Designation: D 689 – 03

An American National Standard

# Standard Test Method for Internal Tearing Resistance of Paper[1]

This standard is issued under the fixed designation D 689; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope

1.1 This test method measures the force perpendicular to the plane of the paper required to tear multiple sheets of paper through a specified distance after the tear has been started, using an Elmendorf-type tearing tester. The measured results can be used to calculate the approximate tearing resistance of a single sheet. In the case of tearing a single sheet of paper, the tearing resistance is measured directly.

NOTE 1—Similar procedures for making Elmendorf-type tear measurements are found in ISO 1974 and TAPPI T414.

1.2 This test method is not suitable for determining the cross-directional tearing resistance of highly directional boards and papers.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 585 Practice for Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Products[2]

D 646 Test Method for Grammage of Paper and Paperboard (Mass per Unit Area)[2]

D 685 Practice for Conditioning Paper and Paper Products for Testing[2]

D 1749 Practice for Interlaboratory Evaluation of Test Methods Used with Paper and Paper Products[2]

E 178 Practice for Dealing with Outlying Observations[3]

2.2 *ISO Standard:*

ISO 1974 Paper—Determination of tearing resistance (Elmendorf method)[4]

2.3 *TAPPI Standard:*

TAPPI T 414 Internal Tearing Resistance of Paper (Elmendorf-Type Method)[5]

## 3. Summary of Test Method

3.1 One or more sheets of the sample material are torn together through a fixed distance by means of the pendulum of an Elmendorf-type tearing tester. The work done in tearing is measured by the loss in potential energy of the pendulum. The instrument scale is calibrated to indicate the average force exerted when a certain number of plies are torn together (work done divided by the total distance torn).

## 4. Significance and Use

4.1 This test method is widely used within the paper industry, in conjunction with other tests of strength, as a predictor of end-use performance of a wide range of grades of papers.

## 5. Apparatus

5.1 *Elmendorf-Type Tearing Tester*—Several types are available and in use throughout the world, principally those of Australian, British, German, Swedish, and United States manufacture. In addition, testing practices also vary.

5.2 *Instrumental and Procedural Variables*—Instruments and practices in use vary in at least two major respects:

5.2.1 *The Design Of The Specimen Clamps*—Together with the structural characteristics of the paper governing the nature of the tear with respect to its splitting tendencies during the test, this has an appreciable influence on the mode of tearing and may result in significant differences **(1)**[6]. The procedure described in 5.3.7 reduces this effect. The clamp designs used by some manufacturers may vary even for their own models. Instruments are available with pneumatically activated grips as well, which minimizes variations due to differences in clamping pressures exerted by manually tightened grips.

5.2.2 *A Combined Variation in Testers and Testing Practices*—As measured tearing resistance increases or decreases for different types of paper, the measurement may

[1] This test method is under the jurisdiction of ASTM Committee D06 on Paper and Paper Products and is the direct responsibility of Subcommittee D06.92 on Test Methods.

Current edition approved April 10, 2003. Published June 2003. Originally approved in 1942 as D 689 – 42 T. Last previous edition apporved in 1996 as D 689 – 96a. Discontinued 1984 and reinstated 1992.

[2] *Annual Book of ASTM Standards*, Vol 15.09.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

[5] Available from the Technical Association of the Pulp and Paper Industrial, P.O. Box 105113, Atlanta, GA 30348.

[6] The boldface numbers in parentheses refer to the list of references at the end of this standard.

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become so large or so small as to be outside the practical range of the instrument. This problem may be overcome in one of two ways; the number of sample sheets tested at one time may be changed, or the mass of the instrument pendulum may be changed either by adding augmenting weights or by replacing the entire pendulum with one of a different known mass. The tearing length must never be varied in an effort to alter the pendulum capacity.

5.2.3 These differences, together with other lesser differences in design details between instruments or testing practices, preclude specifying a tearing instrument and method that would give essentially the same test results when using Elmendorf instruments of different design and manufacture. Even for one specific model, some procedural variables such as the number of plies torn may alter the test values calculated on a single sheet basis substantially. By necessity, this reference method must be arbitrary and is limited to the described procedure used with instruments conforming to all of the requirements specified under 5.3.

