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ISO 11528

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Buildings and civil engineering works — Sealants — Determination of crazing and cracking following exposure to artificial or natural weathering

Bâtiments et ouvrages de génie civil — Mastics — Détermination du tressaillage et du craquelage suite à une exposition au vieillissement naturel ou artificiel

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Reference number
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Foreword

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The committee responsible for this document is ISO/TC 59, *Building and civil engineering works*, Subcommittee SC 8, *Sealants*.

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Buildings and civil engineering works — Sealants — Determination of crazing and cracking following exposure to artificial or natural weathering

1 Scope

This International Standard specifies methods for the assessment of surface defects (crazing and cracking) on sealants after exposure to artificial or natural weathering.

NOTE Sealants are weathered in the laboratory in order to simulate ageing processes occurring during natural weathering. Generally, valid correlations between ageing during artificial and natural weathering cannot be expected because of the large number of influencing factors. Certain relationships can only be expected if the effect of the important parameters (spectral distribution of the irradiance in their photochemically relevant range, temperature of the specimen, type of wetting, wetting cycle relative humidity) on the sealant is known. However, unlike natural weathering, testing in the laboratory is carried out taking into consideration a limited number of variables which can be controlled, and therefore, the results are more reproducible.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 3668, *Paints and varnishes — Visual comparison of the colour of paints*

ISO 6927, *Buildings and civil engineering works — Sealants — Vocabulary*

CIE Publication No.51, *A Method for Assessing the Quality of Daylight Simulators for Colorimetry' (CIE 051.2-1999 (including Supplement 1-1999)*

3 Terms and definitions

For the purposes of this document, the definitions given in ISO 6927 apply.

4 Principle

This International Standard defines an evaluation scheme for designating the quantity and quality of specific surface defects (cohesive cracks and crazes) occurring in sealants as a result of exposure to outdoor or artificial weathering. The sealant test specimens are visually examined and rated for crack density, crack width, and crack depth. The extent of damage in terms of crack width and crack density is determined by visual evaluation and comparison with pictorial references provided in this International Standard. The crack depth is visually assessed with reference to a rating scale.

Visual assessment is carried out under specified illumination and viewing conditions in artificial daylight (D65). Findings are documented by digital photography.

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5 Apparatus

5.1 Standardized lighting apparatus, in accordance with ISO 3668, which is illuminating the test specimen surface with artificial daylight (D65) – 6 500 K.

The quality of simulation of daylight shall be assessed by the method described in CIE Publication No. 51. The spectral distribution of the illuminant shall be in category BC (CIELAB) or better. The level of illumination at the specimen inspection position shall be between 2 000 lx and 4 000 lx.

5.2 Calliper gauge, with an accuracy of ±0,05 mm, for the measurement of deviation of specimen surface flatness.

5.3 Microscope, with a magnification of 10×, for the assessment of surface defects.

6 Observer

Observers shall have normal colour vision and shall be selected carefully because a significant proportion of people have defective colour vision. To avoid eye fatigue effects, pastel or complementary colours shall not be viewed immediately after strong colours. The quality of visual judgements falls off severely if the observer works continuously. Rest periods of several minutes, during which no specimen inspection is attempted, shall therefore be taken frequently.

7 Evaluation specimens

7.1 General

Evaluation specimens are cured sealant samples with or without adjacent substrates (supports) that have been exposed to either natural (outdoor) or artificial weathering. A minimum of two specimens shall be evaluated for each sealant product and weathering condition.

7.2 Specimen thickness

The thickness of the evaluation specimen (cured sealant layer) shall be a minimum of 3 mm.

7.3 Size of inspection surface

The size of the specimen surface that is inspected for surface defects shall be at a minimum 10 mm × 20 mm and at a maximum 40 mm × 50 mm in size.

NOTE Standard-sized test specimens according to ISO 8339 are deemed as providing a suitable inspection surface.

