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WI _____ 250809.05 _____

T _____ 220 _____

BALLOT NO. _____ 02 - SARG _____

DRAFT NO. _____ 01 _____

DATE _____ June 9, 2026 _____

WORKING GROUP
CHAIR _____ N/A _____

SUBJECT
CATEGORY _____ Pulp 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.

Physical Testing of Pulp Handsheets *(Five-year review of Standard Practice T 220 sp-21)*

1. Scope and significance

1.1 This procedure describes the testing of pulp handsheets, prepared in accordance with TAPPI T 205 "Forming Handsheets for Physical Tests of Pulp," for their strength and other physical properties as well as their light-scattering coefficient.

1.2 Information derived from handsheet testing is a measure of the potential contribution of the pulp to the strength of the finished paper product.

2. Summary

2.1 The measurements of handsheet properties to be described are as follows: mass per unit area (grammage), thickness, specific volume, apparent density, opacity, scattering coefficient, tensile strength, stretch, tensile energy absorption, bursting strength, tearing resistance, and MIT folding endurance.

2.2 Five sheets are generally enough for routine control work in a mill on a specified pulp. Ten sheets should be used wherever possible and when testing mechanical pulp in order to provide enough paper to make four tears of ten strips each. This makes it possible to use five sheets for tearing resistance and five other sheets for all other

strength tests. Do not change the sample size as this will change the amount of pulp in the beater and, therefore, change the beating time.

2.3 Results are reported in SI units and strength indexes are calculated on conditioned weight.

3. Conditioning

Inspect the sheets and discard any that are abnormal, (e.g., containing holes, uneven thickness, damaged, containing contaminants such as dirt, plastic, metal bits). Condition in an atmosphere in accordance with TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products” and test the sheets for each characteristic of interest according to the appropriate TAPPI test method for paper but with modifications as specified below.

4. Mass per unit area (grammage)

Determine the average mass per unit area of five conditioned sheets by weighing them together on a balance sensitive to 0.001 g. The area of each sheet is approximate and is taken to be 200 cm². The grammage is ten times the weight of the five sheets.

5. Thickness

5.1 *Apparatus*¹

5.1.1 *Micrometer*, see TAPPI T 411 “Thickness (Caliper) on Paper and Paperboard.”

5.2 *Procedure*

5.2.1 Before cutting the test sheets, obtain their average thickness as follows: Place five sheets in a pile with their glazed surfaces in one direction. Using a motor-driven micrometer as specified in T 411, measure the thickness of the pile of sheets at ten randomly selected points recording the thickness at each point to the nearest 2 μm (0.0001 in.).

5.2.2 If any reading is more than 5% above the others, make a measurement on an adjacent spot to determine if the high reading is caused by a shive, speck, foreign materials such as dirt, glass, plastic, etc. or fiber bundles resulting from a short disintegration time. If so, discard the high readings and note in report.

6. Light-scattering coefficient

6.1 *Apparatus*¹

6.1.1 *Opacimeter*, see TAPPI T 425 “Opacity of Paper (15°/Diffuse, Illuminant A) 89% Reflectance Backing and Paper Backing.”

6.1.2 *Working standard of reflectance*, calibrated to absolute scale as described in T 425.

6.2 *Procedure*

6.2.1 Place the working standard over the opening of the opacimeter and adjust the instrument reading to the value of the absolute reflectance of the working standard.

6.2.2 Obtain the reading R_0 by placing each sheet in the opacimeter with its glazed side against the black body and reading the reflectivity without adjustment of the instrument.

6.2.3 Place the pile of five sheets in the opacimeter with the glazed sides toward the specimen holder and take a reading. Increase the number of sheets in the pile by inserting five more sheets of the same test or, if these are unavailable, sheets from another test that are similar in reflectance between the pile and the specimen holder. Take another reading. If there is a significant difference between the two readings, add additional sheets to the pile until no

¹Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list, available as part of the CD or printed set of Standards, or on the TAPPI website general Standards page.

significant change occurs with the addition of five more sheets. Using this pile of sheets, measure the reflectivity R_{∞} of each of the five test sheets keeping the other four test sheets immediately behind the sheet being tested.

