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Building and civil engineering sealants — Determination of the degree of cure —

Part 1: Build-up of tensile properties in dumbbell-shaped specimens

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 59, *Buildings and civil engineering works*, Subcommittee SC 8, *Sealants*.

A list of all parts in the ISO 24068 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Building and civil engineering sealants — Determination of the degree of cure —

Part 1:
Build-up of tensile properties in dumbbell-shaped specimens

1 Scope

This document specifies a method for the determination of the degree of cure of one- and multi-component sealants as indicated by the build-up of the tensile properties in dumbbell-shaped specimens during cure.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 37, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties*

ISO 5893, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Specification*

ISO 6927, *Building and civil engineering sealants — Vocabulary*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Principle

The degree of cure of a dumbbell-shaped test specimen of a (ambient temperature curing) sealant is determined as the ratio between the value of engineering tensile stress (secant modulus), or maximum tensile strength at any time during cure, and the corresponding value measured after a reference cure period.

5 Apparatus and materials

5.1 Tensile-testing machine with recording device, conforming to ISO 5893 (force class 2 as defined in ISO 7500-1, corresponding to a maximum permissible value of accuracy of ±2 %). The accuracy class

for elongation shall be class D. An appropriate load cell of suitable sensitivity for the sealants to be tested shall be used.

It shall be possible to set the tensile-testing machine at one or more of the following rates of displacement of the driven grip: (100 ± 10) mm/min, (200 ± 20) mm/min and (500 ± 50) mm/min.

The tensile-testing machine shall be equipped with suitable means for measuring strain, such as with a mechanical or non-contacting extensometer (e.g. video-extensometer).

5.2 Template for preparation of sealant sheets, with a thickness of (2 ± 0,2) mm, such as a mould or a plate and frame kit and scraper made from anti-adherent material (e.g. PE, PP, PTFE). The assembly shall allow preparation of sealant sheets of a sufficient size for cutting minimum five test specimens per sheet.

NOTE 1 Test specimens made from sheets of other thickness do not necessarily give comparable results.

NOTE 2 No sealant sheets need to be prepared, if test specimens are directly prepared in suitable moulds (see Clause 7).

5.3 Dies (Type 1, 1A or 2) and cutters, in accordance with ISO 37.

NOTE Dies and cutters are not required, if test specimens are directly prepared in suitable moulds or by other suitable methods (such as water-jetting) (see Clause 7).

6 Conditioning

The equipment used for manufacturing the sealant sheets, the sealant in its unopened package, and the dies shall be conditioned at (23 ± 2) °C and (50 ± 10) % relative humidity for a minimum of 16 h prior to the preparation of sealant sheets and test specimens.

7 Preparation of test specimen

A sufficient number of sealant sheets shall be prepared based on the size of the sealant sheets and the number of cure intervals chosen.

For multi-component sealants, the instructions of the sealant manufacturer regarding the mixing procedure shall be followed. One-component sealants can be applied directly from the original container.

The sealant shall be filled into the cavity and levelled flush with the face of the mould or frame using a suitable scraper, while ensuring that no air pockets are entrapped in the sealant.

The sealant sheet shall then be conditioned (cured) in the mould for a specified period of time (cure interval) at standard conditions of (23 ± 2) °C and (50 ± 10) % relative humidity. One or several arbitrary cure intervals may be selected, as agreed by the parties concerned. Typically, cure intervals are selected from the following: 16 h, 24 h, 48 h, 72 h, 4 d (96 h), 7 d (168 h), 14 d (336 h). Furthermore, a cure interval of 14 d (336 h) or 28 d (672 h) shall be selected as the reference cure, as agreed by the parties concerned.

Other methods of cutting the specimens from the sealant sheets, such as water-jetting, may be applied. However, the type and tolerances of specimen shall correspond to dies (Type 1, 1A or 2) in accordance with ISO 37.

Alternatively, the test specimens may be prepared by casting the sealant directly into suitable moulds (e.g. silicone moulds for organic sealants) with the desired dimensions [sealant thickness of (2 ± 0,2) mm and type and tolerances of specimen corresponding to dies (Type 1, 1A or 2) in accordance with ISO 37].

After completion of each of the selected cure intervals and the reference cure, a minimum of five dumbbell type specimens per test shall be prepared at standard conditions of (23 ± 2) °C and (50 ± 10) % relative humidity by using dies and cutters in accordance with ISO 37.

8 Test procedure

The test procedure shall be carried out at standard conditions of (23 ± 2) °C and (50 ± 10) % relative humidity. A minimum of five test specimens for each selected cure interval and the reference cure shall be tested.

