

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** (as related to insulation jacketing).

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/m²·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/m²·K.) (*C* in inch-pound units: (Btu/h)/ft²/F = Btu/h ft²F.)

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/m²)/(K/m) = W/m K.) (*λ* or *k* in inch-pound units: (Btu/h)/ft²/(F/ft) = Btu/h ft F) or (Btu/h)/ft²/(F/in.) = Btu in./h ft² 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:

$$\text{Flat - slab geometry } \lambda = \frac{Q}{A} \frac{L}{\Delta T} \quad (1)$$

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.

$$\text{Cylindrical geometry } \lambda = \frac{Q}{2\pi l \Delta T} \log_e \frac{r_2}{r_1} \quad (2)$$

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:

$$q = -\lambda \Delta T \quad (3)$$

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:

$$Q = -A\lambda \frac{dT}{du} \quad (4)$$

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.

corrosion retarder (as related to insulation jacketing), n —See **moisture barrier (as related to insulation jacketing)**.

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•K))/((kg/m³)•(J/(kg•K))) = m²/s.) (In inch-pound units: (Btu/(hr•ft F))/((lb/ft³)(Btu/(lb•F))) = ft²/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 $\epsilon(\theta; \phi)$, 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 $\epsilon(2\pi)$, n —the average directional emittance over a hemispherical envelope covering a surface.

emittance, spectral ϵ_λ or $\epsilon(\lambda; \theta; \phi)$, 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} , $\epsilon_{H\lambda}$, $\epsilon_{N\lambda}$, $\epsilon_{\theta\lambda}$, ϵ_{HT} . For most engineering purposes, the hemispherical total emittance ϵ_{HT} suffices.

emittance, total ϵ_T or $\epsilon(t)$, n —an emittance that is an integrated average over all wavelengths of radiant energy emitted.

facer, n —the outermost adhered top or bottom, or both, sheet (or layer) of an insulation product, rigid or flexible, that is comprised of a different material than the insulation itself.

facing, n —a thin covering adhered to the surface of insulation prior to field installation.

fibrous glass, n —A synthetic vitreous fiber insulation made by melting predominantly silica sand and other inorganic materials, and then physically forming the melt into fibers.

DISCUSSION—Commonly referred to as fiber glass.

DISCUSSION—To form an insulation product, there are often other materials applied to the fibrous glass such as binders, oils, etc.

flexible cellular material, n —a cellular material that will not rupture within a specified time when bent around a mandrel at a specified uniform temperature and rate.

DISCUSSION—Test Methods D3574 “Standard Test Methods for Flexible Cellular Materials – Slab, Bonded and Molded Urethane Foams” provides a standard procedure for assessing whether an insulation material is a flexible cellular material.

graybody, n —a body having the same spectral emittance at all wavelengths.

glass fiber, n —fiber manufactured as continuous filament from molten glass, normally used for reinforcement, tissue or textiles.

glass wool, n—See **fibrous glass**.

heat flow; heat flow rate, Q , n —the quantity of heat transferred to or from a system in unit time. (Q in SI units: W .) (Q in inch-pound units: Btu/h .)

DISCUSSION—See **heat flux** for the areal dependence.

DISCUSSION—This definition is different than that given in some textbooks, which may use \dot{Q} , or q to represent heat flow rate. The ISO definition uses Φ .

heat flux, q , n —the heat flow rate through a surface of unit area perpendicular to the direction of heat flow.

(q in SI units: W/m^2)

(q in inch-pound units: $Btu/h/ft^2 = Btu/h\ ft^2$)

DISCUSSION—This definition has been used as heat flux density, or density of heat flow rate (defined as areal density of heat flow rate by ISO).

heat flux transducer, HFT, n —a device containing a thermopile (or equivalent) that produces an output which is a function of the heat flux.

DISCUSSION—In the past this device may also have been known as a heat flow meter, heat flux meter, heat flow sensor, or heat flux sensor.

DISCUSSION—The HFT output may also be a function of mean temperature, attachment, application, and environmental situation.

homogeneous material, n —a material in which relevant properties are not a function of the position within the material.

DISCUSSION—Homogeneity depends on the scale of the volume element used to examine the material. The purposes of Committee C16 are best suited if a macroscopic viewpoint is taken such that the standard insulating materials are considered homogeneous (for example, fibrous and cellular insulations), at least in the heat flow direction and time frame involved in a thermal test.

DISCUSSION—Relevant properties may be a function of such variables as time, direction, or temperature.

humidity, absolute, n —the mass of water vapor per unit volume.

humidity, relative, n —the ratio of the mol fraction of water vapor present in the air to the mol fraction of water vapor present in saturated air at the same temperature and barometric pressure. Approximately, it equals the ratio of the partial pressure or density of the water vapor in the air to the saturation pressure or density, respectively, at the same temperature.

jacket, n —a covering installed over insulation.

