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SYSTEMS OF MECHANICALLY FASTENED FLEXIBLE ROOF WATERPROOFING SHEETS

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

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1 SCOPE OF THE EAD

1.1 Description of the construction product

This EAD covers systems of mechanically fastened flexible roof waterproofing sheets (MEFAWAS).

The MEFAWAS is a particular combination of a defined set of components, such as one or more waterproofing sheets or welding materials installed in the works by application and/or incorporation and/or assembly of the components in conformity with particular design methods and/or particular execution methods to form a watertight layer on top of the roof.

This EAD in particular covers single or multi-layer waterproof coverings connected to the load-bearing structure by point or linear fasteners (Annex 3). These fasteners can pass through or not (without penetration) of the waterproofing sheet, e.g. by induction. Furthermore, the MEFAWAS may include the insulation material as an integrated part of the MEFAWAS.

The waterproof coverings are limited to continuous watertight kits based on flexible sheets made of: polymeric, bituminous or rubber materials and manufactured in the factory.

The load-bearing structures can be made of metal, concrete or timber. These MEFAWAS are made of non-load bearing construction elements.

This EAD does not cover the assessment of the whole roof. But the elements of the roof structure that may affect the performance of the waterproofing system have to be considered.

The Fastening system is an assembly of components intended to secure a waterproofing system to the load-bearing structure by means of point fasteners or linear fasteners. Whilst primarily intended to secure the covering against wind uplift forces, the system may contribute to securing intermediate layers such as thermal insulation, or a vapour control layer.

The following fasteners are used for MEFAWAS: point fasteners and powder actuated fasteners.

A fastener can be made of a washer, a metal sleeve and a screw or of a plastic washer with an integrated sleeve and a metal shank. Two fasteners at spacing less than or equal to 120 mm in the same top flange are regarded as one fastener.

Kits on timber structures fastened by clout nails are outside the scope of this EAD.

The manufacturer can provide:

- i) A complete kit, including sheet, fasteners and (sometimes) insulation, or
- ii) The flexible roof waterproofing sheet alone (without fasteners or insulation). In this case, the characteristics of the components of the MEFAWAS shall be detailed in the ETA by reference to the relevant technical specification or, if this is not possible, by stating the trade name of the component.
- iii) The fastener can be marketed separately, with an individual ETA.

The product is 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 product as he considers necessary.

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

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

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

1.2.1 Intended use(s)

The intended use of these MEFAWAS are the waterproofing of the roof, preventing the passage of water from one plane to another. MEFAWAS do not contribute directly to the stability of the roof on which is installed.

These can be used on new or existing (retrofit) roofs. It can also be used on horizontal surfaces (singular details).

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 for the intended use of 10 years when installed in the works (provided that these MEFAWAS are subject to appropriate installation (see 1.1)). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product, the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works¹.

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.

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

1.3 Specific terms used in this EAD

1.3.1 Axial fastener failure. Equal to the pull out of a fastener, or failure of a fastener in the direction perpendicular to the surface.

1.3.2 Jointing technique. Sealing of at least two layers of waterproofing sheets, e.g. bonding (torch, adhesive) or welding (hot air, chemicals).

1.3.3 Linear fastener. Commonly a continuous strip or lath of metal or other material perforated by point fasteners intended to secure the waterproof covering in the general area of the roof and/or at its perimeter.

1.3.4 Point fastener. Commonly a shaft, in the form of a screw, nail or expanding anchor, together with a disc-shaped washer or collar. Forces may be transmitted to the fastener by the clamping action of the washer or by bond between a plastic surface on the washer and a plastic roof covering, or by other means.

1.3.5 Loads. Corrected load (W_{char}) = test load modified by correction factors of the test.
Admissible (design) load (W_{adm}) = the load per fastener derived from the test load (W_{char}) (see Annex 1).

1.3.6 Roof. The structural deck and all the layers on it, including the surface that is exposed to the weather and including the necessary details.

1.3.7 Structural deck. The part of the roof that, as a construction element, has to transfer both permanent and variable loads to the other parts of the building.

1.3.8 Induction fastening system. It is based on electromagnetic induction welding technology and is suitable for e.g. TPO and PVC sheets. The system can use the same fastener to secure both the insulation and the sheet to the deck without penetrating the roofing material.

1.3.9 Point fastener. A shaft, in the form of a screw, nail or expanding anchor, together with a disc-shaped washer or collar. Forces may be transmitted to the fastener by the clamping action of the washer or by bonding between a plastic surface on the washer and a plastic roof covering.

1.3.10 Powder actuated fastener. A fastener, which is shot, fired into the substrate.

1.3.11 MEFAWAS. Systems of mechanically fastened flexible roof waterproofing sheets.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

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, testing for issuing the ETA is not required.

Table 1 shows how the performances of systems of mechanically fastened flexible roof waterproofing sheets are assessed in relation to the essential characteristics.

Table 1.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

System (MEFAWAS)			
Nº	Essential characteristic	Assessment method	Type of expression of product performance (level, class, description)
Basic Works Requirement 2: Safety in case of fire			
1	External fire performance of roofs	2.2.1.1	Class
Basic Works Requirement 3: Hygiene, health and the environment			
2	Content, emission and/or release of dangerous substances	2.2.1.2	Level
Basic Works Requirement ER4: Safety and accessibility in use			
3	Resistance to wind loads (Wind uplift test: W_{adm})	2.2.1.3	Level

Table 1.2 Essential characteristics of the components of the MEFAWAS and methods and criteria for assessing their performance in relation to those essential characteristics

Sheet			
Nº	Essential characteristic	Assessment method	Type of expression of product performance (level, class, description)
Basic Works Requirement 2: Safety in case of fire			
4	Reaction to fire	2.2.2	Class
Basic Works Requirement 3: Hygiene, health and the environment			
5	Resistance to peel (joint)	2.2.2.1	Level
6	Resistance to shear (joint)	2.2.2.2	
7	Resistance to tear	2.2.2	
8	Resistance to cold bending/folding	2.2.2	
9	Resistance to water pressure	2.2.2	
10	Resistance to water vapour permeability	2.2.2	
11	Tensile properties	2.2.2	
12	Resistance to static and impact loading	2.2.2	
13	Dimensional stability	2.2.2	
14	Thickness	2.2.2	
15	Flow resistance at elevated temperature for bituminous sheets	2.2.2	
16	Resistance to ageing media	2.2.2.3	Class
Basic Works Requirement ER4: Safety and accessibility in use			
17	Slipperiness	2.2.2.4	Level
Fasteners			
Nº	Essential characteristic	Assessment method	Type of expression of product performance (level, class, description)
Basic Works Requirement 2: Safety in case of fire			
Basic Works Requirement ER4: Safety and accessibility in use			
18	Fastener axial load	2.2.3.1	Level
19	Resistance to fastener unwinding	2.2.3.2	
20	Mechanical resistance/brittleness of plastic fastener	2.2.3.3	
21	Resistance to corrosion of metallic fastener	2.2.3.4	
22	Mechanical resistance after heat ageing of plastic fasteners	2.2.3.5	

Insulation			
Nº	Essential characteristic	Assessment method	Type of expression of product performance (level, class, description)
Basic Works Requirement 2: Safety in case of fire			
23	Reaction to fire	2.2.4	Class
Basic Works Requirement 3: Hygiene, health and the environment			
24	Compressibility	2.2.4	Level
Basic Works Requirement 6 Energy economy and heat retention			
25	Thermal transmission	2.2.4	Level

2.2 Methods and Criteria for assessing the performance of the product in relation to essential characteristics of the product²

2.2.1 MEFAWAS essential characteristics

2.2.1.1 External fire performance³

- The roof (including the complete roof covering) in which the kit is intended to be incorporated, installed or applied shall be tested using the test method relevant for the corresponding external fire performance roof class, in order to be classified according to EN 13501-5, or
- The roof (including the complete roof covering) in which the kit is intended to be incorporated, installed or applied is considered "deemed to satisfy" all the provisions for external fire performance of all national regulations of the Member States without the need for testing on the basis that it is included within the definitions given in EC decision 2000/553/EC and provided that any national provisions on the design and execution of works are fulfilled, or
- The roof (including the complete roof covering) in which the kit is intended to be incorporated, installed or applied is considered to satisfy the requirements for the relevant performance class of the characteristic external fire performance in accordance with the EC decision 2000/553/EC without the need for further testing on the basis of its conformity with the specification of the product detailed in that decision and its intended end use application being covered by that Decision.

2.2.1.2 Content, emission and/or release of dangerous substances

The performance of the product (components of the kit) related to the emissions and/or release and, where appropriate, the content of dangerous substances will be assessed on the basis of the information provided by the manufacturer⁴ after identifying the release scenarios (in accordance with EOTA TR 034) taking into account the intended use of the product and the Member State where the manufacturer intends his product to be made available on the market.

The identified intended release scenario for the product and intended use with respect to dangerous substances is: S/W2: Product with indirect contact to soil, ground- and surface water.

