BRITISH STANDARD

BS EN 14024:2004
Incorporating Corrigendum No. 1

Metal profiles with thermal barrier — Mechanical performance — Requirements, proof and tests for assessment

The European Standard EN 14024:2004 has the status of a British Standard

ICS 91.060.10; 91.060.50

British Standards

National foreword

This British Standard is the official English language version of EN 14024:2004.

The UK participation in its preparation was entrusted by Technical Committee B/538, Doors, windows, shutters, hardware and curtain walling, to Subcommittee B/538/1, Windows, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

Additional information

The adoption of this British Standard introduces a range of test criteria to assess the suitability of the thermal barrier material incorporated within metal profiles, which has not previously been covered by British Standards. Thermal barriers containing existing polyurethane products, as used in the UK for the past 25 years, may therefore not meet the ageing procedure requirements given in Clause 5, Method 1, Method 2 and Method 3. These products are likely to continue to be present in the marketplace but may not be able to conform to the requirements of this standard.

It is expected that products conforming to this standard will become available in the UK following the possible citing of this standard in the revisions of:

— *Building Regulations Approved Document L1 — Conservation of fuel and power in dwellings*; and

— *Building Regulations Approved Document L2 — Conservation of fuel and power in buildings other than dwellings*

expected to be published in 2005/2006.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

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Summary of pages

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EUROPEAN STANDARD

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EUROPÄISCHE NORM

EN 14024

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English version

Metal profiles with thermal barrier - Mechanical performance - Requirements, proof and tests for assessment

Profilés métalliques à rupture de pont thermique - Performances mécaniques - Exigences, preuve et essais pour évaluation

Metallprofile mit thermischer Trennung - Mechanisches Leistungsverhalten - Anforderungen, Nachweis und Prüfungen für die Beurteilung

This European Standard was approved by CEN on 29 July 2004.

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 Central Secretariat or to any CEN member.

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Foreword

This document (EN 14024:2004) has been prepared by Technical Committee CEN/TC 33 “Doors, windows, shutters, building hardware and curtain walling”, the secretariat of which is held by AFNOR.

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 2005, and conflicting national standards shall be withdrawn at the latest by April 2005.

This text includes a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This document specifies requirements for assessment of the mechanical strength of metal profiles incorporating a thermal barrier. It also specifies the tests to determine the characteristic values of mechanical properties of the thermal barrier profile and to assess the suitability of the thermal barrier material used.

This document applies to thermal barrier profiles designed mainly for windows, doors, window walls and curtain walls. It does not apply to thermal barriers made only of metal profiles connected with metal pins or screws.

Thermal barrier profiles are used in various fields of applications and demand a differing assessment of their mechanical performance depending on their intended use. This document takes this into account by two fields of application: one for windows, doors and related components and one for profiles in façades.

2 Normative references

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

EN ISO 4600*, Plastics – Determination of environmental stress cracking (ESC) – Ball or pin impression method (ISO 4600:1992).*

3 Terms, definitions and symbols

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

3.1
thermal barrier profile
profile composed of two or more metal sections connected by at least one thermally insulating (non-metallic) part

NOTE 1 The thermal barrier contributes to load transmission.

NOTE 2 The thermal barrier can be continuous or in parts.

3.2 Use categories

3.2.1
category W
thermal barrier profiles mainly designed for windows, doors and secondary constituent parts of curtain walls

NOTE Thermal barrier profiles designed for windows and doors do not usually require proof by calculation for mechanical resistance.

3.2.2
category CW
thermal barrier profiles mainly designed for the constituent parts of curtain walls with spans greater than 2,25 m

NOTE Constituent parts of curtain walls usually need proof by calculation relating to mechanical resistance and deflection.

3.2.3
temperature categories
two temperature categories, defined and to be chosen according to the intended use

Temperature category	Low test temperature LT	High test temperature HT
TC 1	(-10 ± 2) °C	(70 ± 3) °C
TC 2	(-20 ± 2) °C	(80 ± 3) °C

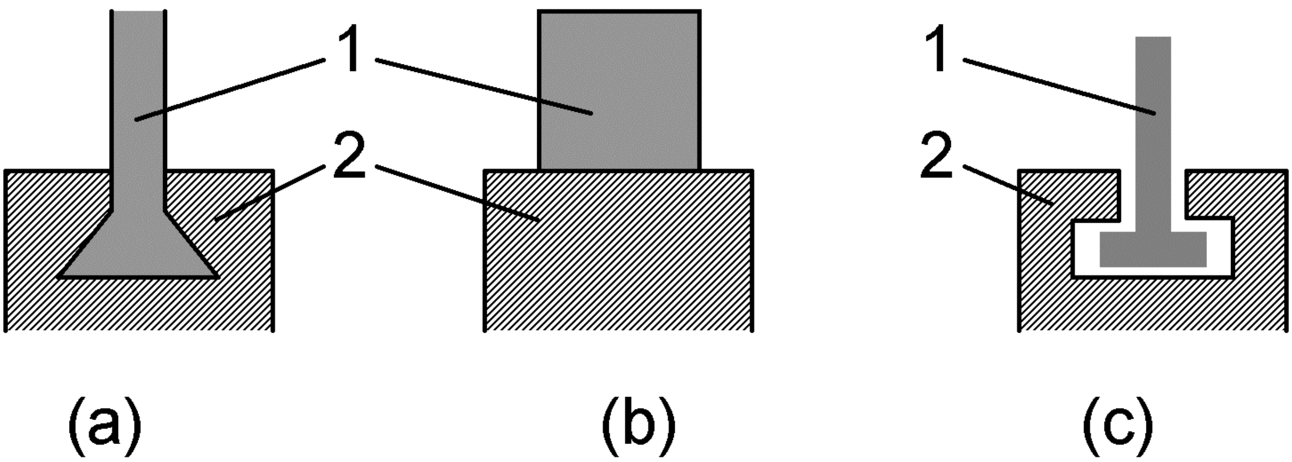
NOTE Temperature category TC 2 includes temperature category TC 1.

