HOW DO THE COATINGS WORK?

So why can our insulating coatings be so thin and achieve the same goal as standard batt-type insulation? First, we must understand what heat is and its transfer methods before we can explain why the coating is so efficient.

Heat/cold is actually defined as the way in which light wave energy is transmitted into or through a particular substrate. This light wave energy is broken down into two important classifications: Visible and non-visible spectrums. The visible spectrum of light is what we see as color - red, blue, green, etc. The non-visible spectrums of light are above the visible spectrums include ultra-violet, x-rays, and gamma rays. All substrates and materials on the earth are affected differently by these varied spectrums of light. What they absorb or reflect determines what we feel as heat.

As heat is generated, another principle in physics begins. This is known as thermal dynamic heat transfer (TDHT.) TDHT is a never-ending process in which solids, gases and liquids are in the quest to reach equilibrium. Once equilibrium is reached total heat transfer has been achieved. Or in other words, if one thing is hotter than another, both substrates will try to reach the same temperature.

This is where insulation enters the picture. The way in which an insulator blocks this TDHT determines how effective that insulator will be. However, there are three processes in which heat transfers and what medium it uses. These processes are termed as **conduction, convection, and radiation.** In short these terms are respectfully defined:

> **Conduction***: transfer of heat by spreading the vibration of molecules in a solid. (Solid)*
>
> **Convection***: transfer of heat through a fluid (water, air).*
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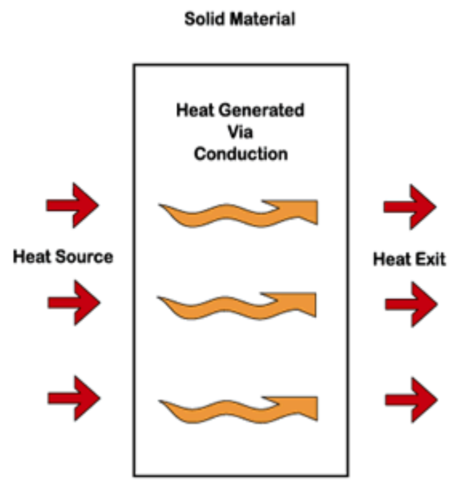
> **Radiation***: transfer of heat by electromagnetic radiation. Needs no vehicle medium. (Sun)*

EMPLOYING BLOCKING AGENTS

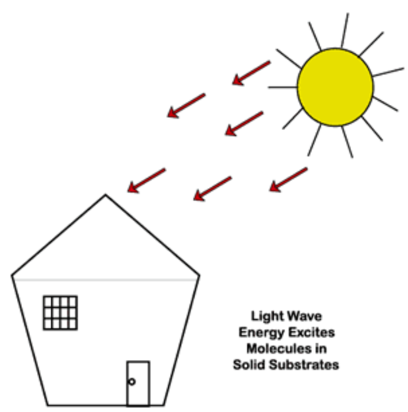
The above heat transfer methods can be expanded in great depth, but typically, most insulators employ a type of heat transfer method known as conduction. The way in which an insulator blocks the transfer of the molecule vibration defines its thermal conductivity (k) or R-Value. The lower the "k" value (or the higher the R-Value), the better the insulator. However, this is only one of the ways in which heat can be blocked. Most conventional (Batt type) insulators use conduction as their main blocking agent to retard heat/cold. What about the other two heat transfer methods? How do they fit into the equation of TDHT dissipation?

As heat is transferred, the above terms all play important roles. This means that by examining these THDT methods, we can effectively design or employ blocking agents to make an insulator more effective. The below terms are descriptions in detail of ways to block TDHT.

CONDUCTION is the transfer of heat, from molecule to molecule, throughout a solid material. The molecules inside the material, which are nearest to a heat source, gain kinetic energy. They vibrate vigorously, and their movement affects the molecules immediately next to them. They pass on some of their energy, spreading heat through the material. Conduction is chiefly associated with solids, because of the closely packed molecular structure of a solid is most suited to it. Metals are very good conductors of heat. Conduction is a point-by-point process of heat transfer. If one part of a body is heated by direct contact with a source of heat, the neighboring parts become heated successively. As shown in the diagram, if a metal rod is placed in a burner, heat travels along the rod by conduction. This may be explained by the kinetic theory of matter. The molecules of the rod increase their energy of motion. This violent motion is passed along the rod from molecule to molecule. In considering the flow of heat by conduction, it is sometimes helpful to compare the flow of heat to the flow of electricity. The temperature difference can be thought of as the pressure, or voltage, in an electrical circuit. The ability of a substance to transfer heat (its thermal conductivity) can be compared to electrical conductivity. When the temperature difference (or voltage) between two points is great, the driving force to move heat (or current) is high. The quantity of heat (or current) transferred will depend upon the temperature difference (or voltage difference) and the resistance to the flow of heat (or current) offered by the conductor.



RADIATION - This process begins when the internal energy of a system is converted into radiant energy at a source such as a heater. This energy is transmitted by waves through space, just as the sun radiates heat outwards through the solar system. Finally the radiant energy strikes a body where it is absorbed and converted to internal energy. It then appears as heat. An electric heater produces radiant energy in this way (see diagram). It may be absorbed, reflected, or transmitted by a body in its path. When the radiant energy is absorbed, the internal energy of the body increases and its temperature rises.



All bodies, whether hot or cold, radiate energy. The hotter a body is, the more energy it radiates. Furthermore all bodies receive radiation from other bodies. The exchange of radiant energy goes on continuously. Thus a body at constant temperature has not stopped radiating. It is receiving energy at the same rate that it is radiating energy. There is no change in internal energy or temperature.

