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WORKING GROUP
CHAIR _____ N/A _____

SUBJECT
CATEGORY
Papermaking Technology and Operations Committee

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.

Machine-Direction Grammage Variation Measurement (Gravimetric Method) *(Five-year review of Official Method T 546 om-22)*

1. Scope

1.1 This procedure can be used to determine the short term machine-direction variation in mass per unit area. These variations can be caused by defects in the stock approach system, headbox, or consistency control. This test method is not intended to identify the source of the variations, but rather to quantify them. The method has particular application to acceptance testing of both the papermaking process and the product.

1.2 This test is laborious, but it is reliable and accurate. It requires cutting out samples, weighing samples, and data evaluation.

1.3 The general procedures outlined in TAPPI T 410 "Grammage of Paper and Paperboard (Weight per Unit Area)" and in TAPPI T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products," are used as basic references for this method. TAPPI T 545 "Cross-Machine Grammage Profile Measurement (Gravimetric Method)" is the counterpart to this method for the cross-machine evaluation.

2. Summary

The machine direction grammage (basis weight) variation is determined by the following steps: sampling a machine direction strip from the outer layers of a parent roll; preconditioning the sample; cutting and trimming the sample into a series of rectangular sheets 300 mm CD × 200 mm MD; discarding those sheets with obvious defects; conditioning the sheets; weighing the sheets. The sheet weights are then analyzed using analysis of variance to determine MD standard deviation and coefficient of variance.

3. Significance

Evaluation of grammage variation from measurements on a machine direction strip is a useful way to analyze the short-term performance of the wet end of a paper machine. This method provides significant accuracy and repeatability to be used for acceptance testing of papermaking equipment and for product specification.

4. Definitions

4.1 *Grammage*, mass per unit area, expressed as grams per square meter (g/m^2). The customary English term is basis weight, expressed in pounds per ream. The ream size must be specified. Common ream sizes are listed in TAPPI T 410.

4.2 *Cross-machine direction*, direction perpendicular to the running direction of the paper machine (CD).

4.3 *Strip*, length of paper in MD.

4.4 *Machine direction*, direction parallel to the running direction of the paper machine (MD).

4.5 *Mean*, arithmetic average.

4.6 *Cut sheet*, a rectangular piece of paper cut from the MD strip on 1 m MD centers.

4.7 *Trimmed sheet*, a rectangular piece of paper trimmed from one of the sheets cut from the sample strip.

5. Apparatus

5.1 The apparatus required for this method is detailed in TAPPI T 410.

5.1.1 *Weighing device*, readable and accurate to within 0.25% of the applied load.

5.1.2 *Cutting device*, having an attachment for ensuring parallelism of the opposite edges.

5.1.3 *Scale*, such as a finely graduated steel rule reading in 0.5 mm, capable of measuring the dimensions of the test specimen to an accuracy of 0.2%.

6. Sampling

6.1 Obtain the requisite strip in accordance with the guidelines of TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product.”

6.2 Obtain a single strip of paper from the outer layers of a parent reel with a diameter of at least 1 m, as shown in Fig. 1. The strip of paper should be nominally 120 m long (MD) and 400 mm wide (CD) and be taken from the approximate centerline of the reel. This strip may be obtained by winding off a butt roll, provided the 400 mm wide (CD) strip is at least 100 mm from the edges.

6.3 This strip must be free from creases, wrinkles, folds, and tears.

6.4 Note the date, time, reel number, and machine number. Mark the wire or bottom side of the strip with “BS.”

6.5 Carefully transfer the sample to a climate-controlled conditioning room. Avoid putting creases, wrinkles, or corrugations in the paper.

6.6 Depending on the purpose of the testing, it may be useful to note any abnormal conditions which occurred while this strip was being produced.

7. Test specimens

7.1 Precondition the test sample strip on the dry side in atmospheres in accordance with TAPPI T 402. Initial drying can be accelerated using an oven.

7.2 Unroll the strip on a long, flat surface. Discard the ends of the strip if they are wrinkled or creased. The discarded portions should be no more than 10 m in length.

