UDC 676.3/.8 : 620.178.7

Transformed

Ref. No. : ISO/R 1974-1971 (E)

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 1974

PAPER

DETERMINATION OF TEARING RESISTANCE

1st EDITION

May 1971

For each individual country the only valid standard is the national standard of that country.

Printed in Switzerland

Also issued in French and Russian. Copies to be obtained through the national standards organizations.

BRIEF HISTORY

The ISO Recommendation R 1974, *Paper – Determination of tearing resistance*, was drawn up by Technical Committee ISO/TC 6, *Paper, board and pulps*, the Secretariat of which is held by the Association Française de Normalisation (AFNOR).

Work on this question led to the adoption of Draft ISO Recommendation No. 1974, which was circulated to all the ISO Member Bodies for enquiry in May 1970. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia	Iran	Sweden
Belgium	Ireland	Switzerland
Canada	Israel	Thailand
Czechoslovakia	Japan	Turkey
Finland	Netherlands	U.A.R.
France	Norway	United Kingdom
Germany	Portugal	U.S.S.R.
Greece	Romania	
India	South Africa, Rep. of	

No Member Body opposed the approval of the Draft.

This Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided to accept it as an ISO RECOMMENDATION.

ISO Recommendation | R 1974 | May 1971

PAPER

DETERMINATION OF TEARING RESISTANCE

1. SCOPE

This ISO Recommendation describes a method for determining the internal tearing resistance of paper. It may also be used for light boards if the tearing resistance is within the range of the instrument used. It does not apply to combined corrugated boards.

2. DEFINITIONS

For the purposes of this ISO Recommendation, *internal tearing resistance* is defined as the mean force required to continue the tearing of an initial cut in a single sheet of paper. If the initial slit is in the machine direction, the result is given as machine direction tearing resistance; similarly for the cross direction.

The *tear factor* is 100 times the tearing resistance divided by the grammage (basis weight) of the paper.

3. PRINCIPLE OF THE METHOD

An initial cut or cuts is/are made

(*a*) in several sheets simultaneously, or

(*b*) in a single sheet of paper.

Several (normally four) sheets together, or the single sheet, are/is torn through a fixed distance using a pendulum to apply the tearing force. The work done in tearing the test piece is measured by the loss in potential energy of the pendulum. The scale is calibrated to indicate the average tearing force (work done divided by the total distance torn). The internal tearing resistance of the paper is determined from the average tearing force and the number of sheets in the test piece.

4. APPARATUS

There are two basic designs of testing apparatus in common use :

– *single tear testers**, in which the test pieces are cut to shape, usually on a guillotine, and a single initial cut is made in the test pieces after clamping on the instrument using a pre-set pivoted knife mounted on the instrument;

– *double tear testers***, in which the test pieces are cut and two initial cuts made, usually on a guillotine, before the test pieces are clamped in the instrument.

In this ISO Recommendation the use of both types of instrument is described.

Under the conditions of this test, the total work done by the pendulum includes the work done in tearing the paper and also the work done in lifting and bending the test piece, overcoming frictional losses between the torn edges of the test piece. With some instruments, the total work done also includes overcoming frictional forces due to the test piece rubbing on the pendulum during the test, but this is a major source of error with some papers and such instruments, and instruments on which this occurs are not to be considered suitable for testing in accordance with the method.

4.1 Single tear testers

The apparatus consists of a suitably mounted pendulum which is free to swing about a horizontal axis from bearings of very low frictional resistance. The paper is held by two clamps, one of which is attached to the frame and the other to the pendulum. The clamping surfaces are at least 25 mm wide and 15 mm deep.

In the initial position, before the paper is torn, the pendulum is displaced from its equilibrium position and held by a hand operated catch. The distance between the clamps is then 2.8 ± 0.3 mm and the clamping surfaces lie in a vertical plane which is perpendicular to the plane of oscillation of the pendulum. The upper edges of the clamping surfaces are in a horizontal line lying at a distance of 104 ± 1 mm from the axis of the pendulum and the plane containing this line and the pendulum axis makes an angle of 27.5° ± 30′ with the vertical.

The method depends on measuring the energy given up by the pendulum in tearing the test piece. A common method of measurement is, for example, by means of a sleeve to which a pointer is attached, mounted on the pendulum coaxially; the position of the pointer relative to the pendulum can be read from a circumferential scale carried on the pendulum. The frictional resistance of this sleeve should be kept within certain specified limits. (For adjustment of this resistance, see Annex A.)

