Grammage of paper and paperboard (weight per unit area)

1. **Scope**

1.1 In the United States the customary or commercial term for expressing the “weight” per unit area (more properly “mass per unit area”) of paper has been “basis weight,” “ream weight,” or “substance.” These are defined as the mass in pounds of a ream of a given sheet size and number of sheets (usually 500 sheets, occasionally 480 sheets). In most other countries the mass per unit area is expressed in grams per square meter, g/m². The French term for mass per unit area, “grammage,” is recommended by ISO Committee TC 6 on Paper for use in English as well as in French because of its convenience and clear relationship to g/m².

1.2 The mass per unit area of paperboard has been expressed in the customary system as the mass in pounds per thousand square feet, and in the metric system as grams per square meter (g/m²).

1.3 The SI metric units, in which grammage (mass per unit area) is expressed in g/m², are the preferred units for TAPPI Test Methods.

2. **Summary**

The area of several sheets of the paper or paperboard is determined from linear measurements and the mass (commonly called “weight”) is determined by weighing. The grammage is calculated from the ratio of the mass to the area after conversion to metric units when necessary.

3. **Significance**

Most paper is bought and sold in accordance with its mass per unit area, and therefore the grammage has great significance both to the consumer and the producer in defining price. The values of many physical properties such as bursting strength, thickness, and bulk are interpreted and specified with regard to grammage.
4. Apparatus

4.1 Weighing device, readable and accurate to within 0.25% of the applied load. When in use, the weighing device shall be shielded from air currents.

4.1.1 Special sheet-weighing devices designed to weigh test specimens of a given size may be used, provided that the above conditions are fulfilled and that the total area of each test specimen (see 6.3) in a single weighing is not less than 500 cm² (80 in.²).

4.1.2 For a test specimen of smaller total area, an analytical balance is essential to obtain the required accuracy.

4.2 Cutting device, such as a “four square” cutter, circular cutter, precise puncher or other device for ensuring parallelism of the opposite edges, normally capable of repeatedly cutting out test specimens whose area, in at least 95 instances out of 100, falls within ± 0.5% of a known area, as determined by the method specified in 5.2.1.

4.2.1 When a template is used for preparing test specimens, the specimen shall be cut accurately as described in 4.2 with a sharp knife on a hard surface, such as a hardwood board.

4.3 Scale, a steel rule graduated in 0.5 mm (1/64 or 1/64 in.) increments, capable of measuring the dimensions of the test specimen to an accuracy of 0.2%.

5. Calibration

5.1 Checking of weighing device.

5.1.1 Check the accuracy of the weighing device frequently (5.3) by applying accurately measured masses with both increasing and decreasing loads. If a sheet-weighing device is used, it must be properly calibrated to the required accuracy (4.1).

5.1.2 Frictional effects shall be sufficiently minimal and the zero reading shall be sufficiently correct so as to attain the required weighing accuracy.

5.2 Checking of cutting device.

5.2.1 Frequently (5.3) check the specimen area cut by using the scale (4.3) to measure 20 test specimens. The cutting accuracy specified in 4.2 is attained when the standard deviation of the individual areas is less than 0.25% of the mean area, in which case this mean area may be used for calculating grammage in subsequent tests.

5.3 Frequency of checking.

5.3.1 The frequency of checking in 5.1 and 5.2.1 should be based on experience. A new device should be checked several times before being put into use. Then, if in continuous use, it should be checked twice daily until stability is established, then weekly, monthly, or less frequently as indicated by its stability, unless moved or unduly disturbed. Because of wear, the cutting device may require more frequent checking than the weighing device.

6. Sampling

6.1 For conformance testing, obtain the sample of the paper or paperboard to be tested in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product.” Otherwise, select a sample that will meet needs for testing.

6.2 After conditioning each test unit of the sample, cut a sufficient number of representative sheets for a total area per test unit of at least 5000 cm² (800 in.²). The dimensions and hence the area of each sheet will depend on the sheet cutting device available. If a template is used, a minimum dimension of 20.0 × 25.0 cm (8 × 10 in.) is recommended.

6.3 Select the number of sheets composing a test specimen (total area of each test specimen at least 500 cm²) to give the required weighing accuracy.

