Machine direction grammage variation measurement (gravimetric method)

1. Scope

1.1 This method describes a procedure which can be applied to determine 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 x 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 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/m²). 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 “Grammage of Paper and Paperboard (Weight per Unit Area).”

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

4.3 Strip, length of paper.

4.4 Machine direction, direction parallel to the running direction of the paper machine (MD).
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, Fiberboard, 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 taken.
7. Test specimens

7.1 Precondition the test sample strip on the dry side in atmospheres in accordance with TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products.” 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 ±0.25% of the mean dimension, per T 410.

7.6 Each sheet will 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.

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.
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.

Table 1. Measured grammage record table.

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>Grammage, $G_{\text{g/m}^2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$G(1)$</td>
</tr>
<tr>
<td>2</td>
<td>$G(2)$</td>
</tr>
<tr>
<td>3</td>
<td>$G(3)$</td>
</tr>
<tr>
<td>4</td>
<td>$G(4)$</td>
</tr>
<tr>
<td>5</td>
<td>$G(5)$</td>
</tr>
<tr>
<td>6</td>
<td>$G(6)$</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>100</td>
<td>$G(100)$</td>
</tr>
</tbody>
</table>

9. Calculations

9.1 Compute the mean grammage of all sheets.

$G_i =$ grammage of sheet $i$

$G =$ mean grammage of all sheets

$n =$ number of sheets (100 - rejected sheets)

$$\bar{G} = \frac{\sum_{i=1}^{n} G_i}{n}$$

9.2 Compute the variance.

$V =$ variance

$$V = \frac{\sum_{i=1}^{n} (G_i - \bar{G})^2}{(n - 1)}$$

9.3 Compute the standard deviation.

$s =$ standard deviation

$$s = \sqrt{V}$$

9.4 Compute the coefficient of variation.

$C =$ coefficient of variation
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\[ C = \frac{S}{G} \]

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 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%
11.2 Reproducibility (between laboratories) = 13.37% in accordance with the definitions of these terms in TAPPI T 1206 “Precision Statement for Test Methods.”

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. Additional Information

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

References


Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Technical Divisions Administrator.