EAD **220009-00-0401**

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April 2015

European Assessment Document for

Kits for green roofs

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 No (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 Scope of the EAD 4

1.1 Description of the construction product 4

1.2 Information on the intended use(s) of the construction product 6

2 Essential characteristics and relevant assessment methods and criteria 7

2.1 Essential characteristics of the kit for green roof as well as of the components for a kit for green roof 7

2.2 Methods and criteria for assessing the performance of the kit in relation to essential characteristics of the kit 15

2.3 Methods and criteria for assessing the performance of the components of the kit in relation to essential characteristics of the components of the kit 16

3 Assessment and verification of constancy of performance 23

3.1 System(s) of assessment and verification of constancy of performance 23

3.2 Tasks of the manufacturer 24

3.3 Tasks of the notified body 28

4 Reference documents 30

Annex A Mounting and fixing procedure for reaction to fire tests and application rules for test results 33

Annex B Ageing procedure for the assessment of the durability of protection layers and drainage layers 37

Annex C conditions concerning the assessment of the kit 38

Annex D Determination of the coefficient of discharge/run-off reference value 39

Annex E Determination of the resistance to rhizomes of the root barrier layer 41

Annex F Determination of the water permeability of loose fill drainage layers and of the vegetation support layer 46

Annex G Determination of the maximum water capacity of the vegetation support layer 49

1 SCOPE OF THE EAD

1.1 Description of the construction product

This EAD is applicable to kits/products for green roofs as described in the following:

The kits for green roofs are placed above the waterproofing layer and consist of the following components (from the bottom up):

- root barrier layer (only if the kit is used on a waterproofing layer which is not root-resistant),
- protection layer,
- drainage layer (possibly with thermal insulating properties),
- filter layer,
- vegetation support layer (roof planting medium / soil).

This document covers kits for green roofs with a roof slope up to 15°.

A separation layer (if necessary to prevent deleterious effects between materials, e.g., laid as first layer above the waterproofing) can optionally be a component of the kit.

This EAD covers also assessment methods for all of the above-mentioned components separately, so that ETAs can be issued also for each single component for marketing as a single product.

The waterproofing layer and the plants are not part of the kit.

An example for a roof build-up using a kit for green roofs is given in Figure 1.1.1 (schematic).

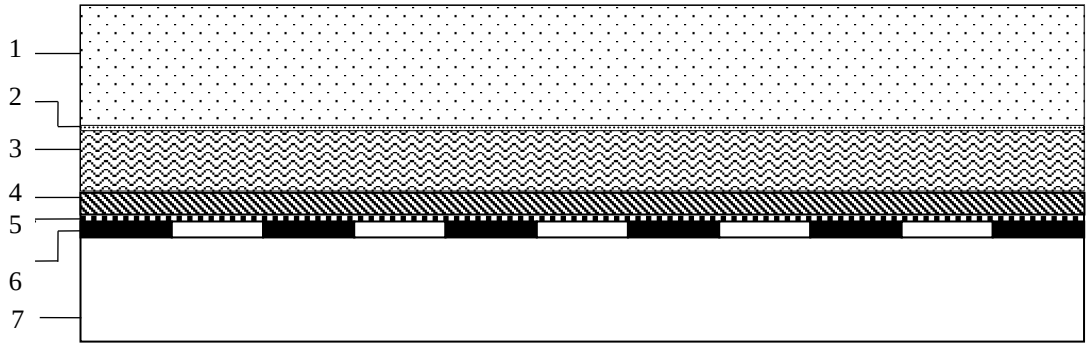

Figure 1.1.1: Schematic example for a kit for green roof

1 vegetation support layer

2 filter layer

3 drainage layer

4 protection layer

5 root barrier layer (optional)

Not part of the kit:

6 waterproofing layer

7 roof structure / substructure (possibly including thermal insulation)

The protection layer provides protection against mechanical damage of the waterproofing layer and can also retain moisture. The drainage layer absorbs surplus water and drains it off to the gutters. The filter layer stops the passage of fines from the vegetation support layer. The vegetation support layer provides the root area for the plants and provides water and nutrients.

It is possible that a component fulfils more than one of the functions mentioned before (e.g., drainage layer with protection properties) or that a composite product is used as a component of the kit (e.g., geo-composite consisting of a drainage and a filter layer). In these cases, the assessment methods are used cumulatively.

This EAD only includes root barrier layers made of flexible, non-bituminous / non-bituminous modified sheets with defined thickness/dimensions and mass per unit area. Liquid applied materials are not covered by this EAD.

The protection layer consists of a board or a mat made of synthetic material (Polyethylene (PE), Polypropylene (PP), Polyester/Polyethylene terephtalate (PET), Polyamide (PA), Polystyrene (PS), Acrylonitrile Butadiene Styrol (ABS), Rubber) with defined thickness/dimensions and mass per unit area. The EAD includes protection layers with maximum apertures of 15 mm. The protection layer is free from metallic parts.

The drainage layer is made up of a geosynthetic material (PE, PP, Polyester/PET, PA, PS, ABS, Rubber) with defined thickness/dimensions/geometry and mass per unit area or loose fill mineral material (aggregates) with defined particle size distribution and bulk density. Only inorganic mineral loose fill material from natural sources (e. g. crushed grains, course gravel) is covered by this EAD. The drainage layer can have thermal insulating properties. In this case the drainage layer is made of EPS (expanded polystyrene) or XPS (extruded polystyrene).

Loose fill drainage layers are made of sharp grained aggregates (crushed grains) and have a minimum thickness of 4 cm at built-in stage.

The filter layer is a geotextile with defined dimensions and mass per unit area for which the intended use "filtration and separation" is given.

The vegetation support layer consists of loose fill material made of mineral aggregates and / or soil. Only soil from natural sources is covered by this EAD. Soil from contaminated sites or other sites providing for material which is not purely natural is not covered by this EAD.

Components containing recycled synthetic materials (e.g., plastics, elastomers) or UV stabilizers are covered by this EAD. If applicable, the use of UV stabilizers and/or recycled material (including origin and composition) shall be indicated in the ETA.

The polymer/material type and the component structure of the root barrier layer, protection layer, drainage layer and filter layer shall be given in the ETA. Also, the material type of the vegetation support layer shall be given in the ETA.

The products are not covered by a harmonised European standard (hEN).

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 products 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

The kits for green roofs provide a suitable permanent habitat for plants. The kits protect the waterproofing membrane against ultra-violet radiation, temperature differences and mechanical damage. If corresponding components are used the kits can have thermal insulation properties.

The kits for green roofs reduce rain water run-off. The kits may also be intended to improve the external fire performance of the roof and provide resistance against wind uplift.

The assessment of the kit and it´s components only applies if the conditions according to Annex C are met.

The assessment of the resistance to wind loads is not covered by this EAD.

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 kit for green roofs or its components, respectively, for the intended use of 25 years when installed in the works, provided that the kit or the component is subject to appropriate installation (see clause 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 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

All undated references to standards or to EADs in this EAD are to be understood as references to the dated versions listed in chapter 4.

2.1 Essential characteristics of the kit for green roof as well as of the components for a kit for green roof

Table 2.1.1 shows how the performance of the **kit for green roof** is assessed in relation to the essential characteristics.

Table 2.1.1 Essential characteristics of the kit for green roof and methods and criteria for assessing the performance of the kit in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	External fire performance of roofs	2.2.1	Class
Basic Works Requirement 4: Safety and accessibility in use			
2	Coefficient of discharge / Run-off reference value	2.2.3	Level
3	Resistance to root penetration	2.3.1.2	Description
4	Resistance to rhizomes	2.3.1.3	Description
5	Behaviour after exposure to bitumen	2.3.1.4	Level
6	Resistance to ozone	2.3.1.5	Description
7	Long-term exposure to heat and water	2.3.1.6	Level
8	Microbiological resistance	2.3.1.7	Level
9	Protection efficiency	2.3.2.2	Level
10	Static puncture behaviour	2.3.2.3	Level
11	Water flow capacity	2.3.3.2[2] or 2.3.4.7[3]	Level
12	Compression behaviour	2.3.3.4[2] or 2.3.4.8[3]	Level
13	Compressive creep	2.3.3.5[2] or 2.3.4.9[3]	Level
14	Particle size distribution of loose fill material	2.3.6.2	Description, level
15	Bulk density of loose fill material	2.3.6.3	Level

[2] For drainage layer without thermal insulating properties

[3] For drainage layer with thermal insulating properties

No	Essential characteristic	Assessment method	Type of expression of product performance
16	Determination of pH	2.3.6.4	Level
17	Organic content	2.3.6.5	Level
18	Nutrient content	2.3.6.6	Level/s
19	Electrical conductivity	2.3.6.7	Level
20	Water permeability	2.3.3.3[2] or 2.3.6.8[4]	Level
21	Maximum water capacity (water storage ability)	2.3.6.9	Level
Basic Works Requirement 6: Energy economy and heat retention			
22	Correction value for thermal transmittance	2.2.2	Level
23	Thermal resistance / thermal conductivity	for EPS: EN 13163, clause 4.2.1 for XPS: EN 13164, clause 4.2.1	Level
24	Long-term water absorption by diffusion	2.3.4.2	Level
25	Long-term water absorption by total immersion	2.3.4.3	Level
26	Resistance to freeze-thaw	2.3.4.4	Level
27	Deformation under specified compressive load and temperature	2.3.4.5	Level
28	Dimensional stability	2.3.4.6	Level
29	Dimensional deviations	2.3.4.10	Class / Level / Description
Aspects of durability			
30	Durability	2.3.2.4[5] or 2.3.3.6[2]	Description, level

The Tables 2.1.2a to 2.1.2f show how the performance of the **components of the kit for green** roof is assessed in relation to their essential characteristics.

[4] For vegetation support layer

[5] For protection layer

Table 2.1.2a shows how the performance of the **root barrier layer** is assessed in relation to the essential characteristics.

Table 2.1.2a Essential characteristics of the root barrier layer and methods and criteria for assessing the performance of the root barrier layer in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Reaction to fire	2.3.1.1	Class
Basic Works Requirement 4: Safety and accessibility in use			
2	Resistance to root penetration	2.3.1.2	Description
3	Resistance to rhizomes	2.3.1.3	Description
4	Behaviour after exposure to bitumen	2.3.1.4	Level
5	Resistance to ozone	2.3.1.5	Description
6	Long-term exposure to heat and water	2.3.1.6	Level
7	Microbiological resistance	2.3.1.7	Level

Table 2.1.2b shows how the performance of the **protection layer** is assessed in relation to the essential characteristics.