5.3 *Required Instrument for This Test Method*:

5.3.1 *Elmendorf Tearing Tester* **(2, 3, 4)**, with a cutout as shown in Fig. 1, which prevents the specimen from coming in contact with the pendulum sector during the test, and having the following elements:

5.3.2 *Stationary and Movable Clamp*—The movable clamp is carried on a pendulum formed by a sector of a circle free to swing on a ball bearing.

5.3.3 *Knife*, mounted on a stationary post for starting the tear.

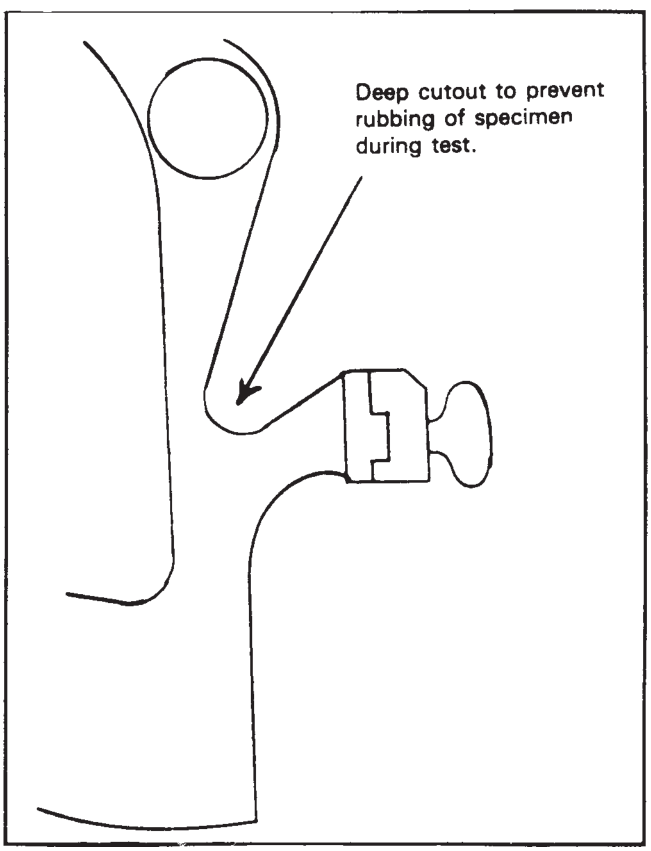


**FIG. 1 Newer Testing Model with Deep Cutout**

5.3.4 *Means for Leveling the Instrument*.

5.3.5 *Pendulum Holder*—Means for holding the pendulum in a raised position and for releasing it instantaneously.

5.3.6 *Means for Registering the Maximum Arc* through which the pendulum swings when released. The registering means may consist of a graduated scale mounted on the pendulum, a pointer mounted on the same axis as the pendulum with constant friction just sufficient to stop the pointer at the highest point reached by the swing of the sector, and an adjustable pointer stop for setting the zero of the instrument.

5.3.6.1 The pointer and scale may be replaced by a digital readout unit which gives readings of equivalent accuracy and precision **(5)**.

5.3.7 With the pendulum in its initial position ready for a test, the clamps are separated by an interval of 2.8 ± 0.3 mm and are so aligned that the specimen clamped in them lies in a plane parallel to the axis of the pendulum, the plane making an angle of 27.5 ± 0.5° with the perpendicular line joining the axis and the horizontal line formed by the top edges of the clamping jaws. The distance between the axis and the top edges of the clamping jaws is 103.0 ± 0.1 mm. The clamping surface in each jaw is at least 25 mm wide and 15.9 ± 0.1 mm deep.

NOTE 2—In the past, it has been the practice for instruments commonly available in the United States to be equipped with 36 ± 1 mm wide jaws. Instruments currently available may be equipped with jaws as narrow as 25 mm. Testing has shown that the effect of jaw width on test results is statistically insignificant. It is recommended, however, that the test specimen length be adjusted to match jaw width. See Note 3.

