Thermal Conductivity of common Materials and Gases

Thermal conductivity of gases, insulation products, aluminum, asphalt, brass, copper, steel and other common materials

Thermal conductivity is a material property that describes ability to conduct heat. Thermal conductivity can be defined as

> *"the quantity of heat transmitted through a unit thickness of a material - in a direction normal to a surface of unit area - due to a unit temperature gradient under steady state conditions"*

Thermal conductivity units are [W/(m K)] in the SI system and [Btu/(hr ft °F)] in the Imperial system.

See also thermal conductivity **variations with temperature and pressure**, for: Air, Ammonia, Carbon Dioxide and Water

Thermal conductivity for common materials and products:

Thermal Conductivity - k - W/(m K) (Btu/(ft h F))			
Material/Substance	**Temperature**		
	25 °C (77 °F)	***125 °C (257 °F)***	***225 °C (437 °F)***
Acetals	0.23		
Acetone	0.16		
Acetylene (gas)	0.018		
Acrylic	0.2		
Air, atmosphere (gas)	0.0262	0.0333	0.0398
Air, elevation 10000 m	0.020		
Agate	10.9		
Alcohol	0.17		
Aluminum			
Aluminum Brass	121		
Aluminum Oxide	30		
Ammonia (gas)	0.0249	0.0369	0.0528
Antimony	18.5		
Apple (85.6% moisture)	0.39		
Argon (gas)	0.016		
Asbestos-cement board	0.744		
Asbestos-cement sheets	0.166		
Asbestos-cement	2.07		
Asbestos, loosely packed	0.15		
Asbestos mill board	0.14		
Asphalt	0.75		
Balsa wood	0.048		
Bitumen	0.17		
Bitumen/felt layers	0.5		
Beef, lean (78.9 % moisture)	0.43 - 0.48		
Benzene	0.16		
Beryllium			
Bismuth	8.1		
Bitumen	0.17		
Blast furnace gas (gas)	0.02		
Boiler scale	1.2 - 3.5		
Brass			
Breeze block	0.10 - 0.20		
Brick dense	1.31		
Brick, fire	0.47		
Brick, insulating	0.15		

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	25 °C (77 °F)	125 °C (257 °F)	225 °C (437 °F)
Brickwork, common (Building Brick)	0.6 -1.0		
Brickwork, dense	1.6		
Bromine (gas)	0.004		
Bronze			
Brown iron ore	0.58		
Butter (15% moisture content)	0.20		
Cadmium			
Calcium silicate	0.05		
Carbon	1.7		
Carbon dioxide (gas)	0.0146		
Carbon monoxide	0.0232		
Cast iron			
Cellulose, cotton, wood pulp and regenerated	0.23		
Cellulose acetate, molded, sheet	0.17 - 0.33		
Cellulose nitrate, celluloid	0.12 - 0.21		
Cement, Portland	0.29		
Cement, mortar	1.73		
Ceramic materials			
Chalk	0.09		
Charcoal	0.084		
Chlorinated poly-ether	0.13		
Chlorine (gas)	0.0081		
Chrome Nickel Steel	16.3		
Chromium			
Chrom-oxide	0.42		
Clay, dry to moist	0.15 - 1.8		
Clay, saturated	0.6 - 2.5		
Coal	0.2		
Cobalt			
Cod (83% moisture content)	0.54		
Coke	0.184		
Concrete, lightweight	0.1 - 0.3		
Concrete, medium	0.4 - 0.7		
Concrete, dense	1.0 - 1.8		
Concrete, stone	1.7		
Constantan	23.3		
Copper			
Corian (ceramic filled)	1.06		
Cork board	0.043		
Cork, re-granulated	0.044		
Cork	0.07		
Cotton	0.04		
Cotton wool	0.029		
Carbon Steel			
Cotton Wool insulation	0.029		
Diamond	1000		
Diatomaceous earth (Sil-o-cel)	0.06		
Diatomite	0.12		
Duralium			
Earth, dry	1.5		
Ebonite	0.17		
Emery	11.6		
Engine Oil	0.15		
Ethane (gas)	0.018		
Ether	0.14		
Ethylene (gas)	0.017		
Epoxy	0.35		
Ethylene glycol	0.25		