6.2.4 Use the average values of R_0 and R_{∞} to calculate light scattering coefficient as described in 13.3.4.

NOTE 1: For greater accuracy, the two measurements should be made on the same specimen area and the weight per unit area of the actual test area used.

NOTE 2: The R_{∞} value must be obtained using the opacimeter as described. A brightness reading cannot be used.

7. Cutting the sheets for remaining physical tests

7.1 Apparatus¹

7.1.1 *Double-knife, 15 mm (0.59 in.) wide cutter*, or a single-knife cutter equipped with a guide to give a strip 15 mm wide.

7.2 Procedure

7.2.1 Place the pile of five sheets on the cutting anvil with the diameter of the pile accurately situated along one of the anvil's edges.

7.2.2 Cut the sheets as shown in Fig. 1. By testing the folding endurance with an MIT tester (Section 11) at one end of a strip, with care, the longer part of the remnant is not appreciably damaged and is quite suitable for another fold test if it is inserted in the tester in such a manner that the folding test is made on the part of the strip that protruded above the top clamp. The strip should not be used for a tensile test as the tension placed on the strip in making the fold test will change the characteristics of the paper.

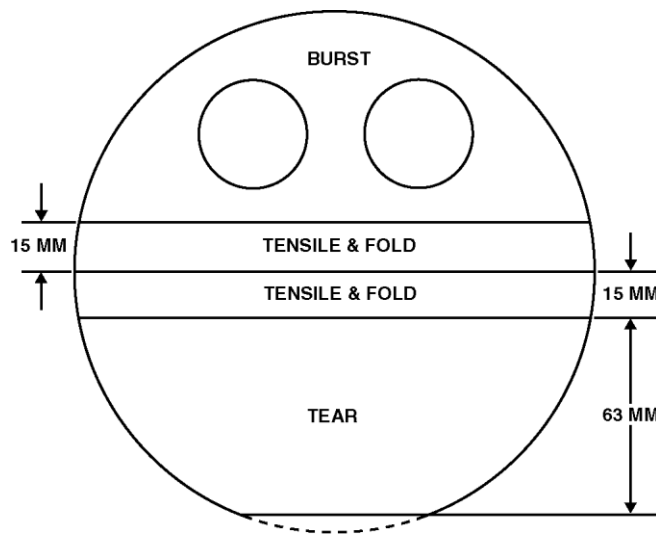


Fig. 1. Division of sheets for testing.

8. Tensile strength (stretch and tensile energy absorption)

8.1 Apparatus¹

8.1.1 *Tensile tester*, see TAPPI T 494 “Tensile Breaking Properties of Paper and Paperboard (Using Constant Rate of Elongation Apparatus).”

8.2 Procedure

8.2.1 Use at least one specimen strip from each of the five test sheets, cutting each strip 15 mm wide. Set the jaws of the tensile tester 100 mm apart.

8.2.2 Determine the tensile strength, stretch, and tensile energy absorption simultaneously in accordance with T 494 except for the size of the specimen.

9. Bursting strength

9.1 Apparatus¹

9.1.1 *Bursting tester*, see TAPPI T 403 “Bursting Strength of Paper.”

9.2 Procedure

9.2.1 Determine the bursting strength by making at least ten bursts one at a time on the segments of five test sheets, the glazed side of each sheet being clamped toward the diaphragm, otherwise in accordance with T 403.

10. Tearing resistance

10.1 Apparatus¹

10.1.1 *Elmendorf tearing resistance tester*, see TAPPI T 414 “Internal Tearing Resistance of Paper.”

10.2 Procedure

10.2.1 Determine the tearing resistance as described in T 414, with modifications indicated below. Clamp the sheets so that their glazed sides face the axis of the instrument and the greater part of the specimen is held in the fixed, not the moving, jaw.

