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Test Report

project: **P 13386-E**

order: Tests on composite system of the waterproofing kit based on
MS-Flexfolie
according to EAD 030350-00-0402

sample description: Liquid applied roof waterproofing kit

sample receipt date: 01-11-2021

test period: November 2021 – September 2022

This test report comprises: 18 pages, attachment with 2 pages

Flörsheim, 26-09-2022

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1 SUBJECT

Polymer Institut was charged by Köster Bauchemie AG, Aurich, Germany, to carry out tests on the liquid applied roof waterproofing kit based on

MS-Flexfolie

according to

EAD 030350-00-0402
Version August 2018
Liquid applied roof waterproofing kits

The test program was agreed with the client.

EAD 030350-00-0402 requires the proof of performance characteristics as a guide for the assessment of usefulness of the „liquid applied roof waterproofing kit“ (LARWK).

Classification for use by the client:

Useful life:	category W2, expected useful life 10 years
Climate zones:	category M & S, moderate and severe climate category TL4, severe low temperature category TH4, severe high temperature
Roof Slope:	category S1 – S4 Slope (<5 till >30) %
User load:	category P4, special

If not specified otherwise all in the following overview listed tests were performed at standard temperature according to EN 23270.



Overview 1: test on the liquid applied roof waterproofing kit

test	reference	date
non-volatile content / solid content	DIN EN ISO 3251	06-2008
infrared spectrum	DIN EN 1767	09-1999
density	DIN EN ISO 2811-2	06-2011
dynamic viscosity	DIN EN ISO 3219	10-1994
ash content	DIN EN ISO 3451-1	11-2008
water vapour permeability	DIN EN 1931	03-2001
water tightness	TR-003	05-2004
resistance to wind loads	TR-004	05-2004
resistance to dynamic indentation	TR-006	05-2004
resistance to static indentation	TR-007	05-2004
resistance to fatigue movement	TR-008	05-2004
crack-bridging capability	TR-013	05-2004
resistance to low temperature	TR-006	05-2004
resistance to high temperature	TR-007	05-2004
resistance to heat ageing	TR-011	05-2004
resistance to dynamic indentation	TR-006	05-2004
resistance to fatigue movement	TR-008	05-2004
tensile properties	DIN EN ISO 527-1	06-2012
resistance to UV-ageing	TR-010	05-2004
resistance to dynamic indentation	TR-006	05-2004
tensile properties	DIN EN ISO 527-1	06-2012
resistance to water ageing	TR-012	05-2004
resistance to static indentation	TR-007	05-2004
resistance to wind loads	TR-004	05-2004
effects of days joint	TR-004	05-2004
minimal / maximal application temperature	ETAG 005 part 6	05-2004
resistance to dynamic indentation	TR-006	05-2004
tensile properties	DIN EN ISO 527-1	06-2012

The test results are included in chapter 4.

2 RECEIPT OF SAMPLES

The following samples were delivered by a forwarding agency on 6th August 2020:

Table 1: receipt of material

no	product	batch	amount
1	MS Flexfolie	2441506-01	2 x 4 kg
2	Polyestervlies	-	1 Rolle
3	CT 121	1 305592	1 kg

A description of the liquid applied roof waterproofing kit can be seen in the following overview.

Overview 2: composition of the system

components of the kit	trade name ^a	description ^a
primer	CT 121	Solvent-free, moisture-tolerant epoxy resin primer
waterproofing layer	MS-Flexfolie	One-component, fast-curing, highly elastic sealant
Fleece	-	Polyester fleece with a basis weight of 165 g/m ²
Waterproofing layer	MS-Flexfolie	One-component, fast-curing, highly elastic sealant

^{a)} declaration of the client

3 PREPARATION OF THE SAMPLES

The samples have been prepared by an employee of Kiwa GmbH Polymer Institut in the laboratory of Kiwa GmbH Polymer Institut in Flörsheim.

Overview 3: Consumption

specimen [mm x mm]	CT 121	First layer MS- Flexfolie with fleece	Second layer MS- Flexfolie
concrete [400 x 400]	ca. 0,4	ca. 1,5	ca. 1,5
Bituminous sheet on insulation [300 x 300]	ca. 0,4	ca. 1,5	ca. 1,5
Bituminous sheet on insulation [200 x 200]	ca. 0,4	ca. 1,5	ca. 1,5
concrete [400 x 400] „1 mm gap“	ca. 0,4	ca. 1,5	ca. 1,5
concrete [400 x 400] „edge on edge“	ca. 0,4	ca. 1,5	ca. 1,5
Free film* [500 x 300]	-	ca. 1,5	ca. 1,5

Free films were produced at the minimum (5 °C) and maximum (35 °C) application temperatures selected by the customer, with consumption rates indicated above.