5.3.8 The instrument measures the energy (work done) used by the pendulum in tearing the test specimen. In order to convert to average tearing force, the energy must be divided by the total distance through which the force is applied. This division may be accomplished by the electronics in digital readout instruments so that the readout is directly in grams-force or in millinewtons (SI unit of force). For pointer and scale instruments, the scale may be in millinewtons or in grams-force for a specified number of plies; for example, when the specified number of plies are torn together, the scale reading gives the average tearing resistance (force) of a single ply.

5.3.9 Instruments of several capacities (2000, 4000, 8000, 16 000 32 000 mN (200, 400, 800, 1600, 3200 gf)) and perhaps others are available, with the several capacities being achieved by individual instruments, interchangeable pendulum sectors, or augmenting weights. The instrument recognized as "standard" for this test method has a capacity of 1600 gf (15.7 N), having a pendulum sector of such mass and mass distribution that its 0 to 100 scale is direct reading in grams-force per ply when 16 plies are torn together. For a 16-ply test specimen, the tearing distance $K = 16 \times 4.3$ cm (tearing distance per ply) $\times 2 = 137.6$ cm. The factor 2 is included since in tearing a given length the force is applied twice the distance. Likewise, for a 16-ply test specimen, the tearing energy per ply for a scale reading of 100 would then be 100 gf × 137.6 cm or 13 760 gf·cm (1349.4 mJ). For some of the instruments of different capacities where different numbers of plies are required, or when the number of plies tested using the "standard" instrument differs from 16, different values of $K$ or the tearing energy per ply, or both, may be calculated.

5.3.10 In the "standard" instrument, the zero reading on the scale is at about 70° from the center line (that is, the vertical balance line when the pendulum hangs freely), the 100 reading is at about 21° from the center line, and a vertical force of 1057.3 ± 2.0 gf (10.369 ± 0.020 N) applied at 22.000 ± 0.005 cm from the pendulum axis is required to hold the pendulum sector at 90° from its freely hanging position. Other tearing instruments will require vertical forces that are factors of 2 greater or smaller than 1057.3 gf and, if calibrated in millinewtons, the zero reading would remain at 70° and the 1000 reading would be at about 19° (or the 981 reading at about 21°).

5.3.11 The cutting knife for the test specimen is centered between the clamps and adjusted in height so that the tearing distance is 43.0 ± 0.2 mm; for example, the distance between the end of the slit made by the knife and the upper edge of the specimen is 43.0 ± 0.2 mm when the lower edge of the 63.0-mm wide specimen rests against the bottom of the clamp.

5.4 Instruments are available for automated testing that incorporates automatic sample insertion, automatic sample cutting, etc. in addition to electronic data readout as specified in 5.3.4. These automated instruments may be used, providing the conditions specified in 5.3 are met.

5.5 *Specimen Cutter*, to ensure parallel specimens 63.0 ± 0.15 mm wide with sharp and clean edges. For this purpose, it is desirable to use the type having two hardened and ground base shears, twin knives tensioned against the base shears, and a hold-down mechanism.

## 6. Sampling and Test Specimens

6.1 Obtain the sample to be tested in accordance with Methods D 585.

6.2 From each test unit of the sample, prepare ten representative specimens in each principal direction of the paper, unless a test in only one direction is required. For each specimen, arbitrarily designate one side of the material in some way, such as "primary side", "print side", "wire side", "side one", etc. For each specimen, keep the designated sides of all the plies facing the same way.

NOTE 3—It has been found **(6)** that there is usually no advantage in testing more than ten specimens of a homogeneous test unit of the sample.

6.3 Cut each ply for a test specimen so that its dimension on the side placed in the clamps is at least 53 mm and the dimension through which the tear will be propagated is 63.0 ± 0.15 mm. Take all the plies to be torn together from a single sheet. If sufficient material is not provided, take from adjacent sheets of a unit.

NOTE 4—The correct dimension for the side of the test specimen that will be placed in the clamps is equal to the distance between the outermost edges of each of the instrument's jaws (±2 mm). For the instrument described in 5.3, that distance is at least 2 × 25 mm (the minimum width for each jaw face) plus 2.8 mm (the distance between the clamps) or at least 53 mm. In the United States, the majority of the instruments have jaws 36 + 1 mm wide. A dimension of 76 ± 2.0 mm for the side of the sample to be held in the clamps is correct.

