of an action

T temperature

V shear force

d depth of face profile or stiffeners, depth of core (d_c)

e distance between centroids of faces, base of natural logarithms (*e* = 2,718 282)

f strength, yield stress

h height of profile

k parameter (E.4.3.2 support reaction capacity), correction factor

n number of webs

q live load

s length of web (s_{w1})

t thickness of face sheet

v variance factor

α coefficient of thermal expansion

β parameter (Table E.10.2 design formulae)

Φ angle

γ partial safety factor, load factor (γ_F)

φ creep coefficient

θ parameter (Table E.10.1 design formulae)

σ stress, compressive strength σ_m, standard deviation

τ shear stress

ψ combination coefficient

Subscripts

C core

F face, action (γ_F)

G permanent load, degree

M material (γ_M)

Q variable action

S sandwich part of the cross-section

c compression, core

d design

i, j index

k characteristic value

nom nominal

s support (L_s = support width), surface (R_{s1})

t time

tol tolerance (normal or special)

0 basic value

1 external face, upper face

2 internal face, lower face

E.1.3 Sign convention used in Annex E

Where relevant, the formulae in this annex assume the following sign convention:

Hogging bending moments are positive (face 1 in tension)

Compressive forces and stresses are positive

Downward loads are positive

Downward deflections are positive

E.2 General

The design values E_d of the effects of the actions shall be calculated and shall be compared with the design values of the corresponding resistance R_d or the relevant serviceability criterion C_d taking into account the appropriate material partial factors γ_M.

It shall be verified by means of calculation and/or testing that that the Formulae (E.1) to (E.4) are satisfied using the procedures in E.5 to E.7.

Ultimate limit state: $E_{ULS:d} \leq R_d$ (E.1)

Serviceability limit state: $E_{SLS:d} \leq C_d$ (E.2)

Where

$E_{ULS;d}$ and $E_{SLS;d}$ are the design values of the effects of the actions, i.e.

$$E_d = \text{the effect of } \Sigma \gamma_f \psi S_{ki} \quad \text{(E.3)}$$

$$R_d = \frac{R_k}{\gamma_M} = \text{design value of the resistance at the ultimate limit state} \quad \text{(E.4)}$$

C_d = limiting design value of the relevant serviceability criterion expressed as the maximum serviceability limit state design stress or limit on deflection taking into account the material partial factor for serviceability limit state design γ_M.

S_{ki} = characteristic value of an action;

γ_F = relevant load factor;

ψ = relevant combination factor;

γ_M = relevant material partial factor;

R_k = calculated or experimental value of the characteristic resistance.

NOTE 1 The procedures which follow conform to the "European Recommendations for Sandwich Panels: Part 1: Design" [2] and present a sub-set of the more detailed procedures which are given in these Recommendations.

NOTE 2 This product standard is primarily concerned with the values of R_d and C_d. The load levels and the levels of safety may be specific to each Member State.

E.3 Actions

E.3.1 General

The actions in E.3.2 to E.3.4 shall be taken into account in the calculations. They shall be considered either individually or in combination using the combination factors in E.5 and E.6.

E.3.2 Permanent actions

The permanent actions to be taken into account in the design shall include the following:

— self-weight of the panel (calculated from the nominal dimensions and mean densities);

— mass of any permanent components of the structure and installation that apply load to the panel;

— permanent imposed deformations, e.g. due to temperatures in cold stores (calculated using nominal values relevant to the specific application).

E.3.3 Variable actions

The variable actions shall include the following, where they are relevant:

— snow (quasi-permanent action);

— live loads (e.g. due to access to a roof or ceiling);

— wind loads;

— construction loads;

— climatic effects (e.g. due to a temperature difference between the faces of a panel).

The temperature gradients resulting from the difference between the outside temperature T_1 and the inside temperature T_2 are variable actions.

NOTE 1 If national specifications do not give values for external temperatures, the following values for the temperature of the outside face may be used:

Depending on the latitude, the height above sea level and the distance from the sea, four different minimum winter temperature levels (T_1) are used throughout the continent of Europe: 0, −10 °C: −20 °C and −30 °C. The temperature of the outer face of a roof panel with an over layer of snow is 0 °C.

The temperature T_1 of the outside face has a maximum summer value which depends upon the colour and reflectivity of its surface. Values of T_1, which are minimum for ultimate state calculations and which are suitable for serviceability calculations, may be taken as follows:

(i)	very light colours	R_G = 75–90	T_1 = +55 °C
(ii)	light colours	R_G = 40–74	T_1 = +65 °C
(iii)	dark colours	R_G = 8–39	T_1 = +80 °C

Where

R_G is the degree of reflection relative to magnesium oxide = 100 %.

In special cases, the maximum temperature of a face exposed to the sun may be determined more precisely on the basis of the actual colour used.

If national specifications do not give values for internal (ambient) temperatures, the following values for the temperature of the inside face may be used. Where internal temperatures are specific to the use of the building (e.g. cold stores, bakeries) the temperature should be provided by the designer or building user.

Summer: T_2 = +25 °C Winter: T_2 = +20 °C

NOTE 2 The greatest difference between the inside and outside temperatures may arise during installation.

E.3.4 Actions due to long term effects

Where relevant, creep of the core material shall be taken into account in the design.

NOTE 1 Creep of the core may cause a change in both stresses and deformations with time.

NOTE 2 Creep is only relevant for panels used as a roof or ceiling.

E.4 Resistance

E.4.1 General

The values of resistance necessary for design shall be determined in accordance with 5.2. In addition, depending on the application, the procedures in E.4.1 and E.4.2 may be required.

NOTE The following characteristic resistance values are required in order to carry out design by calculation in accordance with this annex – see Table E.2.

Table E.2 – Characteristic resistance values

Characteristic resistance values	Clause	Test
Yield strength of the faces	5.1.2	
Shear strength of the core material	5.2.1.2	A.3 or A.4
Compressive strength of the core material (and/or support reaction capacity)	5.2.1.4	A.2 (A.15)
Shear strength after long-term loading (roof and ceiling panels only)	5.2.1.5	A.3.6
Wrinkling strength (positive and negative bending) at normal and higher temperature (or bending resistance)	5.2.1.7	A.5 and A.5.5.5
Wrinkling strength over a central support (positive and negative bending, at normal and higher temperature) determined from the bending resistance (only for panels continuous over two or more spans)	5.2.1.8	A.7 and A.5.5.5

NOTE In Table E.2, the term wrinkling strength includes the local buckling stress of a profiled face in compression.

In addition, the following are required in order to carry out the necessary calculations – see Table E.3.

Table E.3 – Additional calculation requirements

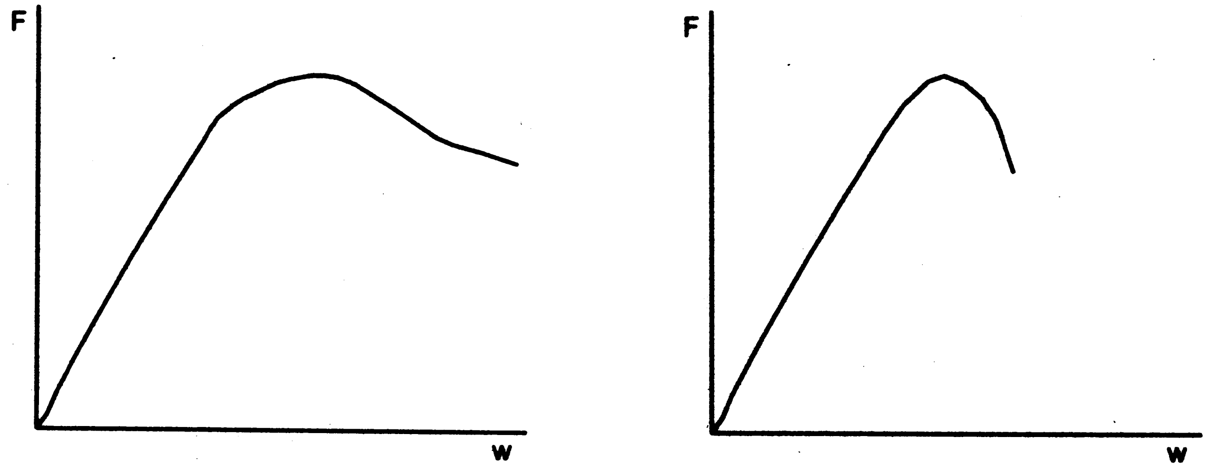
Characteristic values	Clause	Test
Design thickness of the faces	E.7.3	
Shear modulus of the core material	5.2.1.2	A.3 or A.4
Creep coefficient (roof and ceiling panels only)	5.2.1.3	A.6

The comparison of the design values of actions and the design values of resistance according to E.2 is usually carried out in terms of stresses, which are determined from the stress resultants according to E.7.2.5 and E.7.2.6. Determination of the compressive strength (wrinkling stress) of a profiled face from the bending resistance of the panel requires a calculation for which the formulae are given in E.7.5.2 (Table E.10.2).

E.4.2 Residual (rest) bending resistance at an intermediate support

If the load-deflection curve, determined according to A.7, is as shown in Figure E.2 a), the attainment of maximum bending moment at an internal support corresponds to a serviceability limit state. Furthermore, where required, a non-zero rest moment shall be determined and incorporated into the calculations at the ultimate limit state. If the load-deflection curve falls away suddenly, as shown in Figure E.2 b), the attainment of maximum bending moment at an internal support shall be deemed to correspond to the ultimate limit state.

A suitable value for the non-zero rest moment M_{rest} shall be determined from a load-deflection curve type (a) by subtracting the elastic component of deflection and choosing M_{rest} as the moment on the drooping part of the curve corresponding to a “plastic hinge” rotation of 3°.



Key

F load

w deflection

Figure E.2 a) – Load deflection curve (gradual failure with long drooping portion)

Figure E.2 b) – Load deflection curve (sudden failure with rapid loss of load)

An assessment of the residual bending resistance may be made by considering the reduction in the ultimate support moment at a "plastic hinge" rotation of 3°. If this reduction is greater than 40 % of the maximum moment attained, this may be regarded as a "sudden failure" and the rest moment should be considered to be zero.

E.4.3 End support reaction capacity

E.4.3.1 General

The reaction capacity at the end of a panel where the contact face is either plain or lightly profiled shall be determined either by calculation according to E.4.3.2 or by tests on full width panels according to A.15.5.

The reaction capacity at an internal support at the ultimate limit state shall be determined by calculation according to E.4.3.2. This calculation may be improved by using a value of 'k' determined by test according to A.15.5.

The reaction capacity at an internal support at the serviceability limit state shall be determined by test according to A.7.

E.4.3.2 Calculation of the support reaction capacity

The capacity in compression at an end support without an overhang or with an overhang less than 0,6e (Figure A.21) shall be given by (E.5):

$$F_{R1} = B \times (L_S + 0{,}5 \times k \times e) \times f_{Cc} \qquad \text{(E.5)}$$

An end support with an overhang greater than 0.6e shall be treated as an internal support. For the capacity at an end support in shear, see A.15.