Table 2.1.2b Essential characteristics of the protection layer and methods and criteria for assessing the performance of the protection layer in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Reaction to fire	2.3.2.1	Class
Basic Works Requirement 4: Safety and accessibility in use			
2	Protection efficiency	2.3.2.2	Level
3	Static puncture behaviour	2.3.2.3	Level
Aspects of durability			
4	Durability	2.3.2.4	Description, level

Table 2.1.2c shows how the performance of the **drainage layer (without thermal insulating properties)** is assessed in relation to the essential characteristics.

Table 2.1.2c Essential characteristics of the drainage layer (without thermal insulating properties) and methods and criteria for assessing the performance of the drainage layer (without thermal insulating properties) in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Reaction to fire	2.3.3.1	Class
Basic Works Requirement 4: Safety and accessibility in use			
2	Water flow capacity of the drainage layer in the plane	2.3.3.2	Level
3	Water permeability	2.3.3.3	Level
4	Compression behaviour	2.3.3.4	Level
5	Compressive creep	2.3.3.5	Level
Aspects of durability			
6	Durability	2.3.3.6	Description, level

Table 2.1.2d shows how the performance of the **drainage layer made of EPS / XPS (with thermal insulating properties)** is assessed in relation to the essential characteristics.

Table 2.1.2d Essential characteristics of the drainage layer made of EPS / XPS (with thermal insulating properties) and methods and criteria for assessing the performance of the drainage layer made of EPS / XPS (with thermal insulating properties) in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Reaction to fire	2.3.4.1	Class
Basic Works Requirement 4: Safety and accessibility in use			
2	Water flow capacity of the drainage layer in the plane	2.3.4.7	Level
3	Compression behaviour	2.3.4.8	Level
4	Compressive creep	2.3.4.9	Level
Basic Works Requirement 6: Energy economy and heat retention			
5	Thermal resistance / thermal conductivity	for EPS: EN 13163, clause 4.2.1 for XPS: EN 13164, clause 4.2.1	Level
6	Long-term water absorption by diffusion	2.3.4.2	Level
7	Long-term water absorption by total immersion	2.3.4.3	Level
8	Resistance to freeze-thaw	2.3.4.4	Level
9	Deformation under specified compressive load and temperature	2.3.4.5	Level
10	Dimensional stability	2.3.4.6	Level
11	Dimensional deviations	2.3.4.10	Class / Level / Description

Table 2.1.2e shows how the performance of the **filter layer** is assessed in relation to the essential characteristics.

Table 2.1.2e Essential characteristics of the filter layer and methods and criteria for assessing the performance of the filter layer in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Reaction to fire	2.3.5.1	Class
Basic Works Requirement 4: Safety and accessibility in use			
2	Tensile strength	EN 13252, clauses 4.1, table 1, line 1	Level
3	Static puncture	EN 13252, clauses 4.1, table 1, line 6	Level
4	Dynamic perforation resistance	EN 13252, clauses 4.1, table 1, line 7	Level
5	Characteristic opening size	EN 13252, clauses 4.1, table 1, line 11	Level
6	Water permeability normal to plane	EN 13252, clauses 4.1, table 1, line 12	Level
Aspects of durability			
7	Durability	EN 13252, Annex B	Level, Description

Table 2.1.2f shows how the performance of the **vegetation support layer** is assessed in relation to the essential characteristics.

Table 2.1.2f Essential characteristics of the vegetation support layer and methods and criteria for assessing the performance of the vegetation support layer in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Reaction to fire	2.3.6.1	Class
Basic Works Requirement 4: Safety and accessibility in use			
2	Particle size distribution of loose fill material	2.3.6.2	Description, level
3	Bulk density of loose fill material	2.3.6.3	Level
4	Determination of pH	2.3.6.4	Level
5	Organic content	2.3.6.5	Level
6	Nutrient content	2.3.6.6	Level
7	Electrical conductivity	2.3.6.7	Level
8	Water permeability	2.3.6.8	Level
9	Maximum water capacity (water storage ability)	2.3.6.9	Level

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

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

Testing will be limited only to the essential characteristics which the manufacturer intends to declare. If for any components covered by harmonised standards or European Technical Assessments the manufacturer of the component has included the performance regarding the relevant characteristic in the Declaration of Performance, retesting of that component for issuing the ETA under the current EAD is not required.

In many cases, for the assessment of the performance of the kit in relation to specific essential characteristics reference is made to the assessment methods allocated to its components because the performance of the component(s) is representative for the performance of the kit. This is related to those essential characteristics of the kit indicated in table 2.1.1 for which the assessment methods are given in chapter 2.3.

2.2.1 External fire performance of roofs

The roof (including the complete roof covering) in which the kit is intended to be incorporated, installed or applied shall be tested using one or several of the test methods according to CEN/TS 1187 relevant for the corresponding external fire performance roof class(es) according to EN 13501-5.

The test shall be carried out with a roof slop of 15° and in dry condition (equilibrium moisture at a climate of 23°C/50% relative humidity) without planting.

The roof (including the complete roof covering) in which the kit for green roof is intended to be incorporated, installed or applied shall be classified according to Commission Decision 2001/671/EC, as amended by Commission Decision 2005/823/EC, in connection with EN 13501-5 and considering the provisions of CEN/TS 16459 for the extended application of test results.

The obtained class(es) shall be stated in the ETA together with a clear description of the assembly of the roof(s) which is/are covered by the classification.

2.2.2 Correction value for thermal transmittance

For the correction of the thermal transmittance of the kit using single drainage layers with thermal insulating properties following Annex F.4 of EN ISO 6946 $(f \cdot x) = 0.04$ $(W \cdot day)/(m^2 \cdot K \cdot mm)$ shall be used without the need for testing.

The correction $(f \cdot x) = 0.04$ $(W \cdot day)/(m^2 \cdot K \cdot mm)$ shall be given in the ETA.

2.2.3 Coefficient of discharge / Run-off reference value

The coefficient of discharge/run-off reference value of rainfall r shall be determined according to Annex D of this EAD.

The coefficient of discharge/run-off reference value shall be indicated in the ETA in conjunction with the intensity of rainfall r to which the indicated level applies.

The assessed roof build-up shall be described in detail in the ETA. It shall be stated clearly to which roof build-up(s) the given level(s) applies/apply. In particular the description and the minimum thickness of the drainage layer / the vegetation support layer and the maximum roof slope shall be given in the ETA. A value determined on a certain construction thickness applies also to higher construction thicknesses.

2.3 Methods and criteria for assessing the performance of the components of the kit in relation to essential characteristics of the components of the kit

Also this chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

2.3.1 Root barrier layer

2.3.1.1 Reaction to fire

The root barrier layer shall be tested using the test method(s) relevant for the corresponding reaction to fire classes(es) according to EN 13501-1. The product shall be classified according to Commission Delegated Regulation (EU) No 2016/364 in connection with EN 13501-1.

The provisions of Annex A.1 shall be considered for testing purposes as well as for the extended application of test results.

The obtained class shall be stated in the ETA together with those conditions (see addressed parameters in Annex A.1) for which the classification is valid.

2.3.1.2 Resistance to root penetration

The resistance to root penetration shall be determined according to EN 13948.

If no root penetration can be detected after testing and on the basis of the evaluation according to EN 13948, clause 8, "no root penetration detected" shall be indicated in the ETA. Otherwise, „root penetration detected“ shall be indicated.

2.3.1.3 Resistance to rhizomes

The resistance to rhizomes shall be determined according to Annex E of this EAD.

If no rhizome penetration can be detected after testing and on the basis of the evaluation according to Annex E.4, "no rhizome penetration detected" shall be indicated in the ETA. Otherwise, „rhizome penetration detected“ shall be indicated.

2.3.1.4 Behaviour after exposure to bitumen

The behaviour after exposure to bitumen shall be tested according to EN 1548.

Following EN 13956, clause 5.2.18, the change in modules of elasticity (for homogeneous sheets) or the mass loss (for sheets with an insert) shall be indicated in the ETA.

2.3.1.5 Resistance to ozone (sheets made from elastomeric materials only)

The resistance to ozone shall be determined according to EN 1844 with at least 3 test specimens.

The test result (cracking occurred / no cracking occurred) shall be indicated in the ETA.

2.3.1.6 Long-term exposure to heat and water

The sheets are conditioned in accordance with:

- for heat: EN 1296 for 28 days at 70±2 °C
- for salt water: EN 1847 for 28 days at 60 ± 2 °C

Before and after conditioning the sheets shall be tested according to EN 12311-2, method A. At least 5 test specimens (50 mm x 200 mm) in longitudinal direction and also in transverse direction shall be used.

The maximum reduction in tensile force / strength in % of the initial value shall be indicated in the ETA.

2.3.1.7 Microbiological resistance

The microbiological resistance shall be determined following EN 12225. Before and after conditioning the sheets (at least 5 test specimens of 50 mm x 200 mm in longitudinal direction and also in transverse direction) are tested according to EN 12311-2, method A (deviating from EN 12225).

The maximum reduction in tensile force / strength in % of the initial value and the result of a visual inspection shall be indicated in the ETA.

2.3.2 Protection layer

2.3.2.1 Reaction to fire

The protection layer shall be tested using the test method(s) relevant for the corresponding reaction to fire classes(es) according to EN 13501-1. The product shall be classified according to Commission Delegated Regulation (EU) No 2016/364 in connection with EN 13501-1.

The provisions of Annex A.1 shall be considered for testing purposes as well as for the extended application of test results.

The obtained class shall be stated in the ETA together with those conditions (see addressed parameters in Annex A.1) for which the classification is valid.

2.3.2.2 Protection efficiency

The protection efficiency shall be determined according to EN ISO 13428.

The residual thickness s_r of the lead plate shall be indicated in the ETA.

2.3.2.3 Static puncture behaviour

The static puncture behaviour shall be determined according to EN ISO 12236.

The static puncture behaviour (push-through force Fp [kN]) shall be given in the ETA.

2.3.2.4 Durability

The durability of the protection layer is determined following Annexes B.2 and B.4 of EN 13252 for an intended use of 25 years, considering the amendments given in Annex B of this EAD.

Before and after ageing the tensile strength of the protection layer shall be tested according to EN 29073-3.

In accordance with EN 13252, for each test the residual tensile strength after ageing shall be at least 50 % of the initial value. In the ETA it has to be indicated whether this level has been achieved.

Furthermore, the maximum time of exposure after installation shall be given in the ETA.

2.3.3 Drainage layer (<u>without</u> thermal insulating properties)

2.3.3.1 Reaction to fire

One of the two following options shall apply:

a) For drainage layers made of loose fill inorganic mineral materials only:

The drainage layer is considered to satisfy the requirements for performance class A1 of the characteristic reaction to fire in accordance with the Commission Decision 96/603/EC, as amended by Commission

Decisions 2000/605/EC and 2003/424/EC, without the need for testing on the basis of it fulfilling the conditions set out in that Decision and its intended use being covered by that Decision.

