Designation: D 4826 - 88 (Reapproved 2002)

Standard Practice for Units of Measurement and Conversion Factors for Pulp, Paper, and Paperboard¹

This standard is issued under the fixed designation D 4826; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

- 1.1 This practice covers the application of the International System of Units (abbreviated SI) within the field of pulp, paper, and paperboard. The SI units have been adopted by ISO, ASTM, and TAPPI as the preferred units for use in their standards and test methods.
- 1.2 Details of SI are given in various parts of ISO Standards 31 and 1000, and in ASTM Standard E 380. Application of this information is not always easy, as some properties cannot at this time be expressed in SI, some can be expressed in various units all within SI, and various multiples can be used. Such variation can lead to confusion in reporting test results and in quoting values for properties.
- 1.3 In order to overcome such problems within the pulp, paper, and paperboard field, ISO/TC6 has recommended appropriate units in ISO Standard 5651. These recommendations are reproduced in this practice, together with other information and recommendations.

2. Referenced Documents²

2.1 ASTM Standards:

IEEE/ASTM SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System^{3,4}

2.2 ISO Standards:

ISO 31 Quantities, Units and Symbols, Parts 0–13⁴
ISO 1000 SI Units and Recommendations for the Use of Their Multiples and of Certain Other Units⁴

3. Summary of Practice

3.1 This practice covers the units recommended for use in expressing the properties of pulp, paper, and paperboard and

other quantities found in the pulp, paper, and paperboard documents. It also provides the conversion factors for converting customary units to metric units or other recommended units, and marks with an asterisk (*) when the conversion factor is exact.

- 3.2 Units recommended in ISO 5651 are marked (+) or (#), with the latter indicating that the recommended unit for pulp, paper, and paperboard is not a preferred SI unit.
- 3.3 The international symbol for each unit is given in square brackets [] following the name of the unit.

4. Significance and Use

- 4.1 Uniformity in expressing the results of testing and in quoting property values is needed for improved communication in commerce and research.
- 4.2 The table of recommended units and symbols and the rules for using them provided in this practice will aid in achieving uniformity.

5. Procedure

5.1 In converting from the customary units to the recommended form, multiply the test value expressed in customary units by the conversion factor to obtain the test value in the recommended form. As an example, suppose that the property of interest is the thickness of a sheet of paper, and that this has been determined to be 5.3 mils. Examination of the table shows that in Section 1.2, Thickness, the conversion factor from mils to micrometres, is exactly 25.4. Multiplying 5.3 by 25.4, the test value in the recommended units is 134.62 μ m. Generally, the converted value should be rounded to the same number of significant figures or one more than in the value in customary units, depending, respectively, on whether the first digit of the new value is more or less than that of the original value. Thus, in this case, the converted value would be 135 μ m.

Note 1—The rounding rule given here is easy to remember and does not result in the loss of significant information. For more detailed information on rounding, see ASTM Practice E 380.

5.2 If the property of interest had been the thickness of corrugated board of, for example, 180 mils, the value would be converted to millimetres, not micrometres. The conversion factor is 0.0254 and the value in the recommended form is 4.57

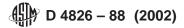
¹ This practice is under the jurisdiction of ASTM Committee D06 on Paper and Paper Products and is the direct responsibility of Subcommittee D06.92 on Test Methods.

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² For the full titles of the standards and other documents listed in the table, see the ISO. ASTM, and TAPPI indexes.

³ Availabe from ASTM International, www.astm.org (Excerpts in Related Material section of all ASTM volumes.)

⁴ Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.



- or 4.6 mm, depending on whether the zero in the last digit of 180 is significant or simply holding the decimal place.
- 5.3 Generally, if the table allows a choice in the recommended form, choose that form that would have no more than three significant figures in front of the decimal point for most of the values and only one place after the decimal point. However, use, for example, 0.13 mm, not 130 μ m, if the zero in 130 is not significant.
- 5.4 To minimize variety, it is recommended (and the table generally shows) that only prefixes representing 1000 raised to an integral power be used. Thus use:

| 10 ⁹ | giga- | G |
|-----------------|--------|---|
| 10 ⁶ | mega- | M |
| 10 ³ | kilo- | k |
| 10^{-3} | milli- | m |
| 10^{-6} | micro- | μ |
| 10^{-9} | nano- | n |

However, in expressing area or volume, the prefixes hecto-, deka-, deci-, and centi- may be needed, for example, cubic centimetres.

