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Corrugating medium — Determination of the edge crush resistance after laboratory fluting

*Papier cannelure pour carton ondulé — Détermination de la
résistance à la compression sur chant après cannelage en laboratoire*



Reference number
ISO 16945:2014(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*.

Introduction

This International Standard evaluates the ability of corrugating medium to contribute to the compression strength of a corrugated box. It is a procedure for measuring the edgewise compression strength of a laboratory-fluted strip of corrugating medium. The corrugated medium is fluted by passing it between heated rollers. Two different test procedures are then widely used.

- a) The fluted corrugating medium is compressed immediately after fluting (i.e. 20 s to 25 s after fluting).
- b) The fluted corrugating medium is conditioned for 30 min to 35 min after fluting under standard laboratory test conditions before being compressed.

Procedure a) generally gives considerably higher results than those obtained with procedure b). The differences in results are claimed to be caused by the lower moisture content (and thus higher stiffness) of the unconditioned fluted corrugating medium.

Since considerable advantages are claimed for both procedures and both are widely used, this International Standard describes both procedures.

Test values and failure modes in this approach are expected to be different than those for ring crush method and short span compression test (SCT).

NOTE This test is sometimes referred to as CCT (corrugated crush test) or CFC (corrugated fluted crush test).

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Corrugating medium — Determination of the edge crush resistance after laboratory fluting

1 Scope

This International Standard specifies two methods for the determination of the edge crush resistance of a corrugating medium after laboratory fluting. The procedures are applicable to any corrugating medium to be used after fluting in the manufacture of corrugated fibreboard.

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 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*

ISO 536, *Paper and board — Determination of grammage*

ISO 13820, *Paper, board and corrugated fibreboard — Description and calibration of compression-testing equipment*

3 Terms and definitions

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

3.1

edge crush resistance

CCT

maximum edgewise compression force per unit length that a laboratory fluted test piece will withstand before onset of break under the test conditions specified in this International Standard

Note 1 to entry: Edge crush resistance is expressed in kilonewtons per metre (kN/m).

3.2

edge crush resistance index

edge crush resistance divided by the grammage

Note 1 to entry: The result is expressed in newton metres per gram (Nm/g).

4 Principle

The principle is as follows:

- a) fluting of the paper by passing it between heated rollers and mounting in a holder with the flutes placed vertically;
- b) application of a compressive force and determination of the maximum force per unit length.

5 Apparatus

5.1 Cutting device, for cutting the test pieces to the required specifications, see [Clause 8](#).

5.2 Fluter, consisting of a pair of matched steel corrugating rolls. The rolls shall be capable of being maintained at a temperature of $175\text{ °C} \pm 8\text{ °C}$. The temperature is controlled by any suitable method. Check the temperature when the rolls are in motion.

One roll is motor-driven at $4,5\text{ r/min} \pm 1,0\text{ r/min}$ and the rolls are held in mesh by a force of $(100 \pm 10)\text{ N}$ exerted between the rolls and distributed evenly across the teeth, under test conditions. In some instruments, the force between the rolls is applied by a spring acting in a slide. In such instruments, friction in this device can result in the force which acts upon the test piece being considerably less than the force required to displace the rolls initially. When verifying that an instrument conforms to the requirements given in this subclause, it is therefore necessary to measure the force required to prevent the undriven roll from moving towards the driven roll, from a position about $200\text{ }\mu\text{m}$ away.

The essential characteristics of each roll are the following (see also [Figure 1](#)):

— roll diameter:	$228,5\text{ mm} \pm 0,5\text{ mm}$;
— roll thickness:	$16\text{ mm} \pm 1\text{ mm}$;
— number of teeth:	84 (see Note 3 below);
— radius of teeth at peak:	$1,5\text{ mm} \pm 0,1\text{ mm}$;
— radius of teeth at base:	$2,0\text{ mm} \pm 0,1\text{ mm}$;
— depth of teeth:	$4,75\text{ mm} \pm 0,05\text{ mm}$;
— distance between teeth (peak to peak around the arc):	$8,55\text{ mm} \pm 0,05\text{ mm}$.

In order to optimize the matching of pairs of rolls, pairs of rolls should be selected in which the differences in dimensions between the two are substantially less than the tolerances shown. Prior to first use, the rolls should be run at the operating temperature for about 6 h with a mild abrasive on the teeth. The two rolls should then be marked in some way so that, after removal for cleaning or maintenance, they can be reassembled with exactly the same teeth in mesh.