Leachable substances. For the intended use covered by the release scenario S/W2 the performance of the product concerning leachable substances has to be assessed, if the product contains agents for root penetration. A leaching test with subsequent eluate analysis must take place, each in duplicate. Leaching tests of the sheet containing agents for root penetration are conducted according to CEN/TS 16637-2:2014. The leachant shall be pH-neutral demineralised water and the ratio of liquid volume to surface area must be 25 ± 5 l/m².

² All undated references to hEN or standards at prEN stage, EOTA report etc. in this EAD are to be understood as references to the dated versions listed in clause 4

³ If the membrane manufacturer has not declared the "reaction to fire performance" of the membrane but the manufacturer of the kit intends to declare this performance then this test will have to be performed in this ETA.

⁴ The manufacturer may be asked to provide to the TAB the REACH related information which he must accompany the DoP with (cf. Article 6(5) of Regulation (EU) No 305/2011). The manufacturer is **not** obliged:

- To provide chemical constitution and composition of the product (or of constituents of the product) to the TAB, or
- To provide a written declaration to the TAB stating whether the product (or constituents of the product) contain(s) substances which are classified as dangerous according to Directive 67/548/EEC and Regulation (EC) No 1272/2008 and listed in the "Indicative list on dangerous substances" of the SGDS. Any information provided by the manufacturer regarding the chemical composition of the products may not be distributed to EOTA or to TABs.

A sandblasted glass plates coated with the sheet (maximal thickness according to the technical data sheet) shall be prepared. The edges are not sealed. The cut edges of the sheet strip exposed to the eluent should be included in the calculation as a leachable area.

The eluates taken after 6 hours / 1 day / 2 days and 6 hours / 4 days / 9 days / 16 days / 36 days / 64 days shall be analysed for all environmentally relevant parameters, presumably at least the following:

- TOC according to EN 1484.
- pH-value according to EN ISO 10523.
- Electrical conductivity according to EN 27888.
- Agents for root penetration concentration ($\mu\text{g/L}$), agents for root penetration release [$\mu\text{g/m}^2$] and the cumulative agents for root penetration release (g/m^2) according to appropriate test method.

In eluates of "6 hours" and "64 days", the following biological tests shall be conducted:

- Acute toxicity test with *Daphnia magna* Straus according to EN ISO 6341.
- Toxicity test with algae according to ISO 15799.
- Luminescent bacteria test according to EN ISO 11348-1, EN ISO 11348-2 or EN ISO 11348-3.
- For each biological test, EC20-values shall be determined for dilution ratios 1:2, 1:4, 1:6, 1:8 and 1:16.

If the parameter TOC is higher than 10 mg/l, the following biological tests shall be conducted with the eluates of "6 hours" and "64 days" eluates: Biological degradation according to OECD Test Guideline 301 part A, B or E.

Determined toxicity in biological tests must be expressed as EC20-values for each dilution ratio. Maximum determined biological degradability must be expressed as "...% within ...hours/days". The respective test methods for analysis must be specified.

2.2.1.3 Resistance to wind loads of the MEFAWAS (Wind uplift test)

The test shall be carried out in accordance with EN 16002 (Annex 1). The W_{adm} , sheets and fasteners of the test shall be stated in the ETA (Annex 1).

2.2.2 Sheets essential characteristics

The essential characteristics of the membranes (table 1.2) shall be stated in the ETA according to EN 13707 or EN 13956.

Besides to the characteristics include in the different EN of membranes, it is necessary performing the following tests before and after different ageing conditions, and the sheets slipperiness without ageing tests.

The essential characteristics to be stated in the ETA will be in accordance with those that the manufacturer intends to declare.

2.2.2.1 Peel resistance of sheets joints (for single-layer waterproof coverings only) and for point fastening without penetration to sheet

Testing of the sheet with respect to peel resistance is performed as described in EN 12316-1 for bitumen sheets and EN 12316-2 for plastic and rubber sheets. The result shall be stated in the ETA.

Point fastening without penetration to sheet (e.g.: induction fasteners). The method EN 12316-2 with the following modification: the head of fastener will be fitted to the centre of sheet (width of the washer and length enough ($\geq 10\text{cm}$ each side) to introduce in the device) according to manufacturer installation. The fastener can install in a real support (Steel deck, wood etc.) to avoid little movement of the washer during the test (Picture 1).



Picture 1. Peeling fastener-sheet

2.2.2.2 Shear resistance of sheets joints (for single-layer waterproof coverings only)

Testing the joint strength is performed as described in EN 12317-1 for bitumen sheets and EN 12317-2 for plastic and rubber sheets. The result shall be stated in the ETA.

2.2.2.3 Resistance to ageing media

The results of the tests carry on after ageing tests (indicated below) must comply with:

If the decrease in the peel/shear resistance of the joint and the peel⁵ of fastener-sheet is $\leq 20\%$ (and for cold bending/folding $\leq 15\text{ }^{\circ}\text{C}$ after ageing this may be considered to be applicable to an expected working life of at least 10 years since the overall quality of the kit is proven by the wind uplift test.

If the decrease in the peel/shear resistance of the joint and the peel of fastener-sheet is $> 20\%$ and for cold bending/folding $> 15\text{ }^{\circ}\text{C}$ after ageing, further investigations (e.g. establishing further points on the degradation curve and/or level of tested value after ageing) shall be undertaken by the Assessment Body.

The average value (peel/shear resistance) and the lowest temperature (Resistance to cold bending/folding) after each ageing test shall be stated in the ETA.

2.2.2.3.1 Heat ageing

Testing of the sheet with respect to the heat ageing is performed as described in EN 1296 (for bituminous and polymeric sheets), for 28 days at $70\pm 2\text{ }^{\circ}\text{C}$ to peel/shear resistance and 84 days at $70\pm 2\text{ }^{\circ}\text{C}$ for cold bending/folding test. For the system with point fastening without penetration to sheet (e.g.: induction fasteners) the heating time will be increase up to 168 days.

2.2.2.3.2 Water ageing

Testing of the sheet with respect to the water ageing is performed as described in EN 1847 (for bituminous and polymeric sheets) for 28 days at $60\pm 2\text{ }^{\circ}\text{C}$. The ageing test is performed only for adhered joint (no melted) and point fastening without penetration to sheet (e.g.: induction fasteners).

2.2.2.3.3 Ultra violet (UV) radiation ageing

Testing of the sheet with respect to the UV ageing is performed as described in EN 1297 (for bituminous and polymeric sheets) during 1000 h according to the product standard or according to EOTA Technical Report no. 10 using Climate Class S and a radiant exposure equivalent to 2 years.

The UV test is not performed on mineral finished materials with a good granule retention (according to EN 12039).

2.2.2.4 Slipperiness of the sheets

The coefficient of friction is determined on the sheets in accordance with EN 13893:2002. The result shall be stated in the ETA.

Roof surfaces of bituminous products are not slippery and do not need to be tested. For bituminous products, the ETA shall state: Not slippery

⁵ The failure mode of this test has to be relevant for the joint, and it must be in the joining area

2.2.3 Fasteners essential characteristics

2.2.3.1 Fasteners axial loading

This test method determines the axial failure of a fastener under static loading, irrespective of the failure mode according to Annex A2.1. The mean value as well as the 5%-fractil are determined according to EN 1990 and the failure mode is noted. The 5%-fractile multiplied by a correction factor α is the characteristic value of the mechanical resistance (tension resistance). R_k shall be stated in the ETA together with all necessary information about the tested substrates.

2.2.3.2 Resistance to fastener unwinding

This test method according to Annex A2.2 determines the resistance to unwinding of a fastener. The rotation made by the fastener head after 500 and 900 cycles and any vertical movement made by the fastener shall be stated in the ETA.

The rotation of the fastener head after 500 cycles shall be $\leq \frac{1}{4}$ turn.

The rotation of the fastener head after 900 cycles shall be $\leq \frac{1}{2}$ turn.

Allowing for the pitch of the fastener thread, the calculated vertical displacement shall be ≤ 1 mm per fastener turn.

2.2.3.3 Mechanical resistance/brittleness of plastic fastener

This method (Annex A2.3) is intended to test the impact resistance and brittleness of the plastic fastener before and after ageing.

The impact resistance is expressed as the drop height in mm, which has not caused damage on the sleeve or washer of the fastener. The drop height to pass the test shall be stated in the ETA. The drop height shall be ≥ 1000 mm.

2.2.3.4 Resistance to corrosion of metallic fastener

This test method according to Annex A2.4 determines the resistance to corrosion of metallic fastener. The number of cycles shall be stated in the ETA.

Fasteners for use without restrictions on the risk of corrosion and condensation shall be made of materials which are deemed to satisfy the requirements on corrosion, e.g. fasteners made from austenitic stainless steel according to EN 10088-1.

Carbon steel fasteners shall resist to 15 cycles (15 % surface corrosion) with an exception of fasteners for bituminous multilayered systems where 2 cycles (0 % surface corrosion) or 7 cycles (5 % surface corrosion) can be accepted for buildings without humidity or condensation risks in the roof assembly and as long as it does not conflict with national provisions, provided that the use of the building does not change.