6. Notation

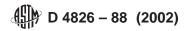
6.1 The quantities given in square brackets in the second and fourth columns are symbols, not abbreviations. Hence, do

- not use abbreviation marks. When two of these symbols are multiplied, as in Section 9.18, dynamic viscosity in pascal seconds, use a raised (center) dot between the symbols, thus Pass
- 6.2 The same symbol is used for the plural, so adding an s for the plural is incorrect. Thus, write fifty-two grams as 52 g. Also the symbol for per is a slash (/), not the letter p, and scientific notation is used for squares, cubes, and higher powers. Thus, write fifty-two grams per square metre as 52 g/m², not gpsm nor gsm.
- 6.3 The symbols and the names of units are not mixed in the same expression. Therefore, g per square metre, grams/square metre, grams/m², g/sq m, and g per m² are all incorrect.
- 6.4 In the text, write out the name of the unit, except when preceded by a numerical value. Thus use "determine the mass in grams to the nearest 0.1 g." However, expressions like "one gram" or "two to three grams" may be used when the value as well as the unit of measurement must be written out.

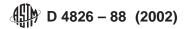
7. Keywords

7.1 conversion factors; paper; paperboard; pulp; units of measure

| | TABLE Continued | | | | |
|-------|--|--|-------------|---|--|
| | Property and ISO Standard | To Convert Values Expressed in Customary Units | Multiply by | To Obtain Values Expressed in Recommended Form | |
| | | Name [Symbol] | *exactly | Name [Symbol] | |
| 1. | General Properties | | | | |
| 1.1 | Grammage (mass per unit area in g/m²) | pounds per ream, $17 \times 22 - 500$ [lb/ream, $17 \times 22 - 500$] | 3.7597 | + grams per square metre [g/m²] | |
| | Basis weight (mass per unit area on ream basis) | pounds per ream, $24 \times 36 - 500$ [lb/ream, $24 \times 36 - 500$] | 1.6275 | grams per square metre [g/m²] | |
| | , | pounds per ream, $25 \times 38 - 500$ [lb/ream, $25 \times 38 - 500$] | 1.4801 | grams per square metre [g/m²] | |
| | ISO 536, 3039, 5270, 5638 | pounds per ream, $25 \times 40 - 500$ [lb/ream, $25 \times 40 - 500$] | 1.4061 | grams per square metre [g/m²] | |
| | ASTM D 646 | pounds per 1000 square feet [lb/1000 ft ²] | 4.8824 | grams per square metre [g/m²] | |
| | TAPPI T 410 | pounds per 3000 square feet [lb/3000 ft ²] | 1.6275 | grams per square metre [g/m²] | |
| | | pounds per 3300 square feet [lb/3300 ft ²] | 1.4795 | grams per square metre [g/m²] | |
| 1.2 | Thickness (caliper) | mils (or points or thousandths of an inch) | *25.4 | + micrometres [µm] | |
| 1.2 | ISO 534, 3034 | mils [mil or 0.001 in.] | *0.0254 | + ⁿ millimetres [mm] | |
| | ASTM D 374, D 645 | This [thin or oloo this] | 0.0204 | " for corrugated fiberboard | |
| | TAPPI T411 | | | for corrugated liberboard | |
| 1.3 | Apparent density | pounds per cubic foot [lb/ft ³] | 16.01846 | kilograms per cubic metre [kg/m ³] | |
| 1.3 | ISO 534, 5270 | pounds per cubic foot [lb/ft ³] | 27679.90 | kilograms per cubic metre [kg/m²] | |
| | ASTM D 202 | pounds per cubic root [ib/it.] | 27.679.90 | # " grams per cubic centimetre | |
| | | pourius per cubic incri (ib/in.) | 27.67990 | [g/cm ³] | |
| | TAPPI T 258, T 694 | | | ⁿ for paper and paperboard | |
| 1.4 | Bulking thickness ISO 534 | mils [mil or 0.001 in.] | *25.4 | + micrometres [µm] | |
| | TAPPI T 220 | | | | |
| 1.5 | Book bulk | mils [mil or 0.001 in.] | *0.0254 | millimetres [mm] | |
| | ASTM D 2175 | | | | |
| | TAPPI T 500 | | | | |
| 1.6 | Hygroexpansivity ISO 8226 | | | + percent [%] (by length) | |
| 1.7 | Dimensional change after immersion in water ISO 5635 | er | | + percent [%] (by length) | |
| 1.8 | Drainability of pulp (freeness): | | | | |
| 1.8.1 | Canadian standard freeness | | | + numerical value (CSF) [no. (CSF)] | |
| 1.0.1 | ISO 5267/2 | | | + numerical value (CSI) [no. (CSI)] | |
| | TAPPI T 227 | | | | |
| 1.8.2 | Schopper-Riegler freeness | | | + numerical value [SR number] | |
| | ISO 5267/1 | | | + numerical value [SIX number] | |
| 2. | Strength Properties | | | | |
| 2.1 | Tensile strength | pounds-force per inch [lbf/in.] | 0.1751268 | + kilonewtons per metre [kN/m] | |
| | ISO 1924, 3781, 5270 | pounds-force per 15 millimetre width [lbf/15 mm] | 0.29655 | kilonewtons per metre [kN/m] | |

