EUROPEAN ASSESSMENT DOCUMENT

EAD 040650-00-1201

December 2017

EXTRUDED POLYSTYRENE FOAM BOARDS AS LOAD BEARING LAYER AND / OR THERMAL INSULATION OUTSIDE THE WATERPROOFING

www.eota.eu

This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

The extruded polystyrene foam boards are made of rigid cellular plastics material extruded from polystyrene or one of its copolymers and which has a closed cell structure. Multi-layered boards with XPS-layers perpendicular to the edges of the board, i.e. layers parallel to the surface of the final board are also covered. The boards can have special edge treatment (tongue and groove, shiplap etc.).

The extruded polystyrene foam boards do not contain Hexabromocyclododecane (HBCD).

The extruded polystyrene foam boards are not fully covered by the following harmonised technical specification: EN 13164.

The deviations from the standards are:

- Because of the specific applications the products have to fulfil higher requirements and properties concerning the load bearing function (see intended use a) according to clause 1.2.1 / BWR 1 according to Table 1). Furthermore the possibility to declare the thermal conductivity based on an ageing procedure representing a time average value of about 50 years of use (deviating from EN 13164, Annex C) shall be given.

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The extruded polystyrene foam boards are intended to be used as load bearing layer and thermal insulation outside the waterproofing. The boards can be installed in one or several layers. The boards are laid uniformly on the substrate to which they are applied. In particular the following applications are covered:

a) Load bearing and thermal insulation underneath foundation slabs
b) External horizontal and vertical thermal insulation of in-ground constructions in non-structural applications (also in case of groundwater)
c) Inverted roof insulation (including park deck and green roof applications)

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the insulation boards for the intended use a) of 50 years and for the intended uses b) and c) of 25 or 50 years (depending on ageing procedure given in clause 2.2.12 and on extrapolation time within assessing the creep according to clause 2.2.3.2) when installed in the works (provided that the thermal insulation boards is subject to appropriate installation (see 1.1)) These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product, the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[1].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD (if necessary in addition to the definitions in CPR, Art 2)

1.3.1 Single-layer board

Factory made board made of one layer of extruded polystyrene foam, generally with foam skins on upper and lower surface

1.3.2 Factory-made multi-layered board

Factory made board made of two or more layers of extruded polystyrene foam which are bonded together by chemical and/or physical adhesion. This EAD only covers boards with layers parallel to the surface of the final board.

1.3.3 Multiple layer installation

Single-layer boards installed on site in two or three layers (as two-layered or three-layered thermal insulation)

1.3.4 Foam skin

Smooth thin layer on the upper and lower surfaces of the boards

1.3.5 Adhesion layer

Chemical or physical connecting ply between two boards

1.3.6 Core layer

Inner area of the boards without foam skin or adhesion layer

1 The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

2.1.1 Essential characteristics in case of intended use a) according to clause 1.2.1 - Load bearing and thermal insulation underneath foundation slabs

Table 1 shows how the performance of the extruded polystyrene foam boards is assessed in relation to the essential characteristics in case of intended use a) according to clause 1.2.1.

Table 1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics in case of intended use a) according to clause 1.2.1

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Compressive stress or compressive strength	See clause 2.2.1.1	level
2	Characteristic value of compressive stress or compressive strength	See clause 2.2.2	level
3	Compressive creep	See clause 2.2.3.1	level
4	Behaviour under shear load (large-sized specimen)	See clause 2.2.4	level
5	Creep under shear load	See clause 2.2.5	level
6	Creep under combined compressive and shear load	See clause 2.2.6	level
7	Compressive modulus of elasticity	See clause 2.2.7	level
8	Adhesion behaviour under compressive and shear load on large-sized samples	See clause 2.2.8	level
9	Density	See clause 2.2.9	level
10	Shear strength	See clause 2.2.10	level
Basic Works Requirement 2: Safety in case of fire			
11	Reaction to fire	See clause 2.2.11	class

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 6: Energy economy and heat retention			
12	Thermal resistance / Thermal conductivity	See clause 2.2.12	level
13	Water absorption	See clause 2.2.13	level
14	Freeze-thaw resistance	See clause 2.2.14	level
15	Water vapour transmission	See clause 2.2.15	level
16	Geometrical properties	See clause 2.2.16	level
17	Deformation under specified compressive load and temperature conditions	See clause 2.2.17	level
18	Dimensional stability under specified conditions	See clause 2.2.18	level
19	Tensile strength perpendicular to faces	See clause 2.2.19	level
20	Determination of volume percentage of closed cells	See clause 2.2.20	level

2.1.2 Essential characteristics in case of intended use b) and c) according to clause 1.2.1 – External horizontal and vertical thermal insulation of in-ground constructions (also in case of groundwater) and Inverted roof insulation (including park deck and green roof applications)

Table 2 shows how the performance of the extruded polystyrene foam boards is assessed in relation to the essential characteristics in case of intended use b) and c) according to clause 1.2.1.

Table 2 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics in case of intended use b) and c) according to clause 1.2.1

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Reaction to fire	See clause 2.2.11	class
Basic Works Requirement 6: Energy economy and heat retention			
2	Thermal resistance / Thermal conductivity	See clause 2.2.12	level
3	Water absorption	See clause 2.2.13	level
4	Freeze-thaw resistance	See clause 2.2.14	level
5	Water vapour transmission	See clause 2.2.15	level

No	Essential characteristic	Assessment method	Type of expression of product performance
6	Geometrical properties	See clause 2.2.16	Level, class
7	Compressive stress or compressive strength	See clause 2.2.1.2, 2.2.1.3	level
8	Density	See clause 2.2.9	level
9	Deformation under specified compressive load and temperature conditions	See clause 2.2.17	level
10	Dimensional stability under specified conditions	See clause 2.2.18	level
11	Tensile strength perpendicular to faces	See clause 2.2.19	level
12	Determination of volume percentage of closed cells	See clause 2.2.20	level
13	Shear strength	See clause 2.2.10	level
14	Compressive creep	See clause 2.2.3.2	level

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

For sampling, conditioning and testing (dimensions of the test specimens, minimum number of measurements, specific conditions), EN 13164 shall apply, unless otherwise is specified in the following. The test specimens shall be chosen to cover the intended product parameter (thickness and density range). If the tests are carried out on specimens with minimum and maximum total thickness the results can be applied for the thicknesses in between, unless otherwise is stated in the following.