3.3 Mechanical design systems

3.3.1
type A system
system which is designed to transfer shear and in which shear failure will not negatively affect the transverse tensile strength

3.3.2
type B system
system which is designed to transfer shear and in which shear failure will negatively affect the transverse tensile strength

3.3.3
type O system
system which is designed to transfer no shear to the thermal barrier or profile which has an insufficient shear strength



a) Type A system b) Type B system c) Type O system

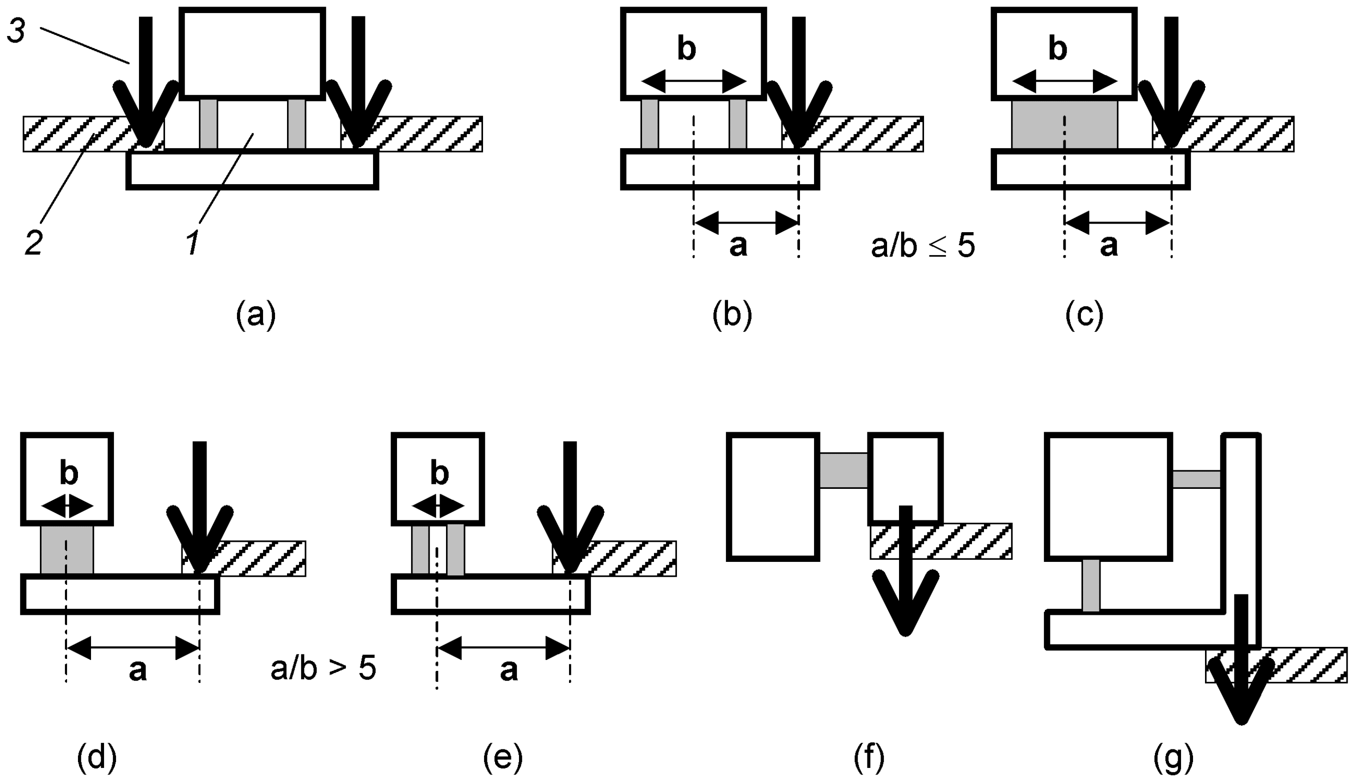
Key
1 Thermal barrier
2 Metal

Figure 1 — Schematic diagram of mechanical design systems

3.4 Geometric design types

3.4.1
type 1 profile
profile in which the load is symmetric (see Figure 2a)) or near to symmetry, i.e. the eccentricity of the load a/b does not exceed the value 5 (see Figure 2b) and c))

3.4.2
type 2 profile
profile in which the load is asymmetric, i.e. all profiles not covered by type 1 (see Figure 2d), e), f) and g))



a) symmetrically loaded profile (type 1)

b) and c) near symmetrically loaded profiles with eccentricity a/b ≤ 5 (type 1)

d) and e) asymmetrically loaded profiles with eccentricity a/b > 5 (type 2)

f) and g) non-symmetric profiles (type 2)

Key

1 Thermal barrier profile

2 Infill elements (i.e. glass or panels)

3 Line load

Figure 2 — Examples of geometric design types

3.5 Symbols and indexes

Symbol	Meaning	Unit
Q	transverse tensile strength	N/mm
T	shear strength	N/mm
c	elasticity constant	N/mm²
l	length of the test specimen	mm
f	deformation	mm
Δh	deformation	mm
F	force	N
A_1	design factor for type B	
A_2	creep factor	
Indexes		
c	characteristic value which has a 95% chance of being exceeded based on a logarithmic normal distribution with 75% confidence	
N	new, before artificial ageing	
M1	after artificial ageing, method 1	
M2	after artificial ageing, method 2	
M3	after artificial ageing, method 3	
mean	mean value	
req	required	
max	maximum	
LT	low temperature	
RT	room temperature	
HT	high temperature	

4 Requirements

4.1 General

For assessing the shear depending on the thermal barrier systems, three types A, B and O (see 3.3) shall be distinguished.

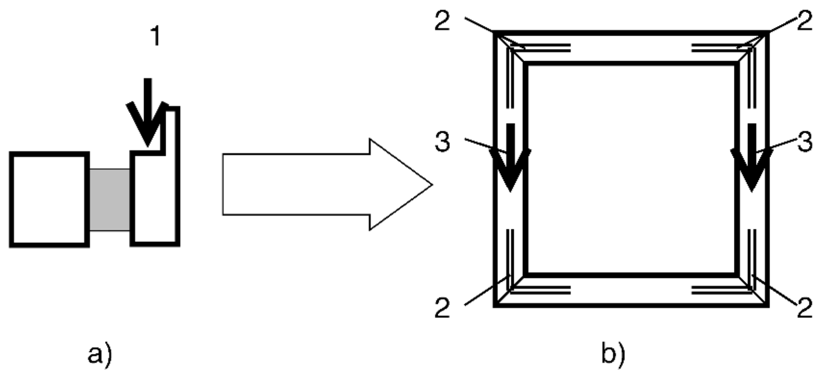
Because of the intrinsic safety of type A, shear and tensile strength may be considered independently, whereas type B requires an assessment under superposition of loads.

The transverse tensile strength of type A and type O shall be determined after simulated shear failure. For type O only the transverse tensile strength shall be determined, no shear strength and elasticity constant will be given.

