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T 233

BALLOT NO. 02 - SARG

DRAFT NO. 02

DATE May 29, 2025

WORKING GROUP CHAIR Donald Guay

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.

Fiber Length of Pulp by Classification

(Ten-year review of Classical Method T 233 cm-15)

(Underscores, notes, and strikethroughs show changes from Draft 1)

1. Scope

1.1 This method is designed to measure the weighted average fiber length of a pulp. If a fiber is *1* mm in length and weighs *w* mg, then for a given pulp, the weighted average length (L) is $\Sigma(wl)/\Sigma w$, or the sum of the products of the weight times the length of each fiber divided by the total weight of the fibers in the specimen.

1.2 Use of either Clark type or Bauer-McNett type classifier will produce identical results within the stated precision.

1.3 Fiber length may also be measured by TAPPI T 271 "Fiber Length of Pulp and Paper by Automated Polarized Optical Analyzer Using Polarized Light." The results may not agree as the measurement methods are not the same.

2. Significance

2.1 Fiber length is a fundamental property of pulp. There have been indications (*1, 2*) that, provided the coarseness of the fibers remains constant, the tensile strength of a sheet made from relatively unbeaten pulp (other factors being the same) will vary as $L^{1/2}$, the burst strength will vary as L, the fold endurance as L^5, and the tear resistance as $L^{3/2}$. These relationships will be true independent of the uniformity of lengths of the fibers, whether they are a mixture of various lengths or all of one length, but the numerical values of the exponents will decrease as the pulp is beaten. The density of the sheet will be appreciably affected by L if the fibers are the same coarseness.

2.2 The numerical average fiber length is of much less significance. If the fibers are of mixed lengths, it is an arbitrary measurement, largely influenced by the lower limit adopted, below which a particle is no longer regarded as a fiber. The weighted average fiber length of a pulp may exceed the numerical average length several times, if particles down to a length of 0.01 mm are included in an estimate of the numerical averages.

2.3 Ideally, it would be desirable to classify a pulp sample into a very large number of fractions and weigh and measure the length of each in order to determine the weighted average length. In practice, however, satisfactory results may be obtained from the weights and lengths of five graduated fractions which are provided by a four-screen classifier.

3. Apparatus

3.1 *Fiber classifier*[1]. Any good classifier with four or more screens is suitable, and the two types described in the Appendix will give identical results if used as described in Section 5. Preferably the series of screens used for a given sample should be selected so that not much more than one-fourth of a specimen is held on the coarsest screen. It is also desirable to provide for the closer separation of the longer-fibered fraction than the short ones, since the weight effect of the long fibers is the greatest. The recommended series of screens is given in 3.1.2.

3.1.1 The series of screens used in the classifier is not of great importance if the weighted average fiber length is calculated, because the smaller the screen mesh used before a compartment, the more will be the quantity of that fraction retained and the less will be its average length. Table 1 lists the usual screens and dimensions of their openings:

3.1.2 Recommended openings in the series of screens used for the classification of pulp are as follows:

3.1.2.1 For long-fibered pulps: Tyler screens 10 (1.68 mm), 14 (1.19 mm), 28 (0.595 mm), and 48 (0.297 mm).

3.1.2.2 For medium-fibered pulps: Tyler screens 14 (1.19 mm), 28 (0.595 mm), 48 (0.297 mm), and 100 (0.149 mm).

3.1.2.3 For short-fibered pulps: Tyler screens 28 (0.595 mm), 48 (0.297 mm), 100 (0.149 mm), 150 (0.105 mm), or 200 (0.074 mm) for groundwood.

3.1.3 As a guide to the selection of the screens, a good classifier will retain most of the fibers on a given screen if the fiber lengths are over twice the mesh opening, unless they are very flexible.

3.2 *Disintegrator*, for the preparation of dry samples. The disintegrator is described in TAPPI T 205 "Forming Handsheets for Physical Tests of Pulp."

Table 1. Screen openings.

Tyler series	*Opening, mm*	*U. S. standard*
10	1.68	12
12	1.41	14
14	1.19	16
20	0.841	20
28	0.595	30
35	0.420	40
48	0.297	50
65	0.210	70
100	0.149	100

[1] Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list in the set of TAPPI Test Methods, or may be available from the TAPPI Quality and Standards Department.

150	0.105	140
200	0.074	200

3.3 *Stock containers*: crock, 18 L or larger; beaker, 4000 mL, preferably of polyethylene or stainless steel, with mark at 3000 mL and also marked with its net weight.