7.4 Flatness of inspection surface

The inspection surface of the evaluation specimens shall be nearly flat, i.e. the deviation of the inspection surface from a perfect plane shall not exceed ±2 mm at any point across the inspection surface. Deviation from the plane is measured by placing a straight-edge steel ruler across the specimen and using a standard pointed depth gauge (calliper gauge, 5.2). The measured value shall be expressed as concave (+) when the surface layer is facing towards the ruler and as convex (–) when the surface layer is facing away from the ruler.

7.5 Conditioning of evaluation specimens

The evaluation specimens shall be conditioned at (23 ± 2) °C and (50 ± 10) % relative humidity (standard atmosphere 23/50 class 2 according to ISO 291) for a minimum of 16 h prior to inspection.

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8 Procedure

8.1 Viewing of evaluation specimens

View the evaluation specimens at a distance of 30 cm to 40 cm and an angle of 45° to 60° with illumination at an angle of 90° or vice versa in a controlled lighting apparatus (5.1) under standardized lighting conditions [conforming to CIE standard illuminant artificial daylight (D65) – 6500 K].

8.2 Assessment of test specimens prior to exposure

If evaluation specimens are not obtained from the field and therefore are available prior to exposure, each specimen shall be inspected. Specimens with any significant application defects (bubbles, deviations from planarity, etc.) shall be discarded.

8.3 Weathering

The evaluation specimens shall be exposed to natural (outdoor) or artificial weathering.

NOTE Weathering can be carried out with or without simultaneous or sequential cyclic movement. For a discussion of different weathering methods see, for instance, ISO 11617 or the RILEM Technical Recommendations. [2][3][4]

8.4 Assessment of test specimens after exposure

After exposure to natural (outdoor) or artificial weathering, the evaluation specimens are inspected visually under controlled lighting conditions (see 8.1). Inspection of the evaluation specimens may occur in their non-extended state or, preferably, in an extended state. The extension amplitude applied during inspection of the evaluation specimens shall be reported in the test report (extension amplitude of non-extended specimens: 0 %).

The specimens shall be examined for evidence of loss of adhesion and cohesion or any surface changes (cracking, crazing, chalking, etc.) of the sealant beads. Certain types of degradation that are only visible at the back surface may occur. Report any relevant observation, such as splitting of the sealant surface, depolymerization (reversion) of the bulk sealant, etc.

Determine the rating for quantity, width, and depth of cohesive cracks over the inspection area according to Table 1, Table 2, and Table 3, respectively. Assess the quantity of cohesive cracks by reference to Table 1 and by using, as an example, Figure 1 a) and Figure 1 b), depending on the type of cracking. The degree of degradation (crack width, crack density, and crack depth) can vary over the specimen surface. In such cases, the determination of the crack width, crack density, and crack depth shall be made at several locations on the specimen surface and the minimum and maximum value shall be reported.

NOTE 1 Figure 1 a) shows cracking without preferential direction and Figure 1 b) shows cracking in one preferential direction. Other forms of cracking occur, but the principles of assessing the quantity remain the same (see Annex A).

Use measuring devices capable of reading to 0,05 mm for crack depth and width.

NOTE 2 Various tools for the determination of crack depth, which are often used in the study of corrosion-induced pitting and cracking, for example, measuring microscope, digital optical micrometer, and digital pit and crack depth gauges are commercially available.

If required for the proper rating of surface defects of outdoor weathered specimens, remove surface contamination by detergent wash followed by water rinse. No aggressive solvents should be used. Brushing or wiping of the surface may damage the surface topology and should be avoided. Ultrasonically aided cleaning is often particularly effective in achieving satisfactory surface decontamination.

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For specimens exposed to natural (outdoor) weathering, dirt deposited on the surface from the atmosphere or surface mould growth may mask some of the cracking and crazing. In this case, efforts shall be made to remove the dirt or mould by suitable means.