The capacity at an internal support shall be given by Formula (E.6):

$$F_{R2} = B \times (L_S + k \times e) \times f_{Cc} \qquad \text{(E.6)}$$

Where

B is the width of panel;

L_S is the width of support;

e is the distance between centroids of the faces;

f_{Cc} is the declared value of the compressive strength following initial type testing;

k is the distribution parameter.

k shall either be determined by testing according to A.15.5, or the following values shall be used:

— for rigid plastic foams and cellular glass cores where $e < 100$ mm, $k = 0{,}5$;

— for rigid plastic foams and cellular glass cores where $e \geq 100$ mm, $k = 0{,}5$ with $e = 100$ mm in Formulae (E.4) and (E.5);

— for all other cases, $k = 0$.

E.5 Combination rules

E.5.1 General

The principles by which the relevant combinations of actions shall be compared with the corresponding resistances to give appropriate safety levels at both the ultimate and serviceability limit states shall be in accordance with E.5.2 to E.5.5.

The principles and procedures in this annex are in accordance with EN 1990. However, the recommended values of combination factors and material partial factors are particular to sandwich panels and reflect the special characteristics of this product, notably the increased importance of temperature stresses and deflections, the potentially highly variable nature of characteristics influenced by the properties of the core material and the influence of creep.

Values determined according to National Regulatory Requirements of any of these factors may be used provided that these have been formally declared as being appropriate for sandwich panels.

NOTE Temperature is often the dominant load case and may cause greater stresses and/or deflections than wind, snow or imposed load.

E.5.2 Ultimate limit state

The ultimate limit state, which corresponds to the maximum load-carrying capacity of the panel, shall be characterised by the most critical of the following failure modes either individually or in combination:

— yielding of a face of the panel with consequential failure;

— wrinkling (local buckling) of a face of the panel with consequential failure;

— shear failure of the core;

— failure of the bond between the face and the core;

— shear failure of a profiled face layer;

— crushing of the core at a support;

— failure of the panels at the points of attachment to the supporting structure.

E.5.3 Combination of the effects of actions for the ultimate limit state

For each load case, the design value for the effects of actions at the ultimate limit state shall be obtained by summing the effects of the separate actions multiplied by their appropriate load factors and combination coefficients as shown in Table E.4.

Table E.4 – Design values of effects of actions for use when combining actions for the ultimate limit state according to EN 1990

Permanent actions G_d (self-weight etc.)	Variable actions Q_d	
	Dominant with its characteristic value	Others with their combination value
$\gamma_G \times G_k$	$\gamma_{Q1} \times Q_{k1}$	$\gamma_{Qi} \times \psi_{0i} \times Q_{ki}$

The design values in Table E.4 shall be combined in the following way according to Formula (E.7):

$$S_d = \gamma_G G_k + \gamma_{Q1} Q_{k1} + \sum_{i>1} \gamma_{Qi} \psi_{0i} Q_{ki} \qquad \text{(E.7)}$$

Where

G_k is the characteristic value of the permanent action;

Q_{k1} is the characteristic value of the dominant variable action;

Q_{ki} is the characteristic value of the non-dominant variable action i ($i > 1$);

γ_G is the partial safety factor for the permanent action;

γ_{Qi} is the partial safety factor for the variable action i;

ψ_0 is the combination coefficient of a variable action i (see Table E.6).

E.5.4 Serviceability limit state

The verification of the serviceability limit state shall be sufficient to ensure the proper functioning of the panels under the serviceability loads. The serviceability limit state shall be characterised by one of the following:

— yielding of a face of the panel without consequential failure;

— wrinkling (local buckling) of a face of the panel without consequential failure;

— shear failure of the core;

— failure of the bond between face and core;

— the attainment of a specified deflection limit;

— the attainment of specified amounts of axial movement in the panel due to thermal expansion and contraction in the faces.

In the absence of any other information from national standards, the following indicative deflection limits may be used.

Roofs	and	- short-term loading	span/200

ceilings		
	- long term loading (including creep)	span/100
Walls		span/100

NOTE There has been a perception that thermal expansion and contraction in the faces causes thermal bow such that the axial movement at the ends of the panels can be neglected. Recent research has shown that this is not always the case. Thermal bow reduces the axial movement but does not eliminate it. The movement that remains may be significant and needs to be considered in the detailing of the connections. This effect is likely to be a potential problem only in special cases with long panels e.g. 20 m with aluminium facings, particularly at end laps.

E.5.5 Combination of the effects of actions for the serviceability limit states

For each load case, the design value for the effects of actions at the serviceability limit state shall be obtained by summing the effects of the separate actions multiplied by their appropriate load factors and combination coefficients as shown in Table E.5.

Verification of the serviceability limit state shall include consideration of both stresses and deflections.

The first (rare) combination shall be used to ensure that there is no visible damage to the panel at the serviceability limit state.

NOTE For this purpose, it is usually sufficient to check that there is no wrinkling or yielding of the face material in compression at an intermediate support.

The second (frequent) combination shall be used to control deflections.

The load factors γ_G and γ_Q shall be taken as 1,0 except where specified otherwise.

Table E.5 – Design values of effects of actions for use when combining actions for serviceability limit states

Combination	**Permanent actions G_d**	**Variable actions Q_d**	
		Dominant	**Others**
Characteristic (rare)	G_k	Q_{k1}	$\psi_{0i} \times Q_{ki}$
Frequent	G_k	$\psi_{11} \times Q_{k1}$	$\psi_{0i} \times \psi_{1i} \times Q_{ki}$

a) Characteristic (rare) combination (for resistance at intermediate supports) according to Formula (E.8):

$$S_d = \sum_{j\geq 1} G_{kj} + Q_{k1} + \sum_{i>1} \psi_{0i} Q_{ki} \quad \text{(E.8)}$$

b) Frequent combination (for deflections) according to Formula (E.9):

$$S_d = \sum_{j\geq 1} G_{kj} + \psi_{11} Q_{k1} + \sum_{i>1} \psi_{0i} \psi_{1i} Q_{ki} \quad \text{(E.9)}$$

Where

ψ_{0i} is the combination coefficient of a variable action *i* (*i* > 1) to be used in characteristic combinations,

ψ_{11} is the combination coefficient of the dominant action effect Q_{k1} to be used in frequent combinations and

ψ_{1i} is the combination coefficient of the other action effects Q_{ki} (*i* > 1) to be used in frequent combinations.

Values for combination coefficients ψ_{0i} and ψ_{1i} shall be as given in Table E.6.

E.6 Combination coefficients and safety factors

E.6.1 Combination coefficients

Values of the combination coefficients ψ_0 and ψ_1 defined in E.5.3 and E.5.5 shall be as given in Table E.6 unless these are given in whole or in part in national regulatory requirements concerning sandwich panels (Table E.7). It is not permissible to remove the combination factor for temperature if no value is given in the national regulatory requirements.

Table E.6 – Values of combination coefficients ψ_0 and ψ_1

Combination coefficients	Factors		
	Snow	Wind	Temperature
ψ_0	0,6	0,6	0,6 / 1,0 [a]
ψ_1	0,75 / 1,0 [b]	0,75 / 1,0 [b]	1,0

[a] Coefficient ψ_0 = 1,0 is used if the winter temperature T_1 = 0 °C is combined with snow.

[b] Coefficient ψ_1 = 0,75 for snow and wind is used if the combination includes the action effects of two or more variable actions and coefficient ψ_1 = 1,0 for snow and wind is used if there is, in the combination, only a single action effect representing the variable actions and it is caused by either the sole snow load or the sole wind load, acting alone.

Table E.6 should be read in conjunction with Table E.8.

As an alternative to the values in Table E.6, the values in Table E.7, which are according to EN 1990, may be used when required by national regulatory requirements.

Table E.7 – Alternative values of combination coefficients ψ_0 and ψ_1

Combination coefficients	Factors		
	Snow	Wind	Temperature
ψ_0	0,5 or 0,7 [a]	0,6	0,6
ψ_1	0,2 or 0,5 [a]	0,2	0,5

[a] The higher values of snow load coefficient are applicable to Finland, Iceland, Norway and Sweden (see EN 1991–1-3) and to the remainder of CEN Member States for sites at an altitude greater than 1 000 m above sea level.

E.6.2 Load factors

Values of the load factors γ_F given in Table E.8 shall be used unless national regulatory requirements require other values. It is not permissible to remove the temperature action if no load factor is given in the national regulatory requirements. The factor in parentheses for permanent actions shall be used if the effect of the action is favourable.

Table E.8 – Load factors γ_F

Actions	Limit state	
	Ultimate limit state	**Serviceability limit state**
Permanent actions *G*	1,35 (1,00)	1,00
Variable actions	1,50	1,00
Temperature actions	1,50 [a]	1,00
Creep effects	1,00	1,00

[a] Temperature actions may be replaced by 1,35 when regulatory provisions valid in the country of use of the panel so require.

E.6.3 Material factors

E.6.3.1 General

Material safety factors γ_M shall reflect the variability of the mechanical properties of sandwich panels, as indicated by the results of initial type testing and factory production control. Two alternative approaches are given and one or other shall be used.

In E.6.3.2, γ_M is determined on the basis of test results. Initially, this determination may be on the basis of values obtained during initial type testing but, subsequently, it shall be checked against the results of factory production control and the material safety factors adjusted as necessary. The procedure is also applicable to families of test results defined and evaluated in accordance with 6.3.3.

In E.6.3.3, nominal values of γ_M are given based on past experience.

These values shall be used unless National Standards require the use of other values.

E.6.3.2 Determination of γ_M based on test results

The material safety factors γ_M for the ultimate and serviceability limit states shall be determined according to EN 1990. The following formulae may be used:

For the ultimate limit state Formula (E.10):

$$\gamma_M = 1,05 e^{2,115 v} \tag{E.10}$$

For the serviceability limit state Formula (E.11):

$$\gamma_M = 1,0 e^{0,755 v} \tag{E.11}$$

where

v is the standard deviation of L_n (x);

x is the population of test results (see E.6.3.1).

The above formulae may also be used to obtain unified safety factors for complete families of test results evaluated according to 6.3.3 provided that:

v is the standard deviation of L_n (x_n);

x_n is the normalised population of test results.

E.6.3.3 Nominal values of γ_M based on past experience

The values of γ_M given in Table E.9 shall be used.

NOTE The material safety factors given in Table E.9 are examples of values that may be obtained for a product with relatively consistent properties such as continuously laminated PUR or PIR. They may be unsafe for products with less consistent properties.

