TECHNICAL REPORT

POINT THERMAL TRANSMITTANCE OF PLASTIC ANCHORS FOR ETICS

TR 025

May 2016

EUROPEAN ORGANISATION FOR TECHNICAL ASSESSMENT
WWW.EOTA.EU

Contents

1 SCOPE

1.1 General

This document serves for evaluating the thermal insulation of anchors for use in Thermal Insulation Composite Systems (ETICS) according to EAD 040083-00-04.04 [1]. It is based on the calculation inputs of standards ISO 10211 [2] and ISO 6946 [3].

The correct assessment of the thermal performance of an ETICS assumes that the effect of anchors used to fix the ETICS to the substrate is known. It generally applies that each anchor in the ETICS acts as thermal bridge and an increased heat loss occurs in the sphere of influence of the anchor. The extent of the heat loss depends on the construction of the wall and the thermal properties of the anchor: The higher the thermal resistance of the undisturbed wall, the higher the influence of the anchors related to the heat transfer coefficients of the wall.

The characteristic value of the thermal properties of an anchor is the point thermal transmittance χ of the anchor. This value is not a product constant but a value depending on the thermal conductivities and thicknesses of the substrate and the insulating layer.

To simplify the procedure the χ-value can be determined in the most unfavourable substrate, where the anchor may be used according to the European Technical Assessment. Alternatively the χ-value can be determined and declared for each base material group separately.

The point thermal transmittance χ can increase or decrease with increasing thickness of the insulating material depending on the type of anchor. The behaviour is not linear (cf. Figure 1.1).

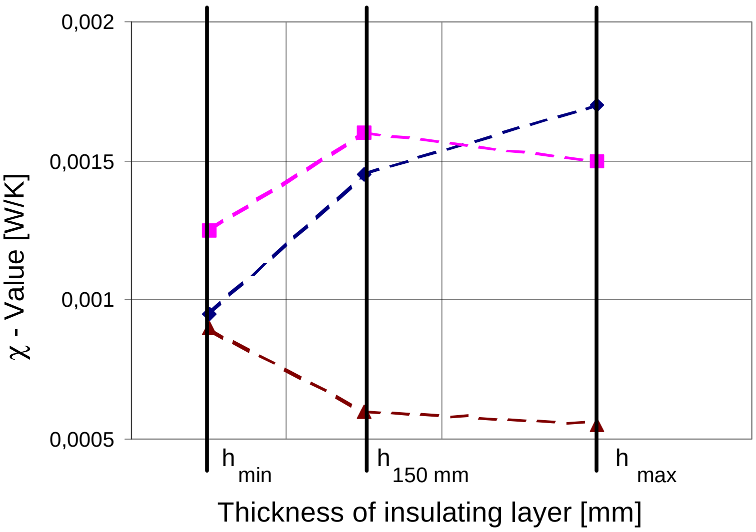

Figure 1.1 Point thermal transmittance χ depending on the thickness of the insulating layer

Thermal Insulation Composite Systems are produced in a large range of thicknesses (approx. between 50 mm and 450 mm). At present the average thickness of the insulating layer in Europe is approx. 100 mm with a tendency to rise. As it is shown in Figure 1.1, the χ-value can increase with a greater thickness of the insulating layer. The great thicknesses of the insulating layer, however, represent a small area of the market only.

The point thermal transmittances χ should be listed separately for thicknesses of the insulating layer of the Thermal Insulation Composite System "up to 150 mm" and "greater than 150 mm". This is necessary in order to not require the most unfavourable χ-value for the entire area of the insulating layer thickness as representative dimension.

