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Testing of paper and board — Compressive strength of a sample held in S-shape

Essais des papiers et des cartons — Résistance à la compression d'un échantillon tenu en forme de S

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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 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*.

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.

Introduction

The compressive strength of a sample fixed into an S-shape is tested analogous to the SCT (short-span compression test)[1] where the maximum compressive force which the sample withstands is measured parallel to the plane of the paper. During this test, the sample strip is subjected to double bending and then assumes the shape of the letter “S”, which is why the test is referred to as “S-test”. In comparison to the SCT, the clamps of the “S-test” are positioned with an offset and larger spacing. This is a test method with a good correlation to 1st yield of the load curve during a CMT (corrugated medium test) [2,3] measurement.

Testing of paper and board — Compressive strength of a sample held in S-shape

1 Scope

This document specifies a test method for determining the compressive strength of a sample fixed into an S-shape in the machine direction.

This document is applicable to papers with a grammage of 80 g/m^2 to 220 g/m^2; different grammages can lead to unreliable results.

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 186, *Paper and board — Sampling to determine average quality*

ISO 187, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
S-test value
maximum strength of a corrugating medium when subjected to double bending until failure occurs in relation to the sample width under specified conditions

Note 1 to entry: The results are expressed in kilonewtons per metre (kN/m).

4 Principle

The sample is fixed between two clamping devices as such to create a 1 mm offset to the plane of the sheet. Subsequently, a compressive force is applied parallel to the plane of the paper. This results in double bending over a test length of 4 mm. Failure of the structure at the maximum load occurs in the form of buckling.

5 Apparatus

5.1 Cutting device

The cutting device shall be suitable for preparing sample strips with a width of (15,0 ± 0,1) mm and a minimum sample length of 90 mm. The edges of the sample shall be cleanly cut and free from any damage.

5.2 S-test apparatus

5.2.1 General

The S-test apparatus is provided with two clamping devices for inserting the 15 mm wide test piece (Figure 1, key 1 + 3 as well as 2 + 4). A clamping jaw pair (Figure 1, key 1 + 3) is movable in the direction of testing while another clamping jaw pair (Figure 1, key 2 + 4) is at a fixed position within the same plane. A clamping jaw (Figure 1, key 2 + 4) is also connected to the load cell.

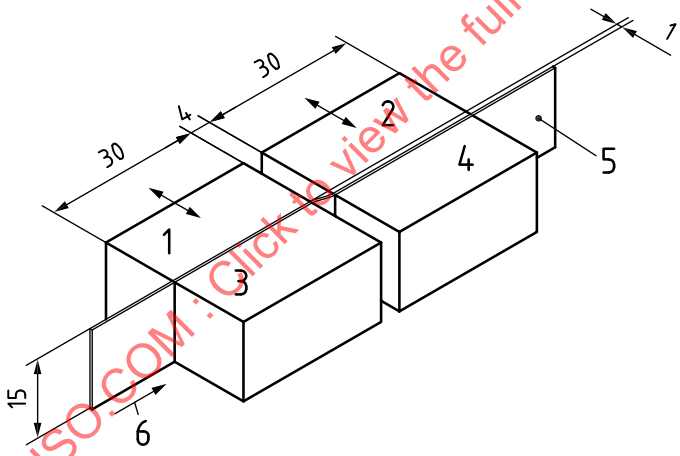
During the measurement process, the movable clamping jaw pair (Figure 1, key 1 + 3) moves on a straight line towards the fixed clamping jaw pair (Figure 1, key 2 + 4) at a test rate of (3,0 ± 1,0) mm/min.

The free clamping length between the clamping jaw pairs is (4,0 ± 0,1) mm. Additionally, the clamping jaw pairs show a mutual offset of (1,00 ± 0,05) mm within the plane. The four clamping jaws have a length of (30 ± 2) mm each.

Each clamping jaw pair consists of a fixed (front) jaw and a movable (rear) jaw for closing the clamp. The clamping force applied between the jaws should be constant and ensure secure gripping of the test piece during measurement. The clamps shall be able to hold the test piece in position with a constant clamping force of (2 300 ± 500) N.

The clamping jaws shall be constructed as such to grip the test piece over its entire width. The clamping jaws shall be free from any burrs and the edges in contact with the test piece in the 4 mm span shall not be blunted.

Dimensions in millimetres



Key

1 clamp, short way to go
2 clamp, long way to go
3 + 4 fixed clamps
5 test piece
6 direction of testing

NOTE The clamping jaw pairs 1 + 2 and 3 + 4 can also be positioned back-to-front.

Figure 1 — Schematic illustration of the clamping jaw pairs with inserted test piece

5.2.2 Sequence

The closing sequence of the clamps shall be as follows: Upon insertion of the test piece, the clamping jaw pair with the larger opening closes first. After a waiting time of approximately 1 s, the other clamp closes, thereby already pulling the test piece strip into the measurement position with a 1 mm offset (see Annex B).

Deviations from this clamping order can stress the test piece and can impact the results.

6 Inspection and maintenance

6.1 General

The test apparatus should be inspected for its functionality and measurement accuracy at regular intervals. The inspection interval is subject to the frequency of use, the ambient conditions and the requirements of the manufacturing process or the products, respectively.

6.2 Force measuring device

The test apparatus shall be constructed as such to enable calibration of the force indication using suitable reference standards (load cell or test weights).

The load cell should be calibrated at a minimum of five graduated measurement points within the application range of the force indication. The maximum permissible deviation for a range between 10 N and 300 N is ±1 % of the respective set-point.

6.3 Clamping jaws

The clamp spacing of (4,0 ± 0,1) mm and the lateral offset of (1,00 ± 0,05) mm shall be checked by using a suitable means of measurement.