Table E.9 – Material safety factors γ_M

Property to which γ_M applies	**Limit state**	
	Ultimate limit state	**Serviceability limit state**
Yielding of a metal face	1,1	1,0
Wrinkling of a metal face in the span ($v \leq 0,09$)	1,25	1,1
Wrinkling of a metal face at an intermediate support (interaction with support reaction)	1,25 [a]	1,1
Shear of the core ($v \leq 0,16$)	1,5	1,1
Shear failure of a profiled face	1,1	1,0
Crushing of the core ($v \leq 0,13$)	1,4	1,1
Support reaction capacity of a profiled face	1,1	1,0
Failure of a fastener	1,33 [b]	1,0 [b]
Failure of an element at a point of connection	1,33 [b]	1,0 [b]

[a] The material factor for wrinkling at the ultimate limit state is needed if the design is based on elastic analysis or if a non-zero bending resistance at intermediate supports is utilised in a design based on plastic analysis.

[b] If the characteristic value of the strength of a fastening is not based on a sufficient number of tests for a statistically reliable value to be obtained, higher values of the material safety factors shall be used.

E.7 Calculation of the effects of actions

E.7.1 General

In the determination of the internal stress resultants and deflections, the shear flexibility of the core shall be taken into account. For this purpose, a constant value of the shear modulus of the core, corresponding to an average value at normal indoor temperature, shall be used. The stress resultants shall then be determined using the methods described in E.7.2.

E.7.2 Methods of analysis

E.7.2.1 General

One or other of the following methods of analysis shall be used:

— elastic analysis;

— plastic analysis.

Elastic analysis shall be used for the serviceability limit state and may be used for the ultimate limit state.

Plastic analysis shall only be used for the ultimate limit state and shall be used whenever the design is controlled by bending stresses at an internal support. Plastic analysis shall not be used when the first failure mode is a shear failure of the core, unless the core material has adequate plastic shear capacity.

E.7.2.2 Elastic analysis

The action effects S (bending moments, normal and shear forces, deflections, axial movements due to thermal expansion and contraction) resulting from the combination of all actions applied to the sandwich panels shall be found by using the theory of elasticity taking into account the shear flexibility of the core material.

Formulae for some frequently encountered cases are given in:

— E.7.4 for panels with lightly profiled faces;

— E.7.5 for panels with profiled faces.

E.7.2.3 Plastic analysis

The bending moment distribution at the ultimate state in a continuous sandwich element may be chosen arbitrarily, provided that the internal stress resultants are in equilibrium with the actions, which shall be equal to or higher than the most unfavourable combination of factored actions, and that the internal stress resultants nowhere exceed the plastic resistance of the cross-section.

In plastic analysis calculations at the ultimate limit state, a continuous multi-span sandwich panel may be replaced by a series of simply supported panels with zero bending resistance at intermediate supports. In this calculation model, stresses caused by the temperature difference between the faces vanish in sandwich panels with flat or lightly profiled faces.

Alternatively, the test procedure in E.4.2 allows a non-zero rest moment to be determined at an internal support. The bending moments at internal supports at the ultimate limit state may be chosen to be equal to or less than the inelastic moment of resistance determined in this way and reduced by a material safety factor according to Table E.9.

E.7.2.4 General structural principles

It shall be assumed that, for the range of deformations to be considered, except where “plastic hinges” are assumed in plastic design, the materials of the core and faces remain linearly elastic. It shall also be assumed that the extensional stiffness of the core is so small in comparison to that of the faces that the influence of longitudinal normal stresses in the core may be neglected. The load bearing capacity of a sandwich panel shall then be divided into two components (see Figures E.3 and E.4):

a) For bending moments:

   into a moment component M_F in the metal faces and a moment component M_S (the sandwich part) arising from the normal forces N_{F1} and N_{F2} in the faces multiplied by the distance between the centroids *e*.

b) For shear forces:

   into a shear force component V_F in the faces and a shear force component V_S in the sandwich part of the section.

If the faces of a sandwich panel are thin and flat or they are lightly profiled, the bending stiffness of the faces ($B_{F1} = E_{F1}.I_{F1}$, $B_{F2} = E_{F2}.I_{F2}$) is small and has a negligible effect on the stress distributions and deflections of the panel, in which case, the bending stiffness of the faces shall be neglected ($B_{F1} = B_{F2} = 0$) in the analysis and the calculations shall be based on the stress resultants $M_S = e \times N_{F1} = e \times N_{F2}$ and V_S only (see Figures E.3 and E.4, Formulae (E.12) and (E.15)).

NOTE 1 Normal forces N_{F1} and N_{F2} cause a uniform compressive and tensile stress distribution over the external and internal faces, while the bending moments M_{F1} and M_{F2} result in normal stresses which vary linearly over the depths of the faces. Local buckling of a compressed web of a face profile makes the normal stress distribution in the face nonlinear.

NOTE 2 The shear force V_S causes a constant shear stress distribution τ_C over the depth of the core, when the compressive and tensile rigidity of the core layer in the longitudinal direction of the sandwich panel is ignored. The shear forces V_{F1} and V_{F2} cause shear stresses τ_{F1}, τ_{F2} in the face layers with non-vanishing bending rigidity.

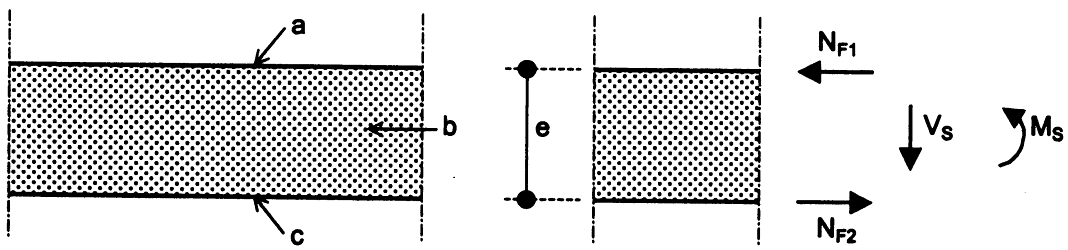
These shear stresses τ_{F1}, τ_{F2} shall be assumed to be a constant over the depths of the webs of the metal face profiles (see Figure E.6 and Formula (E.16)).

The figures and formulae that follow assume the following sign convention:

— "Sagging" bending moments (tension on the lower face) are positive

— Tensile face forces 'N' are positive

— Tensile stresses are positive.



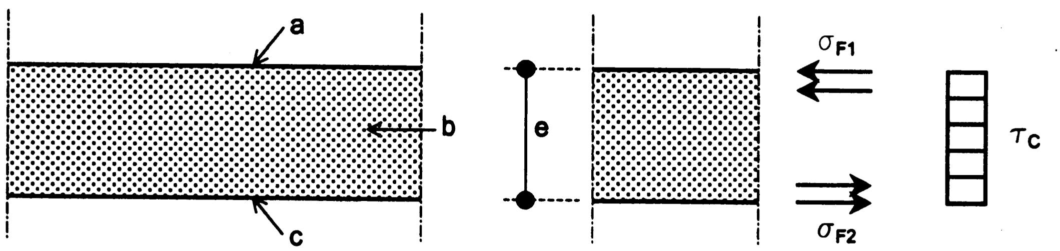
Key

a face 1

b core

c face 2

Figure E.3 – Stress resultants in a thin (flat or lightly profiled) faced sandwich panel



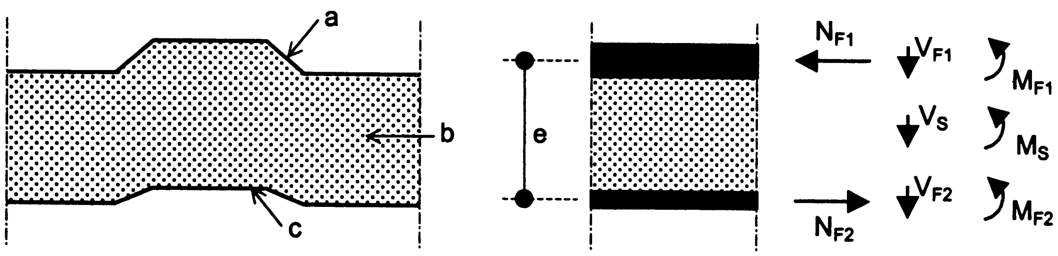
Key

a face 1

b core

c face 2

Figure E.4 – Stress distribution over the cross-section in a thin faced sandwich panel



Key

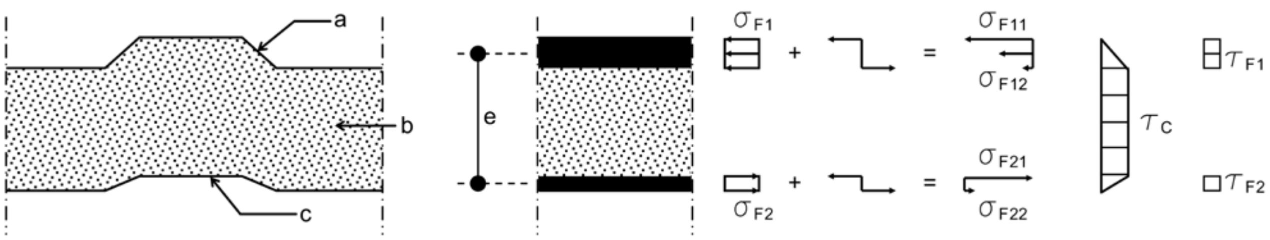
a face 1

b core

c face 2

Figure E.5 – Stress resultants in a sandwich panel with profiled faces

In panels with one or both profiled (thick) faces, the bending stiffness of the faces shall not be neglected ($B_{F1} + B_{F2} \neq 0$). The stress resultants in the cross-section shall be $M = M_S + M_{F1} + M_{F2}$ and $V = V_S + V_{F1} + V_{F2}$ (see Figures E.5 and E.6 and Formulae (E.13), (E.15) and (E.16)).



Key

a face 1

b core

c face 2

Figure E.6 – Stress distribution over the cross-section in a sandwich panel with profiled faces

E.7.2.5 Bending stresses

After carrying out a suitable analysis according to E.7.2, E.7.3 and E.7.4, the bending stresses in the faces shall be determined using Formulae (E.12) to (E.14):

$$\sigma_{F1} = -\frac{N_{F1}}{A_{F1}} = -\frac{M_S}{e\,A_{F1}}, \qquad \sigma_{F2} = \frac{N_{F2}}{A_{F2}} = \frac{M_S}{e\,A_{F2}} \tag{E.12a,b}$$

$$\sigma_{F11} = \sigma_{F1} - \frac{M_{F1}}{I_{F1}} d_{11},\ \sigma_{F12} = \sigma_{F1} + \frac{M_{F1}}{I_{F1}} d_{12} \tag{E.13a,b}$$

$$\sigma_{F21} = \sigma_{F2} - \frac{M_{F2}}{I_{F2}} d_{21},\ \sigma_{F22} = \sigma_{F2} + \frac{M_{F2}}{I_{F2}} d_{22} \tag{E.14a,b}$$

Where

A_{F1} and A_{F2} are the cross-sectional areas of the faces;

I_{F1}, I_{F2} are the second moments of area of the faces

and other symbols are defined in Figure E.1 and Figures E.3 to E.6.