2.2.3.5 Mechanical resistance after heat ageing of plastic fasteners

For plastic fasteners not exposed to UV or water, no assessment against these two factors is required. Where the fastener is exposed to either of these, an appropriate assessment method determined by the Technical Assessment body shall be used. Plastic fasteners are tested as follows:

- Heat ageing of the plastic part of the fastener for 28 days at 80 ± 2 °C.
- Heat ageing of the Charpy test specimen according to EN ISO 3167 for 28 days at 80 ± 2 °C.

Before and after ageing the plastic part of the fastener is submitted to testing in 2.2.3.5. The drop height to pass the test shall be stated in the ETA. The drop height shall be ≥ 1000 mm.

Before and after ageing the Charpy test specimen is tested according to EN ISO 179-1. The test results after ageing shall not deviate more than 20 % from the test results before ageing shall be stated in the ETA.

2.2.4 Insulation essential characteristics

If the MEFAWAS includes the thermal insulation, the essential characteristics of the insulation shall be stated in the ETA according to the Declaration of Performance of the manufacturer (EN 13162, EN 13163, EN 13164, EN 13165, EN 13166, etc.).

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System of Assessment and Verification of Constancy of Performance to be applied

For the products covered by this EAD, the applicable legal act is Commission Decision 98/143/EC of 3 February 1998 (published in OJ L 42, 14.02.1998, p. 58).

The system is 2+.

3.2 Tasks of the manufacturer

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

Table 3. Control Plan for the manufacturer

Sheet							
Subject/Type of control		Test or control method		Criteria, if any	Minimum n° samples	Minimum frequency	
Incoming material							
Bitumen	Declaration of manufacturer		Conformity with the order		Every delivery		
	Penetration	EN 1426	Acc. to control Plan	3	Every delivery		
	Relevant methods of assessment shall be declared by the manufacturer			---	Every delivery		
Polymer (used in bitumen sheets)	Declaration of manufacturer		Conformity with the order		Every delivery		
	Density	EN 1675	Acc. to control Plan	3	Every delivery		
	Penetration (mixture with bitumen)	EN 1426		3	Every delivery		
	Softening temperature	EN 1427		3	Every delivery		
	Relevant methods of assessment shall be declared by the manufacturer				---	Every delivery	
PVC, TPO, etc.	Declaration of manufacturer		Conformity with the order		Every delivery		
	Density	EN 1675	Acc. to control Plan	3	Every delivery		
	% Ash content	EN ISO 3451-1		3	Every delivery		
	Tensile characteristics	EN 12311-2		3	Every delivery		
	Relevant methods of verification shall be declared by the manufacturer				---	Every delivery	
Internal reinforced	Declaration of manufacturer		Conformity with the order		Every delivery		
	Type / nature	IR/ TG/ Declaration manufacturer	Acc. to control Plan	---	Every delivery		
	Tensile characteristics	ISO 9073-2, 3 / ISO 3342		3	Every delivery		
	Weight / Area	ISO 9073-1 / ISO 3374		3	Every delivery		
	Relevant methods of assessment shall be declared by the manufacturer				---	Every delivery	
Mineral Aggregate	Declaration of manufacturer		Conformity with the order		Every delivery		
	Particle size distribution	EN 933-1	Acc. to control Plan	3	Every delivery		
	Moisture content			3	Every delivery		
	Relevant methods of assessment shall be declared by the manufacturer				---	Every delivery	
Other components	Relevant methods of assessment shall be declared by the manufacturer			---	Every delivery		
Finished sheet							
Visual aspect		EN 1850-1,-2		Acc. to control Plan	3	Batch	
Lenght (m)		EN 1848-1,- 2			3	Batch	
Width (cm)					3	Daily	
Overlap (cm)					3	Batch	
Thickness (mm), overlap					3	Batch	
Weight (kg)		EN 1849 -1, -2			3	Batch/weekly	
Weight/ surface (kg/m ²)					3	Batch/weekly	
Flow mm 100°C		EN 1110, EN 1133-1,-2			3	Batch/weekly	
Cold bending T°C		EN1109, EN 495-5			3	Batch/weekly	
Dimensional sability (A)		EN 1107-1, -2			3	Batch/weekly	
Tensile strength		EN 12311-1,-2			3	Batch/weekly	
Elongation (%)					3	Batch/weekly	
Heat Ageing	Flow		EAD: 2.2.4.12		<20 % Initial value	3	Once per year (1/year min)
	Cold bending T °C						
	Peel overlap			EN1109, EN 495-5			
	Peel on washer (induction, other)			EAD:2.2.4.1			
	Shear overlap		EN 12317-1, -2				
*Nail shear (N/5cm) initial for reinforced		EN 12310-1, -2		Acc. to control Plan	3		
Nail shear (N/5cm) Heat ageing for unreinforced		EN 1296	EN 12310-1,-2		3		
Relevant methods of assessment shall be declared by the manufacturer					---	---	

Fastener					
Subject/Type of control		Test or control method	Criteria, if any	Minimum n° samples	Minimum frequency
Incoming material		Suppliers certificate 3.1 according to EN 10204 for steel and plastic materials, including density according to ISO 1183 and Melt Flow Index (MFI) according to ISO 1183. For induction coating certificate 3.1 according to EN 10204 (to confirm)	Yes or no compared to the data sheet	-	Each delivery
Dimensions	Thread geometry (thread pitch, inner- & outer diameter)	Checks on finished products based on detailed drawings of the products (including manufacturing tolerances)	Acc. to control Plan	5	Per batch
	Drill point or piercing point geometry			5	Per batch
	Shank dimension			5	Per batch
	Head style			5	Per batch
	Supporting threads			5	Per batch
	Thickness plastic plug			5	Per batch
Ageing test		2.2.3.4 / 2.2.3.5		5	1 year
Relevant methods of assessment shall be declared by the Applicant				---	---

Primers / Tack coats / Finish layer					
Subject/Type of control		Test or control method	Criteria, if any	Minimum n° samples	Minimum frequency
Incoming material		Declaration of manufacturer or relevant methods of assessment shall be declared by the Applicant	Conformity with the order		Every batch
Viscosity		EN ISO 2555 / EN ISO 2431 prEN 1781 / EN ISO 3219	Acc. to control Plan	3	Every batch
Density		EN 1675		3	Every batch
Volatile content		EN ISO 3251/ prEN 1768/EN ISO 1428		3	Every 10 batches
Ash content		EN ISO 345-1 / EN ISO 1879		3	Once a year
Curing time(progress of hardness)		prEN 1789 / EN ISO 2535		3	Every 10 batches

Note. If the manufacturer (regarding the components he buys from the market with DoP) would take into account the Declaration of Performance issued by the manufacturer of that components. In this case, no retesting is necessary for those tests included in Declaration of Performance.

3.3 Tasks of the notified body

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

Table 4 Control plan for the notified body; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of specimens	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	Inspection of the factory and the factory production of the manufacturer as described in the control plan	Control of devices,, personal, equipment and the documentation of the FPC	See control plan		When stating the production process or when starting a new production line
Continuous surveillance, assessment and evaluation of factory production control					
2	Continuous surveillance, assessment and evaluation of factory production control as describe in the control plan including an annual inspection of the factory	Control of devices,, personal, equipment and the documentation of the FPC	See control plan		Once per year

4 REFERENCE DOCUMENTS

As far as no edition date is given in the list of standards thereafter, the standard in its current version at the time of issuing the European Technical Assessment, is of relevance (Table 5).