## 7. Calibration and Adjustment

7.1 As noted in Section 5, several Elmendorf-type testers are available and in use at the present time. Minor differences in calibration or adjustment procedures, or both, may apply to instruments obtained from different vendors that comply with 5.3, thus specific calibration procedures which may be used for all instruments complying with 5.3 is impossible. The information contained in this section is to be used as a guide in placing an individual instrument into proper calibration for use in performing the test.

7.2 *Verification of Scale*—Once the scale has been verified, it is unnecessary to repeat this step, provided the tester is kept in adjustment and no parts become changed or perceptibly worn. The scale may be verified either by the potential energy method or by the method which uses the check weights obtainable from the manufacturer. The potential energy method is relatively time-consuming and complicated. The check weight method is relatively simple.

7.2.1 *Potential Energy Method*—The procedure **(7)** for verification is as follows: Anchor and level the tester. Clamp a known weight (in grams), $W$, to the radial edge of the sector beneath the jaws, the center of gravity of the weight (including means of attaching) having been previously marked by a punched dot on the face of the weight that is to be toward the front of the instrument. Close the jaw of the clamp in the sector. Raise and set the sector as for tearing a sheet and, by means of a surface gage or cathetometer, measure in centimetres, to the nearest 0.01 cm, the height, $H$, of the center of gravity of the weight above a fixed horizontal surface. Then release the sector, allow it to swing and note the pointer reading. Without touching the pointer, raise the sector until the edge of the pointer just meets with its stop, in which position again determines the height, $h$, of the center of gravity of the weight above the fixed surface.

7.2.2 Use the following formula for the standard 1600-gf tester:

$$W(h - H) \text{ in gf} - \text{cm} \quad (1)$$

where:

| | | |
|---|---|---|
| the pointer reading | = | $W(h - H)/K$, and |
| $K$ | = | 137.6 cm. |

For other instruments graduated for grams-force of greater or lesser capacity, the reading will be factors of 2 greater or smaller. If graduated for millinewtons, the additional factor 9.81 must be applied.

7.2.2.1 One or more weights may be clamped on the edge of the sector for each calibration point. The work done in raising each weight is calculated and added together.

7.2.2.2 If the deviations of the indicated readings are greater than one-half division, the instrument should be returned to the manufacturer for repair and adjustment.

7.2.3 *Verification of Scale—Check Weight Method*—Use check weights calibrated for suitable scale values (that is, 20, 50, and 80 % of pendulum capacity.) Different check weights are needed for each pendulum capacity. These weights should be so constructed that each weight can be inserted in the clamps by the procedure used for a test specimen.

7.2.3.1 With the pendulum in the raised position, open the clamp of the pendulum. Slide the weight into position and fasten it securely into the clamp. The body of the weight must be beneath the clamp. Depress the pendulum stop, thus releasing the pendulum. Hold down the stop until after the pendulum swing is completed, and catch the pendulum on the return swing. Read the indicating device to the nearest division.

7.2.3.2 Repeat this procedure with each of the check weights.

7.2.4 *Verification of Scale—Purchased Calibration Weight Method*—Calibration weights may or may not be available from the manufacturer of the instrument for use in calibration. Order calibration weights at the same time as the instrument (see 7.2.4).

7.3 *Adjustment of Tearing Distance*—To check the 43.0-mm tearing distance, apply a small amount of graphite (from an ordinary pencil) to the cutting knife. When the cut is made some of the graphite transfers to the paper, contrasting the cut from the uncut portion of the paper and facilitating the measurement. Make this measurement with a vernier caliper with a depth gage or a quality steel rule, readable to 0.2 mm or better under magnification. An alternative procedure is to use a go, no-go gage, which may be available from the manufacturer of the instrument.

7.4 *Adjustment of Instrument for Operation*:

7.4.1 *Pendulum Notching*—Sometimes, as a result of frequent use, a notch is worn in the pendulum sector at the point of contact with the sector stop, giving a jerky release of the pendulum. If this happens, either repair the sector by cutting out and replacing the worn edge, or adjust the height of the stop to the very lowest point of the sector edge. In this case, recheck the calibration of the scale.

