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Standard Terminology Relating to Thermal Insulation[1]

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1. Scope

1.1 This standard provides definitions, symbols, units, and abbreviations of terms used in ASTM standards pertaining to thermal insulating materials, and to materials associated with them.

1.2 This terminology is not intended to be used to classify insulation materials as having particular properties. Rather, classification of insulation materials is to be done by the material standards themselves.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E456 Terminology Relating to Quality and Statistics

E2282 Guide for Defining the Test Result of a Test Method

2.2 *ISO Standard:*

ISO 7345 Thermal Insulation—Physical Quantities and Definitions[2]

3. Terminology

3.1 *Definitions:*

absorptance, *n*—the ratio of the radiant flux absorbed by a body to that incident upon it.

absorption, *n*—transformation of radiant energy to a different form of energy by interaction with matter.

apparent thermal conductivity, λ_a, k_a, *n*—a thermal conductivity assigned to a material that exhibits thermal transmission by several modes of heat transfer resulting in property variation with specimen thickness, or surface emittance. See **conductivity, thermal**.

DISCUSSION—Thermal conductivity and resistivity are normally considered to be intrinsic or specific properties of materials and, as such, should be independent of thickness. When nonconductive modes of heat transfer are present within the specimen (radiation, free convection) this may not be the case. To indicate the possible presence of this phenomena (for example, thickness effect) the modifier "apparent" is used, as in apparent thermal conductivity.

DISCUSSION—Test data using the "apparent" modifier must be quoted only for the conditions of the measurement. Values of thermal conductance (material *C*) and thermal resistance (material *R*) calculated from apparent thermal conductivity or resistivity, are valid only for the same conditions.

DISCUSSION—Test data labeled with "apparent" shall not include any equipment related measurement errors induced due to measurement attempts beyond an apparatus range or calibration.

DISCUSSION—Use of the "apparent" modifier with system *C* or system *R* measurements is not permitted.

apparent thermal resistivity, r_a, *n*—a thermal resistivity assigned to a material that exhibits thermal transmission by several modes of heat transfer resulting in property variation with specimen thickness, or surface emittance. See **resistivity, thermal**.

DISCUSSION—See entire discussion under **apparent thermal conductivity.**

area weight, *n*—weight per unit area for a specified sample, in units of $lb/ft^2 (kg/m^2)$.

aerogel, *n*—a homogeneous, low-density solid phase material derived from a gel, in which the liquid component of the gel has been replaced with a gas.

[1] This terminology is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.94 on Terminology.

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[2] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

DISCUSSION—The resulting material has a porous structure with an average pore size below the mean free path of air molecules at standard atmospheric pressure and temperature.

batt, *n*—blanket insulation manufactured to dimensions as required by a specific application.

blackbody, *n*—the ideal, perfect emitter and absorber of thermal radiation. It emits radiant energy at each wavelength at the maximum rate possible as a consequence of its temperature, and absorbs all incident radiance.

blanket, *n*—flexible insulation product, supplied rolled or flat.

blanket insulation, *n*—a relatively flat and flexible insulation in coherent sheet form furnished in units of substantial area.

blanket insulation, metal mesh, *n*— blanket insulation covered by flexible metal-mesh facings attached on one or both sides.

block insulation, *n*—rigid insulation preformed into rectangular units.

board insulation, *n*—semirigid insulation preformed into rectangular units having a degree of suppleness particularly related to their geometrical dimensions.

calcium silicate, *n*—insulation composed principally of hydrous calcium silicate, and which usually contains reinforcing fibers.

cellular elastomeric, *n*—insulation composed principally of natural or synthetic elastomers, or both, processed to form a flexible, semirigid, or rigid foam which has a predominantly closed-cell structure.

cellular glass, *n*—insulation composed of glass processed to form a rigid foam having a predominantly closed-cell structure.

cellular polyimide, *n*—insulation composed of the reaction product in which the bonds formed between monomers during polymerization are essentially imide units forming a cellular structure.

cellular polystyrene, *n*—insulation composed principally of polymerized styrene resin processed to form a rigid foam having a predominantly closed-cell structure.

cellular polyurethane, *n*—insulation composed principally of the catalyzed reaction product of polyisocyanate and polyhydroxy compounds, processed usually with fluorocarbon gas to form a rigid foam having a predominantly closed-cell structure.

cellulosic fiber, *n*—insulation composed principally of cellulose fibers usually derived from paper, paperboard stock, or wood, with or without binders.

cement, finishing, *n*—a mixture of dry fibrous or powdery materials, or both, that when mixed with water develops a plastic consistency, and when dried in place forms a relatively hard, protective surface.

cement, insulating, *n*—a mixture of dry granular, flaky, fibrous, or powdery materials that when mixed with water develops a plastic consistency, and when dried in place forms a coherent covering that affords substantial resistance to heat transmission.

cladding, *n*—See **jacket**.

closed cell foam, *n*—a material comprised predominantly of individual non-interconnecting cellular voids.

coating, *n*—a liquid or semiliquid that dries or cures to form a protective finish, suitable for application to thermal insulation or other surfaces in thickness of 30 mils (0.76 mm) or less, per coat.

conductance, film, *n*—the time rate of heat flow from a unit area of a surface to its surroundings, induced by a unit temperature difference between the surface and the environment.

DISCUSSION—The environment is a fluid (liquids or gases). *h* depends on the nature of fluid motion past the surface (laminar or turbulent). (*h* in SI units: $W/m^2 \cdot K$).

conductance, thermal, *C*, *n*—the time rate of steady state heat flow through a unit area of a material or construction induced by a unit temperature difference between the body surfaces.

$$C = q/\Delta T$$

A conductance (*C*) associated with a material shall be specified as a material *C*. A conductance (*C*) associated with a system or construction of materials shall be specified as a system *C*. (*C* in SI units: W/m^2K.) (*C* in inch-pound units: $(Btu/h)/ft^2/F = Btu/h\ ft^2F$.)