Permanent loads which stress the thermal barrier are not covered by this document with the following exceptions:

a) the tension (transversal tensile stress) caused by conventional glazing systems with preformed seals;

b) in the case of type A or type B systems the shear stress in the vertical profile caused by the self-weight of the infill element. The transfer of the load from the horizontal profile to the vertical profile by mechanical means is required (see Figure 3).



a) horizontal profile section

b) front view of a frame

Key

1 Self-weight of infill element

2 Mechanical means (mechanical edge connection)

3 Transferred self-weight

Figure 3 — Transfer of the self-weight of the infill element to the vertical profile by mechanical means

4.2 Material of the thermal barrier

Thermal barrier composed of non-metallic materials, e.g. PA or PU based systems or improved synthetic materials, shall be tested in accordance with 5.2.

The aim of the test procedures is to assess the thermal barrier material independently of the shape of the thermal barrier and of the profile design.

Materials used for the thermal barrier shall conform to the following requirements:

a) the characteristic value of transverse tensile strength after immersion in water (see 5.2.2) or after exposure to humidity (see 5.2.3) shall correspond to Q_{req} given in Table 1 depending on the category of use. The decrease of the characteristic value shall not exceed 30 % as compared to Q_c^N at the corresponding temperature;

b) customary window and facade cleaning agents or cutting and drilling oils shall not cause tensile cracks (see 5.2.4);

c) exposure to sudden stress (see 5.2.5) shall not cause decrease in characteristic value of transverse tensile strength of more than 30 % as compared to $Q_c{}^N{}_{RT}$.

4.3 Mechanical resistance

Depending on the category of use of the profile and the type of the thermal barrier system (geometry and technology) the characteristic values of the mechanical resistance shall conform to the requirements of Table 1.

EXAMPLE $Q_c{}^{M1}{}_{LT} \geq Q_{req}$ in category CW means that the characteristic transverse tensile strength after ageing method 1 determined at low temperature LT should be not less than 20 N/mm.

Table 1 — Requirements for strength and deformation

Type	Category W		Category CW
	Q_{req} = 12 N/mm		Q_{req} = 20 N/mm
Geometry 1 (symmetric)			
A+B	$T_c{}^{N}{}_{RT} \geq 24$ N/mm Ageing method 1 $\Delta h \leq 1$ mm $Q_c{}^{M1}{}_{LT} \geq Q_{req}$ $Q_c{}^{M1}{}_{HT} \geq Q_{req}$	Ageing method 2 $f \leq 2$ mm $Q_c{}^{M2}{}_{RT} \geq 12$ N/mm $T_c{}^{M2}{}_{RT} \geq 24$ N/mm	Proof according to 4.4 Ageing method 1 $\Delta h \leq 1$ mm $Q_c{}^{M1}{}_{LT} \geq Q_{req}$ $Q_c{}^{M1}{}_{HT} \geq Q_{req}$ Ageing method 3 A_2
O	Ageing method 1 $\Delta h \leq 1$ mm $Q_c{}^{M1}{}_{LT} \geq Q_{req}$ $Q_c{}^{M1}{}_{HT} \geq Q_{req}$	Ageing method 2 $f \leq 2$ mm $Q_c{}^{M2}{}_{RT} \geq 12$ N/mm	Proof according to 4.4 Ageing method 1 $\Delta h \leq 1$ mm $Q_c{}^{M1}{}_{LT} \geq Q_{req}$ $Q_c{}^{M1}{}_{HT} \geq Q_{req}$
Geometry 2 (non-symmetric)			
A+B	$T_c{}^{N}{}_{RT} \geq 24$ N/mm Ageing method 2 $f \leq 3$ mm $Q_c{}^{M2}{}_{RT} \geq Q_{req}$ $T_c{}^{M2}{}_{RT} \geq 24$ N/mm		Not covered by this document
O	Ageing method 2 $f \leq 3$ mm $Q_c{}^{M2}{}_{RT} \geq Q_{req}$		

4.4 Static proof

Thermal barrier profiles designed for category W normally do not require proof by calculation for mechanical resistance (ultimate limit state). Calculation of deflection (serviceability state) may be necessary.

A proof by calculation relating to mechanical resistance and deflection shall be performed for thermal barrier profiles designed for category CW. Calculations shall be based on the acknowledged provisions and technology (see Annex A).

Based on the resulting characteristic data, and if there are identical connecting areas, thermal barrier profiles with differing metal profile sections can be calculated (see Annex B).

5 Tests

5.1 General

5.1.1 Test specimens

Test specimens shall be selected from representative profiles.

If various surface finishes or production procedures are used (e.g. anodizing, wet lacquering, powder coating), the most unfavourable finish - according to knowledge acquired - shall be chosen.

5.1.2 Test temperature

Three temperatures for testing shall be applied as follows:

- LT low test temperature (see 3.2.3);
- RT room temperature (23 ± 2) °C;
- HT high test temperature (see 3.2.3).

The temperature of the test specimen (as a whole) shall be maintained during the test.

5.1.3 Pre-test conditioning

Prior to testing in accordance with 5.3 or 5.4, the test specimens shall be kept in the laboratory for a period of two days under normal laboratory conditions, i.e. (23 ± 3) °C and (50 ± 10) % relative humidity.

5.2 Suitability of the thermal barrier material

5.2.1 General

The suitability of the material of thermal barrier is assessed by tests. The tests are not to be repeated on each set (series) of profiles supposed the thermal barrier material is unchanged.

The performance under wet climate (see 5.2.2 and 5.2.3) is assessed in terms of the transverse tensile strength. A protection of the cut edges may be necessary.

5.2.2 Performance after immersion in water

The length of the test specimens shall be (100 ± 1) mm.

Determine the initial value of the transverse tensile strength at RT according to 5.3.2 and the characteristic value $Q_c^N{}_{RT}$ accordingly. Store 20 test specimens in water at a temperature of (23 ± 2) °C for a period of 1 000 h. After storing the test specimens for a further period of 24 h under standard conditions (see 5.1.3), the transverse tensile strength shall be tested at the low and high test temperature in accordance with 5.3.2 and the characteristic values shall be evaluated in accordance with 5.3.3 and 5.6.1.

5.2.3 Performance after exposure to humidity

The length of the test specimens shall be (100 ± 1) mm.

Determine the initial value of the transverse tensile strength at RT according to 5.3.2 and the characteristic value $Q_c^N{}_{RT}$ accordingly. Store 10 test specimens for a period of 96 h in a hot and humid atmosphere, i.e. at (85 ± 5) °C and at a relative humidity greater than 90 %. After storing the test specimens for a further period of 24 h under standard conditions (see 5.1.3), the transverse tensile strength shall be tested at room temperature in accordance with 5.3.2 and the characteristic values shall be evaluated in accordance with 5.3.3 and 5.6.1.

