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T 271

BALLOT NO. 02 SARG

DRAFT NO. 01

DATE 6/1/2023

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.

Fiber length of pulp and paper by automated optical analyzer using polarized light

(Five-year review of Official Method T 271 om-18: Approval of T271 Draft 1)

1. Scope

1.1 This is an automated method by which the numerical and weighted average fiber lengths and fiber length distributions of pulp and paper can be measured using light polarizing optics in the range of 0.1 mm to 7.2 mm.

1.2 The fiber length can also be measured using the following methods: TAPPI T 232 "Fiber Length of Pulp by Projection" and TAPPI T 233 "Fiber Length of Pulp by Classification."

2. Summary

2.1 The measuring principle of this method is optical and is based on the ability of the fiber to change the direction of light polarization.

2.1.1 The fibers suspended in water are routed through a fiber orienting channel (F.O.C.) where the image lengths of individual fibers are measured.

2.1.2 A F.O.C. is placed between a light source and a photosensor matrix. The elements of the matrix detect the length of the fiber from the projected image of the fiber.

2.2 On either side of the F.O.C., crossed polarizers are positioned to eliminate the effect of objects other than fibers, e.g., non-optically active fillers and air bubbles, which are not able to change the direction of polarization.

3. Significance

3.1 Pulp and paper made from wood consists of fibers and fiber fragments. The length distribution of different fibers in the pulp can contribute to various properties of the final product.

4. Apparatus

4.1 The apparatus (Fig. 1) consists of a sample transport system and a measurement section.

4.2 A *transport system* of a F.O.C. (1), through which fibers dispersed in a liquid are drawn. [Numbers in parentheses refer to numbers on Fig. 1.] The F.O.C. orients the fibers into a plane, or tube, normal to the light path and no thicker than a nominal 0.5 mm or less in the direction of the light path.

4.3 *Measurement system:*

4.3.1 A light source (2) is located on one side of the F.O.C. and a photosensor matrix (3) on the opposite side of the F.O.C. The photosensor matrix indicates the fiber length from the image of the fiber passing by. The wavelength of light for the light source and the photosensor matrix must be spectrally matched.

4.3.2 Crossed polarizers (4, 5) are located between the light source and the photosensor matrix.

4.3.3 An analyzer with resolution equal to, or better than, 100 μm (see Note 1).

NOTE 1: Measuring cellulosic particles between 0.1 mm and 0.2 mm will require an analyzer to have a resolution of 50 μm or smaller.

5. Test specimen

5.1 If the pulp or paper is being tested to evaluate a pulp or paper lot, obtain a sample in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard or Related Product.” It is essential that the test specimens of dry pulp or paper do not contain any cut edges.

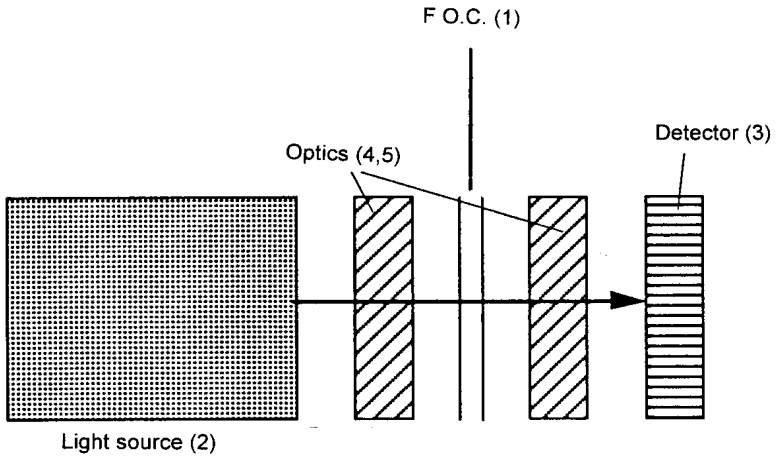

Fig. 1. The apparatus/measurement principle.

