
**Paper and board — Automated off-line
testing of physical properties for CD
(cross direction) profiles**

*Papier et carton — Essais hors ligne — Mesure des propriétés
physiques pour profils ST (sens travers) sur bancs automatisés*

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ISO 18522:2016

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Reference number
ISO 18522:2016(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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 6, *Paper, board and pulps*.

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Introduction

The automated off-line testing of cross direction (CD) profiles of paper and board was introduced in the 1980s. The apparatus available then was equipped with various modules for the determination of basic physical properties such as grammage, thickness, Bendtsen roughness, air permeance, etc. In the 90s, more advanced modules were developed for tensile, tear and bending testing. Modules for the measurement of the optical properties with the C/2°, D50/2° and D65/10° illuminants are also available.

The principal benefits of automated off-line testing are the speed with which the results are obtained and the small number of staff required to operate the testing apparatus.

Testing with stand-alone instruments implies much longer time before the results are available. Automated off-line testing improves the repeatability in testing as the operator dependency disappears.

In most of the countries producing paper and board, some type of automated off-line testing of CD profiles is carried out.

For the determination of physical properties, this document refers, where possible, to the relevant International Standards for the description and calibration of the equipment required. The results from automated off-line testing are widely accepted by the customers although the conditioning requirements stated in ISO 187 are not met.

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Paper and board — Automated off-line testing of physical properties for CD (cross direction) profiles

1 Scope

This document specifies the procedures for determining the cross direction profiles of physical properties of paper and board using automated off-line testers. Where available for a given measurement, the relevant International Standard is referred to. It is applicable to most kinds of paper and board, but is not relevant for tissue and corrugated board.

In this document, it is left to the paper and board producer and the customer to agree upon which properties are relevant. The results are reported as mean values or as profiles across the machine. Some properties are reported in index form.

The result obtained using the relevant ISO standard based on stand-alone equipment is used in case of challenge or dispute, if not otherwise agreed.

NOTE 1 The results obtained using specimens conditioned according to ISO 187 and stand-alone test instruments will, for some paper properties, differ from those obtained with unconditioned specimens and automated off-line testers. An investigation was made to only a limited extent, where the automated off-line testing was compared to stand-alone instruments, including the impact of conditioning. A summary of this investigation is reported in [Annex B](#).

NOTE 2 It is also possible to evaluate properties in the machine direction (MD), but this is usually only used for trouble-shooting.

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 186:2002, *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 534, *Paper and board — Determination of thickness, density and specific volume*

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 1924-3, *Paper and board — Determination of tensile properties — Part 3: Constant rate of elongation method (100 mm/min)*

ISO 1974, *Paper — Determination of tearing resistance — Elmendorf method*

ISO 2469:2014, *Paper, board and pulps — Measurement of diffuse radiance factor (diffuse reflectance factor)*

ISO 2470-1, *Paper, board and pulps — Measurement of diffuse blue reflectance factor — Part 1: Indoor daylight conditions (ISO brightness)*

ISO 2470-2, *Paper, board and pulps — Measurement of diffuse blue reflectance factor — Part 2: Outdoor daylight conditions (D65 brightness)*