4 TESTS

4.1 Content of non-volatile components / solid content

The non-volatile-matter content was determined according to DIN EN ISO 3251 *“Paints, varnishes and plastics – Determination of non-volatile-matter content”* with the following conditions in a triple determination

Heat cabinet: air circulation heating cabinet
 Temperature: 105 °C
 Exposure time: 3 h
 Used shell: tin lid Ø 74 mm

4.2 Infrared spectrum

The infrared spectra was recorded in accordance with DIN EN 1767 *“Products and systems for the protection and maintenance of concrete structures - test methods - infrared analysis”* with FTIR spectrometer from ALPHA (Fa. Bruker), ATR technique in the wavenumber range 4000-500 cm⁻¹ without pretreatment of the components.



4.3 Density

The density was determined according to DIN EN ISO 2811-2 "Coating substances - determination of density - Part 2: Immersed body method" in two separate tests with a solid sphere (10 cm³).

4.4 Dynamic viscosity

The dynamic viscosity was determined according to DIN ISO 3219 "Plastic - polymer/resins in liquid state or as emulsions or dispersions - determination of viscosity using a rotational viscosimeter with defined shear rate" at a test temperature of 23 °C. The measurement was carried out twice.

Testing device:	rotational viscosimeter company Anton Paar (type MCR 51)
measurement system:	cone-plate: 50-1
share rate:	500 s ⁻¹
increase in shear rate:	constant
evaluation / measurement time:	automatic interpolation given in the chapter results

4.5 Water-vapour permeability

The determination of the water-vapour permeability was carried out according to DIN EN 1931 „Flexible sheets for waterproofing – Bitumen, plastic and rubber sheets for roof waterproofing – Determination of water-vapour transmission properties“.

The test bodies (diameter 90 mm) were drilled from the film and conditioned for 24 hours.

Then they were bonded vapour tight in a diffusion cup which contains waterfree calcium chloride to get a relative humidity of 0 %.

The cups were weighed and stored in a desiccator which contains saturated sodium chloride to get a relative humidity of 75%. They were weighed until they reached constant diffusion rates.

4.6 Water tightness

The water tightness was tested according to the EOTA Technical Report 003 „Determination of the water tightness“.

The test specimens were exposed 24 h to the upper side with a water column of 1000 mm which corresponds app 0.1 bar. As a hygroscopic indicator a mixture of bromophenol blue (0.5 %) with powdered sugar (99.5 %) was used.

The hygroscopic indicator was embedded between two filter papers, which lay between the upper side of the test specimen and the test apparatus. The test is passed, when no discoloration of the indicator is detected at 3 samples.

4.7 Resistance to wind loads

The resistance to wind loads of the system has been tested following the EOTA Technical Report 004 „Determination of the resistance to delamination“. Differing from EOTA Technical Report 004 the coating of the test specimens was drilled wet with a core driller at 5 testing areas (∅ 50 mm) to a depth of 10 mm into the substrate.

Afterwards the surplus water was removed and the testing areas were cleaned. Before testing, the bond strength stamps were bonded with a 2 component PU-adhesive on the drilled surface. After a cure time of about 20 hours the test took place with a calibrated testing device.

Testing conditions:

Testing device: Bond strength testing device of BPM Wennigsen GmbH
Easy M, Type F10D, max force 10 kN
Testing speed: 300 N/s
Bond strength stamp: steel stamp (\varnothing 50 mm)
Adhesive: 2-component PU-adhesive

4.8 Resistance to dynamic indentation

The test was carried out using coated concrete slabs (pos. 1 table 1) and the less coated EPS sheets (pos. 6 table 1) according to EOTA Technical Report 006 "*Determination of the resistance to dynamic indentation*". The detection of water tightness was done by visual inspection and in case of doubts with a coloured water column of 100 mm subsequent verification of a staining of the concrete.

