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Standard Terminology Relating to Conditioning, Chemical, and Thermal Properties[1]

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1. Scope

1.1 This standard is the compilation of definition of technical terms related to conditioning, chemical, and thermal properties in textiles. Terms that are generally understood or adequately defined in other readily available sources are not included.

1.2 For other ASTM defined conditioning terms, refer to Terminology E41. For other terms associated with textiles, refer to Terminology D123, Relating to Textiles.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles
E41 Terminology Relating To Conditioning
D578 Specification for Glass Fiber Strands
D579 Specification for Greige Woven Glass Fabrics
D580 Specification for Greige Woven Glass Tapes and Webbings
D581 Specification for Glass Fiber Greige Braided Tubular Sleeving
D885/D885M Test Methods for Tire Cords, Tire Cord Fabrics, and Industrial Filament Yarns Made from Manufactured Organic-Base Fibers
D1776 Practice for Conditioning and Testing Textiles
D1907 Test Method for Linear Density of Yarn (Yarn Number) by the Skein Method
D2118 Practice for Assigning a Standard Commercial Moisture Content for Wool and its' Products
D2494 Test Method for Commercial Mass of a Shipment of Yarn or Manufactured Staple Fiber or Tow
D2970/D2970M Test Methods for Testing Tire Cords, Tire Cord Fabrics, and Industrial Yarns Made From Glass Filaments
D3887 Specification for Tolerances for Knitted Fabrics
D4772 Test Method for Surface Water Absorption of Terry Fabrics (Water Flow)

3. Terminology

3.1 *Definitions:*

absolute humidity, *n*—the mass of water vapor present in a unit volume of air.

DISCUSSION—Common units of measure for absolute humidity are grams per cubic metre or grains per cubic foot. The amount of water vapor is also reported in terms of mass per unit mass of dry air, for example, grams per kilogram, or grains per pound, of dry air. This value differs from values calculated on a volume basis and should not be referred to as **absolute humidity**. It is designated as humidity ratio, specific humidity, or **moisture pick-up**.

absorption, *n*—a process in which one material (the absorbent) takes in or absorbs another (the absorbate); as the absorption of moisture by fibers. (See also **adsorption**. Compare **desorption** and **resorption**.) **D4772**

accelerated conditioning, *n*—a process that uses humidity generation and precise temperature controls to rapidly bring a textile to equilibrium in a standard atmosphere.

DISCUSSION—Accelerated conditioning may be achieved in closed cabinets, rooms or process lines designed such that equilibrium can be achieved in a much shorter time, such as 2 to 10 min, compared to typical conditioning times.

adsorption, *n*—a process in which the surface of a solid takes on or adsorbs in an extremely thin layer molecules of gases, of dissolved substances, or of liquids with which it is in contact. (See also **absorption** and **moisture equilibrium**. Compare **desorption** and **resorption**.)

atmosphere for testing, *n*—air at ambient conditions of relative humidity and temperature in which tests or experiments are conducted. (See also **standard atmosphere for testing**.)

DISCUSSION—In the hierarchy of terms, *atmosphere* is the generic term where the air is ambient with conditions "controlled" by local weather and therefore variable. **Atmosphere for testing** is a delimited term in which the use of the atmosphere is restricted for a certain purpose. In a **standard atmosphere for testing**, the conditions are specified (standardized) and controlled for routine testing and for testing reproducibility. On this basis, there is no real reason for not referring to the specified atmospheres that have been traditionally used for testing glass textiles or tire cords, etc., as **standard atmospheres for testing** those materials.

[1] This terminology is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.51 on Conditioning and, Chemical and Thermal Properties.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

bicomponent fiber, *n*—a fiber consisting of two polymers which are chemically different, physically different, or both.

birefringence (double refraction), *n*—a property of anisotropic materials which manifests itself as a splitting of a light ray into components having different vibration directions which are transmitted at different velocities.

DISCUSSION—The vibration directions of the components are the principal axes of the material and the corresponding indices of refraction are its principal (maximum of minimum) refractive indices. Numerically, birefringence is the difference between the maximum and minimum refractive indices.

bulk density, *n*—apparent mass per unit volume.

DISCUSSION—In testing the termal transmittance of fabrics, bulk density is calculated from the fabric weight per unit area and the thickness value used to calculate thermal conductivity.

clo, *n*—unit of thermal resistance defined as the insulation required to keep a resting man (producing heat at the rate of 58 W/m^2) confortable in an environment at 21°C, air movement 0.1 m/s, or roughly the insulation value of typical indoor clothing. (Syn. intrinsic clo).

