TECHNICAL REPORT

Exposure procedure for artificial weathering

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Foreword

EOTA Technical Reports are developed as supporting reference documents to European Technical Approval Guidelines and can also be applicable to a Common Understanding of Assessment Procedures, an EOTA Comprehension Document or an European Technical Approval, as far as reference is made therein.

EOTA Technical Reports go into detail in some aspects and express the common understanding of existing knowledge and experience of the EOTA bodies at a particular point in time.

Where knowledge and experience is developing, especially through approval work, such reports can be amended and supplemented.

When this happens, the effect of the changes upon the European Technical Approval Guidelines will be laid down in the relevant comprehension documents, unless the European Technical Approval Guideline is revised.

This EOTA Technical Report has been prepared by the EOTA Working Group 04.02/01 – "Liquid applied roof waterproofing Kits" and endorsed by EOTA.

1 Scope

This EOTA Technical Report specifies exposure procedures for artificial weathering, for the apparatuses and the conditions for exposing test specimens, being a cured assembled "system" of a liquid applied roof waterproofing kit, to laboratory light sources, elevated temperature, humidity and wetting conditions.

Distinction is made of to two different sets of conditions for exposure, defined as "conditions M" and "conditions S", based on the different climatic zones of use in Europe, for either apparatuses with Xenon arc light source or fluorescent UV light source.

Annex A gives the reason for the choice of the exposure conditions.

Annex B gives the spectral irradiance of typical light sources of an artificial weathering apparatus.

Annex C gives the calculation method for the determination of the radiation and exposure time to be used for artificial weathering.

2 Principle

Test specimens, being a cured assembled "system" of a liquid applied roof waterproofing kit, are exposed in a Xenon arc or fluorescent UV artificial weathering apparatus at a specified irradiance, Black and White Standard Temperature, relative humidity and spray cycles.

After defined UV radiant dose the changes in characteristics, to be specified by the nature of the cured assembled "system", are determined.

3 Apparatus

3.1 Artificial weathering apparatus

- with a Xenon arc light source or

- with a fluorescent UV light source.

The apparatus shall comply with EN ISO 4892 – Parts 1, 2 and 3 and with the following specifications.

3.1.1 Xenon arc light source

In accordance with method A of EN ISO 4892 - Part 2, with a spectral irradiance of (550 ± 55) W/m^2 in the bandpass of 290 nm to 800 nm and a spectral irradiance of (60 ± 12) W/m^2 in the bandpass of 290 nm to 400 nm.

3.1.2 Fluorescent UV light source

In accordance with EN ISO 4892 - Part 3, a laboratory light source type 1 (UV-A 340 nm peak) where radiant emission below 400 nm makes up at least 80% of its total light output and where radiant emission below 300 nm is less than 2% of its total light output, with a spectral irradiance of (45 ± 10) W/m^2 in the bandpass of 300 nm to 400 nm.

3.1.3 Test chamber

Containing a frame to retain the test specimens holders.

3.1.3.1 Specimen holders for Xenon arc light source apparatus.

The specimen holders for Xenon arc light source apparatus shall be in accordance with clause 4.7 of EN ISO 4892 – Part 2.

3.1.3.2 Specimen arrangement for fluorescent UV light source apparatus (in accordance with prEN 1297).

The test specimen racks shall allow the specimens to

- lie flat in the plane $\geq$ 5° above the horizontal;
- be mounted so that the exposed face is in the plane of the uniform irradiance.

The specimens shall be attached to stainless steel platens of at least the same size as the specimens by appropriate means.

The attachment shall leave an area open to free irradiation in order that subsequent tests can be performed on irradiated parts of the specimen.

For inclinations near to horizontal the specimens may alternatively be placed in stainless steel pans of at least the same size as the specimens.

The specimens shall be weighted in this arrangement by means of a U shaped stainless frame.

The external dimensions of the frame shall correspond to the specimen size.

The cross section of the steel section shall be (5 ± 0,5) mm by approximately 10 mm.

The dimension of (5 ± 0,5) mm stands for the width of the cross section, i.e. the plane that is in contact with the specimen.

If the specimens are placed in pans, the lower end of the pans shall have sufficient slits or holes to avoid any collection of water.

3.1.4 Spray nozzles

To provide a uniform and continuous wetting of the exposed test specimens for defined periods of time.

For fluorescent UV light source apparatus the flow rate through the nozzles shall be (10 ± 3) l/(min.m²) of the exposed surface.

3.1.5 Means of providing controlled humidity

At the defined level.

3.1.6 Means of controlling air temperature

Within the test chamber.

