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

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[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.

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.

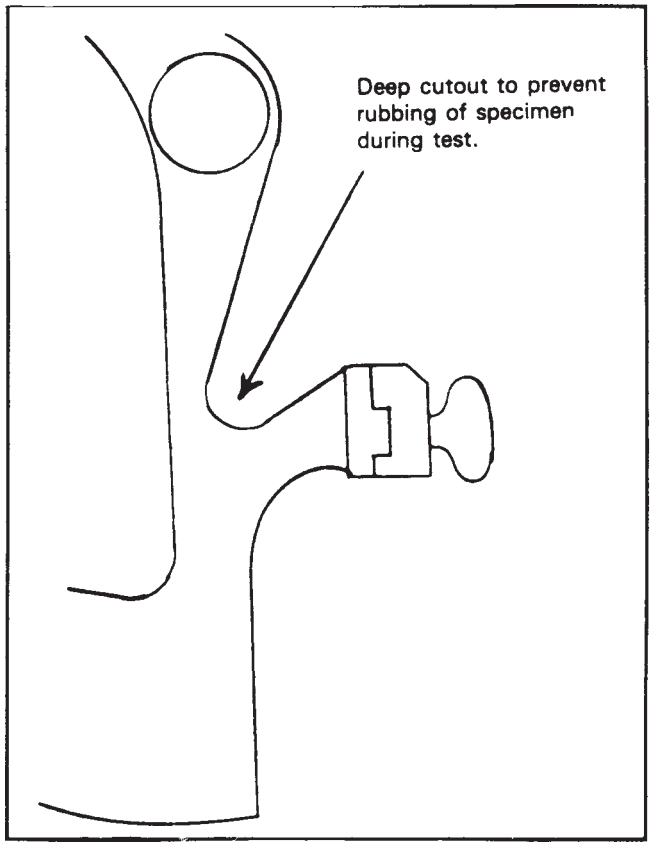

FIG. 1 Newer Testing Model with Deep Cutout

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 $\times$ 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