Table 5. Reference documents

CEN/TS 16637-2: 2014	Construction products. Assessment of release of dangerous substances - Part 2: Horizontal dynamic surface leaching test
DIN 50018: 2013	Testing in a saturated atmosphere in the presence of sulphur dioxide
EN ISO 3451-1: 2008	Plastics - Determination of ash - Part 1: General methods
EN 10088-1: 2015	Stainless steel – Part 1: List of stainless steels
EN 10204: 2006	Metallic products – types of inspection documents
EN 10346: 2015	Continuously hot-dip coated steel flat products - Technical delivery conditions
EN 1107-1: 2000	Flexible sheets for roofing – Determination of dimensional stability; Part 1: Bitumen sheets
EN 1107-2: 2001	Flexible sheets for roofing – Determination of dimensional stability; Part 2: Plastic and rubber sheets
EN 1109: 2013	Flexible sheets for roofing – Bitumen sheets – Determination of flexibility at low temperature
EN 1110: 2011	Flexible sheets for waterproofing - Bitumen sheets for roof waterproofing – Determination of flow resistance at elevated temperature
EN 12039: 2017	Flexible sheets for roofing – bitumen sheeting – Determination of loss of granules
EN 12310-1: 2000	Flexible sheets for roofing – Determination of nail shank tear resistance – Part 1: Bitumen sheets
EN 12310-2: 2001	Flexible sheets for waterproofing - Determination of resistance to tearing - Part 2: Plastic and rubber sheets for roof waterproofing
EN 12311-1: 2000	Flexible sheets for roofing – Determination of tensile properties – Part 1: Bitumen sheets
EN 12311-2: 2013	Flexible sheets for roofing – Determination of tensile properties – Part 2: Plastic and rubber sheets
EN 12316-1: 2000	Flexible sheets for roofing – Determination of peel resistance of joints – Part 1: Bitumen sheets
EN 12316-2: 2013	Flexible sheets for roofing – Determination of peel resistance of joints – Part 2: Plastic and rubber sheets
EN 12317-1: 2000	Flexible sheets for roofing – Determination of shear resistance of joints – Part 1: Bitumen sheets
EN 12317-2: 2011	Flexible sheets for roofing – Determination of shear resistance of joints – Part 2: Plastic and rubber sheets
EN 12430: 2013	Thermal insulation products for building applications – Determination of behavior under point load
EN 12667: 2002	Building materials – Determination of thermal resistance by means of guarded hot plate and heat flow meter methods – Products of high and medium thermal resistance
EN 12691: 2018	Flexible sheets for waterproofing – Testing of roofing – Determination of resistance to impact loading
EN 12730: 2017	Flexible sheets for roofing – Determination of resistance to static loading
EN 12939: 2001	Building materials – Determination of thermal resistance by means of guarded hot plate and heat flow meter methods – Thick products of high and medium thermal resistance
EN 1296: 2001	Flexible sheets for waterproofing – Bitumen, plastic and rubber sheets for roofing – Artificial ageing by long term exposure to elevated temperature
EN 1297: 2006	Flexible sheets for roofing; determination of resistance to UV and water ageing; part 1: bitumen sheeting
EN 13501-1: 2007	Fire classification of construction products and building elements. Part 1 Classification using test data from reaction to fire tests
EN 13501-5: 2007	Fire classification of construction products and building elements. Part 5: Classification using test data from external fire exposure to roof tests
EN 13707: 2014	Flexible sheets for waterproofing – reinforced bitumen sheets for roof waterproofing – Definitions and characteristics
EN 13893: 2003	Resilient, laminate and textile floor coverings – Measurement of dynamic coefficient of friction on dry surfaces.
EN 13956: 2013	Flexible sheets for waterproofing – Plastic and rubber sheets for roof waterproofing – Definitions and characteristics
EN 1426: 2015	Bitumen and bituminous binders - Determination of needle penetration
EN 1427: 2015	Bitumen and bituminous binders – Determination of softening temperature – Ring and ball method.
EN 1428: 2012	Bitumen and bituminous binders – Determination of water content in bitumen emulsions – Azeotropic distillation.
EN 1484: 1998	Water analysis - Guidelines for the determination of total organic carbon (TOC)
EN 16002: 2010	Flexible sheets for waterproofing - Determination of the resistance to wind load of mechanically fastened flexible sheets for roof waterproofing
EN 1602: 2013	Thermal insulating products for building applications - Determination of the apparent density

EN 1847: 2010	Elastomeric and thermoplastic sheets for waterproofing – Method of exposure to liquid chemicals including water
EN 1848-1: 2000	Flexible sheets for waterproofing - Determination of length, width and straightness - Part 1: Bitumen sheets for roof waterproofing
EN 1848-2: 2001	Flexible sheets for waterproofing - Determination of length, width, straightness and flatness - Part 2: Plastic and rubber sheets for roof waterproofing
EN 1849-1: 2000	Flexible sheets for waterproofing. Determination of thickness and mass per unit area - Part 1: Bitumen sheets for roof waterproofing
EN 1849-2: 2010	Flexible sheets for waterproofing. Determination of thickness and mass per unit area - Part 2: Plastic and rubber sheets for roof waterproofing
EN 1850-1: 2000	Flexible sheets for waterproofing - Determination of visible defects - Part 1: Bitumen sheets for roof waterproofing
EN 1990: 2003	Eurocode - Basis of structural design
EN 27888: 1994	Water quality; determination of electrical conductivity
EN 495-5: 2013	Thermoplastic and elastomeric roofing and sealing sheets; low temperature folding test
EN ISO 9073-2: 1997	Textiles - Test methods for nonwovens - Part 2: determination of thickness
EN ISO 10523: 2012	Water quality- Determination of pH
EN ISO 1133-1: 2012	Plastics - Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics - Part 1: Standard method
EN ISO 1133-2: 2012	Plastics - Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics - Part 2: Method for materials sensitive to time-temperature history and/or moisture
EN ISO 11348-1: 2009	Water quality - Determination of the inhibitory effect of water samples on the light emission of <i>Vibrio fischeri</i> (Luminescent bacteria test) – Part 1: Method using freshly prepared bacteria
EN ISO 11348-2: 2009	Water quality - Determination of the inhibitory effect of water samples on the light emission of <i>Vibrio fischeri</i> (Luminescent bacteria test) – Part 2: Method using liquid-dried bacteria
EN ISO 11348-3: 2009	Water quality - Determination of the inhibitory effect of water samples on the light emission of <i>Vibrio fischeri</i> (Luminescent bacteria test) – Part 3: Method using freeze-dried bacteria
EN ISO 1675: 2000	Plastics - Liquid resins - Determination of density by the pycnometer method
EN ISO 179-1: 2000	Plastics - Determination of Charpy impact properties - part 1: non-instrumented impact test.
EN ISO 2431: 2012	Paints and varnishes – Determination of flow time by use of flow cups
EN ISO 2535: 2011	Plastics – Unsaturated polyester resins – Measurement of gel time at ambient temperature
EN ISO 2555: 2018	Plastics – resins in the liquid state or as emulsions or dispersions - Determination of apparent viscosity by the Brookfield Test method
EN ISO 3167: 2014	Plastics - Multipurpose test specimens
EN ISO 3219: 1995	Plastics - Polymers/resins in the liquid state or as emulsions or dispersions - Determination of viscosity using a rotational viscometer with define shear rate
EN ISO 3251 : 2008	Paints, varnishes and plastics – Determination of non-volatile matter content
EN ISO 3451-1: 2008	Plastics – Determination of ash – Part 1: General methods
EN ISO 6341: 2013	Water quality - Determination of the inhibition of the mobility of <i>Daphnia magna</i> Straus (Cladocera, Crustacea) - Acute toxicity test (ISO 6341:2012)
EN1850-2: 2001	Flexible sheets for waterproofing - Determination of visible defects - Part 2: Plastic and rubber sheets for roof waterproofing
EOTA TR 034: 2015	EOTA Technical Report TR 034: General checklist for EADs/ETAs – Content and/or release of dangerous substances in construction products
ISO 15799: 2007	Soil quality- Guidance on the ecotoxicological characterization of soils and soil materials
ISO 3342: 2011	Textile glass - Mats - Determination of tensile breaking force
ISO 3374: 2000	Reinforcement products - Mats and fabrics - Determination of mass per unit area
ISO 6988: 1996	Testing in alternating atmosphere containing sulphur dioxide
ISO 9073-1: 1989	Textiles - Test methods for nonwovens - Part 1: Determination of mass per unit are
ISO 9073-3: 1989	Textiles - Test methods for nonwovens - Part 3: Determination of tensile strength and elongation
ISO 933-1: 2000	Tests for geometrical properties of aggregates - Part 1: Determination of particle size distribution - Sieving method
prEN 1768	Products and systems for the protection and repair of concrete structures – Test methods – Determination of volatile and not volatile matter
prEN 1781	Products and systems for the protection and repair of concrete structures -Test methods - Determination of viscosity
prEN 1789	Products and systems for the protection and repair of concrete structures - Test methods – Surface drying test – Ballotini method
prEN 1879	Products and systems for the protection and repair of concrete structures – Test methods – Determination of ash by direct calcinations
Regulation (EC) 1272/2008	Regulation (EC) No 1272/2008, Regulation on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006

ANNEX 1: FULL SCALE TESTING AND SMALL SCALE TESTING

A1.1 Full scale testing (EN 16002)

The test will be performed according to EN 16002 with the followings considerations:

At least one combination of components is tested in the full scale wind uplift test. Determination of a representative combination to be tested is done in cooperation with the applicant. The combination that is tested will have the highest characteristic resistance of the combinations mentioned in the Assessment. The characteristic resistances of other combinations are found by interpolation based on either calculation, if possible, or on small scale testing. Extrapolation to a higher value from the full scale test results is not an option because of the uncertainty of the failure mode.

Whilst there will always be at least one full scale wind uplift test, the manufacturer can always request additional full scale wind uplift tests on other combinations.

The test is performed on the whole assembled system, i.e. the load-bearing structure, the insulation (if part of the system) and the mechanically fastened sheet. Even if a vapour control layer is a part of the system the test is carried out without the vapour control layer, since this may influence the failure loads in a positive way and the test shall be carried out in a worst case scenario. The test results will also then be applicable when the vapour control layer is included in the assembled system.

The admissible (design) load per fastener (W_{adm}) is calculated according to the following formula:

$$W_{adm} = W_{char}/1,5$$

Where 1,5 is partial factor for a material property, also accounting for model uncertainties and dimensional variations (Other more restrictive values ($>1,5$) can be used according to National regulations, etc.).