NOTE 1: As a consequence of the above rules which allow for flexibility in the selection of sheet weighing and cutting devices, the number of test specimens representing a test unit and the number of sheets per test specimen will depend on the choice of weighing and cutting devices, as illustrated by the following examples:

(a) If for a particular sample of paper, the sheet weighing device requires the weighing together of two sheets at least 20.0 × 25.0 cm to obtain the requisite weighing accuracy, then each test specimen will consist of two sheets at least 20.0 × 25.0 cm, and five such test specimens (each a pair of sheets) will be needed to obtain the required total area of 5000 cm².

(b) If the available precise cutting device gives a sheet size of 4.00 × 4.00 in. (approximately 10 × 10 cm), then for the same paper and sheet weighing device used above, each of the needed five test specimens would require 10 sheets.

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1 Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list in the bound set of TAPPI Test Methods, or may be available from the TAPPI Technical Operations Department.
NOTE 2: For some uses, grammage variation across the web or roll is of interest; e.g., the original wide roll (or web) may be slit into narrow rolls, each 7.5 to 10 cm (3 to 4 in.) wide for medical packaging. A ‘‘tailing-off’’ of the grammage near the edge of the web could be unacceptable. In such cases, test specimens should be taken from selected positions across the web and the grammage reported separately for each position.

7. Conditioning

7.1 Condition and test the test specimens in an atmosphere in accordance with TAPPI T 402 ‘‘Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products,’’ unless grammage ‘‘as received’’ is required.

7.2 The precision of this work is such that hysteresis has important effects; therefore, precondition the test specimens so that the equilibrium moisture content is approached from the drier state.

8. Procedure

8.1 If the cutting accuracy specified in 4.2 is attained (see 5.2.1), use the mean area obtained in 5.2.1; otherwise, determine the area of each test specimen to within 0.3%, i.e., measure the dimensions of each sheet to within 0.2%.

8.2 If the special sheet-weighing device is used, be sure that the dimensions of the sheets are within 0.2% of the required size; otherwise, make a correction in accordance with the following formula:

\[
G = \frac{A' \times G'}{A}
\]

where

- \(G\) = corrected indicated mass per unit area
- \(G'\) = indicated mass per unit area of the test specimen
- \(A'\) = area of the test specimen for which the device is calibrated
- \(A\) = area of the weighed test specimen

8.3 Weigh each test specimen to within 0.25%.

9. Calculations

9.1 From the measurements, calculate the mass per unit area of each test specimen. If \(M\) is the mass and \(A\) is the area of the test specimens in the units of measurements, then the grammage in grams per square meter (g/m\(^2\)) may be calculated by the formula:

\[
G = \frac{K \times M}{A}
\]

where \(K\) is the conversion factor given in Table 1.
Table 1.  Conversion factors

<table>
<thead>
<tr>
<th>Units of measurement</th>
<th>Conversion factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass (M)</td>
<td>Area (A)</td>
</tr>
<tr>
<td>Gram</td>
<td>10,000</td>
</tr>
<tr>
<td>Gram in.</td>
<td>1,550</td>
</tr>
<tr>
<td>Indicated weight (lb) for 500-sheet ream</td>
<td>9,070</td>
</tr>
<tr>
<td>Indicated weight (lb) for 500-sheet ream in.</td>
<td>1,406</td>
</tr>
</tbody>
</table>