- ISO 2471, *Paper and board — Determination of opacity (paper backing) — Diffuse reflectance method*
- ISO 2493-1, *Paper and board — Determination of bending resistance — Part 1: Constant rate of deflection*
- ISO 2758, *Paper — Determination of bursting strength*
- ISO 2759, *Board — Determination of bursting strength*
- ISO 5627, *Paper and board — Determination of smoothness (Bekk method)*
- ISO 5631-1, *Paper and board — Determination of colour by diffuse reflectance — Part 1: Indoor daylight conditions (C/2°)*
- ISO 5631-2, *Paper and board — Determination of colour by diffuse reflectance — Part 2: Outdoor daylight conditions (D65/10°)*
- ISO 5631-3, *Paper and board — Determination of colour by diffuse reflectance — Part 3: Indoor illumination conditions (D50/2°)*
- ISO 5636-3, *Paper and board — Determination of air permeance (medium range) — Part 3: Bendtsen method*
- ISO 5636-6, *Paper and board — Determination of air permeance (medium range) — Part 6: Oken method*
- ISO 8254-1, *Paper and board — Measurement of specular gloss — Part 1: 75° gloss with a converging beam, TAPPI method*
- ISO 8254-2, *Paper and board — Measurement of specular gloss — Part 2: 75° gloss with a parallel beam, DIN method*
- ISO 8254-3, *Paper and board — Measurement of specular gloss — Part 3: 20° gloss with a converging beam, TAPPI method*
- ISO 8791-2, *Paper and board — Determination of roughness/smoothness (air leak methods) — Part 2: Bendtsen method*
- ISO 8791-4, *Paper and board — Determination of roughness/smoothness (air leak methods) — Part 4: Print-surf method*
- ISO 9416, *Paper — Determination of light scattering and absorption coefficients (using Kubelka-Munk theory)*
- ISO 9895, *Paper and board — Compressive strength — Short-span test*
- ISO 11475, *Paper and board — Determination of CIE whiteness, D65/10° (outdoor daylight)*
- ISO 11476, *Paper and board — Determination of CIE whiteness, C/2° (indoor illumination conditions)*

3 Terms and definitions

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

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 cross direction sample CD sample

cut from edge to edge of a mother reel or post winder reel in the cross direction (CD), having a width in the machine direction (MD) appropriate for the tests to be carried out

Note 1 to entry: A typical width along the machine direction is about 300 mm.

4 Principle

This document describes the procedure for the determination of CD profiles of physical properties of paper and board using the relevant automated off-line testers on the market which fulfil the requirements of this document. The results are reported as mean values or as profiles across the machine. Some properties are reported in index form.

5 Apparatus

5.1 Sample cutter

5.1.1 A motor driven cutter for cutting the CD samples, capable of accurately cutting samples perpendicular to the edges of the reel from edge to edge, and the width to an accuracy so that test methods which are sensitive to direction changes are not influenced. Control that the width (MD) does not vary so as to influence test methods which are sensitive to direction changes. Means may be provided for controlling the sample and feeding it to the test line, such as automated winding of the CD sample onto a removable cylinder which can be inserted in the automated off-line tester.

5.1.2 It is possible to use **manual sample cutters**. The sample can be trimmed to the accuracy required of motor driven sample cutters using a table top cutter.

5.2 Automated off-line testers

There are a number of automated off-line testers on the market for which testing in many cases is based on existing International Standards. They are typically composed of an unwinder followed by several units placed sequentially, with the destructive test measuring heads located at the end of the line. Some test lines are equipped with a moisture content module providing the possibility of correcting the values if needed.

Some of the test methods are not the same as those in the equivalent reference standards for stand-alone instruments. In these cases, correction factors and correction procedures can be a way to get results that correlate with those obtained using the reference standards.

The equipment shall be calibrated in accordance with the instructions in the relevant International Standards. Where this is not possible, for example, in the case of non-standard testers or alternative methods, advice may be provided on calibration by the manufacturer or any suitable party, allowing due regard to the measurement capability of the tester.

6 Sampling

6.1 General

The sampling of CD profiles is performed according to ISO 186. If sampling according to the procedure described in the main body of ISO 186 is impossible, impracticable or inappropriate, alternative sampling procedures as described in ISO 186:2002, Annex A can be used.

Sampling can be performed using hand or motor driven cutters. Before taking the CD sample, remove all damaged layers from the outside of the reel. CD samples are normally taken from every produced reel, or according to some other specific routine decided at each mill. The number of CD samples taken is determined by the number of tests to be performed and the amount of required material for later follow-up testing. Normally, one CD sample is used for testing directly in the automated off-line testers. When taking CD samples, ensure that the front side (FS) and drive side (DS), and top side and bottom side are identified, e.g. by marking the FS and top side.