6. Procedures

6.1 *Disintegration.*

6.1.1 *Dry pulp samples*. Disperse the sample as described in TAPPI T 205 or disintegrate it in a manual disintegrator (Fig. 2). For good fiber dispersion of the disintegrated sample, one method is to use the manual disintegrator as follows: Put the sample (0.8 - 1.3 g for long-fibered softwood pulps and 0.3 - 0.5g for hardwood pulps) and 150 mL of distilled water in the disintegrator, and move the piston up and down until the sample has been disintegrated completely. Presoaking is to be preferred for pulps difficult to disperse. Fibers must be properly separated, with no fiber bundles or fiber-to-fiber bonds remaining in the test specimen. When the sample is completely dispersed, dilute with distilled water to a consistency of 0.02 ± 0.005% for softwood, and 0.0075 ± 0.0025% for hardwood. The sample volume after dilution should be at least 5L to insure a homogenous mixture. Treat mixed furnish pulps as softwood pulps for determining final consistency.

6.1.2 *Wet pulp samples.* Dilute to approximate consistency per manufacturers recommendations to give accurate measurements.

6.1.3 *Ordinary papers.* Disintegrate the paper according to method A as described in TAPPI T 401 "Fiber Analysis of Paper and Paperboard." Treat paper samples as softwood pulps for determining final consistency.

6.2 *Test sample concentration.* Dilute to the suspension concentration recommended by the instrument's manufacturer, or to that determined by tests over a range of concentrations to give accurate measurements.

6.2.1 Take a 50 mL ± 0.05 mL sample of the dilution using a pipette with a tip opening of at least 2 mm in diameter.

6.2.2 When taking the sample, agitate the dilution continuously. Do not stir with a rotary movement, because the sample dilution will not be homogenous. Move the pipette both horizontally and vertically during

sampling.

6.3 *Running the sample.* The minimum number of fibers to measure shall be that at which the average fiber length reaches a steady state variance of 0.01 mm. If the apparatus does not provide continuous fiber length values, then measure a minimum of 5000 fibers.

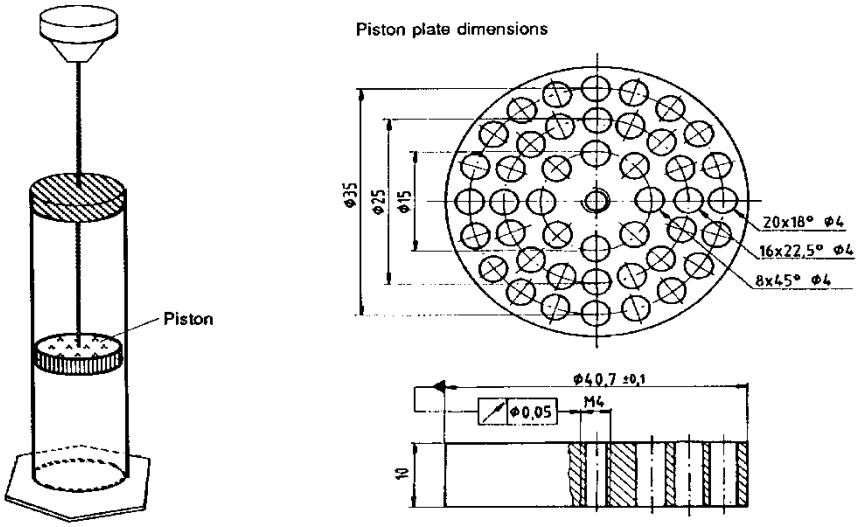

Fig. 2. Manual disintegrator (dimension units are in mm).

7. Calibration check

Perform the calibration check of the analyzer with fibers that polarize light, of known fiber length distribution. During the calibration, measure the intensity of the light and use it to standardize the optical path. (See instrument manufacturer's recommendations.)

8. Calculation

8.1 Arithmetic average of fiber length (L_A). Calculate the arithmetic average fiber length from the number of measured fibers (n_i) in different length fractions (i = the total number of fractions, when resolution is a minimum of 50μm) and from the average length of the fraction (l_i) (*1*). N = the maximum number of fractions greater than or equal to 144.

$$L_A = \frac{\sum_{i=1}^{N} n_i l_i}{\sum_{i=1}^{N} n_i}$$

8.2 Length weighted average fiber length (L_L). The arithmetic average fiber length is not always the most commonly used indicator of the fiber length because the effect of short fibers is emphasized. The commonly used expression is the length weighted average fiber length (*2*,*3*).