3.4 *Dipper*. A domestic, wide-mouth, plastic-ware cup or a polyethylene, wide-mouth measuring cup with handle, 8- or 16-oz size (225- or 450-mL).

3.5 *Büchner funnel and flask*. A 90-mm diameter funnel is preferable.

3.6 *Filter paper*, fast-flowing, for funnel and classifier. A closely woven cloth may be used instead.

3.7 *Timer*, stopwatch or clock with a second hand.

3.8 *Projector*, for the measurement of fiber lengths. One is described in TAPPI T 232 "Fiber Length of Pulp Projection" and another by Clark (*3*).

3.9 *Other apparatus*: graduated cylinders or beakers to hold 500 and 2000 mL; beakers, preferably plastic or stainless steel, 4000 mL.

4. Sampling and test specimens

4.1 Obtain a sample of 24 g of moisture-free pulp by a previously determined sampling procedure. If the pulp is dry (less than 30% moisture content) soak it in water for at least 4 h and disintegrate in the standard disintegrator (TAPPI T 205) until no fiber bundles remain. The end point to be determined visually by cylinder; if fiber bundles remain, continue disintegration and repeat dilution procedure. If the pulp is moist or in slush form, disintegrate until no fiber bundles remain using the procedure previously discussed.

4.2 It is not easy to measure out an exact weight of long-fibered pulp, especially in a concentrated suspension. The following procedure gives more accurate results than measuring a quantity of concentrated suspension in a graduated cylinder to determine its consistency and then measuring the required volume for classification.

4.2.1 For the 5-g specimen required in the Clark classifier, dilute the 24-g sample to 8 L in the crock, giving a consistency of about 0.30% as for sheet making in accordance with TAPPI T 205.

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4.2.2 For the 10-g specimen required in the Bauer-McNett classifier, dilute the 24-g sample to 8 L only. Stand the 2000-mL cylinder or a tared beaker next to the 4000-mL beaker and the crock. Stir the stock vigorously with the dipper or cup, add a cupful to the beaker, stir again, and add about two-thirds of a cup to the 2000-mL cylinder or tared beaker. Stir again and repeat the division so that when about 5000 mL have been distributed there will be about 1800 mL in the cylinder or tared beaker and about 3000 mL in the 4000-mL beaker. Weigh the beaker and contents and subtract the tare weight of the beaker.

4.3 Record the exact volume or weight in the tared beaker or cylinder (do not try to adjust the volume); pour through a tared filter paper in the funnel, dry, and weigh. Subtract the weight of the filter paper and calculate the extra volume of stock to add to the 4000-mL beaker so that it will contain 5.0 or 10.0 g of pulp (moisture-free). After vigorously stirring the stock in the container, measure out this extra volume (about 330 mL) and add to the 3000 mL in the beaker. During the measuring operations, keep the suspensions well stirred so as to prevent any settling of the fibers both in the container and in the measuring cup. The contents of the latter should be swirled around continuously except while pouring.

NOTE 1: For ordinary purposes, since the result is calculated as a percentage, it is not important to add exactly 5 or 10 g of pulp to the classifier. Accordingly, measure about 3333 mL into the 4000-mL beaker with alternate dips while adding a lesser quantity to a 1000- or 2000-mL graduated cylinder or the tared beaker. Weigh, then add the measured 3333-mL specimen to the classifier, after which the suspension in the 1000-mL cylinder or the tared beaker may be filtered, dried, and weighed to determine the exact weight of the specimen added. If within 10% of the required weight, the percentages of the quantity added, found in the different compartments, will not be greatly affected.

4.4 If the sample is not in slush form and test sheets are not required, accurate 5- or 10-g specimens may be prepared from a sample of dry or moist pulp prepared as follows:

4.5 Determine the moisture content of the sample in accordance with TAPPI T 208 "Moisture in Wood, Pulp, and Paperboard by Toluene Distillation" or TAPPI T 210 "Sampling and Testing Wood Pulp Shipments for Moisture" and weigh a specimen equal to 5.0 or 10.0 g moisture-free. If dry, disintegrate the specimen in 1500 mL

of water in the disintegrator (TAPPI T 205) for 25 min. and dilute to 3333 mL or concentrate to 1000 mL with the Büchner funnel, as required. Do not use a high-speed electric mixer, because it may cut the fibers appreciably.