1.2 Specific terms

Plastic anchor	=	a manufactured, assembled component for achieving anchorage between the base material and the fixture.
Fixture	=	component to be fixed to the base material, in this case external thermal insulation composite system.
Anchorage	=	an assembly comprising base material, plastic anchor and fixture.
χ	=	point thermal transmittance of an anchor [W/K]
$\chi(h_{min})$	=	point thermal transmittance of an anchor for the minimum insulating layer thickness according to the manufacturers specification [W/K]
χ(150 mm)	=	point thermal transmittance of an anchor for insulating layer thickness of 150 mm [W/K]
$\chi(h_{max})$	=	point thermal transmittance of an anchor for the maximum insulating layer thickness according to the manufacturers specification [W/K]
$\chi(h \leq 150)$	=	nominal value of the point thermal transmittance of an anchor in the range of minimum insulating layer thickness up to and including 150 mm [W/K]
$\chi(h > 150)$	=	nominal value of the point thermal transmittance of an anchor in the range of 150 mm up to the maximum insulating layer thickness [W/K]
$\chi(h_{min} – h_{max})$	=	nominal value of the point thermal transmittance of an anchor in the entire range of the insulating layer thickness [W/K]
h	=	insulating layer thickness of the Thermal Insulation Composite System [mm]
h_{min}	=	minimum insulating layer thickness according to the manufacturer instruction [mm]
h_{max}	=	maximum insulating layer thickness according to the manufacturer instruction [mm]
U_c	=	modified heat transfer coefficient of the wall (with ETICS and anchor) [W/(m²·K)]
U	=	heat transfer coefficient of the wall with ETICS, without thermal bridges [W/(m²·K)]
n	=	number of anchors per m² [1/m²]
R_{se}	=	external heat transfer resistance [(m²·K)/W]
R_{si}	=	internal heat transfer resistance [(m²·K)/W]
R_P	=	equivalent thermal resistance of the test specimen [(m²·K)/W]
A	=	cross cut end of the relevant test cuboid, vertical to the heat flow [m²]
ΔT	=	temperature difference between internal and external temperature [K]
θ_{se}	=	external temperature [°C]
θ_{si}	=	internal temperature [°C]
L^{3D}	=	thermal coupling coefficient for 3-dimensional calculation [W/K]

Indices:

a,b,c,d,e	=	base material groups
min, max	=	minimum / maximum value
si	=	interior surface
se	=	exterior surface
c	=	corrected value

2 ASSESSING OF POINT THERMAL TRANSMITTANCES

2.1 Determination of point thermal transmittances

The point thermal transmittance χ results from:

$$\chi = \frac{U_c - U}{n} \quad \text{[W/K]} \qquad (2.1)$$

For each insulating layer thickness and for each base material group calculated with the point thermal transmittances are to be determined according to 3.2.2.

The calculated value will be rounded to four decimal places.

2.2 Determination of the nominal value

The nominal values will be determined from the χ-values for each base material group calculated with:

Case 1: Different nominal values for the areas of insulating layer thickness

The nominal value of the point thermal transmittance χ will be determined for the significant areas as follows:

$\chi(h \leq 150)$ the major value of $\chi(h_{min})$ and χ(150 mm)

$\chi(h > 150)$ the major value of $\chi(h_{max})$ and χ(150 mm)

Case 2: No distinction between areas of insulating layer thickness

If only one significant χ-value shall be given as nominal value, it results as peak value from all tests according to 3.2.2:

$\chi(h_{min} - h_{max})$ peak value for the range from $h = h_{min}$ to $h = h_{max}$

The nominal value of the point thermal transmittances has to be rounded upwards and shown in the following steps in W/K:

0 / 0,001 / 0,002 / 0,003 / 0,004 / 0,006 / 0,008

The step "0 W/K" may be taken, if the peak value of the point thermal transmittance χ in the considered range is smaller than 0,0005 W/K.

In the ETA for the anchor the following note shall be recorded for the step "0 W/K":

"The thermal bridge effect of the anchor is smaller than 0,0005 W/K and can therefore be neglected in the calculation".

