Designation: D 6548 – 00 (Reapproved 2005)

An American National Standard

Standard Test Method for Resistance to Mechanical Penetration of Sanitary Tissue Papers (Ball Burst Procedure) [1]

This standard is issued under the fixed designation D 6548; 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.

1. Scope

1.1 This test method describes the measurement of the resistance to mechanical penetration of sanitary tissue papers. Application to other paper types is possible but is not covered here.

1.2 *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:* [2]

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

D 685 Practice for Conditioning Paper and Paper Products for Testing

D 774/D 774M Test Method for Bursting Strength of Paper

D 1968 Terminology Relating to Paper and Paper Products

D 4826 Practice for Units of Measurement and Conversion Factors for Pulp, Paper, and Paperboard

E 4 Practices for Force Verification of Testing Machines

E 122 Practice for Choice of Sample Size to Estimate, With a Specified Tolerable Error, the Average Characteristic of a Lot or Process

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology D 1968 or the *Dictionary of Paper*.[3]

4. Summary of Test Method

4.1 In this test method, a test specimen is clamped between two concentric rings whose inner diameter defines the circular area under test. A penetration assembly the top of which is a smooth, spherical steel ball is arranged perpendicular to and centered under the rings holding the test specimen. The penetration assembly is raised at a specified constant rate of speed such that the steel ball contacts and eventually penetrates the test specimen to the point of specimen rupture. The maximum force applied by the penetration assembly at the instant of penetration is reported as the resistance to mechanical penetration.

5. Significance and Use

5.1 Resistance to mechanical penetration is an important characteristic of consumer sanitary tissue products including toilet tissue, facial tissue, table napkins, and paper towels; therefore, it is also an important characteristic of the unconverted tissue paper from which these products are made.

5.2 The penetration principle used in this test method is found in Test Methods D 4833, F 1306, and D 3787. The equipment in these methods generally is an adaptor for ball burst testing mounted on a tensile testing machine and is not included in this test method as data supporting its use in mechanical penetration of sanitary tissue is not available. This test method describes a self-contained testing apparatus, which is in use in the tissue industry.

5.3 The equipment used in this test method differs from that in Test Method D 774 and the two methods give different results. The advantages of this test method for use with tissue include improved correlation with resistance to mechanical penetration of the end use product, as well as, improved ease of use and precision of data when used with tissue products, which characteristically have higher extensibility and lower strength properties than other grades of paper to which Test Method D 774 is better suited.

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[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.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from the Technical Association of the Pulp and Paper Industry, 15 Technology Parkway South, Norcross, GA 30092.

6. Apparatus

6.1 *Self-Contained Resistance to Penetration Tester (Ball Burst Tester)*[4], comprised of the following components:

6.1.1 A penetration assembly consisting of the following:

6.1.1.1 *Spherical Penetration Member*, a 1.588 ± 0.005-cm (0.625 ± 0.002-in.) diameter stainless steel ball finished spherical to 0.0001 cm (0.00004 in.) or less.

6.1.1.2 The spherical penetration member is affixed permanently to the end of a 9.525 ± 0.254 mm (0.375 ± 0.01 in.) solid steel rod

6.1.1.3 A mechanism to transmit the force applied to the ball bearing through the rod to a suitable load cell.

6.1.1.4 For testing the resistance to penetration of tissue, a 2000 or 5000-g load cell will be suitable. Other load cells, both larger and smaller, also may be available. As an alternate, the instrument may provide for various full scale ranges from a single load cell using suitable electronics. The load cell shall conform to the requirements in Practice E 4, and shall measure loads accurately to ± 0.25 % of the total capacity of the load cell used.

6.1.1.5 A suitable mechanism for moving the assembly up and down at a constant rate in a direction perpendicular to the plane wherein the sample is fixed. This mechanism may provide for a variable or fixed speed of movement. For purposes of this test method, the rate of movement shall be 12.7 ± 0.6 cm/min (5.00 ± 0.25 in./min). The distance of travel of the probe may be variable, however for this test method, travel shall be such that the upper most surface of the spherical ball shall reach a distance of 3.49 cm (1.375 in.) above the plane of the sample clamped in the tester.