DISCUSSION—A facing is a type of jacket.

jacket (as related to insulation jacketing), n —a protective covering installed over thermal insulation.

jacketing, n —See **jacket, n** .

knit-line, n —a localized region within a foamed plastic insulation, typically noted as a “line” in a cross-section, that forms during manufacturing processes when concurrent flows or streams, or consecutive applications of foam plastic, meet.

lagging-covering, n —See **jacket (as related to insulation jacketing)**.

DISCUSSION—lagging-insulation is usually applied in the form of cut, pieced together or mitered parts.

lagging-insulation, n —Insulation used on pipe, tanks, ducts, vessels, or other mechanical equipment.

DISCUSSION—Lagging-insulation is usually applied in the form of cut, pieced together or mitered parts.

laminate jacket—a thin, flexible sheet material intended for use as a jacket over thermal insulation on pipe, duct, or equipment, and consisting of multiple layers of polymer film and aluminum foil bonded together.

DISCUSSION—A laminate jacket is available with or without a factory applied pressure sensitive adhesive.

DISCUSSION—Laminate jacket is commercially available in different widths, it typically is provided in approximate widths of pipe insulation sections.

DISCUSSION—A laminate jacket can also include a polymer coating as a top surface.

laminate tape, n —a thin, flexible sheet material intended for use as a tape to seal and secure a laminate jacket over thermal insulation on pipe, duct, or equipment.

DISCUSSION—Laminate tape always has a factory applied, pressure sensitive adhesive which first requires removal of a release liner.

DISCUSSION—Laminate tape is commercially available in several different widths.

DISCUSSION—A laminate tape can also include a polymer coating as a top surface.

loose fill insulation, n —insulation in granular, nodular, fibrous, powdery, or similar form designed to be installed by pouring, blowing, or hand placement.

mastic, n —a material of relatively viscous consistency that dries or cures to form a protective finish, suitable for application to thermal insulation in thickness greater than 30 mils (0.76 mm) per coat.

mean specific heat, n —the quantity of heat required to change the temperature of a unit mass of a substance one degree, measured as the average quantity over the temperature range specified. (It is distinguished from true specific heat by being an average rather than a point value.) (In SI units: $J/kg\cdot K$) (In inch-pound units: $Btu/lb\cdot F$)

metal lagging, n —See **jacket**.

microporous insulation, n —material in the form of compacted powder with an average interconnecting pore size comparable to or below the mean free path of air molecules at standard atmospheric temperature and pressure.

DISCUSSION—Microporous insulation may contain fibers to add integral strength and may contain opacifiers to reduce the amount of radiant heat transmitted.

mineral fiber, n —insulation composed principally of fibers manufactured from rock, slag, or glass, with or without binders.

mineral wool, n —A synthetic vitreous fiber insulation made by melting predominantly igneous rock, and or furnace slag, and other inorganic materials, and then physically forming the melt into fibers.

DISCUSSION—To form an insulation product, there are often other materials applied to the mineral wool such as binders, oils, etc.

moisture barrier (as related to insulation jacketing), *n*—a polymeric film or coating applied to the inner surface of metal jacketing for the primary purpose of reducing electrolytic, pitting, or crevice corrosion of the jacketing

DISCUSSION—Moisture barriers are not water vapor barriers or water vapor retarders

moisture retarder (as related to insulation jacketing), *n*—See **moisture barrier** (as related to insulation jacketing).

overall coefficient of heat transfer—See **transmittance, thermal**.

open cell foam, *n*—a material comprised predominantly of interconnecting cellular voids.

perlite, *n*—insulation composed of natural perlite ore expanded to form a cellular structure.

perm, *n*—the mass rate of water vapor flow through one square foot of a material or construction of one grain per hour induced by a vapor pressure gradient between two surfaces of one inch of mercury or in units that equal that flow rate.

DISCUSSION—This empirically derived permeance unit was developed by cooperation of eight laboratories in the United States and Canada to delineate the moisture migration rate below which there would be low probability for induced moisture problems in ordinary constructions, such as houses, apartments, and conventional buildings in climates that are not greater than 5 000 degree heating-days or are hot and humid for which continual air conditioning would be recommended. Perms are not limited to buildings.

DISCUSSION—Evaluations in perms can be made in multiple or fractional perms. However, no combination of SI units will express the same flow rate without a numerical coefficient. A perm defines the same flow rate, regardless of units, world-wide.

