According to Wikipedia, The **R-value** is a measure of thermal resistance for materials and assemblies of materials (*such as insulation panels, floors, and walls*) in the building and construction industry. It gives an indication of how quickly they will lose heat (*their thermal resistance*). The higher the value of R, the better the thermal performance and heat retention of the material or assembly, and the slower any heat loss. The R-value for a given material or assembly depends on its resistance to heat conduction, as well as the thickness.

I. Discussion of Value determination in respect to the SBS-R30 Insulation Coating

There are three (3) fundamental modes of heat transfer; **conduction**, **convection and radiation**. R-values only attempt to deal with **conduction** and do not take into account the other forces that affect the performance of insulation. "**R-value**" **is not a measured value** – but **is a calculated value** derived from testing (*such as the ASTM C-518*) and obtaining the material's Thermal Conductivity at the tested thickness.

Fourier's law (*the law of heat conduction*) is an empirical law based upon observation that states: "***the time rate of heat transfer through a material is proportional to the negative gradient in the temperature and to the area***."

According to Gordon P. Hart PE, "*In most applications, the primary feature of a thermal insulation material is its ability to reduce heat exchange between a surface and the environment, or between one surface and another surface. This is known as having a low value for thermal conductivity. Generally, the lower a material's thermal conductivity, the greater its ability to insulate for a given material thickness and set of conditions*".

Physics defines thermal conductivity as ability of material to transmit heat; measured by the industry standard ASTM C-518 test in **Btu•in/hr•ft^2•°F** (*k-value*). However, in Europe, for example, the units for the measurement of thermal conductivity is **W/mK** (λ-value). Simply put, the lower the k-value (*or λ-value*), the better the material is as a thermal insulator (*smaller is better*). The industry standard for measuring thermal transfer (*k-value*) is the ASTM C-518 test in the USA. (*As a general reference, λ-value = $^{k\text{-value}}/_{6.95}$. This is important, because some manufacturers, in the USA, try to obscure the ease of the R-value calculation, by showing λ-value and not the k-value.*)

However, "*smaller is better*" is not intuitively easy for consumers to grasp, as most USA consumers have been indoctrinated into the "*bigger is better*" philosophy by mass marketing.

The concept of the R-value was created (*originally by Marketing*) to help indicate the energy efficiency of a building material, by depicting "larger is better" numbers. To do this, they simply took the inverse of the ASTM C-518 measured k-value number. Thus, it became quite easy for consumers to understand that an equivalent R-19 insulation is better than R-11 (*bigger is better*), rather than trying to explain how a λ-value of 0.05 is better than a λ-value of 0.09 (*smaller is better*).

A. Why are there testing standards for products?

According to the International Conference of Building Officials (**ICBO**), the International Code Council (**ICC**), and American Society for Testing and Materials (**ASTM**) – among others, it is summarized as "**Fairness and Safety**".

In a market-driven society, manufacturers are often pitted against one another in a quest to win over the hearts and minds of consumers. The building industry is a particularly competitive one, with manufacturers of both similar and alternative materials competing head-to-head for a share of construction spending.

If standards like those produced by ASTM did not exist to support the building codes, the quality of building products and materials could degenerate to dangerously low levels. By setting standards and benchmarks for quality, a level playing field is maintained while competition—the hallmark of our free enterprise system—is preserved.

Through the ASTM testing results, the building owner, Architectural Engineer, building official (*among others*) can now make well-informed and unprejudiced decision about a material's fitness for use (*compliance*). Basically, the ASTM test results provide the answer and without bias.

A grouping of manufacturers, consumers, trade associations, or agencies can develop a standard to suit its own purposes or aims, but only when a standard is developed in accordance with clear-cut rules of procedure and openness of process does it earn the stature necessary for regulatory reference in building codes.

Codes and standards also help to neutralize powerful economic entities wishing to preserve their hegemony by erecting barriers to entry into the markets they serve. The use of codes allows new products and technology fair access into existing markets by providing a level playing field – meet the testing requirements and the product(s) can be used.

B. What is the ASTM test for R-value?

R-value is not a measured value – it is calculated (*equivalent*) value. Simply put, R-value is the inverse of the **ASTM C-518** measured k-value of a material at the material's tested thickness.

$$\mathbf{R = {}^{1}/_{k\text{-value}}\ @\ tested\ thickness}$$

C. Fiberglass insulation seems to be commonly used as a thermal insulation material. What is ASTM measured k-value and the equivalent R-value?

Fiberglass insulation, only deals with heat transfer by thermal conductance. The other heat transfer modes, convection and radiation, are not even considered. At **1-inch thickness**, fiberglass insulation has an ASTM measured **k-value of 0.24 Btu•in/hr•ft²•°F**; approximately equal to a **λ-value of 0.04 W/mK**. These values are substantiated in Owens Corning Insulating Systems Publication No. 14774-V, among similar ones from other manufacturers.

