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RILEM TC 139-DBS: DURABILITY OF BUILDING SEALANTS

RILEM TECHNICAL COMMITTEES

Durability test method - Determination of changes in adhesion, cohesion and appearance of elastic weatherproofing sealants for high movement façade joints after exposure to artificial weathering

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1. INTRODUCTION

Weatherproofing joint seals in light-weight building façades (curtain-wall cladding) are exposed to frequent cyclic movements. This joint movement imposes cyclic mechanical strain on the seal, which, depending on the exposure conditions and the construction design, can vary substantially in rate and amplitude. The joint seals are subjected to movement immediately after installation and are therefore exposed to continuous cyclic movement during their curing period. During cure, the rheological characteristics of cured-in-place sealants gradually change from being viscous, semi-fluid materials to non-flowable elastomers and most sealants, in particular one-component products, can take a considerable time (over four weeks) to cure. Continuous building movement coupled with slow sealant curing time can lead to permanent and detrimental changes in sealant bead geometry and performance characteristics.

During their entire service life, joint seals are exposed to cyclic mechanical strain and environmental degradation factors. Cyclic joint movement, sunlight, temperature variations (heat, cold) and moisture (water) are considered to be the primary environmental and service degradation factors leading to sealed joint failure.

This technical recommendation provides a framework for assessing the effects of cyclic movement and weathering in a laboratory-based procedure. While default values for the test parameters are provided in the test method, test conditions can be adapted by the experimenter to better reproduce local climatic or service conditions.

2. SCOPE

This RILEM recommendation specifies a laboratory procedure for determining the effects of cyclic movement and artificial weathering on laboratory cured, elastic weatherproofing joint sealants (one- or multi-component) for use in high movement building façade applications.

3. NORMATIVE REFERENCES

The following standards contain provisions, which, through reference in this text, constitute provisions of this RILEM Technical Recommendation (RTR). At the time of publication, the editions indicated were valid.

ASTM G151 (1997) Standard Practice for Exposing Non-metallic Materials in Accelerated Test Devices that Use Laboratory Light Sources.

CIE Publication No. 85: 1989, Recommendations for the Integrated Irradiance and the Spectral Distribution of Simulated Radiation for Testing Purposes; Solar Spectral Irradiance, ISBN 3 900 734 224.

ISO 4892-1: 1998 Plastics - Methods of Exposure to Laboratory Light Sources - Part 1: General Guidance.

ISO 4892-2: 1994 Plastics - Methods of Exposure to Laboratory Light Sources - Part 2: Xenon Lamps.

ISO 4892-3: 1994 Plastics - Methods of Exposure to Laboratory Light Sources - Part 3: Fluorescent UV Lamps.

ISO 6927: 1981 Building Construction - Jointing Products - Sealants Vocabulary.

ISO 8339: 1984 Building Construction – Jointing Products – Sealants – Determination of Tensile Properties.

ISO 9047: 1989 Building Construction - Sealants - Determination of Adhesion/Cohesion Properties at Variable Temperatures.

ISO/DIS 11431: 2000 Building Construction – Sealants – Determination of Adhesion/Cohesion Properties After Exposure to Heat and Artificial Light Through Glass and to Water.

ISO/DIS 11600: 1999 Building Construction – Sealants – Classification and Requirements.

ISO 13640: 1996 Building Construction - Definition of Test Substrates.

JIS A 1439-1997 Test Methods of Sealants for Sealing and Glazing in Buildings.

4. DEFINITIONS

For the purpose of this RILEM technical recommendation, the definitions provided in ISO 6927 apply.

5. SUMMARY OF TEST PROCEDURE (PRINCIPLE)

Test specimens are prepared in which the sealant to be tested adheres to two parallel contact surfaces (substrates). Sealant specimens are conditioned either statically (no movement) or dynamically (exposed to cyclic movement). The conditioned sealant specimens are then exposed to repetitive cycles of artificial weathering (light, heat and moisture) and cyclic movement under controlled environmental conditions (degradation cycles). Weathering is carried out for eight weeks (default value) in an artificial weathering machine. This is followed (optionally) by rapid mechanical fatigue cycling (default: 200 cycles). Then the specimens are exposed to two thermo-mechanical cycles as defined in ISO 9047 (section 8, first week), using the full amplitude suggested as the movement range of the sealant under test.

After completion of each degradation cycle, the specimens are extended to their full rated extension and held there as the sealant beads are visually examined for changes in appearance, cohesion and adhesion. The depth of any cohesive or adhesive flaw is determined according to the rules provided in ISO/DIS 11600 and the general condition of the sealant is reported. The weathering exposure, the cyclic movement, and the examination for failures constitute a degradation cycle and the degradation cycle is repeated as often as desired to achieve a certain exposure.

A schematic representation of the test procedure is shown in Fig. 1.