E.7.2.6 Shear stresses

After carrying out a suitable analysis according to E.7.2, E.7.3 and E.7.4, the shear stresses in the core and faces respectively shall be determined using Formulae (E.15) and (E.16):

$$\tau_C = \frac{V_S}{eB} \qquad \text{(E.15)}$$

$$\tau_{F1} = \frac{V_{F1}}{n_1 s_{w1} t_1}, \quad \tau_{F2} = \frac{V_{F2}}{n_2 s_{w2} t_2} \qquad \text{(E.16a,b)}$$

Where

s_{w1} and s_{w2} are lengths of the webs of the profiled faces,

n_1 and n_2 are the numbers of the webs in the profiled faces of the panel.

E.7.2.7 Support reactions

The reactions at internal and end supports shall be determined by testing or analysis according to E.7.3.

E.7.2.8 Thermal expansion and contraction

Thermal expansion and contraction at the ends of a panel arise as a combination of the linear thermal expansion and contraction of the metal faces due to changes of temperature and the axial strains due to thermal bow. The axial strains due to thermal bow tend to reduce the movement of the outer face and induce compensating movements in the inner face. Where required for the detailing of connections, these movements may be calculated by integrating the face strains arising from the sandwich component of the bending moments associated with thermal bow.

NOTE 1 See E.5.4 NOTE regarding serviceability and where this effect is likely to be a potential problem.

A safe approximation to the net thermal movement over the length L of a long panel may be determined as A safe estimate of the net thermal movement over the length L of a long panel may be determined as follows.

Sandwich component of bending moment, $M_S = e\left(\frac{E_{F1} A_{F1} E_{F2} A_{F2}}{E_{F1} A_{F1} + E_{F2} A_{F2}}\right)\left(T_2 \alpha_2 - T_1 \alpha_1\right)$

Elongation of face 1 = $L \alpha_1 T_1 + \rho \frac{M_S L}{e A_{F1} E_{F1}}$

Elongation of face 2 = $L \alpha_2 T_2 - \rho \frac{M_S L}{e A_{F2} E_{F2}}$

Where ρ is a reduction coefficient for end effects which, in the absence of a more accurate value, may be taken to be 0,85 where the exposed outer face is steel and 0,7 where it is aluminium.

NOTE 2 In this context, “long” may be taken to mean a panel continuous over 6 or more spans. For shorter panels this approximation will tend to underestimate the net movement as a consequence of end effects.

NOTE 3 The panels themselves are very rigid so that any relative movement of the faces due to thermal expansion and contraction is mainly taken up by the connections. Experience has shown that, in the majority of cases, the movements that arise can be accommodated by conventional fastening systems. Situations where the connection detailing may require more detailed consideration are long panels, panels with an aluminium outer face and long roofs where panels butt end to end. Combinations of these factors are likely to be particularly critical.

E.7.3 Static system, geometry and thickness

The static system used in the calculation of sandwich panels shall be in accordance with the number and location of supports in the practical application for both pressure and uplift loads. The lengths of spans are determined as being the distances between the mid-lines of the supports. Sandwich panels are usually assumed to rotate and to move axially on the supports without restraint, thus corresponding to 'simple' support conditions between the sandwich panel and the support. If partial or full rigidity against the rotation at supports is utilised in design calculations, the validity of the assumption shall be verified experimentally.

Dimensions which are of significance for the static behaviour and resistance, such as the depth and width and the dimensions of the face profiles, shall correspond to the actual dimensions of the sandwich panel product in question. If nominal dimensions are used in calculations, the real dimensions shall agree with the dimensions used in the calculations within the tolerances given in 5.2.5.

The design thickness of a steel facing sheet shall be taken as $t_d = t_{nom} - t_{zinc} – 0{,}5\ t_{tol}$, where t_{nom} is the nominal thickness of the steel sheet, t_{zinc} the total thickness of the zinc layers (or similar protective coating) and t_{tol} the normal or special tolerance according to EN 10143. If the special tolerance according to EN 10143 is fixed, the design thickness shall be taken as $t_d = t_{nom} - t_{zinc}$ (without any reduction). The design thickness of other metal facing sheets, such as those made of aluminium, stainless steel or copper shall be determined so that they represent statistically reliable minimum thickness values. For these materials the design thickness shall be taken as $t_d = t_{nom} – 0{,}5\ t_{tol}$ for normal tolerances and $t_d = t_{nom}$ for special tolerances. In all formulae in this European Standard, the design thickness is denoted by t.

E.7.4 Sandwich panels with plane or lightly profiled faces

E.7.4.1 General

In sandwich panels with flat faces or with faces which are only lightly profiled, the bending stiffness of the faces shall be neglected in comparison with the bending stiffness of the sandwich part of the cross-section. No division of the global stress resultants into components shall be conducted.

NOTE The total bending moment is carried by normal forces in the faces and the total shear force by shear stresses in the core.

E.7.4.2 Single span panels

The static behaviour of single span sandwich panels shall be illustrated by the expressions for the stress resultants and deflections caused by a uniformly distributed load and a temperature difference (stress resultants per unit width) given in Table E.10.1.

E.7.4.3 Continuous multi-span panels

NOTE With continuous sandwich panels (multi-span panels), the shear flexibility of the core gives rise to smaller moments at the internal supports than would arise with a shear-stiff connection between the faces.

The static behaviour of continuous sandwich panels shall be illustrated by the expressions for the bending moment, support reaction and shear force at mid-support and the deflection in the spans caused by a uniformly distributed load and a temperature difference on a continuous two or three span sandwich panel (stress resultants per unit width) given in Table E.10.1.

E.7.5 Sandwich panels with strongly profiled faces

E.7.5.1 General

NOTE When the bending stiffness of a face in a sandwich panel cannot be neglected, the panel is itself statically indeterminate in addition to any global structural indeterminacy that may be present.

Explicit solutions are given in the references for a few simple cases but, in general, numerical methods of analysis, e.g. the finite element method, shall be used.

E.7.5.2 Single span panels

Solutions for a simply supported sandwich beam with strongly profiled faces or with faces having large material thickness and loaded by a uniformly distributed load or temperature difference shall be as given in Table E.10.2. The stress resultants are defined per unit width.

E.7.5.3 Continuous multi-span panels

Multi-span sandwich panels with profiled (thick) faces shall be designed either by calculation (see Note 2) or by testing.

NOTE 1 The stress resultants and deflections of continuous sandwich panels with thick faces can be determined analytically for the most important simple cases. However, in many cases (e.g. panels with unequal spans) the expressions become relatively complicated and require the use of either design charts or computer software to find numerical solutions for practical design.

NOTE 2 Additional information on the design calculations for sandwich panels of all types, including multi-span, thick-faced panels, is given in a number of texts, for example '*Lightweight sandwich construction'.* [3]

E.7.6 The influence of time on shear deformations of the core

NOTE 1 Typical core materials, especially the plastic foams, are visco-elastic materials in which the deformations increase in the course of time even if the loads remain constant. In the core, long-term loading causes shear creep which may be considered as a reduction in the shear modulus G_C of the core.

NOTE 2 The stresses and deflections due to shear creep of the core require a separate calculation in accordance with E.7 using the reduced value of the shear modulus G_{Ct}.

Where relevant, the reduced value of the shear modulus, G_{Ct}, shall be determined for a time period of 2 000 h for snow load and 100 000 h for permanent actions (dead load). The reduced shear modulus is given by Formula (E.17):

$$G_{Ct} = \frac{G_C}{1+\varphi_t} \qquad \text{(E.17)}$$

Where

φ_t is the creep coefficient.

φ_t shall be determined by test according to A.6 or by using the following values:

For rigid plastic foams (PUR, EPS, XPS):

φ_t = 2,4 for t = 2 000 h;

7,0 for t = 100 000 h.

For mineral wool:

φ_t = 1,5 for t = 2 000 h;

4,0 for t = 100 000 h.

Creep under snow load shall be neglected in regions where snow does not regularly lie for more than a few days.

If φ_t is less than 0,5, creep effects shall be neglected in thin faced sandwich panels, i.e. in panels with flat or micro or lightly profiled faces.

E.8 Panels with special profiles

E.8.1 General

For the purposes of this section, panels with special profiles are typified by a panel with a conventional inner face and an outer face that has a profile which is not uniform along the length of the panel. However, other arrangements are not precluded provided that they are amenable to design using similar principles and procedures to those described in this section.

NOTE A typical example of a special profile is an outer metal face which is formed in 3-dimensions to simulate a tiled profile.

Panels with special profiles shall be designed using the principles and procedures described in this annex modified only as necessary to take account of the particular characteristics of the special profile.

E.8.2 Determination of the effective properties of the faces and the core

The properties shall be determined on the basis of bending tests according to A.5 in order to determine the characteristic moment of resistance in both positive and negative bending.

If the failure mode in negative bending is tensile yielding in the profiled face, a further set of bending tests shall be carried out in which the profiled face is replaced by a plane face of similar thickness. The results of these tests are then used to determine the wrinkling strength of the lower face in accordance with A.5.

NOTE This may be achieved by removing the profile and machining the core flat and then bonding a replacement face using adhesives or it may be a special manufacture with a nominally identical core material.

The yield strength of the profiled face is somewhat arbitrary and it is sufficient to use the guaranteed value as the basis of the calculations. The bending strength of the profiled face shall be neglected. The effective depth of the section shall be taken as the distance from the centroid of the inner face to an arbitrary point at the centre of the profiled face.

An effective area of the positive face for the purposes of design shall now be calculated on the basis of compressive yield using simple bending theory. If the panel is to be designed for a range of core depths, this effective area may vary with the depth of the panel. If yielding of the profiled face was also the failure mode in negative bending, an effective area for this case shall also be calculated. The effective area for design is then the lower of the two effective areas.

The shear strength and modulus of the core shall be determined according to A.3 with the profiled face replaced by a suitable flat face as described above.

E.8.3 Design of panels with special profiles

The sequence given in E.8.2 provides sufficient information for the conventional design formulae to be used. The resulting model includes an estimate of the deflection. This shall be checked against the load deflection curves from the bending tests. If this is not conservative, it shall be corrected by inserting an effective Young's modulus for the outer face into the design formulae.

NOTE The deflection correction is not considered to be critical as, with profiles of this type, the spans are relatively small and deflection is rarely significant.