NOTE 2: For ordinary purposes it may save time to weigh a test specimen in solid form, to be approximately 5 or 10 g, followed immediately by weighing another specimen for a moisture determination. The latter may be dried while the classification is proceeding and the result used to calculate the exact weight of the test specimen added to the classifier.

5. Procedure

5.1 *Classification with the Clark classifier*.

5.1.1 Make sure that the screens are free from fibers. They may be easily cleaned, especially when dry, by using two suede-shoe brushes (having fine brass bristles) and pulling them out radially across the face of the screen after pressing the bristles of each brush lightly together, a brush being on each side of the screen. Hose off the screens and compartments.

5.1.2 Turn on the water to the constant level tank so it just overflows thus, if the metering cock is properly adjusted, supplying water to the compartments at the rate of 10 L/min. Place all the drain plugs (including the 3.2-mm diameter intercompartmental plus) in position, and when the tub is full of water, start the motor driving the classifier screens.

5.1.3 When flow conditions are steady and with the 3333-mL specimen with 5.0 g at hand, start the stopwatch or set the clock to ring at 5 min. plus a few seconds. Exactly at the start of the 5-min. period, close the cock in the line from the constant level tank to the tub and pour the specimen uniformly into the first compartment so that the time elapsed is 20 s (at the rate of about 10 L/min.). When the pouring is complete, immediately open the closed cock to allow the flow of water from the constant level tank to continue for the remainder of the 5-min. period. With a little water, rinse all the fibers from the container into the first compartment.

NOTE 3: A time-operated electric solenoid in the water supply line is desirable in place of the stopwatch or clock.

5.1.4 While the classification is proceeding, clean the drainage cups, add a tared, moistened filter paper or filter cloth to each, and place the cups in position.

5.1.5 At the end of the 5-min. period ± 5 s, stop the water flow from the tank. As soon as the overflow from the last compartment has nearly ceased, stop the screens, remove the drain plugs from each compartment, and allow the contents to drain into the cups.

NOTE 4: If any compartment drains too slowly, insert a length of glass or copper tubing down the drain pipe to release trapped air.

5.1.6 When the tubs are empty, start the screens, pull out the small intercompartmental plugs and, with the hose, backwash the screens into the compartments, and rinse them off. When each compartment is empty, it is desirable to fit a one-hole stopper and connecting rubber tube into each drain pipe and blow down to remove the excess water from the pulp pads in the cups.

5.1.7 Remove each pad and, with a finger, clean off any pulp adhering to the inside of the cup. Fold into a semicircle, then squeeze the pad and filter paper tightly between the palms of the hands, or pass the pad through the rolls of a wringer to remove as much water as possible. The pads also may be drained on a blotter or towel to remove excess water. Mark each pad with an indelible pencil to identify it.

5.1.8 Dry the pads in an oven at 105°C to constant weight. Weigh each to within 0.01 g and

subtract the weight of its filter paper. Alternatively, the filter paper may first be separated from the pad.

NOTE 5: A 5-min classification period gives fractions with a satisfactory degree of sharpness of separation for normal purposes. Sharper fractions will be secured by a longer running time, e.g., 10 min., with a slower flow of water, but the percentages in the various compartments will then change.

5.2 *Classification with the Bauer-McNett classifier*.

5.2.1 Brush and wash the screens to ensure that they are free from fibers.

5.2.2 Turn on the water so that the constant level tank just overflows. The water supplied to the compartments should then flow at the rate of 11.355 L/min. When the tanks are full of water, start the motor. Exactly at the start of the 20-min. period, turn off the flow of water and pour the 3333-mL specimen uniformly into the first compartment for 18 s (at the rate of about 11-35 L/min.), then turn on the flow of water again.

5.2.3 When the flow conditions are steady, start the timer to ring at 20 min. ± 10 s. With a little water, rinse all the fibers from the container into the first compartment.

5.2.4 While the classification is proceeding, clean the drainage cups and secure a tared filter cloth to each.

NOTE 6: If desired, a tared filter paper may be supported on a piece of muslin used as a backing cloth which, when the pad is removed, is stripped away.

5.2.5 After the 20-min. time period, shut off the water and as soon as the overflow from the last compartment has nearly ceased, stop the motor and remove the drain plugs from each tank to allow the contents to drain into the cups.

NOTE 7: If any tank drains too slowly, insert a length of glass or copper tubing down the drain pipe to release trapped air.