Default test parameters and, for some procedures, alternative options are defined in this technical recommendation (see Table 1). In cases of dispute, the default method is the reference method. The experimenter may deviate from the default values for the following test parameters (deviations from the default values must be highlighted in the test report):

a) Substrate – default: anodised aluminium as specified in ISO 13640;

b) Support dimensions – default: 75 mm x 12 mm x 6 mm as specified in ISO 8339;

c) Conditioning method (A, B or C) – default: A;

d) Artificial light source (xenon-arc, fluorescent UVA-340 lamp) – default: xenon-arc;

e) Weathering procedure: duration of artificial weather-

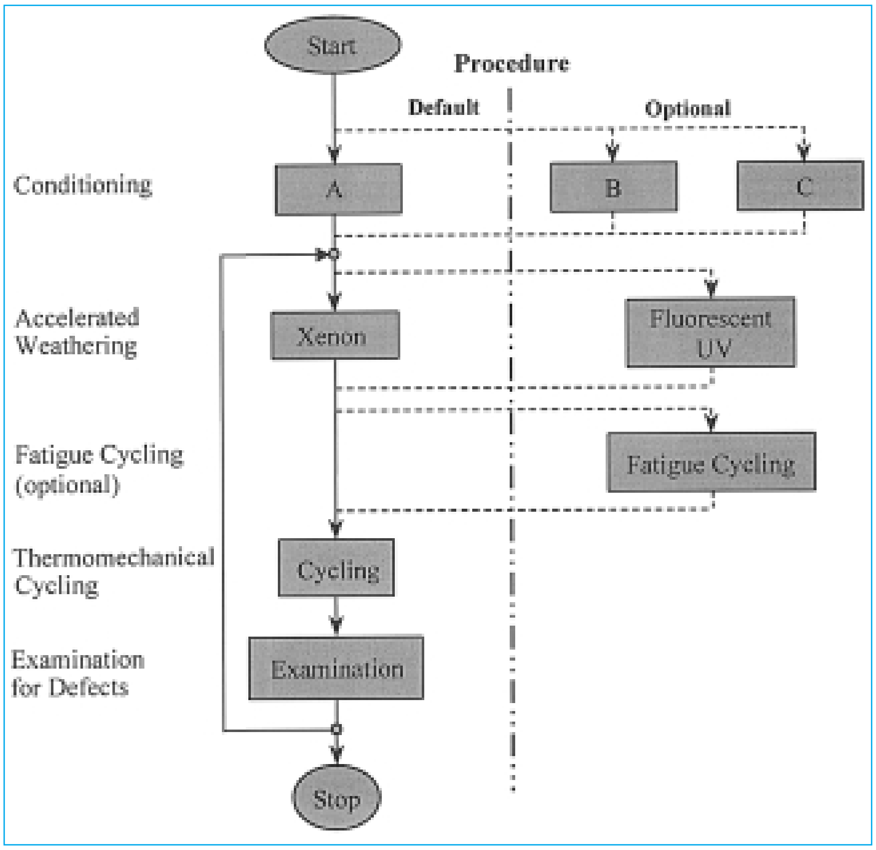

Fig. 1 – Schematic flow-chart of test procedure.

Table 1 – Overview of default and alternative choices of key test parameters		
Procedure	Default	Alternative Option
Conditioning	A	B or C
Movement parameters for Conditioning C	1 cycle/day ± 7.5% amplitude 2.4 hour periods trapezoidal waveform extension/compression rate 70 ± 20 mm/min 1st stroke in tension	
Accelerated weathering	Xenon arc light and water spray 102 min. light at 65 ± 5°C black standard thermometer and 60 ± 10% rel. humidity 18 min. light with water spray 672 cycles (8 weeks) or Xenon arc light and water immersion 102 min. light at 65 ± 5°C black standard thermometer; 18 min. light during water immersion 672 cycles (8 weeks)	Fluorescent ultraviolet radiation and water-spray (FL/UVA-340 lamps) 8h UV at 65 ± 5°C black panel thermometer 4h UV with water spray 112 cycles (8 weeks)
Fatigue degradation	--	Isothermal cycling
Movement parameters for isothermal cycling	5 cycles/min at rated movement capability amplitude 200 cycles total	
Thermomechanical cycling	2 cycles at rated movement capability amplitude (ISO 9047, 1st week)	

ing, type of moisture exposure (spraying or immersion), the temperature of light exposure, the temperature of moisture exposure, the timing of light and moisture/water cycle – default values are specified for xenon arc/water-spray, xenon-arc/water immersion weathering;
f) Rapid fatigue cycling (optional): inclusion of fatigue cycling, amplitude and duration (number of cycles) of fatigue cycling, default: 200 cycles;
g) Thermo-mechanical cycling (ISO 9047 type): amplitude and duration (number of cycles) – default values are specified in the test procedure.

In the future, it is hoped that the test parameters can be linked with specific climatic zones and actual exposure conditions on site.

6. SIGNIFICANCE AND USE

The use of this method is intended to induce property changes in sealants associated with typical end use conditions. The repeated exposure of sealant specimens to cycles of artificial weathering and cyclic movement is meant to simulate a natural weathering environment of sealants installed in curtain-wall joints exposed to high joint movement. Exposures are not intended to simulate the deterioration caused by localised environmental conditions, such as atmospheric pollution, biological attack or salt-water exposure.