Table E.10.1 – Design formulae for one-, two- and three-span panels with plane or lightly profiled faces

	Shear at end support	Shear at internal support	Intermediate support reaction	Bending moment in (end) span	Bending moment at internal support	Maximum deflection in span
Single span of L Uniform load q	$\frac{qL}{2}$			$\frac{qL^2}{8}$		$\frac{5qL^4}{384B_S}(1+3,2k)$
Temperature difference $T_1 - T_2$						$\frac{\theta L^2}{8}$
Two equal spans of L Uniform load q	$\frac{qL}{2}\left(1-\frac{1}{4(1+k)}\right)$	$\frac{qL}{2}\left(1+\frac{1}{4(1+k)}\right)$	$qL\left(1+\frac{1}{4(1+k)}\right)$	$\frac{qL^2}{8}\left(1-\frac{1}{4(1+k)}\right)^2$	$-\frac{qL^2}{8}\frac{1}{1+k}$	$\frac{qL^4}{48B_S}\frac{0,26+2,6k+2k^2}{1+k}$
Temperature difference $T_1 - T_2$	$-\frac{3B_S\theta}{2L}\frac{1}{1+k}$	$\frac{3B_S\theta}{2L}\frac{1}{1+k}$	$\frac{3B_S\theta}{L}\frac{1}{1+k}$	$-\frac{3B_S\theta}{4}\frac{1}{1+k}$	$-\frac{3B_S\theta}{2}\frac{1}{1+k}$	$\frac{\theta L^2}{32}\frac{1,1+4k}{1+k}$
Three spans of L Uniform load q	$\frac{qL}{2}\left(1-\frac{1}{5+2k}\right)$	$\frac{qL}{2}\left(1+\frac{1}{5+2k}\right)$	$qL\left(1+\frac{1}{2(5+2k)}\right)$	$\frac{qL^2}{8}\left(1-\frac{1}{5+2k}\right)^2$	$-\frac{qL^2}{10+4k}$	$\frac{qL^4}{24B_S}\frac{0,83+5,6k+2k^2}{5+2k}$
Temperature difference $T_1 - T_2$	$-\frac{6B_S\theta}{L}\frac{1}{5+2k}$	$\frac{6B_S\theta}{L}\frac{1}{5+2k}$	$\frac{6B_S\theta}{L}\frac{1}{5+2k}$	$-3B_S\theta\frac{1}{5+2k}$	$-6B_S\theta\frac{1}{5+2k}$	$\frac{\theta L^2}{4}\frac{1,06+k}{5+2k}$

$$B_S = \frac{E_{F1}A_{F1}E_{F2}A_{F2}e^2}{(E_{F1}A_{F1}+E_{F2}A_{F2})} \qquad k = \frac{3B_S}{L^2G_CA_C} \qquad \theta = \frac{\alpha_2T_2-\alpha_1T_1}{e}$$

A_C = cross-sectional area of the core (G_CA_C = S = shear rigidity of the core)

NOTE For geometry and section properties, see Figure E.1. For stress systems, see Figures E.3 and E.4.

Table E.10.2 – Design formulae for single span panels with one profiled face and one flat or lightly profiled face

	Shear at end support	Shear at internal support	Face bending moment in span M_{F1}	Sandwich bending moment in span M_S	Maximum deflection in span
Single span of L Uniform load q	$\frac{qL}{2}$		$\frac{qL^2}{8}\beta$	$\frac{qL^2}{8}(1-\beta)$	$\frac{5qL^4}{384B_S}(1+3,2k)(1-\beta)$
Temperature difference $T_1 - T_2$	0		$-B_{F1}\theta(1-\beta)$	$B_{F1}\theta(1-\beta)$	$\frac{\theta L^2}{8}(1-\beta)$

For uniform load, $\beta = \frac{B_{F1}}{B_{F1} + \frac{B_S}{1+3.2k}}$ For temperature difference, $\beta = \frac{B_{F1}}{B_{F1} + \frac{B_S}{1+2.67k}}$

NOTE 1 Other quantities are as for Table E.10.1.

NOTE 2 For geometry and section properties, see Figure E.1. For stress systems, see Figures E.5 and E.6.

Annex F
(informative)

Significant technical changes between this European Standard and the previous edition

Annex F provides details of significant technical changes between this European Standard and the previous edition.

NOTE The technical changes referred to include the significant technical changes from the EN revised but is not an exhaustive list of all modifications from the previous edition.

Table F.1 – Technical changes in this European Standard

Section	Clause/Table/Figure	Type of change	Note
2 Normative references		New	EN 506: EN 508–2: EN 508–3: EN 1363–2: CEN/TS 13381–2: EN 15254–5: EN ISO 6270-1
		Modified	EN 10326 to EN 10346
		Deleted	EN 502, EN 10327
3 Terms and definitions		New	3.2: 3.3: 3.11: 3.12: 3.21: 3.22
4 Symbols, abbreviations		Modified	*A: B: L:U: α: λ: PVC*
5 Requirements, properties and test methods	5.1.2.1.1 and Table 1	Modified	Clarification of types of steel
	5.1.2.1.2	New	New clause on backface coating
	5.1.2.2: 5.1.2.3; 5.1.2.4	Modified	Notes on types of facing material
	5.1.3.2	Modified	
	5.2.1.2 and Table 2	New	Major revision – shear strength and modulus
	5.2.1.5	Modified	
	5.2.1.7	Modified	Modified approach to bending resistance and wrinkling strength
	5.2.2	New	λ to be declared
	5.2.3.1 and Table 3	Modified	
	5.2.3.2	Modified	'Roofs' added
	5.2.4.1	Deleted	
	5.2.4.1(new, was 5.2.4.2)	Modified	New Note on Fire Classification added
	5.2.4.2	Modified	CEN/TS 13381–2 added
	5.2.4.3	Modified	Reference to CWFT
	5.2.5 Table 4	Modified	Amendment to D.2.9
	5.2.7	Modified	Declared values amended

Section	Clause/Table/Figure	Type of change	Note
6 Evaluation of conformity, testing, assessment and sampling	6.1	New	Grouping of products into families clarified
	6.2.2	New	Use of existing test data
	6.2.4 Table 5	New	Tested panel thickness added
	6.2.5 and Table 6	New	Shortened ITT testing programme
	6.3.1	Modified	Use of existing test data
	6.3.2	New	Clarification if values have to be reduced
	6.3.4.2	Modified	
	6.3.5.2 and Table 7	Modified	Modifications concerning tension, compression and shear strength testing
	6.3.5.2 Table 8	Modified	Revised test frequency
	6.3.6.2 Table 9	Modified	Reference to incompletely bonded panels included
	6.4	New	Use of values from families of tests
7 Classification	Clause 7 and Table 10	Modified	5.2.1, 5.2.2, 5.2.5.4, 5.2.7 and Note 'c'
8	8.1	Modified	'f' and Note
Annex A	A.1.3	Modified	Reference to incompletely bonded panels included
	A.1.4: A.2.4	Modified	Test procedure modified
	A.3.1: A.3.2:	Modified	Clarification of procedures. Revised Figure A.4
	A.3.3	Modified	Clarification – thicker panels
	A.3.3 Figure A.5	New	Figure corrected
	A.3.4	Modified	Test procedure modified
	A.3.5.1: A.3.5.2	Modified	Clarification of definitions
	A.3.5.3 and Figure A.6	New	Clause covering incompletely bonded panels
	A.3.6.1	Modified	Calculation procedure modified
	A.4.1: A.4.2: A.4.3: A.4.4	Modified	Major revision covering apparatus, specimens and procedure
	A.4.5	New	Calculation procedures revised to cover different types of facings and loading methods
	A.5.1: A.5.2: A.5.3	Modified	Clarification of loading, support and procedures
	A.5.4	Modified	Test procedure modified
	A.5.5.3: A.5.5.4	Modified	Major revisions
	A.5.6	Deleted	
	A.6.2: A.6.3	Modified	Clarification
	A.6.4	Modified	Revised test procedure

Section	Clause/Table/Figure	Type of change	Note
	A.6.5.2	Modified	Clarification
	A.7.5	Modified	Procedure where both faces are fully profiled
	A.9.2	New	Revised procedure for repeated loads
	A.10.2.1.2	Modified	Revised criteria for λ
	A.10.3: A.10.4	Modified	Revised calculation methods for ‘U’ value
	A.12.5	Modified	Revised calculation methods for air permeability
	A.13.3	Modified	Mounting and fixing clarification
Annex A continued	A.14.3	Modified	Mounting and fixing clarification
	A.15.2	Modified	Mounting and fixing clarification
	A.16.4	New	Interpolation and extrapolation of test results
Annex B	B.2.3.1	Modified	Revised sampling procedure
	B.2.4.2: B2.5	Modified	Revised test procedure and acceptance criteria
	B.3.2.1.1 and Figure B.1	Modified	Modified test chamber
	B.3.3.1: B.3.3.2	Modified	Clarification regarding test specimens
	B.3.5	Modified	Revised acceptance criteria
	B.5.3	Modified	Clarification regarding test specimens
	B.5.5	Modified	Revised acceptance criteria
	B.7.2: B.7.3: B.7.4: B.7.5	Modified	Clarification regarding test specimens, apparatus, testing and calculations
Annex C	C.1.1	Modified	Clarification of principles
	C.1.1.3.1.1: C.1.1.3.1.4; C.1.1.3.2	Modified	Mounting and fixing clarification
	C.1.2.1: C.1.2.2: C.1.2.3	Modified	Revised mounting and fixing and test method
	C.1.3 Table C.1	Modified	Joint design and Figure C.3; adhesive; Note ‘a’
	C.1.3 Table 3.1	Deleted	‘Protection over cut edges’
	C.2.1	Deleted	
	C.2.1	New	New general clause
	C.2.2	New	Mounting and fixing clarification - walls
	C.2.3.1: C.2.3.2: C.2.3.3	Modified	Clarification on mounting and fixing and loading
	C.2.4: Table C.2: Table C.3	New	New separate clauses for wall and roof application
	C.3	Modified	Amended in accordance with CWFT
Annex D	D.2.9	Modified	Tolerances

Section	Clause/Table/Figure	Type of change	Note
Annex E	Introductory note	New	
	E.1.3	New	Clarification on sign convention
	E.5.4	Modified	Added characterisation and note
	E.6.3.1: E.6.3.2: E.6.3.3	Modified	Clarification
	E.7.2.4 Figure E.6	Modified	Figure corrected
	E.7.2.8	New	
	E.7.3	Modified	Clarification on tolerances
	E.8	New	
Annex ZA	Tables ZA.1.1 and ZA.1.2	Modified	
	Tables ZA.2 and ZA.3.1	Modified	
	ZA.3.2: ZA.3.3: ZA.3.4	Modified	Modified in accordance with changes to normative clauses
	Figures ZA.1, ZA.2, ZA.3 and ZA.4	Modified	Modified in accordance with changes to normative clauses

Annex ZA
(informative)

Clauses of this European Standard addressing the provisions of the EU Construction Products Directive

ZA.1 Scope and relevant characteristics

This European Standard has been prepared under Mandate M/121 “Internal and external wall and ceiling finishes” and Mandate M/122 “Roof coverings” given to CEN by the European Commission and the European Free Trade Association.

The clauses of this European Standard shown in this annex meet the requirements of Mandates M/121 and M/122 given under the EU Construction Products Directive (89/106/EEC).

Compliance with these clauses confers a presumption of fitness of the sandwich panels covered by this annex for their intended uses indicated herein; reference shall be made to the information accompanying the CE marking.

This annex has the same scope as Clause 1 of this standard with regard to the products covered. It establishes the conditions for the CE marking of sandwich panels intended for the uses indicated below and shows the relevant clauses applicable (see Tables ZA.1.1 and ZA.1.2).