6.1.2 A means to secure the test specimen for testing consisting of upper and lower concentric rings of approximately 0.64 mm (0.25 in.) thick aluminum between which the sample is held firmly by mechanical or air activated clamps during testing. The specimen clamping rings for use in testing tissue products 8.89 ± 0.03 cm (3.50 ± 0.01 in.) in internal diameter and approximately 6.5 in. (16.5 cm) in outside diameter. The clamping surfaces of the clamping rings are coated with a commercial grade of neoprene approximately 0.16 cm (0.625 in.) thick having a Shore hardness of 70–85 (A scale). The neoprene need not cover the entire surface of the clamping ring, but must be coincident with the inner diameter, thus having an inner diameter of 8.89 ± 0.03 cm (3.50 ± 0.01 in.), and at least 1.27 cm wide thus having and an external diameter of 11.4 ± 0.03 cm (4.50 ± 0.01 in.). Fig. 1 shows the instrument clamping system in the open position (no specimen in place). Figure 7 shows the clamping surface of one of the two concentric rings which form the clamps.

6.1.3 A readout system for displaying the force applied to the test specimen through the penetration assembly at test specimen failure. The minimum requirement is a digital or analog display showing the maximum force applied at test specimen failure. Strip chart or video screen display are also quite suitable. In the case of a recorder or video trace, the data must be presented in such a way that the user can readily determine the maximum force value durifdng the test. Where data reporting is based upon computer algorithms, it is the responsibility of the manufacturer of the instrument to clearly document the calculation basis for the values that are reported, and that they determine the maximum force for the test for use in making the calculation required in Section 13.

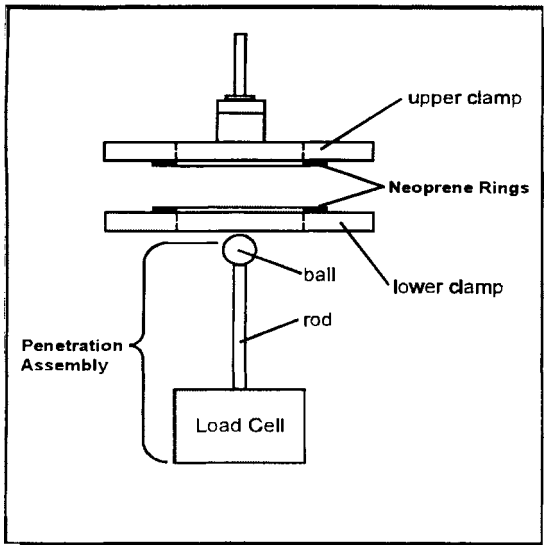

FIG. 1 Burst Clamp and Ball/Rod Probe Pre-Sampling Loading

7. Sampling

7.1 *Acceptance Sampling*—Acceptance sampling shall be in accordance with Practice D 585.

7.2 *Sampling for Other Purposes*—The sampling and number of test specimens depends upon the purpose of the testing. Practice E 122 is recommended.

8. Test Specimen

8.1 The exact dimension of the portion of the test specimen tested is defined by the inner dimensions of the clamping system.

8.2 Toilet tissue is frequently produced in rolls of perforated sheets approximately 10 to 11 cm (4 to 4.5 in.) by 10 to 11 cm (4 to 4.5 in.). In testing such toilet tissue, it is convenient to remove a test specimen consisting of three connected sheets. The outer two sheets are used for moving the sample into the clamping system, while the middle sheet is subjected to the test. For toilet tissue that is perforated in other lengths or unperforated, remove a test specimen approximately 30 cm (12 in.) in length.

8.3 Other sanitary tissue products generally may be tested using a single delivered unit (napkin, facial tissue, or towel) of the product.

8.4 For sanitary tissue paper that has not been converted into a finished product, a test specimen about 30 cm (12 in.) by at least 10 cm (4 in.) wide should be cut for testing.

8.5 For sanitary converted tissue products, testing is done on the products as received, regardless of the number of plies (one, two, or three or more) which are supplied as a product unit.

[4] The only known manufacturer of an instrument meeting the requirements herein is the Thwing-Albert Instrument Company, 10960 Dutton Rd., Phila., Pa 19154–3285. If there are other suppliers of this equipment, they are encouraged to Contact the Committee D06 Chairman through ASTM Headquarters.

8.6 Sanitary tissue that has not been converted into a finished product is tested one ply thick unless agreed to the contrary by the parties interested in the testing.

