INTERNATIONAL STANDARD

ISO 12625-12

First edition
2010-01-15

Tissue paper and tissue products —

Part 12: Determination of tensile strength of perforated lines — Calculation of perforation efficiency

Papier tissue et produits tissues —

Partie 12: Détermination de la résistance à la rupture par traction des lignes de prédécoupe — Calcul de l'efficacité des perforations

Reference number
ISO 12625-12:2010(E)

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Published in Switzerland

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12625-12 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 172, *Pulp, paper and board*, in collaboration with Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

ISO 12625 consists of the following parts, under the general title *Tissue paper and tissue products*:

— *Part 1: General principles for the use of terms*

— *Part 3: Determination of thickness, bulking thickness and apparent bulk density*

— *Part 4: Determination of tensile strength, stretch at break and tensile energy absorption*

— *Part 5: Determination of wet tensile strength*

— *Part 6: Determination of grammage*

— *Part 7: Determination of optical properties*

— *Part 8: Water-absorption time and water-absorption capacity, basket-immersion test method*

— *Part 9: Determination of ball burst strength*

— *Part 12: Determination of tensile strength of perforated lines — Calculation of perforation efficiency*

The following part is under preparation:

— *Part 13: Determination of the spectral reflectance factor (brightness) at the wavelength R 457 nm with and without UV stimulus and opacity*

Introduction

Tissue papers such as toilet paper and kitchen towel are often pre-cut. They are used after separation of two consecutive sheets.

It is important to know the efficiency of the pre-cut perforations.

The perforation strength should be enough to ensure the product cohesion, but not too high, so that sheets can be easily separated. Depending on the type of tissue product, forces can be applied perpendicular to the perforation lines, or in the direction of the perforation lines.

This part of ISO 12625 has been prepared by harmonizing those standards applicable to tissue paper and tissue products that are currently in use. It specifies a procedure to determine perforation efficiency based on the method described in ISO 12625-4 for the determination of the tensile strength of tissue paper and tissue products.

Tissue paper and tissue products —

Part 12:
Determination of tensile strength of perforated lines — Calculation of perforation efficiency

1 Scope

This part of ISO 12625 specifies a test method for the determination of the tensile strength of perforated lines of tissue paper. It uses a tensile-testing apparatus operating with a constant rate of elongation.

This method is only used for measuring machine-direction tensile strength, that is for cross-direction perforations on tissue paper.

The calculation of perforation efficiency is also specified in this part of ISO 12625.

It is expressly stated that the detection of impurities and contraries in tissue paper and tissue products can be carried out according to ISO 15755.

For the determination of moisture content in tissue paper and tissue products, ISO 287 can be applied.

2 Normative references

The following referenced documents are indispensable for the application 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*

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

ISO 1924-2, *Paper and board — Determination of tensile properties — Part 2: Constant rate of elongation method (20 mm/min)*

ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 12625-1, *Tissue paper and tissue products — Part 1: General guidance on terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12625-1 and the following apply.

3.1
tensile strength
S
maximum tensile force per unit width that a test piece will withstand before breaking in a tensile test

3.2
perforation efficiency
E_p
difference between the tensile strengths of non-perforated and perforated material from the same sample divided by the tensile strength of non-perforated material

NOTE 1 The performance efficiency is expressed as a percentage.

NOTE 2 The higher the perforation efficiency, the easier the sheet separation.

3.3
tie bar
uncut zone in the perforation line

4 Principle

A perforated test piece of tissue paper or tissue product, of given dimensions, is stretched to break in the machine direction at a constant rate of elongation using a tensile-testing apparatus that measures and records the tensile force as a function of the elongation of the test piece.

From the recorded data, the tensile strength is calculated.

In order to determine the perforation efficiency, measurements are performed both on perforated and non-perforated tissue products.

5 Apparatus

5.1 Tensile-testing apparatus

The tensile-testing apparatus shall be in accordance with ISO 1924-2. It is capable of stretching a test piece of tissue paper or tissue product of given dimensions, at a constant rate of elongation of (50 ± 2) mm/min, and recording the tensile force as a function of elongation.

The force-measuring system shall measure loads with an accuracy of ± 1 % of the reading or ± 0,05 N, whichever is the greater. It shall be calibrated and verified in accordance with the requirements of ISO 7500-1.