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Feathers	0.034		
Felt insulation	0.04		
Fiberglass	0.04		
Fiber insulating board	0.048		
Fiber hardboard	0.2		
Fire-clay brick 500°C	1.4		
Fluorine (gas)	0.0254		
Foam glass	0.045		
Dichlorodifluoromethane R-12 (gas)	0.007		
Dichlorodifluoromethane R-12 (liquid)	0.09		
Gasoline	0.15		
Glass	1.05		
Glass, Pearls, dry	0.18		
Glass, Pearls, saturated	0.76		
Glass, window	0.96		
Glass, wool Insulation	0.04		
Glycerol	0.28		
Gold			
Granite	1.7 - 4.0		
Graphite	168		
Gravel	0.7		
Ground or soil, very moist area	1.4		
Ground or soil, moist area	1.0		
Ground or soil, dry area	0.5		
Ground or soil, very dry area	0.33		
Gypsum board	0.17		
Hairfelt	0.05		
Hardboard high density	0.15		
Hardwoods (oak, maple..)	0.16		
Helium (gas)	0.142		
Honey (12.6% moisture content)	0.5		
Hydrochloric acid (gas)	0.013		
Hydrogen (gas)	0.168		
Hydrogen sulfide (gas)	0.013		
Ice (0°C, 32°F)	2.18		
Ingot iron	47 - 58		
Insulation materials	0.035 - 0.16		
Iodine	0.44		
Iridium	147		
Iron			
Iron-oxide	0.58		
Kapok insulation	0.034		
Kerosene	0.15		
Krypton (gas)	0.0088		
Lead			
Leather, dry	0.14		
Limestone	1.26 - 1.33		
Lithium			
Magnesia insulation (85%)	0.07		
Magnesite	4.15		
Magnesium			
Magnesium alloy	70 - 145		
Marble	2.08 - 2.94		
Mercury, liquid			
Methane (gas)	0.030		
Methanol	0.21		
Mica	0.71		
Milk	0.53		

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Mineral wool insulation materials, wool blankets ..	0.04		
Molybdenum			
Monel			
Neon (gas)	0.046		
Neoprene	0.05		
Nickel			
Nitric oxide (gas)	0.0238		
Nitrogen (gas)	0.024		
Nitrous oxide (gas)	0.0151		
Nylon 6, Nylon 6/6	0.25		
Oil, machine lubricating SAE 50	0.15		
Olive oil	0.17		
Oxygen (gas)	0.024		
Palladium	70.9		
Paper	0.05		
Paraffin Wax	0.25		
Peat	0.08		
Perlite, atmospheric pressure	0.031		
Perlite, vacuum	0.00137		
Phenolic cast resins	0.15		
Phenol-formaldehyde moulding compounds	0.13 - 0.25		
Phosphorbronze	110		
Pinchbeck	159		
Pitch	0.13		
Pit coal	0.24		
Plaster light	0.2		
Plaster, metal lath	0.47		
Plaster, sand	0.71		
Plaster, wood lath	0.28		
Plasticine	0.65 - 0.8		
Plastics, foamed (insulation materials)	0.03		
Platinum			
Plutonium			
Plywood	0.13		
Polycarbonate	0.19		
Polyester	0.05		
Polyethylene low density, PEL	0.33		
Polyethylene high density, PEH	0.42 - 0.51		
Polyisoprene natural rubber	0.13		
Polyisoprene hard rubber	0.16		
Polymethylmethacrylate	0.17 - 0.25		
Polypropylene, PP	0.1 - 0.22		
Polystyrene, expanded styrofoam	0.03		
Polystyrol	0.043		
Polyurethane foam	0.03		
Porcelain	1.5		
Potassium	1		
Potato, raw flesh	0.55		
Propane (gas)	0.015		
Polytetrafluoroethylene (PTFE)	0.25		
Polyvinylchloride, PVC	0.19		
Pyrex glass	1.005		
Quartz mineral	3		
Radon (gas)	0.0033		
Red metal			
Rhenium			
Rhodium			
Rock, solid	2 - 7		