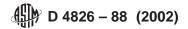


| | Property and ISO Standard | To Convert Values Expressed in Customary Units | Multiply by | To Obtain Values Expressed in Recommended Form |
|--------------|--|--|---|--|
| | ASTM D 202, D 828 TAPPI T 404, T 494, T456, T 220, T 813 | pounds-force per 15 millimetre width [lbf/15 mm] kilograms-force per 25 millimetre width [kgf/25 mm] kilograms-force per centimetre [kgf/cm] ounce-force per inch [ozf/in.] grams-force per millimetre [gf/mm] newtons per 15 millimetre width [N/15 mm] | 0.67378 0.39227 *0.980665 10.945 *9.80655 66.66667 | kilonewtons per metre [kN/m] kilonewtons per metre [kN/m] kilonewtons per metre [kN/m] " newtons per metre [N/m] " newtons per metre [N/m] " for tissue towels |
| 2.2 | Tensile index ISO 1924, 5270 | kilometres breaking length [km] | *9.80665 | + newton metres per gram [N·m/g] |
| 2.3 | Breaking length (to be replaced by tensile index) ISO 1924 TAPPI T 220, T 231, T 494 | metres [m] | *0.001 | + kilometres [km] |
| 2.4 | Stretch at break (elongation) ISO 1924 ASTM D202 TAPPI T 220, T 404, T 494 | | | + percent [%] (by length) |
| 2.5 | Tensile energy absorption (TEA) ISO 1924 TAPPI T494 | foot pounds-force per square foot [ft-lbf/ft²] inch pounds-force per square inch [in-lbf/in.²] kilograms-force metres per square metre [kgf-m/m²] | 14.59390 175.1268 *9.80665 | + joules per square metre [J/m²] joules per square metre [J/m²] joules per square metre [J/m²] #millijoules per gram [mJ/q] |
| 2.6 | Tensile energy absorption index ISO 1924 Bursting strength | pounds force per square inch [psi] or points | 6.894757 | + kilopascals [kPa] |
| | ISO 2758, 2759, 3689 ASTM D 774, D 2529, D 2738 TAPPI T 403, T 807, T 810 | kilograms-force per square centimetre [kgf/cm²] kilonewtons per square metre [kN/m²] | 0.0980665 *1.000 | megapascals [MPa] kilopascals [kPa] |
| 2.8 | Burst index (formerly burst factor) | Burst factor computed as: grams-force per square centimetre per (grams per square metre) [(gf/cm²)/(g/m²)] | *0.0980665 | #kilopascal square metres per gram [kPa·m²/g] |
| | ISO 2758, 2759, 3689, 5270 TAPPI T 220 | | | |
| 2.9 | Tearing strength ISO 1974, 5270 ASTM D689 | grams-force [gf] | *9.80665 | + millinewtons [mN] |
| 2.10 | TAPPI T 414, T220, T496 Tear index (replaces tear factor) | Tear factor computed as: 100 grams-force | *0.0980665 | #millinewton square metres per gram [mN·m²/g] |
| | ISO 1974, 5270 TAPPI T 220 | per (gram per square metre) [100 gf/(g/m²)] | | gram [miv-m /g] |
| 2.11 | Puncture resistance ISO 3036 ASTM D 781 TAPPI T 803 | centimetre kilograms-force [cm-kgf] scale units (= 0.305 cm-kgf) foot pounds-force [ft-lbf] inch pounds-force [inlbf] inch ounces-force [inozf] | *0.0980665 0.0299 1.355818 0.1129848 7.061552 | + joules [J] joules [J] joules [J] joules [J] millijoules [mJ] |
| 2.12 | Adhesion strength of glue bonds of corrugated fibreboard TAPPI T 813 | pounds-force per inch [lbf/in.] | 0.1751268 | + kilonewtons per metre [kN/m] |
| 2.13 | Z-direction tensile strength TAPPI T 506 | kilograms-force per millimetre [kgf/mm] pounds-force per square inch [lbf/in.²] kilograms-force per square centimetre [kgf/cm²] | *9.80665 6.894757 *98.0665 | kilonewtons per metre [kN/m] + kilopascals [kPa] kilopascals [kPa] |
| 2.14 2.15 | Internal bond Edge tearing resistance (Finch) ASTM D 827 TAPPI T 470 | foot pounds-force per square inch [ft-lbf/in.²] pounds-force [lbf] kilograms-force [kgf] | 2101.5 4.44822 *9.80665 | joules per square metre [J/m²] newtons (N) newtons (N) |
| 2.16 | Tensile strength retention after immersion (or wet tensile strength) ISO 3781 ASTM D 829 TAPPI T 456 | | | percent [%] (or see 2.1) |
| 2.17 | Bursting strength retention after immersion ISO 3689 | | | percent [%] |
| 3. | Folding, Bending and Compression Properties | | | |
| 3.1 | Static bending force ISO 2493 | pounds-force [lbf] grams-force [gf] | 4.448222 *9.80665 | + newtons [N] + millinewtons [mN] |
| 3.2 | Bending stiffness ISO 5629 TAPPI T 489, T 535, T820 | gram-force centimetres [gf-cm] gram-force centimetres [gf-cm] pound-force inches [lbf-in.] | *98.0665 *0.0980665 0.1129848 | + micronewton metres [µN·m] + millinewton metres [mN·m] + newton metres [N·m] |
| 3.3 | Bending strength (modulus of rupture) TAPPI T 655, T 1003 | pounds-force per square inch [lbf/in.²] | 6.894757 | kilopascals [kPa] |
| 3.4 | Flat crush resistance of corrugated board ISO 3035 ASTM D 1225 | pounds-force per square inch [lbf/in.²] kilograms-force per square centimetre [kgf/cm²] | 6.894757 *98.0665 | + kilopascals [kPa] kilopascals [kPa] |