The specific test conditions take the following products for installation into account:

- extruded polystyrene foam boards as single-layer boards
- extruded polystyrene foam boards as factory-made multi-layered boards
- multiple layer installation: single-layer boards installed on site as two-layered or three-layered thermal insulation

This EAD contains provisions on how to declare certain performance characteristics. These provisions only apply if the manufacturer wishes to declare a performance for the relevant product characteristic.

2.2.1 Compressive stress or compressive strength

2.2.1.1 Compressive stress or compressive strength in case of intended use a)

Compressive stress at 10 % deformation σ_{10} or compressive strength σ_m of single-layer boards and factory-made multi-layered boards is determined in accordance with EN 826 after conditioning (according to EN 13164). The thickness, length and width of the test specimens should be equal to the total thickness of the board. At least five cubical test specimens each should preferably be taken from three different lots.

Each measured value may not be more than 10 % lower than the level which will be stated in the ETA.

The force-displacement curve according to EN 826 should be recorded.

Compressive stress at 10 % deformation or compressive strength is given in the ETA using levels with steps of 10 kPa.

Note:
The test is also performed after freeze-thaw exposure – see clause 2.2.14.

Additional test if multiple layer installation is intended:

The testing of the compressive stress at 10 % deformation or compressive strength following EN 826 is performed on large size specimens with dimensions of 1200 mm x 1200 mm x total thickness of the intended multiple layer installation (e. g. two and/or three layer of single boards). Therefore, single layer boards in delivery length (1200 mm) and a width of 600 mm are used. The second layer of the large size specimen is laid horizontally rotated by 90°.

Density, board thickness and flatness degree of the used single boards are documented. 5 specimens each of the largest two-layer and/or three-layer total thickness are tested.

Concerning slip deformation, the compressive stress, σ_a, and initial displacement X_a, until the conventional elastic zone (distinct straight portion of the force-displacement curve) is reached should be stated in the ETA.

2.2.1.2 Compressive stress or compressive strength in case of intended use b) and c)

Compressive stress at 10 % deformation or compressive strength is determined according to EN 826 in accordance with EN 13164 and given in the ETA using levels with steps of 10 kPa.

Note 1: The test in chapter 2.2.1.2 is not required if the test according to chapter 2.2.1.1 is used.

Note 2: The test is also performed after freeze-thaw exposure – see clause 2.2.14.

2.2.1.3 Compressive stress or compressive strength in the transverse and longitudinal directions

(only in case of application b) with an embedding depth greater than 3,50 m to groundwater)

The testing of the compressive stress at 10 % deformation or compressive strength in the transverse (σ_{trav}) and longitudinal (σ_{long}) directions is performed according to EN 826.

The thickness of the test specimens corresponds to the total thickness of the board. Five cubical specimens (preferably be taken from different lots) are tested.The test specimen should be cut from parts of the boards near the edges. Differing from EN 826 the surface parallel to the edge of the board is stressed by load.

The mean values of compressive stress at 10 % deformation or compressive strength in the transverse (σ_{trav}) and longitudinal (σ_{trav}) directions are given in the ETA using levels with steps of 10 kPa.

2.2.2 Characteristic value of compressive stress or compressive strength

The characteristic value of compressive stress or compressive strength is defined on basis of statistical analysis of the measured results of compressive stress at 10 % deformation or compressive strength (see 2.2.1.1).

The statistical analysis is carried out in accordance with EN 1990, clause 4.2 for the 5%-fractile value for a one-sided confidence level of 75 % under unknown or known variance using ISO 12491. For the first 35 test results the variance of the normal population should be considered as unknown.

The characteristic value of compressive stress or the compressive strength $\sigma_{0,05}$ is given in the ETA together with the number of sample measurements (n), the sample mean value (σ_{mean}) and the standard deviation (s_σ).

2.2.3 Compressive Creep

2.2.3.1 Compressive creep in case of intended use a)

The long-term creep behavior under compressive load of single-layer boards, factory-made multi-layered boards and specimen of multiple layer installations is performed according to EN 1606 deviating from EN 13164 as follows.

Load stages

If the Findley parameters are required the creep test should be carried out minimum at three different compression load stages in order to estimate the parameters of Findley approach as a function of the applied compression stress. The recommended load stages are 20 %, 30 %, and 40 % of the average value of compressive stress at 10 % deformation or the compressive strength (see section 2.2.1.1).

Specimen

The specimens for the determination of the creep behavior are taken from the same sample as the specimens that were used for the compressive test according to EN 826.

The thickness, length and width of the test specimens should be equal to the total thickness of the product. It is recommended to test minimum three specimens under each of the three selected compression load stages. These specimens are extracted from three different boards where each board preferably comes from a different lot. Thereby, the potential variation in creep response of the same product between the different lots as well as the variation between the different specimens within the same lot could be taken into account by evaluating the creep behavior.

Test time

For the intended use of 50 years the test time (extrapolation time of 50 years) is 20 months (608 days).

The following values for each load stage σ_c are stated in the ETA:

- The initial thickness reduction X_0
- The creep deformation after test time X_{ct}
- The creep deformation extrapolated to 50 years X_{ct50}
- The total thickness reduction extrapolated to 50 years X_{t50}

Note:

The insulation thicknesses to be tested for the multi-layer installation e.g: 3 x 100 mm and 2 x 120 mm total thickness.

2.2.3.2 Compressive creep in case of intended use b) and c)

Compressive creep and total thickness reduction are determined according to EN 1606 in accordance with EN 13164 and stated in the ETA using levels according to EN 13164.

Note: The test in chapter 2.2.3.2 is not required if the test according to chapter 2.2.3.1 is used.

2.2.4 Behaviour under shear load (large-sized specimen)

The shear test on specimen of single-layer boards and factory-made multi-layered boards is performed in accordance with the guidelines in EN 12090, yet the specimen size is determined as stated below.

The thickness of the test specimen should be the total thickness of the product. In addition, the relative dimensions between the thickness and the length of the test specimen should be kept equal to a ratio of 1:4. The width should be equal to delivery width. The dimension of the test specimen parallel to the shear loading direction is referred to as the length of the specimen.

At least five test specimens each from three different lots should be tested in shear conditioning that the failure does not take place in the bonding material between specimen and test-setup. The specimens by which the failure took place in the bonding material should be excluded and replaced by new ones.

