F. A. Q.

Frequently Asked Questions about ASTEC

Frequently Asked Questions (F.A.Q.) About ASTEC

1. How does ASTEC compare with "traditional" insulation?

First, "traditional" insulation is meant to be *mass insulation* for protection against *heat transfer* by *conduction*. **ASTEC** protects against *heat transfer by radiation*. Both mass insulation (i.e. fiberglass wool, polyurethane foam, etc.) and radiation control coatings (i.e., **ASTEC)** have value and one does not necessarily replace the other. In many cases, radiation control coatings complement mass insulation to give it *added value benefits*.

"Traditional" insulation (i.e. fiberglass wool) is usually installed on the underside of a roof or inside the walls of a building and absorbs heat from the roof's exterior surface. Since heat always travels from a "hot" environment to a (relatively) "colder" environment, the absorbed heat energy transfers into the building where temperatures during sunlight hours are normally lower than the *ambient air temperature*. Where mass insulation is applied to the exterior surface of the roof (i.e. polyurethane foam), the same principles of heat management apply.

Ordinary construction materials (i.e.: metal roof) absorb between 90 and 95% of the heat from solar radiation and they develop very high roof temperatures. While the thickness of mass insulation is the key to a lower rate of heat transfer (the thicker the mass insulation material, the more resistance to heat transfer), this form of <u>heat management</u> may not be cost effective. At some point, the cost of increasing the thickness of mass insulation exceeds the added insulation benefits.

ASTEC prevents 85% of the heat from solar radiation from ever getting into the roof because of its high solar reflectivity (varying between 85% and 94% depending on the wavelength of the *electromagnetic radiation* incident upon the roof). This primary function of **ASTEC** refers to <u>heat prevention.</u> The old adage prevails: it is better to prevent than to cure!

Heat management is also an important feature of **ASTEC** thermal properties. The 15% of heat (from solar radiation) absorbed into the protective layer of **ASTEC** is easily and quickly dissipated with **ASTEC's** high *thermal emissivity* of 0.91 which removes the heat at a fast rate (the perfect rate is 1.0). Thermal emissivity is the rate at which a surface radiates heat compared to the perfect emitter ("a *blackbody")* at the same temperature. The higher the rate of thermal emissivity, the greater the radiated heat back to the outside. Ordinary construction materials and mass insulation have thermal emissivities ranging between 0.10 (galvanized iron roof) and 0.40.

By comparison with ordinary construction materials, **ASTEC** will have a substantially "cooler" surface temperature as it absorbs 70% to 80% less heat, and it radiates absorbed heat faster than traditional construction materials and mass insulation.

ASTEC provides reduced building cooling load requirements and as a system, it also provides other value-added benefits which are not found in ordinary construction materials or in mass insulation.

- corrosion control
- protection against *UV* degradation
- long lasting waterproofing
- virtual elimination of *thermal shock*
- monolithic and flexible system
- environmentally acceptable water-based products
- low cost installation
- minimized roof maintenance
- architecturally attractive
- cost effective exterior insulation and finish system
- noise abatement factor/acoustical benefits

When comparing **ASTEC** with mass insulation, **ASTEC's** Total Solution approach is superior, more comprehensive, and more cost effective.

2. What kind of training is available from ICC and under what terms and conditions?

ASTEC training has two components: (1) the theory and (2) the practice. Details of the theory training program are provided below. The practical aspects of ASTEC training are based on a specific field application (metal roof, EPDM roof, asphalt roof, concrete deck, asbestos-cement roof, sidewall, etc.). Training is available at the manufacturing site at no cost to new dealers except their own out-of-pocket expenses. Should a new dealer prefer to have training in-country or on (his) site, he would then be responsible for the trainer's out-of-pocket expenses.

Thermal Dynamics of ASTEC

This Program was developed by **ICC International** to provide its Dealers with a simple but thorough examination of heat transfer management using **ASTEC** coatings to reduce cooling loads and increase energy savings. The three primary objectives of this program are:

a) to achieve a solid understanding of heat transfer by radiation
b) to effectively measure energy savings (kWh) using **ASTEC** coatings, and
c) to calculate the savings in terms of dollars and return on investment for each application.