Since the natural environment varies with respect to time, geography and topography, it may be expected that the effects of natural weathering will vary accordingly. Therefore, the correlation of the test data obtained using this experimental procedure with the behaviour of a sealant subjected to actual weathering and service conditions (geographic locations, sealant orientation, et cetera) on a given building is unknown. The use of this method as a predictor of the service life of a sealed joint for a given climate and location and on a given building has not been demonstrated.

The results obtained with this recommended procedure will vary depending on the choice of the experimental test parameters (light source, exposure temperatures, movement amplitudes, et cetera). When conducting laboratory-based exposures, it is important to consider how well the artificial test conditions reproduce property changes and failure modes associated with end-use environments for the sealants to be tested. The applicability of test data therefore will be at the discretion of the users of this method and depends on their interpretation of the movement and exposure conditions of a given job site situation.

As a method of test, the procedure can be practised with any substrate, but the standard (default) test substrate is anodised aluminium. It should be noted that a job site will have many substrates and all or most of them will be different from the standard test substrate. Thus, results obtained with this method using the standard test substrate will not be predictive of actual field adhesion.

7. APPARATUS

7.1 Supports

Aluminium supports for the preparation of test specimens (two supports are required for each specimen) of dimensions 75 mm x 12 mm x 6 mm (as shown in Fig. 2). For the specification of the anodised aluminium, refer to ISO 13640. If other support materials are to be used, they must be characterised and must be described

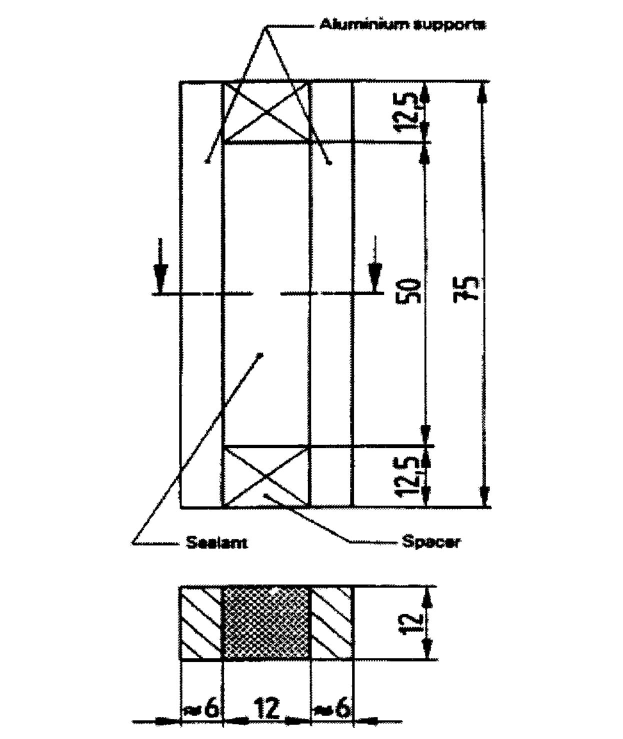

Fig. 2 – Test specimen with anodised aluminium supports (all measurements in millimetres).

in the test report. If other support dimensions, such as specified in JIS A 1439-1997, are used, they must be described in the test report and care must be taken to ensure the same level of irradiance and water exposure at the specimen surface as described in 7.12 and 7.13.

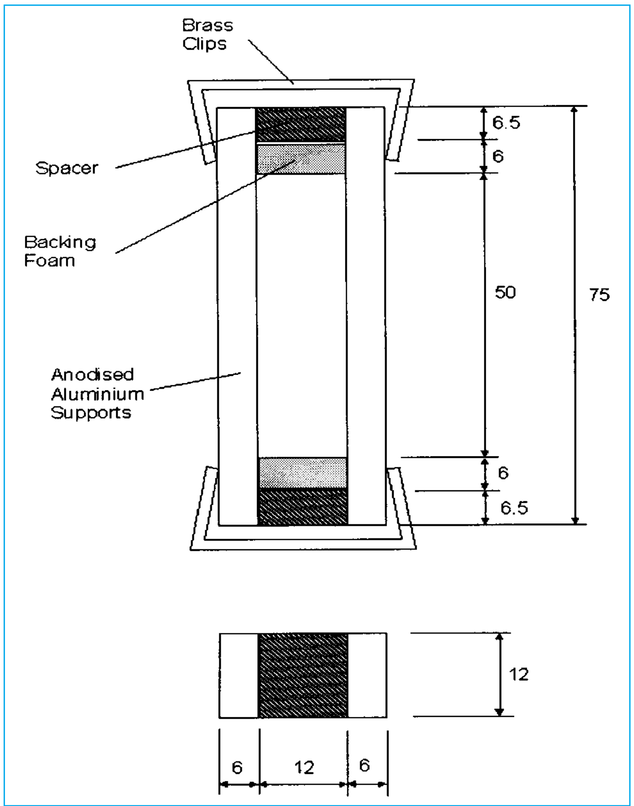

Fig. 3 – Test specimen preparation for dynamic conditioning (all measurements in millimetres).