The shear strength (τ_{large}) is given in the ETA.

2.2.5 Creep under shear load

The long-term creep deformation under shear load of single-layer boards and factory-made multi-layered boards is to be measured according to the test procedure described in ANNEX A following EN 1606 regarding the determination of creep behaviour and EN 12090 regarding the test arrangement (in horizontal position).

Load stages

When the determination of the stress-dependent Findley parameters is not required, the creep test should be performed under a shear stress level of 35 % of the average value of shear strength, measured in accordance with section 2.2.4.

Optional:

To determine the stress-dependent Findley parameters, the creep test should be carried out minimum at three different shear load stages. The recommended load stages are 20 %, 30 %, and 40 % of the shear strength, measured in accordance with section 2.2.4.

Specimen size and number

The thickness of the large size test specimen should be the total thickness of the product. In addition, the relative dimensions between the thickness and the length of the test specimen should be kept equal to a ratio of 1:4. The width should be equal to delivery width. The dimension of the test specimen parallel to the shear loading direction is referred to as the length of the specimen.
When the Findley parameters are not required as a function of stress, three specimens (maximum thickness, preferably from three different lots) are tested.

Optional:
When the Findley parameters are required as a function of stress, minimum three specimens (maximum thickness) are tested under each of the three selected load stages.

Test time

For the intended use of 50 years the test time (extrapolation time of 50 years) is 20 months (608 days).

The following values for each load stage τ_c are stated in the ETA:

- The value of the initial sliding $X_{\tau 0}$
- The creep deformation after test time $X_{\tau 0}$
- The creep deformation extrapolated to 50 years $X_{\tau ct50}$
- The total sliding extrapolated to 50 years $X_{\tau t50}$

2.2.6 Creep under combined compressive and shear load

The long-term creep deformation under combined compressive stress and shear stress of single-layer boards and factory-made multi-layered boards shall be measured in accordance with the test procedure described in ANNEX A.

Load stages

When the Findley parameters are not required as a function of stress, three large size specimens from three different lots are tested. In this case the load stages applied are recommended to be a compression stress equal to 30 % of the compression stress at 10 % compression strain, measured according to section 2.2.1.1, and in addition to a shear stress equal to 35 % of the shear strength, measured according section 2.2.4.

Optional:
To calculate the stress-dependent Findley parameters, it is required to carry out three creep tests under combined shear-compression stress state with the following recommended load stages combinations:

- Shear stress equal to 20 % of the shear strength with a compression stress equal to 40 % of the compression stress at 10 % compression strain,

- Shear stress equal to 30 % of the shear strength with a compression stress equal to 30 % of the compression stress at 10 % compression strain,
- Shear stress equal to 40 % of the shear strength with a compression stress equal to 20 % of the compression stress at 10 % compression strain,

Specimen size and number

In case that the stress-dependent Findley parameters are not of interest, the creep test is carried out on three large size specimens. Preferably these three specimens should be taken from three different lots. The specimen size is the same as that used to determine the shear behavior in section 2.2.4.

Optional:

When the Findley parameters are required as a function of combined compressive and shear stress, minimum three specimens (maximum thickness) are tested under each of the three selected load stages.

Test time

For the intended use of 50 years the test time (extrapolation time of 50 years) is 20 months (608 days).

The following values for each load stage (σ_c and τ_c) are stated in the ETA:

- The initial thickness reduction X_0
- The creep deformation after test time X_{ct}
- The creep deformation extrapolated to 50 years X_{ct50}
- The total thickness reduction extrapolated to 50 years X_{t50}
- The value of the initial sliding $X_{\tau 0}$
- The creep deformation (sliding) after test time $X_{\tau ct}$
- The creep deformation(sliding) extrapolated to 50 years $X_{\tau ct50}$
- The total sliding extrapolated to 50 years $X_{\tau t50}$

2.2.7 Compressive modulus of elasticity

Modulus of elasticity in compression, E, is determined perpendicular to the faces of the product in accordance with EN 826. The thickness of the test specimens corresponds to the total thickness of the product. At least five cubical test specimens should be taken.

2.2.8 Adhesion behaviour under compressive and shear load on large-sized samples

The determination of the adhesive friction coefficient of single-layer boards and factory-made multi-layered boards is performed in accordance with the test procedure described in ANNEX A using boards with the lowest and the highest level of compressive strength to be covered by the ETA (e.g. CS(10\Y)300 and CS(10\Y)700).

The test is carried out with 3 load stages: 5/15/30 % of the compressive stress according to section 2.2.1.1.

Per load stage 5 specimens with the dimensions of 50 cm x 100 cm x thickness are used.

The adhesive friction coefficient is determined for the following settings:

a) Adhesive friction coefficient between the extruded polystyrene foam boards (μ_{xps})

b) Adhesive friction coefficient between the extruded polystyrene foam boards and in-situ concrete as well as a concrete finished part with foil (μ_{foil})

c) Adhesive friction coefficient between the extruded polystyrene foam boards and in-situ concrete without foil (μ_{conc})

d) Adhesive friction coefficient between the extruded polystyrene foam boards and a concrete finished part without foil ($\mu_{precast}$)

The adhesive friction coefficient is given in the ETA depending on the setting.

2.2.9 Density

The density is determined in accordance with EN 1602 at 5 test specimens with delivery dimensions.

The density range of the products covered by the ETA is given in the ETA.

2.2.10 Shear strength

The shear strength of single-layer boards and factory-made multi-layered boards is determined in accordance with EN 12090 and EN 13164. Factory-made multi-layered boards should be tested with all the layers included. If the dimensions (e.g. thickness) are too large for the test apparatus, a representative smaller (e.g. thickness) specimen may be cut, which should include at least one bond layer.

The shear strength is given in the ETA.

Note:
For factory-made multi-layered boards this test is also performed after freeze-thaw exposure – see clause 2.2.14.

2.2.11 Reaction to fire

The extruded polystyrene foam boards are tested using the test method(s) relevant for the corresponding reaction to fire class (EN ISO 11925-2) in order to be classified according to Commission Delegated Regulation (EU) No 2016/364 in connection with EN 13501-1. Concerning mounting and fixing conditions see EN 13164.

2.2.12 Thermal resistance and thermal conductivity

The thermal conductivity at 10 °C is determined according to EN 12667 or EN 12939 for thick products in general accordance with EN 13164.

