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SUBJECT
CATEGORY _____ Physical Properties _____

RELATED
METHODS _____ See "Additional Information" _____

CAUTION:

This Test Method may include safety precautions which are believed to be appropriate at the time of publication of the method. The intent of these is to alert the user of the method to safety issues related to such use. The user is responsible for determining that the safety precautions are complete and are appropriate to their use of the method, and for ensuring that suitable safety practices have not changed since publication of the method. This method may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Safety Data Sheets, which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this method, the user must determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

Tensile Breaking Strength of Water-Saturated Paper and Paperboard ("Wet Tensile Strength") *(Five-year review of Official Method T 456 om-22)*

1. Scope

1.1 This method describes the procedure for the determination of the tensile strength of paper and paperboard after saturation with water.

1.2 This procedure is applicable to papers and paperboard (excluding corrugated board) that will be subjected to stress while wet, either during processing or use. Such materials include but are not limited to papers used in map-making, photography, and blue prints, bags and food wraps. Previous versions of this method (om-10 and earlier) included tissue and towel products in its scope; however, the scope now excludes these products, since other test methods are available, and are recommended since they are more specific and appropriate for quantifying the wet tensile properties.

2. Summary

2.1 Specimens are selected and saturated with distilled water either by immersion or with the use of the Finch cup. After saturation, the wet tensile breaking strength is evaluated using a tensile tester.

2.2 The analyst using this method must determine the required immersion time that ensures saturation and reports such time along with the test results. Depending on the relative ease of handling of the wet paper sample, the analyst may choose between two test procedures described in this method: Section 8.2 describes the procedure for sample immersion and blotting before clamping straight in the tensile tester grips. Section 8.3 describes the procedure for more delicate or difficult to handle samples, where the samples are clamped in a “Finch-cup” device before being wetted.

3. Significance

The wet tensile breaking strength is an important performance characteristic of papers that will be processed wet, or that will be subjected to wetting, whether accidentally or intentionally during use. Example of such products include, but are not limited to tissue products, photographic paper, bags, moisture food wraps, saturating papers, and any other papers subjected to stress during processing or use, while wet. Previous versions of this method (om-10 and earlier) included tissue and towel products; however, the method now excludes these products, since other test methods are available, and are recommended since they are more specific and appropriate for quantifying the wet tensile properties.

4. Definitions

4.1 *Wet tensile breaking strength*; the maximum tensile force per unit width (kN/m) that a test specimen will withstand before rupture, after the specimen has been wetted with water under specified conditions. The conditions specified in this test method are those required to saturate the sample with water.

4.2 *Saturation*; the state of the test sample when further immersion time (in water) reduces the ‘wet tensile breaking strength’ by <10%, using the immersion time intervals detailed in this method, with a minimum immersion time no less than 10 minutes.

5. Apparatus

5.1 *Tensile tester*, as described in T 494 “Tensile Breaking Properties of Paper and Paperboard (Using Constant Rate of Elongation Apparatus).” When testing samples with a ‘Wet Tensile Breaking Strength’ force less than 10 N, the force measuring device must be accurate to +/- 1% of the actual “Wet Tensile Breaking Strength” force.

5.2 *Blotting paper* (needed only if using immersion/straight-hang procedure in 8.2); the paper used should comply with the requirements in TAPPI T 205 “Forming Handsheets for Physical Tests of Pulp.”

5.3 *Finch wet strength device* (needed only if using the Finch-cup procedure in 8.3), a wet strength device (Fig. 1) consisting of an inverted stirrup about 38 mm (1.5 in.) in width and about 76 mm (3 in.) in length, made of metal straps by which a horizontal rod, about 28 mm (1.1 in.) in length and 5 ± 0.05 mm (0.188 ± 0.002 in.) in diameter, is supported. Between the straps and under the horizontal rod is a small, vertically movable container for holding water or other liquid. When the liquid container is locked in its uppermost position, the horizontal rod is immersed in the liquid to a depth of at least 19 mm (0.75 in.). A thin metal tang forming the lower part of the inverted stirrup permits it to be fastened in the lower clamp of a tension testing machine. This device is not required if the sample is saturated by immersion.

6. Sampling and conditioning

Select specimens in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard or Related Product” and condition as required in TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets and Related Products.”