5.2.6 After the tanks have been drained, carefully wash down the screens and tanks with a hose. When empty, it is desirable to fit a one-hole stopper and connecting rubber tube into each drain pipe and blow down to remove excess water from the pulp pads in the cups, or the excess water may be removed by means of an aspirator.

5.2.7 Remove each pad and, with a finger, clean off any pulp adhering to the inside of the cup. Fold the pad into a semicircle, then squeeze the pads between the hands or pass the pad through the rolls of a domestic wringer to remove as much water as possible. The pads may also be drained on a blotter or towel to remove excess water. Mark each pad with an indelible pencil to identify it.

5.2.8 Dry the pads in an oven at 105°C to constant weight and weigh each to within 0.01 g. The weight of the cloth filters usually remains constant, and they may be indelibly identified with their number and weight.

6. Calculations

6.1 If W is the weight of the specimen added to the classifier, w_1, w_2, w_3, and w_4 are the moisture-free weights of the pads from the four compartments, respectively, and w_5 is the moisture-free weight of the pulp lost through the fines screen; then

$$w_5 = W - (w_1 + w_2 + w_3 + w_4)$$

6.2 If the average length of the fractions in the compartments is not known, determine them as described in TAPPI T 232 or by Clark (*4*) by taking a small specimen from the pad of each compartment before drying. Determine also the average fiber length of the fibers passing the last screen, from a composite specimen taken during the operation of the classifier. For ordinary work, since it has little effect on the result, the average length of the finest fraction may be assumed to be 0.2 mm if the last screen is 48-mesh, and 0.1 mm if it is 100-mesh. If l_1, l_2, l_3, l_4, and l_5 are the average lengths in millimeters of the fibers in each fraction, and L is the weighted average fiber length of the pulp sample, then

$$L = \frac{(w_1 l_1 + w_2 l_2 + w_3 l_3 + w_4 l_4 + w_5 l_5)}{W}$$

7. Report

7.1 Preferred reporting procedure.

7.1.1 Report to the nearest 0.1% the weight percent retained on each screen and the percent that passed through the last screen.

7.1.2 For example if using screens of 30, 50, 100, and 200 mesh the weight percent retained on the first screen would be calculated by (using the values calculated in section 6.1):

$$w_1 x(100\%)/W$$

The weight percent for the other screens would be calculated in a similar manner. The percent passing the last screen would be calculated by:

$$w_5 x(100\%)/W$$

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The reported percents would be:

$P_{>30}$, $P_{30\text{-}50}$, $P_{50\text{-}100}$, $P_{100\text{-}200}$, and $P_{<200}$.

7.2 Alternate reporting procedure.

7.2.1 Report the weighted average fiber length of the sample in millimeters, to the nearest 0.05 mm.

7.2.2 If desired, report also the percentages by weight of the fibers retained on each of the screens used, giving its opening in millimeters. In this case, record also the make of classifier used, weight of sample, time of processing, flow of water, and any other pertinent details.

8. Precision

8.1 Repeatability (within a laboratory) = 0.09 mm. This value is based on 4 replicate tests using a softwood pulp having a weighted average length of 3.04 mm.

8.2 Reproducibility (between laboratories) = not known; according to definitions of these terms in TAPPI T 1200 “Interlaboratory Evaluation of Test Methods to Determine TAPPI Repeatability and Reproducibility.”

9. Keywords

Pulp, Fiber length, Classification, Fiber classification, Classifiers, Clark classifier, Bauer-McNett classifier, Screens

10. Additional information

10.1 Effective date of issue: To be assigned.

10.2 The designation of this procedure as a classical method was reaffirmed by ballot of the Pulp Properties Committee in 1995. At that time the procedure was modified to reflect the present practices of processing pulp and reporting of results. Section 4.1 was changed from a fixed disintegration revolutions (time) to a procedure that requires disintegration to be carried out until all fiber bundles are removed. At this time the “preferred reporting procedure” was added to reflect common industrial practice. This method, formerly TAPPI T 233 os-75, has been reclassified as a Classical Method. Such procedures are no longer in common use or have been superseded by advanced technology; they are technically sound, have a history of use, and contain a body of literature references that make their preservation valuable.