Thus, the class A1 shall be stated in the ETA.

b) For drainage layers made of geosynthetics only:

Drainage layers made of geosynthetics shall be tested using the test method(s) relevant for the corresponding reaction to fire class(es) according to EN 13501-1. The product shall be classified according to Commission Delegated Regulation (EU) No 2016/364 in connection with EN 13501-1.

The provisions of Annex A.1 shall be considered for testing purposes as well as for the extended application of test results.

The obtained class shall be stated in the ETA together with those conditions (see addressed parameters in Annex A.1) for which the classification is valid.

2.3.3.2 Water flow capacity of the drainage layer in the plane

The water flow capacity of the drainage layer in the plane (run-off at the lower level of the drainage layer) shall be determined following EN ISO 12958-1 with the following modifications (table 2.3.3.2.1):

Table 2.3.3.2.1: Test conditions for the assessment of the water flow capacity

Test condition	Load	hydraulic gradient
1	20 kPa	i=0.01
2	20 kPa	i=0.02
3	20 kPa	i=0.1
4	20 kPa	i=0.4
5	20 kPa	i=1.0

For all test conditions the following applies:

- the test built-up shall represent the practical installation conditions considering Manufacturer's Product Installation Instructions (MPII),
- lower boundary: rigid (e.g., concrete or polyethylene-liner) *,
- upper boundary: soft (foam rubber) *,
- for loose fill drainage layers: The test shall be performed with the drainage layer thickness representing the intended thickness covered by the ETA. If the intended thickness exceeds 10 cm the test shall be performed with a drainage layer thickness of 10 cm. In this case the results determined at 10 cm apply also to higher thicknesses.

* Other boundaries can be used for special applications.

The water flow capacity shall be stated in the ETA together with the corresponding test conditions (which surface of the drainage layer is up/down) and used boundaries.

2.3.3.3 Water permeability (for loose fill drainage layers only)

The water permeability shall be determined according to Annex F of this EAD.

The water permeability shall be stated in the ETA.

2.3.3.4 Compression behaviour (for geosynthetics only)

The short-term compressive strength shall be determined according to EN ISO 25619-2.

The compressive strength shall be stated in the ETA. For products for which the compressive strength cannot be determined, the deformation at 20 kPa shall be indicated.

2.3.3.5 Compressive creep (for geosynthetics only)

The compressive creep properties shall be determined according to EN ISO 25619-1, chapter 5, with a load of 15 kPa at 25°C for a period of 10000 hours.

The compressive creep properties shall be stated in the ETA (total thickness reduction ε [%] and compressive creep ε_{cc} [%]).

2.3.3.6 Durability (for geosynthetics only)

The durability of the drainage layer shall be tested following Annexes B.2 and B.4 of EN 13252 for an intended use of 25 years considering the amendments and deviations given in Annex B of this EAD.

The compressive strength according to EN ISO 25619-2 or the tensile strength according to EN 29073-3 or EN ISO 13934-1 is determined before and after ageing. The results of both methods are considered equivalent. The test according to EN ISO 25619-2 (compressive strength) is the reference method. The method used shall be presented along with test results.

For each test the residual strength after ageing shall be at least 50 % of the initial value in accordance with EN 13252. In the ETA it has to be indicated whether this level has been achieved.

Furthermore, the maximum time of exposure after installation shall be given in the ETA.

2.3.4 Drainage layer (EPS / XPS) with thermal insulating properties

2.3.4.1 Reaction to fire

Drainage layers made of EPS or XPS shall be tested using the test method(s) relevant for the corresponding reaction to fire class(es) according to EN 13501-1. The product shall be classified according to Commission Delegated Regulation (EU) No 2016/364 in connection with EN 13501-1.

The provisions of EN 15715, clause 5 together with tables A.6 and A.7 (for EPS) as well as A.10 and A.11 (for XPS) shall be considered for testing purposes and for the extended application of test results.

The obtained class shall be stated in the ETA together with those conditions (see addressed parameters in the aforementioned tables of EN 15715) for which the classification is valid.

For those products which are already covered by EN 13163 (EPS) and EN 13164 (XPS) respectively, the reaction to fire class shall be taken from their Declaration of performance and stated in the ETA without re-testing.

2.3.4.2 Long-term water absorption by diffusion

The long-term water absorption by diffusion shall be determined in accordance with EN ISO 16536. Before testing the test specimens shall be stored for at least 6 hours at (23 ± 5) °C.

The long-term water absorption by diffusion shall be stated in the ETA using the levels according to EN 13163 (for EPS) or EN 13164 (for XPS).

2.3.4.3 Long-term water absorption by total immersion

The long-term water absorption by total immersion shall be determined in accordance with EN ISO 16535, method 2A. Before testing the test specimens shall be stored for at least 6 hours at (23 ± 5) °C. The test shall be carried out at (23 ± 5) °C using water with a temperature of (23 ± 5) °C.

The long-term water absorption by total immersion shall be stated in the ETA using the levels according to EN 13163 (for EPS) or EN 13164 (for XPS).

2.3.4.4 Resistance to freeze-thaw

The freeze-thaw resistance shall be determined in accordance with EN 12091 using samples from clause 2.3.4.2 prepared by water absorption by diffusion.

Before freeze-thaw cycling the compressive strength / compressive stress at 10% deformation shall be determined according to EN ISO 29469.

Following freeze-thaw cycling the additional water absorption (WV) and the compressive strength / compressive stress at 10% deformation according to EN ISO 29469 shall be determined.

The additional water absorption (WV) after freeze-thaw cycling shall be indicated in the ETA in levels with steps of 1 %. The maximum level is given in the ETA.

After the freeze-thaw test the reduction in compressive strength / compressive stress of the dry sample shall not exceed 10 % of the initial value according to EN 13163 / EN 13164.

The initial value of compressive strength / compressive stress at 10 % deformation shall be given in the ETA following EN 13163 (for EPS) or EN 13164 (for XPS).

2.3.4.5 Deformation under specified compressive load and temperature

The deformation in thickness under specified load and temperature shall be determined according to EN 1605 for test condition 1 (20 kPa / 80 °C / 48 h) and test condition 2 (40 kPa / 70 °C / 168 h).

The maximum change of the relative deformation in % (difference between the relative deformation ε1 after step A and ε2 after step B) shall be indicated in levels according to EN 13163 (for EPS) or EN 13164 (for XPS). The relative deformation shall not exceed the value of 5 %.

2.3.4.6 Dimensional stability

The dimensional stability at a temperature of 70°C and a relative humidity of 90% for 48 hours shall be determined according to EN 1604.

The relative changes shall be indicated in the ETA following EN 13163 (for EPS) or EN 13164 (for XPS).

2.3.4.7 Water flow capacity of the drainage layer in the plane

The water flow capacity of the drainage layer in the plane (run-off at the lower level of the drainage layer) shall be determined following EN ISO 12958-1 with the following modifications (see table 2.3.4.7.1):

Table 2.3.4.7.1: Test conditions for the assessment of the water flow capacity

Test condition	load	hydraulic gradient
1	20 kPa	i=0.01
2	20 kPa	i=0.02
3	20 kPa	i=0.1
4	20 kPa	i=0.4
5	20 kPa	i=1.0

For all test conditions the following applies:

- the test built up shall represent the practical installation conditions considering MPII ,
- lower boundary: rigid (e.g., concrete or polyethylene-liner) *,
- upper boundary: soft (foam rubber) *.

* Other boundaries can be used for special applications.

The water flow capacity shall be indicated in the ETA together with the corresponding test conditions (which surface of the drainage layer is up/down) and used boundaries.

2.3.4.8 Compression behaviour

The short-term compressive strength shall be determined according to EN ISO 25619-2.

The compressive strength shall be stated in the ETA. For products for which the compressive strength cannot be determined, the deformation at 20 kPa shall be stated.

2.3.4.9 Compressive creep

The compressive creep properties shall be determined according to EN ISO 25619-1, chapter 5 with a load of 15 kPa at 25 °C for a period of 10000 hours.

The compressive creep properties shall be indicated in the ETA (total thickness reduction ε [%] and compressive creep ε_{cc} [%]).

2.3.4.10 Dimensional deviations

The dimensions shall be determined according to EN 13163 (for EPS) or EN 13164 (for XPS).

If necessary, appropriate drawings should be included in the ETA.

The dimensional deviations following EN 13163 (for EPS) or EN 13164 (for XPS) shall be given in the ETA.

2.3.5 Filter layer

2.3.5.1 Reaction to fire

The filter layer shall be tested using the test method(s) relevant for the corresponding reaction to fire class(es) according to EN 13501-1. The product shall be classified according to Commission Delegated Regulation (EU) No 2016/364 in connection with EN 13501-1.

The provisions of Annex A.1 shall be considered for testing purposes as well as for the extended application of test results.

The obtained class shall be stated in the ETA together with those conditions (see addressed parameters in Annex A.1) for which the classification is valid.

2.3.6 Vegetation support layer

2.3.6.1 Reaction to fire

One of the two following options shall apply:

a) If possible, the vegetation support layer is considered to satisfy the requirements for performance class A1 of the characteristic reaction to fire in accordance with Commission Decision 96/603/EC, as amended by Commission Decisions 2000/605/EC and 2003/424/EC, without the need for testing on the basis of it fulfilling the conditions set out in that Decision and its intended use being covered by that Decision.

b) Otherwise, the vegetation support layer shall be tested, using the test methods relevant for the corresponding reaction to fire class according to EN 13501-1. The vegetation support layer shall be classified according to Commission Delegated Regulation (EU) No 2016/364 in connection with EN 13501-1.

   The provisions of Annex A.2 shall be considered for testing purposes as well as for the extended application of test results.

   The obtained class shall be stated in the ETA together with those conditions (see addressed parameters in Annex A.2) for which the classification is valid.

2.3.6.2 Particle size distribution of loose fill material

The particle size distribution of the vegetation support layer shall be determined according to EN 933-1.

The particle size distribution, the maximum particle size as well as the fraction of particles < 0,063 mm and > 4 mm [% by mass] shall be given in the ETA.

2.3.6.3 Bulk density of loose fill material

The bulk density of the vegetation support layer shall be determined according to EN 1097-3 (bulk density under dry conditions).

The bulk density shall be given in the ETA.

2.3.6.4 Determination of pH

The determination of pH shall be determined according to EN 13037.

The pH shall be given in the ETA.

2.3.6.5 Organic content

The organic content shall be determined according to EN 13039.

The organic content shall be given in the ETA.

