

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS C 2300-2 : 2010

(JEIA/JSA)

**Cellulosic papers for electrical
purposes—Part 2: Methods of test**

ICS 29.035.10

Reference number : JIS C 2300-2 : 2010 (E)

PROTECTED BY COPYRIGHT

 **Documents**
Document Sharing Hub

27 S

Date of Establishment: 2010-06-21

Date of Public Notice in Official Gazette: 2010-06-21

Investigated by: Japanese Industrial Standards Committee
Standards Board

Technical Committee on Electricity Technology

JIS C 2300-2:2010, First English edition published in 2012-02

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

© JSA 2012

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

PROTECTED BY COPYRIGHT

Contents

	Page
Introduction.....	1
1 Scope	1
2 Normative references	1
3 Terms and definitions	3
4 General notes on tests	3
5 Size	3
5.1 Thickness	3
5.2 Width and length of sheet	4
5.3 Width and diameter of roll	4
6 Grammage	4
6.1 Principle.....	4
6.2 Test pieces	5
6.3 Procedure	5
6.4 Results	5
7 Apparent density	5
7.0A General	5
8 Tensile strength and elongation	5
8.1 Principle.....	5
8.2 Test pieces	6
8.3 Procedure	6
8.4 Results	6
9 Internal tearing resistance	7
9.1 Principle.....	7
9.2 Test pieces	7
9.3 Procedure	7
9.4 Results	7
10 Edge-tearing resistance	7
10.1 Test apparatus	7
10.2 Test pieces	8
10.3 Procedure	9
10.4 Results	9
11 Bursting strength	9
11.1 Principle.....	9
11.2 Test piece.....	9

11.3	Procedure	9
11.4	Results	9
12	Folding endurance	10
12.1	Test apparatus	10
12.2	Test pieces	10
12.3	Procedure	10
12.4	Results	10
13	Moisture content	10
13.1	Principle	10
13.2	Test pieces	10
13.3	Procedure	10
13.4	Results	10
14	Ash content	11
14.1	Principle	11
14.2	Test pieces	11
14.3	Procedure	11
14.4	Results	11
15	Conductivity of aqueous extract	11
15.0A	General	11
15.1	Method A	11
15.2	Method B	13
16	pH of aqueous extract	13
16.1	Test apparatus	13
16.2	Procedure	14
16.3	Results	14
17	Chloride content	14
17.1	General matters of chloride content measurement	14
17.2	Measuring method	15
18	Sulphate content	19
19	Conductivity of organic extract	19
20	Determination of sodium and potassium content (flame atomic absorption spectrometric method)	19
20.1	Principle	19
20.2	Procedure	20
21	Air permeability	20
21.0A	General	20
21.1	Method A	20
21.2	Method B (Gurley tester method)	21
21.3	Method C (Emil Greiner method)	21

22	Rate of water absorption	22
22.0A	General	22
22.1	Method A (Klemm method)	23
22.2	Method B	26
23	Oil absorption (modified Cobb method)	26
23.0A	General	26
23.1	Test apparatus	26
23.2	Test pieces	27
23.3	Procedure	27
23.4	Results	28
24	Electric strength	28
24.1	In the case of alternate current	28
24.2	In the case of direct current	30
25	Dissipation factor and permittivity of unimpregnated paper and impregnated paper	32
25.0A	General	32
25.1	Method A	32
25.2	Method B	34
25.3	CR value	35
26	Conducting paths	35
26.0A	General	35
26.1	Method A	35
26.2	Method B	37
26.3	Method C (iron particles)	39
27	Heat stability	39
27.0A	General	39
27.1	Internal tearing resistance	39
27.2	Bursting strength	40
27.3	Degree of polymerization	40
27.4	Heat deterioration rate	40
Annex JA (informative)	Comparison table between JIS and corresponding International Standard	41

Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard submitted by Japan Electrical Insulating and Advanced Performance Materials Industrial Association (JEIA)/Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

Consequently **JIS C 2111:2002** has been withdrawn and partially replaced with **JIS C 2300** series of which this Standard is a part.