Table 1 — Rating for quantity of cohesive cracks

Rating	Quantity of cracks (Q)
0	None, i.e. no detected cracks
1	Very few, i.e. some just detectable cracks
2	Few, i.e. small number of cracks
3	Moderate, i.e. medium number of cracks
4	Considerable, i.e. significant number of cracks
5	Dense, i.e. dense pattern of cracking

Table 2 — Rating for width of cohesive cracks

Rating	Width of cracks
0	Not visible at 10× magnification
1	Only visible under magnification up to 10×
2	Just visible with normal (or corrected) vision (<0,1 mm wide)
3	Clearly visible with normal (or corrected) vision (0,1 mm to <0,5 mm wide)
4	Large cracks generally 0,5 mm to 1 mm wide
5	Very large cracks generally more than 1 mm wide

Table 3 — Rating for cohesive crack depth

Rating	Depth of cracks
0	No cracks detectable at 10× magnification
1	Shallow surface crack depth (<0,1 mm depth)
2	Medium surface crack depth (0,1 mm to 1 mm depth)
3	Significant surface crack depth (>1 mm to 3 mm depth)
4	Very significant surface crack depth (>3 mm to 10 mm depth)
5	Cohesive failure (>10 mm depth)

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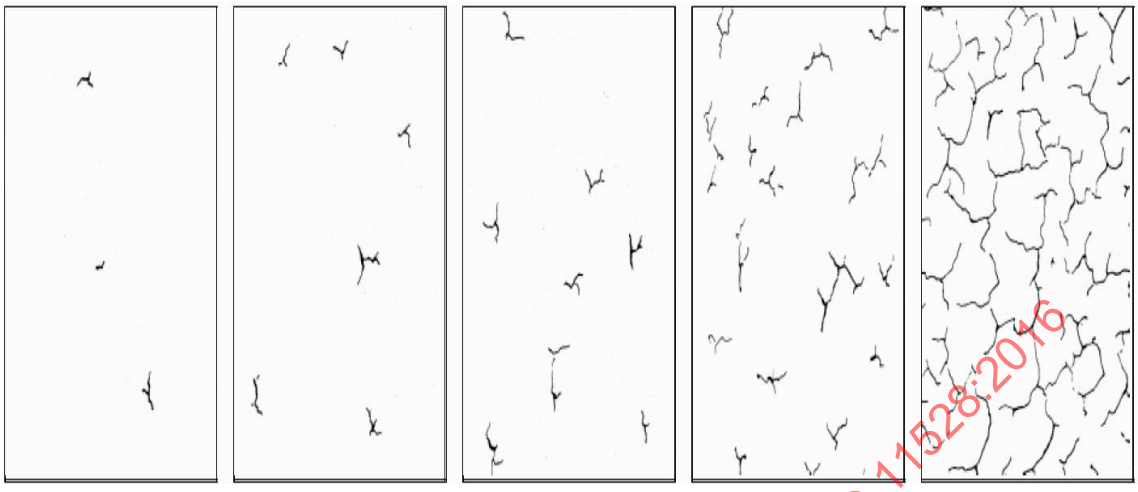
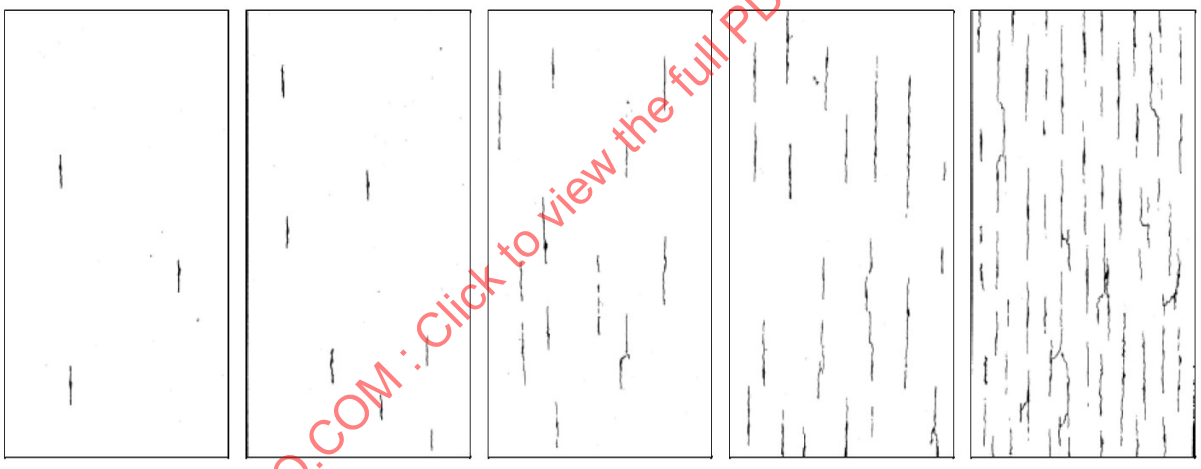