2.3.6.6 Nutrient content

The nutrient content shall be determined according to EN 13651 and/or according to EN 13652. The results of both methods are considered equivalent. The test according to EN 13651 is the reference method. The method used shall be presented along with test results.

The nutrient content (N, P_2O_5, K_2O, Mg) shall be given in the ETA.

2.3.6.7 Electrical conductivity

The electrical conductivity shall be determined according to EN 13038.

The electrical conductivity shall be given in the ETA in mS/m.

2.3.6.8 Water permeability

The water permeability shall be determined according to Annex F of this EAD.

The water permeability shall be indicated in the ETA.

2.3.6.9 Maximum water capacity (water storage ability)

The maximum water capacity shall be determined according to Annex G of this EAD.

The maximum water capacity shall be indicated in the ETA.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance

Kit for green roofs:

The applicable European legal act is Commission Decision 98/436/EC, as amended by Commission Decision 2001/596/EC.

The applicable AVCP system is 4 for any use except for uses subject to external fire performance regulations.

For uses subject to external fire performance regulations the applicable AVCP system is 3 (for kits requiring testing) or 4 (for kits deemed to satisfy without testing).

Vegetation support layer:

The applicable European legal act is Commission Decision 98/436/EC, as amended by Commission Decision 2001/596/EC.

The applicable AVCP system is 4 for any use except for uses subject to regulations on reaction to fire.

For uses subject to regulations on reaction to fire the applicable AVCP system is 1, 3 or 4.

Root barrier layer, the protection layer, the drainage layer without thermal insulating properties and filter layer:

The applicable European legal act is Commission Delegated Regulation 2015/1958.

The applicable AVCP system is 2+ for any use except for uses subject to regulations on reaction to fire.

For uses subject to regulations on reaction to fire the applicable AVCP systems regarding reaction to fire are 1, or 3, or 4 depending on the conditions defined in the said Decision.

Drainage layer with thermal insulating properties:

The applicable European legal act is Commission Decision 1999/91/EC, as amended by Commission Decision 2001/596/EC.

The applicable AVCP system is 3 for any use except for uses subject to regulations on reaction to fire.

For uses subject to regulations on reaction to fire the applicable AVCP systems regarding reaction to fire are 1, or 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 kits for green roofs in the process of assessment and verification of constancy of performance are laid down in Table 3.2.1a.

The actions to be undertaken by component manufacturer or the kit manufacturer for the different components of the kits for green roofs are laid down in Tables 3.2.1b to 3.2.1g.

Table 3.2.1a Control plan for the manufacturer of the kit for green roofs; 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	Continuous control that the provisions given in Tables 3.2.1b to 3.2.1g are fulfilled, as relevant with regard to the components which belong to the kit as placed on the market by the manufacturer	See control plan	See control plan	-	According to tables 3.2.1b to 3.2.1g

Table 3.2.1b Control plan for the manufacturer for the root barrier layer; 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	Thickness and mass per unit area	EN 1849-2	According to control plan	1	once per batch
2	Tensile force / Tensile stress	EN 12311-2	According to control plan	EN 12311-2	once per week

Table 3.2.1c Control plan for the manufacturer for the protection layer; 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	Reaction to fire	2.3.2.1	According to control plan	1	once per year
2	Thickness	EN ISO 9863-1	According to control plan	1	once per batch
3	Mass per unit area	EN ISO 9864	According to control plan	1	once per batch
4	Protection efficiency	2.3.2.2	According to control plan	EN ISO 13428	once per week
5	Tensile strength	EN ISO 10319	According to control plan	EN ISO 10319	once per week

Table 3.2.1d Control plan for the manufacturer for the drainage layer without thermal insulating properties; 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	Reaction to fire	2.3.3.1 Case "b)"	According to control plan	1	once per year
2	Dimensions / Geometry (for geosynthetics)	EN ISO 9863-1 EN ISO 9863-2	According to control plan	1	once per batch
3	Mass per unit area (for geosynthetics)	EN ISO 9864	According to control plan	1	once per batch
4	Compression behaviour (for geosynthetics)	2.3.3.4	According to control plan	EN ISO 25619-2	once per week
5	Particle size distribution (for loose fill drainage layers)	EN 933-1	According to control plan	1	once per week or once per batch
6	Bulk density (for loose fill drainage layers)	EN 1097-3	According to control plan	1	once per batch

Table 3.2.1e Control plan for the manufacturer for the drainage layer with thermal insulating properties (EPS / XPS); 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	Reaction to fire	2.3.4.1	According to control plan	1	EN 13163/ EN 13164, Table B.2
2	Dimensions / Geometry	2.3.4.10	According to control plan	1	EN 13163/ EN 13164, Table B.1
3	Compression behaviour	2.3.4.8	According to control plan	EN ISO 25619-2	once per week
4	Thermal resistance / thermal conductivity	for EPS: EN 13163, clause 4.2.1 for XPS: EN 13164, clause 4.2.1	According to control plan	1	EN 13163/ EN 13164, Table B.1
5	Long term water absorption by diffusion	2.3.4.2	According to control plan	EN 13163/ EN 13164	once per year
6	Resistance to freeze-thaw	2.3.4.4	According to control plan	EN 12091	once every two years
7	Compressive stress at 10 % deformation	2.3.4.4	According to control plan	EN 13163/ EN 13164	EN 13163/ EN 13164, Table B.1

Table 3.2.1f Control plan for the manufacturer for the filter layer; 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	Mass per unit area	EN ISO 9864	According to control plan	1	once per batch
2	Reaction to fire	2.3.5.1	According to control plan	1	once per year
3	Characteristics according to EN 13252	EN 13252	According to control plan	EN 13252	EN 13252, Table A.2

Table 3.2.1g Control plan for the manufacturer for the vegetation support layer; 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	Reaction to fire	2.3.6.1 Case "b)"	According to control plan	1	once per year
2	Particle size distribution	2.3.6.2	According to control plan	1	once per week or once per batch
3	Bulk density	2.3.6.3	According to control plan	EN 1097-3	once per batch
4	Determination of pH	2.3.6.4	According to control plan	EN 13037	twice per year
5	Organic content	2.3.6.5	According to control plan	EN 13039	once per week or once per batch
6	Electrical conductivity	2.3.6.7	According to control plan	EN 13038	twice per year

3.3 Tasks of the notified body

3.3.1 Tasks of the notified body related to the root barrier layer, the protection layer, the drainage layer without thermal insulating properties and the filter layer

The cornerstones of the actions to be undertaken by the notified body of the products in the process of assessment and verification of constancy of performance are laid down in Table 3.3.1.

Table 3.3.1 Root barrier layer, protection layer, drainage layer without thermal insulating properties and filter layer - 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					
1	The Notified Body will ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the products. In addition, where the intervention of the Notified Body is necessary because the conditions for the applicability of system 1 are fulfilled, the notified body will consider especially the clearly identifiable stage in the production process which results in an improvement of the reaction to fire classification (e.g., an addition of fire retardants or a limiting of organic material).	Verification of the complete FPC, to be implemented by the manufacturer	See control plan	-	Before certification (When starting the production or a new production line and after modification of the production process)
Continuous surveillance, assessment and evaluation of factory production control					
2	The Notified Body will ascertain that the system of factory production control and the specified manufacturing process are maintained taking account of the control plan. Where the intervention of the Notified Body is necessary because the conditions for the applicability of system 1 in the Decisions are fulfilled, the notified body will consider especially the clearly identifiable stage in the production process which results in an improvement of the reaction to fire classification (e.g., an addition of fire retardants or a limiting of organic material)	Verification of the controls carried out by the manufacturer on the raw materials, on the process and on the product as indicated in Tables 3.2.1b to 3.2.1d and 3.2.1f	See control plan	-	Annually

3.3.2 Tasks of the notified body related the drainage layer with thermal insulating properties and the vegetation support layer

The intervention of the notified body is only necessary for reaction to fire for products/materials for which a clearly identifiable stage in the production process results in an improvement of the reaction to fire classification (e.g., an addition of fire retardants or a limiting of organic material).

The cornerstones of the actions to be undertaken by the notified body of the products in the process of assessment and verification of constancy of performance are laid down in Table 3.3.2.

Table 3.3.2 Drainage with thermal insulating properties and vegetation support layer - 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					
1	The notified body shall verify the ability of the manufacturer for a continuous and orderly manufacturing of the product covered by the European Technical Assessment, taking especially into account a limiting of organic material, the addition of fire retardants and/or another clearly identifiable stage in the production process which results in the improvement of the reaction to fire classification. In particular the following items shall be appropriately considered – presence of suitable test equipment – presence of trained personnel – the suitability of the factory production control established by the manufacturer – full implementation of the prescribed test plan	Verification of the complete FPC, to be implemented by the manufacturer	See control plan	-	Before certification (When starting the production or a new production line and after modification of the production process)
Continuous surveillance, assessment and evaluation of factory production control					
2	It shall be verified that the system of factory production control and the specified manufacturing process are maintained, taking into account a limiting of organic material, the addition of fire retardants and/or another clearly identifiable stage in the production process which results in the improvement of the reaction to fire classification. In particular the following items shall be appropriately considered: – 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	Verification of the controls carried out by the manufacturer on the raw materials, on the process and on the product as indicated in Tables 3.2.1e and 3.2.1g	See control plan	-	Annually

4 REFERENCE DOCUMENTS

EN 933-1:2012	Tests for geometrical properties of aggregates - Part 1: Determination of particle size distribution - Sieving method
EN 1097-3:1998	Tests for mechanical and physical properties of aggregates - Part 3: Determination of loose bulk density and voids
EN 1296:2000	Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roof waterproofing - Method for artificial ageing by long-term exposure to elevated temperature
EN 1548:2007	Flexible sheets for waterproofing - Plastic and rubber sheets for roof waterproofing - Method for exposure to bitumen
EN 1604:2013	Thermal insulating products for building applications - Determination of dimensional stability under specified temperature and humidity conditions
EN 1605:2013	Thermal insulating products for building applications - Determination of deformation under specified compressive load and temperature conditions
EN 1844:2013	Flexible sheets for waterproofing - Determination of resistance to ozone - Plastic and rubber sheets for roof waterproofing
EN 1847:2009	Flexible sheets for waterproofing – Plastics and rubber sheets for roof waterproofing – Methods for exposure to liquid chemicals, including water
EN 1849-2:2019	Flexible sheets for waterproofing - Determination of thickness and mass per unit area - Part 2: Plastic and rubber sheets for roof waterproofing
EN 12056-3:2000	Gravity drainage systems inside buildings - Part 3: Roof drainage, layout and calculation
EN 12091:2013	Thermal insulating products for building applications - Determination of freeze-thaw resistance
EN 12225:2020	Geosynthetics - Method for determining the microbiological resistance by a soil burial test
EN 12311-2:2013	Flexible sheets for waterproofing - Determination of tensile properties - Part 2: Plastic and rubber sheets for roof waterproofing
EN 12447:2021	Geotextiles and geotextile-related products - Screening test method for determining the resistance to hydrolysis in water
EN 13037:2011	Soil improvers and growing media - Determination of pH
EN 13038:2011	Soil improvers and growing media - Determination of electrical conductivity
EN 13039:2011	Soil improvers and growing media - Determination of organic matter content and ash
EN 13651:2001	Soil improvers and growing media - Extraction of calcium chloride/DTPA (CAT) soluble nutrients
EN 13652:2001	Soil improvers and growing media - Extraction of water soluble nutrients and elements