7. Test specimens

7.1 Cut at least ten test specimens from each test unit of the sample in each principle direction of the sample (machine direction and cross direction) 25.4 mm (1.00 in) wide and optimally at least 230 mm (9 in.) long as described in T 494. To the highest degree possible, avoid areas of the sample containing folds, embossing, or printing.

7.2 For certain finished product items, a test specimen of the specified length is impossible to obtain because of the dimensions, either length, width or both, of the material being tested. In such cases, cut the sample of the longest length possible.

7.3 Additional test specimens should be cut to enable determination of the time necessary to achieve saturation of the specific material being testing (see section 8).

8. Procedure

8.1 Make all tests in the testing atmosphere specified in TAPPI T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets and Related Products."

8.2 When testing materials which are designed to maintain wet strength either in processing or in use and can be handled without difficulty when wet, including, but not limited to papers such as photographic papers, map papers, blueprint papers, bag papers, proceed as follows using the technique referred to henceforth as "Immersion/Straight-hang":

8.2.1 Immerse the test specimens in distilled water maintained at $23.0 \pm 2^{\circ}\text{C}$ ($73.4 \pm 3.6^{\circ}\text{F}$) for the required period of time for saturation. Record the exact time used with the test results.

8.2.2 To help determine the period of time required for saturation, make preliminary tests on each of five specimens cut in the machine direction and saturated by immersion for different known periods of time. In all preliminary tests the increase in time intervals should be sufficient to be determinative. In general, each succeeding interval should be about double that of the previous one. For paper or paperboard which is difficult to saturate, it may be necessary to make preliminary tests after immersion for 2, 4, 8, 16 and 24 h. When less than a 10% loss in tensile strength occurs between two time intervals, consider the longer period as the minimum time of immersion for the final test. For specimens that saturate more quickly, time periods shorter than 2 hours are permitted, but must not be less than 10 minutes immersion, and it must also show that the same doubling of time produces <10% loss in tensile.

NOTE 1: For some papers and testing situations, it may be desirable to add a chemical wetting agent to the water in order to decrease the required time for saturation. If this is done, the chemical name and concentration level (in the water) must be included with the test results in the report section (9.3).

8.2.3 Test as many specimens as is required to establish the saturation time for the paper being tested.

8.2.4 After the saturation time has expired (the time of saturation will vary greatly depending on caliper, sizing, etc.), withdraw the strip, lay it flat and straight on a pad of blotting paper, and press lightly to remove excess water.

8.2.5 Immediately after blotting, place the test specimen in the tensile testing machine and break the specimen as required in 6.8-6.10 of T 494.

8.2.6 The use of excessively high clamping pressures should be avoided. Only sufficient clamping pressure should be applied to prevent the specimen from slipping. Excessively high clamping pressure will result in straight line breaks in, and immediately adjacent to, the clamping zone. However, too low a clamping pressure will result in slippage and/or shows an abrupt discontinuity in the force elongation curve with failure of the specimen beyond the clamping zone.

8.2.7 For each test unit, compute the wet tensile breaking strength (kN/m) as the average breaking force (kN) divided by the width of the sample strip (m) in each principal direction.

8.3 When testing materials which are designed to have lower levels of wet strength and which cannot be handled without difficulty when wet, proceed as follows using the technique referred to henceforth as "Finch":

8.3.1 Fasten the wet strength device (Fig. 1) in the lower clamp of the tension testing machine so that the horizontal rod is parallel to the clamp faces and is otherwise symmetrically located with respect to the clamps. Adjust the position of the lower clamp so that the horizontal rod is about 76 mm (3 in.) below the upper clamp.

8.3.2 For specimens cut from materials of small dimensions (section 7.2) where the 230 mm (9 in) length (section 7.1) cannot be achieved, the position of the lower clamp, and hence the horizontal rod, must be decreased as required to accommodate the material being tested.

8.3.3 Move the liquid container to its lowest position and almost fill with distilled water at the proper temperature of $23.0 \pm 2^{\circ}\text{C}$ ($73.4 \pm 3.6^{\circ}\text{F}$). Wipe dry the horizontal rod and its supports, and thread the test specimen

under the rod. Place the ends of the specimen together, remove the slack, and fasten them in the upper clamp of the tension testing machine. The specimen shall be centrally located with respect to the horizontal rod and the upper clamp. Raise the water container and lock in its uppermost position, immersing the looped end of the specimen to a depth of at least 19 mm (0.75 in.).