Construction product: Self-supporting double skin metal faced insulating sandwich panels – Factory made products

Intended uses:
a) roofs and roof cladding
b) external walls and wall cladding; and
c) walls (including partitions) and ceilings within the building envelope.

Classifications for reaction to fire, fire resistance and external fire performance shall be accompanied by a description of the system tested. For examples see Figure ZA.2, Figure ZA.3 and Figure ZA.4.

Table ZA.1.1 – Relevant clauses for internal and external wall and ceiling finishes

Essential Characteristics	Requirement clauses in this European Standard	Mandated levels and/or classes	Units and notes
Mechanical resistance	5.2.1	-	MPa
Thermal transmittance	5.2.2	-	W/m^{2}K and W/mK
Reaction to fire	5.2.4.1 and C.1	A1 to F	Classification
Fire resistance	5.2.4.2 and C.2	See EN 13501–2	Classification or NPD
Flexural tensile strength (ceilings)	See mechanical resistance [a]	-	
Water permeability	5.2.6	-	Classes of convenience A, B or C (see A.11.5) or NPD
Air permeability	5.2.7	-	n and C -values or NPD
Water vapour permeability	5.2.8	-	“Pass” or NPD
Airborne sound insulation	5.2.9	-	R_w (C:C_{tr}) or NPD
Sound absorption	5.2.10	-	Single value α_w or NPD
Durability	5.2.3 [b] and Annex B	-	“Pass”. Colour / Reflectivity where applicable
Dangerous substances	5.2.11	-	

[a] Flexural tensile strength (for ceilings only) is covered under mechanical resistance. May be NPD for internal use.

[b] The ageing effect on thermal performance is covered under thermal transmittance.

Table ZA.1.2 – Relevant clauses for roof coverings

Essential Characteristics	Requirement clauses in this European Standard	Mandated levels and/or classes	Units and notes
Mechanical resistance	5.2.1	-	MPa Creep – number value
Thermal transmittance	5.2.2	-	W /m^{2}K and W/mK
External fire performance - roofs	5.2.4.3 and C.3	B_{ROOF}(t1), B_{ROOF}(t2), or B_{ROOF}(t3) according to Commission Decision 2006/600/EC, or X_{ROOF}(t4)	Classification
Reaction to fire	5.2.4.1 and C.1	A1 to F	Classification
Fire resistance	5.2.4.2 and C.2	See EN 13501–2	Classification or NPD
Water permeability	5.2.6	-	Classes of convenience A, B or C (see A.11.5) or NPD
Air permeability	5.2.7	-	n and C -values or NPD
Water vapour permeability	5.2.8	-	"Pass" or NPD
Airborne sound insulation	5.2.9	-	R_w (C:C_{tr}) or NPD
Dimensional variation	5.2.5 and Annex D	-	"Pass"
Durability	5.2.3 [a] and Annex B	-	"Pass". Colour / Reflectivity where applicable
Dangerous substances	5.2.11	-	
[a] The ageing effect on thermal performance is covered under thermal transmittance.			

The requirement on a certain characteristic is not applicable in those Member States (MSs) where there are no regulatory requirements on that characteristic for the intended use of the product. In this case manufacturers placing their products on the market of these MSs are not obliged to determine or declare the performance of their products with regard to this characteristic and the option "No Performance Determined" (NPD) in the information accompanying the CE marking (see ZA.3) may be used. The NPD option may not be used however where the characteristic is subject to a threshold level, or for mechanical resistance characteristics (5.2.1) that determine fitness for intended use.

ZA.2 Procedures for the attestation of conformity of sandwich panels

ZA.2.1 Systems of attestation of conformity

The systems of attestation of conformity of sandwich panels in:

— Table ZA 0,1.1 in accordance with the decision of the Commission 98/436/EC of 1998-06-22 *(see OJEU L194 of 1998-07-10),* as corrected *(see OJEU L278 of 1998-10-15)* and amended by 2001/596/EC of 2001-01-08 *(see OJEU L209 of 2001-08-02)*, as given in Annex III of the mandate for "Roof coverings, roof lights, roof windows and ancillary products",

— Table ZA 0,1.2 in accordance with the decision of the Commission 98/437/EC of 1998-06-30 *(see OJEU L194 of 1998-07-10),* as corrected *(see OJEU L278 of 1998-10-15)* and amended by 2001/596/EC of 2001-01-08 *(see OJEU L209 of 2001-08-02)*, as given in Annex III of the mandate for "Internal and external wall and ceiling finishes".

These systems are shown in Table ZA.2 for the indicated intended uses and relevant levels or classes.

Table ZA.2 – Attestation of conformity systems

Products	Intended uses	Level(s) or class(es)	Attestation of conformity systems
Factory made sandwich panels	For uses subject to resistance to fire regulations (e.g. fire compartmentation)	Any	3
	As roofing covering subject to reaction to fire regulations	A1*, A2*, B* and C* A1**, A2**, B**, C**, D and E (A1 to E)***, F	1 3 4
	As roof coverings subject to external fire performance regulations	Products requiring testing Products ‘deemed to satisfy’ without testing	3 4
	As roof coverings subject to regulations on dangerous substances	–	3
	As roof coverings for all other uses	–	4
Factory made sandwich panels	As internal or external finishes, as complete elements, used for fire Protection of walls or ceilings	Any	3
	As internal or external finishes in wall or ceilings subject to reaction to fire regulations	A1*, A2*, B* and C* A1**, A2**, B**, C**, D and E (A1 to E)***, F	1 3 4
	As internal or external finishes in walls or ceilings, as relevant, subject to regulations on dangerous substances	–	3
	As internal or external finishes in walls or ceilings for all other uses mentioned in the mandate	–	4

* Products/materials for which a clearly identifiable stage in the production process results in an improvement of the reaction to fire classification (e.g. an addition of fire retardants or a limiting of organic material).

** Products/materials not covered by footnote (*).

*** Products/materials that do not require to be tested for reaction to fire (e.g. products/materials of Class A1 according to Commission Decision 96/603/EC).

System 1: See Directive 89/106/EEC (CPD) Annex III.2.(i), without audit testing of samples.

System 3: See Directive 89/106/EEC (CPD) Annex III.2.(ii), Second possibility.

System 4: See Directive 89/106/EEC (CPD) Annex III.2.(ii), Third possibility.

The attestation of conformity of the sandwich panels in Tables ZA.1.1 and ZA.1.2 shall be according to the evaluation of conformity procedures for the relevant levels and classes (Table ZA.2) indicated in Tables ZA.3.1 to ZA.3.3 resulting from the application of the clauses of this European Standard indicated therein.

For sandwich panels the footnote* of Tables ZA.2, ZA.3.1 and ZA.3.2 applies except when it can be demonstrated to the notified body for a particular product that no stage in the production process will result in an improvement of the reaction to fire classification (see Table ZA.2, footnote**).

Table ZA.3.1 – Assignment of evaluation of conformity tasks for sandwich panels under system 1

Tasks		Content of the task	Evaluation of conformity clauses to apply
Tasks under the responsibility of the manufacturer	Factory production control (FPC)	Parameters related to all characteristics of Tables ZA.1.1 and/or ZA.1.2 relevant for the intended use	6.3
	Further testing of samples taken at factory	All characteristics of Tables ZA.1.1 and/or ZA.1.2 relevant for the intended use	6.3
	Initial type testing by a notified test lab	All characteristics of Tables ZA.1.1 and/or ZA.1.2 relevant for the intended use, i.e. resistance to fire, external fire performance other than CWFT, release of regulated substances, and reaction to fire in classes A1*, A2*, B* and C*	6.2
	Initial type testing by the manufacturer	All remaining characteristics of Tables ZA.1.1 and/or ZA.1.2 relevant for the intended use, i.e. mechanical resistance, sound insulation/ absorption, thermal resistance, air permeability, water permeability, durability, dimensional tolerances	6.2
Tasks under the responsibility of the product certification body	Initial type testing	Reaction to fire (Classes A1*, A2*, B*, C*)	6.2
	Initial inspection of factory and of FPC	Parameters related to characteristics of Tables ZA.1.1 and/or ZA.1.2 relevant to reaction to fire	6.3
	Continuous surveillance, assessment and approval of FPC	Parameters related to characteristics of Tables ZA.1.1 and/or ZA.1.2 relevant to reaction to fire	6.3
* See Footnote to Table ZA.2.			

Table ZA.3.2 – Assignment of evaluation of conformity tasks for sandwich panels under system 3

Tasks		**Content of the task**	**Evaluation of conformity clauses to apply**
Tasks under the responsibility of the manufacturer	Factory production control (FPC)	Parameters related to all characteristics of Tables ZA.1.1 and/or ZA.1.2 relevant for the intended use	6.3
	Initial type testing by the manufacturer	All characteristics of Tables ZA.1.1 and/or ZA.1.2 relevant for the intended use, i.e. mechanical resistance, sound insulation/ absorption, thermal resistance, air permeability, water permeability, durability, dimensional variation, other than those shown below	6.2
	Initial type testing by a notified test laboratory	Reaction to fire (Classes A1**, A2**, B**, C**, D, E), resistance to fire, external fire performance other than CWFT, release of regulated substances	6.2
** See Footnote to Table ZA.2.			

Table ZA.3.3 – Assignment of evaluation of conformity tasks for sandwich panels under system 4

Tasks		**Content of the task**	**Evaluation of conformity clauses to apply**
Tasks under the responsibility of the manufacturer	Factory production control (FPC)	Parameters related to all characteristics of Tables ZA.1.1 and/or ZA.1.2 relevant for the intended use	6.3
	Initial type testing by the manufacturer	All characteristics of Tables ZA.1.1 and/or ZA.1.2 relevant for the intended use, i.e. mechanical resistance, sound insulation/absorption, thermal resistance, air permeability, water permeability, durability, dimensional variation	6.2

ZA.2.2 Certificate and Declaration of Conformity

(In case of products with system 1): When compliance with the conditions of this annex is achieved, the certification body shall draw up a certificate of conformity (EC Certificate of conformity), which entitles the manufacturer to affix the CE marking. The certificate shall include:

— name, address and identification number of the certification body;

— name and address of the manufacturer, or his authorised representative established in the EEA, and place of production;

NOTE 1 The manufacturer may also be the person responsible for placing the product onto the EEA market, if he takes responsibility for CE marking.

— description of the product (type, identification, use, ...);

— provisions to which the product conforms (i.e. Annex ZA of this EN);

— particular conditions applicable to the use of the product (e.g. provisions for use under certain conditions);

— the number of the certificate;

— conditions and period of validity of the certificate, where applicable;

— name of, and position held by, the person empowered to sign the certificate.

(In case of products under system 3): When compliance with the conditions of this annex is achieved, the manufacturer or his agent established in the EEA shall prepare and retain a declaration of conformity (EC Declaration of conformity), which entitles the manufacturer to affix the CE marking. This declaration shall include:

— name and address of the manufacturer, or his authorised representative established in the EEA, and place of production;

NOTE 2 The manufacturer may also be the person responsible for placing the product onto the EEA market, if he takes responsibility for CE marking.