7.2 Spacers

Spacers for the preparation of the specimens, of dimensions 12 mm x 12 mm x 12.5 mm, with anti-adherent surface (see Fig. 2). If the spacers are made of material to which the sealant adheres, their surface must be made anti-adherent, *e.g.* by a thin wax coating.

7.3 Spacers for dynamic conditioning

Spacers for the preparation of the specimens, of dimensions 12 mm x 12 mm x 6.5 mm with anti-adherent surface (see Fig. 3).

7.4 Closed-cell polyethylene foam end-pieces

Closed-cell polyethylene foam for the preparation of dynamic conditioned specimens, of dimensions 12 mm x 12 mm x 6.5 mm (see Fig. 3).

7.5 Anti-adherent substrate

Anti-adherent substrate for the preparation of test specimens, *e.g.* polyethylene (PE) or polytetrafluoroethylene (PTFE) film, preferably according to the advice of the sealant manufacturer.

7.6 Separators

Separators, of appropriate dimensions to hold the test specimens in extension by the rated movement capability of the sealant.

7.7 Container

Container filled with demineralised or distilled water, for conditioning according to Method B.

7.8 Ventilated convection-type oven

Ventilated convection-type oven, capable of being maintained at (70 ± 2)°C, for conditioning according to method B and for ISO 9047 thermo-mechanical cycling tests.

7.9 Non-corroding metal clips

Non-corroding metal (*e.g.* brass) clips, capable of clamping the specimens in a fixed position during assembly and transfer into movement device (7.10.1) (see Fig. 3).

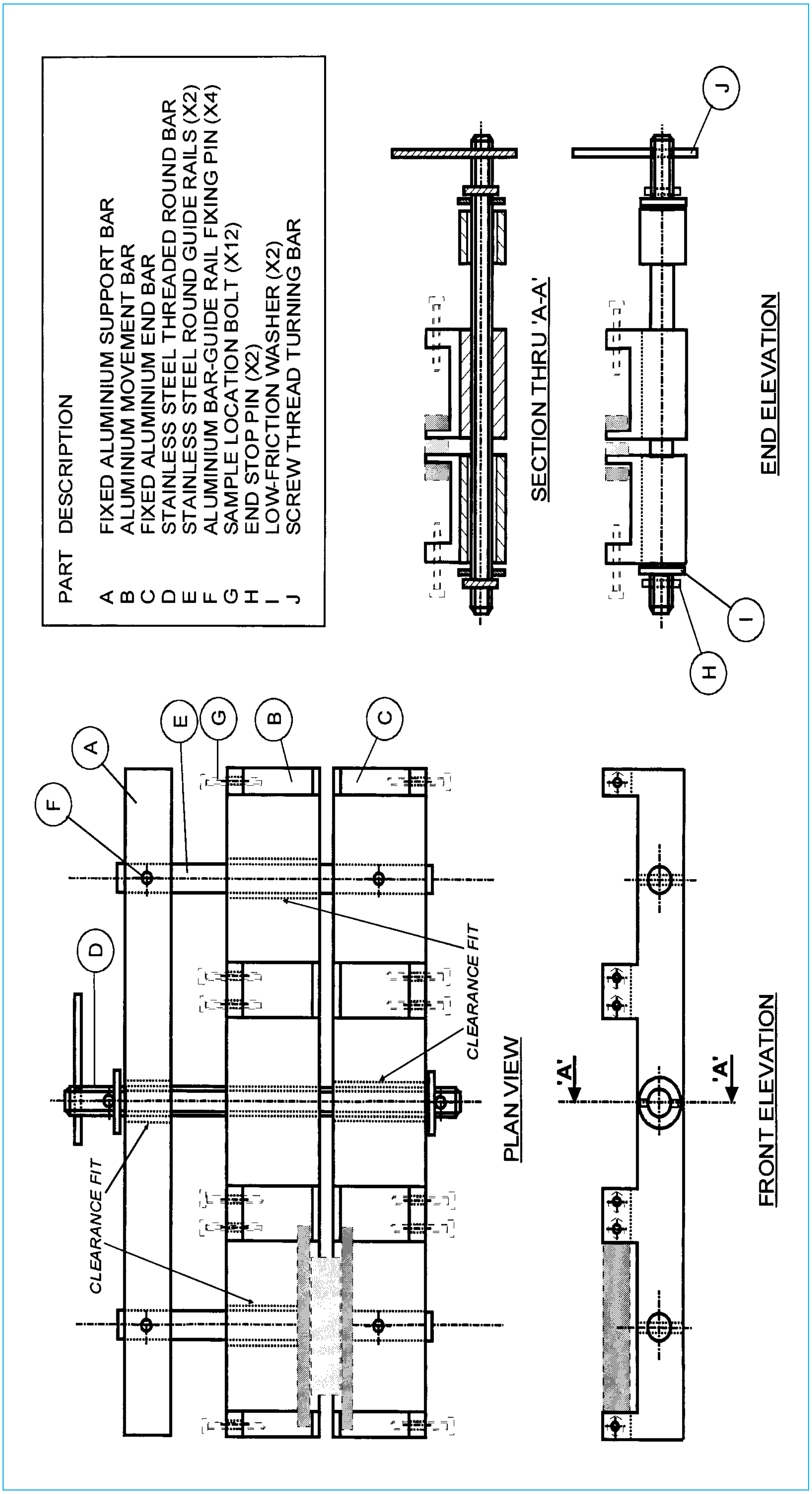

Fig. 4 – Drawing of cyclic movement device for movement during conditioning (Conditioning C).

