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Pulps — Laboratory sheets — Determination of physical properties

Pâtes — Feuilles de laboratoire — Détermination des propriétés physiques

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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 of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 172, *Pulp, paper and board,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 5270:2012), which has been technically revised.

The main changes are as follows:

— 6.2: rewriting of the subclause;

— 6.3: permission to perform optical tests on sheets formed using the Rapid-Köthen method if the sheets are dried at room temperature;

— 6.4: introduction of a minimum area for grammage determination;

— 7.2 inclusion of the option to report strain at break following determination of tensile properties;

— 7.5: inclusion of the option to determine air permeance using the Oken method.

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

This document provides the determination of physical properties of both low-grammage sheets and high-grammage sheets, prepared according to ISO 5269-1, ISO 5269-2 or ISO 5269-3. The oven-dry grammage of low-grammage sheets is (60 ± 2) g/m^2 using the conventional sheet former, as described in ISO 5269-1 and ISO 5269-3, or (75 ± 2) g/m^2 using the Rapid-Köthen sheet former, as described in ISO 5269-2 and ISO 5269-3. The oven-dry grammage of high-grammage sheets is 140 g/m^2, with a tolerance of 3 % using the conventional and the Rapid Köthen sheet formers, except for the z-directional tensile strength where the grammage is ≥90 g/m^2.

This document refers to the relevant International Standards for paper and board for the description and calibration of the required equipment, and for the calculation and reporting of results. This document, however, specifies the procedures for testing laboratory sheets where the amount of material is limited, compared to testing of paper and board to which the relevant International Standards referred to are applicable, and for that reason there can be a discrepancy in the procedures.

Pulps — Laboratory sheets — Determination of physical properties

1 Scope

This document specifies the relevant International Standards used for the determination of physical properties of laboratory sheets made of all types of pulps.

It is applicable to laboratory sheets prepared in accordance with ISO 5269-1, ISO 5269-2 or ISO 5269-3.

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 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 2470-1, *Paper, board and pulps — Measurement of diffuse blue reflectance factor — Part 1: Indoor daylight conditions (ISO 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 2493-2, *Paper and board — Determination of resistance to bending — Part 2: Taber-type tester*

ISO 2758, *Paper — Determination of bursting strength*

ISO 5626, *Paper — Determination of folding endurance*

ISO 5636-3, *Paper and board — Determination of air permeance (medium range) — Part 3: Bendtsen method*

ISO 5636-4, *Paper and board — Determination of air permeance (medium range) — Part 4: Sheffield method*

ISO 5636-5, *Paper and board — Determination of air permeance (medium range) — Part 5: Gurley method*

ISO 5636-6, *Paper and board — Determination of air permeance (medium range) — Part 6: Oken method*

ISO 7263 (all parts), *Corrugating medium — Determination of the flat crush resistance after laboratory fluting*

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 degrees (outdoor daylight)*

ISO 11476, *Paper and board — Determination of CIE whiteness, C/2° (indoor illumination conditions)*

ISO 12192, *Paper and board — Determination of compressive strength — Ring crush method*

ISO 15754, *Paper and board — Determination of z-directional tensile strength*

3 Terms and definitions

No terms and definitions are listed in this document.

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/

4 Principle

Determination of physical properties of laboratory sheets using the procedure and equipment described in the relevant International Standards given in Tables 1 and 2. The results are, if applicable, reported in index form.

5 Apparatus

The equipment shall be calibrated in accordance with the requirements in the relevant International Standards referred to in Tables 1 and 2.

6 Trimmed laboratory sheets

6.1 Selection of laboratory sheets

Depending on the properties to be tested, determine the number of laboratory sheets required using Table 1 and/or Table 2 (these summarise test piece requirements). The properties measured shall be jointly determined by the pulp producer and the pulp user. The specification of the number of test pieces needed for each property defines the area required for testing and thus the number of sheets.

Each sheet shall be free of visible defects.

6.2 Conditioning of laboratory sheets

Condition the laboratory sheets in the standard atmosphere (23 ± 1) °C and (50 ± 2) % relative humidity, or in the atmosphere allowed in tropical countries, in accordance with ISO 187.