Additional or alternative to EN 13164 the thermal conductivity is determined according to 2.2.12.1 or 12.2.12.2 depending on blowing agent.

Note:
It is also possible to give the thermal conductivity λ_D in full accordance with EN 13164 based on the ageing procedure which represents a time average value of about 25 years of use.

2.2.12.1 Determination of thermal conductivity in case of products with a blowing agent mixture consisting of CO_2, isobutene, HFC 134a, HFC 152a and additives as e.g. ethanol and dimethyl ether

Deviating from Annex C of EN 13164 the test specimens are stored for at least 45 days at (23 ± 2) °C and (50 ± 5) % relative humidity prior to cutting into slices and the individual slices are stored at (23 ± 2) °C and (50 ± 5) % relative humidity for a time period of (90 +2/-2) days prior to testing independent of the thickness of the board. This ageing procedure represents a time average value of about 50 years of use.

The thermal conductivity $\lambda_{D(90d)}$, based on $\lambda_{90/90}$ (representing at least 90 % of the production with a confidence level of 90 %, rounded upwards to the nearest 0,001 W/(m·K)) is given in the ETA in levels with steps of 0,001 W/(m·K).

2.2.12.2 Determination of thermal conductivity in case of products with a blowing agent mixture not covered by 2.2.12.1

In case of other blowing agents the thermal conductivity at 10 °C together with a cell gas analysis via gas chromatography is determined after the following time periods:

a) On intact specimen after 45 days of preliminary storage at (23 ± 2) °C and (50 ± 5) % relative humidity
b) On specimen after 60 days of storage after cutting and conditioning according to EN 13164, Annex C

c) On specimen after 90 days of storage after cutting and conditioning according to EN 13164, Annex C

Depending on the test results (cell gas concentration, thermal conductivity under step a), b) and c)) it can be necessary to extend the storage time of the slices by additional (90 +2/-2) days prior to testing. In this case the results of the thermal conductivity at 10 °C and cell gas analysis after 45 days and after the additional storages as well as the chosen storage time of the slices are given in the ETA.

An extension of the storage time is not necessary, if test results of cell gas analysis via gas chromatography for the separated blowing agent or a compound of a mixture and of the thermal conductivity are evaluated and meet the values as follows:

$(Z_{60} – Z_{90})/(Z_0 – Z_{90}) \leq 0,25$

with Z_0 Vol-% fractions of gas component after 45 days of preliminary storage according a)
Z_{60} Vol-% fractions of gas component after 60 days of storage according b)
Z_{90} Vol-% fractions of gas component after 90 days of storage according c)

$(\lambda_{90} – \lambda_{60})/(\lambda_{90} – \lambda_0) \leq 0,25$

with λ_0 Thermal conductivity after 45 days of preliminary storage according a)
λ_{60} Thermal conductivity after 60 days of storage according b)
λ_{90} Thermal conductivity after 90 days of storage according c)

This ageing procedure represents a time average value of about 50 years of use.

2.2.12.3 Moisture conversion coefficient

The moisture conversion coefficient f_ψ [m^3/m^3] can be given in the ETA.

The moisture conversion coefficient can be taken from EN ISO 10456 or determined as described in ANNEX B.

2.2.13 Water absorption

2.2.13.1 Long term water absorption by total immersion

Long term water absorption by total immersion of single-layer boards and factory-made multi-layered boards is determined according to EN 12087 (method 2A).

In case of factory-made multi-layered boards the drip-off time should be at most 10 sec. (deviating from EN 12087). The specimen size (length and width) of factory-made multi-layered boards with thicknesses greater than 200 mm should be at least equal to the total thickness of the tested board.

The water absorption by total immersion is given in the ETA using the levels according to EN 13164.

2.2.13.2 Long term water absorption by diffusion

Water absorption by diffusion is determined according to EN 12088 in accordance with EN 13164.

The water absorption by diffusion is given in the ETA using the levels according to EN 13164.

2.2.14 Freeze-thaw resistance

Freeze-thaw resistance after long term water absorption by diffusion is determined according to EN 12091 in accordance with EN 13164 using the wet test specimens from having done the water diffusion test in accordance with EN 12088 (see 2.2.13.2).

Following EN 13164, after freeze-thaw cycling the reduction in compressive stress at 10 % deformation or in compressive strength of the re-dried specimens, when tested in accordance with EN 826, shall not exceed 10 % of the initial value.

In addition for multi-layered boards:

The reduction in tensile strength perpendicular to faces and, if required, in shear strength after the freeze-thaw cycling of the re-dried specimen is determined in accordance with EN 1607 and EN 12090. The reduction in shear strength and/or in tensile strength perpendicular to faces is given in the ETA. If the reduction in shear strength is given, an indication of the reduction in tensile strength perpendicular to faces is not necessary. The reduction in shear strength and the reduction in tensile strength perpendicular to faces shall not exceed 10 % of the initial value according to EN 13164, Annex D.

The freeze-thaw resistance after long term water absorption by diffusion, *FTCDi*, is giving in the ETA as additional water absorption, W_V, from the 300 freeze-thaw cycling in levels with steps of 1 % by volume in accordance with EN 13164.

2.2.15 Water vapour transmission

The water vapour transmission properties are determined in accordance with EN 12086, climatic condition A.

For single layer boards, the water vapour diffusion resistance factor μ is given in the ETA.

In addition for multi-layered boards:

The water vapour transmission properties are determined on sliced specimens whichever include the foam skins, the core layer and the adhesion layer. The sliced thickness of the specimens that include the foam skins and of the specimen that include the adhesion layer should not be greater than 10 mm.

For multi-layered boards the water vapour diffusion resistance factor μ_{skin}, μ_{core} and μ_{ad} for the individual layers (foam skins, adhesion layer etc.) is given in the ETA.

2.2.16 Geometrical properties

2.2.16.1 Thickness

The thickness is determined according to EN 823 in accordance with EN 13164. Measuring set-up 3 (see EN 823, clause 7.2, figure 2) should be used independent from the width of the board. The tolerances in mm are given in the ETA. Classes according to EN 13164 can be used.

2.2.16.2 Length, width

The length and width are determined according to EN 822 in accordance with EN 13164. Length and width are given in the ETA considering the tolerances according to EN 13164.

2.2.16.3 Squareness

The squareness on length and width is determined according to EN 824 in accordance with EN 13164. The squareness is given in the ETA considering the tolerances according to EN 13164.