7.10 Cyclic movement devices

7.10.1 Cyclic movement device for dynamic conditioning

Cyclic movement device for movement during conditioning (Conditioning C), manually operated, capable of moving a sealed joint specimen to controllable dimensions at a movement rate of 70 ± 20 mm/min (see Fig. 4). The imposed movement waveform is trapezoidal.

7.10.2 Cyclic movement device for ISO 9047 thermo-mechanical cycling

Cyclic movement device, for ISO 9047 thermo-mechanical cycling, capable of extension and compression at a rate of 5.5 ± 0.7mm/min.

7.10.3 Cyclic movement device for fatigue cycling

Cyclic movement device for rapid fatigue cycling, capable of subjecting the test specimens to five extension and compression cycles per minute at a rate of 10 to 120 mm/min (such equipment is described in JIS A 1439-1997).

7.11 Refrigeration enclosure

Refrigeration enclosure, capable of holding the test specimens during extension and capable of operating at (-20 ± 2)°C.

7.12 Fully automated test chamber with an artificial light source

Fully automated test chamber with an artificial light source (see 7.13), capable of exposing the test specimens to radiation under controlled conditions of temperature and moisture or water, complying with the requirements of ISO 4892, Parts 1, 2 and 3. The radiation is always directed towards the same surface of the sealant specimen (see Fig. 2). Standard practices for operating such accelerated weathering chambers are described in ISO 4892-1.

In fully automated test equipment, exposure to water for this test method is accomplished by water spraying the specimen surface or immersing the test specimens in water[1,2]. Contamination of the water is to be avoided. The purity of the water to be used is described in ISO 4892, Part 1. The spray and immersion water is kept at a constant temperature, which shall be below 40°C.

Suitable equipment and test procedures for cyclic exposures to water are described in ISO 4892, Parts 1, 2 and 3. Water is a key factor contributing to the ageing of sealants, especially in combination with exposure to light. In xenon arc devices that use water spray for wetting, relative humidity during the light period, shall be maintained at 60 ± 10% r.h.[3]

In the immersion technique, the test specimens are placed in a chamber that is periodically flooded with either recirculated or running water. During immersion, the specimens are completely covered by water. The maximum temperature attained by a black coloured sealant is determined with the black standard thermometer (BST) held under water on the same plane and distance from the surface as the test specimens. The immersion system shall be made from corrosion resistant materials that do not contaminate the water employed.

7.13 Artificial light source

Light sources for the simulation of the global radiation at the surface of the earth are subject to development. The degree of approximation to the spectral power distribution according to CIE publication No. 85 (Table 4) depends on the type of lamp. Xenon-arc lamps and special metal halide lamps, both with suitable filters, are regarded as adequate. Since xenon-arc lamps are more widely used, they are considered the default for the purpose of this RTR.

Several factors can change the intensity and the spectral power distribution of the artificial light source during service. The experimenter must comply with the manufacturer's recommendations and the requirements of ISO 4892 to maintain constant irradiation conditions.

7.13.1 Xenon-arc light source (default)

Xenon-arc light source with direct daylight filters, for the simulation of terrestrial daylight as defined in the CIE publication No. 85 (1989). The spectral power distribution of the radiation shall comply with the requirements outlined in ISO 4892, Part 2, Method A. Irradiance at the surface of the test specimens between the wavelengths of 300 and 800 nm shall be set at 550 W/m^2 and maintained at ± 75 W/m^2. If, exceptionally, other intensities will be used, these shall be stated in the test report. Irradiance below 300 nm shall not exceed 1 W/m^2. The irradiance shall not vary by more than ± 10% over the whole specimen exposure area.

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1) For adequate heat transfer to occur during the condensation period in the fluorescent UV/condensation device a specimen thickness of less than 20 mm is required (dimensions of the supports included). Since the condensation process provided in the fluorescent UV/condensation apparatus is generally not applicable to the type of sealant specimens tested, wetting in this RTR is carried out by water spray on the exposed specimen surface.

2) Data generated with these two methods of water exposure (spray or immersion) in a round robin test on a set of sealants for revision of ISO 11431 showed acceptable correlation, although contributions to the various degradation mechanisms acting in the specimens (e.g. hydrolysis, thermal shock, leaching of formulation components, et cetera) can differ between these exposures. The degree of correlation between these two methods thus may vary depending on the specific sealant tested.