8.7 Modern sanitary tissue products may be embossed, printed, perforated for ease in dispensing, or folded or exhibit a combination of these features. To the highest degree possible, place the test specimen in the clamping system in such a way that these features (particularly folds and perforations) are not directly over the penetration assembly.

9. Preparation of Apparatus

9.1 Locate the equipment on a laboratory bench or firm table free from vibration. Activate the instrument by turning on the power at least 30 minutes prior to use.

10. Calibration and Standardization

10.1 Calibrate the instrument prior to use using masses of known weight, frequently referred to as "dead weight calibration," following instructions provided by the supplier of the instrument.

11. Conditioning

11.1 Condition the samples in accordance with Practice D 685.

12. Procedure

12.1 Turn on the instrument and calibrate it as described in Sections 9 and 10.

12.2 Prepare five test specimens of the conditioned test specimen as described in Sections 11 and 8.

12.3 Place the first test specimen into the instrument clamping system which is in the released or open condition (Fig. 2).

12.4 Activate the clamping system to clamp the test specimen in place (Fig. 3).

12.5 Activate the test sequence of the instrument causing the penetration assembly to rise at the rate and to the distance described in 6.1.1.5. It may be possible to cause the instrument to automatically lower the probe at the end of the test sequence in preparation for the next test (Figs. 4 and 5).

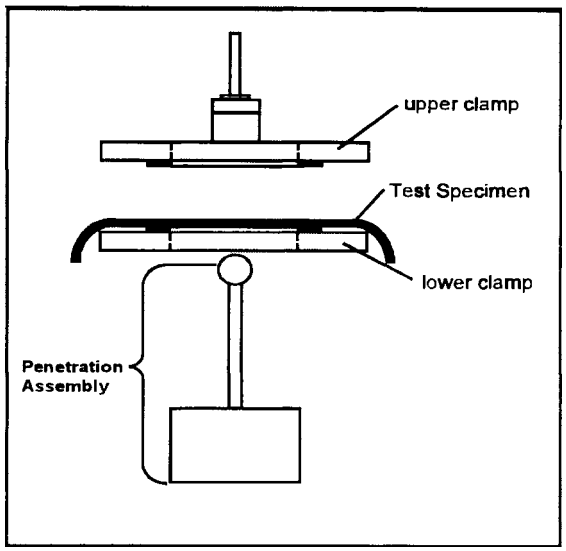

FIG. 2 Sample Loaded

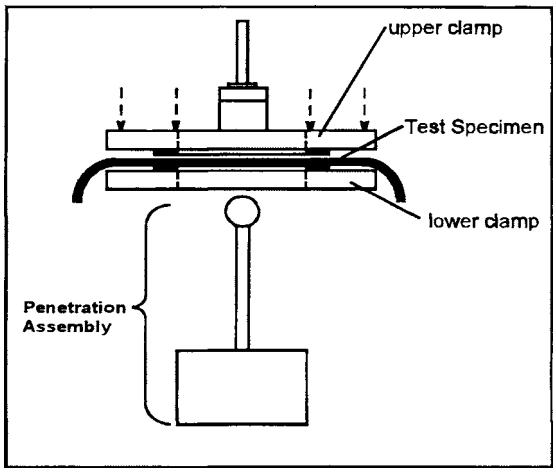

FIG. 3 Upper Clamp Lowered onto Sample

12.6 Upon rupture of the test specimen by the mechanical penetration assembly (Fig. 6), record the measured resistance to penetration force as displayed by the instrument readout system.

12.7 Release the sample clamp mechanism and remove the test specimen upon which testing is complete.

12.8 Repeat steps 12.1-12.7 for the other four test specimens of the sample.

13. Calculation of Results

13.1 Determine the average value of resistance to mechanical penetration for the five test specimens tested by adding the five individual results and dividing by five.

14. Report

14.1 Report the following information:

14.1.1 The average value as determined in Section 13 to the nearest unit when reporting data as grams-force (gf). If results are converted to other units, report to three significant figures.