2.3 Description of the nominal value

The nominal value of the point thermal transmittance χ has to be given for each base material group, in which the anchor may be used according to the European technical assessment. The form can be chosen free from the following alternatives:

2.3.1 Alternative A: Single values (regardless of the base material groups)

Nominal values are only determined for the most unfavourable base material group. The nominal values includes all base material groups, with which the anchor might be used, as index. The area of insulating layer thickness for which the nominal value is valid is stated in brackets behind the "χ".

Indexing of the base material groups is optional when the nominal value is determined from base material group a.

2.3.2 Alternative B: tabulated listing depending on the base material groups

Nominal values are determined for different base material groups. These values have to be stated in a table which includes all base material groups, the anchor might be used with, line by line and the areas of insulation thickness, for which the nominal value shall be given, column by column.

2.3.3 Remark

Section 4 gives examples for the description.

3 DETAILS OF METHOD AND CRITERIA FOR ASSESSMENT

3.1 General

The determination of the point thermal transmittance (χ-value) can be realized by means of calculation or measurement. Both methods are to be carried out for the reference construction described in follow.

The point thermal transmittance χ results from calculation according to section 2.1 with the heat transfer coefficient U_c of the disturbed construction of wall determined by means of calculation (see section 3.3) or by means of measurement (see section 3.4).

3.2 Test sample

3.2.1 Reference construction

For determination of the point thermal transmittance χ the following reference construction is used as basis:

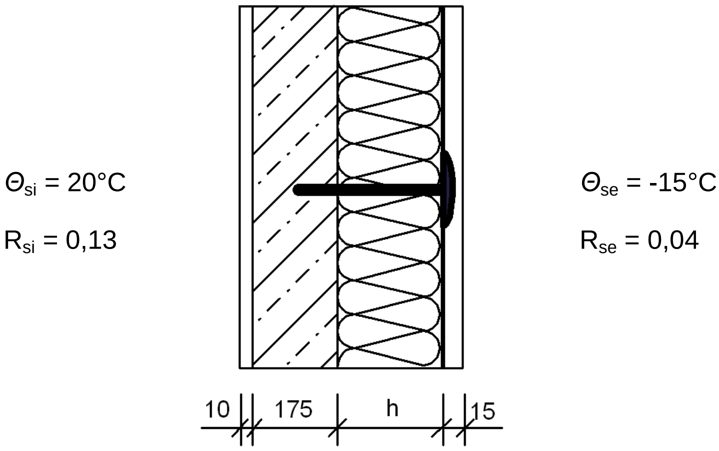

Figure 3.1 Drawing of the reference construction (not full-scale)

The thickness of the insulating layer h is described in section 3.2.2. The anchor has to be arranged according to the installation situation indicated by the manufacturer. The determinations concerning the building component layers remain untouched.

For the building component layers the characteristic values of the material according to EN 12524 [4] are to be used:

Table 3.1 Characteristic design values of the materials of the reference construction

Building component layer	Design value of thermal conductivity [W/(m·K)]	Thickness of the layer [mm]
(1) interior plaster: gypsum plaster without aggregate	0,57	10
(2) substrate	see Table 3.2	175
(3) insulating layer	0,035	see section 3.2.2
(4) external rendering: lime-cement plaster	1,0	15

The point thermal transmittance χ has to be determined for the most unfavourable substrate, with which the anchor may be used according to the European Technical Assessment. Alternatively the χ-value can be determined and declared for each base material group separately. Only base material groups, in which the anchor may be used according to the ETA, might be used for calculation.
A determined value covers all substrates with a lower thermal conductivity also. When selecting normal weight concrete as the substrate for determination, the determined value may cover all base material groups.

Table 3.2 Characteristic design values of the base material groups

Base material group	Description	Design value of thermal conductivity [W/(m·K)]
A	Normal weight concrete	2,30
B	Solid masonry	1,20
C	Hollow or perforated masonry	0,56
D	Lightweight aggregate concrete with open structure	0,36
E	Autoclaved aerated concrete	0,16

3.2.2 Thickness of insulating layer

The thickness of the insulating material has a significant influence on the point thermal transmittance χ. The nominal value of the point thermal transmittance χ will be determined for the ranges of insulating layer thickness $h \leq 150$ mm and $h > 150$ mm.