Heat transfer by radiation is not proportional to the difference in temperature between the hot and cold objects as it is in the case of heat transfer by conduction and convection. It is proportional to the difference between the fourth powers of the absolute temperatures of the two objects. Thus heat transfer by radiation is enormously more effective at high temperatures than at low temperatures. Radiation transfer depends also upon the shape of the radiating object.

As radiational heat is understood the following new terms of emissivity, transmittance, and absorptance describe how radiational heat is transferred from one medium to the next. The following terms are described below.

Within Radiation, the block agents can be effectively broken down into the following categories:

> **REFLECTION** occurs when light rays hit a surface and bounce off changing direction. Mirrors are usually used to demonstrate the reflection of light because their shiny surfaces reflect light more than dull rough surfaces. This is important when applied to heat because heat as well is transferred in a light wave. Reflection plays a role in reflecting the light waves and thus returning the waves, which also employ heat. Therefore if a substrate is exposed to the sun and its enormous amount of light as well as radiated energy a large portion of the energy is then transferred into the substrate. However if the substrate employs a white and shiny surface a large portion of energy transferred, is reflected back into the atmosphere.
>
> This theory also works for radiated energy that can be reflected back to a substrate if the energy is transmitted from within. For example, if a pipe is covered with a shiny surface the reflected energy is then transmitted back to the pipe. If the surface were black the energy would simply be radiated to the atmosphere.
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> Thus reflection plays an important role when considering how energy is either lost or gained.
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> **EMISSIVITY** is the ratio of its power radiated per unit surface area to the power radiated per unit surface area of a black body at the same temperature. Materials with high emmitance radiate more heat than materials with low emmitance. For example, black surfaces have an emmitance of 0.98 and a polished aluminum surface has an emmitance of 0.04. Aluminum tends to block radiant heat transfer while black surfaces tend to emit significant heat.

E = POWER1 (AREA1) / POWER2 (AREA2)

WHERE: power1 = radiative power of unit ; AND power2 = radiative power of a perfect black body

ABSORPTIVITY and is defined as the fraction of the total incident radiation absorbed by the surface Therefore, if the temperature of the surface is constant and energy is conserved, the emissivity is equal to the absorptivity.

TRANSMITTANCE is the amount of energy that is transferred to a substrate. A low transmittance is desired for thermal insulators. This prevents heat transfer through the insulator by radiation.

MASCOAT'S COATINGS

All of our coatings employ a highly reflective particle composition structure (hollow ceramic glass insulating particle) to reflect light wave energy (*heat)* away from the substrate and back to the atmosphere in which it originated. (From a microscopic point of view, the particle looks like a piece of popcorn and small irregular spherical objects). This means that the coating deals with the heat prior to absorption to the substrate. Imagine a Thermos bottle. The coating is very similar in this respect. The coating actually reflects upwards of 85% of the heat generated back to the respective substrate or atmosphere. Now substrates remain cooler to the touch because they do not gain the heat like before.

Mascoat's thermal insulating coatings unusually low emmitance (when compared to other surfaces with high emissivities of 0.9 or greater) allow little heat-radiated into the atmosphere starting the heat transfer process. This means that substrates feel actually cooler than if compared by a thermometer.

And its transmittance and absorptance rates are very effective when compared to other conventional insulators allowing no transmittance due to its solid white color and also since it is light colored, no gained absorptance whatsoever. This means that the coating does not gain infrared energy like other surfaces.

Thus our coatings use the best in materials to help retard or stop the total heat transfer. This brings up an interesting conclusion on adding these heat-blocking principles together to represent the total heat transfer through a material. In the past it has been safe to describe the way in which an insulator worked mathematically as:

Total Heat transfer (TDHT) = *conductivity of a material*

Yet in all actuality, the full formula of thermal dynamic heat transfer as:

Total heat transfer (THDT) = *Conduction + Radiation Transfer + Convection*

Where Radiation = (Reflectivity + Emissivity + Transmittance + Absorptance)

This way of thinking applies to any type of insulator or insulating method. Without examining the whole, effective mathematical calculations will not describe insulating coatings or other insulators that use reflection to their advantage.

R VALUES AND HOW THEY APPLY TO INSULATING COATINGS

So how do insulating coating materials compare to conventional insulators? This question is probably the biggest hurdle for insulating coating technology. Briefly, most insulators describe their effectiveness by a thermal conductivity (k) that can be converted into an "R Value" (1/k). If we described insulating coatings by a thermal conductivity value alone, we would not effectively forecast the actual temperature differential that an insulating coating produces. This is due to the way in which the thermal conductivity test is designed and what it tests (ASTM-C177.) Currently there is no thermal conductivity test for an insulating coating.

So how do we effectively describe the way an insulating coating performs compared to conventional insulation materials?

This led to the development of an engineered comparison test. The test compares conventional thermal insulation materials (with an R-Value) to insulating coating materials. Although not ASTM certified, if done correctly it can forecast temperature differentials across various substrates in a controlled state.

CONCLUSION

In conclusion, TDHT is more than just a study of conductive thermal dynamics. Heat transfer is generated through multiple sources and performance of an insulator is solely dependent on the blocking agents employed against the heat transfer. The power to insulate lies within the power of its blocking agents.

If you need to have supportive engineered study data, please contact us directly so we can offer our services. We have on staff personnel that can correctly perform these calculations with all variables considered.