Testing device and parameters:

Testing device: Erichsen impact-testing device model 304
Drop height: 30 cm
Drop mass: 2 kg
Load: 5.9 J (impact energy)

Indentors:

Depending on classification $I_4 = \varnothing 6$ mm, $I_3 = \varnothing 10$ mm, $I_2 = \varnothing 20$ mm, $I_1 = \varnothing 30$ mm

4.9 Resistance to static indentation

The test was carried out using coated concrete slabs (pos. 1 table 1) and coated EPS sheets (pos. 6 table 1) according to EOTA Technical Report 007 "*Determination of the resistance to static indentation*" under standard conditions according to DIN EN 23270, unless shown otherwise. On three marked areas the test specimen gets a load type of different weight in combination with a spherical steel indenter. In this test 3 spherical indentors with a diameter of 10 mm were used at the same time to transfer the weight. The detection of water tightness was done by visual inspection and in case of doubts with a coloured water column of 100 mm subsequent verification of a staining of the concrete.

Load

Depending on classification: $L_4 = 250$ N, $L_3 = 200$ N, $L_2 = 150$ N, $L_1 = 70$ N

4.10 Resistance to fatigue movement

The test of the resistance to fatigue movement was carried out according to EOTA Technical Report 008 "*Determination of the resistance to fatigue movement*" at 3 coated concrete prisms with the dimensions of 150 mm x 50 mm x 50 mm were cut of a coated concrete slab (pos. 1 of Table 1). To realize a width change of the crack, a gap holder of



1 mm thickness between the sawn ends of the concrete test specimens was placed. During the test a tensile load produced a 2 mm gap inside of the concrete test specimens, started from the 1 mm gap. Afterwards the test specimens were compressed to a gap with a width of 0 mm. These both processes were one cycle. After the test ended, the test specimens were examined visually to crack formation or debonding. If the result was doubtful the water tightness of the roof waterproofing kit was detected using a pipe of sufficient size to impose a water column of 100 mm for 24 hours.

Testing device and parameters:

Testing device:	servo-hydraulic testing device S59 (100 kN) including an automatic cooling chamber to reach a temperature of -10 °C
Testing speed:	16 mm/h = 0.001 Hz
Testing temperature:	-10 °C
Starting gap width:	1.0 mm = zero value for displacement transducer
Maximum gap:	2 mm
Minimum gap:	0 mm
Number of cycles:	1000

4.11 Resistance to low temperature

The test was carried out using coated concrete slabs (pos.1 table 1) according to Technical Report 006 "*Determination of the resistance to dynamic indentation*" at TL classification.

Testing device and parameter see chapter 4.9.

4.12 Resistance to high temperature

The resistance of the system to high temperatures was carried out on coated concrete slabs (pos. 1 table 1) according to EOTA Technical Report 007 "*Determination of the resistance to static indentation*".

Execution, testing device and parameter see chapter 4.10.

4.13 Resistance to extreme low temperatures - Crack-bridging capability

The crack bridging capability was tested according to EOTA Technical Report TR-013 "*Determination of crack bridging capability*" 05-2004. Three specimens with the dimension of 290 mm x 50 mm x 40 mm were cut of the coated concrete slab.



4.14 Resistance to heat ageing

The effect of the heat ageing to the resistance of the liquid applied roof waterproofing kit against mechanical damage was tested referring to the classification of the customer which is given in the chapter 4.

The system applied on concrete slabs and free films were heat aged according to the EOTA Technical Report 011 „*Exposure procedure for accelerated ageing by heat*“ at a temperature of 80 ± 2 °C for a period given in the chapter results.

4.14.1 Resistance to dynamic indentation

The resistance to dynamic indentation after heat ageing was carried out on coated concrete slabs (pos. 1 table 1) according to EOTA Technical Report 006 “*Determination of the resistance to dynamic indentation*” at TL classification.

Execution, testing device and parameter see chapter 4.9.

4.14.2 Resistance to fatigue movement

The test of the resistance to fatigue movement after heat ageing was carried out according to EOTA Technical Report 008 „*Determination of the resistance to fatigue movement*” at 3 concrete prisms with the dimensions of 150 mm x 50 mm x 50 mm.

Testing temperature: -10 °C

Amount of cycles: 50

Execution, testing device and parameter see chapter 4.11.

4.14.3 Tensile properties

The tensile properties of free films were determined according to EN 527-2 “*Plastics- Determination of tensile properties- Part2: Test conditions for moulding and extrusion plastics*”. Five specimens were tested.