7.3 Beginning at one end, cut (100) rectangular sheets approximately 400 mm (CD) x 300 mm (MD) from the strip.

7.4 Sheets will be taken every 1 m so that the MD distance between sheet edges will be 700 mm, as shown in Fig. 2.

7.5 Trim each sheet to a rectangle of 300 mm CD by 200 mm MD using a suitable knife, guillotine, or paper cutter. The dimensions of the trimmed sheets shall lie within $\pm 0.25\%$ of the mean dimension, per T 410.

7.6 Each sheet shall be located in the approximate CD center of the strip.

7.7 Examine each sheet. Reject any sheet which contains clearly visible lumps of slime, pitch, filler, or similar defects with a total area greater than 1 cm².

7.8 Reject any sheet that has holes in it with an area exceeding 1 cm², as well as any sheets which have been damaged such that the dimensions cannot be established within the prescribed degree of accuracy.

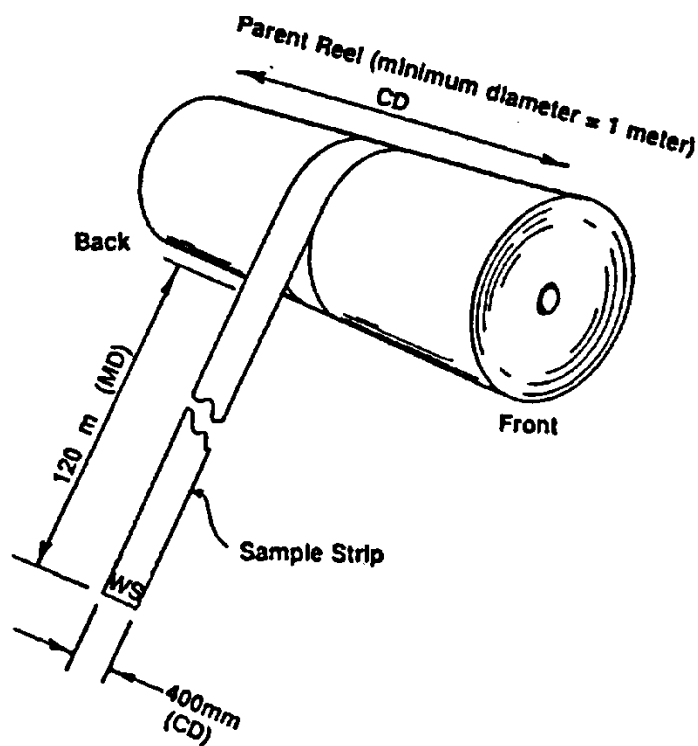


Fig. 1. Sampling.

7.9 Abandon any test in which the total number of rejected sheets exceeds 3.

7.10 Place the sheets into stacks no greater than 10 mm thick and allow the samples to be conditioned for at least 24 h as outlined in T 402.

Table 1. Measured grammage record table.

Sample no.	Grammage, G_i g/m^2
1	G(1)
2	G(2)
3	G(3)
4	G(4)
5	G(5)
6	G(6)
•	•
•	•
•	•
100	G(100)