NOTE 1—Results from this test are typically reported simply in gf. To convert to mN, multiply the results in gf by 9.80665, as shown in Practice

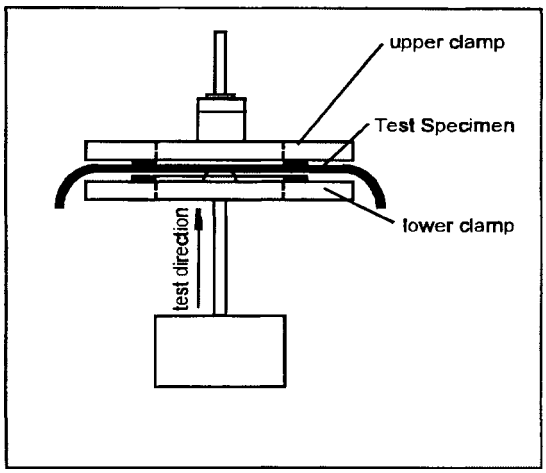

FIG. 4 Ball/Rod Probe Raised into Samples

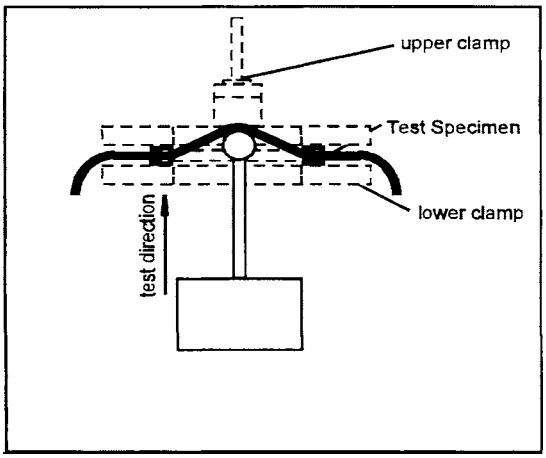

FIG. 5 Sample Stretches as Ball Probe Applies Force against Sample

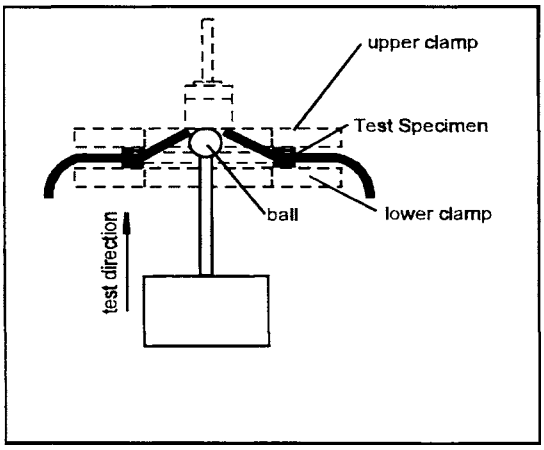

FIG. 6 Ball Probe Penetrates Sample to Rupture

D 4826. The correct SI measurement units for a bursting strength (and the property being measured here is a form of bursting) are force per unit area, and are correctly expressed as pascals. Where reporting in this convention is requested, convert the measured penetration force in mN to kN and divide by the original test specimen area in m^2 (put actual value here as defined by the inner diameter of the clamping ring). This will give the measured value in kN/m^2 or kPa. See Practice D 4826 for other possible conversions and expression of results. The user of this test method is reminded that results from the procedure described here differ from those determined using Test Method D 774, regardless of the units in which data are reported.

14.1.2 The maximum and minimum values measured.

14.1.3 Any deviations from the requirements in this test method.

15. Precision and Bias

15.1 *Repeatability (within a laboratory)*:

15.1.1 A single commercial tissue laboratory ran numerous replicate tests on the major grades of tissue products using the procedure in this test method over a period of six months. Tissue products of many different production dates and locations are included. For this reason, the repeatability limits are somewhat larger than would be the case if a more closely defined population of product were tested. These data are provided as an initial indication of method precision. A standard round robbin precision study will be conducted after a history of use of this method is established.

15.1.2 The within laboratory repeatability, pooled across products of the same type (class), was found to be as follows:

Product	Mean Value (gf)	Repeatability (gf)	%
Kitchen towels	626	68	11
Facial tissue	291	26	9
Toilet tissue	212	18	8

15.2 *Reproducibility (between laboratories)*—A repeatability study will be conducted in conjunction with the planned round robbin.