The ASTM testing measures the thermal conductivity (*k or λ-value*) per the tested thickness, which is necessary to calculate the equivalent R-value per that thickness. Simply, R is the inverse of the k-value at the measured thickness ($R = {}^{1}/_{k\text{-value}}$ @ measured thickness). Therefore, a 1-inch fiberglass insulation with an ASTM measured **k-value of 0.24 Btu•in/hr•ft²•°F** would provide an **equivalent R-4.2 per 1-inch** of fiberglass insulation.

- $R = {}^{1}/_{k}$ @ 1-inch; $R = {}^{1}/_{0.24}$ @ 1-inch; resulting in an equivalent R-4.2 @ 1-inch. (***Do the math***.)

Thus, in order to achieve an R-30, R-30 is divided by R-4.2/1-inch = 7.2-inches. One would think that this means; in order to achieve an equivalent R-30, then approximately 7.2-inches of the subject fiberglass insulation would be required. Unfortunately, a fiberglass insulation material's thermal resistance efficiency per inch is reduced, if used at a thicknesses greater than what its thermal conductivity (*k or λ-value*) was measured at.

Recognizing this, the Federal Trade Commission (FTC) issued the "**R-Value Rule**" stating the fiberglass insulation manufacturers using "**R-value per inch**" calculations (*based upon the k or λ-value measured at 1-inch*) must also state "***The R-value of this insulation varies with thickness, the thicker the insulation, the lower the R-value per inch***." In accordance with this rule, the "thermally absorbent" "air-trapper" fiberglass insulation manufacturers (*such as Owens Corning Insulating Systems, among others*), specify, in their literature, that in order to achieve an **equivalent R-30**, approximately **9.5-inches** would be needed; an **equivalent of R-3.1 per inch**. (*This is a 25% reduction from a calculated R-4.2/inch to an average equivalent of R-3.1/inch @ R-30.)*

D. What are the typical ASTM measured k-values and equivalent R-values for fiberglass insulation?

The following tables are excerpts from the information contained with the named manufacturers data sheets.

Knauf Insulation			
Premium Building Insulation			
Thermal performance per: **ASTM C-518**			
Tested Thickness: 1-inch			
R-Value (Total)	Thickness (Inch)	R-Value (per Inch)	K-value per Inch (Btu•in/hr•ft2•°F)
11	3.50	3.14	0.3182
13	3.50	3.71	0.2692
19	6.25	3.04	0.3289
22	6.50	3.38	0.2955
25	8.50	2.94	0.3400
26	9.00	2.89	0.3462
30	10.00	3.00	0.3333
38	12.00	3.17	0.3158

Owens Corning			
Pink Fiber Glass Thermal Batt Insulation			
Thermal performance per: **ASTM C-518**			
Tested Thickness: 1-inch			
R-Value (Total)	Thickness (Inch)	R-Value (per Inch)	K-value per Inch (Btu•in/hr•ft2•°F)
11	3.50	3.14	0.3182
13	3.50	3.71	0.2692
19	6.25	3.04	0.3289
25	8.00	3.13	0.3200
30	9.50	3.16	0.3167
38	12.00	3.17	0.3158

CertainTeed			
Building Insulation			
Thermal performance per: **ASTM C-518**			
Tested Thickness: 1-inch			
R-Value (Total)	Thickness (Inch)	R-Value (per Inch)	K-value per Inch (Btu•in/hr•ft2•°F)
11	3.50	3.14	0.3182
13	3.50	3.71	0.2692
19	6.25	3.04	0.3289
22	6.50	3.38	0.2955
25	8.00	3.13	0.3200
26	8.00	3.25	0.3077
30	10.00	3.00	0.3333
38	12.00	3.17	0.3158

Johns Manville			
GoldLine Building Insulation			
Thermal performance per: **ASTM C-518**			
Tested Thickness: 1-inch			
R-Value (Total)	Thickness (Inch)	R-Value (per Inch)	K-value per Inch (Btu•in/hr•ft2•°F)
11	3.50	3.14	0.3182
13	3.50	3.71	0.2692
19	6.50	2.92	0.3421
22	7.50	2.93	0.3409
25	8.25	3.03	0.3300
30	10.25	2.93	0.3417
38	12.50	3.04	0.3289

E. There are other thermal insulations used, are they held to the same standards?

All building materials are held to certain testing standards to determine their compliance for use. These standards (*in the USA*) are known as the **ASTM**. As seen from the Table in C (*above*), the standard for the measurement of thermal conductivity (*k- value*) is the **ASTM C-518** test. There are other ASTM tests to measure thermal conductivity and they all provide uniform k-values, when compared to each other. There is no biasedness or prejudice in ASTM testing. The results are valid and uniformly applied.

F. What are the typical equivalent R-values and ASTM measured k-values for the various other traditional thermal insulation materials?

The following are excerpts from various manufacturer's data sheets and represent an average of the data disclosed.