Care shall be taken in handling CD samples as contact with bare hands can appreciably affect the chemical, physical, optical, surface and other characteristics of the paper or board. Use of cotton gloves

is recommended during the sampling procedure. CD samples shall be free from wrinkles, folds and dirt and protected from exposure to conditions which may change the relevant properties. Avoid contact with the surface that is to be tested and place the CD sample on a clean table if necessary.

The average of a single CD profile for a specific sheet property may not be the same as the average obtained by the sampling procedures described in ISO 186.

Differences in average values may be due to the machine position (FS, DS or mid position) in which the samples are taken, the variability in paper properties and the number of positions in which the CD sample is tested, and not only the difference between sampling of reels in ISO 186 and in this document.

NOTE Winding the reel too tightly might cause problems with other measurements (e.g. bending measurements) for high grammage grades such as liquid board and folding box board.

6.2 Cutting samples

Cut the CD sample (3.1) perpendicular to the machine direction from edge to edge of the reel and of the required width using a sample cutter (5.1). The sample shall be clean, wrinkle-free and free of atypical defects.

7 Conditioning

As with non-automated testing, for quick feedback for the production line, it is usually impracticable to condition samples according to ISO 187. Locate the automated off-line tester in a conditioned test room meeting the requirements of ISO 187 and allow sufficient time for the CD sample to partially condition before testing of properties sensitive to moisture content is carried out. The time required will depend on equipment available for rapid conditioning and the grammage of the sample. It is desirable for preconditioning to be carried out as the first step.

NOTE Usually, the testing is started within 3 min to 15 min from sampling in the machine hall.

A suitable method for accelerated conditioning is described in Annex A.

The principle is that a CD sample is placed on a bench where air, meeting the temperature and relative humidity requirements of ISO 187, passes through the sample by means of vacuum fans. The specific time needed depends on the type of material and is more effective for lower grammages, <300 g/m². Mechanical properties like bending resistance and tear resistance are sensitive to the moisture content. In production, conditioning according to ISO 187 may not be practicable, instead, an accelerated conditioning can be used.

8 Procedure

8.1 General

A standard orientation and direction should be selected for feeding CD samples into the automated off-line tester. Ensure that the CD sample is fed into the tester with the chosen direction and orientation.

Choose the right configuration for your testing including the following:

- the machine direction width of the CD sample;
- properties to be tested;
- step length between tests;
- number of measurement points in the cross direction for each property;
- profile and/or mean value of properties.

The International Standards referred to in 8.2 to 8.18 are the currently most used and can be used in agreements between concerned parties.

NOTE Precision data, if available, are normally presented in the International Standard in question and with the calculations made according to ISO/TR 24498^[1] and TAPPI T 1200 sp-07.^[3]

8.2 Determination of single sheet thickness, density and specific volume (ISO 534)

ISO 534 shall be used for this test. Any deviations shall be reported. The number of measurements in the CD is decided by the producer with consideration to the machine width.

Express the result for single sheet thickness in micrometres to three significant figures, apparent sheet density in grams per cubic centimetre to three significant figures and apparent specific sheet volume in cubic centimetres per gram to three significant figures.

NOTE In some countries, particularly in North America, the 50 kPa pressure is still widely used, but does not conform to ISO 534 and different results will be obtained using this pressure.

8.3 Determination of grammage (ISO 536)

ISO 536 shall be used for this test with the following deviations; the area of the test piece shall be at least 100 cm² and the area determined to an accuracy of 0,5 %. Any other deviations, or if another method is used, this shall be reported. The number of measurements in the CD is decided by the producer with consideration to the machine width.

The grammage test area is normally trimmed by using a punch or a knife.

The balance shall be shielded from air currents. The mass of the trimmed specimen shall be determined to an accuracy of 0,2 % and the grammage shall be reported to three significant figures.