10.2.2 For chemical pulps, cut sections from five test sheets in the manner shown in Fig. 2 and test the five sections (plies) together, making four tears across the width of the sections, each being through a total tearing distance of 215 mm (5×43 mm). If the scale on the tearing resistance tester is in grams, multiply the average reading on the standard tester by 3.2 (i.e., $16/5$) to obtain the force in grams required to tear a single sheet. If the specimens should be such that five sheets together give a reading above 60, reduce the number of sheets torn together to two and multiply the observed reading by 8 to give the force in grams to tear a single sheet. If the instrument scale is in millinewtons, divide the reading by the number of sheets torn.

10.2.3 For mechanical pulps, use ten sheets (plies) and multiply the average reading by 1.6 to obtain the force in grams required to tear a single sheet.

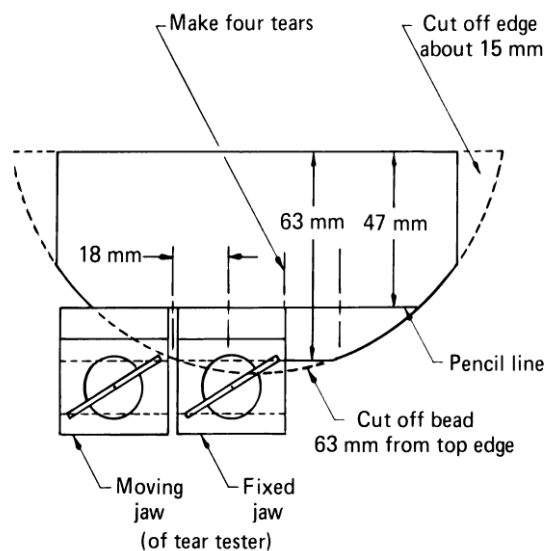


Fig. 2. Detail of tearing test

NOTE 3: Accuracy is enhanced, especially if the segments of sheets are cut somewhat narrow, if a template is used to draw a pencil line 47.0 mm from the centrally cut edges of the pack of specimens as shown in Fig. 2. When it is clamped in the jaws of the instrument, align the pack so that the scribed line coincides with the top edges of the jaws. The knife should be checked to cut 4.0 mm above these edges, to give the standard tearing distance of 43.0 mm. If an instrument's digital display limits the number of available test plies (i.e., 1, 2, 4, 8, 16 plies), test the number of plies closest to the recommended number in the method and keep the total tearing distance for all test specimens for a given sample constant (i.e., 5 each, 4-ply tears for chemical pulps). Note any modifications in the report.

11. Folding endurance

11.1 Apparatus¹

11.1.1 *MIT folding tester*, see TAPPI T 511 “Folding Endurance of Paper (MIT Tester).”

11.2 Procedure

11.2.1 Determine the folding endurance of the 15-mm-wide strip of paper cut as shown in Fig. 1.

11.2.2 With the MIT tester, only a 10-mm portion or so of the strip needs to be clamped in the lower (moving) jaw and the exact tension of 1 kg applied, leaving the extra length of the strip projecting through the upper jaw. Because the part of the strip above the upper clamp is not appreciably affected by the test, the upper end of the strip can be used for another fold test making the fold in the part of the strip that was above the clamp.

11.2.3 For a referee test, make 20 determinations using 10 strips and making two tests on each strip. See Section 7.2.2 for additional information.

NOTE 4: The folding test is very sensitive to moisture. Accordingly, avoid touching the vicinity of the fold line with the fingers. The fold tester should be equipped with a fan to draw room air across the head to keep it cool (see T 511).

12. Moisture content

12.1 Apparatus¹

12.1.1 See TAPPI T 550 “Determination of Equilibrium Moisture in Pulp, Paper, and Paperboard for Chemical Analysis.”

12.2 Procedure

12.2.1 Determine the moisture content using the procedures described in T 550 on scrap samples of the pulp handsheets being tested.

13. Other tests

If desired, other tests, such as porosity (air pressure, applied to the glazed side of the sheets), stiffness, zero span, etc., may be made according to accepted procedures.