Q = 1 Q = 2 Q = 3 Q = 4 Q = 5

a) Cracking without preferential direction



b) Cracking in one preferential direction

Figure 1 — Examples for assessing the quantity of cohesive cracks

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Figure 1 a) and Figure 1 b) are based on observation area of 10 mm × 20 mm (pictorial standards were adapted from ISO 4628-4).

8.5 Photo documentation of evaluation specimens

Visual inspection and documentation of visual aspect are supplemented by photographic documentation to aid in the communication of the findings. The surface condition of the specimen observed after each exposure interval shall be documented photographically (minimum 75 mm × 100 mm print size) with a minimum resolution of 800 dpi (31,5 dots per millimetre). The digital photo shall be furnished with a minimum 9-megapixel camera (colour photo in "true colour" setting) to document the findings. The camera shall be positioned on a fixed mounting in such a manner that the photo is taken at an angle of 80° to 90° [nearly vertically, see Figure B.6)]. The long side of the specimen shall be aligned with the horizontal axis of the photo. The photo shall be furnished at a distance of 30 cm to 50 cm from the evaluation specimen with a lens that results in the long-edge of the specimen representing a minimum of 80 % of the photo's horizontal axis. All digital photos shall be made in uncompressed format (RAW, TIF, or similar) or, at a minimum, in high quality, low compression JPEG format. Compression in JPEG

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format shall not affect reproduction of the smallest resolvable feature in each of the two horizontal dimensions. All photographs shall have an indication of scale in both directions within the picture plane (XY). Photo-documentation of the evaluation specimens may occur in their non-extended state or, preferably, in their extended state. The extension amplitude applied during photo documentation of the evaluation specimens shall be reported in the test report (extension amplitude of non-extended specimens: 0 %).

NOTE 1 Scale bars of known size (shown in both X and Y direction) are the most suitable option to express the magnification of the photo.

Image files shall not be manipulated or adjusted in any way that could lead to misinterpretation of the information present in the original image.

NOTE 2 Inappropriate manipulation includes, but is not limited to: a) the introduction, enhancement, movement, or removal of specific feature(s) within an image; b) adjustments of brightness, contrast, or colour balance that obscure, eliminate, or misrepresent any information. Sharpening of photos may also lead to loss of information present in the original image.

The resolution of the camera's sensor shall be chosen such that a minimum of 3 pixels are used to capture the smallest resolvable feature in each of the two horizontal dimensions (XY).

The Nyquist-Shannon sampling theorem suggests that a point object should be oversampled at least two times in X and Y directions. Because adequate contrast is essential to correctly resolve structures, 2,5 times to 3 times oversampling is more appropriate. Undersampling of an image, i.e. using too few pixels to accurately describe a small feature, can yield artefacts, which masquerade as real structures, leading to misinterpretation of the image data.

The lighting of the sealant specimen shall ensure good contrast and accurate colour representation in the photo image (see Annex B).