2.2.16.4 Flatness

The flatness is determined according to EN 825 in accordance with EN 13164. The tolerances in mm/m are given in the ETA.

2.2.17 Deformation under specified compressive load and temperature conditions

Deformation under specified compressive load and temperature conditions of single-layer boards and factory-made multi-layered boards is determined according to EN 1605 in accordance with EN 13164 and given in the ETA using levels according to EN 13164.

The dimensions (length and width) of the test specimens should correspond to the total thickness of the boards.

Alternatively, the difference between the relevant deformation, ε_1, after step A and, ε_2, after step B as described in EN 1605 can be given in steps of 1 % in the ETA.

2.2.18 Dimensional stability under specified conditions

Dimensional stability under specific temperature and humidity conditions is determined according to EN 1604 in accordance with EN 13164 at a temperature of 70 °C and a relative humidity of 90 % (DS(70,90)) and given in the ETA using the level according to EN 13164. The specimen size (length and width) of factory-made multi-layered boards with thicknesses greater than 200 mm should be equal to or greater than the total thickness of the boards.

In addition dimensional stability at a temperature of - 30 °C can be determined according to EN 1604. The relative changes in length and width and the relative reduction in thickness is given in the ETA.

2.2.19 Tensile strength perpendicular to faces

The tensile strength perpendicular to faces of single-layer boards with a thickness > 120 mm (in case intended use a) and factory-made multi-layered boards is determined according to EN 1607 in accordance with EN 13164 and given in the ETA using levels according to EN 13164.

Note:
For factory-made multi-layered boards this test is also performed after freeze-thaw exposure – see clause 2.2.14.

2.2.20 Determination of volume percentage of closed cells

In conjunction with the tests in 2.2.12 closed cell content is tested in accordance with EN ISO 4590 (method 1 with correction, conditioning specimen for 45 days) and given in the ETA.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

In case of intended use a) according to clause 1.2.1 the applicable European legal act is: Decision 95/467/EC (structural bearings).

The system is:

System 1 (where requirements on individual bearings are critical) or

System 3 (where requirements on individual bearings are not critical)

`Critical` in the sense that those requirements may, in case of failure of the bearing, put the works or parts thereof in states beyond those regarded as serviceability and ultimate limit states.

In case of intended use b) and c) according to clause 1.2.1 the applicable European legal act is: Decision 1999/91/EC (thermal insulation products).

The system is: System 3 for any use except for uses subject to regulations on reaction to fire performance. For uses subject to regulations on reaction to fire the applicable AVCP systems are 1, 3 or 4 depending on the conditions defined in the said Decision.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.

Table 3 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
1	Compressive stress or compressive strength	see EN 13164	Acc. to control plan	3	see EN 13164
2	5%-fractile of compressive stress or compressive strength	See clause 2.2.2	Acc. to control plan		twice per year
3	Compressive creep / intended use a)	see EN 13164	Acc. to control plan	min + max thickness	once per year
4	Compressive modulus of elasticity	see EN 13164	Acc. to control plan	1	see EN 13164
5	Density	See clause 2.2.9	Acc. to control plan	3	once per day

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
6	Shear strength	See clause 2.2.10	Acc. to control plan	3	twice per year
7	Reaction to fire	see EN 13164	see EN 13164	see EN 13164	see EN 13164
8	Thermal resistance / Thermal conductivity	See clause 2.2.12	Acc. to control plan	1	see EN 13164[2]
9	Water absorption	See clause 2.2.13	Acc. to control plan	3	twice per year
10	Freeze-thaw resistance	See clause 2.2.14	Acc. to control plan	2	twice per year
11	Water vapour transmission	see EN 13164	see EN 13164	1	see EN 13164
12	Geometrical properties	See clause 2.2.16	Acc. to control plan	see EN 13164	see EN 13164
13	Deformation under specified compressive load and temperature conditions	See clause 2.2.17	Acc. to control plan	3	twice per year
14	Dimensional stability under specified conditions	see EN 13164	see EN 13164	2	twice per year
15	Tensile strength perpendicular to faces	See clause 2.2.19	Acc. to control plan	3	twice per year
16	Determination of volume percentage of closed cells	See EN 13164	Acc. to control plan	1	once per year

3.3 Tasks of the notified body

The intervention of the notified body is only necessary

- in case of intended use a) according to clause 1.2.1 and where requirements on individual bearings are critical;
- in case of intended uses b) and c) according to clause 1.2.1 in so far as the conditions for the applicability of system 1 as defined in Decision 1999/91/EC are fulfilled.

The cornerstones of the actions to be undertaken by the notified body of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 4.

[2] Initial values: 1 per 24 h
Aged values (according to clause 2.2.12): once per year

Table 4 Control plan for the notified body; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control *(for system 1only)*					
1	The notified body shall verify the ability of the manufacturer for a continuous and orderly manufacturing of the product according to the European Technical Assessment. In particular the following items shall be appropriately considered – personnel and equipment – the suitability of the factory production control established by the manufacturer – full implementation of the prescribed test plan				Before certification
2	Basic Works Requirement 1: Mechanical resistance and stability Essential characteristics: Clauses 2.2.1.1, 2.2.2, 2.2.3.1, 2.2.4 to 2.2.10	Presence of suitable test equipment			
		Presence of trained personnel			
		Presence of an appropriate quality assurance system and the necessary stipulations			
3	Basic Works Requirement 2*: Safety in case of fire Essential characteristics: Clause 2.2.11	Presence of suitable test equipment			
		Presence of trained personnel			
		Presence of an appropriate quality assurance system and the necessary stipulations			
Continuous surveillance, assessment and evaluation of factory production control *(for system 1only)*					
4	It shall be verified that the system of factory production control and the specified manufacturing process are maintained taking into account of the control plan.				Annually
5	Basic Works Requirement 1: Mechanical resistance and stability Essential characteristics: Clauses 2.2.1.1, 2.2.2, 2.2.3.1, 2.2.4 to 2.2.10	Inspection of factory, of the production of the product and of the facilities for factory production control			
		Evaluation of the documents concerning factory production control			
		Issuing a report of surveillance			
6	Basic Works Requirement 2*: Safety in case of fire Essential characteristics: Clause 2.2.11	Inspection of factory, of the production of the product and of the facilities for factory production control			
		Evaluation of the documents concerning factory production control			
		Issuing a report of surveillance			

* Only relevant for products of class C and higher.

