Definitions of Common Heat Transfer and Insulation Terms

Architects, contractors and builders use various "factors" to express the insulation value of a material or a composite structure including factors such as U, C and R. The most common is the **R-value**, which is used in the building industry to rate the insulation properties of construction materials and building assemblies. Material suppliers often speak of products having a particular K factor.

K-Factor (Thermal Conductivity Factor) – K-Factor is the rate at which heat flows through a material. It measures the heat in BTUs that passes through one square foot of a homogeneous substance, 1 inch thick, in an hour, for each degree F temperature difference and is expressed in BTU/ft2/F/hr./inch. The lower the K-value of a particular material the higher its insulating value.

Textbook definition of K-Factor: The time rate of steady heat flow through a unit area of a homogeneous material induced by a unit temperature gradient in a direction perpendicular to that unit area.

Insulation materials usually have K-Factors less than one and are reported at what is called Mean Temperature. To determine the mean temperature, measure the surface temperatures on both sides of the insulation, add them together and divide by two.

When comparing the insulating value of different types of insulations, it's important to look at K-Factor and the mean temperature. As mean temperatures rise, the K-Factor also rises.

C-Factor (Thermal Conductance Factor) - The C-Factor is also a rate of heat transfer through a material and is equal to the K-Factor by dividing the C-Factor by the thickness of the insulation. C-Factor with a material of 1 inch thickness would be equal to the K factor. C-factor of the same material at three inches thickness is 1/3 of the K-factor; at two inches, it is 1/2 the K-factor. C-Factor is expressed as the number of BTUs which will pass through a square foot of material with 1°F temperature difference for a specified thickness. The formula is the reciprocal of the R-Factor formula. The lower the C value, the better insulator the material.

R-Value (Thermal Resistance Value) - The National Commercial & Industrial Insulation Standards Manual defines R-Value as a measure of the ability of a material to retard heat flow rather than to transmit heat (measure of the resistance to heat flow). Thermal resistance designates thermal resistance values: R-13 equals 13 resistance units. The higher the "R", the higher (better) the insulating value.

R-value can be determined for a single material at a specific thickness. As the thickness of the insulation increases, the resistance to heat flow also increases.

R can be determined in TWO ways:

1.) R = 1 divided by the-C factor of the material ("R" is the numerical reciprocal of C, thus R=1/C).

2.) R = the thickness divided by the K factor ("R" is the numerical reciprocal of K times the thickness of the material, thus R= thickness/K).

Example: For rigid urethane foam with a K-factor of 0.133 at 3-inch thickness R = (3) / (0 .133) = 22.5

At two inches thickness R = (2) / (0.133) = 15

U-factor is the overall coefficient of heat transfer (conductivity) for all the elements of construction, as well as the environmental factors. An example would be the U-factor of a composite structure such as gypsum wallboard, fiberglass core and exterior wood sheathing. The U-factor should not be used with a single material, only with combinations.

A U-factor is determined by adding the C-Factors of the various individual materials making up a composite structure. U=C1+C2+C3, etc. If the materials are not in close contact, the C-factor of an air space must be included in the calculation. Units are expressed as BTU/ft2/f/hr. The smaller the U-factor, the better the insulation value of the composite structure. The usual standard is determined at a temperature gradient of 24ºC at 50% humidity in no wind conditions.

Heat Transferred Rate is the rate at which heat gets transferred. The heat transfer rate depends upon (1) the thickness of the material, (2) the thermal conductivity (this depends on the composition of the material), (3) surface area of the material, and 4) the temperature difference between the sides of the material.