3.1.7 Black Standard thermometer

In accordance with clause 4.1.5.1.1 of EN ISO 4892 - Part 1, with a response time less than 1 minute and a means of recording maximum temperatures during each cycle.

3.1.8 White Standard thermometer

In accordance with clause 4.1.5.1.1 of EN ISO 4892 - Part 1, and with means of recording maximum temperatures during each cycle.

3.1.9 Device

To determine the UV radiant exposure in the wavelength region 280 nm to 400 nm expressed in joules per square metre (J/m^2).

3.1.10 Device (solar eye control)

To monitor the level of radiation output of the light source(s).

NOTE 1 – It is recognised that not all the above parameters can be met on all apparatuses at the present moment, but all apparatuses must comply with these requirements from 1 January 2003.

NOTE 2 – Relative spectral irradiance data are given in Annex B to this document.

3.2 Demineralised water

Grade 3 according to ISO 3696.

NOTE – In general the temperature of the water to be used in the spraying procedure will be (25 ± 5) °C.

3.3 Cycle timer

A continuously operating cycle timer shall be provided to program the selected cycle of UV and spraying periods.

Hour meters shall be provided to record total time of operation and total time of UV exposure.

4 Test specimen

4.1 Dimensions

The test specimen is the assembled “system” of a liquid applied roof waterproofing kit.

The dimensions of test specimens shall be determined by the size of the test specimen racks or holder and shall in any way be of sufficient size to provide the test specimens needed for the test methods to evaluate any exposure effects on the resistance of the roof waterproofing kit as specified in the relevant Complementary Part.

NOTE – In general to avoid possible effects, due to exposure to artificial weathering, at the edges of the test specimens meant for evaluation purposes, these test specimens shall be prepared from exposed samples, with greater dimensions.

4.2 Number

The number of test specimens equals the number of test specimens needed for those test methods used to evaluate any exposure effects on performance as specified under clause 5.6.9 plus at least three series of specimens for recommended checks between times.

4.3 Preparation

The product shall be applied as prescribed by the manufacturer in such a way, that a free sample is obtained (e.g. by using siliconised paper).

After curing of the assembled “system”, the test specimens shall be cut from these free samples with dimensions as defined in clause 4.1.

The test specimens shall be placed loose-laid in the specimen rack or holder.

NOTE – When the installed product incorporates a supporting layer, tests shall not be performed at lap joints in this supporting layer.

4.4 Curing and conditioning

The free samples of the assembled “system’ shall be cured at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) % for at least the period as prescribed by the manufacturer.

The test specimens, prepared from the cured free samples, shall be conditioned at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) % for a period of at least 16 hours and at the most for 168 hours (one week).

5 Procedure

5.1 General

For the simulation of the different climates in Europe there are different exposure conditions defined in Annex C as:

- **exposure conditions "M"**: for simulation of moderate climate (**M**)
- **exposure conditions "S"** : for simulation of severe (hot and dry) climate (**S**)

The reasons of the choice of different exposure conditions are given in Annex A.

5.2 Exposure conditions "M" for Xenon-arc weathering apparatus

5.2.1 The Black Standard Temperature (BST) shall be (60 ± 3) °C.

The air temperature in the test chamber shall be controlled to a constant value such that the BST equals the required value at the end of the dry period.

5.2.2 The White Standard Temperature (WST) shall be between 40°C and 45°C.

NOTE – The WST is predetermined by the procedure in clause 5.2.1. It should lie within the specified range, otherwise the manufacturer of the weathering apparatus should be contacted.

5.2.3 The spray cycle used shall be 18/102 (18 minutes spraying / 102 minutes dry period) in accordance with EN ISO 4892 - Part 2.

NOTE – Sample surfaces have to be continuously sprayed during the spray period, otherwise the manufacturer of the weathering apparatus should be contacted.

5.2.4 The relative humidity during the dry period shall be (65 ± 5) %.

5.3 Exposure conditions "S" for Xenon-arc weathering apparatus

5.3.1 The Black Standard Temperature (BST) shall be (70 ± 3) °C.

The air temperature in the test chamber shall be controlled to a constant value such that the BST equals the required value at the end of the dry period.

5.3.2 The White Standard Temperature (WST) shall be between 50°C and 55°C.

NOTE – The WST is predetermined by the procedure in clause 5.3.1. It should lie within the specified range, otherwise the manufacturer of the weathering apparatus should be contacted.

5.3.3 The spray cycle used shall be 18/102 (18 minutes spraying / 102 minutes dry period) in accordance with EN ISO 4892 - Part 2.