This **JIS** document is protected by the Copyright Law.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

JIS C 2300 consists of the following 3 parts under the general title “*Cellulosic papers for electrical purposes*”:

Part 1: Definitions and general requirements

Part 2: Methods of test

Part 3-1: Specifications for individual materials—Electrical insulating paper

Cellulosic papers for electrical purposes—Part 2: Methods of test

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **IEC 60554-2** published in 2001 with some modifications of the technical contents.

The portions with continuous sidelines or dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with explanations is given in Annex JA.

1 Scope

This Standard specifies the test methods to be used in testing cellulosic papers for electrical purposes (hereafter referred to as “papers”) to meet the requirements prescribed in the individual product standards.

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows:

IEC 60554-2:2001 *Cellulosic papers for electrical purposes—Part 2: Methods of test* (MOD)

The symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall be applied and the revisions (including amendments) made thereafter shall not be applied. For those without the indication of the year, the most recent edition (including amendments) shall be applied.

JIS B 7502 *Micrometer callipers*

JIS B 7507 *Vernier, dial and digital callipers*

JIS C 2110:1994 *Testing methods for electric strength of solid insulating materials*

JIS C 2138 *Electrical insulating materials—Methods for the determination of the relative permittivity and dielectric dissipation factor*

NOTE : Corresponding International Standard: IEC 60250 *Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths* (MOD)

JIS C 2320 *Electrical insulating oils*

NOTE : Corresponding International Standard: IEC 60296 *Fluids for electro-technical applications—Unused mineral insulating oils for transformers and switchgear* (MOD)

JIS K 0122 General rules for ion selective electrode method

JIS K 0127 General rules for ion chromatographic analysis

JIS K 0400-48-10 *Water quality—Determination of sodium and potassium—Part 3: Determination of sodium and potassium by flame emission spectrometry*

NOTE : Corresponding International Standard: ISO 9964-3 *Water quality—Determination of sodium and potassium—Part 3: Determination of sodium and potassium by flame emission spectrometry* (MOD)

JIS K 8001 General rule for test methods of reagents

JIS P 8112 *Paper—Determination of bursting strength*

NOTE : Corresponding International Standard: ISO 2758 *Paper—Determination of bursting strength* (MOD)

JIS P 8113 *Paper and board—Determination of tensile properties—Part 2: Constant rate of elongation method*

NOTE : Corresponding International Standard: ISO 1924-2:1994 *Paper and board—Determination of tensile properties—Part 2: Constant rate of elongation method* (IDT)

JIS P 8114 Paper and board—Determination of folding endurance—Schopper method

JIS P 8116 *Paper—Determination of tearing resistance—Elmendorf tearing tester method*

NOTE : Corresponding International Standard: ISO 1974 *Paper—Determination of tearing resistance (Elmendorf method)* (MOD)

JIS P 8117 Paper and board—Determination of air permeance and air resistance (medium range)—Gurley method

JIS P 8124 *Paper and board—Determination of grammage*

NOTE : Corresponding International Standard: ISO 536:1995 *Paper and board—Determination of grammage* (MOD)

JIS P 8127:1998 *Paper and board—Determination of moisture content of a lot—Oven-drying method*

NOTE : Corresponding International Standard: ISO 287 *Paper and board—Determination of moisture content of a lot—Oven-drying method* (MOD)

JIS P 8140 *Paper and board—Determination of water absorptiveness—Cobb method*

NOTE : Corresponding International Standard: ISO 535 *Paper and board—Determination of water absorptiveness—Cobb method* (MOD)

JIS R 3503 Glass apparatus for chemical analysis

IEC 60216 *Guide for the determination of thermal endurance properties of solid electrical insulating materials*

IEC 60243-1:1998 *Electrical strength of insulating materials—Test methods—Part 1: Tests at power frequencies*

IEC 60450 *Measurement of the average viscometric degree of polymerization of new and aged cellulosic electrically insulating materials*

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply.

3.1 specimen

rectangle of paper cut to given dimensions from a reel or a sheet drawn from selected units

3.2 test piece

quantity of paper on which each single determination is carried out in accordance with the method of test

It may be taken from a specimen; in some instances it may be the specimen itself.