DISCUSSION—Numerically the clo is equal to 0.155 $K \cdot m^2/W$.

commercial allowance (CA), *n*—a defined value, equal to the commercial moisture regain, plus a specified allowance for finish, used with the mass of scoured, oven-dried yarn, to compute (1) yarn linear density, (2) the commercial or legal mass of a shipment or delivery of any specific textile material (see also *commercial moisture regain*), or (3) the mass of a specific component in the analysis of fiber blends. **D1907, D2494, D3887**

commercial mass, *n*—billed mass as determined by a generally accepted method or as agreed upon between the purchaser and seller. **D2494**

commercial moisture content, *n—in wool*, the moisture calculated as a percentage of the mass of the wool, top, noils, yarn, fabric, etc., in the "as-is" condition; that is, containing whatever moisture, oil, grease, or other extraneous matter that may be present. **D2118**

commercial moisture regain (CMR), *n*—a formally adopted, defined value, to be used with the oven-dried mass of textile fibers, when calculating the commercial mass of a shipment or delivery.

DISCUSSION—The assigned commercial moisture regain value is usually higher than the experimental moisture regain value for the same material.

condition, *v*—to bring a material to moisture equilibrium with a specified atmosphere.

density, *n*—mass per unit volume.

DISCUSSION—Due to the volume of included air, the apparent density of fibers and yarns will differ from the densities of the materials of which the fibers and yarns are composed. Test results for fiber density will also vary depending on the test method used. Density is commonly expressed as grams per cubic centimetre (g/cm^3), but the preferred term in the International System of Units is kilograms per cubic metre (kg/m^3). Multiply g/cm^3 by 1000 to obtain kg/m^3 and mulitply lb/ft^3 by 16.018 to obtain kg/m^3.

desorption, *n*—a process in which a sorbed material is released from another material, as the desorption of moisture from fibers; the reverse of absorption, adsorption, or both.

dew point, *n*—the temperature below which condensation of water vapor begins to take place when the atmosphere is cooled.

DISCUSSION—As air is cooled, the amount of water vapor which it can hold decreases. If air is cooled sufficiently, the saturation water-vapor pressure becomes equal to the actual water-vapor pressure and any further cooling beyond this point will normally result in the condensation of moisture.

effective insulation ratio, *n*—indicates the increase in insulation afforded by the fabric in comparison to the uncovered test plate under specified conditions of test.

extractable matter, *n*—nonfibrous material in or on a textile not including water, which is removable by a specified solvent or solvents as directed in a specified procedure.

DISCUSSION—Nonfibrous material is usually oily, waxy, resinous, or polymeric in nature, but may also include other material, such as protein, particularly if ethyl alcohol is used, or in, the extracting solvent.

fiber birefringence, *n*—the algebraic difference of the index of refraction of the fiber for plane polarized light vibrating parallel to the longitudinal axis of the fiber and the index of refraction for light vibrating perpendicular to the long axis.

DISCUSSION—Fiber birefringence may be either positive or negative, and is not necessarily referred to the principal optical axes of the material.

fiber density, *n*—mass per unit volume of the solid matter of which a fiber is composed, measured under specified conditions.

DISCUSSION—Unless otherwise indicated, fiber density is understood to be measured by immersion (buoyancy) techniques, at standard atmosphere for testing, excluding effects due to included air and swelling or dissolving of the fiber by the immersion fluid.

heat transfer coefficient, *n*—see thermal transmittance.

humidity, *n*—the condition of the atmosphere in respect to water vapor. (Compare **absolute humidity** and **relative humidity**.)

hygrometer, *n*—any instrument for measuring the humidity of the atmosphere.

intrinsic clo, *n*—see clo.

mean temperature, *n*—the average of the hot plate temperature and the temperature of the calm, cool air that prevailed during the test.

moisture, *n—as used with textiles*, water absorbed, adsorbed, or resorbed by a material. (See also **water**.)

moisture as-is, *n*—deprecated term. See **moisture content**.

moisture as-received, *n*—deprecated term. See **moisture content**.

moisture content, *n—at moisture equilibrium*, that part of the total mass of a material that is absorbed or adsorbed water, compared to the total mass. (Compare **moisture pick-up** and **moisture regain**.)

DISCUSSION—Moisture is usually expressed as a percentage and is calculated using the equation:

$$C = 100\,(A - D)/A$$

where:

C = moisture content, %,
A = mass of material before drying, and
D = mass of the dried material.