ISO 187 recommends that the equilibrium condition be attained by the sorptive process unless otherwise specified. For tests in which the hysteresis of the equilibrium moisture content can lead to errors that are significant, ISO 187 requires the sample to be pre-conditioned before conditioning unless it is known that conditioning will result in an equilibrium moisture content equivalent to that achieved by sorption or the samples have been prepared in accordance with ISO 5269-1.

If the laboratory sheets have been prepared using the conventional sheet former, according to ISO 5269-1 or ISO 5269-3, the sheets will reach equilibrium moisture content by desorption and shall

be tested at this moisture content. Thus, such sheets shall not be preconditioned and if they have been or might have been subjected to a relative humidity below the lower limit such that their moisture content might have decreased, they shall be discarded. Precautions shall be taken to ensure that the equilibrium moisture content reached is the same as that which is reached on the outer desorption curve. Such precautions may include:

1) Storing the wet laboratory sheets and rings in protective plastic bags if the atmosphere of the conditioning room or chamber is outside, or likely to be outside, the limits specified in ISO 187;

2) Storing them in protective plastic bags following conditioning. If the moisture content of the sheets exhibits appreciable hysteresis, exposure of conditioned sheets to a relative humidity above the upper limit will take the moisture content away from the outer desorption curve. The sheets shall not be returned to the outer desorption curve by exposing them to a high relative humidity as they can shrink if exposed to a relative humidity above 70 %.

If the laboratory sheets have been prepared using the Rapid-Köthen sheet former, according to ISO 5269-2 or ISO 5269-3, the sheets will reach equilibrium by sorption of moisture. For such sheets, if the test atmosphere has been outside the prescribed limits and there is any chance that the conditioned moisture content of the sheets has been changed by such an excursion, the sheets shall be subjected to preconditioning, and reconditioned (see ISO 187).

Keep the laboratory sheets in the conditioning atmosphere until testing is completed.

NOTE The moisture content and thus the physical properties of laboratory sheets at a given relative humidity (e.g. at 50 % RH) depend on the moisture history of the sheets. The moisture content of sheets dried from high relative humidity to low relative humidity follows a different, higher moisture content, path in comparison with sheets taken from low to high relative humidity, an effect called hysteresis. For laboratory sheets prepared using the Rapid-Köthen sheet former (ISO 5269-2 and ISO 5269-3), the moisture content at 50 % RH is reached from a lower relative humidity by sorption of moisture, whereas for laboratory sheets prepared using the conventional sheet former (ISO 5269-1 and ISO 5269-3), the moisture content at 50 % RH is reached by desorption of moisture. Sheets prepared using the conventional sheet former will thus have higher moisture content at equilibrium than those prepared using the Rapid-Köthen sheet former.

6.3 Optical properties

For certain purposes, it can be desirable to measure optical properties of laboratory sheets prepared using the conventional sheet former according to ISO 5269-1 or ISO 5269-3. Depending on the purpose, light scattering and light absorption coefficients, opacity, ISO brightness and CIE whiteness may be measured. Light scattering and absorption coefficients, and opacity, shall not be measured on high-grammage sheets. ISO brightness shall be determined using ISO 2470-1, CIE whiteness using ISO 11475 or ISO 11476, light scattering coefficient and light absorption coefficient using ISO 9416, and opacity using ISO 2471.

The standard method for the preparation of laboratory sheets for the determination of brightness and whiteness is given in ISO 3688.

Optical tests shall not be performed on sheets prepared using the Rapid-Köthen sheet former (ISO 5269-2 or ISO 5269-3), unless drying is carried out at room temperature, as the high temperature used for drying in the standard procedure can affect the optical properties.

NOTE ISO 3688 requires preparation of sheets having a grammage of 225 g/m^2 in a sheet former (see ISO 5269-1 and ISO 5269-2 for details of the equipment) or in a Büchner funnel and includes additional requirements.