	= 1 gr/h·ft ² ·in·Hg	I-P units
	= 57.2·10 ⁻¹² kg/s·m ² ·Pa	SI fundamental
1 perm {	= 57.2·10 ⁻¹² s/m	SI reduced
	= 57.2 ng/s·m ² ·Pa	SI modified
	= 0.66 g/24 h·m ² ·mm Hg	SI obsolete

permeability, water vapor—See **water vapor permeability**.

permeance, water vapor—See **water vapor permeance**.

pipe insulation, *n*—insulation in a form suitable for application to cylindrical surfaces.

radiance, *n*—the rate of radiant emission per unit solid angle and per unit projected area of a source in a stated angular direction from the surface (usually the normal).

DISCUSSION—The term “intensity of radiation” is often used as a synonym for radiance.

radiant flux density, *n*—the rate of radiant energy emitted from unit area of a surface in all radial directions of the overspreading hemisphere.

reflectance, *n*—the fraction of the incident radiation upon a surface that is reflected from the surface.

DISCUSSION—For an opaque surface, the sum of the reflectance and the absorptance is unity at equilibrium.

DISCUSSION—Absorptances and reflectances are of various types, as are emittances. For most engineering purposes, the counterparts of the hemispherical total emittance suffice. Further, the terms absorptivity

and reflectivity, like emissivity, are restricted to apply to materials having opaque, optically flat surfaces.

reflective insulation, *n*—insulation depending for its performance upon reduction of radiant heat transfer across air spaces by use of one or more surfaces of high reflectance and low emittance.

resistance, abrasion, *n*—the ability to withstand scuffing, scratching, rubbing, or wind-scouring.

resistance, freeze-thaw, *n*—resistance to cycles of freezing and thawing that could affect application, appearance, or performance.

resistance, impact (toughness), *n*—ability to withstand mechanical blows or shock without damage seriously affecting the effectiveness of the material or system.

resistance, thermal, *R*, *n*—the quantity determined by the temperature difference, at steady state, between two defined surfaces of a material or construction that induces a unit heat flow rate through a unit area.

$$R = \Delta T/q \quad (5)$$

A resistance (*R*) associated with a material shall be specified as a material *R*. A resistance (*R*) associated with a system or construction of materials shall be specified as a system *R*. (*R* in SI units: K/(W/m²) = K m²/W.) (*R* in inch-pound units: F/(Btu/h/ft²) = F ft² h/Btu.)

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

DISCUSSION—See first and second discussions under **conductance, thermal**. For insulation applied to cylinders, thermal resistance is expressed in terms of unit linear length or unit area of the cylindrical surface.

DISCUSSION—For the case where the heat flow rate depends upon air flow within the system, moisture content and migration, or radiant energy transparency, the situation must be fully described.

resistivity, thermal, *r*, *n*—the quantity determined by the temperature difference, at steady state, between two defined parallel surfaces of a homogeneous material of unit thickness, that induces a unit heat flow rate through a unit area. (*r* in SI units: m K/W.) (*r* in inch-pound units: h ft F/Btu or, h ft² F/Btu in.)

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

DISCUSSION—See the definition and discussions under **conductive, thermal**. Also, see the definition of **apparent thermal resistivity**.

resistivity, water vapor—See **water vapor resistivity**.

sample, *n*—a group of items, observations, test results, or portions of material, taken from a large collection of items, observations, test results, or quantities of material, which serves to provide information that may be used as a basis for making a decision concerning the larger collection. **E456, E2282**

soaking heat, *n*—a test condition in which the specimen is completely immersed in an atmosphere maintained at a controlled temperature.

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soaking heat, *n*—a test condition in which the specimen is completely immersed in an atmosphere maintained at a controlled temperature.

DISCUSSION—Permeance is a performance evaluation and not a property of a material.

water vapor pressure, n —the pressure of water vapor at a given temperature; also the component of atmospheric pressure contributed by the presence of water vapor.

water vapor resistance, n —the steady vapor pressure difference that induces unit time rate of vapor flow through unit area of a flat material (or construction that acts like a homogeneous body) for specific conditions of temperature and relative humidity at each surface.

DISCUSSION—Vapor resistance is the reciprocal of vapor permeance. It is the arithmetic product of the resistivity and thickness.

water vapor resistivity, n —the steady vapor pressure difference that induces unit time rate of vapor flow through unit area and unit thickness of a flat material (or construction that

acts like a homogeneous body), for specific conditions of temperature and relative humidity at each surface.

DISCUSSION—Vapor resistivity is the reciprocal of vapor permeability.

water vapor retarder (barrier), n —a material or system that significantly impedes the transmission of water vapor under specified conditions.

water vapor transmission rate, n —the steady water vapor flow in unit time through unit area of a body, normal to specific parallel surfaces, under specific conditions of temperature and humidity at each surface.

wetting and adhesion, surface, n —the mutual affinity of and bonding between finish and the surface to which it is applied.

wood fiber, n —insulation composed of wood fibers, with or without binders.

DISCUSSION—This is a type of cellulosic fiber insulation.

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