4 General notes on tests

Unless otherwise specified in each clause, the specimen, after being cut, shall be conditioned for not less than 16 h or until constant mass is reached in an atmosphere of $23\text{ °C} \pm 2\text{ °C}$ and relative humidity of $(50 \pm 5)\%$. The test pieces shall be measured in this atmosphere. However, the conditions of this conditioning may be decided upon agreement between the parties concerned with acceptance.

In case of dispute, the conditioning atmosphere shall be $23\text{ °C} \pm 1\text{ °C}$ and $(50 \pm 2)\%$ relative humidity and shall be approached from the dry side (after drying at 70 °C to a moisture content less than 4 %).

Unless otherwise specified, the number of specimens shall be three.

Unless otherwise specified, the result shall be expressed by the mean value. However, the central value may be taken as the result. In this case, the highest and lowest values shall also be recorded and the test report shall clearly reflect that the central value has been taken as the result.

Where it is impracticable to control the atmosphere in the test room to $23\text{ °C} \pm 2\text{ °C}$ and relative humidity $(50 \pm 5)\%$, the specimen shall be conditioned in a well-closed container which is controlled to the relative humidity of $(50 \pm 5)\%$, and then a test shall be immediately performed in a room controlled to the temperature $23\text{ °C} \pm 5\text{ °C}$ (room temperature) and relative humidity $(50 \pm 5)\%$. In this case, the temperature and humidity used in the test shall be stated in the test report.

5 Size

5.1 Thickness

5.1.1 Measuring instrument and measuring method

The measuring instrument shall be as follows. Unless otherwise specified, it shall be in accordance with either of the following methods. The method used shall be recorded.

- a) **Measurement using an external micrometer** Use the external micrometer with a measurement length of 25 mm or less specified in **JIS B 7502** or that with an accuracy equivalent or superior to this. The diameter of the measuring plane shall be 6.35 mm and the pressure shall be $155 \text{ kPa} \pm 15 \text{ kPa}$. For the measurement, rotate the micrometer at a travel speed of about 0.05 mm/s at a time, and after the measurement plane lightly touches the side face of the test piece in parallel, read the graduation at the clicking noise of the ratchet. In the case of an automatic stop type, read the value at the time of stop.
- b) **Measurement using a thickness gauge** Use the thickness gauge of which the pressure face has a diameter of $14.3 \text{ mm} \pm 0.5 \text{ mm}$ and the pressure between pressure faces is $55 \text{ kPa} \pm 5 \text{ kPa}$ or any gauge with an accuracy equivalent or superior to this, and lower the lower end of the plunger as gently as possible from at a distance of at least 0.6 mm from the test piece surface and perform the measurement.

5.1.2 Determination of the thickness of single sheets of paper

Cut out a test piece of a size of 200 mm in the machine direction (flow direction) from the full-width specimen without creases, and measure the thickness at 10 points in the test piece at approximately equal intervals in the width direction.

5.1.3 Determination of the thickness of folded sheets of paper

Fold the full-width specimen without creases at right angles to the machine direction to five or ten folds, and measure the thickness at three points or more at approximately equal intervals at a distance of at least 15 mm inside from the end folded along the fold. Divide the measured value thus obtained by the number of folds of the paper to calculate the thickness per one sheet at each measurement point, and express by the mean value.

5.2 Width and length of sheet

For measurement of the width and length of a sheet, spread the paper on a flat table, and measure at three points for each using a proper measuring gauge with an accuracy of 0.5 mm or more without tension applied and express by the mean value.

5.3 Width and diameter of roll

For measurement of the width of a roll, the outer diameter of a roll, the outer diameter of a roll core and the inner diameter of a roll core, measure them at each of the three points obtained by trisecting the circumference of one roll, as it is rolled, using the vernier calliper specified in **JIS B 7507** or any measuring gauge equivalent to or superior to this, and express by the mean value.

6 Grammage

6.1 Principle

For the grammage, the area of each test piece and its mass are measured, and the mass per square metre is calculated.

6.2 Test pieces

Three test pieces with an area of 500 cm² or more shall be cut from the specimen.

6.3 Procedure

The measurement of the grammage shall be performed in accordance with the following method and the method specified in **JIS P 8124**. However, clause 4 and 5 a) of **JIS P 8124** are not taken into consideration.