A1.2 Small scale testing

Purpose of small scale testing is to form the basis for interpolation and reduce the amount of full scale testing.

Principles/limitations on the use of small scale testing: The test results are used to calculate a k-value smaller than 1. Each change of component will lead to a k-value. Additional changes will lead to additional application of the k-value.

Additional limitations on the use of the small scale test concept shall be determined by the test laboratory and the Assessment body in co-operation, based on their experience.

Procedure for the use of small scale testing: Based on the characteristic resistance of the kit determined in the full scale wind uplift test, the characteristic resistance of other combinations can be calculated using the following formula:

$$W_{adm,nc} = k \times W_{adm,oc}$$

where:

$W_{adm,nc}$ is the admissible (design) load per fastener of the new combination.

$W_{adm,oc}$ is the admissible (design) load per fastener of the original combination (as determined in the full scale wind uplift test).

k is a correlation factor between the strength of the new combination and the original combination, both determined by small scale testing.

The factor k can never be smaller than 0,5 or larger than 1,0. If the k-value is smaller than 0,5, the small scale concept cannot be used and a new full scale test is necessary.

Determination of k value: The determination method is based on the characteristics of each component either derived by small scale testing or obtained from the documents accompanying a CE-marked product. In case of testing, the tests are performed on new materials.

There are four possibilities for changes, which can be covered by small scale testing: Variations of the fastener, variations of the sheet, variations of the jointing technique and variations in the substrate. The following clauses give an overview of possible changes, where the small scale tests can be used and which tests should be performed.

Changing of the sheet. The Table 6 shows the possible changes in the sheet and the necessary tests.

Table 6. Overview of small scale testing for changing the sheet

Change of the sheet element	Test concept applicable		
	Tensile test, T	Tear test, Te	Peel test, P
Material group (within family)*	X	X	---
Reinforcement (within family)	X	X	X
Thickness	X	X	--

*) Distinction is made between material families; bitumen reinforced sheets (EN 13707) and plastic and rubber sheets (EN 13956). Within EN 13707 distinctions are made between material groups: Oxidized bitumen, elastomeric bitumen and plastomeric bitumen. This grouping shall be taken into account. Example of material type: SBS, APP.

Within EN 13956 distinctions are made between material groups: plastics, rubbers and thermoplastic rubbers. This grouping shall be taken into account. Example of material groups: EVAC, FPP, PIB, PVC, EPDM, TPE, FPO, ECB.

The small scale concept is only possible between products from the same material group.

The above concept is valid only if the following conditions are fulfilled:

$$0,7 < T_{nc} / T_{oc} \text{ (if } T_{nc} / T_{oc} > 1 \text{ then maximum calculation value} = 1)$$

$$0,7 < T_{enc} / T_{eoc} \text{ (if } T_{nc} / T_{oc} > 1 \text{ then maximum calculation value} = 1)$$

$$k = (T_{nc} / T_{oc}) * (T_{enc} / T_{eoc})$$

T_{nc} : Tensile resistance of new element

T_{oc} : Tensile resistance of old element

T_{enc} : Tear resistance of new element

T_{eoc} : Tear resistance of old element

$$0,7 < P_{nc} / P_{oc} \text{ (if } P_{nc} / P_{oc} > 1 \text{ then maximum calculation value} = 1)$$

$$k = (T_{nc} / T_{oc}) * (T_{enc} / T_{eoc}) * (P_{nc} / P_{oc})$$

For changes only affecting the peel resistance, the following reduction factor shall be taken into account.

$$k = P_{nc} / P_{oc}$$

P_{nc} : peel resistance of new element

P_{oc} : peel resistance of old element

Changing of the jointing technique. Changes in the jointing technique the test of peel resistance of the joint

$$k = P_{nc} / P_{oc}$$

P_{nc} : peel resistance of new element

P_{oc} : peel resistance of old element

Changing of the substrate. The following principles apply when changing the substrate within the same family.

If a new timber or steel substrate is thicker and/or stronger or if a new concrete substrate has a higher compressive strength and density than the one used in the full scale test, a new test is not necessary. The value determined in the full scale test will be valid for the new substrates. The factor k is in this case $k=1$.

The test result is valid for the same mechanically fastened flexible sheets applied on other types of substrates (including all types of insulation) provided that the admissible loads from the full scale wind load test (W_{adm}), characteristic load divided with the material partial factor, is equal or lower than the admissible load (W_{adm}) for the fastener in other substrates than the substrate that was used for the test. The admissible load for the fastener in other substrates is determined from the characteristic load according to Annex 2. Material partial factor for fastening in different substrate types are selected from applicable National standard, EN standard or National Annex for the specific substrate. The factor k is in this case 1.

Changing of the fastener. The overview of small scale testing for variations in the fasteners is given in A 2.5. The following reduction factor(s) shall be taken into account:

$$k = R_{nc} / R_{oc} \geq 0,5$$

R_{nc} : Resistance of new element

R_{oc} : Resistance of old element

ANNEX 2. TESTS FOR FASTENERS FOR MECHANICALLY FASTENED ROOF WATERPROOFING KITS

The assessment of the fasteners for a component ETA is described below. Necessary supplementary testing in case of changes to the fasteners is described in Annex A1.2 (Small scale testing). Tests required are:

- Axial loading.
- Resistance to unwinding.
- Mechanical resistance/brittleness of the plastic fastener.
- Corrosion resistance.

A2.1. Axial loading test

Test method. This test method determines the axial failure of a fastener under static loading, irrespective of the failure mode.

Test apparatus. Test machine, which can be operated with static tensile forces. Load cell to measure the force. Deformation gauge. Holding device for the substrate. Device for applying the force to the fastener (Figure 6).

Test specimen. Plastic sleeves are stored for 2 weeks in testing laboratory at 23 ± 2 °C and 50 ± 5 % RH.

The fasteners shall be installed in the specified substrate according to the manufacturer's installation guide.

The substrates used in the test are defined in the test of wind uplift (Full scale testing).

The test is performed at 23 ± 2 °C and 50 ± 5 % RH.

Procedure. The fastener and substrate are secured in the test machine in such a manner that any effects of bending are as far as possible avoided. The machine shall be operated at a speed of 5 - 10 mm/min. 10 specimens of fastener and substrate are tested.

Evaluation of test results. The failure load of the fastener is found for each specimen. The mean value as well as the 5%-fractile are determined according to EN 1990 and the failure mode is noted. The 5%-fractile multiplied by a correction factor α is the characteristic value of the mechanical resistance (tension resistance) R_k of the fastener.

Metal substrates. In order to determine the mean value and the 5%-fractile the single test results shall be multiplied by a correction factor α which depends on the failure mode:

- Pull out failure: $\alpha = (R_m/R_{m,test}) \times (t_N/t_{test}) \leq 1,0$
 R_m = tensile strength of the metal substrate according to technical delivery condition
 $R_{m,test}$ = tensile strength of the metal substrate used for the test
 t_N = nominal core thickness of the metal substrate
 t_{test} = core thickness of the metal substrate used for the test
- Other failure modes: $\alpha = 1,0$

Concrete substrates. In order to determine the mean value and the 5%-fractile the single test results shall be multiplied by a correction factor α which depends on the failure mode.

- Pull out failure of metallic anchors α shall be determined according to EAD 330232-00-0601 "Mechanical fasteners for use in concrete" chapter 2.0, as follows: $\alpha = (f_c/f_{c,test})^{0,5} \leq 1,0$
 f_c = nominal compression strength of the concrete
 $f_{c,test}$ = compression strength of the concrete used for the test
- Other failure modes and pull out failure of plastic anchors: $\alpha = 1,0$

Aerated concrete substrates. In order to determine the mean value and the 5%-fractile the single test results shall be multiplied by a correction factor α which depends on the failure mode.

- Pull out failure of substrate: α shall be determined as follows: $\alpha = (p^{3/4} f_c) / (p_{test}^{3/4} f_{c,test}) \leq 1,0$
 f_c = nominal compression strength of the aerated concrete in dry condition
 $f_{c,test}$ = compression strength of the aerated concrete used for the test in dry condition
 p = nominal density of the aerated concrete in dry condition
 p_{test} = density of the aerated concrete used for the test in dry condition
- Other failure modes: $\alpha = 1,0$

Timber substrates. In order to determine the mean value and the 5%-fractile the single test results shall be multiplied by a correction factor α which depends on the failure mode

- Pull out failure of substrate: $\alpha = p/p_{\text{test}} \leq 1,0$
 p = nominal density of the timber
 p_{test} = density of the timber used for the test
- Other failure modes: $\alpha = 1,0$

A2.2. Testing of resistance to unwinding (not relevant for linear fasteners)

Test method. This test method defines the conditions for testing the unwinding resistance of the mechanical fasteners. The test is only relevant for fasteners fixed onto metal decks. The test relates to coupling mechanisms (fastener plus washers) intended to secure the roof waterproofing sheet, laid over an insulation, onto galvanised steel sheet.