4 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 European Technical Assessment is of relevance.

EN 822	Thermal insulating products for building applications - Determination of length and width
EN 823	Thermal insulating products for building applications - Determination of thickness
EN 824	Thermal insulating products for building applications - Determination of squareness
EN 825	Thermal insulating products for building applications - Determination of flatness
EN 826	Thermal insulating products for building applications - Determination of compression behaviour
EN 1602	Thermal insulating products for building applications - Determination of the apparent density
EN 1604	Thermal insulating products for building applications - Determination of dimensional stability under specified temperature and humidity conditions
EN 1605	Thermal insulating products for building applications - Determination of deformation under specified compressive load and temperature conditions
EN 1606	Thermal insulating products for building applications - Determination of compressive creep
EN 1607	Thermal insulating products for building applications - Determination of tensile strength perpendicular to faces
EN ISO 10456	Building materials and products-Hygrothermal properties-Tabulated design values and procedures for determining declared and design thermal values
EN 12086	Thermal insulation products for building applications-Determination of water vapour transmission properties
EN 12087	Thermal insulation products for building applications-Determination of long term water absorption by immersion
EN 12088	Thermal insulating products for building applications - Determination of long term water absorption by diffusion
EN 12091	Thermal insulation products for building applications-Determination of freeze-thaw resistance
EN 12667	Thermal performance of building materials and products-Determination of thermal resistance by means of guarded hot plate and heat flow meter methods-Products of high and medium thermal resistance
EN 12939	Thermal performance of building materials and products - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Thick products of high and medium thermal resistance
EN 13501-1	Fire classification of construction products and building elements-Part 1: Classification using test data from reaction to fire tests
ISO 12491	Statistical methods for quality control of building materials and components
EN ISO 4590	Rigid cellular plastics - Determination of the volume percentage of open cells and of closed cells

ANNEX A CREEP AND ADHESION TEST PROCEDURE

A.1 Creep test under shear stress - Test-Setup and Procedure

The concept of performing the creep test under shear stresses is illustrated in Figure (1). The test specimen is to be bonded between two steel plates where one of these plates is fixed and the other is to move freely in the horizontal direction parallel to the other plate. Any tilting that could happen in the movable plate through shear load application should be prohibited.

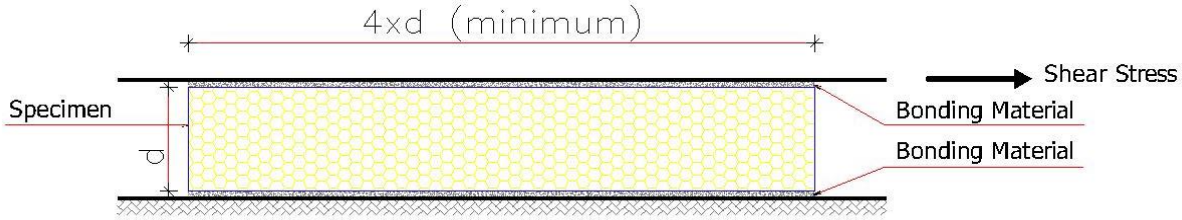

Figure (1) – Sketch of the Shear Creep Test-Setup

The regulations stated in EN 1606 regarding the test duration, load application, and when the creep deformations should be recorded, are followed here also to perform the creep test under shear stresses. Moreover, modelling and extrapolating the creep deformations under shear stresses are performed following the computational procedures in Annex A in EN 1606.

A.2 Creep test under combined compressive and shear stress - Test-Setup and Procedure

The concept of performing the creep tests under combined shear-compression stress state is illustrated in Figure (2). Test specimen is to be bonded between two steel plates where the bottom plate is fixed and the upper one is to move freely in both the horizontal and the vertical directions.

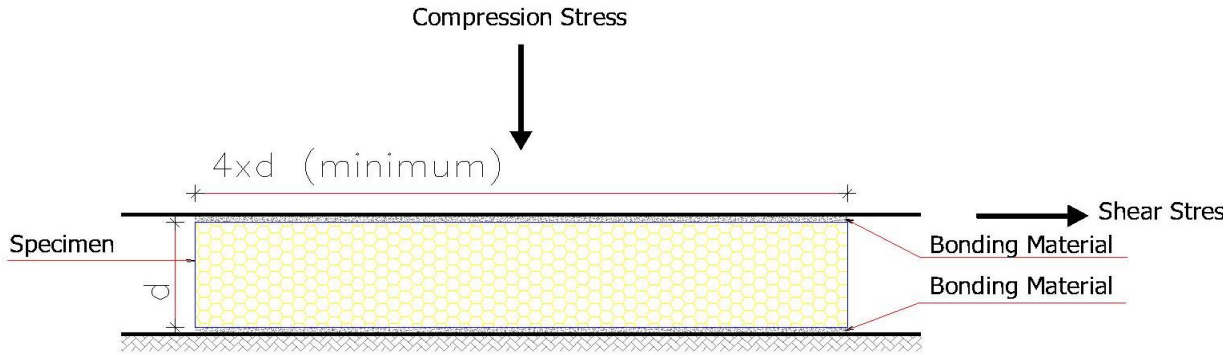

Figure (2) – Sketch of the Combined Shear-Compression Creep Test-Setup

The test is recommended to start by applying the compression stress firstly and then the shear stress.

As stated previously, the regulations stated in EN 1606 regarding the test duration, load application, and when the creep deformations should be recorded, are followed here as well to perform the creep test under both shear and compression stresses. Shear and compression creep deformations are to be recorded separately.

Moreover, each of the creep deformations under shear and compression stresses are modelled and extrapolated separately based on the computational procedures in Annex A in EN 1606.

A.3 Adhesion behaviour under compressive and shear load on large-sized specimen

A.3.1 Adhesive friction coefficient between the extruded polystyrene foam boards

The concept of performing the test to determine the friction coefficient between the extruded polystyrene foam boards is illustrated in Figure (3). Each test specimen is bonded on one steel plate whereby the lower steel plate is fixed on the testing stand. The steel plate of the upper specimen is fully movable in the horizontal and vertical direction. Any tilting that could happen in the movable plate through shear load application has to be prohibited.

The test is started by applying the compression stress first afterwards the shear stress can be applied.