Testing device and parameter:

Testing device: universal testing device UPM 1445, Fa. Zwick

Specimen's type: 1B according to EN 527-2

Test speed: 200 mm/min



4.15 Resistance to UV-ageing

For testing aging effects of UV-radiation in the presence of moisture the liquid applied roof waterproofing kit was tested corresponding to the specified characteristics of the system according to the test conditions for the climatic zone given in the chapter results according to EOTA Technical Report 010 "*Exposure procedure for artificial weathering*" using fluorescent tubes (UV-A) with the following conditions:
Testing device and parameter:

Testing device: Weiss UV-Global UV3-200
Sample rotation: reordering every 2 weeks

Test parameters for UV-radiation:

Light source type: fluorescent light source, according to EN ISO 4892-3
Illuminance: 40 W/m²
Standard-black-temperature: 60 °C ± 3 °C
Spray cycle: 1 h spraying at 23 °C
5 h dry period at 60 °C and 10 % r.H.

4.15.1 Resistance to dynamic indentation

The resistance to dynamic indentation after heat ageing was carried out on coated concrete slabs (pos. 1 table 1) according to EOTA Technical Report 006 "*Determination of the resistance to dynamic indentation*" at -10 °C.

Execution, testing device and parameter see chapter 4.9.

4.15.2 Tensile properties

The tensile properties of free films were determined according to EN 527-2 "*Plastics - Determination of tensile properties – Part 2: Test conditions for moulding and extrusion plastics*". 5 specimens were tested.

Execution, testing device and parameter see chapter 4.15.3.

4.16 Resistance to water ageing

For testing aging effects of water aging the liquid applied roof waterproofing kit was tested corresponding to the working life category of the system according to the test conditions for the climatic zone given in the chapter results at 60 ± 2 °C according to EOTA Technical Report 012 "*Exposure procedure for accelerated ageing by hot water*".

4.16.1 Resistance to static indentation

The test was carried out using coated concrete slabs (pos. 1 table 1) according to EOTA Technical Report 007 "*Determination of the resistance to static indentation*" at TH classification.

Execution, testing device and parameter see chapter 4.10.

4.16.2 Resistance to wind loads

The resistance to wind loads of the system has been tested following the EOTA Technical Report 004 „*Determination of the resistance to delamination*“ on water aged specimens.

Execution, testing device and parameter see chapter 4.8.

4.17 Effects of days joint

For the test of the effect of day joints a concrete slab was applied two times. Between both layers there was a waiting period of 28 days. Afterwards the test of the resistance to wind loads was determined following the EOTA Technical Report 004 „*Determination of the resistance to delamination*“.

Execution, testing device and parameter see chapter 4.8.

4.18 Minimal / maximal application temperature

In order to check if it's possible to get a satisfactory bonded system also at the minimal and maximal application temperature comparative tests of tensile strength and dynamic indentation were done.

4.18.1 Resistance to dynamic indentation

The resistance to dynamic indentation on specimens which were produced at minimal and maximal application temperature was carried out on the less compressible substrate according to EOTA Technical Report 006 “*Determination of the resistance to dynamic indentation*”.

Execution, testing device and parameter see chapter 4.9.

4.18.2 Tensile properties

The tensile properties of free films produced at minimal and maximal application temperature were determined according to EN 527-2 “*Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion plastics*”.
5 specimens were tested

Execution, testing device and parameter see chapter 4.15.3.

5 RESULTS

Table 2: non-volatile content

substance	non-volatile content / solid content [M.-%]	
	single values	mean value
MS-Flexfolie	97,5 ; 97,5 ; 97,5	97,5
CT 121	97,3 ; 97,2 ; 97,0	97,2

Table 3: Infrared spectrum-

Substance	component	Condition of the substances	figure in attachment
MS-Flexfolie	-	As delivered	1
CT 121	A	As delivered	2
	B	As delivered	3

Table 4: density

Substance	component.	Density [g/cm ³]	
		Single values	Mean value
MS-Flexfolie	-	1,438 ; 1,438	1,438
CT 121	A	1,136 ; 1,135	1,136
	B	1,038 ; 1,037	1,038

Table 5: dynamic viscosity

Substance	Comp.	Shear rate [1/s]	dynamic viscosity [mPas]	
			single values	mean value
MS-Flexfolie	-	250	10.100 ; 10.500	10.300
CT 121	A	500	2.400 ; 2400	2.400
	B		290 ; 290	290



Table 6: water vapour permeability – MS-Flexfolie

No.	water-vapour transmission rate g [g/(m ² *d)]	diffusion-equivalent air layer thickness s _d [m]	mean layer thickness d [mm]	water vapour diffusion resistance factor μ []
1	16,7	2,2	2,27	947
2	16,2	2,2	2,30	963
3	15,1	2,4	2,35	1015
4	16,0	2,3	2,33	966
5	15,6	2,3	2,25	1025
Mean value	15,9	2,3	2,30	980