7.4.2 *Clamp Alignment and Knife Condition*—Rest the pendulum sector against its stop, and check the alignment of the clamps. Adjust the pendulum stop if necessary. Verify by visual check that the knife is centered between the clamps, and adjust if necessary. Check the sharpness of the knife. A dull knife will result in a square notch near the top of the cut with the paper pushed out. If necessary, sharpen the knife with a rough stone; a rough edge is better than a sharp, smooth edge. Check the tearing distance and adjust the height of the knife if necessary. Do not change the dimensions of the specimen to adjust the tearing distance.

7.4.3 *Instrument Mounting*—Support the instrument on a table so rigid that there will be no perceptible movement of the table or instrument during the swing of the pendulum. Any movement of the instrument base during the swinging of the pendulum may be a significant source of error.

NOTE 5—Threaded bolt holes are usually provided in the base of the instrument and may be used to secure the instrument to the table. An alternative procedure is to place the instrument on a guide which ensures that the instrument always has the same position on the table. Such a guide may be available from the manufacturer of the instrument.

7.4.4 *Instrument Leveling*—Level the instrument so that with the sector free, the line on the sector indicating the vertical from the point of suspension is bisected by the edge of the pendulum stop mechanism.

7.4.5 *Pendulum Friction (Older Instruments)*—Draw a pencil line on the stop-mechanism 25 mm to the right of the edge of the sector stop. Raise the sector to its initial position and set the pointer against its stop. On releasing the sector and holding the sector stop down, the sector should make at least 20 complete oscillations before the edge of the section which engages the stop no longer passes to the left of the pencil line. Otherwise, clean, oil, and adjust the bearing.

7.4.6 *Pendulum Friction (Newer Instruments)*—In recent years, a new type of frictionless bearing made of synthetic material has been used. This bearing will not necessarily allow the pendulum sector to make 20 complete oscillations as the older one did. This does not mean that there is excess friction in the pendulum swing. These newer bearings should not be oiled. Consult the instructions supplied with the instrument for guidance.

7.4.7 *Pointer Zero Reading*—Operate the leveled instrument several times with nothing in the jaws, the movable jaw being closed. If zero is not registered, the pointer stop should be adjusted until the zero reading is obtained. Do not change the level to adjust the zero.

7.4.8 *Pointer Friction*—Set the pointer at the zero reading on the scale before releasing the sector, and after release see that the pointer is pushed not less than 2.5 mm nor more than 4.0 mm beyond the zero. If the pointer friction does not cause it to lie between these two distances, remove the pointer, wipe the bearing clean, and apply a trace of good clock oil to the groove of the bearing, adjust the spring tension or make other adjustments to achieve the specified friction. Reassemble, readjust the zero setting, and recheck the pointer friction.

7.5 *Instruments with Digital Readout*—For instruments with digital readout, the pointer is generally absent. These specifications relating to the pointer are ignored and the values from the digital readout employed are used for zeroing and scale verification.

## 8. Conditioning

8.1 Precondition the sample on the dry side and condition in accordance with Practice D 685.

## 9. Procedure

9.1 Level and adjust the testing apparatus, if necessary, before each set of tests.

9.2 Make all tests under standard atmospheric conditions in accordance with Practice D 685.

9.3 Raise the pendulum sector to its initial position and set the pointer against its stop.

9.3.1 When a digital readout unit is present, ignore instructions in this section regarding the pointer. Operate the readout unit following the manufacturer's instructions.

9.4 Center the specimen in the clamps with the bottom edge carefully set against the stops. Securely clamp the specimen, using approximately the same pressure on both clamps, and make the initial slit. Depress the pendulum stop as far as it will go, thus releasing the pendulum. Hold down the stop until after the tear is completed and catch the pendulum on the return swing without disturbing the position of the pointer.

9.5 Determine from a preliminary test or the product specification how many plies are needed to make up a specimen.

When torn together on the instrument having a 15.7-N (1600-gf) capacity the plies should give an instrument scale reading nearest 40 % of full scale.