The point thermal transmittance χ for the three thicknesses of insulating layer has to be determined as follows:

$\chi(h_{min})$ = for the smallest thickness of the insulating layer indicated by the manufacturer h_{min}

$\chi(150\ mm)$ = for the thickness of the insulating layer h = 150 mm

$\chi(h_{max})$ = for the biggest thickness of the insulating layer indicated by the manufacturer h_{max}

In case the value $\chi(150\ mm)$ is smaller than $\chi(h_{min})$, testing of $\chi(h_{max})$ can be neglected. It is assumed that in any case $\chi(h_{max})$ is smaller than or equal to $\chi(150\ mm)$.

3.2.3 Anchor properties

The thermal conductivities of the anchor materials are to be assessed according to EN 12524 [4] or ISO 10456 [5]. The dimensions are to be determined by means of a test specimen or they are to be taken from the manufacturer's technical documentation.

3.2.4 Boundary conditions

The heat transfer resistances result according to ISO 6946 [3] for the horizontal thermal conductivity:

$R_{se} = 0{,}04\ (m^2 \cdot K)/W$

$R_{si} = 0{,}13\ (m^2 \cdot K)/W$

For the measurement applies:

The temperature difference between inside and outside shall be $\Delta T = 35$ K

(e.g.: $\theta_{se} = -15$ °C ; $\theta_{si} = 20$ °C).

The edge surfaces of the test specimen are to be considered as adiabatic.

3.3 Calculations according to ISO 10211 [2]

For the determination of the point thermal transmittance, the thermal transmittance of the wall with anchor Uc has to be determined for each of the constructions considered.

3.3.1 Construction of a finite system

As significant section for the calculation of the thermal bridge effect a cuboid-shaped section of the wall containing an anchor shall be assumed. The anchor is to be placed in the centre of the area considered. In case the anchor is rotationally symmetric in its shape, a partial circular section of the anchor, which is placed in an edge of the area considered, can also be used for the calculation or the calculation can be done in polar coordinates.

The dimensions of the area to be considered has to be chosen according to ISO 10211 [2] so that the disturbance caused by the anchor has no effects on the edges.

The thermal conductivity of potential cavities is to be determined according to ISO 6946 [3].

3.3.2 Subdivision of the system

The subdivision of the system for calculation by means of the numerical method must be accomplished in accordance with ISO 10211 [2].

Annex A, section A.2 (d) of this standard determines that the subdivision must be sufficiently fine, that if n subdivisions are chosen, the sum resulting from the heat flows does not deviate from the subdivisions more than 1 % which would result in the case of 2n subdivisions.

3.3.3 Determination of the thermal transmittance

The thermal transmittance U_c of the wall section with anchor will be determined according to ISO 10211 [2].by the thermal coupling coefficient calculated

$$U_c = \frac{L^{3D}}{A} \qquad [W/(m^2 \cdot K)] \qquad (A.11.1)$$

Deviating from ISO 10211 [2] the thermal transmittance has to be determined with five decimal places. This is necessary because the point thermal transmittance χ to be calculated has to be given rounded to four decimal places.

The thermal transmittance U of the undisturbed wall is calculated according to ISO 6946 [3].

3.4 Measurement

The determination of the thermal transmittance U_c must be determined in accordance with DIN EN 1946, Part 1 to 4 [6]. The measurement can be realised according to EN ISO 8990 [7] or EN 1934 [8]. A reference test specimen is to be used according to section 3.2.

The thermal transmittance U of the undisturbed wall is to be measured according to the same method as for the thermal transmittance U_c.

Note

When placing the anchor, the distance to the edge and between the anchors should not fall below 300 mm.