EN 13163:2012 +A1:2015	Thermal insulation products for buildings - Factory made products of expanded polystyrene (EPS) - Specification
EN 13164:2012 +A1:2015	Thermal insulation products for buildings - Factory made extruded polystyrene foam (XPS) products - Specification
EN 13238:2010	Reaction to fire tests for building products – Conditioning procedures and general rules for selection of substrates
EN 13252:2016	Geotextiles and geotextile-related products - Required characteristics for use in drainage systems
EN 13501-1:2018	Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests
EN 13501-5:2016	Fire classification of construction products and building elements - Part 5: Classification using data from external fire exposure to roofs tests
EN 13823:2020 +A1:2022	Reaction to fire tests for building products – Building products excluding floorings exposed to the thermal attack by a single burning item
EN 13948:2007	Flexible sheets for waterproofing – Bitumen, plastic and rubber sheets for roof waterproofing – Determination of resistance to root penetration
EN 13956:2012	Flexible sheets for waterproofing - Plastic and rubber sheets for roof waterproofing - Definitions and characteristics
EN 15101-1:2013 +A1:2019	Thermal insulation products for buildings – In-situ formed loose fill cellulose (LFCI) products – Part 1: Specification for the products before installation
EN 15715:2009	Thermal insulation products - Instructions for mounting and fixing for reaction to fire testing - Factory made products
EN 29073-3:1992	Textiles; test method for nonwovens - Part 3: Determination of tensile strength and elongation
EN ISO 1182:2020	Reaction to fire tests for products – Non-combustibility test (ISO 1182:2020)
EN ISO 1716:2018	Reaction to fire tests for products – Determination of the gross heat of combustion (calorific value) (ISO 1716:2018)
EN ISO 6946:2017	Building components and building elements - Thermal resistance and thermal transmittance - Calculation methods
EN ISO 9863-1:2016 +A1:2019	Geosynthetics - Determination of thickness at specified pressures - Part 1: Single layers
EN ISO 9863-2:1996	Geotextiles and geotextile-related products - Determination of thickness at specified pressures - Part 2: Procedure for determination of thickness of single layers of multilayer products
EN ISO 9864:2005	Geosynthetics - Test method for the determination of mass per unit area of geotextiles and geotextile-related products
EN ISO 10319:2015	Geosynthetics - Wide-width tensile test

EN ISO 11925-2:2020	Reaction to fire tests - Ignitability of products subjected to direct impingement of flame - Part 2: Single-flame source test
EN 12226:2012	Geosynthetics - General tests for evaluation following durability testing
EN ISO 12236:2006	Geosynthetics - Static puncture test (CBR test)
EN ISO 12958-1:2020	Geotextiles and geotextile-related products - Determination of water flow capacity in their plane – Part 1: Index test
EN ISO 13428:2005	Geosynthetics - Determination of the protection efficiency of a geosynthetic against impact damage
EN ISO 13438:2018	Geosynthetics - Screening test method for determining the resistance of geotextiles and geotextile-related products to oxidation
EN ISO 13934-1:2013	Textiles - Tensile properties of fabrics - Part 1: Determination of maximum force and elongation at maximum force using the strip method
EN ISO 16535:2019	Thermal insulating products for building applications – Determination of long-term water absorption by immersion
EN ISO 16536:2019	Thermal insulating products for building applications – Determination of long-term water absorption by diffusion
EN ISO 25619-1:2021	Geosynthetics - Determination of compression behaviour - Part 1: Compressive creep properties
EN ISO 25619-2:2015	Geosynthetics - Determination of compression behaviour - Part 2: Determination of short-term compression behaviour
EN ISO 29469:2022	Thermal insulating products for building applications - Determination of compression behaviour
CEN/TS 1187:2012	Test methods for external fire exposure to roofs
CEN/TS 16459:2019	External fire exposure of roofs and roof coverings - Extended application of test results from CEN/TS 1187

Annex A Mounting and fixing procedure for reaction to fire tests and application rules for test results

A.1 Provisions for root barrier layers, protection layers, drainage layers made of geosynthetics and filter layers

A.1.1 EN ISO 1182 and EN ISO 1716

These test methods are relevant for reaction to fire classes A1 and/or A2.

The following parameters shall be considered for choosing and preparing the test specimens and the execution of tests:

- product variations of a defined product family[6,7],
- density,
- organic content,
- type and amount of flame retardants.

In addition, thickness and weight per unit area of each layer of non-homogenous products shall be considered, when calculating the total Q_{PCS} value of the entire product.

The results of these tests considering the aforementioned parameters are valid for

- all product variations of the same product family,
- with the same density (if only one was tested) or a density between highest and lowest density tested,
- with equal or lower organic content,
- with the same type and equal or higher amount of flame retardants,
- with any thickness in case of homogenous products and
- with the same thickness and weight per unit area of the layers of non-homogenous products used for calculating the total Q_{PCS} value of the entire product or
- with any thickness and weight per unit area between the highest and lowest values of these two parameters of the layers of non-homogenous products used for calculating the total QPCS value of the entire product.

A.1.2 EN 13823 (SBI test)

This test method is relevant for reaction to fire classes A2 to D according to EN 13501-1.

Dimension of the test rig and the test specimens

The dimensions of the specimens shall be as prescribed in the test standard. On the long wing of each test specimen at least one vertical and one horizontal joint shall be considered as prescribed in the test standard (200 mm for away from the inner corner of the test specimen and 500 mm above the floor of the specimen trolley). Execution of the joints shall be done with the minimum overlapping of the layers according to the instructions of the manufacturer for the application.

Substrate and fixing

Considering the intended use of the products, the test specimens shall be mechanically fixed onto an appropriate standard substrate according to EN 13238.

For fixing purposes metal screws and washers shall be used with their lowest number needed for a proper fixing of the test specimens on the substrate (at least one fixing mean in each corner of the various parts of the specimens).

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6 as defined by a certain combination of raw materials and produced in a certain type of production process

7 To permit the TAB to apply extended application rules for the test results, it is recommended that the manufacturer should provide (but is not obliged to do so) sufficient information (e. g., on the basis of the composition of the product in question), allowing the TAB to determine – with regard to the various product parameters - which products or product variants shall be submitted to testing and to reduce the number of tests required.

Test specimens

The following parameters shall be considered when preparing the test specimens:

- product variations of a defined product family[6,7]: Each relevant product variation (see parameters below) of the same product family shall be considered within the tests.
- thickness: Where relevant, the highest as well as the lowest thickness of the product shall be tested.
- density / weight per unit area: Where relevant, highest as well as the lowest density and weight per unit area respectively shall be tested.
- organic content: Where relevant, the product variation with the highest organic content shall be tested.
- flame retardants: Where relevant, each different type of flame retardants and that product variation with the lowest amount of this flame retardant shall be tested.
- orientation: If relevant, the specimen shall be mounted and tested with lengthwise and crosswise orientation to the product direction.

Application of test results

The results of tests taking into consideration completely the aforementioned parameters are valid for:

- all product variations of the same product family with,
- the tested thickness only or with any thickness between highest and lowest value tested,
- the tested density / weight per unit area only or with any density / weight per unit area between highest and lowest value tested,
- equal or lower organic content than tested,
- the same type and equal or higher amount of flame retardants and
- any orientation of the product.

A.1.3 EN ISO 11925 (small ignition source test)

This test method is relevant for reaction to fire classes B to F according to EN 13501-1.

Dimensions of the test specimens and preparation

The dimension of the test specimens shall be as prescribed in the test standard. No joints shall be considered when preparing the test specimens.

Substrate

The test specimens shall be tested free-hanging without any substrate behind. This configuration is considered as the probably most onerous specimen configuration for these types of products within tests with this test method.

If tests on free-hanging specimens fail, the specimens shall be fixed and tested again onto an appropriate standard substrate according to EN 13238. If it is intended to determine one of the classes B, C or D, the substrate shall be the same one as used for the SBI tests according to EN 13823 (see A.1.2).

Test specimens and application of test results

The same rules as stated in clause A.1.2 shall apply regarding the product parameters to be considered when choosing and preparing the test specimens as well as regarding the application of test results.

Type of flame exposure

The specimens shall be tested with surface flame exposure as well as with edge flame exposure (see clauses 7.3.3.1 and 7.3.3.2 of the test standard). In case of multi-layer products, an additional set of tests with edge flame exposure on each single layer of specimens turned 90 degrees on their vertical axis shall be executed, if the conditions of clause 7.3.3.2.3 of the test standard are fulfilled.

A.2 Provisions for the vegetation support layer

A.2.1 EN ISO 1182 and EN ISO 1716

The same rules as stated in clause A.1.1 shall apply, whereby "density" relates to the bulk density of the vegetation support layer.

A.2.2 EN 13823 (SBI test)

This test method is relevant for reaction to fire classes A2 to D according to EN 13501-1.

Dimension of the test rig and the test specimens

The dimensions of the specimens shall be as prescribed in the test standard. Since the vegetation support layer consists of loose-fill material, a specimen holder as described in EN 15101-1 shall be used, but with the following modifications (considered as necessary to reduce the influence of the specimen holder on the test results):

- use of a single metal mesh with a wire diameter of 1.5 mm and rectangular format of the mesh openings of 25 mm x 25 mm,
- positioning of only one steel angle with dimensions 10 x 10 x 1,5 mm in the internal corner of the holder (instead a massive steel-square stud or timber stud) which is only connected at bottom and top edge with the profiles at the backside of the specimen holder,
- movable clamps or rails at bottom and top edge of the holder for a flexible positioning of the substrate boards inside the specimen holder for testing different thicknesses of the vegetation support layer.

Substrate and fixing

The specimen holder shall be mounted directly in front of an appropriate standard substrate according to EN 13238 (if 200 mm thick specimens shall be tested) or the selected standard substrate according to EN 13238 shall be inserted in the specimen holder and be fixed with the movable clamps / rails (if a smaller thickness than 200 mm shall be tested).