- a) Measure the area and mass of a test piece and obtain by calculation.
- b) Measure the mass with an accuracy of 0.5 %.

In order to confirm the variation of the grammage of the full width, when the grammage in the width direction is measured, the details of the procedure shall be in accordance with individual product standards.

6.4 Results

The grammage shall be expressed in grams per square metre (g/m²).

7 Apparent density

7.0A General

For the apparent density measurement, unless otherwise specified, either of the following methods may be used. The method used shall be recorded.

- a) **Method A** The apparent density shall be calculated from each thickness and grammage of three test pieces. The measurement of thickness shall be performed as specified in 5.1. The measurement of the grammage shall be performed as specified in clause 6. The apparent density shall be expressed in grams per cubic centimetre (g/cm³).
- b) **Method B (method for obtaining the apparent density in the absolute dry condition)** Weigh out approximately 2 g from the specimen used for the thickness test, or the test piece of the mass specified in an individual product standard into the weighing bottle specified in **JIS R 3503**, dry at 105 °C ± 2 °C for 3 h or more, after leaving it to cool in a desiccator containing a silica gel, measure the mass, and obtain the apparent density from grammage in the absolute dry condition and the volume before heating by calculation. The measurement of thickness shall be performed as specified in 5.1.1. Measure the mass with an accuracy of not more than 0.5 %. Express the result by the mean value using the unit of grams per cubic centimetre (g/cm³).

8 Tensile strength and elongation

8.1 Principle

Measurement of the tensile strength and elongation required to cause failure of test pieces 15 mm by approximately 250 mm, cut from both directions of the paper, when applied under standard test conditions.

8.2 Test pieces

Nine test pieces shall be cut from each of the machine direction and the cross direction of the specimen. However, test pieces may be as decided by agreement between the parties concerned with acceptance.

8.3 Procedure

The tensile strength and elongation shall be measured in accordance with the method specified in **JIS P 8113**.

8.4 Results

The result shall be expressed by the mean value for each direction. The tensile strength shall be expressed in kilo newtons per metre (kN/m), newtons per 15 millimetre (N/15 mm), or (MPa) by the following formula.

$$S = \frac{F}{w}$$

where, S : tensile strength (kN/m)
 F : force at the time of cutting (N)
 w : width of test piece (mm)

$$T = \frac{F}{w \times a}$$

where, T : tensile strength (MPa)
 F : force at the time of cutting (N)
 w : width of test piece (mm)
 a : thickness of test piece (mm)

In addition, instead of the tensile strength, the result may be expressed as the breaking length (km) rounded to the nearest 100 m.

$$L = \frac{1}{9.8} \times \frac{F}{W \times b} \times 10^3$$

where, L : breaking length (km)
 F : force at the time of cutting (N)
 W : grammage of test piece (g/m²)
 b : width of test piece (m)

The elongation shall be expressed as percentage (%) to the separation of jaws that fix the both ends of a test piece.

$$E = \frac{D - D_0}{D_0} \times 100$$

where, E : elongation (%)
 D_0 : jaw separation (mm)
 D : gap at the time of cutting (mm)

9 Internal tearing resistance

9.1 Principle

The force required for tearing a notched sheet of paper is determined.

9.2 Test pieces

Unless otherwise specified, the test pieces shall have the dimensions specified in **JIS P 8116**, and nine test pieces shall be cut from each of the machine direction and the cross direction of the specimen.

The length to be torn by the pendulum after a notch is given by a knife shall be $43.0 \text{ mm} \pm 0.5 \text{ mm}$.

9.3 Procedure

Perform the measurement in accordance with **JIS P 8116** using the Elmendorf tearing tester specified in **JIS P 8116**.

9.4 Results

The measurements obtained in each direction, expressed by the mean value, shall be taken as the result. The internal tearing resistance shall be expressed in millinewtons (mN).

10 Edge-tearing resistance

10.1 Test apparatus

An edge-tear stirrup (see figure 1) shall be used, attached to the tensile testing apparatus as described in **JIS P 8113**. The edge-tear stirrup consists of a thin steel plate (A) having a shallow V-notch (hereafter referred to as "V-notch") supported on the edge by the ends of a stirrup-shaped frame.