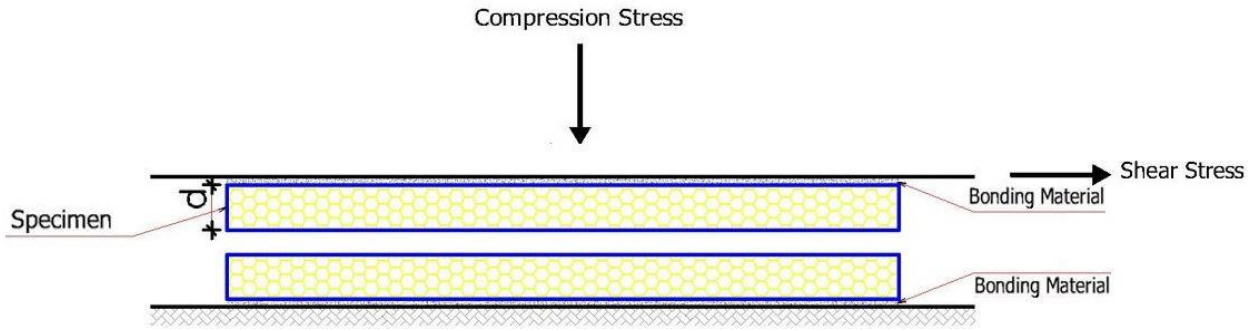

Figure (3) – Sketch of the test-setup to determine the adhesive friction coefficient between the extruded polystyrene foam boards

A.3.2 Adhesive friction coefficient between the extruded polystyrene foam boards and in-situ concrete as well as a concrete finished part with foil

The concept of performing the test to determine the friction coefficient between the extruded polystyrene foam boards and a concrete finished part with foil is illustrated in Figure (4). The test specimen is bonded on one steel plate. Afterwards it is placed on a precast concrete plate which is fixed against horizontal movement on the test stand. Between the concrete part and the polystyrene foam board a foil is placed. The steel plate with the attached foam board is fully movable in the horizontal and vertical direction. Any tilting that could happen in the movable plate during shear load application has to be prohibited.

The test is started by applying the compression stress first, afterwards the shear stress can be applied.

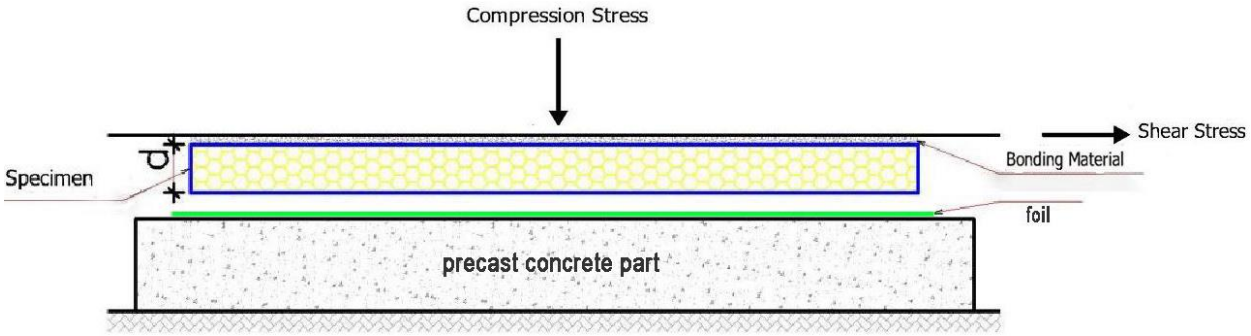

Figure (4) – Sketch of the test-setup to determine the adhesive friction coefficient between the extruded polystyrene foam boards and a concrete finished part with foil

A.3.3 Adhesive friction coefficient between the extruded polystyrene foam boards and in-situ concrete without foil

The concept of performing the test to determine the friction coefficient between the extruded polystyrene foam boards and a concrete finished part without foil is illustrated in Figure (5). The test specimen is bonded on one steel plate and an in-situ concrete part is concreted surface to surface against the foam board. The steel plate with the attached foam board is fully movable in the horizontal and vertical direction, the concrete part is fixed against horizontal movement. Any tilting that could happen in the movable plate during shear load application has to be prohibited.

The test is started by applying the compression stress first, afterwards the shear stress can be applied.

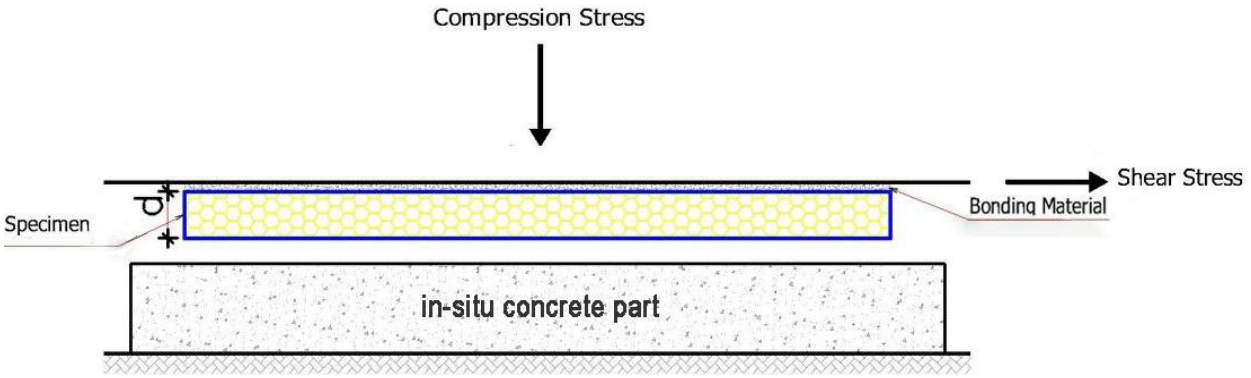

Figure (5) – Sketch of the test-setup to determine the adhesive friction coefficient between the extruded polystyrene foam boards and a concrete finished part with foil

A.3.4 Adhesive friction coefficient between the extruded polystyrene foam boards and a concrete finished part without foil

The concept of performing the test to determine the friction coefficient between the extruded polystyrene foam boards and a concrete finished part without foil is illustrated in Figure (6). The test specimen is bonded on one steel plate. Afterwards it is placed on a precast concrete plate which is fixed against horizontal movement on the test stand. The steel plate with the attached foam board is fully movable in the horizontal and vertical direction. Any tilting that could happen in the movable plate during shear load application has to be prohibited.