5.2.4 Testing for tensile cracks

To demonstrate the compatibility of a chemical agent with the material of the thermal barrier the following test procedure shall be executed.

In order to test for tensile cracks, place 10 test specimens of the material of thermal barriers for a period of 1 000 h in window and façade cleaning agents, and/or drilling and cutting oils specified by the test laboratory client in coordination with the test laboratory. Testing shall be carried out in accordance with EN ISO 4600, method A. Pins having a diameter of 3,1 mm, 3,2 mm, 3,3 mm and 3,4 mm shall be used.

5.2.5 Testing for brittleness

The transverse tensile strength of 10 test specimens shall be determined in accordance with 5.3 at a test temperature of -10°C. The feed rate shall be 200 mm/min. The characteristic values shall be evaluated according to 5.3.3 and 5.6.1.

5.3 Transverse tensile strength (Q)

5.3.1 Test specimens

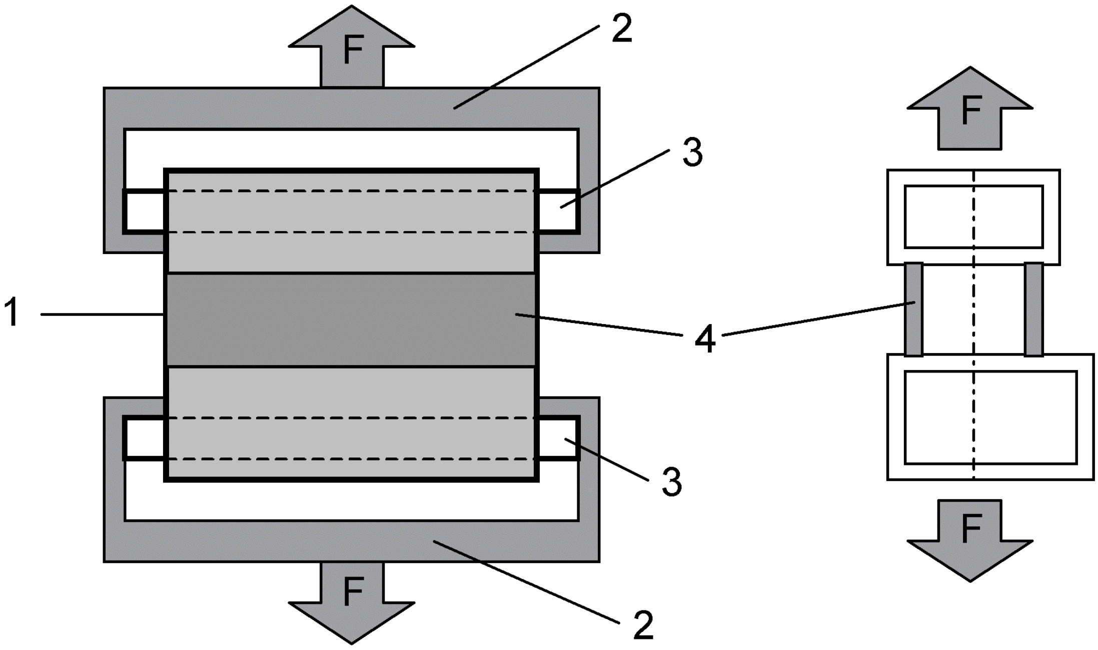
Test specimens shall preferably be 100 mm in length. In order to determine the characteristic transverse tensile strength 10 test specimens shall be tested at the intended temperature and evaluated in accordance with 5.6.

The size can be reduced to a minimum of 18 mm if the cutting is done carefully to avoid shock to the connection between the thermal break and the metal.

Type A or type O systems shall be tested after shearing failure, i.e. the shear connection of metal profile sections and thermal barrier comes apart. A shear failure shall be assumed to have taken place in the case of a displacement of 2 mm of the metal profile sections to each other.

5.3.2 Test procedure

In order to determine the transverse tensile strength the device shown in Figure 4 shall be used. The feed rate shall be in the range of 1 mm/min to 5 mm/min. The test device shall generate a symmetric load.



Key

1 Test specimen

2 Stirrup

3 Support bar

4 Thermal break

Figure 4 — Side view and front view of a test device (schematic) for determining the transverse tensile strength

5.3.3 Evaluation

The value of the tensile strength for each test specimen shall be calculated as follows:

$$Q = \frac{F_{\max}}{l} \qquad (1)$$

where

Q is the tensile strength (N/mm);

F_{max} is the maximum tensile load (N);

l is the length of the test specimen (mm).

5.4 Shear strength and elasticity constant (T, c)

5.4.1 Test specimens

The length of each test specimen shall be (100 ± 1) mm. In order to determine the characteristic shear strength and the elasticity constant 10 test specimens shall be tested at the intended temperature.

If the compound connection is not continuous, the test specimens shall include a minimum of two connections, which will give the test specimen length required.

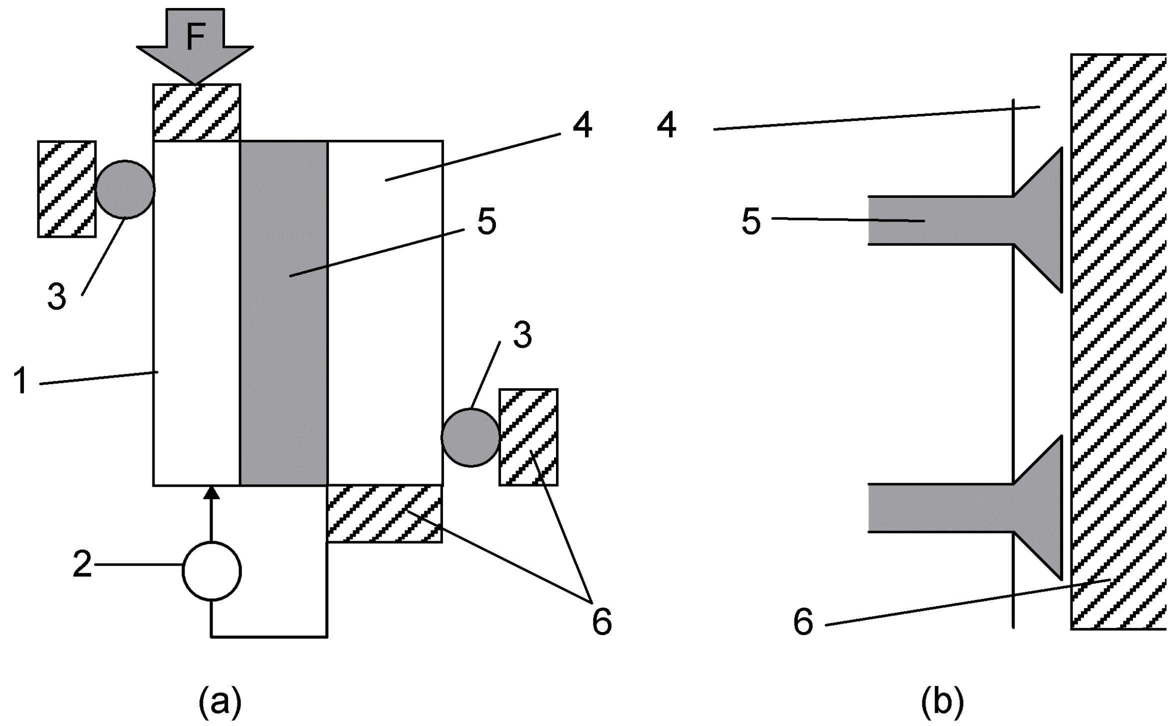
NOTE A reduction in the length of the test specimen is permitted if it is proven that short test specimens have comparable characteristic values.