The pointer engages an adjustable stop on the base plate, and the scale pointer and stop are so arranged that the scale reading is a measure of the work done in tearing the paper test piece. The adjustable pointer stop provides a means for setting the scale reading at zero when no work is done in tearing. This adjustment provides an approximate compensation for pendulum and pointer friction at other positions.

The pivoted knife used to produce the initial tear should be so mounted that the distance to be torn after cutting will be 43.0 ± 0.5 mm, and the distance above the clamp of the end of the tear should be 4.0 ± 0.5 mm.

The instrument should be adjusted and checked as described in Annex A, and calibrated as described in Annex B.

In order to provide for the measurement of a wide range of tearing resistance, interchangeable pendulums or additional weights may be used. Each pendulum or pendulum/weight combination will have a different scale factor or different scale and may have different base zero marks.

Most instruments have graduated scales, the scale reading then being the appropriate tearing resistance for a given number of sheets, most frequently 8, 16 or 32. When testing four sheets simultaneously as specified in this method, the scale reading should then be multiplied by 2, 4 or 8 respectively to give the tearing resistance in millinewtons as indicated in section 7.

In some instruments of this type, it is possible for a test piece of the dimensions specified in this method to foul the pendulum during the test. Such instruments, without modification, are not to be considered suitable for testing in accordance with this ISO Recommendation.

* Examples are the APITTA-Elmendorf, Lhomargy and Thwing-Elmendorf tear testers.

** An example is the Marx-Elmendorf tear tester.

4.2 Double tear testers

The apparatus consists of a suitably mounted pendulum which is free to swing about a horizontal axis from bearings of very low frictional resistance. The paper is held by two clamps one of which is attached to the frame and the other to the pendulum. The clamp attached to the frame should be at least 100 mm long and 10 mm deep, and the clamp attached to the pendulum should be at least 50 mm long and 10 mm deep. Both clamps should be symmetrical about the plane of the pendulum.

In the initial position before the paper is torn, the pendulum is displaced from its equilibrium position and held by a hand operated catch. The clamping surfaces should be so arranged that when the clamps are closed with no test piece in position, the clamp attached to the instrument frame has vertical clamping surfaces and the clamping surfaces of the clamp attached to the pendulum are in the same horizontal plane as the top edge of the frame clamp, with the edges of the clamps separated by a distance of 10.0 ± 0.5 mm. The upper edges of the clamping surfaces of the clamp attached to the frame should be in a horizontal line lying at a distance of 100 ± 1 mm from the axis of the pendulum.

The method depends on measuring the energy given up by the pendulum in tearing the test piece. A common method of measurement is, for example, by means of a sleeve to which a pointer is attached, mounted on the pendulum coaxially; the position of the pointer relative to the pendulum can be read from a circumferential scale carried on the pendulum. The frictional resistance of this sleeve should be kept within certain specified limits. (For adjustment of this resistance, see Annex A.)

The adjustable pointer stop provides a means for setting the scale reading at zero when no work is done in tearing. This adjustment provides an approximate compensation for pendulum and pointer friction at other positions.

The instrument should be adjusted and checked as described in Annex A, and calibrated as described in Annex B.

In order to provide for the measurement of a wider range of tearing resistance, interchangeable pendulums or additional weights may be used. Each pendulum or pendulum/weight combination will have a different scale factor or different scale and may have different base zero marks.

Most instruments have graduated scales, the scale reading then being the appropriate tearing resistance for a given number of sheets, normally three. When testing four sheets simultaneously as recommended in this method, the scale reading should be multiplied by 0.75 to give the tearing resistance in millinewtons as indicated in section 7.

5. PREPARATION OF TEST PIECES

5.1 Sampling

Sampling should be carried out in accordance with ISO Recommendation R 186, *Methods of sampling paper and board for testing.* No creases, obvious flaws or watermarks should be included in the test area and test pieces should not include any part of the sample within 15 mm of the edge of any sheet or roll. If it is necessary to include watermarks, this fact should be reported.

5.2 Conditioning

The paper should be conditioned before the test pieces are cut, in accordance with ISO Recommendation 187, *Method for the conditioning of paper and board test samples,* and cutting and testing should be carried out under these conditions.

5.3 Cutting of test pieces

5.3.1 *Single tear testers.* Arrange four specimens with their machine directions parallel and their wire sides facing the same way. Through all four specimens cut rectangular test pieces between 50 mm and 80 mm wide with edges parallel to the desired test direction, and of such a length that after the initial tear has been made in the manner prescribed, the untorn length of the test piece is 43.0 ± 0.5 mm long. The edges of the test piece should be free and not stuck together. If desired for better precision, the rectangular test pieces may be cut singly and then assembled in sets of four.