The test is started by applying the compression stress first afterwards the shear stress can be applied.

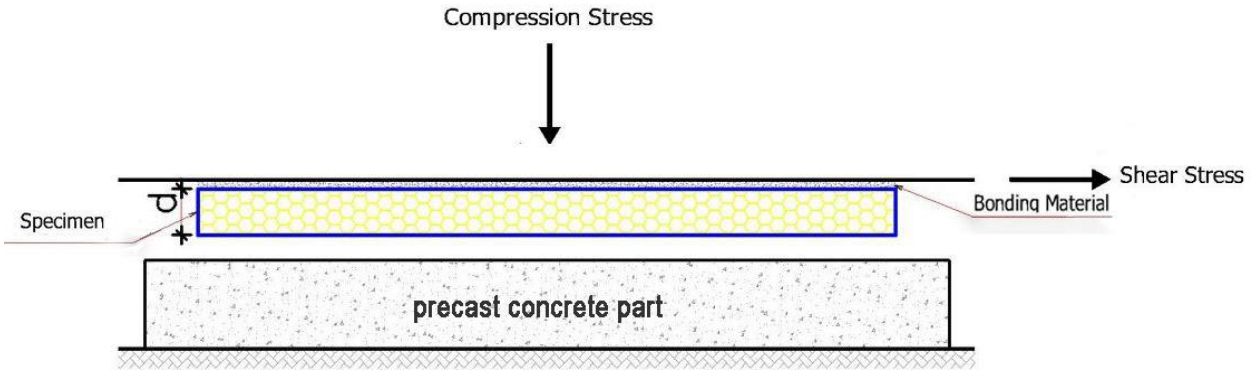

Figure (6) – Sketch of the test-setup to determine the adhesive friction coefficient between the extruded polystyrene foam boards and a concrete finished part with foil

ANNEX B DETERMINATION OF THE MOISTURE CONVERSION COEFFICIENT f_ψ

B.1 Scope

This Annex specifies the method for determination of the moisture conversion coefficient f_ψ of the thermal conductivity of the insulation.

B.2 Principle

The moisture conversion coefficient is determined on the basis of measurements of the thermal conductivity at several moisture conditions.

The conditioning of samples is performed by water absorption by diffusion (EN 12088).

B.3 Apparatus

B.3.1 Water absorption by diffusion apparatus

Water absorption by diffusion apparatus is in accordance with EN 12088.

B.3.2 Heat flow meter

A horizontal single specimen heat flow meter apparatus.

B.3.3 Polyethylene film

Either a polyethylene film or bag capable of being sealed vapour tight.

B.4 Test specimen

Five test specimens, of length and width dimensions 500 mm x 500 mm x total thickness, are preferably taken from different production lots.

B.5 Procedure

B.5.1 The test specimens are dried at 70 °C until constant mass, smaller than 0,1 % of initial mass per day, is attained.

B.5.2 The thermal conductivity is determined at a mean temperature of 10 ± 0,3 °C according to EN 12667 using a heat flow meter apparatus with a temperature difference of 10 to 15 °C.

B.5.3 The mean value $\lambda_{10,dry}$ is calculated to the nearest 0,0001 $W(m \cdot K)^{-1}$.

B.5.4 The water absorption is accelerated by putting the specimens into a diffusion test apparatus, according to EN 12088, until a range of 1 % to 2 % by volume has been reached. If necessary the Standard's test period of 28 days shall be prolonged until the range is reached. The test specimens are turned over every 7 days.

The test is stopped if the range of 1 % to 2 % has not been reached after 84 days. In this case the specimens showing the water absorption after 84 days are used for the next steps of the test procedure.

B.5.5 The test specimens are wrapped in polyethylene film or placed in a polyethylene bag, and sealed, for three weeks to allow homogeneous distribution of humidity within the test specimen at 23 ± 5 ºC.

B.5.6 The thermal conductivity measurement is repeated (see B.5.2) using the heat flow meter apparatus with a temperature difference of 4 to 6 °C. The specimens are made on the wrapped specimens to avoid loss of water vapour during the measurements. The lower plate of the apparatus is used as hot side and the upper plate as cold side. The heat flow direction and small temperature difference is required to avoid movement of humidity during measurement.

B.5.7 The following steps in the water absorption test is carried out by placing the test specimens into the diffusion test apparatus until 3 to 5 % by volume is achieved. If necessary the Standard's test period of 28 days shall be prolonged until the range is reached. The test specimens are turned over every 7 days.

The test is stopped if the range of 3 to 5 % has not been reached after 84 days. In this case the specimens showing the water absorption after 84 days are used for the next steps of the test procedure. The calculated conversion coefficient applies only up to the water absorption reached in the test (see B.5.13).

B.5.8 The test specimens are wrapped in polyethylene film or placed in a polyethylene bag, and sealed, for three weeks to allow a homogeneous distribution of humidity within the test specimen.

B.5.9 The thermal conductivity measurement is repeated using a temperature difference of 4 to 6 °C as described above.

B.5.10 The mean slope of the curve is determined by regression.

B.5.11 $\lambda_{10,\psi}$ is the value of thermal conductivity determined by evaluation of the curve at a mean humidity content ψ after step B.5.7.

B.5.12 The moisture conversion coefficient is determined in accordance with EN ISO 10456:

$$f\psi = \frac{\ln \frac{\lambda_{10,\psi}}{\lambda_{10,dry}}}{\psi}$$

where, $f\psi$ is the moisture conversion coefficient volume by volume
$\lambda_{10,dry}$ is the thermal conductivity of the thermal insulation dry
$\lambda_{10,\psi}$ is the thermal conductivity of the thermal insulation following water absorption by diffusion
ψ is the corresponding moisture content volume by volume at $\lambda_{10,\psi}$.

B.5.13 Restrictions concerning the application of this method:

If the water absorption of 3 to 5 % has not been reached according to B.5.7 the calculated conversion coefficient $f\psi$ applies only up to the water absorption reached.

The calculated value $f\psi$ shall not be less than 1.5 and/or 60 % of the moisture conversion coefficient quoted in EN ISO 10456 (the higher numerical value is applied).

If the value is less than 1.5 and/or 60% of the moisture conversion coefficient quoted in EN ISO 10456 then the value is set to 1.5 and/or 60 % (the higher numerical value is applied).