5.4.2 Test procedure

In order to determine the shear strength T and elasticity constant c, place the test specimen in a test device, the principle is shown in Figure 5. The test specimen shall be guided laterally. The forces shall be transmitted to the profile by a rigid support in such a way as to ensure uniform distribution of the load but without any contact with the thermal barrier material. The rigid support shall not restrain an eventual slip of the thermal barrier material.

NOTE In case of a slender thermal barrier, problems of stability may occur. In this case the test device should provide for the risk of buckling without affecting the shear strength.

The feed rate shall be 1 mm/min to 5 mm/min. The loads applied and the corresponding shear deformations shall be recorded up to the maximum load or at least 2 mm deformation if there is slip. The displacement shall be measured directly on the test specimen.



a) side view

b) top view (blow up)

Key

1 Test specimen

2 Displacement gauge

3 Guide

4 Metal profile

5 Thermal barrier

6 Rigid support

Figure 5 — Test device for determining shear strength and elasticity constant (schematic)

5.4.3 Evaluation

The value of the shear strength for each test specimen shall be calculated as follows:

$$T = \frac{F_{\max}}{l} \tag{2}$$

where

T is the shear strength (N/mm);

F_{max} is the maximum shear load (N);

l is the length of the test specimen (mm).

The elasticity constant c shall be obtained from the increase of the curve of deformation under load (stress-strain-curve) after the beginning of the deformation. The following equation shall apply:

$$c = \frac{\Delta F}{\Delta\delta \ x \ l} \tag{3}$$

where

c is the elasticity constant (N/mm²);

ΔF is the increase of the shear load (N);

$\Delta\delta$ is the corresponding displacement (mm);

l is the length of the test specimen (mm).

5.5 Ageing

5.5.1 General

Depending on the application and the type of geometry of the profile an ageing procedure in accordance with Table 2 shall be used.

Table 2 — Ageing procedure

System	Category	
	Category W	Category CW
Type 1	Method 1 or method 2	Method 1 and method 3
Type 2	Method 2	Not covered by this document

5.5.2 Method 1

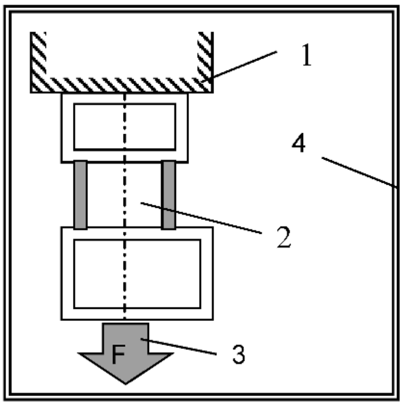
5.5.2.1 Test method

Type A or type O systems shall be tested after shearing failure, i.e. the shear connection of metal profile sections and thermal barrier comes apart. A shear failure shall be assumed to have taken place in the case of a displacement of 2 mm of the metal profile sections to each other.

NOTE Test specimens which passed the test in 5.4 may be used.

For Type B systems test specimens shall be tested in the initial state.

Expose the test specimens to a constant transverse load of 10 N/mm for a period of 1000 h at the temperature HT, (see Figure 6).



Key

1 Support

2 Test specimen fixed to the support

3 Permanent transverse load of 10 N/mm

4 Chamber to provide the temperature HT for 1 000h

Figure 6 — Test device (schematic) for ageing method 1

5.5.2.2 Evaluation

The remaining deformation Δh after ageing shall be determined (see Figure 7). This measurement shall be taken within 0,1 mm.

After storing the test specimens for a further period of 24 h under standard condition (see 5.1.3), the transverse tensile strength test shall be carried out at the appropriate temperature and the characteristic value shall be evaluated.

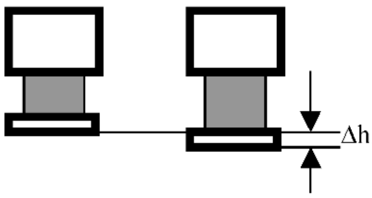


Figure 7 — Method 1: Measurement of the remaining deformation

5.5.3 Method 2

5.5.3.1 Test method

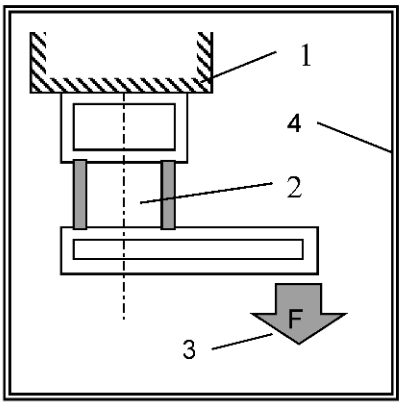
Place a profile bar with a length of at least 500 mm in a climatic chamber with air circulation. Fix the upper profile section to a rigid support (see Figure 8). Subject the profile bar simultaneously to temperature cycles and mechanical stresses.

5.5.3.2 Mechanical load cycle

The load applied shall be determined from the length of the profile bar in such a way as to exert a constant load of (1,00 ± 0,01) N/mm on the flange of the profile. In addition to the constant load a cyclic load of (0,25 ± 0,01) N/mm shall be exerted (see Figure 9). Loads shall be applied in a direction parallel to the bottom of the rebate (see Figure 8) for 1 000 000 cycles (see Figure 9).