— description of the product (type, identification, use,...), and a copy of the information accompanying the CE marking;

NOTE 3 Where some of the information required for the Declaration is already given in the CE marking information, it does not need to be repeated.

— provisions to which the product conforms (i.e. Annex ZA of this EN);

— particular conditions applicable to the use of the product, (e.g. provisions for use under certain conditions);

— name and address of the notified laboratory(ies);

— name of, and position held by, the person empowered to sign the declaration on behalf of the manufacturer or his authorised representative.

(In case of products under system 4): When compliance with the conditions of this annex is achieved, the manufacturer or his agent established in the EEA shall prepare and retain a declaration of conformity (EC Declaration of conformity), which entitles the manufacturer to affix the CE marking. This declaration shall include:

— name and address of the manufacturer, or his authorised representative established in the EEA, and place of production;

NOTE 4 The manufacturer may also be the person responsible for placing the product onto the EEA market, if he takes responsibility for CE marking.

— description of the product (type, identification, use,...), and a copy of the information accompanying the CE marking;

NOTE 5 Where some of the information required for the Declaration is already given in the CE marking information, it does not need to be repeated.

— provisions to which the product conforms (i.e. Annex ZA of this EN);

— particular conditions applicable to the use of the product (e.g. provisions for use under certain conditions);

— name of, and position held by, the person empowered to sign the declaration on behalf of the manufacturer or of his authorised representative.

The above mentioned declaration and certificate shall be presented in the language or languages accepted in the Member State in which the product is to be used.

ZA.3 CE Marking and labelling

ZA.3.1 General

The manufacturer or his authorised representative established within the EEA is responsible for the affixing of the CE marking. The CE marking symbol to affix shall be in accordance with Directive 93/68/EEC and shall be shown on the packaging of the sandwich panels (each package to be marked). Panels shall not be placed on the market without packaging.

The CE marking symbol, on its own or together with some or all of the following information on the product and its essential characteristics may appear on the packaging (see example in Figure ZA.1) and/or the commercial documentation. If not all of the information appears on the packaging, then all information, including a repeat of that given on the packaging, shall be given on the commercial documentation (see examples in Figure ZA.2 (roofs), Figure ZA.3 (external walls) and Figure ZA.4 (internal walls/ceilings)).

ZA.3.2 Information accompanying CE Marking symbol – Internal walls and ceilings

The following information shall accompany the CE Marking symbol:

— name or identifying mark of the manufacturer;

— address of production plant (if relevant);

— identification number of the notified body (only relevant for system 1);

— number of the certificate of conformity (only required under system 1);

— last two digits of the year of CE marking;

— number of this European Standard (EN 14509) with date of Revision e.g. 2012;

— description of the product: generic name, grade and thickness of facing materials, metalic coating mass and coating type and thickness, core material and thickness, mass, density and intended use;

— product name and type;

— reaction to fire (Classification including any mounting and fixing conditions, or Class F);

— fire resistance (Classification including any mounting and fixing conditions, or NPD);

— tensile strength (Value);

— shear strength (Value);

— reduced long term shear strength – ceilings only (Value);

— shear modulus (core) (Value);

— compressive strength (core) (Value);

— creep coefficient (Value for t = 2 000 h and t = 100 000 h);

— bending resistance[a] in span – positive and negative bending (Value);

— bending resistance[a] at an internal support – positive and negative bending (Value);

— wrinkling strength[a] (Value) and tested span:

face 1;

— wrinkling strength[a] in span;

— wrinkling strength[a] at a support (continuous panels) for loads pressing at an internal support;

face 2:

— wrinkling strength[a] in span;

— wrinkling strength[a] at a support (continuous panels) for loads pressing at an internal support;

— thermal transmittance $U_{d,s}$ (Value) and $\lambda_{declared}$ (Value);

— airborne sound insulation (Classification or NPD);

— sound absorption (Classification or NPD);

— resistance to point loads – ceilings – where required. The maximum achieved load and tested span shall be declared;

— resistance to access loads (for occasional foot traffic without additional protection) – ceilings – where required. Pass required before affixing CE Marking;

[a] Either the wrinkling strength or bending resistance shall be declared

The ‘No performance determined’ (NPD) option shall not be used where the characteristic is subject to a threshold level or for mechanical resistance characteristics (5.2.1), which determine fitness for intended use. The NPD option may be used for other characteristics when and where the characteristic, for a given intended use, is not subject to regulatory requirements.

NOTE Reaction to fire Class F is equivalent to NPD for this characteristic.

ZA.3.3 Information accompanying CE Marking symbol – External walls

The following information shall accompany the CE Marking symbol:

— name or identifying mark of the manufacturer;

— address of production plant (if relevant);

— identification number of the notified body (only relevant for system 1);

— number of the certificate of conformity (only required under system 1);

— last two digits of the year of CE marking;

— number of this European Standard (EN 14509) with date of Revision e.g. 2012;

— description of the product: generic name, grade and thickness of facing materials, metalic coating mass and coating type and thickness, core material and thickness, mass, density and intended use;

— product name and type;

— reaction to fire (Classification including any mounting and fixing conditions, or Class F);

— fire resistance (Classification including any mounting and fixing conditions, or NPD);

- tensile strength (Value);
- shear strength (Value);
- shear modulus (core) (Value);
- compressive strength (core) (Value);
- bending resistance[a] in the span – positive and negative bending (Value) and tested span:
  - positive bending, ambient temperature;
  - positive bending, elevated temperature (see A.5.5.5);
  - negative bending, ambient temperature;
  - negative bending elevated temperature (see A.5.5.5);
- bending resistance[a] at an internal support – positive and negative bending (Value):
  - positive bending, ambient temperature;
  - positive bending, elevated temperature (see A.5.5.5);
  - negative bending, ambient temperature;
  - negative bending elevated temperature (see A.5.5.5);
- wrinkling strength[a] (Value):

  inner face:
  - wrinkling strength[a] in the span, ambient temperature;
  - wrinkling strength[a] at an internal support (continuous panels) for loads pressing on a support, ambient temperature;

  outer face:
  - wrinkling strength[a] in the span, ambient temperature;
  - wrinkling strength[a] in the span, elevated temperature (see A.5.5.5);
  - wrinkling strength[a] at a support (continuous panels) for suction loads, ambient temperature;
  - wrinkling strength[a] at a support (continuous panels) for suction loads, elevated temperature (see A.5.5.5);
- thermal transmittance $U_{d,s}$ (Value) and $\lambda_{declared}$ (Value);
- water permeability (Classification or NPD);
- air permeability (Values or NPD);
- airborne sound insulation (Classification or NPD);
- sound absorption (Classification or NPD);

— durability (Statement of colour and reflectivity levels). Pass required before affixing CE Marking.

[a] Either the wrinkling strength or bending resistance shall be declared

The ‘No performance determined’ (NPD) option shall not be used where the characteristic is subject to a threshold level or for mechanical resistance characteristics (5.2.1), which determine fitness for intended use. The NPD option may be used for other characteristics when and where the characteristic, for a given intended use, is not subject to regulatory requirements.

NOTE Reaction to fire Class F is equivalent to NPD for this characteristic.

ZA.3.4 Information accompanying CE Marking symbol – Roofs

The following information shall accompany the CE Marking symbol:

— name or identifying mark of the manufacturer;

— address of production plant (if relevant);

— identification number of the notified body (only relevant for system 1);

— number of the certificate of conformity (only required under system 1);

— last two digits of the year of CE marking;

— number of this European Standard (EN 14509) with date of Revision e.g.2012;

— description of the product: generic name, grade and thickness of facing materials, metalic coating mass and coating type and thickness, core material and thickness, mass, density and intended use;

— product name and type;

— reaction to fire (Classification including any mounting and fixing conditions, or Class F);

— fire resistance (Classification including any mounting and fixing conditions, or NPD);

— external fire performance – roofs (Classification, or Class F_{ROOF});

— tensile strength (Value);

— shear strength (Value);

— reduced long term shear strength (Value);

— shear modulus (core) (Value);

— compressive strength (core) (Value);

— creep coefficient (Value for t = 2 000 h and t = 100 000 h);

— bending resistance [a] in the span– positive and negative bending (Value) and tested span:

  — positive bending, ambient temperature;

  — positive bending, elevated temperature (see A.5.5.5);

  — negative bending, ambient temperature;

  - negative bending elevated temperature (see A.5.5.5);
- bending resistance [a] at an internal support – positive and negative bending (Value):
  - positive bending, ambient temperature;
  - positive bending, elevated temperature (see A.5.5.5);
  - negative bending, ambient temperature;
  - negative bending elevated temperature (see A.5.5.5);
- wrinkling strength[a] (Value):

  inner face:
  - wrinkling strength[a] in the span, ambient temperature;
  - wrinkling strength[a] at an internal support (continuous panels) for loads pressing on a support, ambient temperature;

  outer face):
  - wrinkling strength[a] in the span, ambient temperature;
  - wrinkling strength[a] in the span, elevated temperature (see A.5.5.5);
  - wrinkling strength[a] at an internal support (continuous panels) for uplift loads, ambient temperature;
  - wrinkling strength[a] at an internal support (continuous panels) for uplift loads, elevated temperature (see A.5.5.5);
- thermal transmittance $U_{d,s}$ (Value) and $\lambda_{declared}$ (Value);
- water permeability (Classification or NPD);
- air permeability (Values or NPD);
- airborne sound insulation (Classification or NPD);
- resistance to point loads – roofs – where required. The maximum achieved load and tested span shall be declared;
- resistance to access loads. (for occasional foot traffic without additional protection) – roofs – where required. Pass required before affixing CE Marking;
- durability (Statement of colour and reflectivity levels). Pass required before affixing CE Marking.

[a] Either the wrinkling strength or bending resistance shall be declared

The 'No performance determined' (NPD) option shall not be used where the characteristic is subject to a threshold level or for mechanical resistance characteristics (5.2.1), which determine fitness for intended use. The NPD option may be used for other characteristics when and where the characteristic, for a given intended use, is not subject to regulatory requirements.

NOTE Reaction to fire Class F and external fire performance Class F_{ROOF} are equivalent to NPD for these characteristics.

ZA.3.5 Example of CE Marking and descriptive information

Figure ZA.1 gives an example of the CE Marking and descriptive information to be given on the packaging. Figure ZA.2 (roofs), Figure ZA.3 (external walls) and Figure ZA.4 (internal walls and ceilings) give examples of the information to be given on the accompanying documents unless all the relevant information has been placed on the packaging.

The CE marking shall be presented in the language or languages accepted in the Member State in which the product is to be used.