6.4 Determination of grammage, bulking thickness and apparent bulk density

Trim at least four laboratory sheets, using a punch, or a ruler and a pair of scissors, to obtain a defined size so that the area can be determined to an accuracy of 0,5 %. For low-grammage sheets, use Table 1 to establish a suitable size for the trimmed sheets that allows them to be used for cutting test pieces for other tests. The minimum area for determination of grammage shall be 150 cm^2.

Before cutting test pieces, determine the grammage of the conditioned trimmed sheets using ISO 536. The mass of the trimmed sheets shall be determined to an accuracy of 0,2 % and the grammage shall be reported in g/m^2 to three significant figures.

Measure the bulking thickness of a pack of four trimmed sheets, with the same sides up, using ISO 534. Take measurements at five different places of the pack, taking care that the sheets are not displaced when changing the position of the pack for each measurement. Calculate and report the mean bulking thickness of a single sheet in µm to three significant figures.

Calculate and report the apparent bulk density according to ISO 534, in g/cm^3, to three significant figures.

If circular sheets having a diameter of 158 mm are produced, only two test pieces for the determination of flat crush resistance or ring crush resistance can be cut from each sheet. These test pieces may be used for the determination of grammage noting the requirement for a minimum area of 150 cm^2.

6.5 Preparation of test pieces

From the conditioned trimmed sheets, cut a sufficient number of test pieces depending on the property to be determined. The minimum number of test pieces for low-grammage sheets is given in Table 1 and for high-grammage sheets in Table 2.

Table 1 — Test piece dimensions and minimum number of test pieces recommended for low-grammage sheets

Property	International Standard	Target grammage (oven-dry basis) g/m^2		Test piece dimensions mm		Minimum number of test pieces
		Conventional	Rapid-Köthen	Length	Width	
Tensile properties	ISO 1924-2 ISO 1924-3	60	75	At least 100 ± 2 between clamps + extra length for complete clamping	15 ± 0,1	8 from at least 4 sheets
Tear index	ISO 1974	60	75	According to the testing apparatus		2[a] from at least 4 sheets
Burst index	ISO 2758	60	75	Wide enough to be securely clamped		8 from at least 4 sheets
Air permeance	ISO 5636-3 ISO 5636-4 ISO 5636-5	60	75	50 × 50		8 from at least 2 sheets
Folding endurance	ISO 5626	60	75	According to the testing apparatus	15,0 ± 0,1	6 from at least 3 sheets

[a] Each test piece consists of four pieces.

Table 2 — Test piece dimensions and minimum number of test pieces recommended for high-grammage sheets

Property	International Standard	Target grammage (oven-dry basis) g/m^2		Test piece dimensions mm		Minimum number of test pieces
		Conventional	Rapid-Köthen	Length	Width	
Bending resistance index	ISO 2493-1 ISO 2493-2	140	140	>70	38,0 ± 0,2	6 from at least 2 sheets
Flat crush resistance index	ISO 7263 (all parts)	140	140	>150	12,7 ± 0,1	6 from at least 2 sheets
Ring crush resistance index	ISO 12192	140	140	150,0 to 152,5	12,7 ± 0,1	10 from at least 2 sheets

Table 2 *(continued)*

Property	International Standard	Target grammage (oven-dry basis) g/m²		Test piece dimensions mm		Minimum number of test pieces
		Conventional	Rapid-Köthen	Length	Width	
Short span compression index	ISO 9895	140	140	>70	15,0 ± 0,1	10 from at least 2 sheets
Z-directional tensile strength	ISO 15754	≥90	≥90	Larger than the tester platens		5 from at least 4 sheets

7 Procedures for physical properties (low-grammage sheets)

7.1 General

For determination of the physical properties given in this clause, use the equipment stated in the relevant International Standard. The equipment shall be maintained and calibrated as stated in that International Standard.

As the physical properties in general increase with increasing grammage, they shall be reported in index form, i.e. the result shall be divided by the conditioned grammage, in g/m², of the trimmed sheets, determined in accordance with 6.4.

NOTE ISO 15361 is applicable to pulps describing the determination of zero-span tensile strength, wet or dry.