5.5.3.3 Temperature cycle

Concurrent with the mechanical stresses, the temperature of the ambient air shall be varied between the temperatures LT and HT according to the cycle shown in Figure 10. The total time is determined by the number of mechanical cycles. Temperatures shall be controlled within ± 5 °C.



Key

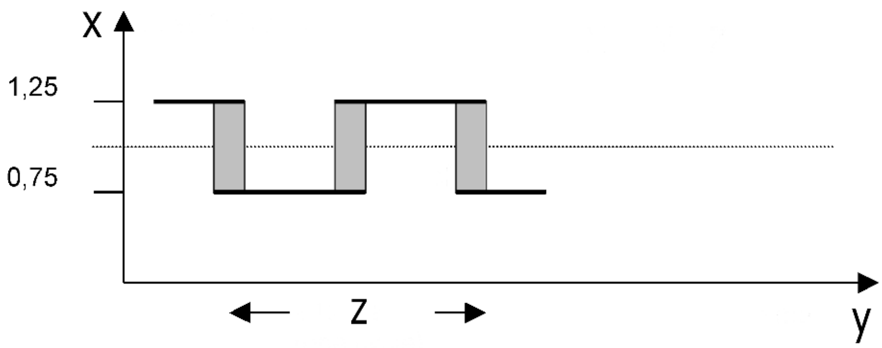
1 Rigid support

2 Test specimen fixed to the support

3 Permanent load with cyclical variation

4 Chamber with temperature control to provide the temperature cycle

Figure 8 — Test device (schematic) for ageing method 2



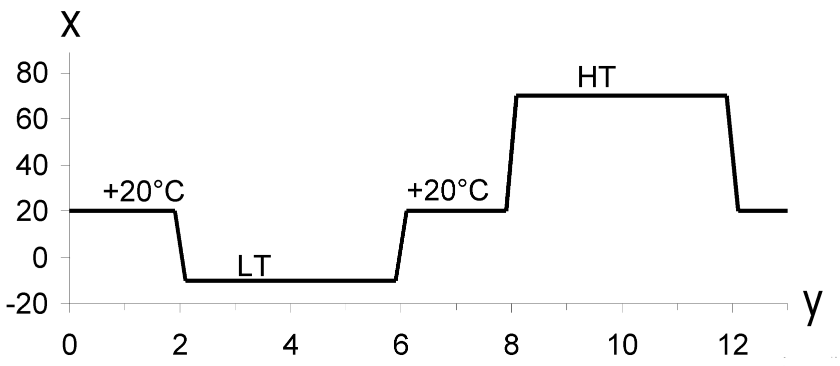
Key

x Load in N/mm

y Time

z 2 to 4 s (one cycle)

Figure 9 — Method 2: Load cycle



Key

x Temperature in C °

y Time in h

Figure 10 — Method 2: Temperature cycle (12 h)

5.5.3.4 Evaluation

The remaining elongation (deformation) f after ageing shall be determined as shown in Figure 11. This measurement shall be taken within 0,1 mm.

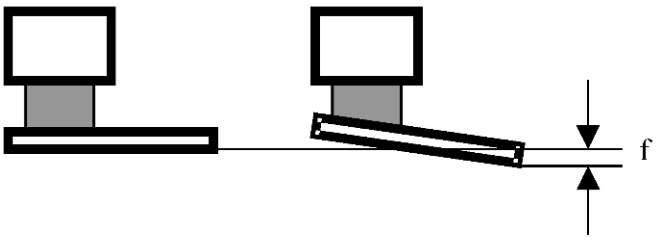


Figure 11 — Method 2: Measurement of the remaining deformation

5.5.3.5 Preparation of the test specimens after ageing test

After the ageing test the profile bar shall be cut into the appropriate length for the test specimens.

5.5.4 Method 3

This test shall be used to determine the creep factor A_2.

A load corresponding to 1/3 of the characteristic value of short-time shear strength at a temperature of HT ($T_c{}^{N}{}_{HT}$) shall be applied to 10 test specimens for a period of 1 000 h at the high temperature HT. After storing the test specimens for a further period of 24 h under standard condition (see 5.1.3), the shear strength shall be tested at room temperature and the characteristic value shall be evaluated.

5.6 Characteristic values

5.6.1 Transverse tensile strength

The characteristic transverse tensile strength shall be determined from the measured values as 5 % quantiles based on a logarithmic normal distribution with 75 % confidence, i.e. in the case of 10 test specimens:

$$Q_c = Q_{mean} - 2{,}02 \times s \qquad (4)$$

where

Q_{mean} is the mean value of the measured values at the test temperature;

s is the corresponding estimated standard deviation.

5.6.2 Characteristic shear strength

NOTE For type O systems no values are given.

The characteristic shear strength shall be determined from the measured values as 5 % quantiles based on a logarithmic normal distribution with 75 % confidence, i.e. in the case of 10 test specimens:

$$T_c = T_{mean} - 2{,}02 \times s \qquad (5)$$

where

T_{mean} is the mean value of the measured values at the test temperature;

s is the corresponding estimated standard deviation.

5.6.3 Ageing effect, creep factor A_2

NOTE 1 For type O systems no values are given.

The creep factor of the shear strength shall be determined from the characteristic values of the shear strength at the temperature RT before and after the ageing method 3 as follows:

$$A_2 = T_c{}^{N}{}_{RT} \,/\, T_c{}^{M3}{}_{RT} \qquad (6)$$

Where the coefficient A_2 is less than 1, its value shall be taken equal to 1.

NOTE 2 The factor A_2 can be assumed equal to 1,2 if the ageing behaviour is known and if the thermal break presents the same characteristics, i.e. material and geometry are similar to other profiles tested previously.

5.6.4 Combined shear and tensile stress, design-factor A_1

NOTE For type O systems no values are given.

For type A systems shear and tensile stress are independent, therefore the design factor A_1 = 1.

As there is no equivalent stress criterion for type B systems, the safety design factor of the shear strength shall be determined from the characteristic values of the tensile strength at high temperature HT and the required strength as follows:

$$A_1 = (1 - Q_{req} \,/\, Q_c{}^{M1}{}_{HT}) \qquad (7)$$

5.6.5 Elasticity constant

NOTE For type O systems no values are given.

The characteristic values of the elasticity constant shall be determined as follows:

— for low temperature: $c_{c,LT} = 0,5\ (c_{mean,LT} + c_{mean,RT})$;

— for room temperature: $c_{c,RT} = c_{mean,RT;}$ (8)

— for high temperature: $c_{c,HT} = 0,5\ (c_{mean,HT} + c_{mean,RT})$.