There is a relationship between **moisture content** and **moisture pick-up** since both may be calculated from the same data. The difference is in the bases used for calculating the percentages, original versus dried material mass. The relationship between moisture content and moisture pick-up is shown by the equations:

$$C = 100\,P/(100+P)$$

$$P = 100\,C/(100 - C)$$

where:

C = moisture content, %, and
P = moisture pick-up, %.

moisture content (dry-basis), *n*—deprecated term. See **moisture pick-up**.

moisture (dry-basis), *n*—deprecated term. See **moisture pick-up**.

moisture equilibrium, *n*—the condition reached by a material when it no longer takes up moisture from, or gives up moisture to, the surrounding atmosphere. (Compare **moisture-free**.)

DISCUSSION—The establishment of equilibrium between a material and the surrounding atmosphere is dependent upon the exposure time, the difference in moisture levels between the material and the atmosphere, and motion of the air about the material. The level at which the moisture in the textile reaches equilibrium depends upon the side from which equilibrium is approached. Because of this difference, equilibrium for textiles should be approached from the dry (but not moisture-free) side which is faster. Superficial equilibrium is reached very rapidly when air comes into contact with the outer surfaces of a textile. Moisture equilibrium can be reached in a reasonable time only if the air to which the sample is exposed is in motion. Moisture equilibrium, with air temperature (in motion) and relative humidity controlled to prescribed levels, is achieved when successive weighings do not show a progressive change in mass greater than the tolerance established for the textile. **D1776, D885/D885M**

moisture-free, *adj—in textiles*, a descriptive term for a material that (1) has been exposed to a flow of desiccated air at a specified temperature until there is no further significant change in mass, or (2) has been treated by a distillation process using a suitable solvent. (Syn. **zero-moisture**.) (Compare **moisture equilibrium**.)

DISCUSSION—Moisture determinations frequently involve the change in mass of an oven-dried specimen. If the air in the oven contains moisture, the oven-dried specimen will also contain some moisture even though it no longer shows a significant change in mass. This is due to the establishment of moisture equilibrium under the existing conditions. To ensure that the specimen is actually moisture-free, it must be exposed to desiccated air until it shows no further significant change in mass. Although heating textiles in dessicated air to temperatures as high as 110°C increases the rate of moisture loss without changing the final equilibrium mass of the moisture-free textile, heating also increases the possibility of removing other matter. The distillation process may be substituted provided the textile does not contain any distillable, water-soluble matter.

moisture pick-up, *n—at moisture equilibrium*, the mass of absorbed and adsorbed water that is held by a material, compared to the mass of the dried material. (Compare **moisture content** and **moisture regain**.)

DISCUSSION—Moisture pick-up is usually expressed as a percentage based on the dried mass of the material and is calculated using the equation:

$$P = 100\,(A - D)/D$$

where:

P = moisture pick-up, %
A = mass of material before drying, and
D = mass of the material after drying under specified conditions.

There is a relationship between **moisture pick-up** and **moisture content** since both may be calculated from the same data. The difference is in the bases used for calculating the percentages, original versus dried material mass. The relationship between moisture content and moisture pick-up is shown by the equations:

$$C = 100\,P/(100+P)$$

$$P = 100\,C/(100 - C)$$

where:

C = moisture content, %, and
P = moisture pick-up, %.

Since **moisture pick-up**, like **moisture content**, involves the original mass, or "as-is, where-is" (from a location with unknown temperature and humidity conditions) state of the material, it is generally unknown if the loss in mass on drying is caused by the loss of any materials other than water.

moisture regain, *n*—the amount of water resorbed by a dried material at specified equilibrium conditions of temperature and humidity, compared to the mass of the dried material. (See **standard moisture regain**.) (Compare **commercial moisture regain, moisture content**, and **moisture pick-up**.)

DISCUSSION—**Moisture regain** is usually expressed as a percentage and is calculated using the equation:

$$R = 100(B - D)/D$$

where:

R = moisture regain, %,
B = mass of material in moisture-equilibrium at specified conditions,
D = mass of material dried under specified conditions.

Since most surface matter can be extracted without appreciably affecting the textile material, or the textile material can be produced without surface matter (except natural fibers), anything removed by drying or distillation after moisture-equilibrium is established is water. This is a key difference between **moisture regain** and **moisture pick-up**, which have been traditionally, but incorrectly, used synonymously.

moisture, wet-basis, *n*—deprecated term. See **moisture content**.

oven-dried, *adj*—a descriptive term for a material that has been heated under prescribed conditions of temperature and humidity until there is no further significant change in the mass of the material.