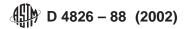


| | Property and ISO Standard | To Convert Values Expressed in Customary Units | Multiply by | To Obtain Values Expressed in Recommended Form |
|------------------|---|---|------------------------------|---|
| 3.5 | Flat crush resistance of laboratory fluted corrugating medium (CMT method) ISO 7263 ASTM D 3806 TAPPI T 809 | pounds-force (CMT) [lbf(CMT)] | 4.448222 | #newtons (CMT) [N(CMT)] |
| 3.6 | Edgewise crush resistance ISO 3037 | pounds-force per inch [lbf/in.] kilograms-force per inch [kgf/in.] | 175.1268 0.38609 | newtons/metre [N/m] + kilonewtons/metre [kN/m] |
| 3.7 | TAPPI T 811 Ring crush ASTM D 1164 TAPPI T 818 | ⁿ pounds-force (for a 6-inch length) [lbf/6 in.] ⁿ kilograms-force (for a 6-inch length) [kgf/6 in.] ⁿ usually expressed simply as "pounds" or "kilograms" | 0.02919 0.06435 | + kilonewtons per metre [kN/m] kilonewtons per metre [kN/m] |
| 3.8 | Fold number, double folds | grams" | | + numerical value (number of double folds) |
| | ISO 5270, 5626 ASTM D 643, D 2176 TAPPI T 423, T 511, T 220 | | | |
| 3.9 | Folding endurance ISO 5270, 5626 ASTM D 2176 TAPPI T 423, T 511 | formerly equivalent to "fold number" (see above), n "the log to the base 10 of the number of double fold | | + log ₁₀ (number of double folds) |
| 4. 4.1 | Surface Properties Roughness, Bendtsen ISO 2494, 8791 | | | #millilitres per minute (Bendtsen) |
| 4.2 | Roughness, Sheffield ISO 2494 | | | [mL/min (Bendtsen)] #Sheffield units |
| 4.3 | TAPPI T 538 Roughness, Print-surf | microns | *1.000 | #micrometres (Print-surf) [µm(Print-surf)] |
| 4.4 | ISO 8791 Smoothness, Bekk ISO 5627 | | | #seconds (Bekk) [s(Bekk)] |
| 4.5 | TAPPI T 479 Coefficient of friction ASTM D 202, D 3247, D3248 | Degrees of angle | | numerical value numerical value = tangent of angle |
| 4.6 4.6.1 | Surface strength: Wax pick | | | Wax number |
| 4.6.2 | ASTM D 2482 Picking velocity, IGT ISO 3782, 3783 TAPPI T 499 | feet per minute [ft/min] | *5.080 | + millimetres per second [mm/s] + metres per second [m/s] |
| 4.6.3 4.7 | Viscosity-velocity-product (VVP), IGT TAPPI T 514 Delamination velocity | kilopoise centimetres per second [kP·cm/s] pascal-seconds metres-per-second [(Pa·s)(m/s)] feet per minute [ft/min] | *1.000 *1.000 *0.00508 | newtons per metre [N/m] newtons per metre [N/m] + metres per second [m/s] |
| 4.8 | ISO 3782, 3783 Surface wettability Initial | | | degrees [°] |
| | Rate ASTM D 724 TAPPI T 458 | | | degrees per second [°/s] |
| 4.9 5. | Specific external surface of pulp Permeability and Absorption Properties | square centimetres per gram [cm²/g] | *0.100 | square metres per kilogram [m²/kg] |
| 5.1 | Water vapor transmission rate | grams per 100 square inches day [g/(100 in.²-d)] | 15.5 | + grams per square metre day [g/(m²·d)] |
| 5.2 | TAPPI T 448, T 464, T 523 Water absorbency—area basis ISO 535, 5637 ASTM D 3285, D 4250 | grams per 100 square centimetres [g/100 cm ²] | *100.000 | + grams per square metre [g/m²] |
| 5.3 | TAPPI T441 Water absorbency—mass basis ISO 5637 ASTM D 4250 | | | + percent [%] (of initial mass) |
| 5.4 | TAPPI T 491 Water absorbency—capillary rise ASTM D 202 | inches [in.] | *25.4 | + millimetres [mm] |
| 5.5 5.6 | Ink absorbency, K and N Ink absorption of blotting paper ASTM D 2177 | | | #"K and N" units seconds per millilitre [s/mL] |
| 5.7 | TAPPI T 431 Saturating capacity of felt | millilitres per 100 grams [mL/100 g] | *1.000 | Kerosine number |