5.2 Tensile-tester clamps

The tensile-testing apparatus shall have two clamps of at least 50 mm in width. Each clamp shall be designed to grip the test piece firmly, but without damage, along a straight line across the full width of the test piece (the clamping line) and shall have a means for adjusting the clamping force.

The clamps should preferably grip the test piece between a cylindrical and a flat surface, with the plane of the test piece tangential to the cylindrical surface. Other types of clamps may be used if it can be ensured that the test piece does not slip or suffer any damage during the test.

During the test, the clamping lines shall be parallel to each other. They shall also be perpendicular to the direction of the applied tensile force and to the long dimension of the test piece.

The distance between the clamping lines (the test span length) shall be (100 ± 1) mm. In cases where the distance between perforations on the finished products is less than 100 mm and it is not possible to obtain a test piece of 150 mm in length (as required in 8.1) containing only one perforation line, a test span length of (50 ± 1) mm shall be used.

This deviation from the specified procedure shall be recorded in the test report.

5.3 Cutting device

The cutting device shall meet the requirements of ISO 536 and shall produce test pieces (50,0 ± 0,5) mm wide, with undamaged, straight, smooth and parallel edges.

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 being made on another type of sample, make sure the specimens taken are representative of the sample received.

7 Conditioning

Condition the samples according to ISO 187, unless otherwise agreed between the parties concerned, and keep them in the standard atmosphere throughout the test.

8 Preparation of test pieces

8.1 Dimensions

8.1.1 Non-perforated test pieces

Non-perforated test pieces shall be (50 ± 0,5) mm in width and at least 150 mm in length, excluding perforations and faults. With the exception of tissue paper or tissue products having an embossed pattern, the test pieces shall be free of creases, kinks, wrinkles, folds or other thickness variations.

Test pieces shall be cut with their length in the machine direction.

8.1.2 Perforated test pieces

Each perforated test piece shall be (50 ± 0,5) mm in width and at least 150 mm in length, excluding faults. With the exception of tissue paper or tissue products having an embossed pattern, the test pieces shall be free of creases, kinks, wrinkles, folds or other thickness variations.

Test pieces shall be cut with their length in the machine direction.

Perforation lines shall be located in the middle of the length of the test pieces.

8.2 Number of test pieces

Cut sufficient test pieces to ensure 10 valid results on non-perforated papers and 10 valid results on perforated papers for each sample of tissue product.

Cut at least 10 test pieces in the machine direction with the perforation line in the middle.

Each of the 10 test pieces should be cut from a different perforation line.

Care should be taken not to handle the test pieces in any way that might decrease the perforation tensile strength (by stretching or breaking any of the perforations).

In addition, cut at least 10 non-perforated test pieces in the machine direction. Each test piece should be cut from different sheets.

9 Procedure

9.1 General

Ensure that the tensile-testing apparatus is calibrated. Check that the force reading is zero when there is no load on the sample.

Adjust the distance between the clamping lines to (100 ± 1) mm. In cases where the test piece length is less than 150 mm, a test piece length of (50 ± 1) mm shall be used.

Set the rate of elongation to (50 ± 2) mm/min (see 5.1).

Carry out all testing in the same standard atmosphere as used for conditioning

9.2 Non-perforated test pieces

Place the non-perforated test piece in the clamps so that any observable slack is eliminated but the test piece is not placed under any significant strain (see Figure 1).

Do not touch the test area of the test piece between the clamps with the fingers. Align and tightly clamp the test piece and carry out the test.

NOTE Any deviation from the vertical line would induce a decrease in the measured strength of the non-perforated test pieces, and thus a lower calculated perforation efficiency than the true one.

Continue the test until the test piece ruptures and record the maximum tensile force.

Repeat the described procedure until 10 valid results are obtained.

Record all the readings, except those for test pieces that break within 5 mm of the clamping line.

9.3 Perforated test pieces

Place the perforated test piece in the clamps so that any observable slack is eliminated but the test piece is not placed under any significant strain. The perforation line shall be (50 ± 5) mm from the upper clamp (see Figure 2).

Do not touch the test area of the test piece between the clamps with the fingers. Align and tightly clamp the test piece and carry out the test.

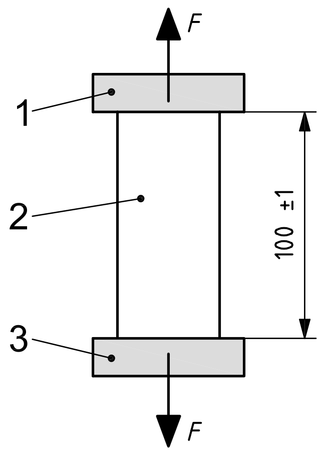
NOTE Any deviation from the vertical line would induce a decrease in the measured strength of the perforated test pieces, and thus a greater calculated perforation efficiency than the true one.