1. Thermodynamics

This short module compares the concept of heat gain in matter, establishes the two fundamental laws of thermodynamics, and introduces the three modes of heat transfer:

(a) Radiation
(b) Conduction
(c) Convection

2. Heat Transfer

This important module defines the three modes of heat transfer, examines solar radiation, and illustrates how the sun's radiation is carried to earth on electromagnetic waves. The analysis of the electromagnetic spectrum focuses on critical radiation from infrared, visible, and ultraviolet rays. This section also addresses the concept of absolute temperature, and introduces the properties of emissivity, reflectivity, and absorptivity.

3. ASTEC: Thermal Properties

This part explains **ASTEC's** solar reflectivity and thermal emissivity.

4. ASTEC: The Total Solution

This segment defines the "perfect" customer requirements and how the **ASTEC** System addresses the customer's needs. The module also highlights the **ASTEC** strengths.

5. Energy Balance Equation

This technical section develops a mathematical model for precise calculation of **ASTEC's** energy savings. The model is expressed in the form of an equation which takes into consideration all three modes of heat transfer: conduction, convection, and radiation. This scientific approach quantifies the heat flux reduction, the energy savings in financial terms, and the cooling load reduction in terms of W/m^2 [Btu / (hr-ft_2)] or tons of refrigeration (TR).

6. Term Definitions

In this section, the following terms are clearly defined: British Thermal Unit (Btu), Conductivity (k factor), Conductance (C factor), Overall Coefficient of Heat Transfer (U-factor), Resistance (R-value), Emissivity (e value), Absorptivity (a), and Reflectivity (p).

7. ASTEC Economics

This very important module establishes a mathematical formula for calculating the energy impact, the maintenance cost reduction, and the repair savings of **ASTEC's** Total Solution on a given structure.

8. ASTEC on the Internet

This important component literally "surfs through the net" and allows the dealers to visit the ICC-ASTEC Web Site for any technical assistance. The ICC-ASTEC Web Site provides direct access to the Engineer's Guide, Frequently Asked Questions (F.A.Q.) About ASTEC, Material Safety Data Sheets, Application Specifications, Sales Literature, Project Report Form, Project Photo Album, References, Dealer Application Form, and a Glossary of technical terms. We are constantly updating our website to reflect new information.

3. What is the k-value or the R-value of ASTEC and how do these values compare with mass insulation?

The R-value is the measure of the resistance of a material to heat flow (or heat gain) by conduction only. The k-value is the measure of thermal conductivity; it measures the rate of heat transfer by conduction through a material from face to face.

The R-value is always the reciprocal of the k-value. For instance, $R = L/k$ and $k = L/R$

where,

R = thermal resistance,

L = thickness,

k = thermal conductivity;

R-19 means 19 hr ft^2 °F / Btu or 3.34 m^2 °C/W.

ASTEC's thermal conductivity (k-value) is very low (0.00345 W/m °K or 0.00199 Btu/h ft °F). A very low k-value indicates a good conductive insulator. But the R-value depends on thickness and *the thickness (L) of ASTEC is so small that the resistance (R-value) is not given serious consideration.* What really counts in preventing heat transfer is **solar reflectivity**. R-value (resistance) is only valid when "managing" heat which has already transferred.

To compare ASTEC's thermal resistance (R-value) to the thermal resistance of polystyrene or of fiberglass, is to compare materials acting on different heat transfer modes (radiation vs. conduction). There is no common ground between radiation and conduction ***except the calculation of the end results (actual heat transfer) in terms of W/m² or Btu/hr/ft².***

The reflectivity and emissivity of most roof surfaces is extremely low (less than 0.20) when compared with ASTEC's high solar reflectivity (p-value: 0.85) and thermal emissivity (ε-value: 0.9).

Therefore, to *avoid heat transfer,* the best way is to reflect radiant heat (stop the heat from coming in the roof to begin with) and to quickly emit any radiation that is absorbed. In dealing with radiation, thickness has no useful value and R-values or k-values are not useful anymore. High reflectivity and emissivity become important.