9 Test report

The test report shall include the following information:

a) a reference to this International Standard, i.e. ISO 11528:—;

b) the name of the test laboratory and date of test;

c) the name and type of sealant;

d) the batch of sealant from which the specimens were produced;

e) the method and date of preparation of the test specimens, thickness of the sealant, colour;

f) the details of the natural or artificial weathering procedure as required by the relevant weathering standard (e.g. the method of conditioning used, type of weathering, duration of exposure, artificial weathering exposure cycle, type of lamp, intensity of light, and if water spray or immersion in water is applied);

g) for specimens weathered outdoors, the presence or absence of surface soiling and/or mould growth; before and after cleaning (if applicable) of the inspection surface: the percentage (%) of estimated coverage of the contamination on the inspection area; the strength (layer thickness) of the contamination, rated as weak, medium, and strong; the method employed in the cleaning of the sealant surface;

h) the ratings for crack severity (width), crack density, and crack depth in accordance with this International Standard, extension amplitude applied during inspection (if applicable);

i) any other relevant observations, such as loss of adhesion, chalking of sealant surface, depolymerization (reversion) of the bulk sealant, etc.;

j) the digital photo documentation, extension amplitude applied during photo documentation;

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k) any deviations from the specified test conditions;

l) any unusual features (anomalies) observed during the test.

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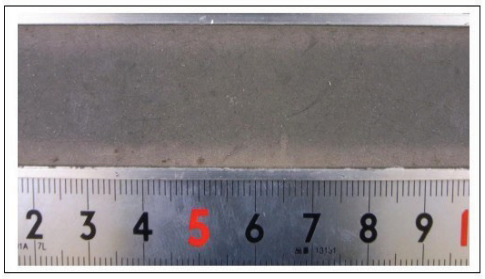
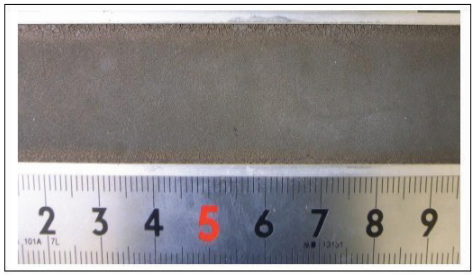
Annex A
(informative)

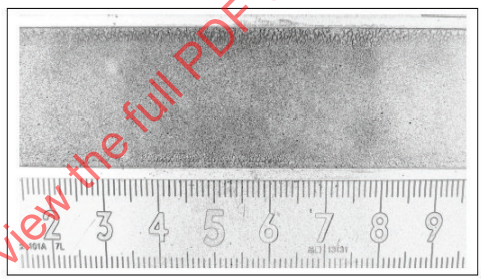
Photographic documentation

Ratings for crack width — Ratings S1 to S5 (S0: No cracks are observed).


Q3 S1


Q3 S1 contour


Q5 S1 B


Q5 S1 B contour


Q5 S1 C


Q5 S1 C contour


Q5 S1 D

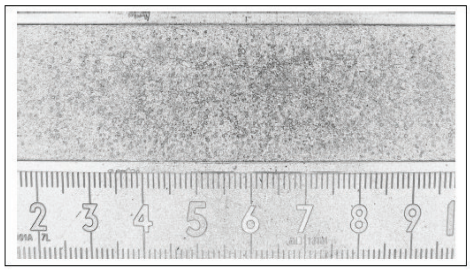

Q5 S1 D contour

Figure A.1 — Crack width: S1

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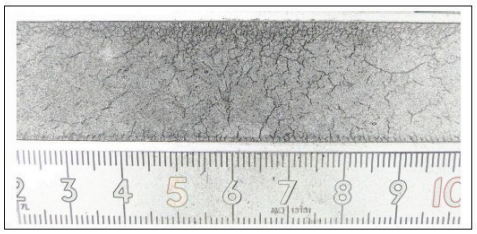
Q2 S2 A