NOTE. – The exact test piece dimensions depend on the design of the instrument clamps used. For some instruments the appropriate dimensions are 50 mm wide × 62 mm long; for others 50 mm wide × 65 mm long or 76 mm wide × 63 mm long. A guillotine giving the appropriate test piece dimensions is normally supplied with the instrument.

Sufficient test pieces should be cut so that a minimum of ten tests may be made with the tear running in the machine and cross directions respectively.

5.3.2 *Double tear testers.* Arrange four specimens with their machine directions parallel and their wire sides facing the same way. Through all four specimens cut rectangular test pieces 100 ± 1 mm × 62 ± 1 mm with the short edges running parallel to the desired test direction. The edges of the test pieces should be free and not stuck together. If desired for better precision, the rectangular test pieces may be cut singly and then assembled in sets of four. Cut two slits starting in one of the longer edges and parallel to the shorter edges, each positioned 25 ± 1 mm from the short edges, each extending to a point 44.0 ± 0.5 mm from the unslit longer edge of the test piece.

NOTE. – A guillotine giving the appropriate test piece dimensions and slit lengths is normally supplied with the instrument.

Sufficient test pieces should be cut so that a minimum of ten tests may be made with the tear running in the machine and cross directions respectively.

6. PROCEDURE

6.1 Single tear testers

Select the appropriate pendulum or pendulum/weight combination. It is desirable to arrange for the mean readings to fall within the range 20 to 80 % of the full scale reading although values based on readings taken outside these limits may be reported.

Immediately before testing, level the instrument as described in Annex A and check both the equilibrium position of the pendulum and the zero reading. Swing the pendulum until it is held in its starting position by the pendulum stop. With the test piece correctly orientated and with the wire sides facing the knife, clamp the test piece centrally in the jaws so that the lower edge of each test piece rests on the bottom of the jaws and the lateral edges of the test piece coincide. Slit the test piece with the pivoted knife and allow the knife to return to the rest position. Ensure that the pointer is in contact with the pointer stop.

By hand depress the pendulum stop smartly and, keeping the stop depressed, catch the pendulum gently as it approaches the initial position on the return swing. Note the reading indicated by the pointer to the nearest 5 units for instruments scaled 0 to 1000 (0.5 for instruments scaled 0 to 100). Return the pendulum and pointer to the initial position, and remove the torn paper. Repeat this procedure for the other test pieces, orientating them wire side left and right alternately.

The path of the tear may deviate from the direction of the knife slit. If the deviation exceeds 10 mm on one or two out of ten tests, these results should be rejected and further tests carried out to bring the number of satisfactory tests up to a minimum of ten. If in more than two of the test pieces the deviation exceeds 10 mm, the results should be included and the fact should be noted in the report.

If, instead of tearing in the normal way, the paper of any test piece peels apart so as to expose a wide band of torn surface (the effect known as "skinning"), the criteria in the preceding paragraph should be applied to the centre line of the torn band through the test pieces.

If the tearing resistance of the paper or board is such that satisfactory results cannot be obtained using a test piece made up from four sheets, tests may be carried out using more or fewer sheets. This fact should be clearly stated in the report.

NOTE. – The apparent tearing resistance is very dependent on the number of sheets torn simultaneously. With some papers the difference in apparent tearing resistances when one and four plies are torn simultaneously may exceed 20 %.

6.2 Double tear testers

Select the appropriate pendulum/additional weight combination. It is desirable to arrange for the mean readings to fall within the range 20 to 80 % of the full scale reading although values based on readings taken outside these limits may be reported.

Immediately before testing, level the instrument as described in Annex A and check both the equilibrium position of the pendulum and the zero reading. Swing the pendulum until it is held in its starting position by the pendulum stop. The two outside tongues of the test piece are then placed in the fixed clamp and the central tongue in the pendulum clamp. First the fixed clamp and then the pendulum clamp should be tightened, so that the test piece projects vertically above the fixed clamp. The test piece should not be strained and a slight bend in the unclamped portion of the tongue can be tolerated. Ensure that the pointer is in contact with the pendulum stop.

By hand depress the pendulum stop smartly and, keeping the stop depressed, catch the pendulum gently as it approaches the initial position on the return swing. Note the reading indicated by the pointer to the nearest 5 units for instruments scaled 0 to 1000 or 1100 (0.5 unit for instruments scaled 0 to 100 or 110). Return the pendulum and pointer to the initial position, and remove the torn paper. Repeat this procedure for the other test pieces, orientating them wire side left and right alternately.