3) The revision of ISO 4892-2 (xenon arc exposure) proposed by ISO/TC 61/SC 6/WG2 in 2001 specifies relative humidity control at 60 ± 10% Generally, automated weathering equipment based on xenon-arc light with water immersion exposure and fluorescent UV lamp type equipment do not allow control of humidity during the light period.

7.13.2 Fluorescent ultraviolet source (option)

Fluorescent UVA-340 lamp(s). The spectral power distribution of the radiation shall comply with the requirements outlined in ISO 4892, Part 3 for a lamp with 343 nm peak emission. Irradiance below 300 nm shall not exceed 1 W/m^2. The irradiance shall not vary by more than ± 10% over the whole specimen exposure area.

7.14 Insulated and uninsulated temperature sensors[4]

Insulated and uninsulated temperature sensors that comply with the requirements outlined in ISO 4892, Part 1, section 5.1.5. Under given operation conditions (uninsulated) black panel thermometers tend to indicate lower temperatures than the (insulated) black standard thermometers. The temperature difference between the two ranges between 3°C and 12°C, being smaller at lower irradiance levels. The default thermometer is the black standard thermometer.

The thermometer shall be mounted on the specimen rack so that its surface is in the same relative position and subjected to the same influences as the test specimens. Readings shall only be taken after sufficient time has elapsed for the temperature to become constant.

8. PREPARATION OF SPECIMENS

Bring the sealant to (23 ± 2)°C before preparation of the specimens (this is generally achieved by conditioning the packaged sealant for 24h at this temperature). Prepare three specimens. For each specimen, assemble two supports (7.1) and two spacers (7.2) (see Fig. 2) and set the assembled specimens up on the anti-adherent substrate (7.5), which is wetted by water with addition of detergents to facilitate subsequent removal from the test specimen.

Follow the instructions of the sealant manufacturer concerning the sealant application, for instance, whether a primer is to be used.

Fill the hollow volume formed by the supports and spacers with the sealant, while taking the following precautions:

a) Avoid the formation of air bubbles;
b) Press the sealant to the inner surfaces of the supports;
c) Trim the sealant surface so that it is flush with the faces of the supports and spacers.

Remove the anti-adherent substrate as soon as possible to allow subsequent conditioning of the test specimens with both upper and lower surfaces being freely exposed.

4) There are inconsistencies between the ISO 4892-1 and ASTM G151 standards in the terminology used for the temperature sensors. In ISO 4892-1, the two types of black temperature sensors are differentiated by referring to the insulated as the "black standard thermometer" and to the uninsulated as the "black panel thermometer". ASTM G151 standard differentiates between the two types by naming them "insulated black panel thermometer" and "uninsulated black panel thermometer". This RTR follows the designation used by ISO 4892-1.

9. CONDITIONING

9.1 General

Condition the specimens in accordance with Methods A, B (static conditioning) or Method C (dynamic conditioning), as agreed between the parties concerned.

9.2 Method A (static conditioning)

After the removal of the anti-adherent substrate, set the specimens on edge, resting on one of the supports. Condition the specimens in this position, with the spacers in place, for 28 days at (23 ± 2)°C and (50 ± 5)% relative humidity.

9.3 Method B (static conditioning)

Condition the specimens first according to Method A. Then subject them three times to the following conditioning cycle:

a) 3 days in the oven (7.8) at (70 ± 2)°C,
b) 1 day in distilled water at (23 ± 2)°C,
c) 2 days in the oven (7.8) at (70 ± 2)°C,
d) 1 day in distilled water at (23 ± 2)°C.

This cycle may be carried out alternatively in the sequence c) – d) – a) – b).

Note: Conditioning B is a normal conditioning method using the influence of water and heat to accelerate the cure of the sealant. It is not intended to give information on the durability of the sealant.

9.4 Method C (dynamic conditioning)

9.4. General

Condition the specimens (see Fig. 3) in a dynamic state as soon as possible after fabrication (within five minutes) at (23 ± 2)°C and (50 ± 5)% relative humidity for a period of two weeks. The following default parameters shall be used: movement shall be one cycle/day at ± 7.5% amplitude, and the period of each cycle shall be 2.4 hours (see Fig. 5 for a schematic representation of the movement cycle). Extension and compression of the test specimen is carried out at a movement rate of 70 ± 20 mm/min. The full movement cycle returns the test specimen back to its original width (12 mm) as part of each cycle.

After the completion of the mechanical cycling, expose the specimens to a further two weeks of static conditioning at (23 ± 2)°C and (50 ± 5)% relative humidity.