The vertical plate with a V-notch is removable from the stirrup frame and two plates of different thickness are supplied for use with papers of different thickness ranges. One plate has a thickness of $1.25 \text{ mm} \pm 0.05 \text{ mm}$ and one plate a thickness of $2.50 \text{ mm} \pm 0.05 \text{ mm}$. The angle of the V-notch shall be $150^\circ \pm 1^\circ$. The sides of the V-notch are semicircular in cross-section and shall be smooth and straight.

Unit: mm

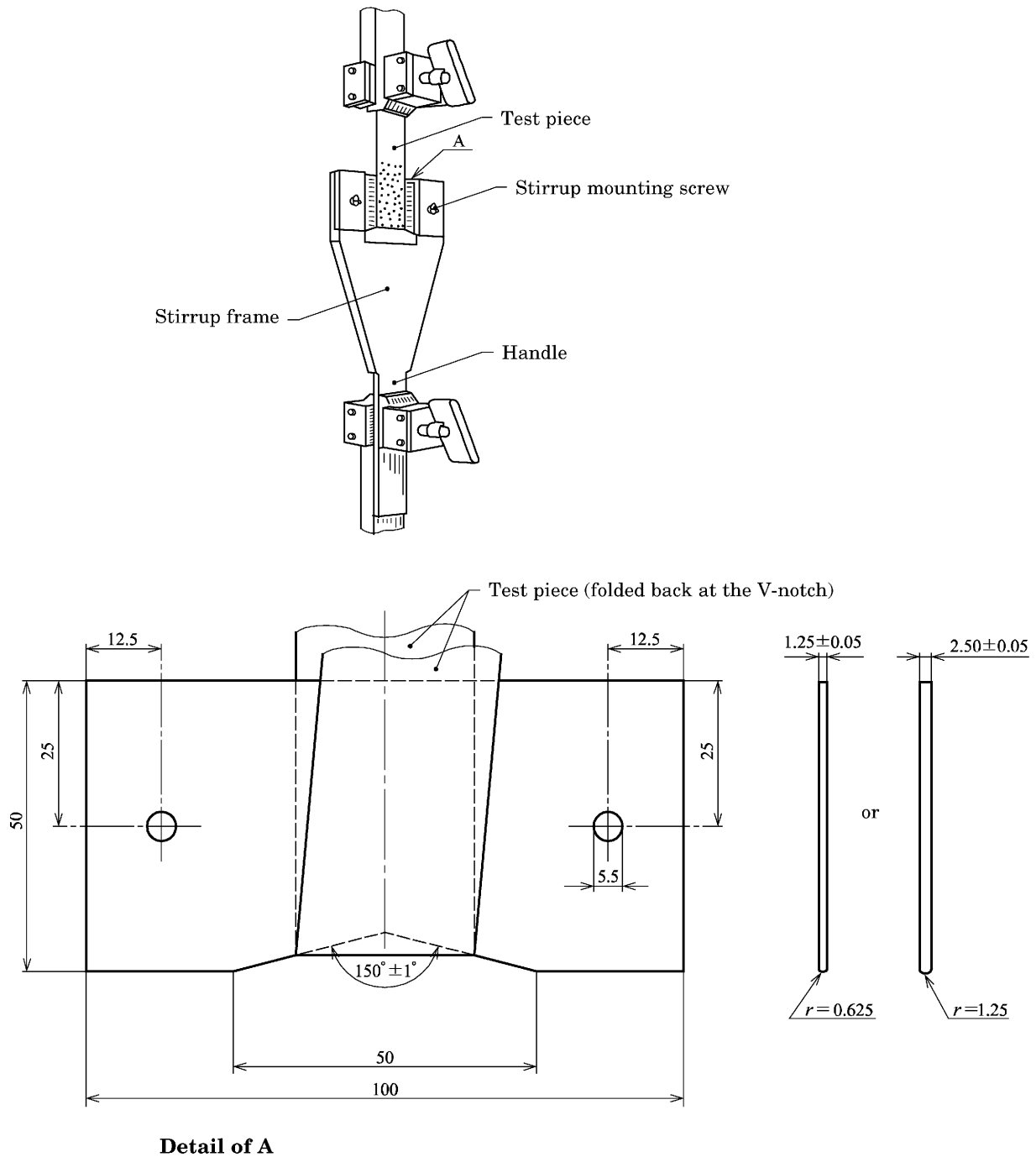


Figure 1 Edge tear stirrup

10.2 Test pieces

Nine test pieces shall be cut from each of the machine direction and the cross direction of the specimen, 15 mm to 25 mm in width and not less than 250 mm in length.