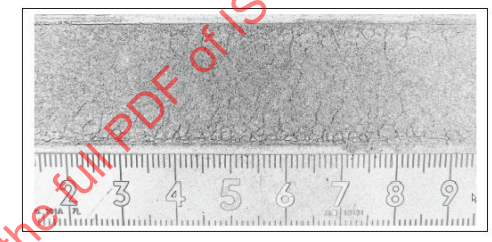


Q2 S2 A contour

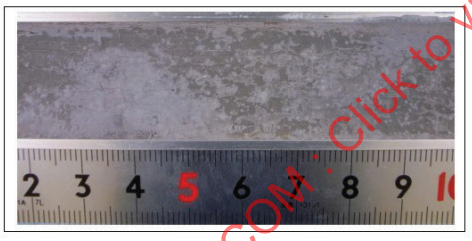
Q2 S2 B

Q2 S2 B contour

Q4 S2 A



Q4 S2 A contour



Q4 S2 B

Q4 S2 B contour

Figure A.2 — Crack width: S2

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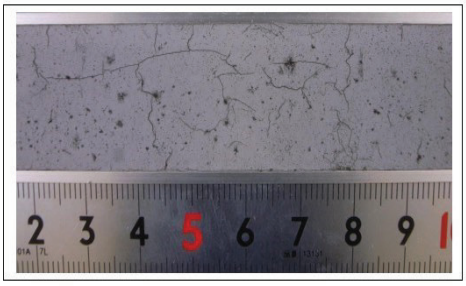
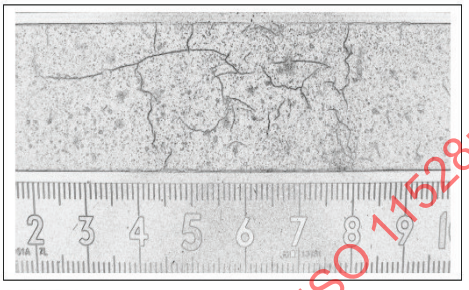
Q2 S3 A

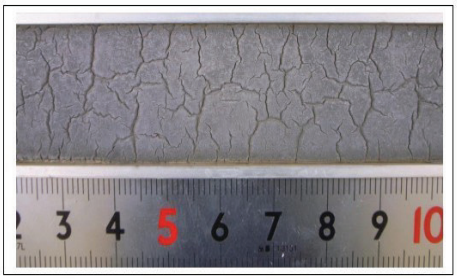
Q2 S3 A contour



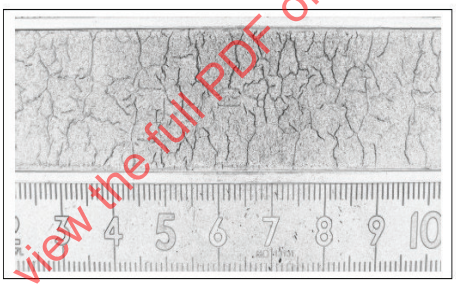
Q3 S3



Q3 S3 contour



Q4 S3 A



Q4 S3 A contour

Figure A.3 — Crack width: S3

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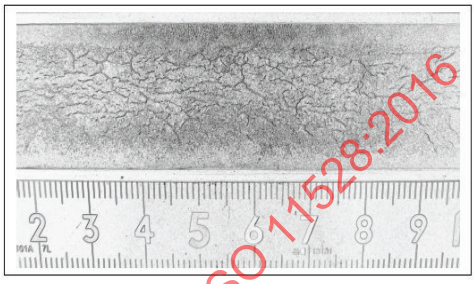
Q3 S4