Continue the test until the test piece ruptures and record the maximum tensile force.

Repeat the described procedure until 10 valid results are obtained.

Record all the readings, except those for test pieces that did not break at the perforation line.

Dimensions in millimetres



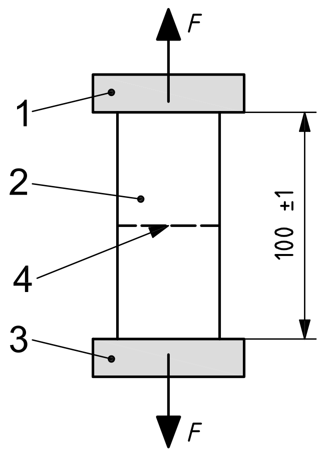
Key

1 upper clamp
2 test piece
3 lower clamp

F tensile force

Figure 1 — Non-perforated test piece

Dimensions in millimetres



Key

1 upper clamp

2 test piece
3 lower clamp
4 perforation line

F tensile force

Figure 2 — Perforated test piece

10 Calculation

10.1 Tensile strength

Calculate the mean tensile force, $\overline{F}$, in newtons, from all single valid test results, F, considering perforated and non-perforated test pieces separately.

Calculate the mean tensile strengths, $\overline{S}$, from Equation (1):

$$\overline{S} = \frac{\overline{F}}{w_x} \times 10^3 \qquad (1)$$

where

$\overline{S}$ is the mean tensile strength, in newtons per metre;

$\overline{F}$ is the mean tensile force, in newtons;

w_x is the initial width, in millimetres, of the test piece (standard 50 mm).

Report the tensile strength, in newtons per metre, to three significant figures for both non-perforated and perforated test pieces.

10.2 Calculation of perforation efficiency

Calculate the perforation efficiency, E_p, from Equation (2):

$$E_p = 100 \times \left[1 - \left(\frac{\overline{S}_p}{\overline{S}_{np}} \right) \right] \qquad (2)$$

where

E_p is the perforation efficiency, expressed as a percentage;

$\overline{S}_p$ is the mean tensile strength of perforated test pieces, in newtons per metre;

$\overline{S}_{np}$ is the mean tensile strength of non-perforated test pieces, in newtons per metre.

Report the perforation efficiency, as a percentage, to three significant figures.

11 Test report

The test report shall include the following information:

a) a reference to this part of ISO 12625;

b) date and place of testing;

c) description and identification of the sample (such as the product category, test span, number of plies);

d) test span if different from 100 mm;

e) number of single values used to calculate the tensile strength and the perforation efficiency;

f) tensile strength in the machine direction for both non-perforated and perforated test pieces, in newtons per metre, rounded to

- 0,1 N/m for loads up to 100 N/m, or
- 1 N/m for loads over 100 N/m;

g) standard deviation or coefficient of variation of the tensile strengths;

h) perforation efficiency, to three significant figures;

i) any departure from this part of ISO 12625 and any other circumstances that may have affected the test results.

12 Precision

12.1 General

In an interlaboratory test, seven laboratories tested 12 samples according to this part of ISO 12625. The results are shown in Tables 1 and 2.

12.2 Tensile strength of non-perforated and perforated products

Table 1 — Results of an interlaboratory test (tensile strength)