9.4.2 Procedure

Place the movement device in 'mid-position' to allow specimens of 12mm joint width to be located into it. Transfer the test specimens and attach them to the movement device within five minutes of fabrication. Take care not to disturb the sealant bead during transfer by holding the test specimens with metal clips (7.9). Once the specimen is firmly located in the movement device (7.10.1), remove the metal retaining clips and spacers carefully, leaving the foam end-pieces at the ends of the joint. Then carry out the following default exposure cycle at (23 ± 2)°C and (50 ± 5)% relative humidity:

a) Start the movement device immediately after the test specimens have been firmly placed into the specimen holders.

b) Place the first stroke such that the specimens are in tension.

c) Subject the specimens to a full movement cycle. Expose the specimens to a movement cycle with a period of 2.4 hours; the specimens being extended to 12.9 mm and compressed to 11.1 mm joint width during the cycle. After completion of the movement cycle, allow the specimens to remain in a static state (fixed at 12 mm joint width) for the remainder of the day.

d) Repeat the procedure of a full movement cycle followed by static conditioning (as in (c)) daily during the first 14 days of dynamic conditioning.

e) Following the first 14 days of dynamic conditioning, remove the foam end-pieces (7.4) from the ends of the joint and take the specimens out of the movement device. Then condition the specimens in a static state at (23 ± 2)°C and (50 ± 5)% relative humidity for a further 14 days.

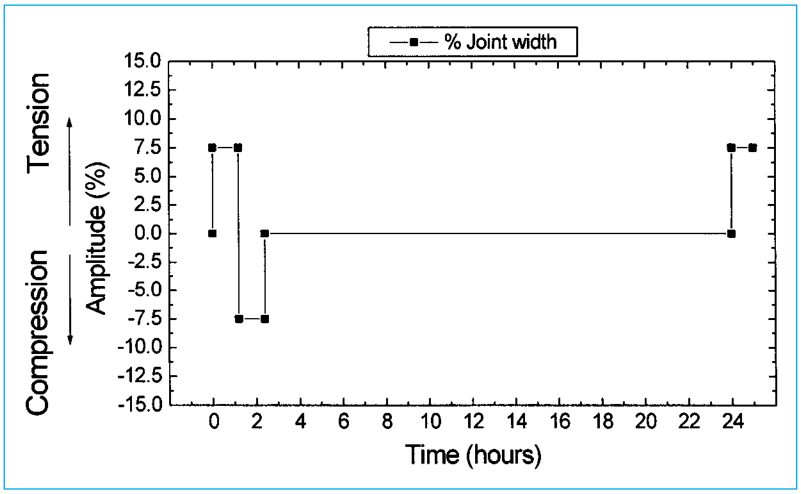

Fig. 5 – Dynamic conditioning – movement waveform imposed by manually adjusted movement vices (2.4 hour period, 1 cycle/day, 70 ± 20 mm/min movement rate).

10. TEST PROCEDURES

10.1 General

After conditioning and removal of the spacers, expose the specimens to the artificial weathering cycle and mechanical movement cycles, as agreed by the parties concerned.

10.2 Accelerated weathering exposure conditions

During the artificial weathering cycle, expose the test specimens to radiation by the artificial light source such that the specimen test surface faces the lamp. During repeated exposure periods, *i.e.* when the specimens are exposed to several degradation cycles, direct the radiation always towards the same surface of the sealant. Mount the test specimens so that the plane of the test surface is at a distance from the lamp(s) consistent with the method for operating the apparatus (ISO 4892-2 or 4892-3). Measure the test temperatures with a black standard thermometer (default) or black panel thermometer (7.14) mounted on the specimen rack so that the face of the temperature sensor is in the same relative position and is subjected to the same influences as the test specimens.

10.2.1 Exposure in automatic weathering equipment – Xenon-arc type (default)

The light source shall be one or more xenon arc lamps with 'direct daylight' filters installed to simulate terrestrial daylight. The spectral power distribution and the operating practices for the automatic weathering equipment shall be as defined in ISO 4892, Part 2. The irradiance level for the 300-800 nm spectral region shall be set at 550 W/m^2 and maintained at ± 75 W/m^2. The equivalent irradiance setting for 300-400 nm shall be 60 W/m^2 maintained at ± 3 W/m^2 and the setting for 340 nm shall be 0.5 $W/(m^2 \cdot nm)$ maintained at ± 0.02 $W/(m^2 \cdot nm)$.

The standard conditions of test (default) are repeated cycles of exposure that consist of eight weeks of exposure in the xenon lamp machine with alternating periods of dry and wet:

a) A dry period of 102 minutes, in which the specimens are exposed to radiation and heat. From the start of the dry period the temperature is allowed to rise, until it reaches a steady temperature of (65 ± 5)°C, as measured on the black standard thermometer (7.14). Relative humidity during the dry period is 60 ± 10% using the xenon arc device with water spray.

b) A wet period of 18 minutes, in which the specimens are exposed to radiation and either water spraying or immersion in water. The water temperature is less than 40°C.

The dry and wet exposures are repeated 672 times (default) (eight weeks total duration in the weathering machine per cycle).

Xenon arc based lamps provide a good representation of the spectral power distribution as defined in the CIE publication No. 85 and therefore are considered as the reference for the purpose of this recommendation.