14. Report

14.1 Report results in terms of their derived units to three significant figures. If the direct test results are reported, i.e., the actual instrument readings, either (a) metric, (b) English, or (c) SI units may be used as is common practice, the units being stated in each case. For derived units, however, such as the various strength indexes, only the SI units are acceptable.

14.2 Calculate and report all the results on the conditioned mass per unit area of the test sheets.

14.3 The calculations of the various items reported are shown below by formulas in which:

r = mass per unit area, g/m²

t = single sheet thickness, μm

T = single sheet thickness, 0.001 in.

b = bursting strength, kPa

B = bursting strength, lbf/in.²

p = tensile break load, kgf on a 15-mm strip

P = tensile break load, lbf on a 0.59-in. strip

e = force to tear a single sheet, g

14.3.1 *Mass per unit area:* in g/m².

14.3.2 *Specific volume (bulk):* calculated as cm³/g: from t/r or $25.4 T/r$.

NOTE 5: The result compares the bulk of the test sheets (measured under the prescribed pressure) to water, which has a “bulk” of 1.0 cm³/g, about the same as a dense glassine.

14.3.3 *Apparent density:* calculate as g/cm³ from r/t or $r/25.4 T$.

14.3.4 *Light scattering coefficient:* obtain the value of sW from the chart in T 425 using the values obtained for R_0 and R_∞ . Scattering coefficient = sW/r .

14.3.5 *Folding endurance:* Obtain the logarithm to the base 10 for each measured number of double folds. Average the logarithms and correct for variations in basis weight by adding $(1.813 - \log r)$ to the average log. Report as the log folding endurance to two significant figures for the mantissa.

14.3.6 *Number of double folds,* an alternative and less preferred result to folding endurance, is determined by reporting the average of the number of double folds measured.

14.3.7 *Bursting strength,* kPa, from the formula 6.89B.

14.3.8 *Tearing resistance,* mN, from the formula 9.807e.

14.3.9 *Tensile strength,* kN/m, from the formula $0.6538 p$ or $0.2966 P$.

14.3.10 *Stretch,* %.

14.3.11 *Burst index,* kPa m²/g, from the formula b/r or $6.89 B/r$.

14.3.12 *Tear index,* mN m²/g from the formula $9.807 e/r$.

14.3.13 *Tensile index,* N m/g from $653.8 p/r$ or $296.6 P/r$.

14.3.14 *Breaking length,* km, calculated from the formula $200p/3r$ or $30.24P/r$.

14.3.15 Percent moisture content on conditioned weight basis.

NOTE 6: The breaking length corresponds to the length in kilometers of a uniformly wide strip of paper which, if held at one end (e.g., freely suspending a coil of that paper by its tab end), would just cause the strip to break under its own weight.

15. Precision

A precision statement for this standard practice is not applicable as precision statements accompany each of the referenced test methods.

16. Keywords

Pulp, Handsheets, Physical tests

17. Additional Information

17.1 Effective date of issue: To Be Assigned.

17.2 The 1996 revision was reissued as a standard practice with the inclusion of the determination and reporting of the moisture content. This revision specifies all test results will be reported on the basis of conditioned weight rather than oven dry weight, substitutes the terms “burst index” and “tear index” for the old terms of “burst factor” and “tear factor,” and introduces the use of SI units. A formula for correcting folding endurance for variations in basis weight has been introduced. Folding endurance is reported as the log fold. The 2010 revision made changes to the reporting of the fold test.

17.3 Related methods: Canadian, PAPTAC D 12; Australian and New Zealand, AS/NZS 1301.208s; ISO 5270; Scandinavian SCAN C 28:76.

References

1. Clark, J. d'A., “The Bulk of Pulp Test Sheets,” *Tappi* **53** (7): 1340 (1970).
2. Clark, J. d'A., “Measuring Stretch Accurately with a Pendulum Tensile Tester,” *Tappi* **53** (3): 503 (1970).
3. Brandon, C. E., “Effect of Basis Weight on Folding Endurance,” *Tappi* **49** (6): 233 (1966).
4. Brandon, C. E., “The Precision of the TAPPI Standard Beater Test,” *Tappi* **41** (9): 129A (1958).

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