Sample, number, machine direction			Mean tensile strength N/m	Standard deviation between laboratories s N/m	Reproducibility coefficient of variation %	Reproducibility limit[a] R N/m
Toilet paper 4-ply	1	NPerf Perf	457 109	23,0 4,9	5,0 4,5	63,8 13,5
Toilet paper 5-ply	2	NPerf Perf	391 64,8	29,0 3,03	7,4 4,68	80,4 8,40
Toilet paper 2-ply	3	NPerf Perf	215 61,9	7,5 2,23	3,5 3,60	20,9 6,18
Toilet paper 3-ply	4	NPerf Perf	340 118	15,9 6,6	4,7 5,6	44,0 18,3
Toilet paper 2-ply	5	NPerf Perf	158 51,7	3,4 3,07	2,1 5,94	9,3 8,51
Industrial wipes	6	NPerf Perf	616 165	24,6 6,1	4,0 3,7	68,2 17,0
Industrial wipes	7	NPerf Perf	597 245	16,4 6,7	2,7 2,7	45,5 18,5
Toilet paper 4-ply	8	NPerf Perf	413 128	14,4 1,2	3,5 0,9	39,9 3,3
Toilet paper 3-ply	9	NPerf Perf	327 109	8,0 4,2	2,4 3,8	22,2 11,6
Toilet paper 3-ply	10	NPerf Perf	464 67,0	20,1 4,32	4,3 6,45	55,7 11,97
Toilet paper 4-ply	11	NPerf Perf	563 83,6	11,9 6,32	2,1 7,56	33,1 17,52
Towels	12	NPerf Perf	390 118	4,2 4,3	1,1 3,6	11,7 11,8

NPerf: non-perforated.

Perf: perforated.

[a] Agreement expected with 95 % probability, $R = 1{,}96\sqrt{2}s$.

12.3 Perforation efficiency

As the efficiency is calculated from the mean of the results, reproducibility values could not be derived from the results obtained.

Table 2 — Results of an interlaboratory test (efficiency)

Sample, number		**Efficiency** %	**Standard deviation between laboratories** s %
Toilet paper 4-ply	1	75,9	1,60
Toilet paper 5-ply	2	83,1	1,11
Toilet paper 2-ply	3	71,1	1,03
Toilet paper 3-ply	4	65,4	1,49
Toilet paper 2-ply	5	67,3	1,56
Industrial wipes	6	73,2	1,35
Industrial wipes	7	59,0	1,81
Toilet paper 4-ply	8	68,6	1,98
Toilet paper 3-ply	9	66,6	1,17
Toilet paper 3-ply	10	85,5	1,57
Toilet paper 4-ply	11	85,0	0,88
Towels	12	69,7	1,11

Annex A
(informative)

Influence of a pre-cut in the perforation line

As the number of tie bars may vary from one test piece to another and in order to always have the same starting point, it was planned during the interlaboratory test to include “non-pre-cut test pieces” where tests are performed on the complete perforation line and “pre-cut test pieces” with a 10 mm pre-cut. The influence of the pre-cutting has thus been studied.

The 10 mm pre-cut was made on one edge by each participating laboratory before testing. This parameter was also considered as a variable.

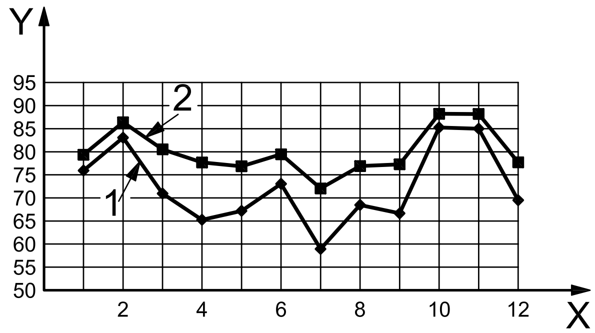
As can be concluded from Table A.1 and Figures A.1 and A.2, measurements of the perforation strength with pre-cut test pieces is not recommended.

As the efficiency is calculated from the mean of the results, reproducibility values could not be derived from the results obtained.

Table A.1 — Results of the interlaboratory test on pre-cut test pieces

Type of paper, sample number		**Efficiency on pre-cut test pieces**	
		Mean tensile strength N/m	**Standard deviation between laboratories** %
Toilet paper 4-ply	1	79,36	1,61
Toilet paper 5–ply	2	86,39	1,50
Toilet paper 2-ply	3	80,48	1,42
Toilet paper 3-ply	4	77,69	2,08
Toilet paper 2-ply	5	76,86	1,09
Industrial wipes 1-ply	6	79,45	1,32
Industrial wipes	7	72,06	3,80
Toilet paper 4-ply	8	76,90	2,00
Toilet paper 3-ply	9	77,28	1,62
Paper towel 3-ply	10	88,23	1,28
Paper towel 4-ply	11	88,18	0,70
Paper towels	12	77,72	3,37

On perforated test pieces, the tensile strength can vary depending on the number of tie bars in the 50 mm perforation line, but it is compensated by the quantity of test pieces used as shown from the standard deviation in Table A.1.