If, on the other hand, you don't effectively deal with heat transfer by radiation, you will then be stuck and forced to deal with heat transfer by conduction once heat penetrates the roof; then, R-value which is directly proportional to thickness, becomes an important factor.

The comparison of a structure with ***ASTEC's** roofing system* purely on the basis of conduction factors (thickness, k-value, density, heat resistance) is counter-productive. Such a comparison does not do justice to the end-users.

In conclusion, there is no acceptable direct comparison between the prevention of heat transfer by radiation and the subsequent management of heat transfer by conduction. A better alternative may be to determine when a total system like **ASTEC** is superior to mass insulation and when both systems may be complementary.

If the roof heat transfers are the only valid points of comparison, let's look at three types of roofs *with* the **ASTEC** system and *without* the **ASTEC** system on a clear, summer, noon-time condition with:

1) No insulation;
2) One (1") inch (2.5 cm) of mass insulation; and
3) One (1") inch (2.5 cm) of mass insulation and gypsum board covering.

Roof Types	Heat Transfer Comparison	
	Uncoated	ASTEC Coating
Metal Only	112.5 BTU/hr ft^2	32.2BTU/hr ft^2
Metal/1" Mass Insulation	38.4 BTU/hr ft^2	10BTU/hr ft^2
Metal/Mass Insul/Gypsum	36.4 BTU/hr ft^2	10BTU/hr ft^2

Thus, **ASTEC** reduces the roof heat transfer by more than 70% over the uncoated roof for all three roof types.

4. How does ASTEC outperform 4 inches (10 cm) of foam insulation?

We compared an ASTEC-coated metal roof without insulation with another metal roof having 10 cm of polyurethane foam. This allowed us to calculate the surface temperature under identical simulated environmental conditions. In addition, the roofs were given a "typical" 40 m length to determine the thermal shock reduction provided by **ASTEC.**

The following steps were followed in the calculations:

1. The thermal properties *(for conduction)* of the materials (metal roof, **ASTEC,** polyurethane foam) specified were based on ASHRAE Fundamental Handbook data.
2. Environmental conditions were given as follows:
   a. Outside Air Temperature: 35˚ C
   b. Inside Air Temperature with Air-Conditioning: 24˚ C
   c. "Clear day" solar radiation factor: 905 W/m^2
3. Constant Values:
   a. The *Stefan-Boltzmann* constant *(for radiation).*
   b. Air film coefficient *(for convection):* we used identical air film coefficients for both, the outside air and the inside air.

CONCLUSION:

The **ASTEC** coated roof surface temperature was calculated at 37.55 C˚.

The roof sprayed with PU foam has a surface temperature of 86.83 C˚.

If the PU were to be sprayed on the underside of the roof as it is sometimes the case to protect the PU from ultra-violet degradation and from water induced delamination, we measured the thermal shock on the bare metal roof as opposed to an **ASTEC** covered roof. Using the coefficient of expansion for galvanized metal and the delta in roof surface temperatures (T_1 - T_2) for a given length (40 m), the calculations further conclude that the **ASTEC** coated roof would reduce thermal shock from 28.82 mm on the metal roof to 1.42mm on an **ASTEC** covered metal roof. This represents a 95% reduction based on a 40m in length metal roof.

It should be noted that ASTEC is practically impervious to UV attacks due to its hard ceramic component. Moreover, the ASTEC "system" provided added benefits in the form of corrosion control and waterproofing. The life cycle cost of ASTEC proves to be more cost effective than conventional mass insulation.

In terms of heat transfer only, 4 inches (10 cm) of PU foam would perform better than **ASTEC** alone. However, heat transfer alone is only part of the solution. Cost effectiveness considers heat gain for thermal shock measurement, heat transfer for energy savings, waterproofing for roof preservation, corrosion control for structural integrity, and many other value-added benefits only offered by **ASTEC**. If a project owner insists on PU purely for heat transfer purpose without consideration of cost effectiveness and other value-added **ASTEC** benefits, the thickness of PU (therefore, the cost) can be minimized and the energy savings increased by adding the **ASTEC** finish coat to the system. The finish coat of **ASTEC #900** would reflect some 85% of the solar radiation — thus enhancing the efficiency of the PU in managing 15% of the absorbed solar radiation instead of the 90% absorption rate of a metal roof.