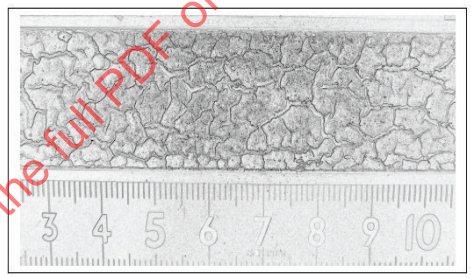
Q3 S4 contour

Q4 S4 A



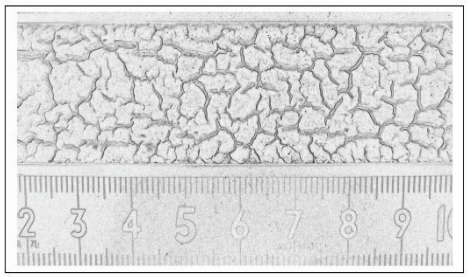
Q4 S4 A contour

Q5 S4 A



Q5 S4 A contour

Q5 S4 B



Q5 S4 B contour

Figure A.4 — Crack width: S4

Q3 S5

Q3 S5 contour

Figure A.5 — Crack width: S5

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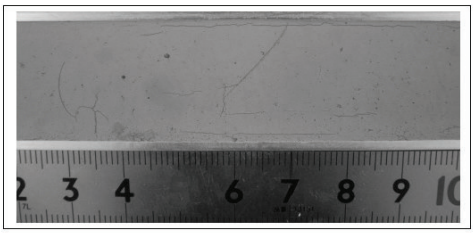
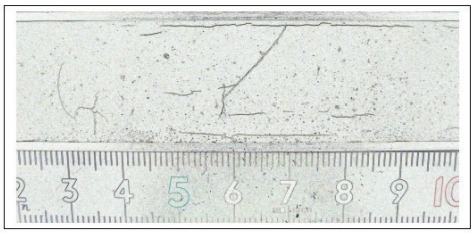
Ratings for crack quantity (density) — Ratings Q1 to Q5 (Q0: No cracks are observed).



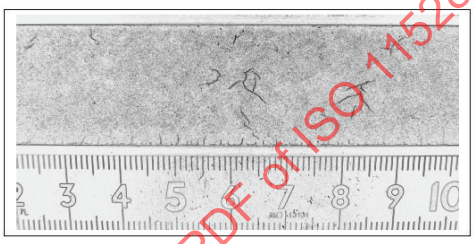
Q1 S3



Q1 S3 contour

Figure A.6 — Crack quantity: Q1

Q2 S3 A



Q2 S3 A contour

Figure A.7 — Crack quantity: Q2

Q3 S3

Q3 S3 contour

Figure A.8 — Crack quantity: Q3

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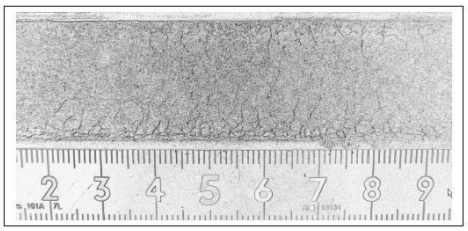
Q4 S2 A



Q4 S2 A contour

Q4 S2 B

Q4 S2 B contour

Figure A.9 — Crack quantity: Q4

Q5 S3 M

Q5 S3 M contour

Q5 S3 N

Q5 S3 N contour

Figure A.10 — Crack quantity: Q5

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Annex B
(informative)

Preparation of the specimen for photography

B.1 General

The following basic procedures for taking photographs should result in good photographic records. These procedures are not the only way to photograph test specimens. Experienced photographers may decide to use different techniques and equipment.

B.2 Preparation of the specimen for photography

A variety of sample holders or fixtures may be used for securely positioning the test specimen at a given tilt during photography. Figure B.1 shows, as an example, an open aluminium sample holder which can hold the test specimen with the attached scale indicator(s).