For kits where the unwinding susceptibility of the fastener is known based on existing test and/or field experience the test is not necessary.

The test is performed with a bituminous sheet reinforced with polyester 180 g/m² (thickness sheet: 4 mm).

The test can also be used to assess the effect any changes in the fastener design may have e.g. change in drill point diameter and thread geometry.

This test can also be performed with supports other than those envisaged in the following.

Principle of test. The test involves subjecting an assembled specimen to the effects of alternating loads simulating the effect of wind induced ripples across the sheet in order to assess the likelihood of it unwinding.

Equipment. Test apparatus as shown in Figure 1.

- Mechanical screwdriver with adapted bit
- Galvanised steel deck 0,7 mm, specifications min. S280 according to EN 10346
- Bituminous sheet with polyester reinforcement 180 g/m² (thickness of sheet: 4 mm)
- Mineral wool insulation having a density of 150 kg/m³±10%, and a nominal thickness of 50 mm. Dimensions: 300 mm x 250 mm (300 mm perpendicular to the direction of manufacture)

Test apparatus:

- | | |
|----------------------------|--|
| 1. Washer | 2. Bituminous sheet with polyester reinforcement |
| 3. Fastener | 4. Galvanised steel sheet |
| 5. Loading mechanism | 6. Mobile arm |
| 7. Insulating panel | 8. Dual action jack |
| 9. Test sample (plan view) | |

Principles of test. A dual action pneumatic jack equipped with adjustable limit switches activates an arm pivoted about a rigidly fixed axis.

This oscillating arm transmits alternating tensile loads to the roof waterproofing sheet (via the loading mechanism and cables) which then transmits these loads to the coupling.

A raked tensile angle of 38° is achieved via suitable positioned pulleys.

The loading mechanism limits the force to which the coupling will be subjected.

Cycle frequency: 90 ± 5 cycles per minute.

Number of cycles: 900. The test can be terminated when unwinding has taken place.

Preliminary adjustments. The mobile arm is positioned horizontally and the length of the cables are adjusted such that the load corresponds to a force of 0,1 kN.

The jack limit switches are adjusted such that when the arm is at maximum inclination (in either direction) the extension of one loading mechanism corresponds to a force of 0,2 kN, the other loading mechanism is relaxed (i.e. zero load)

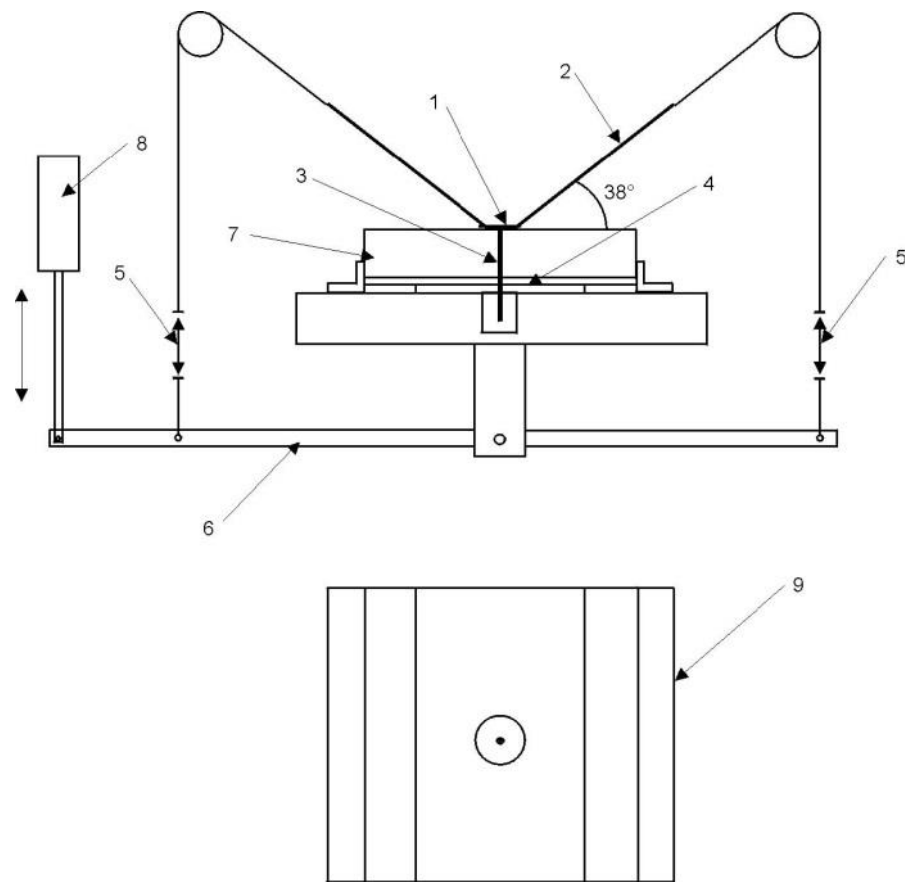


Figure 1. Test apparatus for unwinding test

Procedure. Place the metal sheet into its housing, and then position the specimen of insulation and the sample of roof waterproofing sheet centrally over the metal sheet.

Install the coupling at the centre of the sample using a mechanical screwdriver. Do not fully tighten the fastener. Use a manual screwdriver to finish tightening the fastener until the washer is flush with the surface of the waterproofing sheet (+0, -1 mm). If the fastener has an oblong washer the longitudinal axis shall be perpendicular to the direction of movement.

Using a fine felt-tipped pen, make a reference mark on the fastener head, washer and sheet tin order to monitor the relative movement of the fastener head (possibly also of the washer) relative to the sheet.

Clamp the sample symmetrically onto the sheet and zero the test apparatus (0,1 kN on either side).

Commence the alternate mechanical cycles.

Note. the number of cycles after rotation of the fastener head, i.e. $\frac{1}{4}$ and $\frac{1}{2}$ turn.

Repeat the test in the same way on 9 other samples.

Requirements and evaluation of test results. All fasteners shall meet the requirements specified below.

For each fastener:

- Indicate the rotation made by the fastener head after 500 cycles. The rotation of the fastener head shall be less than or equal to $\frac{1}{4}$ turn.
- Indicate the rotation made by the fastener head after 900 cycles (end of test). The rotation of the fastener head shall be less than or equal to $\frac{1}{2}$ turn.
- Indicate any vertical movement made by the fastener head after 900 cycles. Allowing for the pitch of the fastener thread, the calculated vertical displacement shall be less than or equal to 1 mm per fastener turn.

A2.3. Mechanical resistance/brittleness of the plastic fastener

Test method. This method is intended to test the impact resistance and brittleness of the plastic fastener before and after ageing.

The top edge of the washer is struck by a cylindrical drop weight at an angle of 45° . The angle of impact is obtained by placing the fastener in a special shoe.

The mechanical resistance of the washer is carried out according to EN 12691 Impact resistance with the following amendments:

- The fasteners are stored for two weeks in the testing laboratory at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ RH.
- The vacuum or pressure device is not needed.
- The mass of the drop weight including the tool shall be $2,0 \pm 0,01$ kg.
- The puncturing sphere is replaced by a $\varnothing 30$ mm cylindrical piston made of steel.
- The ballast ring and the expanded polystyrene panel is replaced by a wooden shoe to fix the fastener as shown in Figure 2. The fastener is fitted in the shoe and placed under the drop weight.
- The height is measured from the bottom edge of the puncturing tool to the top edge of the fastener in the shoe.
- The impact resistance is expressed as the drop height in mm, which has not caused damage on the sleeve or washer of the fastener in any of the 5 specimens.

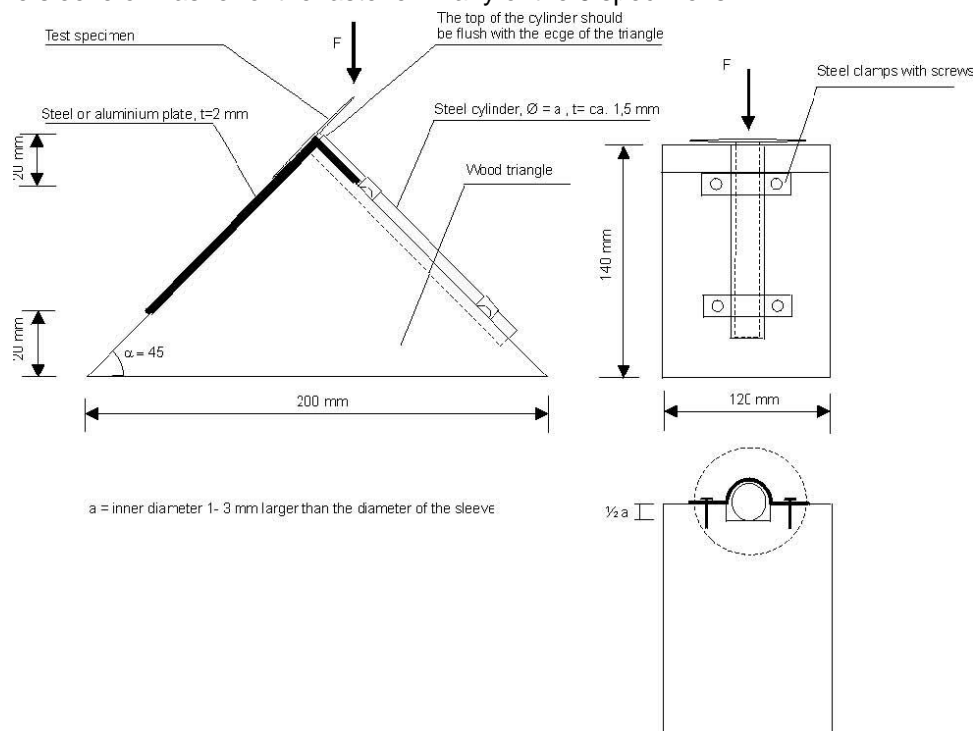


Figure 2: Test apparatus for impact test for plastic fasteners

Requirements and evaluation of test results. Indication of drop height for new fasteners. The drop height shall be $\geq 1,0$ m.