10.2.2 Exposure in automatic weathering equipment - Fluorescent UVA-340/Water Spray Type (option)

The apparatus employed shall conform to the requirements of ISO 4892, Part 3, for a fluorescent UV device with fluorescent UVA-340 lamps having peak emission at 343 nm. The equipment shall be fitted with a suitable spraying unit. It should be noted that for sealants sensitive to long wavelength UV and visible solar radiation, the absence of this radiation in these lamps may distort stability ranking when compared to exterior environment exposure. The achievable target value of irradiance depends on the operating temperature. For the non irradiance controlled device with UVA-340 lamps operating at 65 ± 5°C black panel temperature, the target value for irradiance at 340 nm is 0.70 W/(m^2. nm) maintained at ± 0.2 W/(m^2. nm). The irradiance controlled device shall be set at the control point at an irradiance level of 0.70 maintained at ± 0.05 W/(m^2. nm) at 340 mm.

The standard conditions of test (default) are repeated cycles of exposure that consist of eight weeks of exposure in the fluorescent UV/water spray device with alternating periods of dry and wet (temperature and cycle duration specified are defaults; temperatures specified are measured on the black panel thermometer):

a) Dry Light Period: 8 hours of UV radiation at (65 ± 5)°C, followed by

b) Water Spray Period: 4 hours of UV radiation and water spray. The water temperature is less than 40°C.

The dry light and light/water spray periods are repeated 112 times (default) (eight weeks total duration in the weathering machine per period).

10.3 Cyclic movement of test specimens

10.3.1 Rapid fatigue cycling (optional)

After completion of the accelerated weathering cycle, *optionally* expose the specimens to rapid fatigue cycling at their rated movement capability (*e.g.* ± 25%, ± 50%) in an automatic cycling device (7.10.3) at a rate of five cycles per minute. Set the initial width for the cycling procedure at 12 mm. The default value for the number of fatigue cycles is 200.

10.3.2 Thermo-mechanical cycling (ISO 9047)

After completion of the accelerated weathering cycle or the completion of the *optional* fatigue cycling exposure, subject the specimens to two cycles of low temperature extension and high temperature compression at their rated movement capability (*e.g.* ± 25%, ± 50%). The procedure for the thermo-mechanical cycling is defined in ISO 9047, Section 8, Test Procedure, First week.

10.4 Examination for defects

Upon completion of each degradation cycle (weathering and cyclic movement), remove the specimens from the cycling machine and extend them to their rated movement capability using separators (7.6). For example, for a sealant rated at ± 25% movement capability, extend the specimen to a joint width of 15 mm. Then examine the specimens for evidence of loss of adhesion or cohesion or any surface changes (cracking, crazing, chalking, et cetera). Whenever adhesion and/or cohesion loss is observed, measure the depth of the cracks using a measuring device capable of reading to 0.5 mm. Determine the highest observed value and the nature of the failure (adhesive or cohesive). Because of the excessive stress experienced by the sealant near the corners of the specimen, during both preparation and testing, loss of adhesion and cohesion is more likely to occur in this region. Determine and report whether the adhesive or cohesive cracks fall within this peripheral region or whether they have propagated further into the bulk of the sealant, in accordance with the requirements defined in ISO/DIS 11600 (1999).

10.5 Continuation of degradation cycles

After examination of the specimens, remove the separators and return the specimen width to its original (12 mm) dimension. Place the specimens in the weathering device and repeat the procedure described in sections 10.1 to 10.4. The default value for the total number of degradation cycles is three. However, choose the minimum number of degradation cycles such as to induce a substantial (visible) degradation for the least stable material being evaluated.

11. TEST REPORT

The test report shall include the following information:

a) The name and address of the test laboratory and date of the test;

b) The name, colour and type of sealant;

c) The batch of sealant from which the specimens were produced;

d) The test substrate;

e) The primer used, if applicable;

f) The method of conditioning used (see section 9);

g) The experimental parameters used, *i.e.*:
- Type of artificial weathering procedure used (xenon/spray, xenon/immersion, fluorescent UV/spray);
- Duration of the artificial weathering exposure;
- Type of light source;
- Irradiance settings;
- Temperature and relative humidity of light exposure;
- Whether humidity has been controlled during the light exposure period;
- Type of moisture exposure (spray or immersion) and temperature of water during spray or immersion;
- Timing of light and light/water cycles.

h) Any deviation from the default values specified in this method, *e.g.*:

- The direction of the first stroke in Conditioning Method C (dynamic conditioning), if deviating from the default;
- Details of the fatigue mechanical cycling procedure, if applicable, specifically the number of cycles and the amplitude of cycling;
- Details of the thermo-mechanical cycling (ISO 9047) procedure, specifically the number of cycles and the amplitude of cycling;
- Nature of the thermometer used (if other than black standard thermometer has been used);

If the experimenter deviates from the default values specified, both the default values as well as the actual conditions used must be reported.

i) The type of damage (adhesive or cohesive failure as well as changes in surface appearance), the maximum depth of cracks, and the location of the cracks (bulk or peripheral region) observed after each degradation cycle;

j) The number of degradation cycles;

i) Any other observations the tester considers important in describing the condition of the specimen.

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