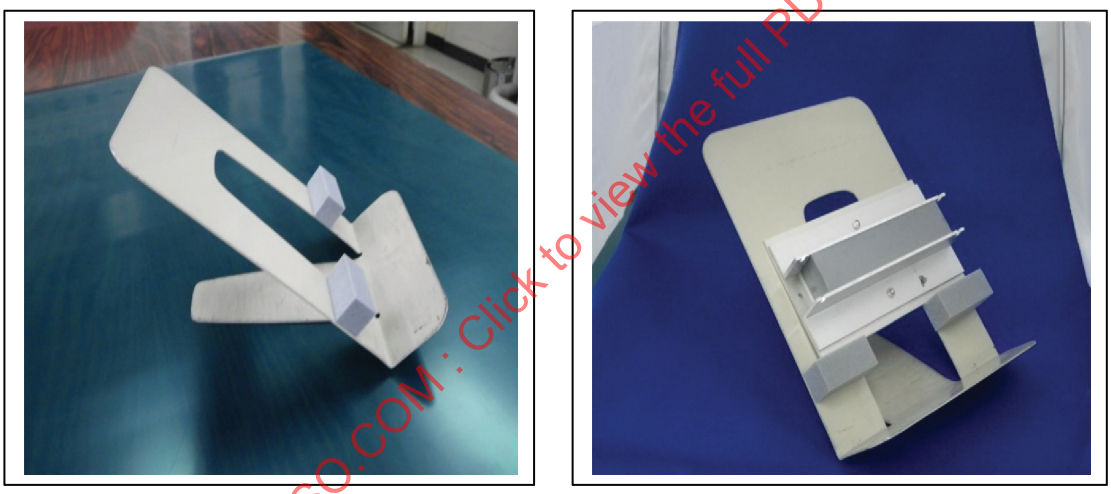

Figure B.1 — Sample holder

The scale indicator(s) can be mounted with the help of suitable attachment devices (see Figure B.2).

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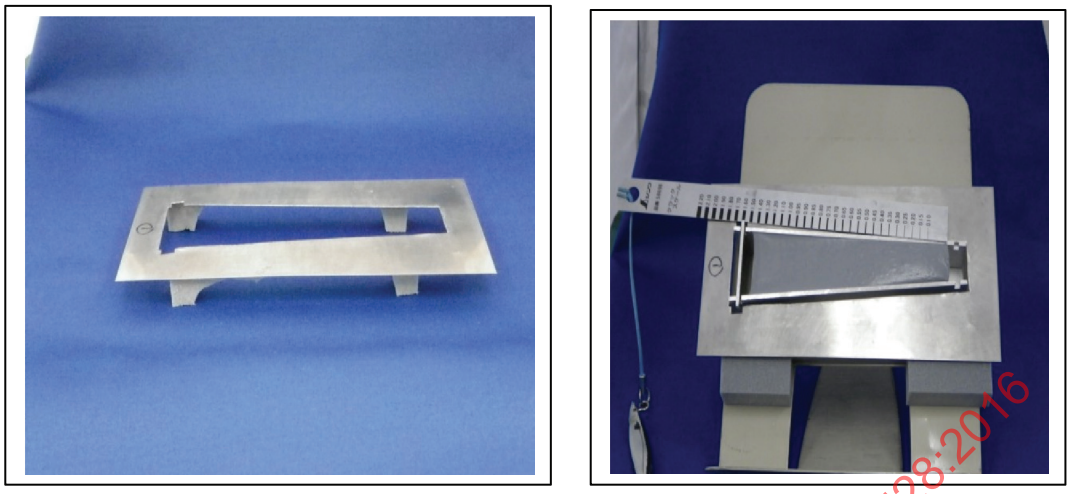

Figure B.2 — Attachment devices

A mask may be placed over the specimen in order to simplify the assessment of surface cracks induced by the weathering and cyclic movement exposure for certain movement amplitude ranges. Figure B.3 shows, as an example, a mask used in the assessment of surface conditionings for three movement amplitude ranges.

Figure B.3 — Mask placed on test specimen

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B.3 Lighting

The most important element in the generation of photographic records is the interaction of light with the subject being imaged. In cases where clarity of surface details is of great importance, controlling light can be especially challenging. The light intensity needed to reveal small surface details, such as cracks and crazing in the surface of a sealant, may often over-compensate the light levels needed in other areas, especially for high colour contrast and/or reflective specimens. Image documentation with optimally-balanced light intensity is difficult. One technique that has shown promise for quick and effective imaging of sealant surfaces is using daylight or artificial light sources in conjunction with a light diffuser dome placed over the specimen to create a diffuse, soft light arena for photography. The lighting of the sealant specimen shall ensure good contrast and accurate colour representation in the photo image.

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