DISCUSSION—An **oven-dried** material retains a small amount of moisture which is dependent upon the temperature and relative humidity of the air supplied to the oven. An **oven-dried** material will only be **moisture-free** if the air supplied to the oven has been desiccated.

precondition, *v*—to bring a sample or specimen of a textile to a relatively low moisture content (approximate equilibrium an atmosphere between 5 and 25% relative humidity) prior to conditioning in a controlled atmosphere for testing.

psychrometer, *n*—a variety of hygrometer comprising a dry bulb temperature indicator and a wet bulb temperature indicator which is cooled to the wet bulb temperature by the spontaneous evaporation of moisture.

refraction, *n*—the deflection from a straight path undergone by a light ray in passing obliquely from one medium (as air) into another (as glass) in which its velocity is different.

refractive index (index of refraction), *n*—the ratio of the velocity of radiation (as light) in the first of two media to its velocity in the second as it passes from one into the other.

DISCUSSION—When refractive index is referred to as a property of a substance, the first medium is understood to be vacuum. The index of refraction is equal to the ratio of the sine of the angle of the incident ray to the sine of the angle of the refracted ray (angles measured from the normal to the common boundary). In general the refractive index of a substance varies with the frequency of the radiation (13).

relative humidity, *n—of air*, the ratio of the pressure of water vapor present to the pressure of saturated water vapor at the same temperature.

DISCUSSION—The ratio of the vapor pressures is expressed as a decimal fraction or, more generally, as a percentage. For normal testing conditions, the ratio of the actual absolute humidity to the maximum possible humidity at the same temperature does not differ appreciably from the ratio of the pressures used in the above definition. The agreement holds for temperatures up to 93°C (200°F) and below saturation.

resorption, *n*—the process by which a material that has given up another material by **desorption** takes up some more of the material given up.

sorption, *n*—the process of taking up or holding a material by **adsorption, absorption**, or both.

specific clo, *n*—the specific thermal resistance in clo units per unit thickness.

standard atmosphere for preconditioning, *n*—a set of controlled conditions as specified in D1776, designed to dry the textile prior to conditioning in the standard atmosphere for testing textiles. (See **moisture equilibrium**.) **D1776**

standard atmosphere for testing, *n*—an atmosphere for testing in which the conditions for relative humidity and temperature are specified and controlled. (Compare **atmosphere for testing**.) **D578, D579, D580, D581, D885/D885M, D2970/D2970M**

standard moisture regain, *n*—the moisture regain of a material at equilibrium with the standard atmosphere for testing textiles. (See **moisture regain** and **moisture equilibrium**.)

temperature difference, ΔT, *n*—temperature difference between two surfaces of a fabric, °C.

temperature regulating factor, TRF, *n*—amplitude of the temperature variation of the hot plate divided by the product of the amplitude of the hot plate flux variation and the steady state R-value, all determined according to the test protocol described below. The temperature regulating factor is useful in comparing fabrics that store and release energy and thereby regulate their surface temperature.

thermal conductance, *n*—see thermal transmittance.

thermal conductivity, *n*—time rate of unidirectional heat transfer per unit area, in the steady-state, between parallel planes separated by unit distance, per unit difference of temperature of the planes. Discussion—Numerically, thermal conductivity equals the product of the heat transfer coefficient and the distance separating the planes. Thus, *k*, the thermal conductivity of the fabric only, is the product of U_2 and the fabric thickness. Units of thermal conductivity are *W/m·K*.

thermal resistance, *n*—reciprocal of thermal transmittance.

thermal resistivity, *n*—reciprocal of thermal conductivity.

thermal transmittance, *n*—time rate of unidirectional heat transfer per unit area, in the steady-state, between parallel planes, per unit difference of temperature of the planes (Syn. thermal conductance, heat transfer coefficient). Discussion—Thermal transmittance is expressed as watts per square metre of test specimen per kelvin difference between the hot plate and the cool atmosphere ($W/m^2 \cdot K$).

Thermal transmittance for three different cases is determined in this method:

U_1 = combined thermal transmittance of the test specimen and air.

U_{bp} = thermal transmittance of the plate without fabric cover ("bare plate"). This property reflects the instrument constant and is used to standardize the plate, and, in conjunction with U_1, is used in the calculation of U_2.

U_2 = thermal transmittance of fabric only. This value corresponds to the *C* value ($W/m^2 \cdot K$) defined and used by ASTM and ASHRAE. In the calculation of this value the assumption is made that the boundary layers of the bare plate and the boundary layers of the fabric are equal. Experimental results indicate that the U_2 values are valid when tested within the limits specified in Section 1.

total clo, *n*—the intrinsic clo plus the thermal resistance from the air boundary.

volatiles, *n*—materials readily vaporizable at relatively low temperatures.

DISCUSSION—When the nature of the loss in mass on heating is not known to be water only; the lost matter should be called "volatiles" with subsequent modification of these moisture content and pick-up terms.

water, *n*—the chemical compound, H_2O. (*Syn.* **moisture**).

zero-moisture, *adj*—See **moisture-free**, the preferred term.

4. Keywords

4.1 moisture; terminology; textiles