Table 7: water tightness

sample	result
1	watertight
2	
3	

Table 8: resistance to wind loads

substrate	storage	bond strength [MPa]		
		single values	mean value	area of failure
concrete	standard temperature	0,7 0,6 0,9 0,6 0,8	0,7	100 % cohesion in the membrane
bituminous sheeting applied EPS		0,2 0,2 0,3 0,1 0,3		
concrete	90 days water ageing (W2)	0,8 0,7 0,9 0,7 0,6	0,7	100 % cohesion failure in the membrane
Concrete – day joints	Standard temperature	0,6 0,7 0,5 0,5 0,5		

Table 9: dynamic indentations

remark	substrate	Temp.	result
initial	concrete	23 °C	I ₄
initial	bituminous sheets applied on insulation material	23 °C	I ₃
low temperature	concrete	-30 °C	TL ₄ / I ₄
100 days, 80 °C heat ageing (W2)			TL ₄ / I ₄
UV-ageing 400 MJ/m ² (W2)		-10 °C	I ₄
minimal application temperature (5 °C)	free film on concrete	23 °C	I ₄
maximal application temperature (35 °C)			I ₄



Table 10: static indentations

remark	substrate	Temp.	result
initial	concrete	23 °C	L ₄
initial	bituminous sheets applied on insulation material	23 °C	L ₃
high temperature	concrete	+90 °C	TH ₄ / L ₄
90 days, 60 °C water ageing (W2)			TH ₄ / L ₄

Table 11: crack bridging capability

remark	temp.	visual inspection	result
initial	-30 °C	no cracks	watertight

Table 12: resistance to fatigue movement

remark	cycles	temp.	visual inspection	result
initial	1000	-10 °C	no cracks	watertight
100 days, 80°C heat ageing (W2)	50	-10 °C	no cracks	watertight

Table 13: tensile properties

remark	tensile strength at break [MPa]		elongation at break [%]	
	single values	mean value	single values	mean value
initial	4,42 4,45 4,06 4,06 3,86	4,17	29,6 33,2 30,8 30,4 32,9	31,4
100 days, 80 °C heat ageing (W2)	3,27 2,67 3,17 2,72 3,21	3,00	35,8 38,4 41,7 41,4 38,6	39,2
UV-ageing 400 MJ/m ² (W2)	3,07 3,48 3,66 4,17 3,62	3,60	41,5 37,8 39,5 46,1 41,4	41,3
minimal application temperature (5 °C)	3,57 3,54 3,23 3,54 3,70	3,52	36,8 27,5 40,9 32,9 35,0	34,6

remark	tensile strength at break [MPa]		elongation at break [%]	
	single values	mean value	single values	mean value
maximal application temperature (35 °C)	3,70 3,37 3,10 3,65 3,73	3,51	52,7 39,9 50,4 48,7 34,8	45,3

Table 14: visual inspection of sample after storages

storage	conditions	classification	visual inspection
heat ageing	100 days 80 °C	W3	no changes noticeable
water ageing	90 days 60 °C	W3	no changes noticeable
UV-ageing	400 MJ/m ²	W3	Yellowing of the free film

Table 15: layer thicknesses

test	thickness [mm]
water tightness	2,2
dynamic indentation	2,2
static indentation	2,3
resistance to fatigue movement	2,4
resistance to low temperature	2,4
crack bridging ability	2,4
Resistance to high temperature	2,3
resistance to heat ageing W3	2,4
resistance to water ageing W3	2,4
resistance to UV-ageing W3	2,4

6 SUMMARY

On behalf of Köster Bauchemie AG, Aurich, Germany, Polymer Institut executed tests on the liquid applied roof waterproofing kit based on

MS-Flexfolie

according to EAD 030350-00-0402 (replaces ETAG no. 005).
The results of the tests can be seen in the previous chapter.

Classification by use

In relation to the present test results the tested LARWK can be classified into the following category.

- Fulfilled requirements for classification:

Useful life:	expected: category W2, expected useful life 10 years
Climate zones:	category M & S, moderate and severe climate category TL ₄ , severe low temperature category TH ₄ , severe high temperature
Roof Slope:	category S1 – S4 Slope (<5 till >30) %
User load:	category P4, special, less compressible substrate Category P3, normal, compressible substrate



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