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Rock, porous volcanic (Tuff)	0.5 - 2.5		
Rock Wool insulation	0.045		
Rosin	0.32		
Rubber, cellular	0.045		
Rubber, natural	0.13		
Rubidium			
Salmon (73% moisture content)	0.50		
Sand, dry	0.15 - 0.25		
Sand, moist	0.25 - 2		
Sand, saturated	2 - 4		
Sandstone	1.7		
Sawdust	0.08		
Selenium			
Sheep wool	0.039		
Silica aerogel	0.02		
Silicon cast resin	0.15 - 0.32		
Silicon carbide	120		
Silicon oil	0.1		
Silver			
Slag wool	0.042		
Slate	2.01		
Snow (temp < 0°C)	0.05 - 0.25		
Sodium			
Softwoods (fir, pine ..)	0.12		
Soil, clay	1.1		
Soil, with organic matter	0.15 - 2		
Soil, saturated	0.6 - 4		
Soot	0.07		
Steam, saturated	0.0184		
Steam, low pressure	0.0188		
Steatite	2		
Steel, Carbon			
Steel, Stainless			
Straw slab insulation, compressed	0.09		
Styrofoam	0.033		
Sulfur dioxide (gas)	0.0086		
Sulfur, crystal	0.2		
Sugars	0.087 - 0.22		
Tantalum			
Tar	0.19		
Tellurium	4.9		
Thorium			
Timber, alder	0.17		
Timber, ash	0.16		
Timber, birch	0.14		
Timber, larch	0.12		
Timber, maple	0.16		
Timber, oak	0.17		
Timber, pitchpine	0.14		
Timber, pockwood	0.19		
Timber, red beech	0.14		
Timber, red pine	0.15		
Timber, white pine	0.15		
Timber, walnut	0.15		
Tin			
Titanium			
Tungsten			

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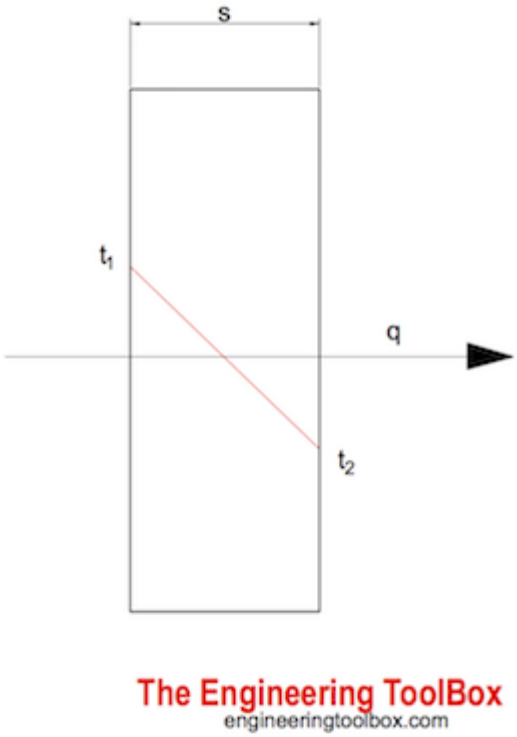
	25 °C (77 °F)	***125 °C (257 °F)***	***225 °C (437 °F)***
Uranium			
Urethane foam	0.021		
Vacuum	**0**		
Vermiculite granules	0.065		
Vinyl ester	0.25		
Water	0.606		
Water, vapor (steam)		0.0267	0.0359
Wax	0.084		
Wheat flour	0.45		
White metal	35 - 70		
Wood across the grain, white pine	0.12		
Wood across the grain, balsa	0.055		
Wood across the grain, yellow pine, timber	0.147		
Wood, oak	0.17		
Wool, felt	0.07		
Wood wool, slab	0.1 - 0.15		
Xenon (gas)	0.0051		
Zinc			

- *1 W/(m K) = 1 W/(m °C) = 0.85984 kcal/(h m °C) = 0.5779 Btu/(ft h °F) = 0.048 Btu/(in h °F) = 6.935 (Btu in)/(ft² h °F)*
- Unit converter - thermal conductivity
- What is conductive heat transfer?