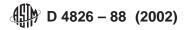
| | Property and ISO Standard | To Convert Values Expressed in Customary Units | Multiply by | To Obtain Values Expressed in Recommended Form |
|-------------------|--|---|-------------------|--|
| | ASTM D 727 | | | |
| 5.8 | TAPPI T 427 Resistance to water penetration | | | + minutes, hours, or days [min, h, or d] |
| | ISO 5633 | | | seconds [s] |
| | ASTM D 779 TAPPI T 433 | | | |
| 5.9 | Water resistance of corrugated fibreboard | | | hours [h] |
| 5.10 | ISO 3038 Water absorption rate | | | [s/0.01 mL] tissue |
| 5.11 | TAPPI T 432 Resistance to grease penetration | | | <pre>[s/0.1 mL] towel + minutes, hours, or days [min, h, or d]</pre> |
| | ISO 5634 ASTM D 722 | | | seconds [s] |
| | TAPPI T 454 | | | |
| 5.12 | Printing ink penetration (Castor oil test) ASTM D 780 TAPPI T 462 | | | seconds [s] |
| 5.13 | Air permeance, general ISO 5636/1 | cubic feet per minute square foot 0.5-inch water [ft 3 /(min·ft 2 ·0.5 in. H $_2$ O)] | 40.83 | + micrometres per pascal second [μm/(Pa·s)] |
| 544 | TAPPI T 251 | as Williams and assistant (Dandtons) for Live in | 0.04404 | |
| 5.14 | Air permeance, Bendtsen ISO 5636/3 | millilitres per minute (Bendtsen) [mL/min | 0.01134 | micrometres per pascal second [µm/ (Pa·s)] |
| 5.15 | Air permeance, Sheffield | (Bendtsen)] millilitres per minute [mL/min] (Sheffield corrected) where A = test area in square millimetres | 162/A | micrometres per pascal second [μ m/ (Pa·s)] |
| 5.16 | Air resistance, general | | | pascal seconds per metre [Pa·s/m] |
| 5.17 | Air resistance, Gurley ISO 3687, 5270, 5336/5 ASTM D 726 TAPPI T 460, T 536 | seconds [s] sometimes expressed as seconds per 100 millilitres | *1.000 | #seconds (Gurley) [s(Gurley)] |
| 6. | Optical Properties | | | |
| 6.1 | Reflectance factor ISO 2469, 2470, 3688 ASTM D 985 | | | + percent [%] |
| 6.2 | TAPPI T 452, T 442, T 525, T 534, T 646 Opacity ISO 2469, 2471 ASTM D 589 | | | + percent [%] |
| 6.3 | TAPPI T 425, T519 Gloss, 75° | | | + percent [%] or numerical value |
| | ISO 8254/1 | | | (gloss units) |
| | ASTM D 1223 TAPPI T 480, T 653 | | | |
| 6.4 | Reflection (optical) density | | | + numerical value |
| 6.5 6.6 | Transmission (optical) density Light absorbing power | | | + numerical value + numerical value |
| 6.7 | Light scattering power | | | + numerical value |
| 6.8 | Light absorption coefficient | square centimetres per gram [cm²/g] | *0.100 | + square metres per kilogram [m²/kg] |
| 6.9 | Light scattering coefficient | square centimetres per gram [cm²/g] | *0.100 | + square metres per kilogram [m²/ kg] |
| 7. | TAPPI T 220 Electrical Properties | | | . |
| 7.1 | Conductivity of extracts | micromhos per centimetre [$\mu\Omega^{-1}$ /cm] | *0.100 | + millisiemens per metre [mS/m] |
| | ISO 6587 ASTM D202 | microsiemens per centimetre [μS/cm] | *0.100 | millisiemens per metre [mS/m] |
| 7.2 | TAPPI T252 Surface resistivity | | | + ohms $[\Omega]$ |
| 7.2 7.3 7.4 | Volume resistivity Electrical strength | ohm centimetres [Ω ·cm] volts per mil [V/mil] | *0.010 0.03937 | + ohm metres [Ω·m] + kilovolts per millimetre [kV/mm] |
| 8. | Composition | vollo por rim [v/rim] | 0.00001 | i Miovolo per minimette [kv/mm] |
| 8.1 | Moisture content (or dry matter content) ISO 287, 638 ASTM D 644, D 2044 | | | + percent [%] (of total mass) |
| | TAPPI T 264, T 208, T 220, T 258, T 412, T 671 | | | |
| 8.2 | Stock concentration ISO 4119 TAPPI T240 | | | + percent [%] (of total mass) |