NOTE – Sample surfaces have to be continuously sprayed during the spray period, otherwise the manufacturer of the weathering apparatus should be contacted.

5.3.4 The relative humidity during the dry period shall be (65 ± 5) %.

5.4 Exposure conditions "M" for fluorescent UV weathering apparatus

5.4.1 The Black Standard Temperature (BST) shall be (50 ± 3) °C.

The air temperature in the test chamber shall be controlled to a constant value such that the BST equals the required value at the end of the dry period.

5.4.2 The spray cycle used shall be 60 minutes / 300 minutes (1 hour spraying and 5 hours dry period) in accordance with EN ISO 4892 - Part 3.

NOTE – Sample surfaces have to be continuously sprayed during the spray period, otherwise the manufacturer of the weathering apparatus should be contacted.

5.4.3 The relative humidity during the dry period shall be (10 ± 5) %.

5.5 Exposure conditions "S" for fluorescent UV weathering apparatus

(The exposure conditions “S” for fluoriscent UV weathering apparatus is in accordance with the exposure procedure in prEN 1297).

5.5.1 The Black Standard Temperature (BST) shall be (60 ± 3)°C.

The air temperature in the test chamber shall be controlled to a constant value such that the BST equals the required value at the end of the dry period.

5.5.2 The spray cycle used shall be 60 minutes / 300 minutes (1 hour spraying and 5 hours dry period) in accordance with EN ISO 4892 - Part 3.

NOTE – Sample surfaces have to be continuously sprayed during the spray period, otherwise the manufacturer of the weathering apparatus should be contacted.

5.5.3 The relative humidity during the dry period shall be (10 ± 5) %.

5.6 Exposure procedure

5.6.1 Expose the test specimens for the weathering tests with the upper surface towards the light source in the artificial weathering apparatus for a radiation dose as specified in ETAG 005 - Part 1 - Table 12.

The remaining reference test specimens are stored in the dark.

5.6.2 The exposure procedure shall be in accordance with EN ISO 4892 and EN 513, respectively with the following modifications.

Before placing the test specimens, prepare the artificial weathering apparatus as follows:

1 select the appropriate filter arrangement for Xenon arc light source to achieve the irradiance in accordance with method A of EN ISO 4892 - Part 2.

2 install the devices for the determination of the radiant exposures defined in 3.1.9 and 3.1.10.

3 install the Black Standard Thermometer and the White Standard Thermometer in such a position that its temperature measurements will be representative for the test chamber.

4 set the test chamber relative humidity to 65% RH for Xenonarc apparatus or 10% RH for fluorescent UV light source apparatus.

5 set the spray cycle in accordance with the type of light source.

6 set the test chamber air temperature to a constant value to achieve the Black Standard Temperature (BST) in accordance with the relevant exposure conditions ("M" or "S") and the type of light source.

7 check the White Standard Temperature (WST) in accordance with the relevant exposure conditions ("M" or "S") and the type of light source.

5.6.3 Mount the test specimens in the holders with the upper surface towards the light source.

NOTE 1 – When the test specimens do not completely fill the racks, the empty spaces shall be filled with blank panels to maintain the test conditions within the test chamber.

NOTE 2 – It is recommended NOT to expose specimens of different nature simultaneously in order to avoid interaction of any kind.

5.6.4 Start the exposure procedure and control and record:

- the air temperature in the test chamber
- the Black Standard Temperature
- the White Standard Temperature
- the relative humidity.

NOTE – It is difficult to specify minimum recording intervals due to differences in equipment and laboratory procedures. The test laboratory should record at intervals that are appropriate to maintain the test conditions in the particular laboratory on a particular apparatus.

5.6.5 At regular intervals check and record the irradiance in accordance with clause 3.1.1 and clause 3.1.2.

5.6.6 The exposure is completed when the specified amount of radiant exposure is reached.

5.6.7 Take the test specimens holder from the test chamber and the specimens from the holders and condition them for a period of at least 16 hours at a temperature of (23 ± 2) °C and at a relative humidity of (50 ± 5) %.

5.6.8 Examine the test specimens visually and note any visible exposure effects.

5.6.9 Prepare the test specimens according to the appropriate test methods for evaluation of any exposure effects on the relevant products characteristics as specified under clause 4.1.

6 Expression of results

6.1 Examine visually unexposed and exposed test specimens and record any occurred exposure effects.

6.2 Observe, compare and record the differences in appearance of the unexposed and exposed test specimens as regards their relevant characteristics.