Considering the "Total Solution" there is no doubt that **ASTEC** outperforms 4 inches (10 cm) of polyurethane foam.

5. What is the difference between a radiant heat barrier and a conductive heat barrier?

From a scientific point of view, the formulae used to calculate heat transfer by conduction and radiation are as follows:

For conduction: $q'' = (T_{OUTSIDE} - T_{SURFACE}/\Sigma R)$

For radiation: $q'' = \varepsilon\sigma(T^4_{SURFACE} - T^4_{SURROUNDINGS})$,

Where,

ΣR = sum or total of thermal resistances
ε = surface thermal emissivity
$\sigma = 5.67 \times 10^{-8}$ (Stefan-Boltzmann constant)

An effective conductive heat barrier (insulation against heat transfer by conduction) reduces the heat transfer by conduction by providing a thermal resistance (R-value). This is where mass insulation such as fiberglass wool, polystyrene, etc. come into play. The main drawback to conductive insulation relates to thickness. The thicker the better. A secondary but equally important drawback of mass insulation is its degradation and consequent loss of R-value with aging or with water (vapor or liquid form) absorption.

An effective radiant heat barrier (protecting against heat transfer by radiation) will stop the heat from entering the building and avoid the problem of managing heat once it has entered the building. This is where ASTEC plays a major role: it prevents up to 85% of the heat transfer by solar radiation and it very effectively manages the balance (15%) of the absorbed heat by re-radiating out of the receiving surface (i.e. roof, wall, etc.) with its high emissivity. An effective radiant heat barrier does not depend on thickness or even R-value; it depends on high solar reflectivity and high thermal emissivity.

Therefore, the radiant heat barrier (i.e.: ASTEC) prevents the problem from occurring while the conductive heat barrier attempts to manage it once it has occurred.

Some applications require a conductive heat barrier only, some projects require a radiant heat barrier only, and others combine both types of heat barriers.

6. How do we calculate the R-value of a simple roof structure?

Every component of the roof (i.e.: GI sheet, concrete, insulation, air space, sheetrock/gypsum, acoustical tiles, etc.) has a given R-value based on its thickness. Basic HVAC data reference books will provide the R-value or the K-value for most construction materials. If you do not have any reference books, we will be happy to tell you the R-value of materials you are considering.

Example:

	Resistance (m2 K)/W	Resistance (h ft² °F)/Btu
External Air Film Coefficient	0.055	0.31
Concrete Slab (2400 kg/m²)	0.714	4.06
Horizontal Airspace (1.5 in/3.81 cm)	0.940	5.34
Acoustical tile (false ceiling)	0.021	0.12
Internal Air Film Coefficient	0.162	0.92
Total Thermal Resistance (ΣR)	1.892	10.75
Overall Thermal Transmittance (1/ΣR) (U-Value)	0.529	0.093

7. What is the overall thermal transmittance value (U-factor) and how does it apply to ASTEC?

In numerical terms, the U-factor is the reciprocal value of the total resistance (1/ΣR). The U-factor is only an indication of the conduction rate of heat transfer; it is a quantitative measurement of how well heat conducts through a roof or wall for a given temperature difference.

For instance, if the total R-values (ΣR) of a roof's several components add up to 1.892 (m^2 K)/W in the metric system or 10.75 (h ft^2 °F)/Btu in the U.S. terminology, then the average thermal transmittance (U-factor) is 0.529 in the metric expression and 0.093 in the U.S. language.

Although **ASTEC** has an excellent k-value, this does not translate into a good R- value only because applied **ASTEC** has very little thickness. Therefore, **ASTEC** does not have a direct impact on the U-factor per se. However, **ASTEC** significantly enhances the U-factor value in that it (a) prevents the absorption of 85% of the solar radiation and (b) reduces heat transfer by as much as 70% by lowering the temperature difference across the roof or wall which, in turn, makes the total resistance much more effective.