8.4 Determination of tensile properties

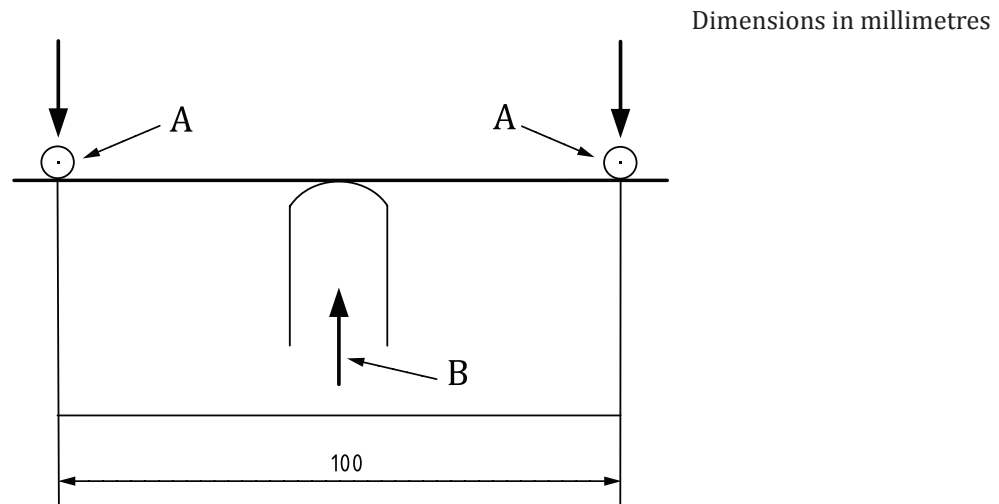
8.4.1 Constant rate of elongation

ISO 1924-2 or ISO 1924-3 shall be used for this test. Any deviations shall be reported.

Various modules which do not conform with ISO 1924-2 or ISO 1924-3 are used in automated off-line testers. The user shall establish the correlation between properties measured using a tensile module and those using a standard ISO test.

NOTE 1 In Annex C, the results of a comparison between stand-alone and automated off-line testing for tensile strength, strain at break and tensile energy absorption (TEA) are presented.

An example of a module is shown in Figure 1 (the figure presented is an example and differs from ISO 1924). The tensile module cuts a specimen with a width of 15 mm from the sample and clamps it at two points located at a distance of 100 mm from each other. The specimen is then pushed upwards until it breaks, and the module measures tensile strength, elongation at break and TEA.

**Key**

A clamps

B force

Figure 1 — Example of a tensile module

NOTE 2 The results of the above test correlate quite well with ISO 1924-3, see [Annex C](#).

Tensile strength, tensile stretch and TEA of paper can be measured both in the machine directions (MD) and cross directions (CD) of a paper sample if separate units are used in the tester.

Report the tensile strength, strain at break and tensile energy absorption to three significant figures. If grammage is known, various indexes can be calculated.

8.4.2 Alternative method

Other constructions of modules may be available on the market and shall be accurately described by the manufacturer. These can use different types of procedures which do not give the same results compared to the relevant part of ISO 1924 and a correlation will then have to be performed on equipment in accordance with ISO 1924.

8.5 Determination of tearing resistance**8.5.1 General**

This procedure of tearing testing is often related to ISO 1974 Elmendorf method, but is not comparable. Correction factors are one way of getting results in conformity with ISO 1974. Another way is to report the value obtained direct from the module.

The modules can use different types of procedures which do not give the same results compared to ISO 1974 and a correlation will then have to be performed on equipment in accordance with ISO 1974.

8.5.2 Tear module type 1

An example of a tear module for automated off-line measurements is shown in [Figure 2](#).

The tearing module (see [Figure 2](#)), measures the tearing resistance of a paper sample, in the machine directions (MD) and cross directions (CD). Two separate modules are needed if both directions are of interest.