7 Test report

The test report shall give the following information:

a. reference to this Technical Report;

b. the name of the testing laboratory;

c. date/period of exposure;

d. a description of the assembled “system”, including dimensions, curing and conditioning;

e. type of artificial weathering apparatus used;

f. type of light sources and filter system used, if any;

g. type of temperature measurements and description;

h. set value of the relative humidity in the test chamber;

i. spray cycle used;

j. conditions of test specimen rotation, if any;

k. UV radiant exposure in MJ/m^2 and, if appropriate, in Xenon-arc apparatus radiant exposure < 800 nm in GJ/m^2;

l. exposure time in hours (h);

m. all visual observations;

n. results of evaluation of exposure effects;

o. all operating details not specified in this Technical Report, such as deviations from the test procedure, as well as incidents likely to have influenced the results.

Annex A

Reasons for the choice of the exposure conditions

A.1 Scope

This Annex A gives the reasons for the choice of exposure conditions for artificial weathering:

- to more accurately simulate natural weathering conditions in moderate and severe (hot and dry) climates in Europe;
- for the purpose of an adequate uniform procedure serviceable for both Xenon-arc and fluorescent UV lamp apparatuses.

A.2 Spray cycles

As the test results of UV radiation in combination with ponding water cycles show no additional and/or specific information for the assessment of the effects of artificial weathering, the decision has been made on expertise support to abandon the ponding water cycles. Consequently the “vertical“ exposure procedure enables the use of both Xenon-arc and fluorescent UV lamp apparatuses, provided similarity in radiant exposure can be performed.

A.3 One year's equivalent UV radiant exposure dose

For the purpose of an adequate uniform artificial weathering procedure for liquid applied roof waterproofing kits, serviceable for both Xenon-arc and fluorescent UV light source apparatuses, the choice has been made for a defined 1 year's equivalent UV radiant exposure dose of 200 MJ/m^2.

For the assessment of “the fitness for use” of roof waterproofing kits the exposure dose is related to the categorization of the installed product to expected working life (see ETAG 005 – Part 1 - Table 12).

A.4 Simulating climate conditions "M" and "S"

Related to the possibility of using apparatuses with different light sources there is the need for differentiation in exposure conditions, in addition to the necessity of varying the exposure conditions to simulate the difference between moderate and severe climatic conditions.

To simulate moderate climate condition "M" (see clause 5.2 and clause 5.4) the BST = 60 °C where chosen for Xenon-arc apparatus; the BST = 50 °C for fluorescent UV lamps apparatus.

The Black Standard Temperature (BST) is the maximum surface temperature of a black polymer specimen.

In contrast to Xenon-arc apparatuses, where white or light coloured specimens show surface temperatures clearly below the BST, in fluorescent UV lamp apparatuses all specimens (whether white or black) have nearly the same surface temperature.

To obtain about the same surface temperatures of medium coloured specimens in Xenon-arc and fluorescent UV lamp apparatuses, the BST in fluorescent UV lamp apparatuses has to be reduced by about 10 K.

Because BST can be controlled in Xenon-arc apparatus by different procedures, the range of WST is prescribed in order to get constant temperature conditions during exposure.

To simulate severe (hot) climate condition "S" (see clause 5.3 and clause 5.5) the BST for both Xenon-arc and fluorescent UV lamps apparatuses were increased by 10 °C with an adjustment of WST.

The proposed spray cycles in Xenon-arc and fluorescent UV lamps apparatuses and the relative humidity’s in the dry periods correspond with the recommendations given in EN ISO 4892 - Parts 2 and 3.

Annex B

Spectral irradiance of typical light sources in artificial weathering apparatus

B.1 General

A variety of Xenon-arc and fluorescent UV lamps can be used for purposes of exposure.

The lamps shown in this Annex are specifically chosen for the exposure procedure.

B.2 Representative spectral irradiance data

All spectral distributions of radiation shown in this Annex are representative only and are not meant to be used to calculate or estimate total radiant exposure for tests in accelerated weathering devices. Actual irradiance levels at the test specimen surface will vary due to the type and/or manufacturer of the lamp used, the age of the lamps, the distance of the lamp array and the air temperature within the chamber. The following data is representative of the spectral irradiance received by a test specimen mounted in the sample plane.

Wavelength range	Irradiance (W/m^2)		
	Xenon arc	Type I (340) fluorescent UV lamp	Fluorescent UV lamps combination
below 290 nm	0	0	0
290 nm to 320 nm	3,3	3,1	3,3
320 nm to 360 nm	23	25	22
360 nm to 400 nm	34	11	18

Table B.1 – Spectral irradiance in weathering apparatuses according to EN ISO 4892 - Parts 2 and 3

Annex C

Calculation method for the determination of the radiation and exposure time to be used for artificial weathering

C.1 Scope

This Annex gives a procedure to calculate the duration of the exposure needed to assess resistance to moderate (M) and severe (S) climates to be used for artificial weathering. In this Annex a justification for the chosen method is included.