8.3.4 The immersion time depends upon the time required to achieve saturation (see 8.2.1). Record the exact time used with the test results.

8.3.5 At the end of the immersion time, immediately initiate the test, which moves the upper jaw at a rate specified of 6.5 in T 494.

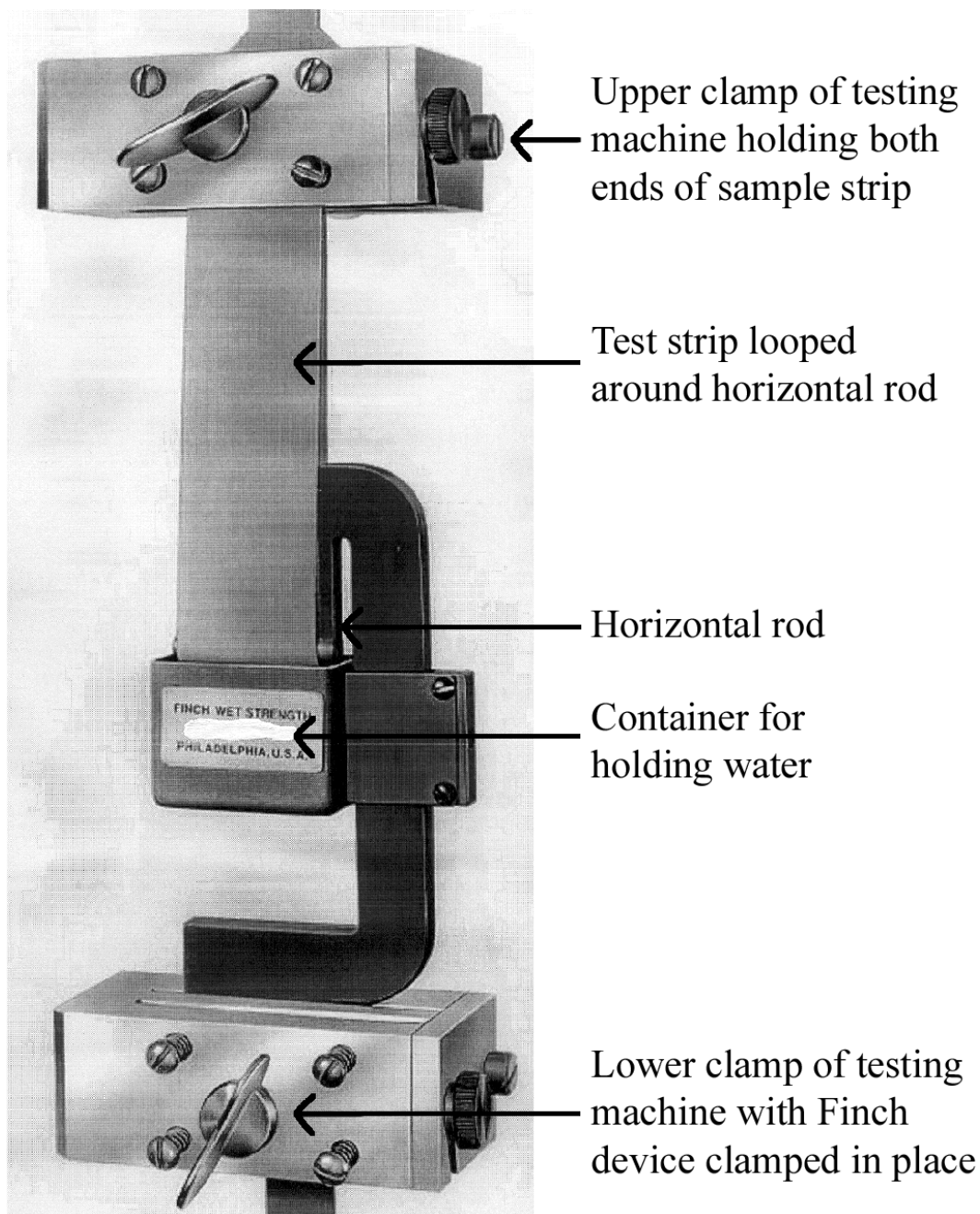


Fig. 1. Finch wet strength device

- 8.3.6 For each test unit, compute the average breaking force (kN) of the sample in each principal direction.
- 8.3.7 For each test unit report the Finch wet tensile breaking strength (kN/m) as the average breaking force divided by the width of the sample strip (m) divided by 2.