10.3 With experience, for a particular kind of pulp, and pretreatment, the average lengths of fibers retained in a given compartment (with a given screen) will be known for a particular classifier operated under set conditions and need not be redetermined. Under controlled operating conditions (with the exception of the first compartment), the average fiber length of the fraction retained in the intermediate compartment (l_2, l_3, l_4) will remain remarkably constant. In the first compartment the average fiber length (l_1) will depend on the species of wood and history of the sample and usually will need to be determined.

10.4 Beating or refining will not substantially change the percentages retained in the intermediate compartments; the main effect is to decrease the percentage on the first screen (perhaps after a slight preliminary increase when fibrillation develops) and to increase the percentage passed through the finest screen by about the same amount.

10.5 Experience has shown that for good separation the fraction on any one screen of a classifier should not exceed 30% of the total weight of the specimen. In the event an excess occurs, screen sizes should be readjusted to reduce the fraction retained on an individual screen.

10.6 Some work (*5*) has indicated that with long-fibered pulps there is only fair agreement between the Clark and the Bauer-McNett classifiers for the percentages on the coarser screens, if of the same mesh, but fairly good agreement for that on the 50-mesh and finer screens; however, the weighted average fiber length of a given sample calculated as described should be the same for both instruments and independent of their construction or time operated. Variations in the shape of, and clearances around, the midfeathers appreciably affect the percentages retained on the screens.

10.7 The average values of fiber length can never be better than crude estimates of the fiber length, and a measurement must be made of the actual length retained in a compartment *(6)*.

10.8 Related method: Scandinavian, SCAN M6 (conditions for McNett apparatus: 10 g for 15 min. at 10 L/min.).

Appendix

A. Clark classifier

A.1 This instrument comprises a horizontal, half-cylindrical trough, 640 mm (25 in.) long by 355 mm (14 in.) diameter, divided axially into four main compartments in each of which is a screen of 330 mm (13 in.) diameter mounted on a common shaft rotated by a gear motor at 48 rpm. The screens are annular, 127 mm (5 in.) inside diameter and 305 mm (12 in.) outside diameter, having an area of about 475 cm^2 (74 $in.^2$). The rim of each screen forms a seal by rotating around the edge of a soft gasket mounted on the inside of the trough.

A.2 By means of a constant headbox with an adjustable outlet cock and a shut-off cock, water is supplied through the compartments of the classifier at a rate of 10 L/min.

NOTE A.1: Some instruments were used operating at a rate of 12.5 L/min. and a total classification time of 41/2 min. The conditions described in this method are refinements.

NOTE A.2: For the routine control of extended beating or refining, it is necessary only to determine the percentage of long fibers in the first compartment. This may be drained after classifying for a period of only 11/2 min. with the 12.5-L/min. flow.

A.4 If another screen or set of screens is desired, the change may be made by stopping the drive shaft with all set screws at the top, loosening them all except that on the collar at the headbox end, withdrawing the shaft, replacing the desired screens into position or, with the older instruments, into the slit tube packing with a circular motion, leaving them with set screws vertical, re-inserting the shaft, and, after moving each screen slightly back and forth to seat it in position, tightening all the set screws.

B. Bauer-McNett classifier

B.1 This instrument comprises four narrow tanks about 355 mm (14 in.) deep, 127 mm (5 in.) wide and 320 mm (12 in.) long, with the narrow ends semicylindrically shaped, each tank having a screen about 335 cm^2 (52 $in.^2$) mounted on one face adjacent to a midfeather.

B.2 The four tanks are supported in a framework, one below the other, in a cascade arrangement. A vertical, cylindrical agitator with short paddles rotates at 580 rpm near one semi-circular end of each tank by means of a belt drive from a vertical motor. This causes the suspension on each tank to flow across the screen and midfeather and circulate horizontally around the tank. An overflow weir is provided at the outgoing side of each screen, and a short pipe leads to the next tank with a finer screen, at a slightly lower level, or from the last tank, to waste. A constant headbox above the tanks supplies water at the rate of 11.35 L/min. (3 U. S. gal/min.).

B.3 The screens in each tank may be taken out for cleaning or changing by loosening a clamping screw and withdrawing the framework with its screen. Care should be taken not to misalign the plate when it is replaced so as not to cause any leakage.

B.4 The incoming water is directed to the bottom of each compartment by means of a weir and a baffle. The consequent motion of the water serves to keep the fibers from settling and to present them repeatedly to the rotating screen through which they will pass if their length is less than twice the screen opening. Experiments have shown that the size and location of the outlet at the bottom of the baffle do not appreciably affect the classification.

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

Department.