The path of the tear may deviate from the direction of the knife slits. If the deviation exceeds 10 mm on one or two out of ten tests, these results should be rejected and further tests carried out to bring the number of satisfactory tests up to a minimum of ten. If in more than two of the test pieces the deviation exceeds 10 mm, the results should be included and the fact should be noted in the report.

If, instead of tearing in the normal way, the paper of any test piece peels apart so as to expose a wide band of torn surface (the effect known as "skinning"), the criteria in the preceding paragraph should be applied to the centre line of the torn band through the test pieces.

If the tearing resistance of the paper or board is such that satisfactory results cannot be obtained using a test piece made up from four sheets, tests may be carried out using more or fewer sheets. This fact should be clearly stated in the report.

NOTES

1. If the sheets curl, ensure that they lean towards and not away from the pendulum by bending them gently at the clamp. In doing so avoid affecting the moisture content of the test areas.

2. The apparent tearing resistance is very dependent on the number of sheets torn simultaneously. With some papers the difference in apparent tearing resistances when one and four plies are torn simultaneously may exceed 20 %.

7. EXPRESSION OF RESULTS

Calculate the mean scale reading and, from the following equations, the tearing resistance or the tear factor :

$$a = \frac{SP}{n}$$

$$X = \frac{100\,a}{w}$$

where

a is the tearing resistance expressed in millinewtons;

S is the mean scale reading in the direction tested;

P is the pendulum factor, i.e. theoretically the number of sheets torn simultaneously for which the pendulum scale has been calibrated to give a direct tearing resistance reading in millinewtons, commonly 3 (double tear testers), 8, 16 or 32 (single tear testers);

n is the number of sheets torn simultaneously (normally four);

X is the tear factor;

w is the grammage (basis weight) expressed in grammes per square metre and determined in accordance with ISO Recommendation R 536, *Determination of paper substance*.

8. TEST REPORT

The test report should include the following particulars :

(*a*) date and place of testing;

(*b*) description and identification of the material tested;

(*c*) the direction of the test;

(*d*) the number of replicate tests carried out if other than ten;

(*e*) the mean tearing resistance in millinewtons or the tear factor, to three significant figures, in the direction tested;

(*f*) the coefficient of variation of the results;

(*g*) the method used (single tear or double tear), and manufacturer and model number of the instrument;

(*h*) the number of sheets torn simultaneously if other than four;

(*i*) whether the tear deviated from the correct path, or extensive "skinning" occurred;

NOTE. – Tests in which these effects have occurred may give spuriously high or low results, which should be interpreted with great caution.

(*j*) any other departures from the recommended procedure;

(*k*) the grammage (basis weight) of the paper or any other factor which may assist the interpretation of the results.

ANNEX A

ADJUSTMENT AND MAINTENANCE OF INSTRUMENTS

The procedure described below should be followed for each of the pendulum/additional weight combinations used.

A.1 SINGLE TEAR TESTERS

A.1.1 Inspection

Check the following items and make any necessary adjustments.

(*a*) *Pendulum shaft.* Check that the pendulum shaft is not bent.

(*b*) *Clamps.* Check that the distance between clamps is 2.8 ± 0.3 mm and that when the pendulum is in its initial position, the clamps are in alignment.

(*c*) *Knife.* Check that the knife fitting is secure, and that the cutting edge is sharp and undamaged. The blade should be situated midway between, and at right angles to, the top of the clamps.

(*d*) *Pointer.* Ensure that the pointer is undamaged and rigidly attached to the sleeve.

A.1.2 Levelling

The instrument should be mounted on a rigid bench and should, if possible, be firmly attached to the bench.

With the pendulum clamp closed, adjust the level of the instrument so that the pendulum hangs vertically and the index marks on the pendulum and base coincide. With the stop depressed, displace the pendulum slightly and after it comes to rest check that the index marks still coincide.

A.1.3 Zero adjustment

After levelling, operate the instrument several times with clamps empty and closed to ascertain whether the pointer registers zero. If zero is not registered, move the adjustable pointer stop.

A.1.4 Pendulum friction

Make a reference mark on the stop mechanism 25 mm to the right of the edge of the pendulum catch. Raise the sector to its initial position and set the pointer so that it does not meet the pointer stop when the instrument is operated.

When the sector is released and the pendulum stop held down, the sector should make at least 35 complete oscillations before the edge of the sector which engages with the catch no longer passes to the left of the reference mark. Otherwise clean, oil or adjust the bearing.