8. How do you compare mathematical equations with established ASHRAE engineering formulations?

DEMONSTRATING ASHRAE AND ICC/ASTEC SURFACE TEMPERATURE EQUATION EQUIVALENCE

ASHRAE 1989 Fundamentals Handbook

Chapter 26. Air-Conditioning Cooling Load.

Page 26.3: Heat Gain Through Exterior Walls and Roofs

Heat Gain Through Exterior Surfaces. The heat balance at a sunlit surface gives the heat flux into the surface q/A in BTU/h ft^2, as:

q/A	=	$\alpha I_t + h_0(t_0 - t_s) - \varepsilon\delta R$ Where
σ	=	absorptance of the surface for solar radiation
I_t	=	total solar radiation incident on the surface, BTU/h*ft^2
h_0	=	coefficient of heat transfer by long wave radiation and convection at the outer surface, BTU/h*ft^2*°F
t_s	=	roof or wall surface temperature, °F
t_0	=	outdoor air temperature, °F
ε	=	hemispherical emittance of the surface
δR	=	difference between the long wave radiation incident on the surface from the sky and surroundings and the radiation emitted by a blackbody at outdoor air temperature, BTU/h*ft^2"

Analysis of ASHRAE terms /definitions relative to the terms /definitions used in the **ICC/ASTEC** report.

ASHRAE		**ICC/ASTEC**
q/A	—>	conduction heat flux, $q''_{conduction} = K/L\,(T_{surface} - T_{inside})$
I_t	—>	solar irradiation, G
α	—>	solar absorptivity, $\alpha = 1 - p$
t_0	—>	outside air temperature, T_{air}
t_s	—>	surface temperature, $T_{surface}$
ε	—>	thermal emissivity, $\varepsilon_{thermal}$
h_o	—>	convective coefficient, h_{film}, plus a "radiation coefficient' not used in **ICC/ASTEC** report, but assume its name "h_r", $h_o = h_{film} + h_r$
σR	—>	radiation from surrounding on surface (σT^4_{surr}) minus air temperature blackbody radiation (σT^4_{air}), $\sigma R = \sigma T^4_{surr} - \sigma T4_{air}$

Substituting the **ICC/ASTEC** values into the ASHRAE equation gives:

$$q''_{conduction} = (I-P)G + (h_{film}+h_r)(T_{air}-T_{surf}) - \varepsilon_{thermal}\,(\sigma T^4_{surr} - T^4_{air})$$

Substituting with: $q''_{conduction} = K / L\,(T_{surf} - T_{inside})$; and expanding:

$(h_{film}+h_r)(T_{air}-T_{surf}) = h_{film}(T_{air}-T_{surf}) + h_r(T_{air}-T_{surf})$ where the radiation heat transfer coefficient, h_r, is defined[1] as:

$$h_r=\varepsilon\sigma(T^4_{air}-T^4_{surf})/(T_{air}-T_{surf})$$

and substituting this gives:

$$(h_{film}+h_r)(T_{air}-T_{surf}) = h_{film}(T_{air}-T_{surf}) + \varepsilon_{thermal}\sigma(T^4_{air} - T^4_{surf})$$

Substituting the above into the top equation:

$$K/L(T_{surf} - T_{inside}) = (I-p)G + h_{film}(T_{air} - T_{surf}) + \varepsilon\sigma T^4_{air} - \varepsilon\sigma T^4_{surf} - \varepsilon_{thermal}\sigma T^4_{surr} + \varepsilon_{thermal}\sigma T^4_{air}$$

If it is assumed that $T_{surr} \approx T_{air}$ then $\varepsilon_{thermal}\sigma T^4_{surr} \approx \varepsilon_{thermal}\sigma T^4_{air}$ and the equation reduces to the form:

$$(1-p)G = \varepsilon_{thermal}\sigma\,(T^4_{surf} - T^4_{air}) + h_{film}\,(T_{surf} - T_{air}) + K/L\,(T_{surf} - T_{inside})$$

As shown, by starting with the ASHRAE equation in the Fundamentals Handbook, the equivalence between the two equations can be demonstrated.