Example - Conductive Heat Transfer through an Aluminum Pot versus a Stainless Steel Pot



The conductive heat transfer through a pot wall can be calculated as

$$q = (k / s) A dT \quad (1)$$

or alternatively

$$q / A = (k / s) dT$$

where

q = heat transfer (W, Btu/h)

A = surface area (m^2, ft^2)

q / A = heat transfer per unit area (W/m^2, $Btu/(h\ ft^2)$)

k = thermal conductivity (W/mK, Btu/(hr ft °F))

$dT = t_1 - t_2$ = temperature difference (^oC, ^oF)

s = wall thickness (m, ft)

Note! - that the overall heat transfer through a surface is determined by the "*overall heat transfer coefficient*" - which in addition to conductive heat transfer - depends on

- the convective heat transfer coefficients on the inside and outside of the surfaces
- the radiant heat transfer coefficients on the inside and outside of the surfaces
- Overall Heat Transfer Calculator

Conductive Heat Transfer through an Aluminum Pot Wall with thickness 2 mm - temperature difference 80°C

Thermal conductivity for aluminum is *215 W/(m K)* (from the table above). Conductive heat transfer per unit area can be calculated as

$q / A = [(215\ W/(m\ K)) / (2\ 10^{-3}\ m)]\ (80\ ^oC)$

$= \underline{8600000}\ (W/m^2)$

$= \underline{8600}\ (kW/m^2)$

Conductive Heat Transfer through a Stainless Steel Pot Wall with thickness 2 mm - temperature difference 80°C

Thermal conductivity for stainless steel is *17 W/(m K)* (from the table above). Conductive heat transfer per unit area can be calculated as

$q / A = [(17\ W/(m\ K)) / (2\ 10^{-3}\ m)]\ (80\ ^oC)$

$= \underline{680000}\ (W/m^2)$

$= \underline{680}\ (kW/m^2)$

Related Topics

- **Insulation** - Heat transfer and heat loss from buildings and technical applications - heat transfer coefficients and insulation methods and to reduce energy consumption
- **Thermodynamics** - Effects of work, heat and energy on systems
- **Material Properties** - Material properties for gases, fluids and solids - densities, specific heats, viscosities and more

Related Documents

- **Aluminum Alloys - Mechanical Properties** - Mechanical properties of aluminum alloys - tensile strength, yield strength and more
- **Brick Densities** - Densities of common types of bricks
- **Butane - Thermal Conductivity** - Online calculators, figures and tables showing thermal conductivity of liquid and gaseous butane, C_4H_{10}, at varying temperarure and pressure, SI and Imperial units
- **Calcium Silicate Insulation** - Thermal conductivity of calcium silicate insulation - temperature and k-values
- **Carbon dioxide - Prandtl Number** - Figures and table showing changes in Prandtl number for carbon dioxide with changes in temperature and pressure
- **Carbon Dioxide - Thermophysical Properties** - Chemical, physical and thermal properties of carbon dioxide. Phase diagram included.
- **Conductive Heat Transfer** - Heat transfer takes place as conduction in a soilid if there is a temperature gradient
- **Cylinders and Pipes - Conductive Heat Losses** - Conductive heat losses through cylinder or pipe walls
- **Ethane - Thermal Conductivity** - Online calculator, figures and table showing thermal conductivity of ethane, C_2H_6, at varying temperature and pressure - Imperial and SI Units
- **Ethylene - Thermal Conductivity** - Online calculator, figures and table showing thermal conductivity of ethylene, also called ethene or acetene, C_2H_4, at varying temperature and pressure - Imperial and SI Units
- **Hydrogen - Thermal Conductivity** - Online calculator, figures and table showing thermal conductivity of hydrogen, H_2, at varying temperature and pressure - Imperial and SI Units
- **Insulation Materials - Temperature Ranges** - Temperature limits for some commonly used insulation materials
- **Mineral Wool Insulation** - Thermal conductivity - temperature and k-values
- **Mortar Types** - ASTM Mortar Types