Key

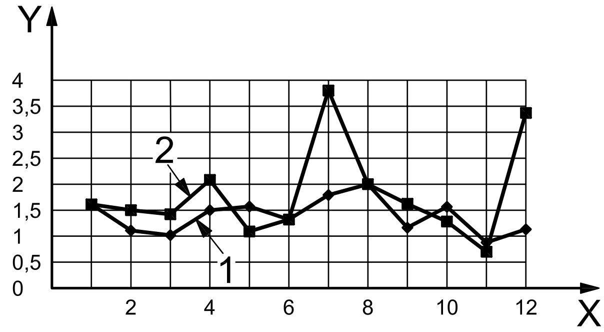
X sample numbers as given in Tables 1, 2 and A.1

Y mean tensile strength, newtons per metre

1 non-pre-cut

2 pre-cut

Figure A.1 — Average efficiency, in percentage



Key

X sample numbers as given in Tables 1, 2 and A.1

Y standard deviation

1 non-pre-cut

2 pre-cut

Figure A.2 — Efficiency, standard deviation between laboratories, in percentage

Annex B
(informative)

Influence of paper ageing

The influence of paper ageing was studied by performing tests on four tissue products (two toilet papers and two paper towels) sampled on the converting line. Seven different laboratories were involved in this study.

The following settings were considered:

— with 23 °C and 50 % relative humidity conditioning after reception by the participating laboratories;

— with 80 °C ageing during 30 min;

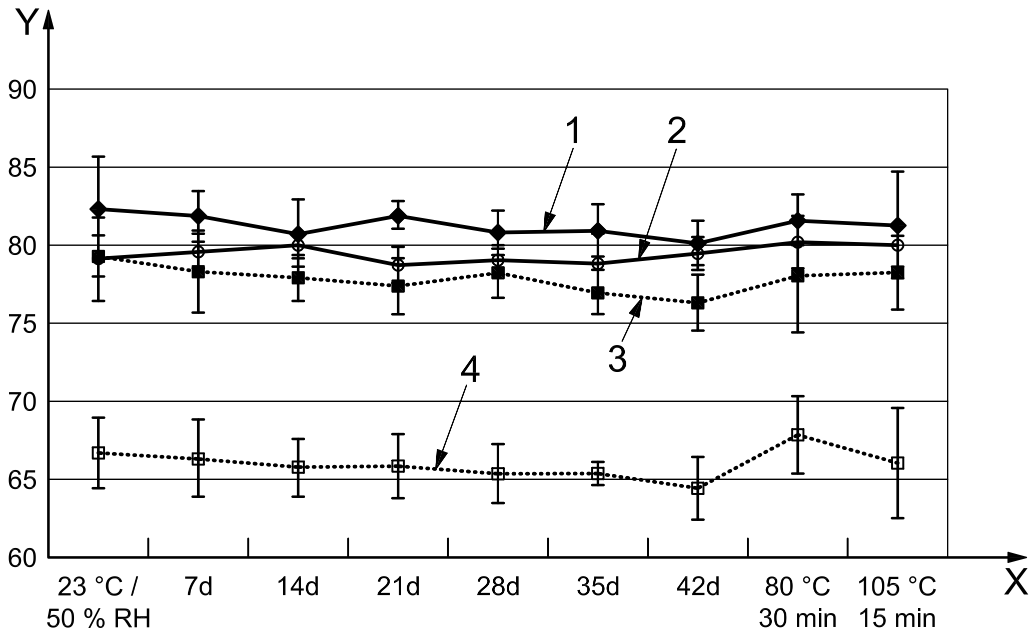
— with 105 °C ageing during 15 min;

— after 1 to 6 weeks, storage at 23 °C and 50 % relative humidity.

The results are reported below and lead to the conclusion that ageing of papers should not be performed before testing the perforation efficiency because

a) the two methods of accelerated ageing produce the same results, and

b) a slight decrease in perforation efficiency with ageing can be observed, but it is not significant due to the standard deviation of the measurements.



Key

X ageing conditions

Y perforation efficiency, %

1 paper 1

2 paper 2

3 paper 3

4 paper 4

Figure B.1 — Perforation efficiency, in percentage, versus ageing conditions

Bibliography

[1] ISO 287, *Paper and board — Determination of moisture content of a lot — Oven drying method*

[2] ISO 12625-4, *Tissue paper and tissue products — Part 4: Determination of tensile strength, stretch at break and tensile energy absorption*

[3] ISO 15755, *Paper and board — Estimation of contraries*

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