[1] P. 281; Principles of Heat Transfer, Frank Kreith, 3rd Ed., 1973, Intext Press; ISBN 0-7002-2411-X

9. Define dry film thickness, theoretical coverage, and solids by volume, solids by weight.

Dry Film thickness: thickness of an applied coating when dry, often expressed in mils or microns (Ref. Industrial Maintenance Coatings Glossary, SSPC 94-16).

Theoretical coverage: the spreading rate of a coating without consideration of waste or loss. Usually 10% is attributed to waste or loss.

Spreading rate: The area of surface covered per coat at a specified dry film thickness per unit volume of coating material. Spreading rate generally is indicated by square feet covered per gallon or square meter covered per liter. (Ref. Industrial Maintenance Coatings Glossary, SSPC 94-16).

Solids by volume: The volume of the nonvolatile portion of a coating composition divided by the total volume, expressed as a percent (Ref. Industrial Maintenance Coatings Glossary, SSPC 94-16). The applicator needs to know the solids by volume to determine the spread for a given area. The solids content by volume of ASTEC #900 is 55%.

Solids by weight: The weight of the nonvolatile portion of a coating composition divided by the total weight of the liquid coating, expressed as a percent (Ref. Industrial Maintenance Coatings Glossary, SSPC 94-16). The manufacturer needs to know the solids by weight to determine if the coating has been made properly.

ASTEC with 55% solids by volume, the dry film thickness (DFT) will be 55%
of the wet film thickness.

1	mil	=	1604 sq. ft	[149m^2]	x	55%	=	882 ft [82.0 m^2]
2	mils	-	802sq.ft	[74.5m^2]	x	55%	=	441 ft [41.0 m^2]
3	mils	-	535sq.ft	[49.7m^2]	x	55%	=	294 ft [27.3 m^2]
4	mils	=	401 sq. ft	[37.3m^2]	x	55%	=	221 ft [20.5 m^2]
5	mils	=	321sq.ft	[29.8m^2]	x	55%	=	176 ft [16.4 m^2]
6	mils	=	267sq.ft	[24.8m^2]	x	55%	=	147 ft [13.7 m^2]
7	mils	=	229sq.ft	[21.3m^2]	x	55%	-	126 ft [11.7 m^2]
8	mils	=	201sq.ft	[18.7m^2]	x	55%	=	110 ft [10.2 m^2]
9	mils	=	178sq.ft	[16.5m^2]	x	55%	-	98 ft [9.1 m^2]
10	mils	-	160sq.ft	[14.9m^2]	x	55%	=	88 ft [8.2 m^2]
11	mils	=	146sq.ft	[13.6m^2]	x	55%	=	80 ft [7.4 m^2]
12	mils	=	134sq.ft	[12.4m^2]	x	55%	=	74 ft [6.8 m^2]
13	mils	=	123 sq. ft	[11.4m^2]	x	55%	=	68 ft [6.3 m^2]
14	mils	=	115sq.ft	[10.7m^2]	x	55%	=	63 ft [5.9 m^2]
15	mils	=	107sq.ft	[9.9m^2]	x	55%	=	59 ft [5.5 m^2]

dft = wet film thickness (wft) X percent solids by volume

10. What is the difference between solar radiation and thermal radiation?

Solar (sun) radiation travels to earth by electromagnetic waves at the speed of light (186,286 miles per second or 300,000 kilometers per second). The *electromagnetic spectrum* carries different kinds of rays (gamma, x-ray, visible, infrared, etc.) each with a different *wavelength* between 0.1 to 150 micrometers long (a micrometer, µm, or a micron is one millionth of a meter) and each with its *own frequency*. The frequency is measured in hertz/sec and it represents the number of waves produced per second. Not all solar radiation reaches the earth but the radiation which penetrates the atmosphere [ultraviolet (0.29 to 0.40 µm), visible (0.40 to 0.76 µm), and near infrared rays (0.76 to 150 µm] has a high energy content (per m^2). This energy is converted to heat energy when it is absorbed in the roof of a building or any object.

Reflectivity is the ability to "deflect" or reject radiant energy like a mirror reflects light. Solar reflectivity is the numerical measurement from 0 to 100% of the total amount of incident solar radiation that is <u>not</u> absorbed by the surface.