| | Property and ISO Standard | To Convert Values Expressed in Customary Units | Multiply by | To Obtain Values Expressed in Recommended Form |
|------------------|---|---|---|---|
| 8.3 | Ash ISO 1762, 2144, 2638 ASTM D 586 TAPPI T 413, T 211 | | | + percent [%] (of dry mass) |
| 8.4 | Other major constituents or coatings: Mass per unit area ASTM D2 423 TAPPI T 405, T 497, T 531, T 532 | (See 1.1 for conversion factors) | | + grams per square metre [g/m²] |
| 8.5 | T 688, T 690, T 691 Other major constituents: Relative mass ISO 624, 692, 699, 3260 ASTM D 202, D 549, D 984, D 1030, D 1224, D 548, D 588, D 590, D 591, D 921, D 982, D 1099, D 1160 TAPPI T 401, T 405, T 406, T 408, T 418, T 419, T 428, T 438, T 429, T 493, T 504, T 612, T 627, T 688, T 691, T 203, T 204, T 207, T 212, T 222, T 235, T 249, T 250, T 255, T 256, T 261 | | | + percent [%] (of dry mass) |
| 8.5.1 8.6 | ASTM D590 Dirt—area basis ASTM D 2019 | parts per million [ppm] (by area) | *1.000 | percent [%] (of conditioned mass) square millimetres per square metre [mm²/ m²] |
| 8.7 | TAPPI T 213, T437 Dirt and shives—mass basis | | | square millimetres per kilogram [mm²/kg] |
| | ISO 5350 TAPPI T 246 | | *** | #100 times number of specks per kilogram [100(no. specks/kg)] |
| 8.8 | Other minor constituents ISO 776, 777, 778, 779, 1830, 9197, 9198 ASTM D 202 TAPPI T 241, T 242, T 243, T 244, T 245, T 247, T 434 | parts per million [ppm] (by mass) | *1.000 | + milligrams per kilograms [mg/kg] |
| 8.9 | Saleable mass ISO 801 TAPPI T210 | | | + kg |
| 8.10 | Degree of delignification Kappa number; Chlorine consumption ISO 302, 3260 | | | + percent [%] or numerical value |
| 8.11 | TAPPI T 236 Copper number ASTM D9 19 TAPPI T 430 | | | number (g copper/100 g fiber) |
| 9. 9.1 | General Units Found in Pulp, Paper, and Paper-Board Testing Documents Linear dimensions, including optical wave- length | angstroms [Å] | *0.100 | nanometres [nm] |
| | lengur | microns mils [mil, or 0.001 in.] inches [in.] feet [ft] miles [mi] | *1.000 *0.0254 *25.4 *0.3048 1.609 | micrometres [µm] millimetres [mm] millimetres [mm] metres [m] kilometres [km] |
| 9.1.1 | Fiber length TAPPI T 232, T 233 | | | millimetres [mm] square millimetres [mm²] |
| 9.2 | Area | square inches [in.²] square feet [ft²] square yards [yd²] acres hectares [ha] square miles [mi²] | *6.4516 *0.09290304 *0.83612736 4046.86 *0.0100 2.589988 | square millimetres [mm ⁻] square centimetres [cm ²] square metres [m ²] square metres [m ²] square kilometres [km ²] square kilometres [km ²] |
| 9.3 | Volume | cubic feet [ft³] cubic yards [yd³] | *1.000 16.38706 28.316585 0.7645549 | cubic millimetres [mm³] cubic centimetres [cm³] cubic decimetres [dm³] cubic metres [m³] |
| 9.4 | Volume of fluids (as above plus:) | fluid ounces (US) [fl oz (US)] fluid ounces (Imp) [fl oz (Imp)] gallons (US) [gal(US)] gallons (Imp) [gal(Imp)] | 29.57353 28.413 3.785412 4.546092 | millilitres [mL] millilitres [mL] litres [l or L] (L preferred, US) litres [L] |
| 9.5 | Mass | ounces (avdp) [oz] | 28.34952 | micrograms [µg] milligrams [mg] grams [g] |