7.2 Tensile properties

Tensile properties shall be determined using ISO 1924-2 or ISO 1924-3 with the exception that, in each case, the distance between the clamps shall be reduced. For testing laboratory sheets, the distance between the clamps shall be (100 ± 2) mm (not 180 mm as required for paper and board). If ISO 1924-2 is used, the rate of elongation shall be (10 ± 2,5) mm/min. If using ISO 1924-3, it shall be (100 ± 10) mm/min.

Test a minimum of eight test pieces from at least four sheets (see Table 1). If the length of a test piece is not sufficient to allow the test piece to be securely clamped, a test length of 90 mm may be used. This deviation shall be stated in the test report.

For some pulp qualities, the test piece can fail quickly, for example when using ISO 1924-2, in less than 5 s, or take some time, for example more than 30 s. In such cases, a different constant rate of elongation may be used, but this rate shall be stated in the test report.

Calculate and report, where appropriate, the results in index form to three significant figures. Strain at break, if determined, shall be reported to the first decimal place.

WARNING — ISO 1924-2 and ISO 1924-3 do not give the same results and it is not possible to predict any relationship between results obtained using ISO 1924-2 and ISO 1924-3. For that reason, the procedure for determination of tensile properties shall always be reported when reporting tensile properties using this document.

7.3 Tear index

Using ISO 1974, determine the tearing resistance of a minimum of two test pieces from at least four sheets where each test piece consists of four pieces (see Table 1). Clamp the test pieces so that their non-glazed sides face the shaft of the pendulum. Carry out at least two such tests.

Calculate and report the tear index, in mNm²/g, to three significant figures.

7.4 Burst index

Using ISO 2758, determine the bursting strength of a minimum of eight test pieces from at least four sheets (see Table 1). Carry out at least one burst test on each side of each of at least four sheets. Test pieces less than 70 mm x 70 mm in area may be used, provided that they are wide enough to be securely clamped.

Report the burst index, in kPa·m^2/g, to three significant figures.

7.5 Air permeance

Using ISO 5636-3, ISO 5636-4, ISO 5636-5 or ISO 5636-6 determine the air permeance with the air pressure applied to the non-glossy side of the sheets, of a minimum of eight test pieces from at least two sheets (see Table 1).

Using ISO 5636-3, calculate and report the air permeance in µm/Pa·s, to three significant figures.

Using ISO 5636-4, calculate and report the air permeance in µm/Pa·s, to three significant figures.

Using ISO 5636-5, calculate the mean time, in s, for the passage of 100 ml of air. Calculate and report air permeance in µm/Pa·s, to two significant figures.

Using ISO 5636-6, calculate and report the air permeance in µm/Pa·s, to two significant figures.

7.6 Folding endurance

Using one of the procedures specified in ISO 5626, determine the logarithm (to the base 10) of the number of double folds obtained for each test piece. Test a minimum of six test pieces from at least three sheets (see Table 1).

Report the folding endurance as the mean of the logarithms, to the second decimal place. Also state the type of tester used and the tension applied, if applicable.

8 Procedures for physical properties (high-grammage sheets)

8.1 General

For determination of physical properties given in this clause, use the equipment stated in the relevant International Standard. The equipment shall be maintained and calibrated as stated in the relevant International Standard.

As physical properties in general will increase with increasing grammage, they shall be reported in index form, i.e. the result shall be divided by the conditioned grammage, g/m^2, of the trimmed sheets, determined in accordance with 6.4.

8.2 Bending resistance index

Using ISO 2493-1 or ISO 2493-2, determine the bending resistance of a minimum of six test pieces from at least two sheets (see Table 2). If the instrument is designed so that deflection is possible only to one side of the unstressed position, test equal numbers of test pieces with opposing surfaces towards the direction of deflection.

Using ISO 2493-1, calculate (as a force) and report the bending resistance index, in N m^6/g^3, to three significant figures.

Using ISO 2493-2, calculate (as a moment) and report the bending resistance index, in µNm m^6/g^3, to three significant figures.

NOTE 1 The bending resistance is proportional to the grammage to the third power.