The inner faces of the clamping jaws should be checked at regular intervals and cleaned as necessary. A clamp impression, for example, by means of pressure-sensitive film, can be used for evaluating the clamping effect. The clamps operate satisfactorily if they produce a uniform and full impression of the entire surfaces of both clamping jaws (see Annex C). Clamping jaws showing any visible damages shall be replaced.

After the test is started, the clamps shall move towards each other at a speed of (3,0 ± 1,0) mm/min.

7 Sampling

If the average quality of a lot is to be determined, sampling shall be carried out in accordance with ISO 186.

If another type of sample is to be tested, make sure that the test pieces taken are representative of the sample received.

8 Conditioning of samples

The sample is preconditioned and conditioned in accordance with ISO 187.

The samples shall be treated very carefully and the area to be tested shall not be touched with bare hands. The samples shall be kept away from moisture, heat or other influences changing the moisture content.

9 Preparation of test pieces

The test pieces are prepared in the same standard atmosphere as used for the conditioning of the sample. Throughout the cutting area, test pieces shall be free from any wrinkles, creases or other visible defects.

The test pieces shall be cut longitudinal to the machine direction with a test piece width of (15,0 ± 0,1) mm and a minimum length of 90 mm. Cut enough test pieces to allow the determination of 20 valid measurements.

Utmost care should be taken when handling the test pieces to prevent damaging of the edges or excessive bending of the test piece. Test pieces should only be touched at their very ends and only as little as necessary. No testing shall take place in areas of the test piece that have previously been subjected to clamping.

10 Procedure

Testing shall be conducted in the same standard atmosphere as used for the conditioning of the test pieces.

The test piece is inserted into the open clamping device, the clamping jaws are closed according to the sequence defined in 5.2.2 and the test run is started. When the maximum load has been exceeded, the test run is terminated, the clamps are opened, the powered pair of clamping jaws are returned to their initial position and the tested test piece is removed.

Record the force to the nearest 1 N, or the resistance directly in kN/m with 2 decimal places.

Repeat the test on sufficient test pieces, so that at least 20 valid results are obtained.

11 Calculation and expression of results

The S-test value S is generally directly indicated at the test apparatus in kN/m and rounded to two decimal places. It is calculated using Formula (1).

$$S = \frac{F_S}{b} \tag{1}$$

where

F_S is the maximum bending force, in newtons;

b is the test piece width, in millimetres.

12 Precision

The repeatability and reproducibility of this method are determined by conducting an interlaboratory comparison study with several types of samples. A description of the samples used in this study and the interlaboratory comparison results are presented in Annex A.

13 Test report

The test report shall include at least the following information:

a) a reference to this document, i.e. ISO 7763:2024;

b) the date and place of testing;

c) the type of test apparatus used;

d) type and designation of the product under test;

e) the conditioning of samples including the standard atmosphere used;

f) the number of individual test runs;

g) arithmetic mean of the S-test value;

h) standard deviation and variation coefficient;

i) any deviations from the test method specified in this document.

Annex A
(informative)

Precision

The repeatability and reproducibility evaluations are based on data from interlaboratory testing conducted by 8 participating testing laboratories using test equipment made by three different manufacturers. For reference purposes, papers have been selected from the CEPI-CTS interlaboratory programme in 2018, namely the papers from the CMT interlaboratory programme (Level 1 and Level 2) and from the SCT interlaboratory programme (Level 2 and Level 4). This resulted in a range of different mean values for the S-test measurement while enabling the reproducibility of precision of the S-test with the two other measurement methods.

Calculations have been made under consideration of ISO 5725-1[4] according to ISO/TS 24498[5] and TAPPI T 1200 sp-07[6] based on a confidence level of 95 %.

Repeatability and reproducibility limits are calculated by multiplying the repeatability and reproducibility standard deviations by 2,77.

The repeatability and reproducibility limits reported (see Table A.1 and Table A.2) are estimations of the maximum difference, which can be expected in 19 of 20 instances, when comparing two test results for material similar to that described under similar test conditions. This estimation can be invalid for other materials or other test conditions.

NOTE 1 The repeatability standard deviation and the within-laboratory standard deviation are identical. However, the reproducibility standard deviation is not the same as the between-laboratory standard deviation. The reproducibility standard deviation includes both the between-laboratory standard deviation and the standard deviation within a laboratory, i.e.:

$$s^2_{\text{repeatability}} = s^2_{\text{within lab}}$$

but

$$s^2_{\text{reproducibility}} = s^2_{\text{within lab}} + s^2_{\text{between lab}}$$

NOTE 2 2,77 = 1,959 96 $\sqrt{2}$, provided that the test results have a normal distribution and that the standard deviation, s, is based on a large number of tests.

Table A.1 — Estimation of repeatability, S-test method

Paper	Number of laboratories	Mean value kN/m	Standard deviation s_r kN/m	Variation coefficient $C_{V,r}$ %	Repeatability limit r kN/m
Recycling, 90 g/m^2	8	0,87	0,051	5,85	0,142
Recycling, 110 g/m^2	8	1,28	0,107	8,39	0,297
Recycling, 150 g/m^2	8	2,54	0,212	8,35	0,587

Table A.2 — Estimation of reproducibility, S-test method

Paper	Number of laboratories	Mean value kN/m	Standard deviation s_R kN/m	Variation coefficient $C_{V,R}$ %	Reproducibility limit R kN/m
Recycling, 90 g/m^2	8	0,87	0,073	8,37	0,203
Recycling, 110 g/m^2	8	1,28	0,123	9,63	0,341
Recycling, 150 g/m^2	8	2,54	0,238	9,40	0,661