9. Report

- 9.1 Report the wet tensile breaking strength value from 8.2.6 or 8.3.7 for each principal direction. Also report the time of the immersion.
- 9.2 Report the procedure used; either section 8.2 (immersion/straight-hang) or 8.3 (Finch).
- 9.3 If any chemical wetting agent was used (to reduce required saturation time, as described in Note 2), report the chemical name and concentration level used in the water.
- 9.4 If desired, report the wet tensile strength in each principal direction as a percentage of the dry tensile strength as determined by T 494. When the Finch wet strength device is used for measuring the wet strength, use it also for measuring the dry strength, but without any water being present.

10. Precision

10.1 Estimates of reproducibility and repeatability for this test method are shown in Table 1. These estimates are based upon an inter-laboratory trial conducted in the year 2002 involving four laboratories and six materials, two grades of tissue, two grades of toweling, and one grade each of uncoated offset and photographic paper. The number of laboratories testing each grade is shown in the column “Labs Included.” The precision estimates are based on ten determinations per test result and three test results per laboratory per grade. While it would have been desirable to have had a larger number of participants, no other laboratories were found who were able to participate in the work. It is therefore recommended that users of this method develop their own precision estimates for specific materials and applications of interest.

- 10.1.1 Immersion/Straight-Hang procedure
Repeatability (within a lab) = 4%
Reproducibility (between laboratories) = 37%
- 10.1.2 Finch cup procedure
Repeatability (within a lab) = 11%
Reproducibility (between laboratories) = 25%
- 10.2 Repeatability and reproducibility are estimates of the maximum difference (at 95%) which should be expected when comparing test results for materials similar to those described above under similar test conditions. These estimates may not be valid for different materials or testing conditions.

11. Keywords

Saturation, Paper, Paperboard, Wet strength, Tensile strength

Table 1. Data table of wet-strength results (kN/m) from inter-laboratory study

<i>Procedure</i>	<i>Material</i>	<i>Grand Mean</i>	<i>Std Dev Btwn Labs</i>	<i>Repeatability r and %r</i>		<i>Reproducibility R and %R</i>		<i>Labs Included</i>
Immersion; Section 8.3	Offset	1.631	0.038	0.029	1.8%	0.107	6.6%	3
Immersion; Section 8.3	Photographic Paper	4.561	1.111	0.294	6.4%	3.086	67.7%	3

12 Additional information

12.1 Effective date of issue: To be assigned.

12.2 Complete saturation of certain types of paper, particularly paperboard, may be significantly accelerated by immersion in (a) degassed distilled water, (b) ordinary distilled water, carrying out the immersion at reduced pressure, or (c) by the addition of a wetting agent to the water (this addition can affect the results of some materials).

12.3 After a prolonged soaking period the pH change of the immersion water caused by the specimen and/or the slow hydrolysis of any wet-strength agent that may be present may cause a further loss of strength (1,2).

12.4 If for some purpose the tensile strength of a paper is measured before it is completely saturated, identify the results so obtained as "tensile strength after soaking in water for ... (time)." Such results are to be distinguished from "wet tensile strength" as defined in this method.

12.5 If a liquid other than distilled water is used, report the results as "tensile strength after soaking in ... (liquid) for ... (time)." Such results are to be distinguished from "wet tensile strength" as defined in this method.

12.6 Related methods: ISO/EN 12625-5; TAPPI T 576 "Tensile properties of towel and tissue products (using constant rate of elongation apparatus)"; Canadian PAPTAC D-10; Scandinavian SCAN P20; British BS 2922; AFNOR (France) QO3-013.

12.7 This method was revised in 1944, 1949, and 1968. It was withdrawn in 1997 and reintroduced in revised form in 2003. The 2010 revision includes a reference to the use of the two-inch and three-inch Finch cup. In the 2015 edition, only a few editorial and grammatical changes were recommended by two voters, including deleting several lines of tissue and towel material from the precision data table since they are no longer part of the method scope.

References

1. Maxwell, C. S., and Reynolds, W. F., *Tappi* **33**(4): 179 (1950).
2. Maxwell, C. S., *Tappi* **35**(5): 220 (1952).

Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department.