Table 2.  Ream weight conversion factors

<table>
<thead>
<tr>
<th>Kind of Paper</th>
<th>Trade or trade size</th>
<th>Trade size area, ft²</th>
<th>P (BW to G)</th>
<th>Q (G to BW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paperboard</td>
<td>1000 ft²</td>
<td>1000.0</td>
<td>4.882</td>
<td>0.205</td>
</tr>
<tr>
<td>Writing and printing</td>
<td>17 × 22 · 500</td>
<td>1298.6</td>
<td>3.760</td>
<td>0.266</td>
</tr>
<tr>
<td>Blotting</td>
<td>19 × 24 · 500</td>
<td>1583.3</td>
<td>3.084</td>
<td>0.324</td>
</tr>
<tr>
<td>Cover</td>
<td>20 × 26 · 500</td>
<td>1805.6</td>
<td>2.704</td>
<td>0.370</td>
</tr>
<tr>
<td>Carbon paper</td>
<td>20 × 30 · 500</td>
<td>2083.3</td>
<td>2.344</td>
<td>0.427</td>
</tr>
<tr>
<td>Cardboard</td>
<td>22 × 28 · 500</td>
<td>2138.9</td>
<td>2.283</td>
<td>0.438</td>
</tr>
<tr>
<td>Bristol and tag</td>
<td>22 ½ × 28 ½ · 500</td>
<td>2226.6</td>
<td>2.193</td>
<td>0.456</td>
</tr>
<tr>
<td>Binder's board</td>
<td>25 1/4 × 30 1/4 · 500</td>
<td>2652.1</td>
<td>1.841</td>
<td>0.543</td>
</tr>
<tr>
<td>Index</td>
<td>25 ½ × 30 ½ · 500</td>
<td>2700.5</td>
<td>1.808</td>
<td>0.553</td>
</tr>
<tr>
<td>News, wrapping, tissue, paperboard, bag paper</td>
<td>24 × 36 · 500 (3000 ft²)</td>
<td>3000.0</td>
<td>1.627</td>
<td>0.614</td>
</tr>
<tr>
<td>Tissue</td>
<td>24 × 36 · 480</td>
<td>2880.0</td>
<td>1.695</td>
<td>0.590</td>
</tr>
<tr>
<td>Book</td>
<td>25 × 38 · 500</td>
<td>3298.6</td>
<td>1.480</td>
<td>0.676</td>
</tr>
<tr>
<td>Newsboard</td>
<td>26 × 38 · 500</td>
<td>3430.6</td>
<td>1.423</td>
<td>0.703</td>
</tr>
<tr>
<td>Former TAPPI standard size</td>
<td>25 × 40 · 500</td>
<td>3472.2</td>
<td>1.406</td>
<td>0.711</td>
</tr>
</tbody>
</table>

9.1.1 If the ream weight in pounds (BW) has been determined for a customary trade size of 500 sheets, the grammage in g/m² may be calculated as follows:

\[ G = P \times BW \]

where \( P \) is the conversion factor given in Table 2.

9.2 Calculate the mean of the results for each test unit, and express in g/m² to three significant figures.

9.3 To convert grammage (\( G \)) to mass in pounds (BW) of custom trade sizes for 500-sheet reams or, for paperboard, 1000 ft², the following formula may be used:

\[ BW = Q \times G \]

where \( Q \) is the conversion factor given in Table 2. Express the results in pounds to three significant figures.

10. Report

10.1 Report the grammage in g/m² to three significant figures for each test unit.
10.2 If the test units have been taken from more than one position across a roll or sheet and information on grammage variation is required (e.g., Note 2), report the average for each position separately.
10.3 If desired, the results may also be reported in pounds for customary trade sizes.
10.4 If the total area of a test unit is less than that specified, state the actual total area tested.
10.5 Report the testing conditions, i.e., in accordance with TAPPI T 402 or as received.
11. **Precision**

11.1 Repeatability of test results within a laboratory = 0.94%.

11.2 Reproducibility of test results between laboratories = 2.84%.

11.3 The above values of precision are averages calculated from 18 reports of the TAPPI/CTS Collaborative Reference Program for Paper. Each test result is an average for approximately 5000 cm$^2$ of paper or paperboard.

12. **Keywords**

Grammage, Mass per unit area, Basis weight

13. **Additional information**


13.2 Table 2 is for 500-sheet reams except as noted. If the trade size uses 480-sheet reams, then the factor $P$ is multiplied by 50/48 or 1.042 for conversion and factor $Q$ is multiplied by 48/50 or 0.960.

13.3 The U.S. Government Printing Office has discontinued using twice the trade size (i.e., 1000 sheets instead of 500) and is now following trade practice.

13.4 To within less than 0.5%, mass per unit area in g/m$^2$ is numerically equivalent to basis weight in pounds (35 × 40-500), so that by adjusting the size of the template most ream weight scales may be used to read directly in g/m$^2$.

13.5 Related method: ISO 536, ASTM D 646-96.

13.6 This method was revised in 1968 and 1979. The latter revision adopted the ISO terminology “grammage.” In 1982, Table 2 was corrected and expanded, Note 2 was added. The 1993 correction deleted a reference to a withdrawn TI Sheet.

*Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Technical Operations Manager.*