A2.4. Testing of resistance to corrosion of metallic fasteners

Test method. The test described in this chapter shall be carried out on fasteners including metal parts unless they are made from materials, which have been proven to be resistant to corrosion. Any fastener including metal components not composed of austenitic stainless steel according to EN 10088-1 shall be subjected to this test.

Determination of the corrosion behavior of fasteners is made by testing in accordance with ISO 6988- Testing in alternating atmosphere containing sulphur dioxide - on a total of 10 fasteners.

The fasteners are to be incorporated into the roof system, as in practice, according to the specifications of the fastener manufacturer. The fasteners are installed in a substrate corresponding to the use of the fastener with a thermal insulation of expanded perlite or mineral wool with a density of at least 150 kg/m^3

and a thickness corresponding to the maximum clamping range of the fastener, unless the insulation forms part of the kit in which case the actual insulation is used. If the clamping range has no influence on the corrosion performance of the fastener, the thickness of the thermal insulation shall be 100 mm. This is not a model of the roof construction but a build up for testing purposes only. The length of the fastener, which passes through or is embedded in the substrate shall be measured individually for each fastener and noted.

The fasteners are removed from the build up without causing further damage to the coating. This is facilitated by either cutting through the substrate and insulation, or - if unscrewing - ensuring that the fastener and washer are removed as a single item (i.e. that the screw thread does not spin in the washer)

The fasteners are subjected to either 2 or 7 or 15 exposure cycles in an alternating humid atmosphere containing 2 liters of sulphur dioxide, concentration SFW 2.0 S in accordance with DIN 50018.

The test specimens are to be arranged centrally in the test chamber by suspending them vertically by the use of an inert thread, such as nylon, with a minimum spacing of 20 mm between them. Only test specimens of the same type are to be used for each test, to rule out test specimens with different corrosion protection systems affecting each other. Washers (in the case of point fasteners); profiles (in the case of linear fasteners); and fastener shafts are to be arranged in the test chamber separately from each other. In order to compensate for the small surface area of the fasteners a galvanised steel blanking plate shall be included to achieve the minimum surface test area of $0,5 \pm 0,1 \text{ m}^2$.

The test specimens are exposed to the effect of condensation from water to which 2 litres of sulphur dioxide (SO_2) has been added. The 2 litres of SO_2 are charged immediately after the test chamber is closed. The heating is switched on to reach a test temperature of $40 \pm 3 \text{ }^\circ\text{C}$ in 95 ± 5 minutes. One cycle comprises two test stages and lasts for a total of 24 hours. In the first test stage, totaling 8 hours (after the heating is switched on), the test specimens are exposed at $40 \pm 3 \text{ }^\circ\text{C}$ to the condensation and the SO_2 . The second test stage begins when the heating is switched off and the test chamber is opened or ventilated. The test specimens are to be left in the chamber, where drying will take place over 16 hours. After the second test stage, the base tank of the test chamber is emptied, cleaned, if necessary, and filled with fresh distilled or de-ionised water. The test chamber is closed and charged with SO_2 . A new cycle begins when the heating is switched on.

When the 2 or 7 or 15 cycles have been completed, the test specimens are removed from the test chamber and examined for surface corrosion (rusting). Any corrosion, which may have formed beneath the corrosion protection coating is also to be recorded. If it is clear that the requirements (below) cannot be achieved before the 2, 7 or 15 cycles are completed, the result is considered unsatisfactory and the test may be terminated.

The head of the fastener and the part of the fastener, which has passed through (metal) or is embedded in (concrete) the substrate, the rim around the external edges of the washer and profiles are not included in the determination of surface corrosion. Visual evaluation is made. In borderline cases, the evaluation shall be undertaken by 3 people, independently of each other.

Requirements and evaluation of test results. Fasteners for use without restrictions on the risk of corrosion and condensation shall be made of materials, which are deemed to satisfy the requirements on corrosion, e.g. fasteners made from austenitic stainless steel according to EN 10088-1.

Carbon steel fasteners shall have undergone an anti-corrosion treatment. In this respect, the moisture content of the material of the load-bearing structure and any condensation likely to occur shall be taken into account.

Carbon steel fasteners shall resist to 15 cycles (15 % surface corrosion) with an exception of fasteners for bituminous multilayered systems where 2 cycles (0 % surface corrosion) or 7 cycles (5 % surface corrosion) can be accepted for buildings without humidity or condensation risks in the roof assembly and as long as it does not conflict with national provisions, provided that the use of the building does not change. The corrosion behavior cycles are to be evaluated as follows:

- After 2 cycles with the test procedure, the metallic parts of all tested fasteners shall not exhibit more than 0% surface corrosion (rust formation) or corrosion formation recognisable beneath the corrosion protection coating.
- After 7 cycles with the test procedure, the metallic parts of all tested fasteners shall not exhibit more than 5 % surface corrosion (rust formation) or corrosion formation recognisable beneath the corrosion protection coating.
- After 15 cycles with the test procedure, the metallic parts of all tested fasteners shall not exhibit

more than 15 % surface corrosion (rust formation) or corrosion formation recognisable beneath the corrosion protection coating.

The number of cycles shall be stated in the ETA.

The Technical Assessment Body shall assess the acceptability of any corrosion below the surface layer and this shall be recorded in the ETA.

A2.5. Supplementary tests in case of fastener modifications

Information about the necessary supplementary testing in case of fastener modifications is given in Table 7. This simplified approach is only applicable if not more than one parameter affecting the mechanical resistance of the fastener is changed (e.g. washer or thread or drill point). For the number of the tests according to Figures 3, 4, 5 and 6 and the evaluation of the corresponding results the rules given in A 2.1 shall be applied. The characteristic value referring to the modified parameter is the mechanical resistance (tension resistance) $R_{k,N}$ of the modified fastener, provided that this characteristic value is lower than the characteristic value $R_{k,O}$ determined by the reference axial loading test ($R_{k,N}/R_{k,O} \leq 1,0$). Otherwise the characteristic value determined by the reference axial loading test is the relevant mechanical resistance (tension resistance) $R_{k,O}$.

The tests listed in Table 7 are not necessary if it is obvious that the modification of the relevant parameter improves the mechanical resistance of the fastener (e.g. modified washer is thicker than original washer of same material or modified material has higher material properties etc.).

Table 7. Modifications to fasteners and required tests

Changes to fastening elements	Washer pull-through test acc. to Fig. 4 & 5	Fastener pull-out test acc. to Fig.3	Axial loading test acc. to Fig. 6	Corrosion test according to A 2.4	Unwinding test according to A 2.2	Mech. Res & Brittleness acc. to A2.3	Influence on mechanical resistance of the fastener
Fastener							
Drill point or piercing point geometry	-	X	-	-	X	-	Yes
Shank dimension	-	X ¹	-	-	-	-	Yes
Head style	X	-	-	-	-	-	Yes
Supporting threads	-	-	-	-	-	-	No
Change coating	-	-	-	X	-	-	No
Heat treatment specifications for steel parts	-	-	-	-	-	-	No
Material	-	X	-	X ²	-	-	Yes
Length of the fastener	-	-	-	-	-	-	No
Thread geometry (thread pitch, inner- & outer diameter)	-	X	-	-	X	-	Yes
Washer without integrated sleeve							
Washer outside dimensions, geometry and shape	X	-	-	-	-	-	Yes
Washer thickness	X	-	-	-	-	-	Yes
Washer strength, material specifications of metal	X	-	-	X ²	-	-	Yes
Washer coating	-	-	-	X	-	-	No
Dimple geometry, diameter	X	-	-	-	-	-	Yes
Plastic materials	X	-	-	-	-	X	Yes
Washer with integrated sleeve							
Plastic anchor expansion zone	-	-	X	-	-	-	Yes
Plastic washer dimensions, geometry and shape	X	-	-	-	-	-	Yes
Plastic materials	X	-	-	-	-	-	Yes

1: Instead of pull-out tests, the tensile resistance of the shank can be calculated ($A_{Shank} \times f_{u,Shank}$); A_{Shank} = cross section of shank; $f_{u,Shank}$ = tensile strength of shank