The dumbbell-shaped specimen shall be:

— inserted into the tensile-testing machine, while ensuring that the end tabs are gripped symmetrically so that the tension is distributed uniformly over the cross-section; and

— extended in accordance with ISO 37 until rupture occurs.

NOTE The compressive force of the grips needs to be finely balanced on the one hand to secure the test specimens and on the other hand to avoid excessive pinching that can lead to premature test specimen failure.

For each test and reference specimen, the stress-strain diagram as well as the values of tensile stress at the chosen elongation (100 % or 60 %, or any other elongation as decided by the parties concerned) and maximum tensile strength shall be recorded.

9 Calculation and expression of test result

9.1 Tensile stress

For each test and reference specimen, the engineering tensile stress (σ) at the chosen elongation shall be determined in accordance with ISO 37 and recorded to three significant digits using Formula (1):

$$\sigma = \frac{F}{S} \tag{1}$$

where

σ is the engineering tensile stress (secant modulus), expressed in newtons per square millimetre;

F is the force at chosen elongation, expressed in newtons;

S is the original (before any load is applied) cross-sectional area of the specimen, expressed in square millimetres.

Determine the arithmetic mean of the tensile stress values recorded for the test and reference specimens, expressed in newtons per square millimetre (N/mm^2), rounded in one step to the rounding interval of 0,01 N/mm^2 in accordance with the provisions of ISO 80000-1:2009, Annex B.

9.2 Tensile strength

For each test and reference specimen the maximum engineering tensile stress (σ_{max}) shall be determined and recorded to three significant digits figures in accordance with ISO 37 by extending the test specimen to breaking point. Determine the arithmetic mean of the tensile strength values recorded for the test and reference specimens, expressed in newtons per square millimetre (N/mm^2), rounded in one step to the rounding interval of 0,01 N/mm^2 in accordance with the provisions of ISO 80000-1:2009, Annex B.

For certain sealants, the maximum elongation may exceed 1 000 %. In these situations, the tensile stress at 1 000 % elongation shall be considered the maximum tensile stress.

NOTE A maximum in the tensile stress-strain curve can occur before the specimen breaks. In such situations, the values of maximum tensile stress and tensile stress at break differ from each other.

9.3 Degree of cure

Calculate the degree of cure, expressed as a percentage as relation of the tensile stress and/or tensile strength of the test specimens to the reference test specimens, using Formula (2):

$$R_c = \frac{X}{X_r} \times 100\,\% \quad (2)$$

where

R_c is the degree of cure, expressed as a percentage;

X is the arithmetic mean of the tensile stress, or tensile strength of the test specimens tested at any time during cure;

X_r is the arithmetic mean of the tensile stress, or tensile strength of the reference test specimens after the reference cure.

The degree of cure shall be denoted as follows: for tensile stress as $R_{c(\sigma)}$, and for tensile strength as $R_{c(\sigma max)}$.

9.4 Rounding of results

Values of tensile stress and maximum tensile strength obtained for the test and reference specimens shall be rounded in one step to the rounding interval of 0,01 N/mm^2 in accordance with the following procedure, which is based on the guidance given in ISO 80000-1:2009, Annex B:

a) if the figure immediately after the last figure to be retained is less than five, the last figure to be retained shall be kept unchanged;

b) if the figure immediately after the last figure to be retained is equal to or greater than five, the last figure to be retained shall be increased by one.

Rounding shall be done in one step and not in two or more successive rounding steps. For example, 2,444 6 rounds to 2,44 and not first to 2,445 and then to 2,45.

10 Test report

The test report shall contain the following information:

a) test laboratory's name and date of test;

b) reference to this document, i.e. ISO 24068-1:2021;

c) name, type (chemical family) and colour of sealant;

d) batch of sealant from which the test specimens are produced;

e) mix ratio of multi-part products, if applicable;

f) method of preparation of test and reference specimens (mechanical die cutting, water jetting, moulding);

g) die type (or specimen type) in accordance with ISO 37;

h) test speed for tensile strength in accordance with ISO 37;

i) stress-strain diagrams for the individual test and reference specimens with documentation of the cure intervals of the test and reference specimens;

j) individual test results for each specimen and arithmetic mean values of tensile stress at the chosen elongation (100 % or 60 %, or any other elongation as decided by the parties concerned), and tensile strength (maximum tensile stress);

k) degree of cure of the sealant for the test parameters tensile stress and/or tensile strength and cure intervals as agreed by the parties concerned;

l) any deviations from this document.