DISCUSSION—The average temperature of a surface is the area-weighted temperature of that surface.

DISCUSSION—When the surfaces of a mass type thermal insulation are not of equal areas, as in the case of thermal transmission in the radial direction, or are not of uniform separation (thickness), the surface area and thickness to which the conductance is assigned must be defined.

DISCUSSION—"Total'' or "areal'' thermal conductance are often used as synonyms for thermal conductance.

DISCUSSION—Thermal conductance and thermal resistance are reciprocals of one another.

DISCUSSION—See Discussion under **resistance, thermal.**

conductivity, thermal, λ or *k*, *n*—the time rate of steady state heat flow through a unit area of a homogeneous material induced by a unit temperature gradient in a direction perpendicular to that unit area. (λ or *k* in SI units: $(W/m^2)/(K/m) = W/m\ K$.) (λ or *k* in inch-pound units: $(Btu/h)/ft^2/(F/ft) = Btu/h\ ft\ F$) or $(Btu/h)/ft^2/(F/in.) = Btu\ in./h\ ft^2\ F$.) (See discussion under **apparent thermal conductivity**.)

DISCUSSION—Thermal conductivity testing is usually done in one of two apparatus/specimen geometries: flat-slab specimens with parallel heat flux lines, or cylindrical specimens with radial heat flux lines. The operational definitions of thermal conductivity for these two cases are given as follows:

where:
Q = heat flow rate,
A = area through which Q passes, and
L = thickness of the flat-slab specimen across which the temperature difference ΔT exists.

The $\Delta T/L$ ratio approximates the temperature gradient.

where:
l = length,
r_2 = the outer radius, and
r_1 = the inner radius of the cylinder.

Eq 1 and Eq 2 are actually special-case simplifications of the more general definition:
thermal conductivity, λ—a tensor property defined by the tensor equation:

where q is the heat flux vector, and ΔT (grad T) is the temperature gradient vector. Except in theoretical discussions, this generalized form of the definition is seldom used. For experimental situations, the geometry of the testing apparatus and the specimen are chosen such that Eq 3 reduces to the one-dimensional scalar equation:

where:
Q = heat flow rate,
A = area through which Q passes,
λ = thermal conductivity, and
dT/du = the temperature gradient in the direction of heat flow.

At steady state, Eq 1 and Eq 2 are consistent with Eq 4 if ΔT is sufficiently small. If ΔT is not sufficiently small, then Eq 1 and Eq 2 define a mean thermal conductivity over the ΔT range, and this range in addition to the mean temperature should be stated.

Discussion—If the measured thermal property indicates that other than conductive heat flows are present, as evidenced by dependence on specimen thickness, air flow, or emittance of bounding surfaces, then this definition does not apply. See also, **apparent thermal conductivity.**

Discussion—Thermal conductivity and thermal resistivity are reciprocals of one another.

Discussion—As an additional reference and discussion along similar lines, see the International Standard ISO 7345 Annex.

coverage, *n*—the area to be covered per unit volume of coating to obtain specified dry thickness and desired performance.

covering capacity, dry, *n*—the area covered to a dry thickness of 1 in. (25 mm) by 100 lb (45.4 kg) of dry cement when mixed with the recommended amount of water, molded and dried to constant weight.

covering capacity, wet, *n*—the area covered to a wet thickness of 1 in. (25 mm) by 100 lb (45.4 kg) of dry cement when mixed with the recommended amount of water, and molded.

density,ρ, *n*—the mass per unit volume of a material. (ρ in SI units: kg/m3.) (ρ in inch-pound units: lb/ft3.)

Discussion—The term mass is used and not weight, due to the buoyancy effect of some low density closed cell insulations.

density, apparent (of applied insulation), *n*—the mass per unit volume of in-place mass thermal insulation.

dewpoint temperature, *n*—the temperature at which condensation of water vapor in a space begins for a given state of humidity and pressure as the vapor temperature is reduced; the temperature corresponding to saturation (100 % relative humidity) for a given absolute humidity at constant pressure.

diatomaceous silica, *n*—insulation composed principally of diatomaceous earth with or without binders, and which usually contains reinforcing fibers.

diffusivity, thermal, *n*—the ratio of thermal conductivity of a substance to the product of its density and specific heat. (In SI units: $(W/(m\cdot K))/((kg/m^3)\cdot(J/(kg\cdot K))) = m^2/s$.) (In inch-pound units: $(Btu/(hr\cdot ft)\ F)/((lb/ft^3)(Btu/(lb\cdot F))) = ft^2/hr$))

emittance, ε, *n*—the ratio of the radiant flux emitted by a specimen to that emitted by a blackbody at the same temperature and under the same conditions.

emittance, directional ε(θ; ϕ), *n*—the ratio of the radiance from a surface in a particular direction to the radiance from a blackbody at the same temperature under the same conditions.

emittance, hemispherical ε_H or ε(2π) , *n*—the average directional emittance over a hemispherical envelope covering a surface.

emittance, spectral ε_λ or ε(λ; θ;ϕ), *n*—an emittance based on the radiant energy emitted per unit wavelength interval (monochromatic radiant energy).

Discussion—Where necessary to avoid confusion, emittances should be designated by subscripts, for example: ε_{HT},$\varepsilon_{H\lambda}$, $\varepsilon_{N\lambda}$, $\varepsilon_{\theta\lambda}$,$\varepsilon_{HT}$. For most engineering purposes, the hemispherical total emittance ε_{HT} suffices.