Test specimens

The following parameters shall be considered when preparing the test specimens:

- product variations of a defined product family[6,7]: Each relevant product variation (see parameters below) of the same product family shall be considered within the tests.
- thickness: Where relevant, the highest as well as the lowest thickness of the product shall be tested.
- bulk density: Where relevant, highest as well as the lowest bulk density shall be tested.
- organic content: Where relevant, the product variation with the highest organic content shall be tested.

Application of test results

The results of tests taking into consideration completely the aforementioned parameters are valid for:

- all product variations of the same product family with,
- the tested thickness only or with any thickness between highest and lowest value tested and also with any higher thickness, if 200 mm thick specimens were tested,
- the tested bulk density only or with any density between highest and lowest value tested,
- equal or lower organic content than tested.

A.2.3 EN ISO 11925 (small ignition source test)

This test method is relevant for reaction to fire classes B to F according to EN 13501-1.

Dimensions of the test specimens and preparation

The dimension of the test specimens shall be as shaped by the specimen holder for loose-fill materials defined in clause 4.5 and shown in figure 5 of the test standard.

Substrate

The test specimens shall be tested free-hanging without any substrate behind.

Test specimens and application of test results

The same rules as stated in clause A.2.2 shall apply regarding the product parameter (except for thickness) to be considered when choosing and preparing the test specimens as well as regarding the application of test results.

Regarding the parameter thickness the test results with a thickness as formed by the standard specimen holder are valid for any other thickness.

Type of flame exposure

The specimens shall only be tested with surface flame exposure (see clauses 7.3.3.1 of the test standard).

Annex B Ageing procedure for the assessment of the durability of protection layers and drainage layers

The durability of protection layers and drainage layers shall be tested following Annex B.2 and B.4 of EN 13252 for an intended use of 25 years considering the following provisions.

Table B.1 Ageing procedure for the assessment of the durability of protection layers and drainage layers

Material type	Ageing procedure* according to
PE	- EN 13252, Annex B.4, clause B.4.2.2 (100°C/28 days) or - EN 13252, Annex B.4, clause B.4.2.2 (deviating from the test standard the tests shall be carried out with a temperature of 90 °C and a test time of 56 days) or - EN 13252, Annex B.4, clause B.4.2.2 (deviating from the test standard the tests shall be carried out with a temperature of 80 °C (water) at 30 bar and with a test time of 28 days)
PP	- EN 13252, Annex B.4, clause B.4.2.2 (100°C/28 days) or - EN 13252, Annex B.4, clause B.4.2.2 (deviating from the test standard the tests shall be carried out with a temperature of 90 °C and a test time of 56 days) or - EN 13252, Annex B.4, clause B.4.2.2 (deviating from the test standard the tests shall be carried out with a temperature of 80 °C (water) at 30 bar and with a test time of 28 days) or - EN ISO 13438 – Method A (100°C/28 days)
Polyester / PET	EN 12447 the tests shall be carried out with a temperature of 80 °C and a test time of 14 days - see EN 13252, Annex B.4, clause B.4.2.1
PA	EN ISO 13438 – Method A (100°C/28 days) and EN 12447
PS	EN ISO 13438 – Method A and EN 12447 (deviating from the test standard the tests shall be carried out with a temperature of 70 °C and a test time of 56 days)
ABS	EN ISO 13438 – Method A (100°C/28 days) and EN 12447
Rubber	EN ISO 13438 – Method A (100°C/28 days) and EN 12447 and EN 1844

* In case different methods are referred to for a material type (PE and PP), the results of the different test methods are considered equivalent. The first test method given above is the reference method. The method used shall be presented along with test results.

Annex C Conditions concerning the assessment of the kit

The components of the kit are protected from weathering, sunlight and mechanical damage during transport and storage by suitable packaging and/or covering unless other measures are provided for this purpose.

All materials of the kit components are compatible with each other or measures are taken to ensure that no deleterious effects occur between materials. For example, a separation layer can be used between the components.

The vegetation support layer does not contain significant impurities.

If the kit does not include a root barrier layer the kit is only used on a root-resistant waterproofing layer or an additional appropriate root barrier layer (not part of the kit) is installed. The whole roof including connections to other building elements, penetrations, etc. is executed root-resistant.

The protection layer of the kit is matched with the waterproofing layer.

The seams of the root barrier layer are appropriately jointed depending on the material (e.g., heat-welded). The root barrier layer is immediately covered after installation to avoid a long-term weathering.

Depending on the compressive strength of the drainage layer appropriate measures are taken during installation to avoid damage of the layer.

The roof is designed with adequate falls. For roofs with a slope of less than 2 % special measures for roof dewatering and drainage will be provided. The roof is designed to avoid the long-term presence of excess water. The roof build-up, the slope and the vegetation are matched with each other. Drainage is designed in accordance with EN 12056-3.

The roof is designed to avoid surface condensation within the building and deleterious condensation within the roof structure.

The assembled system has a sufficient resistance to wind loading (ballasting to resist the wind uplift force) depending on the place of use.

Only undamaged components are installed. The kit is laid on a sufficiently even surface.

The components are installed in a single layer. The joints are in accordance with the provisions in the ETA and the Manufacturer's Product Installation Instructions (MPII) (closely installed with staggered joints or installed with overlaps).

In case of using plants with heavy rhizome growth (e.g., certain species of bamboo and Chinese reeds) special structural arrangements and maintenance are provided in addition to the root barrier layer.

A continuous maintenance (e.g., cleaning, removing of unwanted vegetation, fertilizing, watering, checking the drainage/watering system, plant care) of the green roof is performed depending on the types of greening and the form of vegetation.

Annex D Determination of the coefficient of discharge/run-off reference value

D.1 Principle

The coefficient of discharge / run-off reference value is determined according to the following procedure [8] by determining the water discharge from a green roof build-up during a 15-minute rainfall of r = 300 l/(s·ha) after previous water saturation and draining for 24 hours.

D.2 Apparatus

The following test equipment is required and shall be mounted in a wind and rain protected testing hall:

- measuring tables (5 m x 1 m) with side upstand in accordance with the construction thickness of the green roof build-up to be assessed, sieve grid (approximately 3 mm mesh width) at the end of the drain, adjustable gradient in steps, waterproof seal, gutter or drainage funnel at the end of the slope (with drainage nozzle), see figure D.2.1.
- irrigation device consisting of a nozzle tube with as uniform as possible distribution of the rain (attachment about 60 cm – 80 cm above the build-up to be assessed), all-sided film protection to avoid drift drip, optionally pressure reducer in the supply line for fine regulation of rainfall, flow meter or precision water meter for measuring the rainfall as a function of time (with a stopwatch or electronically),
- measuring device to measure the run-off water volume (per time unit).

Figure D.2.1: Example of measuring tables (which can be made of other material, e.g., wood with sealing)
Source: Daniel Westerholt

The measurement is done either

a) visually
   - by collecting container with water exchange indicator, or
   - by calibrated collecting container, or
   - by precision water meter

   and monitoring of time by using a stopwatch

or

b) electronically
   - by means of weighing, or
   - by precision water meter

   and monitoring of time and volume by using data logger

8 In accordance with attachment B.4 of Appendix B of the "Green Roof Guidelines" (2018) published by FLL.

D.3 Execution
The test shall be carried out with a moist green roof build-up in an un-greened state (unless in case of components that can only be prefabricated in greened state) with a gradient of 2 %.

At first a saturating irrigation is performed until a steady drain of water is maintained for 10 minutes (avoid irrigation drift). Then it follows a drain period of 24 hours so that the state of maximum water capacity is approximately set. After that a rain of 27 l/m² (≙ 300 l/(s·ha)) in 15 minutes in as even an intensity as possible is carried out. The water discharge is recorded during the irrigation period as a function of time. The 15 minutes rain of 27 l/m² shall be repeated 3 times (each after a 24-hour interval of draining).

D.4 Calculation
The coefficient of discharge /run-off reference value is calculated as follows (using the mean values of the 3 test results for the water discharge and the rain volume:

$$C = \frac{water\ discharge\ in\ 15\ minutes\ (in\ liter)}{rain\ volume\ in\ 15\ minutes\ (in\ liter)}$$

Due to the effect of vegetation and rooting 0.05 units are subtracted from the measurement result. For components that can only be prefabricated in greened state (e.g., vegetation mats) this credit is not applicable.

The test result is valid for roofs up to 5° roof pitch.
For higher roof pitches additional measurements should be made with 5°, 10° and 15° roof pitch to allow interpolation between these test results.

Annex E Determination of the resistance to rhizomes of the root barrier layer

E.1 Principle

The resistance to rhizomes is determined according to the following procedure [9]. The root barrier layer is considered to be rhizome-resistant against couch grass if, after the test period, no rhizome ingress nor rhizome penetration is found in any of 8 test containers in which a root barrier layer has been installed, provided that all couch grasses used in the test have shown sufficient growth performance during the entire test phase (at least 40 % of the surface has to be covered by couch grass).

The test will be performed together with the test of the resistance to root penetration. Also the woody plants have to show a sufficient growth performance (at least 80 % of the height and the stem diameter of the plants in 3 control containers which are included into the test without a root barrier layer).

The care of the plants during the growth period shall be carried out according to EN 13948, clause 7.4.

E.2 Apparatus

For the determination of the resistance to rhizomes the following test equipment is needed.

E.2.1 Test conditions and location for the test procedure

A 2-years test and / or a 4-years test is possible for the determination of the resistance to rhizomes. The results of both methods are considered equivalent. The 2-years test is the reference method. The method used shall be presented along with test results.

a) 4-years test

For the 4-years test a hall with climate conditions similar to outdoor conditions shall be used. To create this test conditions the hall should be equipped with a transparent roofing, otherwise open on all sides. Any precipitation is held off so that water logging in the non-draining containers will be avoided.

An unheated greenhouse can also be used if it has sufficient ventilation and allows a frost effect.

b) 2-years test

For the 2-years test a greenhouse with adjustable heating and ventilation shall be used.

The inside temperature in the greenhouse shall be 18 °C (± 3) during the day and 16 °C (± 3) during the night by using the heating. The greenhouse shall be ventilated at an internal temperature of 22 °C (± 3). A persistent temperature over 35 °C shall be avoided in the greenhouse.

E.2.2 Test containers

The used test containers shall have internal dimensions of at least 800 mm x 800 mm x 250 mm (see Figure E.2.2.1). The containers shall be prepared as described in clause E.3 (see "Execution").

The transparent container base (e.g., acrylic glass) shall be a tray with a 20 mm upstand to maintain a constant supply of water in the moisture course. In order to avoid the growth of algae in the moisture layer in the container the transparent base of the container shall be darkened (e.g., with a foil which is impervious to light).