| | Property and ISO Standard | To Convert Values Expressed in Customary Units | Multiply by | To Obtain Values Expressed in Recommended Form |
|----------------------|--|---|---|---|
| | | pounds [lb or lbm, lb preferred] | 0.4535924 | kilograms [kg] |
| 9.6 | Mass per unit length TAPPI T 234 | tons (= 2000 lb) milligrams per 100 metres [mg/100 m] or decigrex | 0.9071847 *0.0100 | metric tons or tonne [t] (= 1000 kg) milligrams per metre [mg/m] |
| 9.7 9.8 | Mass per unit area (also see 1.1, 8.4) Mass per unit volume, or Density (also see 1.3) | tons per 100 square feet [ton/100 ft²] ounces per gallon [oz/gal] | 0.092903 7.489152 | tonne per square metre [t/m²] grams per litre [g/L] |
| | , | pounds per gallon [lb/gal] grams per litre [g/L] | 0.1198264 *1.000 | kilograms per litre [kg/L] kilograms per cubic metre [kg/m³] |
| 9.9 | Time | pounds per cubic inch [lb/in. ³] | 27.67990 | megagrams per cubic metre [Mg/m³] microseconds [µs] milliseconds [ms] seconds [s] minutes [min] (= 60 seconds [s]) hours [h] (= 3.6 kiloseconds [ks]) |
| 9.10 | Speed | feet per second [ft/s] | *0.30480 | days [d] (= 86.4 kiloseconds [ks]) metres per second [m/s] |
| 9.11 | Volume flow rate | feet per minute [ft/min or fpm] gallons per minute [gal/min or GPM] cubic feet per second [ft ³ /s] | *5.080 3.78541 0.02831685 | millimetres per second [mm/s] litres per minute [L/min] cubic metres per second [m³/s] |
| 9.12 | Force | cubic feet per minute [ft³/min or cfm] pounds-force [lbf] (factor exactly | 1.69901 4.448222 | cubic metres per hour [m³/h] newtons [N] |
| | | 4.448 221 615 260 5) ounces-force [ozf] kilograms-force [kgf] | 0.278014 *9.80665 | newtons [N] newtons [N] |
| 9.13 | Force per unit length (linear load) Surface tension TAPPI T 517 | dynes [dyn] pounds-force per inch [lbt/in.] dynes per centimetre [dyn/cm] | *0.0100 0.1751268 *1.000 | millinewtons [mN] kilonewtons per metre [kN/m] millinewtons per metre [mN/m] |
| 9.14 | Force per unit area Pressure Stress | newtons per square metre [N/m²] grams-force per square centimetre [gf/cm²] pounds-force per square foot [lbf/ft²] pounds-force per square inch [lbf/in.² or psi] millimetres of mercury (0°C) [mmHg] inches of water (60°F) [in.H₂O] feet of water (39.2°F) [ftH₂O] inches of mercury (60°F) [in.Hg] inches of mercury (32°F) [in.Hg] atmospheres [atm] | *1.000 *98.0665 47.88026 6.894757 0.133322 0.24884 2.98898 3.37685 3.38638 *0.101325 | pascals [Pa] pascals [Pa] pascals [Pa] pascals [Pa] kilopascals [kPa] kilopascals [kPa] kilopascals [kPa] kilopascals [kPa] kilopascals [kPa] kilopascals [kPa] megapascals [MPa] |