NOTE 6—The work done in tearing a number of sheets of paper includes a certain amount of work to bend the paper continuously as it is torn, to provide for the rubbing of the torn edges of the specimen together, and to lift the paper. The number of plies torn at one time and their size can affect the test result with some papers. Empirical requirements for both the apparatus and the test method are therefore necessary to keep the additional work not used for tearing to a definite quantity. For this reason, in making comparisons between two or more sets of paper of the same type and grammage, use the same number of plies for each set.

9.6 If a single-ply test specimen gives a reading higher than 75 on the standard 1600-gf instrument (75 % of full scale on other instruments), use the next higher capacity instruments with one ply or, if necessary, a still higher capacity instrument.

9.6.1 For weaker papers, the standard 1600-gf instrument may require that 16 or more plies be torn together under the procedure specified in 6.3. For these papers, and provided lower capacity instruments are available, the number of plies may be restricted to four and the next lower capacity instrument may be used whenever the reading falls below 20 % of full scale. ISO 1974 provides for testing four-ply specimens with multiple pendulum instruments. If this alternative procedure is used, state in the report.

9.7 Make only one test per specimen, each specimen consisting of the specified number of plies. For each specimen keep the wire sides of all plies facing the same way. Make tests alternately with the wire sides of all plies toward the pendulum and with the wire sides of all plies away from the pendulum. Make certain that the specimen leans toward and not away from the pendulum by gently creasing the specimen at the clamp if necessary, but in doing so avoid affecting the relative humidity of the test area.

9.8 Record the number of plies and the scale reading to the nearest half division.

9.9 Note and report if the line of tear fails to pass through the top edge of the specimen but deviates to one side. Do not use the reading obtained. If more than one third of the tests exhibit this behavior, this test method should not be used for the material concerned.

## 10. Calculation

10.1 Compute the average of the ten scale readings. Determine by Practice E 178 or by other suitable statistical test, whether a value that appears to be excessively high or low should be included in the average.

10.2 Calculate the average tearing force in millinewtons and, if desired, in grams-force required to tear a single ply as follows:

10.2.1 If the standard 1600-gf instrument with 0 to 100 scale is used:

$$\text{Average tearing force, mN} = (16 \times 9.81 \times \text{average scale reading})/\text{number of plies} \tag{2}$$

$$\text{Average tearing force, gf} = (16 \times \text{average scale reading})/\text{number of plies} \tag{3}$$

10.2.2 If an instrument of different grams-force capacity with 0 to 100 scale is used:

$$\text{Average tearing force, mN} = (16 \times 9.81 \times \text{average scale reading} \times \text{gf}-\text{capacity})/(\text{number of plies} \times 1600\ \text{gf}) \tag{4}$$

$$\text{Average tearing force, gf} = (16 \times \text{average scale reading} \times \text{gf}-\text{capacity})/(\text{number of plies} \times 1600\ \text{gf}) \tag{5}$$

10.2.3 If an instrument has an SI metric scale (for example, 0 to 1000 graduations):

$$\text{Average tearing force, mN} = (16 \times \text{average scale reading} \times \text{capacity, N})/(\text{number of plies} \times 15.7\ \text{N}) \tag{6}$$

$$\text{Average tearing force, gf} = (16 \times \text{average scale reading} \times \text{capacity, N})/(9.81 \times \text{number of plies} \times 15.7\ \text{N}) \tag{7}$$

10.2.4 If an instrument has a direct-reading scale (that is, digital read-out) that directly gives the force per ply when preset for the number of plies:

$$\text{Average tearing force, mN} = \text{average scale reading if directly in millinewtons, or} = 9.81 \times \text{average scale reading if in grams}-\text{force} \tag{8}$$

$$\text{Average tearing force, gf} = \text{average scale reading}/9.81\text{, if scale is in millinewtons, or} = \text{average reading if directly in grams}-\text{force} \tag{9}$$

NOTE 7—Previously, a standard reference material (NBS Standard Sample No. 704) was available for use with this method **(8)**. Currently, this standard reference material has been exhausted and will not be replaced.