NOTE 1 It is recommended to have a guiding device to help feed the test piece perpendicular to the corrugating nip.

NOTE 2 The fluter is identical to that used for ISO 7263[2].

NOTE 3 In some fluters, a full roll is not used.

Dimensions in millimetres

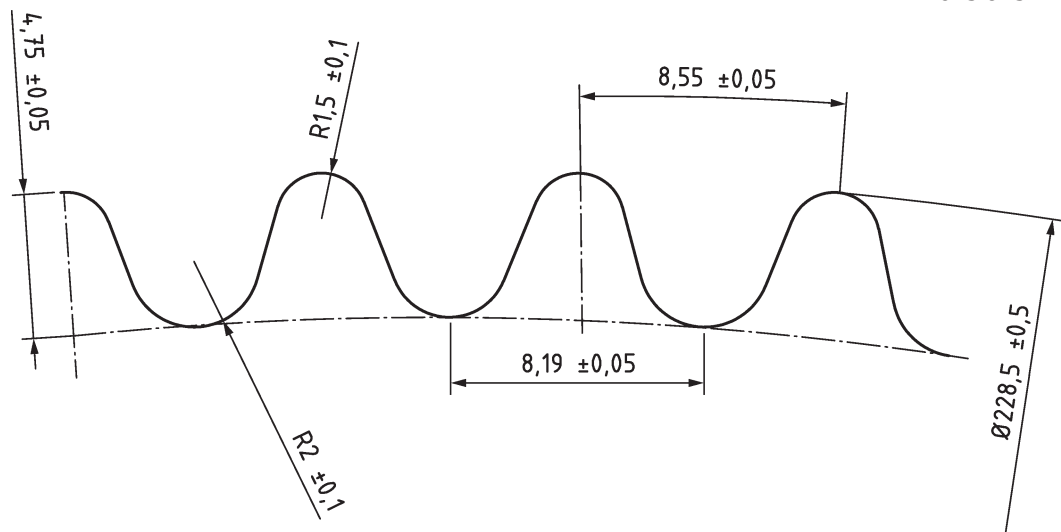
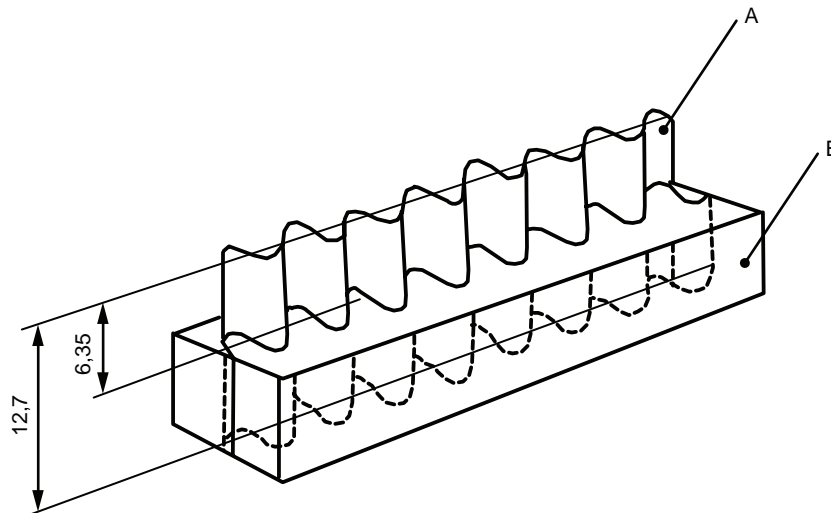


Figure 1 — Profile of corrugating rolls

5.3 Holder, with a profile matching the profile of the corrugated medium, able to hold the test piece so that the flutes are vertical. The holder can be opened for mounting of test pieces. A suitable stopping surface exists so that 6,35 mm width of the specimen is grasped by the holder (see Figure 2).

The fluted crush test piece holder should conform to the same parallelism requirements as the crush tester (see 5.4).

Dimensions in millimetres



Key

- A test piece
- B test piece holder

Figure 2 — Test piece holder

5.4 Compression tester, a motor-driven, fixed-platen type compression tester in accordance with ISO 13820.

6 Sampling

If the tests are being made to evaluate a lot, the sample shall be selected in accordance with ISO 186. If the tests are made on another type of sample, make sure that the specimens taken are representative of the sample received.

7 Conditioning

Condition the samples in accordance with ISO 187.