15.3 *Bias*—This procedure in this test method has no bias because the value of resistance to penetration ("ball burst strength") is defined only in terms of this test method. A comparison with methods whereby "bursting strength" is measured using some other defined procedure has not been done.

16. Keywords

16.1 ball burst; bursting strength; paper; paper products; resistance to mechanical penetration

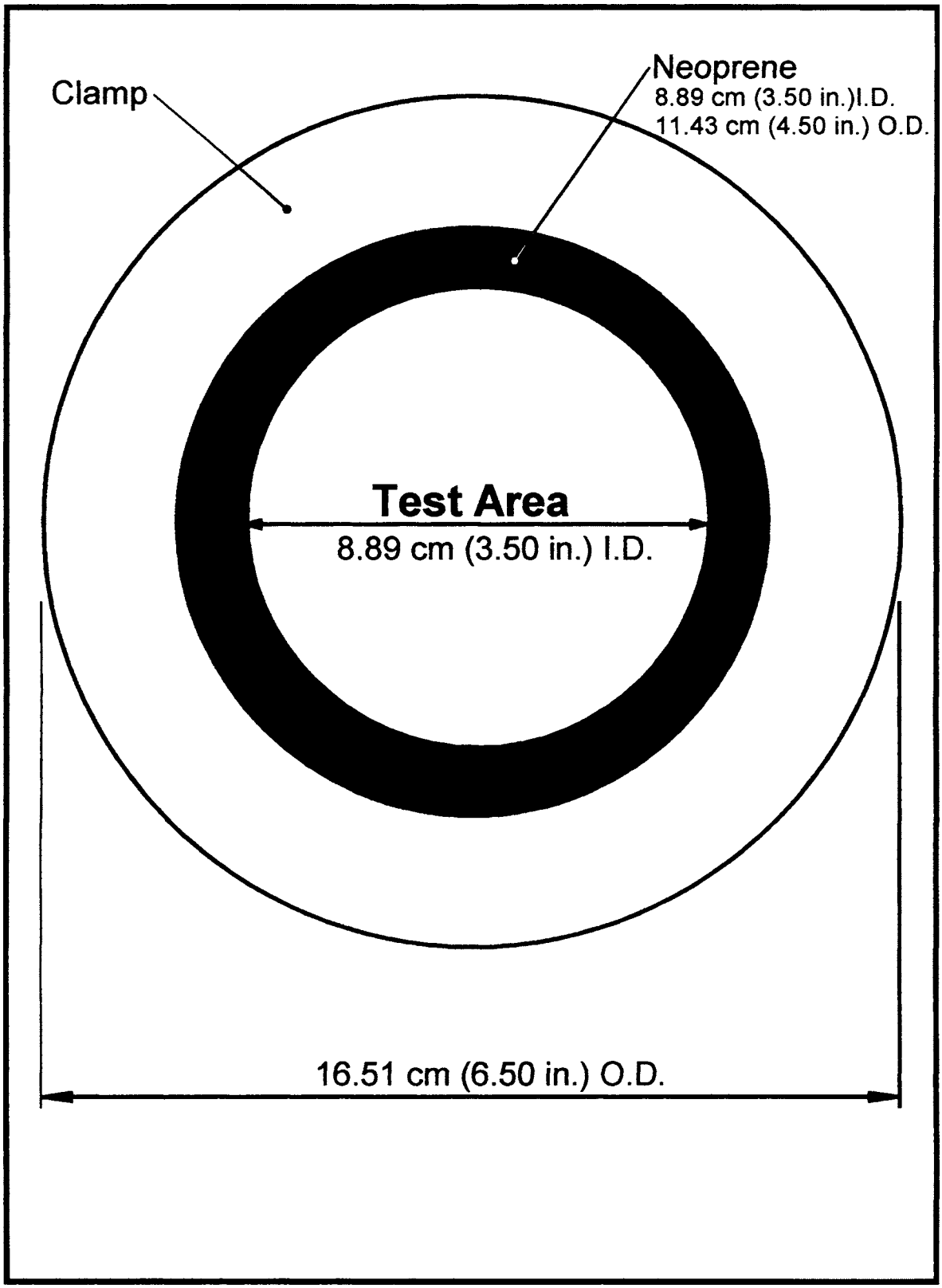

FIG. 7 Clamp View
(surface toward test specimen)