| 9.15 | Torque, or bending moment (also see 3.2) | bars [bar] pound-force feet [lbf-ft] | *100 .35582 | kilopascals [kPa] newton metres [N·m] |
| 9.16 | Energy | dyne centimetres [dyn·cm] metre newtons [m·N] = 10 ⁷ ergs foot-pounds force [ft-lbf] metre kilograms-force [m·kgf] British thermal units, Int. [Btu] kilocalories, Int. Table [kcal] horsepower hours [hp·h] | *0.1000 *1.000 1.35582 *9.80665 1.055056 *4.1868 2.68452 | micronewton metres [μN·m] joules [J] joules [J] joules [J] kilojoules [kJ] kilojoules [kJ] megajoules [MJ] |
| 9.17 | Power | kilowatt hours [kW-h or kWh] foot pounds-force per second [ft-lbf/s] horsepower [hp] (= 550 foot-pounds force per second) | *3.600 1.35582 745.700 | megajoules [MJ] watts [W] watts [W] |
| 9.18 | Dynamic viscosity TAPPI T 630, T 634, T 652, T 662, T 675, T 814 | metric horsepower poise [P] centipoise [cP] | 735.499 *0.100 *1.000 | watts [W] pascal seconds [Pa·s] millipascal seconds [mPa·s] |
| 9.19 | Kinematic viscosity | centistokes [cSt] | *1.000 | square millimetres per second [mm²/s] |
| 9.20 | Limiting viscosity number ISO 5351 | | | #millilitres per gram [mL/g] |
| 9.21 | Illumination | footcandles [fc] footcandles [fc] degrees Fahrenheit [°F] T _C = (5/9)(T _F - 32) | 10.76391 10.76391 | lumens per square metre [lm/m²] lux [lx] |
| 9.22 9.23 | Temperature Temperature change | degrees Celsius [°C] $T_K = T_C + 273.15$ Fahrenheit degrees change [ΔF] | 0.555556 | degrees Celsius [°C] kelvin [K] Celsius degrees change [Δ C] |
| 9.24 | Color temperature | Celsius degrees change [Δ C] | *1.000 | kelvin change [Δ K] kelvin [K] |
| 9.25 9.26 9.27 | Frequency Rotational frequency Plane angle | cycles per second [s ⁻¹] | *1.000 | hertz [Hz] revolutions per second [r/s or s ⁻¹] degrees [°] (decimal subdivisions) + numerical value (pH units) |



Property and ISO Standard

To Convert Values Expressed in Customary Units

Multiply by

To Obtain Values Expressed in Recommended Form

ASTM D7 78

TAPPI T 252, T 435, T 509, T529, T 667

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