8 Preparation of test pieces

Cut at least 10 test pieces in $12,7 \text{ mm} \pm 0,1 \text{ mm}$ wide and $152 \text{ mm} \pm 0,5 \text{ mm}$ long, with the length being cut in the machine direction. The long edges shall be parallel to within $0,01 \text{ mm}$ over the length, clean and without defects.

9 Procedure

9.1 General

The edge crush test can be performed immediately after fluting (see [9.2](#)) or after 30 min of reconditioning (see [9.3](#)).

9.2 Testing immediately after fluting

If the test is to be carried out immediately after fluting, the total time between discharge of the fluted test piece from the fluting rolls and the initial application of the crushing force shall be 20 s to 25 s.

NOTE In a round robin performed in 2012, it was shown that the minimum time required for mounting the test piece and initiating the crushing force is 20 s to 25 s.

9.3 Testing after 30 min of reconditioning

If the test is to be carried out after reconditioning, the test pieces shall be reconditioned for 30 min to 35 min in the conditioning atmosphere used to condition the samples (see [Clause 7](#)). If the test is carried out on reconditioned samples, all of the test pieces can be formed prior to testing.

9.4 Fluting and testing

Start the motor and heat the corrugating rolls (see [5.2](#)) to $175 \text{ }^\circ\text{C} \pm 8 \text{ }^\circ\text{C}$.

Feed a test piece into the fluter ([5.2](#)) with its longer side perpendicular to the nip.

Mount the corrugated test piece in the holder ([5.3](#)) and place the holder in the centre of the lower plate of the compression tester. Start the tester and read, to the nearest 1 N, the maximum force sustained by the test piece.

Perform the crush tests either immediately (see [9.2](#)) or after reconditioning (see [9.3](#)). Repeat the procedure for the remaining test pieces until a total of at least 10 results have been obtained.

10 Calculation

10.1 Edge crush resistance

Calculate the edge crush resistance, CCT , (3.1) to the nearest 0,01 kN/m using Formula (1).

$$CCT = \frac{F}{l} \quad (1)$$

where

CCT is the edge crush resistance in kilonewtons per metre;

F is the maximum compression force in newtons;

l is the length of the test piece, in millimetres, prior to corrugation.

To assist in the immediate identification of the method used to obtain the results, for many purposes, it might be most convenient to express the results in the following form:

$$CCT_0 = 2,50 \text{ kN/m}$$

$$CCT_{30} = 2,20 \text{ kN/m}$$

where CCT denotes “corrugated crush test” and the subscript denotes the time, in minutes, for reconditioning.

Report the number of tests, the arithmetic mean, and the standard deviation of all replicate test results, to the nearest 0,01 kN/m.

10.2 Edge crush resistance index

If required, calculate the edge crush resistance index Y , using Formula (2).

$$Y = 1000 \times \frac{\overline{CCT}}{g} \quad (2)$$

where

Y is the edge crush resistance index in newton metres per gram;

\overline{CCT} is the mean value of the edge crush resistance in kilonewtons per metre;

g is the grammage, in grams per square metre, determined in accordance with ISO 536.

Report the result to the nearest 0,1 Nm/g.

11 Test report

The test report shall include the following information:

- a) a reference to this International Standard;
- b) the date and place of testing;
- c) a description and identification of the product tested;

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- d) the conditioning atmosphere used;
- e) method used to obtain the (CCT_0 or CCT_{30});
- f) report on the number of tests, the arithmetic mean, and the standard deviation of all replicate test results, according to [10.1](#);
- g) if applicable, the edge crush resistance index according to [10.2](#);
- h) details of any deviation from this International Standard;
- i) any other information that can assist in the interpretation of the results.

Annex A (informative)

Precision

A.1 General

In May 2012, an international round-robin was performed in which 11 laboratories from six different countries participated.

Three fluting samples of different grammage were used in the comparative testing. For each sample, the CCT_0 and CCT_{30} were determined.

The data are presented in [Tables A.2](#) to [A.4](#).

The calculations were made according to ISO/TR 24498[3] and TAPPI T 1200[7].

The repeatability standard deviation reported is the “pooled” repeatability standard deviation that is, the standard deviation is calculated as the root-mean-square of the standard deviations of the participating laboratories. This differs from the conventional definition of repeatability in ISO 5725-1[1].

The repeatability and reproducibility limits reported are estimates of the maximum difference which should be expected in 19 of 20 instances, when comparing two test results for material similar to those described under similar test conditions. These estimates might not be valid for different materials or different test conditions. Repeatability and reproducibility limits are calculated by multiplying the repeatability and reproducibility standard deviations by 2,77.