5.7 Test report

5.7.1 General

The report shall give reference to this document.

The tested metal profiles with thermal barrier shall be classified according to

— the mechanical design type A, B or C,

— the intended use category W or CW, in case of use category W the type of geometry,

— the temperature category TC1 or TC2.

The classification shall be clearly stated in the report, e.g.:

Thermal barrier profile type A, use category CW-TC2.

The test report shall provide a precise description of the compound system with information relating to the material of the thermal barrier. The individual values, the statistical evaluation and the type of failure shall be recorded for all tests.

5.7.2 Test report on the suitability of the thermal barrier material

If a former test report is referred to, clear reference to this report shall be given.

Otherwise the values given in Table 3 shall be reported and assessed according to 4.2.

Table 3 — Compilation of test results
Suitability of the thermal barrier material

Test	Test result
5.2.2	$Q_c{}^{5.2.2}{}_{LT}$; $Q_c{}^{5.2.2}{}_{HT}$
5.2.3	$Q_c{}^{5.2.3}{}_{RT}$
5.2.4	list of tested agents (see EN ISO 4600)
5.2.5	$Q_c{}^{5.2.5}$

5.7.3 Test report on the mechanical performances of the profile

Depending on the classification the set of values given in Table 4 shall be reported and assessed according to 4.3.

Table 4 — Compilation of test results
Characteristic values

Type	Category W	Category CW
Geometry 1 (symmetric)		
A	$T_c{}^N{}_{RT}$; $Q_c{}^{M1}{}_{LT}$; $Q_c{}^{M1}{}_{HT}$; Δh or $Q_c{}^{M2}{}_{RT}$; $T_c{}^{M2}{}_{RT}$; f	$Q_c{}^{M1}{}_{LT}$; $Q_c{}^{M1}{}_{HT}$; $T_c{}^N{}_{LT}$; $T_c{}^N{}_{RT}$; $T_c{}^N{}_{HT}$; $c_c{}^N{}_{LT}$; $c_c{}^N{}_{RT}$; $c_c{}^N{}_{HT}$; A_2
B	$T_c{}^N{}_{RT}$; $Q_c{}^{M1}{}_{LT}$; $Q_c{}^{M1}{}_{HT}$; Δh or $Q_c{}^{M2}{}_{RT}$; $T_c{}^{M2}{}_{RT}$; f	$Q_c{}^{M1}{}_{LT}$; $Q_c{}^{M1}{}_{HT}$; $T_c{}^N{}_{LT}$; $T_c{}^N{}_{RT}$; $T_c{}^N{}_{HT}$; $c_c{}^N{}_{LT}$; $c_c{}^N{}_{RT}$; $c_c{}^N{}_{HT}$; A_1; A_2
O	$Q_c{}^{M1}{}_{LT}$; $Q_c{}^{M1}{}_{HT}$; Δh or $Q_c{}^{M2}{}_{RT}$; f	$Q_c{}^{M1}{}_{LT}$; $Q_c{}^{M1}{}_{HT}$; Δh
Geometry 2 (non-symmetric)		
A	$Q_c{}^{M2}{}_{RT}$; $T_c{}^{M2}{}_{RT}$; f	Not covered by this document
B	$Q_c{}^{M2}{}_{RT}$; $T_c{}^{M2}{}_{RT}$; f	Not covered by this document
O	$Q_c{}^{M2}{}_{RT}$; f	Not covered by this document

Annex A
(informative)

Static proof

A.1 Effects

The following effects should be taken into account when calculating the static proof:

a) wind load according to ENV 1991-2-4;

b) horizontal lateral forces according to ENV 1991-2-1;

c) vertical loads according to ENV 1991-2-1;

d) dead load;

e) temperature difference between the exterior and interior metal profile section.

NOTE If it is not nationally stated otherwise, the following temperature differences may be applied for proof by calculation between the internal and external metal profile sections:

ΔT = 35 K (summer);

ΔT = 25 K (winter).

For the determination of the temperature differences the following boundary conditions were assumed:

— outside profile temperature +80 °C (summer);

— outdoor air temperature -20 °C (winter);

— indoor air temperature +20 °C.

A.2 Profiles without shear connection (type O)

A.2.1 Flexural stress

In the case of profiles without shear connection it should be separately proven for the metal profile sections that the resistance of the material (tensile strength, yield stress) should not be exceeded at any part of the section as follows:

$$\gamma_1 \times R_Q \leq R_m / \gamma_m; \qquad (A.1)$$

where

γ_1 is the partial safety factor of external loads;

R_Q is the tension caused by external loads;

γ_m is the partial safety factor of the material;

R_m is the resistance of the material.

A.2.2 Transverse tensile strength

The requirements of 4.3 should be met.

A.2.3 Deflection

Proof should be established based on the moments of inertia of the metal profile sections.

A.3 Profiles with shear connection (types A and B)

A.3.1 General

The proof of load bearing capacity should be carried out for both metal profile sections and the thermal barrier. The proof should be carried out for the following load combinations taking into account the temperature dependence of the characteristic values:

— combination 1 (winter): full wind load and temperature difference θ = 25 K;

— combination 2 (summer): half the wind load and temperature difference θ = 35 K.

A.3.2 Metal profile sections

Proof should be provided that the limiting stress will not be exceeded in any part of the metal profile section if exposed to the worst possible load combination as follows:

$$\gamma_1 \times R_Q + \gamma_2 \times R_T \leq R_m/\gamma_m; \qquad \text{(A.2)}$$

where

γ_1 is the partial safety factor of external loads;

γ_2 is the partial safety factor of temperature differences;

R_Q is the stress caused by external loads;

R_T is the stress caused by temperature differences;

γ_m is the partial safety factor of the material;

R_m is the resistance of the material.

A.3.3 Thermal barrier

Proof should be provided that the characteristic values of the load bearing capacity of the material and/or compound are not exceeded in any part of the product.

Shearing stress from flexion and temperature:

$$\gamma_1 \times S_Q + \gamma_2 \times S_T \leq T_c{}^{N}{}_{\theta} / (A_1 \times A_2); \qquad \text{(A.3)}$$

where

γ_1 is the partial safety factor of external loads;

γ_2 is the partial safety factor of temperature differences;

S_Q is the shear tension caused by external loads;

S_T is the shear tension caused by temperature differences;

$T_c{}^N{}_\theta$ is the shear strength at temperature θ;

A_1 is the design factor;

A_2 is the creep factor.