4 EXAMPLES FOR THE DESCRIPTION OF NOMINAL VALUES OF THE POINT THERMAL TRANSMITTANCE χ

Examples for the description of nominal values of the point thermal transmittance χ

Example 1: Single Values

An anchor might be used in the base material groups A and B for the thicknesses of insulating layer h_{min} = 50 mm to h_{max} = 320 mm. The following nominal values have been determined:

$\chi_A(h \leq 150\ mm) = 0{,}002\ W/K$ and $\chi_A(h > 150\ mm) = 0{,}003\ W/K$

A listing as table is not necessary because the nominal values have been determined for one base material group only. The description is given in single values.

Case 1: Distinction between areas of insulation thickness

$\chi(h \leq 150\ mm) = 0{,}002\ W/K$; $\chi(h > 150\ mm) = 0{,}003\ W/K$

Case 2: One χ-value for the whole area of insulation thicknesses

$\chi(50 - 320\ mm) = 0{,}003\ W/K$

Indexing is not necessary because the nominal value was calculated with base material group A.

Example 2: Table or single values

An anchor might be used in the base material groups B,C and D for the thicknesses of insulating layer

h_{min} = 50 mm to h_{max} = 250 mm. The following nominal values have been determined:

$\chi_B(h \leq 150\ mm) = 0{,}002\ W/K$ and $\chi_B(h > 150\ mm) = 0{,}001\ W/K$

$\chi_D(h \leq 150\ mm) = 0{,}001\ W/K$ and $\chi_D(h > 150\ mm) = 0{,}001\ W/K$

Values for χ_C have not been determined. The values from the next higher base material group B apply for this group also.

Alternative A: Description as single values

One of the following descriptions has to be stated for the anchor:

Case 1: $\chi_{B,C,D}(h \leq 150\ mm) = 0{,}002\ W/K$; $\chi_{B,C,D}(h > 150\ mm) = 0{,}001\ W/K$
Case 2: $\chi_{B,C,D}(50 - 250\ mm) = 0{,}002\ W/K$

Alternative B: Description as table

One of the following descriptions has to be stated for the anchor:

Case 1: Distinction between areas of insulation thickness

Base material group	Description	Thickness of insulation layer	
		h ≤ 150 mm	h > 150 mm
B	Solid masonry	0,002	0,001
C	Hollow or perforated masonry	0,002	0,001
D	Lightweight aggregate concrete with open structure	0,001	0,001

Case 2: One χ-value for the whole area of insulation thicknesses

Base material group	Description	Thickness of insulation layer
		50 mm bis 250 mm
B	Solid masonry	0,002
C	Hollow or perforated masonry	0,002
D	Lightweight aggregate concrete with open structure	0,001

5 REFERENCE DOCUMENTS

As far as no edition date is given in the list of standards thereafter, the standard in its current version at the time of issuing the Technical Report is of relevance.

[1] EAD 040083-00-04.04:
EXTERNAL THERMAL INSULATION COMPOSITE SYSTEMS WITH RENDERING

[2] ISO 10211:2007-12
Thermal bridges in building construction - Heat flows and surface temperatures - Detailed calculations

[3] ISO 6946:2007-12
Building components and building elements - Thermal resistance and thermal transmittance - Calculation method

[4] EN 12524:2000
Building materials and products - Hygrothermal properties - Tabulated design values

[5] ISO 10456:2007-12
Building materials and products - Hygrothermal properties - Tabulated design values and procedures for determining declared and design thermal values

[6] EN 1946
Thermal performance of building products and components - Specific criteria for the assessment of laboratories measuring heat transfer properties
Part 1: Common criteria:1999
Part 2: Measurements by the guarded hot plate method:1999
Part 3: Measurements by the guarded heat flow meter method: 1999
Part 4: Measurements by hot box methods:2000

[7] EN ISO 8990:1996-09
Thermal insulation - Determination of steady-state thermal transmission properties - Calibrated and guarded hot box

[8] EN 1934:1998
Thermal performance of buildings - Determination of thermal resistance by hot box method using heat flow meter – Masonry