Thermal radiation is emitted from objects on earth by electromagnetic waves (infrared rays) of low energy content (therefore, containing less heat) due to the temperature (internal energy) of the object.

Thermal radiation refers to wavelengths extending from 1.50 to 1000 μm. It includes:

The "longer" wavelengths from the middle infrared (1.50 to 5.60 μm), to the far infrared (5.60 to 15.00 μm), and the extreme infrared (15.00 to 1000 μm).

The "longer" wavelength radiation has a very low energy content compared to shorter wavelength radiation. The lower the object's temperature, the longer the wavelength emitted and the lower the rate and energy emitted.

Emissivity: a body continually emits radiant energy at a rate that is related to its temperature and the nature of its surface ($E = \varepsilon\sigma T^4_{SURFACE:}$).

Thermal emissivity is the rate at which a body emits radiant energy compared to a "perfect blackbody" emitter at the same temperature.

Electromagnetic radiation that is absorbed by matter is converted into internal energy, which can be stored, transferred by conduction, converted back into electromagnetic radiation that is given off (emitted) by the material itself.

The amount of radiation heat emitted should equal the amount of heat absorbed minus that conducted (towards the heat sink) because the laws of thermophysics demonstrate that energy is never lost (Law of Conservation of Energy).

11. What is the impact of color on heat reflective coatings?

ASTEC products can be prepared in a variety of colors. However, the colors will have a negative impact on the solar reflectivity of the coating. The following base colors are indicative of the drop in solar reflectivity:

Base brown has a 12% reflectivity which increases to 16% when mixed in a 1 (part white) to 1 (part brown) ratio, 20% in a 4 (part white) to 1 (part brown), and 40% in a 16 to 1 ratio.

Base red has a 22% reflectivity; in the 1 to 1 ratio, it increases its reflectivity to 26% and reaches 40% in the 4 to 1 ratio.
Base gray has a reflectivity of only 9% which raises to 25% on a 1 to 1 ratio.
Base blue has a reflectivity of only 12% but it increases to 49% on a 1 to 1 ratio.
Base green on a 1 to 1 ratio starts at 11% and goes up to 53% in a 4 to 1 ratio.

Base yellow indicates a 43% reflectivity on a 1 to 1 ratio, 65% reflectivity on a 4 to 1 ratio, and 70% reflectivity on a 16 to 1 ratio.

Many clients prefer a loss of reflectivity in exchange for a livelier color than white. Some consider ASTEC white to be too reflective and prefer the other elements of ASTEC's Total Solution: less thermal shock, waterproofing, corrosion control, and aesthetics.

12. What surfaces need special preparation?

Stainless steel, PVC, copper, siliconized surfaces, and aluminized surfaces require "etching" which is usually accomplished with an acid wash.

13. What are 'authorized' and 'non-authorized' applications?

Authorized application: Coating of external surfaces exposed to solar radiation such as walls, roofing structures made of galvanized metal, rubber, approved asphalt roof surfaces, concrete, asbestos tiles and industrial structures such as approved holding, fuel, or cryogenic tanks and pipelines.

Unauthorized application: Any surface not exposed to solar radiation. Steam pipe insulation, built-up roofs with gravel, asphalt shingles, or slate roofs, any surfaces exposed to strong acid concentration, internal applications of kilns, storage tanks, or refrigerated rooms.

14. What is the average shelf life for ASTEC products?

Eighteen months if properly stored inside and away from direct sunlight. Storage temperature limits: between 40 °F (5 °C) and 110 °F (43 °C). The containers (5-gal pails) should be turned upside down every 60 days.

15. If ASTEC keeps the heat out during the summer will it keep the heat in during the winter?

During cold winter days in the northern hemisphere, heat will tend to travel from inside the building towards the colder outside (ambient) air. Although **ASTEC** has a very low k-value (which indicates a high R-value), its thickness will not be enough to act as a conductive insulator for heat transfers through the ceiling and through the roof towards the outside air.

16. How do you prove ASTEC's solar reflectivity and thermal emissivity?

This has been determined in laboratory tests. We have test results from public sector as well as private sector laboratories with test conditions and results. The latest one is a consolidated test report prepared by the Department of Mechanical Engineering at the University of South Carolina.