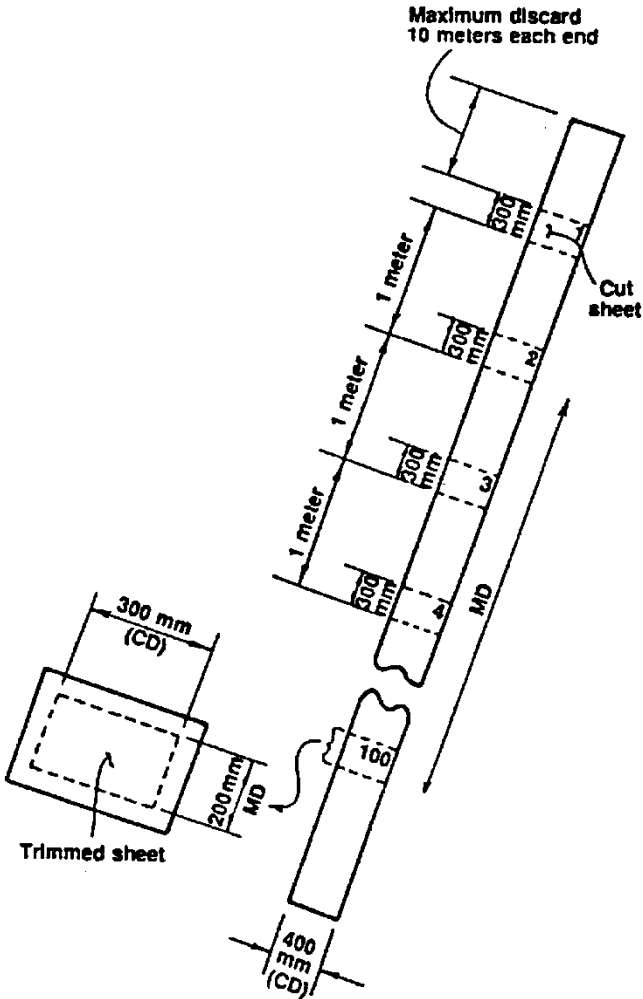


Fig. 2. Sheet removal.

8. Procedure

- 8.1 Weigh each test specimen to within 0.25% in a climate-controlled atmosphere in accordance with T 402 and T 410.
- 8.2 Record the results in a suitable tabular form, such as shown in Table 1.

9. Calculations

- 9.1 Compute the mean grammage of all sheets.

$$\begin{aligned} G_i &= \text{grammage of sheet } i \\ \overline{G} &= \text{mean grammage of all sheets} \\ n &= \text{number of sheets (100 - rejected sheets)} \\ \overline{G} &= \sum_{i=1}^n \frac{G_i}{n} \end{aligned}$$

- 9.2 Compute the variance.

$$\begin{aligned} V &= \text{variance} \\ V &= \sum_{i=1}^n \frac{(G_i - \overline{G})^2}{(n - 1)} \end{aligned}$$

- 9.3 Compute the standard deviation.

$$\begin{aligned} \sigma &= \text{standard deviation} \\ \sigma &= \sqrt{V} \end{aligned}$$

- 9.4 Compute the coefficient of variation.

$$\begin{aligned} C &= \text{coefficient of variation} \\ C &= \frac{\sigma}{\overline{G}} \end{aligned}$$

10. Report

- 10.1 List the grammage for each sheet in an appropriate table in g/m² to three significant figures.
- 10.2 List the mean grammage and the standard deviation in g/m² to three significant figures.
- 10.3 List the coefficient of variation expressed in percent to three significant figures.
- 10.4 The results may also be reported in pounds per ream for customary trade sizes.
- 10.5 Note the maximum and minimum grammage in the table in g/m² to three significant figures.

11. Precision

11.1 Repeatability (within a laboratory) = 11.72%. Reproducibility (between laboratories) = 13.37% in accordance with the definitions of these terms in TAPPI T 1200 "Interlaboratory Evaluation of Test Methods to Determine TAPPI Repeatability and Reproducibility."

11.2 These results were obtained from round robin testing among 10 laboratories. Three paper grades tested in the ten laboratories were fine paper, corrugating medium, and newsprint.

12. Keywords

Basis weight, Variation, Machine direction, Profile

13. Additional Information

13.1 Effective date of issue: To be assigned.

13.2 The interval between samples (section 7.4) may be other than 1 meter, by mutual consent of the parties involved. Report the interval if other than 1 m. Appropriate interval between samples can be calculated based on known problem frequency and the machine speed.

13.3 The changes in the 2010 version were editorial. The only change in the 2015 version was to add Reference 4.

References

1. Wonnacott, T., "Introducing Statistics", Wiley, 1972.
2. Burkhard, G., and Wrist, P.E., "The Evaluation of Paper Machine Stock systems by Basis Weight Analysis," *Pulp Paper Mag. Can.* **55** (13): 188 (1954).
3. Cutshall, K. A., Ilott, G.E., and Rogers, J.R., "Grammage Variation - Measurement and Analysis." PAPTAC Monograph (1988).
4. TAPPI TIP 0404-54 "Headbox approach piping guidelines."

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