A.3.4 Transverse strength

The requirements of 4.3 should be met.

A.3.5 Deflection

Proof relating to deflection should be provided for external loads taking into account the compound effect based on the value of the elasticity constant at RT (c_{RT}).

Annex B
(informative)

Extrapolation of characteristic data

B.1 General

The extrapolations are only permitted within the same category (see 3.2) and type of profiles (see 3.3).

The mechanical characteristics *T*, c, *Q* performed on a typical profile of a particular set can be extrapolated to other sets of profiles, provided the requirements in B.2 and B.3 are respected.

B.2 Shear strength *T* and transverse tensile strength *Q*

In order to have the shear strength *T*, transverse tensile strength *Q* values extrapolated from one set of profiles to another, both sets should be equal concerning the following characteristics:

— the mechanical characteristics of the materials of the thermal barrier (PA, PUR resin, PUR foam, PPO) and the metallic part (aluminium, stainless steel, etc.);

— the technology used to connect the two materials, methodology of this technology:

  — EXAMPLE 1 Technology: insertion of PA thermal barrier profile in an aluminium groove; methodology: notching of the groove, insertion of the thermal barrier profile of the groove, setting (pressing) of the aluminium on the thermal barrier;

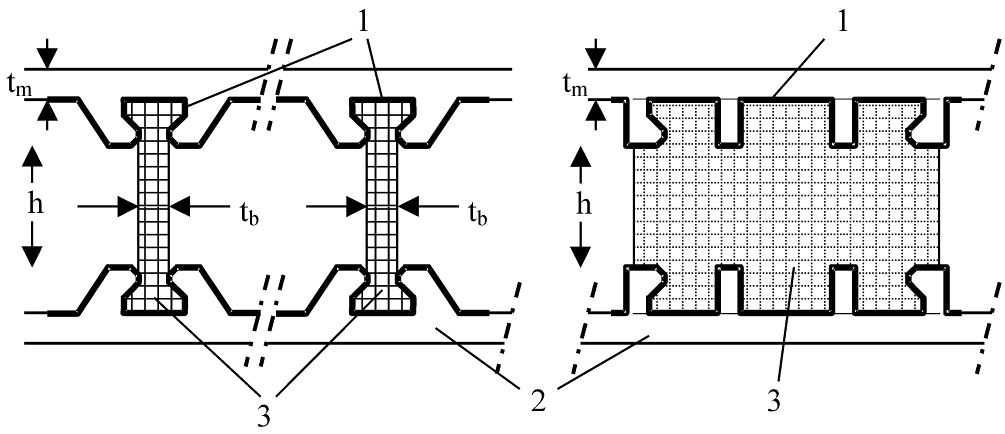
  — EXAMPLE 2 Technology: PUR resin poured in an aluminium section; methodology: notching of the groove, pouring of the resin, removing of the aluminium bridge in order to have two aluminium sections connected by the thermal barrier;

— the geometrical characteristics of the metal part and thermal barrier at their connected interface;

— the thickness (t_b) of the thermal barrier and the thickness of the metallic wall (t_m) at the connection site.

B.3 Elasticity constant c*, creep factor A_2*

In order to extrapolate the c and A_2 values from one set of profiles to another, additionally to the points mentioned for *T* and *Q* in B.2, both sets need to have the same height (h) of the thermal barrier. Extrapolation is nevertheless permitted from a greater height to a smaller one.



Key

1 Connecting interface

2 Metal sections

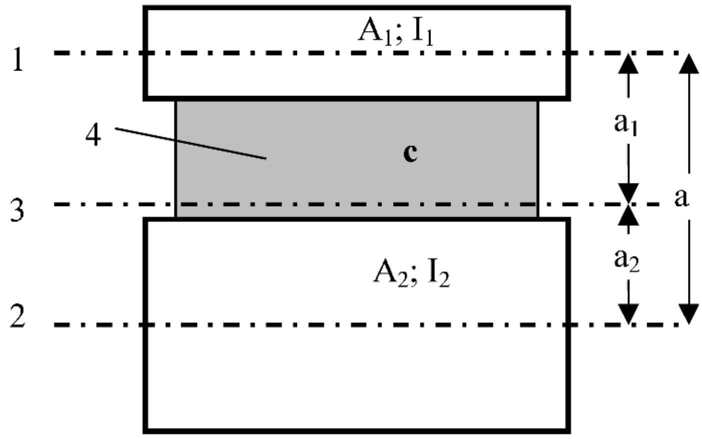
3 Thermal barrier

Figure B.1 — Schematic representation of thermal barriers

Annex C
(informative)

Effective momentum of inertia of thermal barrier profiles

A first step in the design of beams in façades is the calculation of the deflection. The deflection of thermal barrier profiles is calculated by using the normal formula for the deflection but an effective moment of inertia taking into account the elastic connection of the metal profile sections.



Key

1 Centre of mass of metal section 1 with Area A_1 and Moment of inertia I_1

2 Centre of mass of metal section 2 with Area A_2 and Moment of inertia I_2

3 Centre of mass of the composite profile

4 Thermal barrier with elasticity constant c

Figure C.1 — Schematic representation of profile with thermal barrier

The effective moment of inertia is:

$$I_{ef} = I_s \; x \; \frac{1-v}{1-v \; x \; C} \qquad (C.1)$$

where

$I_s = I_1 + I_2 + A_1 a_1^{\,2} + A_2 a_2^{\,2}$ is the rigid moment of inertia; (C.2)

$v = \dfrac{A_1 a_1^{\,2} + A_2 a_2^{\,2}}{I_s}$ is the compound part of the rigid moment of inertia; (C.3)

$C = \dfrac{\lambda^2}{\pi^2 + \lambda^2}$ is a measure of the effect of the elastic connection. (C.4)

The parameter λ depends on the geometry of the profile section, the elasticity constant *c* of the thermal barrier and the modulus of elasticity *E* of the metal (aluminium) and also on the span of the beam *l*

$$\lambda(l) = \sqrt{\frac{c\ x\ a^2\ x\ l^2}{E\ x\ I_s}\ x\ \frac{1}{v(1-v)}} \qquad \text{(C.5)}$$

where

l is span of the beam.

All other symbols are specified above.

NOTE 1 Since λ depends on the span of the beam, the effective moment of inertia is a function of the span. For large spans, the value approaches the rigid value.

NOTE 2 The formula for C is valid for a sinus shaped load, but it also works with high accuracy for constant or triangular shaped loads.

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