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-laboratories standard deviation. The reproducibility standard deviation includes both the between-laboratories standard deviation and the standard deviation within a laboratory. That is to say:

$$s_{\text{repeatability}}^2 = s_{\text{within lab}}^2 \quad \text{but} \quad s_{\text{reproducibility}}^2 = s_{\text{within lab}}^2 + s_{\text{between lab}}^2$$

NOTE 2 $2,77 = 1,96\sqrt{2}$, 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 the repeatability, CCT_0

Sample	Number of laboratories	Mean edge crush resistance, CCT_0 kN/m	Repeatability standard deviation s_r kN/m	Coefficient of variation, $C_{v,r}$ %	Repeatability limit r kN/m
Grade A	11	1,69	0,08	4,73	0,21
Grade B	11	2,28	0,11	4,82	0,31
Grade C	11	3,79	0,18	4,75	0,49

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Table A.2 — Estimation of the repeatability, CCT_{30}

Sample	Number of laboratories	Mean edge crush resistance, CCT_{30} kN/m	Repeatability standard deviation s_r kN/m	Coefficient of variation, $C_{V,r}$ %	Repeatability limit r kN/m
Grade A	11	1,45	0,06	4,14	0,17
Grade B	11	2,05	0,09	4,39	0,25
Grade C	11	3,29	0,12	3,65	0,35

Table A.3 — Estimation of reproducibility, CCT_0

Sample	Number of laboratories	Mean edge crush resistance, CCT_0 kN/m	Reproducibility standard deviation s_R kN/m	Coefficient of variation, $C_{V,R}$ %	Reproducibility limit R kN/m
Grade A	11	1,69	0,21	12,43	0,58
Grade B	11	2,28	0,28	12,28	0,77
Grade C	11	3,79	0,41	10,82	1,13

Table A.4 — Estimation of reproducibility, CCT_{30}

Sample	Number of laboratories	Mean edge crush resistance, CCT_{30} kN/m	Reproducibility standard deviation s_R kN/m	Coefficient of variation, $C_{V,R}$ %	Reproducibility limit R kN/m
Grade A	11	1,45	0,18	12,41	0,49
Grade B	11	2,05	0,25	12,20	0,70
Grade C	11	3,29	0,31	9,42	0,87

Annex B (informative)

Maintenance of fluting rolls (horizontal type)

Uniform meshing of fluting rolls can be checked by using, for example, National Cash Register Tape¹⁾, (CB white NCR paper and CR green tinted NCR paper C2R).

Run a 12,7 mm wide strip of each type of paper through the fluting rolls. The pressure pattern will appear on the green tinted strip. The pressure lines should be uniform and extend the full 12,7 mm width of the strip. If there is more impression at the top or bottom of the rolls, they are not in the same plane; this means that the heating plate has warped, is worn unevenly, or that the bearings are worn. In any case, the fluter should go back to the manufacturer for repair.

The rolls should ride flat on the heating plate. If the drive roll is not flat on the heating plate, loosen the collar directly above the bottom-bearing housing and tap the roll lightly until it is lying flat. It might be necessary to loosen the bottom bearing also. Make this adjustment only when the fluter is up to normal operating temperature. When the roll is flat, tighten all bolts and set screws. Remove the driven roll by taking out the centre bolt and lifting the roll up by bolts inserted in the thread holes provided. Inspect the heating plate for wear of the chrome plating. If worn, a new heating plate should be installed by the manufacturer. The roll can also be inspected for smoothness and wear on the bottom. The spring-loaded post slide can be checked for freeness of movement and lubricated with powdered graphite, if necessary. When the roll is replaced, powdered graphite should be added to the lubricating hole while the roll is turning. Graphite should be added until the grooves under the roll are completely filled. The same holds true for the drive roll.

1) National Cash Register Tape is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

Bibliography

- [1] ISO 5725-1, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*
- [2] ISO 7263, *Corrugating medium — Determination of the flat crush resistance after laboratory fluting*
- [3] ISO/TR 24498, *Paper, board and pulps — Estimation of uncertainty for test methods*
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- [5] TAPPI T 824 om-09, *Fluted edge crush of corrugating medium (flexible beam method)*
- [6] TAPPI T 843 om-09, *Fluted edge crush of corrugating medium (rigid support method)*
- [7] TAPPI T 1200, *Interlaboratory evaluation of test methods to determine TAPPI repeatability and reproducibility*

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