CE 01234	*CE conformity marking, consisting of the "CE"-symbol given in Directive 93/68/EEC.* *Identification number of the certification body (where relevant)*
AnyCo Ltd, PO Box 21, B-1050 XYZ Co **13** 01234-CPD-00234	*Name or identifying mark and registered address of the producer.* *Name and registered address of the supplier (if different from the producer)* *Last two digits of the year in which the marking was affixed* *Certificate number (where relevant)*
EN 14509:2013 Metal faced insulating panel for use in buildings. **Use: Roofs**	*No. of European Standard with Revision date* *Description of product* *End use application*

Figure ZA.1 – Example of CE marking: with packaging

CE

01234

AnyCo Ltd, PO Box 21, B-1050

XYZ Co

13

01234-CPD-00234

EN 14509:2013

Metal faced insulating panel for use in buildings.

Reference: XX1000.

Insulation: PUR Density: 35 kg/m^3 Thickness: 80mm.

Mass: 12 kg/m^2.

Facings:

External: Steel 0,5 mm S 320GD (EN 10346): Coating: PVC/100µm.

Internal: Steel 0,4 mm S 280GD (EN 10346). Coating: SP/12µm.

Use: Roofs

Thermal transmittance: 0,25 W/m^{2}K

Thermal conductivity: 0.020 W/m·K

Mechanical resistance:

Tensile strength 0,12 MPa

Shear strength 0,10 MPa

Reduced long term shear strength 0,080 MPa

Shear modulus (core) 3,0 MPa

Compressive strength (core) 0,14 MPa

Creep coefficient t = 2000 h 2,0

t = 100000 h 7,0

Bending resistance in the span (Tested span 1,8 m)

- +ve bending 3,70 kNm/m
- +ve bending, elevated temperature 3,50 kNm/m
- -ve bending 2,90 kNm/m
- -ve bending, elevated temperature 2,75 kNm/m

Bending resistance at an internal support

- +ve bending 2,60 kNm/m
- +ve bending, elevated temperature 2,50 kNm/m

CE conformity marking, consisting of the “CE”-symbol given in Directive 93/68/EEC.

Identification number of the certification body (where relevant)

Name or identifying mark and registered address of the producer

Name and registered address of the supplier (if different from the producer)

Last two digits of the year in which the marking was affixed

Certificate number (where relevant)

No. of European Standard with Revision date

Description of product

and

For standard metal facings the steel grade is to be declared

For non-standard steels properties of yield stress, ultimate strength and elongation are to be declared from tests.

End use application

Information on regulated characteristics

Creep: roof applications only

Either the wrinkling strength or bending resistance shall be declared

Fire resistance – Classification shall be accompanied by any mounting and fixing conditions. Where required, state the relevant load used and any other restrictions on direct application from test

External fire performance. State classification and slope(s) at which tested or B_{ROOF} if CWFT

Classification or NPD

Values or NPD

Classification or NPD

Load and tested span or NPD

Values / pass or NPD

Statement of colours/reflectivity if subject to durability test DUR1

- -ve bending 3,00 kNm/m
- -ve bending, elevated temperature 2,80 kNm/m
Wrinkling strength (external face)
- in span 100 MPa
- in span, elevated temperature 95 MPa
- at central support 80 MPa
- at central support elevated temperature 75 MPa
Wrinkling strength (internal face)
- in span 100 MPa
- at internal support 90 MPa
Reaction to fire: B–s2,d0 (with steel flashing details)
Fire resistance: E240: EI 15 (load 1,5 kN)
External fire performance: $B_{ROOF(t1, t2, t3)}$ or $B_{ROOF(tX)}$
Water permeability: Class C
Air permeability: n = 0.9: C = 0.001
Water vapour permeability: Impermeable
Airborne sound insulation: R_w (C:C_{tr})
Resistance to point load 1,4 kN 5 m
Repeated access load 2000 cycles: Pass
Durability: Pass – light colours: reflectivity 40–90

Figure ZA.2 – Example of CE Marking (roofs): accompanying information

CE

01234

AnyCo Ltd, PO Box 21, B-1050

XYZ Co

13

01234-CPD-00234

EN 14509:2013

Metal faced insulating panel for use in buildings.

Reference: YY1000.

Insulation:MW. Density: 120 kg/m^3:Thickness 120 mm.

Mass: 20 kg/m^2.

Facings:

External: Steel 0,5 mm S 320GD (EN 10346): Coating: PVC/100µm.

Internal: Steel 0,4 mm S 280GD (EN 10346). Coating: SP/12µm.

Use: External walls

Thermal transmittance: 0,25 W/m^{2}K

Thermal conductivity: 0,035 W/m·K

Mechanical resistance:

Tensile strength 0,12 MPa

Shear strength 0,10 MPa

Shear modulus (core) 6,0 MPa

Compressive strength (core) 0,08 MPa

Bending resistance in the span (Tested span 3 m)

- +ve bending 6,60 kNm/m
- +ve bending, elevated temperature 6,30 kNm/m
- -ve bending 6,60 kNm/m
- -ve bending, elevated temperature 6,30 kNm/m

Bending resistance at an internal support

- +ve bending 5,30 kNm/m
- +ve bending, elevated temperature 5,00 kNm/m

CE conformity marking, consisting of the "CE"-symbol given in Directive 93/68/EEC

Identification number of the certification body (where relevant)

Name or identifying mark and registered address of the producer

Name and registered address of the supplier (if different from the producer)

Last two digits of the year in which the marking was affixed

Certificate number (where relevant)

No. of European Standard with Revision date

Description of product

And

For standard metal facings the steel grade is to be declared

For non-standard steels properties of yield stress, ultimate strength and elongation are to be declared from tests

End use application

Information on regulated characteristics

Either the wrinkling strength or bending resistance shall be declared

Classification or NPD. Classification shall <u>be accompanied by any mounting and fixing conditions and shall</u> be accompanied by any restrictions on direct application

Classification or NPD

Values or NPD

Airborne sound insulation. Only for panels intended for acoustic insulation requirements. Classification or NPD

Sound absorption. Only for panels intended for internal acoustic conditioning. Classification or NPD

Statement of colours/reflectivity if subject to durability test DUR1

- -ve bending 4,60 kNm/m
- -ve bending, elevated temperature 4,40 kNm/m

Wrinkling strength (external face)

- in span 120 MPa
- in span, elevated temperature 115 MPa
- at central support 85 MPa
- at central support elevated temperature 80 MPa

Wrinkling strength (internal face)

- in span 120 MPa
- at central support 110 MPa

Reaction to fire: B–s1,d0 (all applications)

Fire resistance: E240: EI 15

Water permeability: Class C

Air permeability; n = 0.9: C = 0.001

Water vapour permeability: Impermeable

Airborne sound insulation: R_{w} (C:C_{tr})

Sound absorption: Single number rating α_{w}

Durability: Pass – all colours

Figure ZA.3 – Example CE marking (walls): accompanying information

	CE conformity marking, consisting of the "CE"-symbol given in Directive 93/68/EEC
01234	*Identification number of the certification body (where relevant)*
AnyCo Ltd, PO Box 21, B-1050	*Name or identifying mark and registered address of the producer*
XYZ Co	*Name and registered address of the supplier (if different from the producer)*
13	*Last two digits of the year in which the marking was affixed*
01234-CPD-00234	*Certificate number (where relevant)*
EN 14509:2013	*No. of European Standard with Revision date*
Metal faced insulating panel for use in buildings.	*Description of product*
Reference: ZZ1000	*and*
Insulation:MW. Density:120 kg/m^3.Thickness:120 mm.	*For standard metal facings the steel grade is to be declared*
Mass: 20 kg/m^2.	
Facings:	*For non-standard steels properties of yield stress, ultimate strength and elongation are to be declared from tests*
External: Steel 0,5 mm external (non-standard): Coating: PVC/100µm.	*End use application*
Internal: Steel 0,4 mm internal (EN 10346). Coating: SP/12µm.	*Information on regulated characteristics*
Mechanical properties of non-standard steel, external facing:	Ceilings only (where required)
	Either the wrinkling strength or bending resistance shall be declared
Yield stress 220 Mpa	*Classification or NPD. Classification shall be accompanied by any mounting and fixing conditions and shall be accompanied by any restrictions on direct application*
Ultimate strength 270 Mpa	
Elongation 22 %	
Use: internal walls and ceilings	*Classification or NPD*
Thermal transmittance: 0,25 W/m^{2}K	*Values or NPD*
Thermal conductivity: 0,035 W/m·K	*Airborne sound insulation. Only for panels intended for acoustic insulation requirements. Classification or NPD*
Mechanical resistance:	
Tensile strength 0,12 MPa	
Shear strength 0,10 MPa	*Sound absorption. Only for panels intended for internal acoustic conditioning. Classification or NPD*
Reduced long term shear strength 0,08 MPa	*Ceilings only. Load and tested span or NPD*
Shear modulus (core) 6,0 MPa	*Ceilings only. Statement whether suitable for repeated loads without / with additional protection.*
Compressive strength (core) 0,080 MPa	
Creep coefficient t = 2000 h 2,0	
t = 100000 h 7,0	
Bending resistance in the span (Tested span 6 m)	
- +ve bending 6,60 kNm/m	
- -ve bending 6,60 kNm/m	

Bending resistance at an internal support

- +ve bending 5,95 kNm/m

- -ve bending 5,95 kNm/m

Wrinkling strength (face 1)

- in span 120 MPa

- at central support 110 MPa

Wrinkling strength (face 2)

- in span 120 MPa

- at central support 110 MPa

Reaction to fire: B – s1: d0 (all applications)

Fire resistance: E240: EI 15 (load 1,5 kN)

Water permeability: Class C

Air permeability: n = 0.9: C = 0.001

Water vapour permeability: Impermeable

Airborne sound insulation: R_w (C:C_{tr})

Sound absorption: Single number rating α_w

Resistance to point load 1,4 kN 5 m

Repeated access load Unsuitable for repeated loads without additional protection

Figure ZA.4 – Example CE marking (internal walls and ceilings): accompanying information

Bibliography

[1] Commission Decision 2006/600/EC of 04/09/06 amending Decision 2001/671/EC establishing the classes of external fire performance of certain construction products

[2] European Recommendations for Sandwich Panels: Part 1: Design. ECCS/CIB Report – CIB Publication Number 257: 23 Oct 2000. ISBN 90-6363-024-7

[3] Lightweight sandwich construction. Ed J M Davies, Blackwell Science on behalf of CIB Commission W56 and ECCS Working Group TWG 7.9, ISBN 0-6322-004027-0, 2001

[4] EN 10002-1, *Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature*

[5] EN 12524, *Building materials and products - Hygrothermal properties - Tabulated design values*

[6] EN 506, *Roofing products of metal sheet - Specification for self-supporting products of copper or zinc sheet*

[7] EN 508-2, *Roofing products from metal sheet - Specification for self-supporting products of steel, aluminium or stainless steel sheet - Part 2: Aluminium*

[8] EN 508-3, *Roofing products from metal sheet - Specification for self-supporting products of steel, aluminium or stainless steel sheet - Part 3: Stainless steel*

[9] EN 1363-2, *Fire resistance tests - Part 2: Alternative and additional procedures*

[10] EN 1991(all parts), *Eurocode 1: Actions on structures*

[11] EN ISO 9001, *Quality management systems - Requirements (ISO 9001)*

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™