A filling pipe is mounted on the outside of the container (see Figure E.2.2.1), pointing upwards and abutting onto the upstand of the base tray. The water supply into the moisture layer is affected with this filling pipe (with a diameter of 35 mm).

9 In accordance with Appendix C of the "Green Roof Guidelines" (2018) published by FLL.

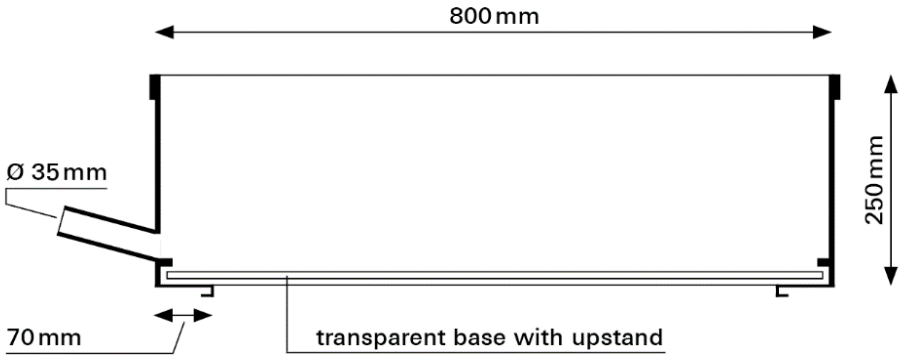

Figure E.2.2.1: Construction design of the test containers

E.2.3 Moisture layer
The moisture layer consists of expanded slate or expanded clay according to table E.2.3.1 with a particle size from 8 mm to 16 mm.
For each test container (800 mm x 800 mm) approximately 32 litre material shall be used for a course depth of 50 mm (± 5 mm).

Table E.2.3.1: Quality of the expanded clay/slate of the moisture layer

Soluble salts (calculated as KCl)	< 0.25 g/100 g
CaO	< 120 mg/100 g
Na_2O	< 15 mg/100 g
Mg	< 15 mg/100 g
Cl^{--}	< 10 mg/100 g
F^{--}	< 1.2 mg/100 g
Determinated with water extracted from the ground material with demineralized water (in a 1:10 (weight/volume) ratio)	

E.2.4 Protective fleece
For the test procedure a geotextile fleece made of synthetic fibres (with a weight of approximately 200 g/m²) shall be used. For each test container (800 mm x 800 mm) approximately 0.64 m² material shall be used. The material compatibility of the used fleece with the root barrier layer to be tested shall be ensured.

E.2.5 Root barrier layer to be tested
The root barrier layer to be tested shall be laid and/ or applied according to clause E.3 (see "Execution"). The surface to be treated (minus the 50 mm depth of the moisture course) amounts to approximately 1.3 m² material (without overlapping) for each trial container (800 mm x 800 mm x 250 mm).

E.2.6 Growing media
The growing media consists of 30 % (by volume) expanded clay or slate with particle size from 8 mm to 16 mm (see clause E.2.3) and 70 % (by volume) minimally decomposed moorland peat.

Calcium carbonate ($CaCl_2$) should be added to bring the pH value between 5.5 and 6.5 (see clause E.2.7). Before filling the container, the vegetation stratum shall be mixed with the initial fertilizing (see clause E.2.8) in a homogenous way.

For each trial container (800 mm x 800 mm) approximately 88 litre material shall be used for the 2-year test (taking into account a substrate supply via plant root balls) and approximately 96 litre material for the 4-year test (with a layer depth of 150 mm ± 10 mm).

E.2.7 pH settings
Different quantities of calcium carbonate ($CaCl_2$) can be necessary in order to set the pH value to 5.5 – 6.5 for the vegetation stratum (see clause E.2.6).

The needed quantity of calcium carbonate can be determined as follows:

5 samples (each 1 litre) shall be taken from the well-mixed vegetation support course. After moisten the samples with water each sample shall be mixed with a different quantity of calcium carbonate (4, 5, 6, 7 and 8 grams).
The samples are stored for 3 days at approximately 20°C (room temperature), each in a closed and labelled plastic bag. Then the pH value of each sample shall be determined.
Depending on the test results of the tested 5 samples the needed quantity of calcium carbonate can be extrapolated.

E.2.8 Fertilizer
For the initial fertilizing a multiple-nutrient fertilizer with approx. 15 % N, 10 % P_2O_5, 15 % K_2O, 2 % MgO and less than 0.5 % Cl as well as a fertilizer containing nutrient trace elements with Fe, Cu, Mo, Mn, B and Zn shall be used.
For each container (800 mm x 800 mm) approximately 30 grams of a multiple-nutrient fertilizer shall be used.

For the repeated fertilizing slow-release fertilizer capsules with approximately 15 % N, 10 % P_2O_5, 15 % K_2O and a release time of 6 – 8 months shall be used.
For each container (800 mm x 800 mm) approximately 30 grams of this fertilizer should be used.

E.2.9 Tensiometer
In each container a tensiometer (with a measuring range of 0 – 600 hPa) shall be installed in order to monitor the watering of the vegetation support course.

E.2.10 Test plants
4 woody plants (alder or pyracantha) and 2 grams of couch grass seeds shall be planted in each container (800 mm x 800 mm). The calculated plant density should be 6,25 woody plants per m² and 3,13 grams seeds per m².

a) <u>4-years test</u>

For the 4-years test the following two plant species shall be used:

- grey alder (alnus incana), height 60 cm – 100 cm, 2-year replanted seedling

- couch grass (agropyron repens), seeds

b) <u>2-years test</u>

For the 2 years test the following two plant species shall be used:

- pyracantha (pyracantha coccinea "orange charmer"), height 60 cm – 80 cm, in a 2 litre container

- couch grass (agropyron repens), seeds

E.2.11 Watering
For the watering water according to table E.2.11.1 shall be used. The water shall be blended with fully desalinated water or with rain water if any of the given values in table E.2.11.1 are exceeded (see table E.2.11.1).

Table E.2.11.1: Quality of the water used for watering

Conductivity	< 1000 µS/cm
Sum earth alkaline	< 5.4 mmol/l
Acid capacity (up to pH 4,3)	< 7.2 mmol/l
Chloride	< 150 mg Cl/l
Sodium	< 150 mg Na/l
Nitrate	≤ 50 mg NO_3/l

E.3 Execution

The resistance to roots and rhizomes ingress and / or penetration is tested with test plants in a test container and under standardized conditions.

The test can be carried out during 4 years outdoors where alders and couch grasses are used as test plants.
Alternatively, a 2-years test can be carried out in a climate-controlled greenhouse using pyracantha and couch grass as test plants. The results of both methods are considered equivalent. The 2-years test is the reference method. The method used shall be presented along with test results.

The used test plants have to show a sufficient growth performance, which shall be checked as follows:
- couch grass: at least 40 % of the surface of the test container has to be covered by couch grass,
- woody plants: the woody plants in the test container have to show a sufficient growth with at least 80 % of the height and the stem diameter of the woody plants in the control containers (which are included also into the test, but without a root barrier layer).

The root barrier layer is installed in 8 test containers with several seams/joints and / or one work interruption joint.
Three more control containers without root barrier layer serve as a control for plant growth.

The containers shall be prepared with the following build-up: moisture lay, protective layer, root barrier layer to be tested, vegetation stratum and planting (from bottom to top).

The moisture layer (with a depth of 50 mm ± 5 mm) is laid directly above the transparent base of the container as the bottom layer. After this the protective layer is cut to size (based on the base area of the container) and laid directly onto the moisture layer.

The root barrier layer to be tested is installed on top of the protective layer with 4 seams at the corners where the walls meet, 2 seams along the base at the corners and 1 T-seam running along the middle (see Figure E.3.1). The root barrier layer shall be brought up to the rim of the container walls.

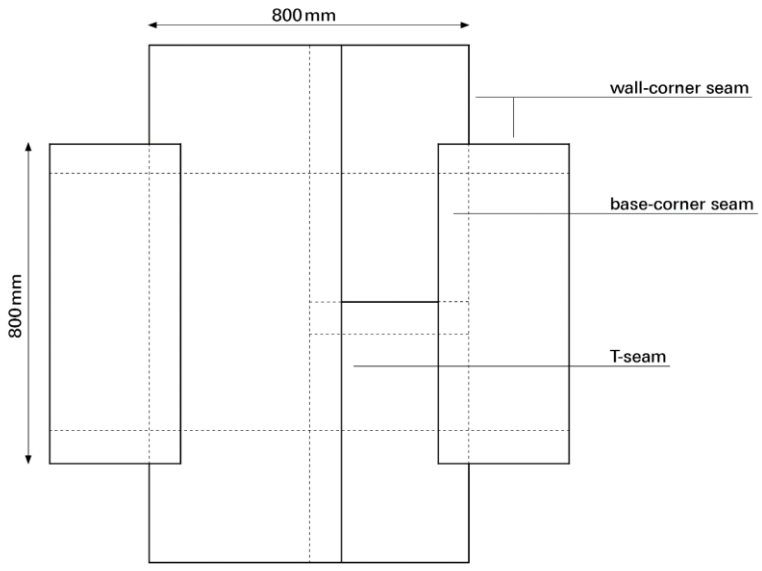

Figure E.3.1: Layout of the seams in the root barrier layer to be tested

The vegetation substrate (with a layer depth of 150 mm ± 10 mm) is filled in the container after the installation of the root barrier layer to be tested.

For the 4-years test 4 "Alnus incana" plants (grey alder) per one container (800 mm x 800 mm) equally spread over the entire surface shall be planted, for the 2-years test 4 "Pyracantha coccinea" plants (see Figure E.3.2). In addition, for both test types 2 grams of seeds of "Agropyron repens" (couch grass) per container are to be sown equally onto the vegetation support layer.

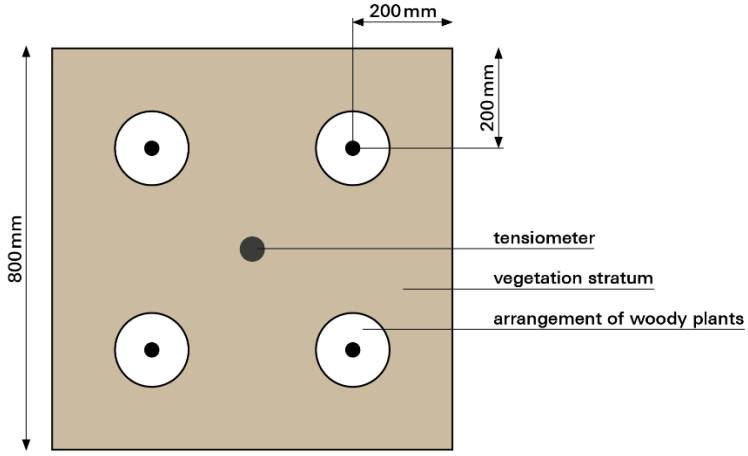

Figure E.3.2: Arrangement of tensiometer and woody plants in the vegetation stratum of a container

The ceramic cell of the tensiometer is placed into the vegetation stratum directly on top of the root barrier layer. The tensiometer shall be placed at an equal distance to the plants in the container (see Figure E.3.2).

