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WI _____ 120808.02 _____

T _____ 410 _____

DRAFT NO. _____ 2 _____

DATE _____ Spring 2013 _____

WORKING GROUP

CHAIRMAN _____ Ann Timberlake _____

SUBJECT

CATEGORY _____ Physical 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 Material 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.

**Grammage of paper and paperboard
(weight per unit area)
(Revision of T 410 om-08)
(underscores and strikeouts indicate changes from Draft 1)**

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/m^2 . 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/m^2 .

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/m^2).

1.3 The SI metric units, in which grammage (mass per unit area) is expressed in g/m^2 , 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. The grammage is also used to calculate the index properties of many strength properties and thus the proper measurement of basis weight is critical for the correct calculation of these indexes.

4. Apparatus¹

4.1 *Scale*, readable and accurate to within 0.25% of the applied load, ~~and, when in use, the scale 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 cm^2 (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 $\pm 0.5\%$ 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 ($1/50$ or $1/64 \text{ in.}$) increments, capable of measuring the dimensions of the test specimen to an accuracy of 0.2%.

¹ Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list, available as part of the CD or printed set of Standards, or on the TAPPI website general Standards page.

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 ~~it~~ to the required accuracy (4.1).

5.1.2 Ensure that frictional ~~Frictional~~ effects are ~~shall be~~ sufficiently minimal and the zero reading is ~~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 Base the ~~The~~ frequency of checking in 5.1 and 5.2.1 ~~should be based~~ on experience. Check a ~~A~~ new device ~~should be checked~~ several times before being put into use. Then, if in continuous use, check ~~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.

(c) If a limited area of sample is available, a test area of not less than 50 cm² may be used.

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

<i>Units of measurement</i>		<i>Conversion Factors</i>
<i>Mass (M)</i>	<i>Area (A)</i>	<i>K</i>
Gram	cm^2	10,000
Gram	in.^2	1,550
Indicated weight (lb) for 500-sheet ream	cm^2	9,070
Indicated weight (lb) for 500-sheet ream	in.^2	1,406

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/m^2 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/m^2 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 ft^2 , 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.

Table 2. Ream weight conversion factors

<i>Kind of Paper</i>	<i>Trade or basic size</i>	<i>Trade size area, ft²</i>	<i>P (BW to G)</i>	<i>Q (G to BW)</i>
Paperboard	1000 ft ²	1000.0	4.882	0.205
Writing and printing	17 × 22 - 500	1298.6	3.760	0.266
Blotting	19 × 24 - 500	1583.3	3.084	0.324
Cover	20 × 26 - 500	1805.6	2.704	0.370
Carbon paper	20 × 30 - 500	2083.3	2.344	0.427
Cardboard	22 × 28 - 500	2138.9	2.283	0.438
Bristol and tag	22 ½ × 28 ½ - 500	2226.6	2.193	0.456
Binder's board	25 1/4 × 30 1/4 - 500	2652.1	1.841	0.543
Index	25 ½ × 30 ½ - 500	2700.5	1.808	0.553
News, wrapping, tissue, paperboard, bag paper	24 × 36 - 500 (3000 ft ²)	3000.0	1.627	0.614
Tissue	24 × 36 - 480	2880.0	1.695	0.590
Book	25 × 38 - 500	3298.6	1.480	0.676
Newsboard	26 × 38 - 500	3430.6	1.423	0.703
Former TAPPI standard size	25 × 40 - 500	3472.2	1.406	0.711

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 cm² of paper or paperboard.

12. Keywords

Basis weight

13. Additional information

13.1 Effective date of issue: to be assigned.

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 When measuring the basis weight in pounds (35 × 40-500), the mass per unit area in g/m^2 is numerically equivalent to within 0.5%. By adjusting the template size of most ream weight scales, the scales can 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. The 2008 and 2012 editions ~~only~~ included only minor editorial changes.

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

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WI _____ 120808.02 _____

T _____ 410 _____

DRAFT NO. _____ 1 _____

DATE _____ May 18, 2012 _____

WORKING GROUP
CHAIRMAN _____ to be determined _____

SUBJECT
CATEGORY _____ Physical Properties _____

RELATED
METHODS _____ See "Additional Information" _____

CAUTION:

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Grammage of paper and paperboard (weight per unit area) (Five-year review of T 410 om-08)

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/m^2 . 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/m^2 .

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/m^2).

1.3 The SI metric units, in which grammage (mass per unit area) is expressed in g/m^2 , 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. The grammage is also used to calculate the index properties of many strength properties and thus the proper measurement of basis weight is critical for the correct calculation of these indexes.

4. Apparatus¹

4.1 *Scale*, readable and accurate to within 0.25% of the applied load. When in use, the scale 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 $\pm 0.5\%$ 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 ($1/50$ or $1/64$ in.) increments, capable of measuring the dimensions of the test specimen to an accuracy of 0.2%.

¹ Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list, available as part of the CD or printed set of Standards, or on the TAPPI website general Standards page.

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.

- (c) If a limited area of sample is available, a test area of not less than 50 cm² may be used.

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%.

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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:

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where K is the conversion factor given in Table 1.

Table 1. Conversion factors

<i>Units of measurement</i>		<i>Conversion Factors</i>
<i>Mass (M)</i>	<i>Area (A)</i>	<i>K</i>
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$$BW = Q \times G$$

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

Table 2. Ream weight conversion factors

<i>Kind of Paper</i>	<i>Trade or basic size</i>	<i>Trade size area, ft²</i>	<i>P (BW to G)</i>	<i>Q (G to BW)</i>
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