17. How do you prove the fact that ASTEC is effective and that it is as good or better than traditional insulation?

a) By measuring temperatures before and after the application, one will quickly realize that an **ASTEC** roof is much cooler than an 'ordinary' roof. If it is cooler, then it is evident that less heat is penetrating. If it is cooler, then it is certain that there is less thermal shock on a metal roof (approximately 90% less thermal shock!). We have data loggers which measure the temperature at various locations on, above, and below the roof and then depict the results on a color graph.

b) By mathematical calculations. The calculations indicate the heat transfer with and without **ASTEC** and measure the corresponding energy savings. On a metal roof, **ASTEC** usually reduces heat transfer by some 70%. On a concrete roof, it will vary between 55% and 65%.

c) With client references as written proof of the results using temperature probes, lower utility bills, and comparing labor productivity rates before and after the application of **ASTEC.**

18. What are the mathematical equations used to calculate heat transfer by (a) conduction, (b) convection, and (c) radiation?

Conduction

$$q'' = k (T_1 - T_2) / L = (T_1 - T_2) / \Sigma R$$

Convection

$$q'' = h_{FILM}(T_2 - T_3)$$

Radiation

$$q'' = \varepsilon\sigma(T^4_2 - T^4_3)$$

Where,
T_1= roof surface temperature
T_2= roof underside temperature
T_3= given room air temperature
h_{film}= 5.67 (for still air above and under the roof)
σ= (sigma) 5.67×10^{-8} [Stefan-Boltzmann]

19. Will ASTEC be effective as a radiant heat barrier on vehicles?

ASTEC is an excellent means of preventing solar radiation from being absorbed into a surface. However, most of the overheating of vehicle interiors occurs from sunlight through side windows, with only a fraction of the heat gain occurring through the roof. **ASTEC** would reduce the heat gain but the effect would not be as effective as tinting the windows would be.

20. What is the effect of applying a clear coating on top of ASTEC?

Adding any kind of coating on **ASTEC** would negatively affect **ASTEC's** reflective index (85%) and it would completely negate the emissivity level of **ASTEC.**

21. Why is it that ASTEC has "different" solar reflectivity values?

The reflectivity values for **ASTEC** vary from 85% to 94%. The variability is due to the fact that reflectivity of a given material is "wavelength dependent".

In other words, certain wavelengths of the solar spectrum are reflected more than others. Between the various wavelengths of ultraviolet radiation, visible radiation, and infrared radiation, we obtain "reflectivity" ranging from 85% to 94%.

It would be too expensive and impractical to determine the reflectivity of every wavelength in the UV to infrared radiation band. In practice, the industry has adopted a standard which consists in taking the average reflectivity.

As for **ASTEC,** we have taken a more conservative approach by using only the lowest reflectivity: 85%.

Normal hemispherical reflectivity:	86.9%
Reflectivity for visible radiation:	92.7%
Thermal emissivity (infrared):	90%
Normal emissivity:	92%

Please note that the normal hemispherical reflectivity (86.9%) represents an average reflectivity for **ASTEC #900**. When we say that **ASTEC #900** has a reflectivity of 85%, we are being very conservative.

22. What is ASTEC's temperature range of service?

Since **ASTEC** products are water-base, it is not possible to apply them when the temperature is 0 °C (32 °F) or lower; it is not practical to apply the products when the temperature is below 5 °C (41 °F). The upper limit for application is approximately 95 °C (203 °F)*.

*In extreme temperature conditions product should be applied in multiple light coats.

23. Will ASTEC provide additional insulation value if the dry film thickness is increased?

ASTEC is always applied with a dry film thickness (dft) between 12 mils (305 microns) and 15 mils (382 microns). Any additional thickness will be wasted because the principle of solar radiation control has nothing to do with thickness but everything to do with solar reflectivity and thermal emissivity.

24. What are the interior dimensions of a 20-ft container?

Interior length: 19 ft and 5 in.
Interior width: 7 ft and 8 in.
Interior height: 7 ft and 9.5 in.
Door opening: Width = 7 ft and 6.0 in.
Height = 7 ft and 5.5 in.

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