NOTE – This calculation method represents a very approximate means of estimation. However, it does put the requirements on some sort of logical basis bearing in mind that natural weathering itself is a very variable phenomenon depending on location, aspect, shading and so on.

C.2 Calculation

C.2.1 The climatic zones are classified M (moderate climate) and S (severe climate) as defined in Table C.1.

	Class M moderate climate	Class S severe climate
annual radiant exposure on horizontal surface	< 5 GJ/m^2 and < 22°C	≥ 5 GJ/m^2 and/or ≥ 22°C
average temperature of the warmest month per year		

Table C.1 – Classification of climatic zones in Europe

If the annual solar radiant exposure on a horizontal surface is equal to or greater than 5 GJ/m^2 and/or the average temperature of the warmest month of the year is equal to or greater than 22 °C the climate is classified as severe (S).

NOTE – Materials which are designed for use in a moderate climate (M) are not used in the severe climate (S).

C.2.2 For the purpose of calculating the duration of the exposure the value for annual radiant exposure of 5 GJ/m^2 is used.

C.2.3 In order to compare this figure with the usual practice in artificial weathering we need to consider not the total radiation energy, as in C.2.2, but that part falling in the ultraviolet region between 300 nm and 400 nm.

This is about 6% of the total radiant exposure.

A further correction of 67% is applied to allow for the fact that not all this radiation is acting at higher summer temperatures and so will be less damaging to the affected surfaces.

This leads to the recommended 1 year's equivalent radiation dose of (0,67 x 0,06 x 5) GJ/m^2 = 201 MJ/m^2 for the wavelength range between 300 nm and 400 nm (see also Table C.2)

Climate type	Moderate (M) and severe (S)	Formula used
1 year's equivalent	0,201	0,67 x 0,06 x 5 (GJ/m^2 year) x 1 (year)
2 year's equivalent	0,400	0,67 x 0,06 x 5 (GJ/m^2 year) x 2 (year)
5 year's equivalent	1	0,67 x 0,06 x 5 (GJ/m^2 year) x 5 (year)

Table C.2 – Recommended radiant exposure for wavelength range 300 - 400 nm in GJ/m^2

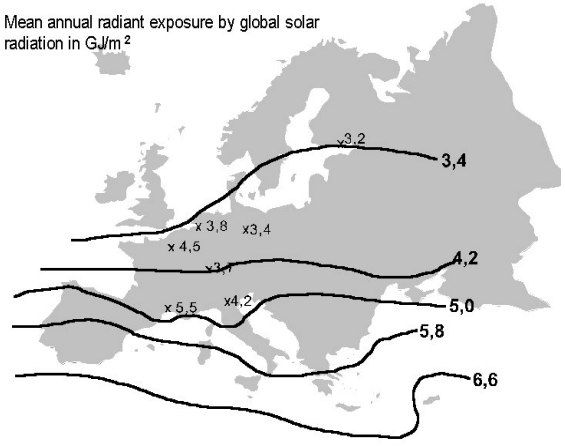
C.2.4 For an artificial weathering device having a time-averaged UV irradiance of E W/m^2 in the wavelength range between 300 nm and 400 nm the exposure times are given in Table C.3.

Where UV irradiance E = 55 W/m^2, this means ca. 5000 h for a 5 year's equivalent.

Climate type	Moderate (M) and severe (S)	Formula used
1 year's equivalent	$\frac{55}{E}$	$\frac{0.200\ (GJ/m^2)}{3600\ (s)\cdot E\ (W/m^2)}\cdot 1h$
2 year's equivalent	$\frac{110}{E}$	$\frac{0.400\ (GJ/m^2)}{3600\ (s)\cdot E\ (W/m^2)}\cdot 1h$
5 year's equivalent	$\frac{275}{E}$	$\frac{1\ (GJ/m^2)}{3600\ (s)\cdot E\ (W/m^2)}\cdot 1h$

Table C.3 – Recommended exposure times for wavelength range 300 nm - 400 nm in 10^3 hours

In order to obtain useful information on the course of possible reaction of test specimens to artificial weathering it is strongly recommended to check and register results at least at three moments during the exposure period. where this additional information leads to a judgement of critical behaviour, such as serious or sudden progress in deterioration, it is recommended to prolong the exposure period until a further check.



NOTE – Isoline 5 can be considered as an indicative borderline between the climatic zones related to temperature

Annex D

Bibliography

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