The containers shall be arranged in a random order with a minimum distance of 0.4 meters between and around the containers. The containers should be placed on stands to facilitate root penetration checks at regular intervals.

The desired high root pressure shall be obtained with dense planting, moderate fertilizing and modest watering.

E.4 Assessment

The assessment of the test process shall be carried out in accordance with EN 13948, clause 8, during the testing time and at the end of the testing time.

During the testing time (2-years or 4-years) the transparent bases of all 8 trial containers shall be examined at intervals of 6 month in order to detect visible roots and rhizomes (e.g., successful root penetration).

At the end of the testing time (2-years or 4-years) the vegetation stratum is taken out of all 8 trial containers in order to examine the root barrier layer for root and rhizome ingress and/ or penetration. Possible root and/or rhizome ingress and penetration into the root barrier layer shall be recorded.

The root barrier layer is considered to be rhizome-resistant against couch grass if, during the test period, no rhizome ingress nor rhizome penetration is found in any test container.

a) Root and/or rhizome ingress

Root/rhizome ingress is to be recorded if roots/rhizomes have established itself in the surface or in the seams of the tested root barrier layer, where subterranean plant parts have actively created cavities and have thus damaged the tested root barrier layer.

b) Root and/or rhizome penetration

Root/rhizome penetration is to be recorded if roots/rhizomes have penetrated the area or the seams of the tested root barrier layer. These roots/rhizomes have used pores present in the root barrier layer or have actively created cavities.

Annex F Determination of the water permeability of loose fill drainage layers and of the vegetation support layer

F.1 Principle

The water permeability of the materials in the compressed state is determined using cylindrical vessels and in the state of maximum water capacity by evaluating of the needed time for a sinking of the water level[10].

F.2 Apparatus

For the determination of the water permeability the following test equipment is needed.

- measuring probe rings: wire ring (approximately 40 mm diameter) on which two measuring tips (45 mm and 35 mm long) are mounted perpendicular to its plane,
- plastic bowls for immersion (with a depth of at least 200 mm),
- spacers to allow water access through the perforated base (about 10 mm deep),
- filter geotextile fleece to cover the top of the specimen (148 mm diameter),
- sieve mesh to cover the top of the specimen (148 mm diameter, mesh 0.6 mm),
- stone sett as a weight to rest on top of the specimen (100 mm x 100 mm),
- plastic bowls to allow the water to drip away, with drainage panels on top of them (made from spherical pieces of bonded foam, at least 50 mm thick),
- cylindrical plastic containers with a perforated base (height 165 mm, inside diameter 150 mm), see figure G.2.1

Perforation radius interval		15°
Perforation perimeter spacing		10 mm
Perforation diameter		5 mm
Number of perforations (see figure F.2.1):		
Centre	1 x 1 =	1
90° intervals	4 x 7 =	28
30° / 60° intervals	8 x 6 =	48
15° / 45° / 75° intervals	12 x 4 =	48
		125

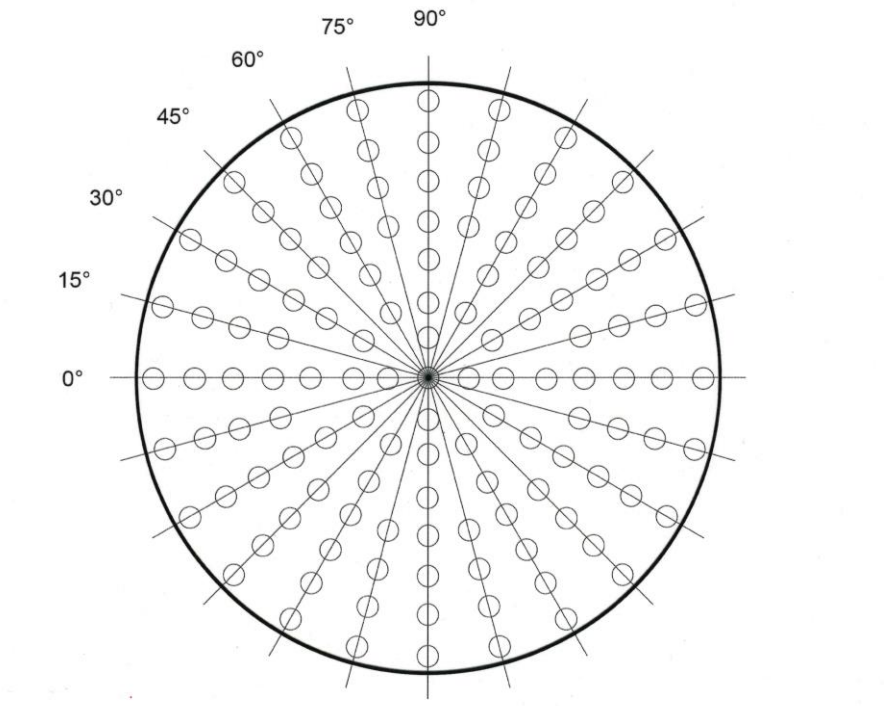

Figure F.2.1: Arrangement of perforations (base of cylindrical plastic container)

10 In accordance with attachment B.3 of Appendix B of the "Green Roof Guidelines" (2018) published by FLL.

F.3 Execution

The test shall be carried out in three parallel tests. In each case the measurement shall be repeated 3 times.

The loose fill material (approximately 2100 ml – 2500 ml) of the drainage layer or vegetation support layer is compressed manually into the above-mentioned cylindrical plastic container by six strikes with a proctor-hammer (drop hammer with a weight of 4.5 kg and a drop height of 450 mm and a steel-plate with a diameter of 145 mm and a thickness of 10 mm).

The surface of the material compressed in cylindrical vessels shall be covered with the geotextile filter fleece and the sieve mesh. The stones are laid on the top of this specimen to prevent this from floating.

These containers shall be placed in plastic bowls where water will be added slowly up to approximately 10 mm below the specimen surface. More water shall be filled in (up to approximately 10 mm above the specimen surface) after the surface of the specimen has been soaked. If necessary, more water should be filled in so that the excess water level is maintained.

The cylinders shall be removed after soaking for 24 hours and placed then on drainage panels over plastic bowls for draining for 2 hours. After placing the measuring probe ring on the top of the specimen the cylinder shall be filled carefully with water from above (submersing by approximately 10 mm – 20 mm). More water shall be added continuously as the water level drops so that the submersion is maintained.

When the water flows out evenly of the holes in the base of the cylinder the actual measurement shall be started (see figure F.3.1). Additional water is filled up to over the measuring probe. The drop-in water level shall be measured and also the time which needs the water level to drop from the top to the bottom measuring probe (i.e., from 45 mm to 35 mm).

Figure F.3.1: Cylindrical plastic container with geotextile filter fleece, sieve mesh and measuring probe ring (on the top of the specimen)
Source: Daniel Westerholt

F.4 Calculation
The water permeability shall be calculated as follows:

mod. $K_f = \frac{1}{t} \times \frac{h}{h+4,0}$ [cm/s]
with
t = time for the sinking of the water level from 45 mm to 35 mm (in s)
h = height of the compressed specimen (in cm)

The test result is the mean value of all measurements (in mm/min).

Annex G Determination of the maximum water capacity of the vegetation support layer

G.1 Principle

The maximum water capacity shall be determined with compacted materials in cylindrical vessels after a total immersion in water for 24 hours followed by drip off for 2 hours[11].

G.2 Apparatus

For the determination of the maximum water capacity the following test equipment is needed.

- plastic bowls for immersion (with a depth of at least 200 mm),
- spacers to allow water access through the perforated base (about 10 mm deep),
- filter geotextile fleece to cover the top of the specimen (148 mm diameter),
- sieve mesh to cover the top of the specimen (148 mm diameter, mesh 0.6 mm),
- stone sett as a weight to rest on top of the specimen (100 mm x 100 mm),
- plastic bowls to allow the water to drip away, with drainage panels on top of them (made from spherical pieces of bonded foam, at least 50 mm thick),
- cylindrical plastic containers with a perforated base (height 165 mm, inside diameter 150 mm), see figure G.2.1

Perforation radius interval		15°
Perforation perimeter spacing		10 mm
Perforation diameter		5 mm
Number of perforations (see figure F.2.1):		
Centre	1 x 1 =	1
90° intervals	4 x 7 =	28
30° / 60° intervals	8 x 6 =	48
15° / 45° / 75° intervals	12 x 4 =	48
		125

Figure G.2.1: Example of a cylindrical plastic container (with a perforated base)
Source: Daniel Westerholt

11 In accordance with attachment B.2 of Appendix B of the "Green Roof Guidelines" (2018) published by FLL.

G.3 Execution

The test shall be carried out in three parallel tests.
The loose fill material (approximately 2100 ml – 2500 ml) of the vegetation support layer is compressed manually into the above-mentioned cylindrical plastic container by six strikes with a proctor-hammer (drop hammer with a weight of 4.5 kg and a drop height of 450 mm and a steel-plate with a diameter of 145 mm and a thickness of 10 mm).
The surface of the material compressed in cylindrical vessels is covered with the geotextile filter fleece and the sieve mesh. The stones are laid on the top of this specimen to prevent this from floating.

These containers shall be placed in plastic bowls where water will be added slowly up to approximately 10 mm below the specimen surface. More water shall be filled in (up to approximately 10 mm above the specimen surface) after the surface of the specimen has been soaked. If necessary, more water should be filled in so that the excess water level is maintained.
The cylinders shall be removed after soaking for 24 hours and placed then on drainage panels over plastic bowls for draining for 2 hours. Then the weight of the container with the specimen is determined after draining the container and removing the cover from the specimen surface. The weight of the specimen (at maximum water capacity) is calculated by subtracting the known cylinder weight.
The volume of the specimen shall be determined with the height of the specimen in the cylinder and the diameter of the used container ($\pi \cdot r^2 \cdot h$). The weight of the specimen in dry condition shall be determined after drying the sample at 105° C.

G.4 Calculation

The maximum water capacity shall be calculated as follows:

$WK_{max} = \frac{(m\,wk - m\,t)\ x\ 100}{V\,wk}$ [vol. %]

with

m_{wk} = mass (weight) at maximum water capacity (in g)

m_t = mass (weight) in dry condition (in g)

The test result shall be expressed as the mean value of 3 parallel tests.