Traditional Thermal Insulation		
Thermal Performance per ASTM C-177, C-518 and/or C-976		
Tested thickness	**1-inch**	
Material	Average R-value/in	K-value per Inch (Btu•in/hr•ft2•°F)
Fiberglass (batt)	3.2	0.3125
Mineral Wool (batt)	3.4	0.2941
XPS styrofoam Board	3.4	0.2941
Cellulose Blown (attic)	3.7	0.2703
Open Cell Spray Foam	3.7	0.2703
EPS styrofoam Board	3.8	0.2632
Cellulose Blown (wall)	3.9	0.2564
Mineral Wool Blown (attic)	4	0.2500
Mineral Wool Blown (wall)	4	0.2500
Fiberglass Blown (attic)	4.3	0.2326
Fiberglass Blown (wall)	4.3	0.2326
Polyurethane Board	6.5	0.1538
Closed Cell Spray Foam	6.8	0.1471
Polyisocyanurate (foil-faced)	8	0.1250

G. How are the technological advances tested?

It is known that from time to time, industry advances with the introduction of new technology for certain applications. This is true in the field of thermal insulation. The long accepted standard for thermal insulation was that of fiberglass insulation. All new thermal insulation product are tested to the same ASTM standards as the accepted thermal insulation products, in order to maintain uniformity and fairness in the industry.

For example, it can be seen from the previous table (*F – above*), that fiberglass batt insulation has the highest ASTM measured k-value of 0.3125 **Btu•in/hr•ft^2•°F** resulting in the lowest equivalent R-value (R-3.2) of the listed technologies.

As thermal insulation technology progressed, the ASTM measured k-values for new products became lower (*and equivalent R-values became higher*). For example, from the table (*F – above*), it is shown that Polyisocyanurate (foil faced) has a very low ASTM measured thermal conductivity (k-value) of 0.1250 **Btu•in/hr•ft^2•°F**; with a corresponding equivalent R-8 for its 1-inch measurement. As lower k-values directly correspond to greater energy savings, it is seen as a technological advancement that should be encouraged – not thwarted.

H. Are there other technological advancements in the field of thermal insulation?

Yes. It is well-known that **Thermal Barrier Coatings** (TBC) and **Ultra-High Performance Thermal Barrier Coatings** (UHP-TBC) are used to protect substrates (*like* *found in gas turbines and such*) from temperatures up to and over 2,000ºC and yet have a thickness of typically between **100 µm (0.0039-inches)** to **2 mm (0.078-inches)**. The **TBC** enables these metallic substrate materials to be used at gas temperatures above their melting points. Under such heat flux conditions, it is the thermal conductivity (*k or λ-value*) of the coating that dictates the temperature drop across the **TBC**. (*The lower the number the greater the drop*.) To further illustrate the benefit of **TBC**s, per US Patent 6,117,560 (*among other research*) it has been estimated that a 50% reduction in thermal conductivity (*k or λ-value*) will reduce the substrate temperature by about 55°C, under thermal loading.

The **SBS-R30 Coating** thermal insulation coating is such a technological advancement in thermal insulation for buildings. The **SBS-R30 Coating** is a true **Thermal Barrier Coating**; taking into consideration all forms of thermal transfer (**conduction**, **convection and radiation**). The **SBS-R30 Coating,** at a thickness of **0.01-inch** *(10-mil, 0.24-mm*), has an accredited ASTM measured **k-value of 0.0139 Btu•in/hr•ft²•°F** (λ-value of 0.002 W/mK); yielding an equivalent R-value greater than R-30 at 0.01-inches. (*Do the math*.)

The same ASTM testing protocol that is being used by the other (now accepted) thermal insulation materials was used for the accredited ASTM testing for the **SBS-R30 Coating**. While the results are remarkable; the accredited ASTM testing is indisputable.

Smarter Building Systems	
Product:	**SBS R-30**
Thermal Performance per:	ASTM C-518
Tested Thickness:	0.01-inch
k-value tested at 0.01-inch (Btu•in/hr•ft2•°F)	0.0139
Equivalent R-Value	> 30
R = 1/k (at the tested thickness)	Do the math

Other useful Engineering measurements

The **SBS-R30 Coating** is considered as an elastomeric material and will maintain flexibility down to -92ºF (-68ºC) and has an upward Service Temperature of over 350ºF (+175ºC). In case of a heavy Hail Storm, the **SBS-R30 Coating** has been tested and found to be able to withstand up to a 2.5-inch hail stone impacting at 140-mph.

ASTM B-117	Salt Fog Test - 500-hours: Passed
ASTM G-53	500-hour accelerate weathering test: double bend with no cracking, highly flexible
ASTM C-518	Thermal Conductivity tested at 0.01-inch: 0.0139 BTU(in)/(h)(ft2)(F)
ASTM C-518	Thermal Conductivity tested at 0.255-mm: 0.002 W/mK
ASTM D-2240	Hardness Shore D: 85
ASTM E-108-91A	Fire Class Rating: Class A
ASTM E-84 Factory Mutual Tested	Fire Class Rating: Class A Flame Spread: < 5 Smoke-Developed: < 25
ASTM D-638	Tensile Strength: 1,393-psi
ASTM E-96	Vapor Transmission: 0.7 perms

Work / Note Page --- Intentionally Left Blank