2: Test is only required for change of austenitic stainless steel to carbon steel

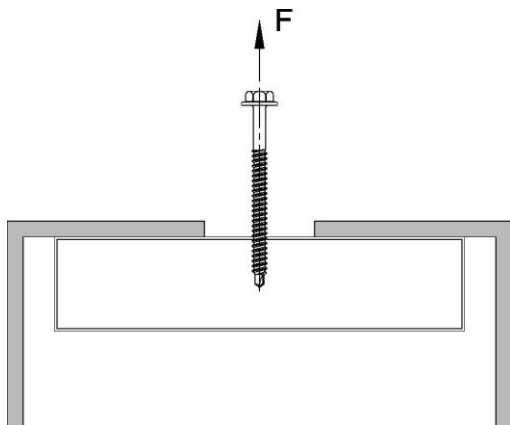


Figure 3. Principle of fastener pull-out test

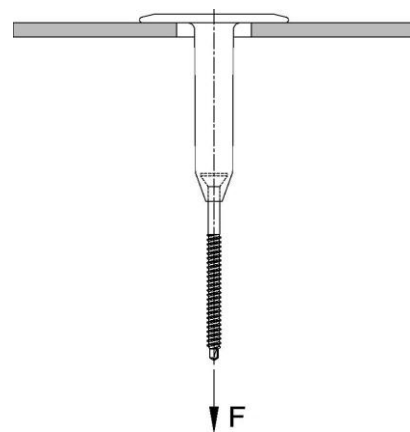


Figure 4. Principle of plastic washer pull-through test

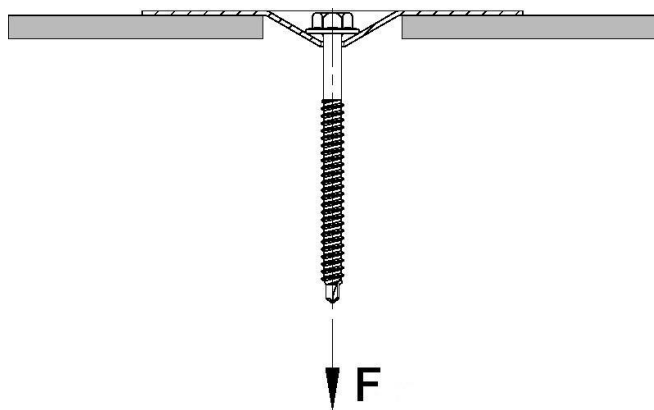


Figure 5. Principle of metallic washer pull-through test

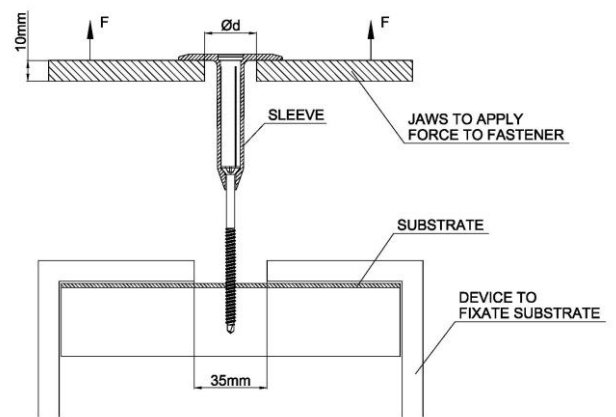
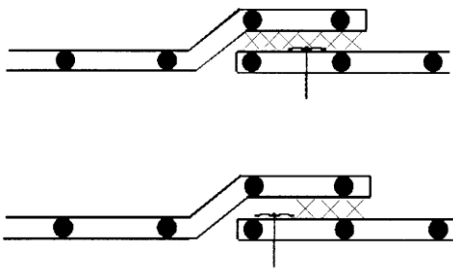


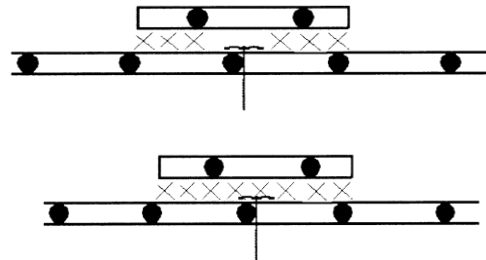
Figure 6. Principle of axial loading test

ANNEX 3. EXAMPLES OF MECHANICALLY FASTENED ROOF WATERPROOFING SHEETS.

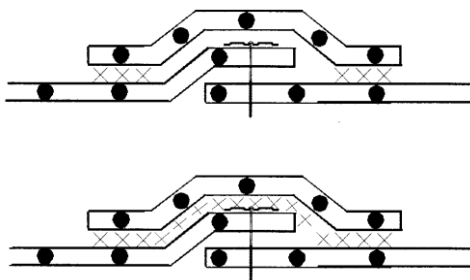
The examples shown below are all examples of kits with flexible sheets. The examples where the joint is fully welded are kits with bituminous, rubber or polymeric sheets with adhered joints. The examples with welded seams are bituminous sheets (hot air) or polymeric sheets (hot air or chemicals). The listed range of examples is non-exhaustive and can be also used for point fastening without penetration to sheet (e.g. induction fasteners).



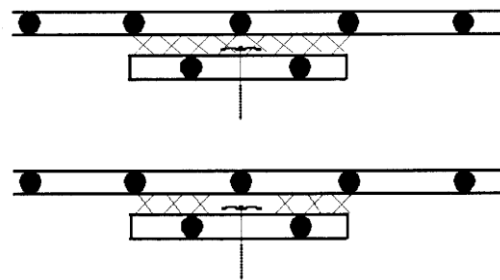
a: Fastenings at seams:
Linear individual fastening in area of overlapping at edge of roofing



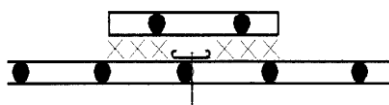
b: Non self-sealing fastening in the plane of the roof.
Individual fastening, independent of seams penetrating the roofing and covered with plates or strips of roofing material welded thereon



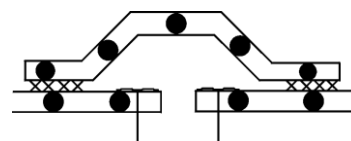
c: Covered fastenings at seams.
Linear individual fastening of overlapping edges of roofing with welded-on strips



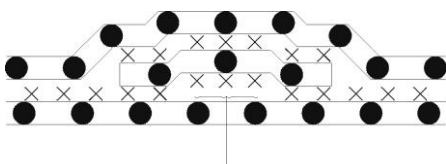
d: Fastening at underside.
Plates or strips of roofing material or composite sheet metal fixed by means of individual fastenings and covered with roofing roof waterproofing bonded or welded thereon



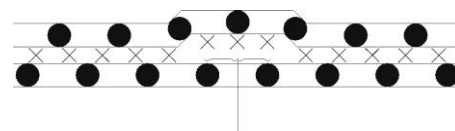
e: Linear fastening bars
Linear fastenings using profiles covered with strips of roofing welded thereon



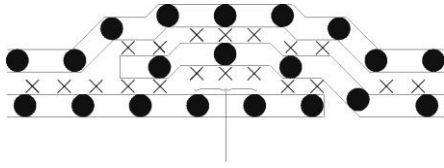
f: Covered fastenings at seams
Joint realised by end to end position of the sheets fixed on both sides and covered with a welded overlap strip



g. Fastening in under layer
Two-layer system with fully fastened under layer and top layer, which is torched or adhered to the under layer (normally bituminous)

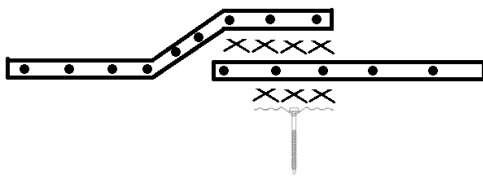


h. Fastening in under layer
Two-layer system with fully fastened under layer and top layer, which is torched or adhered to the under layer (normally bituminous)

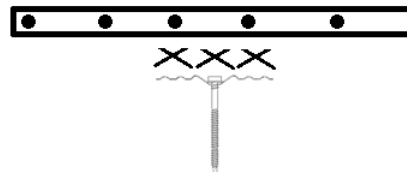


i. Fastening in under layer
Two-layer system with fully fastened under layer and top layer, which is torched or adhered to the under layer (normally bituminous)

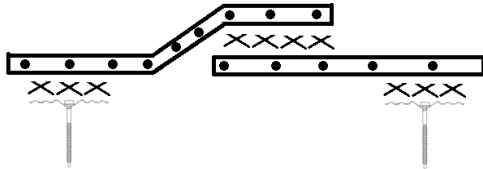
Key to the examples:
xxxxx = bond, welding



j. Fastening at seams without penetration of membrane. Individual fastening in area of overlapping



k: Non self-sealing fastening in the plane of the roof. individual fastening independent of seams, without penetrating the membrane.



L. Fastening without penetration of membrane. Individual fastening out of the area of overlapping