10.3 Calculate the tear index when requested, using the following formula:

$$\text{Tear index} = \frac{\text{average tearing force (mN)}}{\text{average grammage (g/m}^2\text{)}} = \frac{\text{average tearing force (gf)} \times 9.81}{\text{average grammage (g/m}^2\text{)}} \tag{10}$$

10.3.1 The value for average tearing force in 10.3 is that calculated in 10.2. The value for grammage in 10.3 is that determined using Test Method D 646.

## 11. Report

11.1 Report results with the tear parallel with the machine direction as resistance to internal tearing in the machine direction and those with the tear perpendicular to the machine direction as resistance to internal tearing in the cross direction.

11.2 For each principal direction, report the average, maximum, and minimum of accepted test values of the force required to tear a single ply to three significant figures.

11.3 For a complete report, state the number of plies torn at one time; the number and value of any rejected readings and reasons for their rejection; if an augmenting weight was used; the width of the instrument jaws on the instrument used (see Note 1 and Note 3); and the make and model number of the instrument used.

## 12. Precision and Bias (9, 10)

12.1 On the basis of studies made in accordance with Practice D 1749 the standard deviation of a test result, representing the average of ten readings, has been found to be:

12.1.1 1.5 % of the test result for the same material tested within the same laboratory,

12.1.2 2.5 % for different materials tested within the same laboratory, and

12.1.3 4.5 % between laboratories.

12.1.4 4.5 % may be reduced to 3.0 % by using a reference material for standardizing the instruments.

12.2 Two test results, each representing an average of ten readings, may be considered alike with a probability of 95 % when the two results agree within 2.77 times the appropriate standard deviation.

## APPENDIX

**(Nonmandatory Information)**

### X1. OLDER MODEL INSTRUMENTS

X1.1 Some older models of the Elmendorf tearing-strength tester use a pendulum sector other than that shown in Fig. 1. Only those instruments conforming to 5.3 should be used when this test method is specified.

X1.2 Where no instrument is specified in a specification referencing this test method, an instrument conforming to 5.3 should be used.

X1.3 For a specification referencing this test method but requiring a nonconforming instrument, data obtained may be as much as 10 % greater than that which would be obtained using a conforming instrument (**11**).

X1.4 Reference to the tester without deep cutout has been removed from the current revision of this test method, as it does not comply with the requirements of this test method.

## REFERENCES


(**1**) Wink, W. A., and van Eperen, R. H., "Does the Elmendorf Tester Measure Tearing Strength?" *Tappi Journal*, Vol 46, No. 5, May 1963, pp. 323–325.

(**2**) Elmendorf, A., "Strength Test for Paper," *Paper* Vol 26,1920, p. 302.

(**3**) Elmendorf, A., "The Principle of the Elmendorf Paper Tester," *Paper* Vol 28, 1921..

(**4**) Institute of Paper Chemistry, "Tearing Strength of Paper, Part I," Instrumentation Studies XLVI, *Paper Trade Journal* 118 (5), 1944, p 13.

(**5**) Yarber, W. H. II, and Zdzieborski, J. H. George, *Tappi Journal*, Vol 55, 1972, p. 1064.

(**6**) Lashof, T. W., *Tappi Journal*, Vol 45, 1962, p. 656.

(**7**) Clark, J. d'A., Technical Assn. Papers. Series XV 1, 1932, p. 262, *Paper Trade Journal*, Vol 94, No. 1, 1932, p. 33.

(**8**) *Association News and Events*, *Tappi Journal*, Vol 45, No. 4, 1962, p. 113A.

(**9**) Lashof, T. W.," APPA-TAPPI Reference Material Program. I. Interlaboratory Investigation of TAPPI Standard T 414 m-49, Internal Tearing Resistance of Paper," *Tappi Journal*, Vol 45, 1962, p. 656.

(**10**) Lashof, T. W., "APPA-TAPPI Reference Material Program. II. Effectiveness of a Reference Material in Reducing the Between-Laboratory Variability of TAPPI Standard T 414 m-49 for Internal Tearing Resistance of Paper," *Tappi Journal*, Vol 46, No. 3, March 1963, pp. 145–150.

(**11**) Cohen, W. E., and Watson, A. J., "The Measurement of Internal Tearing Resistance," *Proceedings*, Australian Pulp and Paper Industrial Technical Assn., Vol 3, 1949.



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