The test pieces shall be conditioned according to clause 4.

10.3 Procedure

Attach a plate of the proper thickness to the stirrup frame. The plate with the thickness of $1.25 \text{ mm} \pm 0.05 \text{ mm}$ is to be used for papers of up to 0.75 mm in thickness and the plate with the thickness of $2.50 \text{ mm} \pm 0.05 \text{ mm}$ for thicker papers.

Fasten the thin tang of the stirrup in the lower clamp of the tension-testing machine so that the vertical centre line of the stirrup coincides with the line connecting the mid-points of the upper and lower clamps of the testing machine, and so that (the sides of the V-notch) are symmetrically located with the line through the mid-points of the clamps.

The stirrup may be fastened in the upper clamp, if desired. This procedure will require rebalancing the tension-testing machine to compensate for the mass of the stirrup.

Place the lower clamp of the machine so that the lower edge of the upper clamp is about 90 mm above the upper edge of the V-notched plate.

Thread the test piece through the stirrup, under the plate, and bring the two ends together and fasten them in the upper clamp. In this operation, most of the slack in the test piece is taken up, but care shall be exercised not to apply a tearing force to the test piece. Make the application of the first increments of load to the test piece very slowly if possible, to minimize abnormal strains due to inertia effects.

Increase the load so that tearing starts in 5 s to 15 s and record this load in newtons (N).

10.4 Results

Report the mean values for each of the two directions of the paper in newtons, mentioning the thickness of the plate used, the rate of loading and the width and thickness of the test pieces.

11 Bursting strength

11.1 Principle

A test piece, placed in contact with a circular elastic diaphragm, is rigidly clamped at the periphery but free to bulge with the diaphragm. Hydraulic fluid is pumped at a constant rate, bulging the diaphragm until the test piece ruptures. The bursting strength of the test piece is the maximum value of the applied hydraulic pressure.

11.2 Test piece

Unless otherwise specified, the dimensions and the number of test pieces shall be as specified in **JIS P 8112**.

11.3 Procedure

The test piece shall be conditioned as specified in clause 4.

The measurement shall be performed in accordance with **JIS P 8112**.

11.4 Results

The bursting strength shall be expressed in kilopascals (kPa).

12 Folding endurance

12.1 Test apparatus

A folding tester (Schopper type) specified in JIS P 8114.

12.2 Test pieces

Nine strips 15 mm wide, cut in the machine direction, and nine other strips cut in the cross direction.

12.3 Procedure

Clamp the specimen in both clamps. Apply a tension of 5 N for specimens of up to 0.03 mm in thickness and a tension of 10 N for thicker specimens. Determine the number of double folds which the paper withstands, applying a plate of 0.5 mm in thickness with a radius of curvature of 0.25 mm, at a speed of 100 to 200 double folds per minute.

12.4 Results

Report the mean values for each of the two directions of the paper by significant double digits.

13 Moisture content

13.1 Principle

The moisture content of the paper shall be measured according to the mass of the test piece at the time of sampling and after drying.

The test method is according to **JIS P 8127:1998**.

13.2 Test pieces

Three test pieces shall be taken in accordance with **JIS P 8127:1998**.

The mass of the test piece, unless specified in the individual product standard, shall be 1 g to 2 g.

13.3 Procedure

Measure the mass of three test pieces at the time of sampling, and obtain the original mass.

Dry the test piece until constant mass is reached in the thermostat of a temperature of $105\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$. After it is cooled until room temperature is reached in a desiccator containing a desiccating agent, measure the mass to obtain the loss in mass.

13.4 Results

Obtain the moisture content according to the following formula, and report the mean value rounded to one significant figure.

$$M_o = \frac{L_1 - L_2}{L_1} \times 100$$

where, M_o : moisture content (%)