$$L_L = \frac{\sum_{i=1}^{N} n_i l_i^2}{\sum_{i=1}^{N} n_i l_i}$$

8.3 Weight weighted average fiber length (L_W)

$$L_W = \frac{\sum_{i=1}^{N} n_i l_i^3}{\sum_{i=1}^{N} n_i l_i^2}$$

8.4 *Frequency distributions*. Distribution curves show the relative amounts of fibers and fiber related values in each length category along the measurement range. Population distribution is based on the numbers of fibers in categories. Values in each category are calculated using formula:

$$P_i(\%) = \frac{n_i}{\sum_{J=1}^{N} n_j} \times 100$$

In length-weighted distribution total lengths of fibers in each category are used instead of number of fibers. The formula to calculate values in distribution is:

$$P_{l,i}(\%) = \frac{n_i l_i}{\sum_{j=1}^{N} n_j l_j} \times 100$$

where

$P_{l,i}$ is the percentage of length in category *i,*

n_i is the number of fibers in category *I,* and

l_i is average fiber length of the fibers in category *i.*

9. Reports

Report the average fiber length by methods described in 8.1 - 8.3 or fiber length distribution by method in 8.4. If the upper and lower length limits for which the mean fiber lengths are calculated are user-selectable, report these limits with the mean lengths.

10. Precision

10.1 Precision statements for this procedure were determined in accordance with TAPPI T 1200 "Interlaboratory Evaluation of Test Methods to Determine TAPPI Repeatability and Reproducibility."

10.2 Samples of commercial bleached southern pine, Scandinavian pine, birch and eucalyptus pulp were used. The individual samples were taken from the same batch of pulp. The same dilution was analyzed 10 times with three devices conforming to the method's specifications.

10.3 Standard deviation and percent repeatability were calculated as follows:

10.3.1 For each unit:

Average fiber length = the average of the length weighted average fiber length after being analyzed 10 times = x.

Standard deviation (S_e).

Standard deviation of test results ($S_r = S_e$).

Repeatability $r = 2.77\ S_r$.

Repeatability in % = $100\ r/x$.

The result of the repeatability tests are shown in Table 1. Measurements are made with 50 μm resolution.

Table 1. Replicate measurements within a single laboratory.

	Unit 1	*Unit 2*	*Unit 3*
Eucalyptus			
Average fiber length, mm	0.79	0.795	0.800
Standard deviation/mm	0.0036	0.0047	0.0038
Repeatability %	1.26	1.64	1.32
Birch			
Average fiber length	0.850	0.862	0.863
Standard deviation	0.005	0.005	0.006
Repeatability %	1.63	1.61	1.93
Pine			
Average fiber length	2.083	2.128	2.140
Standard deviation	0.017	0.019	0.014
Repeatability %	2.26	2.47	1.81
Southern pine			
Average fiber length	2.453	2.561	2.512
Standard deviation	0.0182	0.0266	0.0428
Repeatability %	2.06	2.88	4.72

10.4 *Reproducibility*. To measure reproducibility samples of Scandinavian pine and birch were analyzed in 16 laboratories. Each laboratory performed three analyses of each material and reported the length-weighted average fiber length. Results of the test are shown in Table 2.

Table 2. Results from round robin tests in 16 laboratories.

	Scandinavian pine	*Birch*
Average fiber length, mm	2.02	0.89
Standard deviation (s_n), mm	0.043	0.015
Average standard deviation (s_e), mm	0.013	0.003
s_R, mm	0.044	0.015
Reproducibility, mm	0.123	0.042
Reproducibility, %	6.1	4.7

11. Keywords

Pulp, Paper, Fiber length, Fiber length distribution, Optical measurement, Polarized light

12. Additional information

12.1 Effective date of issue: To be Assigned

12.2 Related methods: TAPPI T 232 "Fiber Length of Pulp by Projection," TAPPI T 233 "Fiber Length of Pulp by Classification."

12.3 A precision statement has been added and revisions were made in the 1998 update. There were no major changes other than editorial to the 2007 version or this 2012 version.

Literature cited

1. TAPPI T 232 "Fiber Length of Pulp by Projection."
2. Clark, J. D'A., "Pulp Technology and Treatment for Paper," Miller Freeman Publications Inc., San Francisco, 1978.
3. Ilvessalo - Pfaffli. M.-S., v. Alfthan G., "The Measurement of Fiber Length With a Semi-Automatic Recorder," *Paperi ja Puu* **39** (11): s. 509-516 (1957).

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

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