BASIC PRINCIPLES OF INSULATION

1-INTRODUCTION

The obligation to insulate a house or a building has became an indisputable reality. The energy crisis has put the costs of oil, gas and electricity so high that a good insulation will bring significant economies. **It pays to insulate**. Sufficient insulation, properly installed, is still one of the most cost-effective ways available to reduce energy consumption, control rising fuel and electricity costs and provide a comfortable living environment all year long. It is a simple installation procedure. Armed with some guidelines and a few basic tools, even a novice do-it-yourselfer can insulate like a pro.

The purpose of insulation is basically twofold. It must **KEEP THE HEAT IN** throughout our long winter and **KEEP THE HEAT OUT** during our sweltering summer.

Keep in mind, you will only do the job once. Take your time to do it properly. Patience is rewarded when it comes to installing your insulation and vapor barrier. Install the right product today and it will keep working well into the next century.

An efficient insulation system is essential to maintain a comfortable and healthy environment in the building and also to maintain the efficiency of the heating / cooling system. The choice of good insulation material is very important and should be done carefully. It is not an expense but an investment considering it daily pays you back with important energy savings. Once you have made a choice, it is difficult to come back later to improve your insulation without costly expenses.

It is very important to consider that you have to keep the insulation system in very good condition. A failing system without the proper elements installed at the right place could increase the risk of having moisture or water in it. Some insulation products absorbing moisture can easily loose up to 50% of its thermal efficiency.

2-FUNCTION AND ELEMENTS OF A GOOD INSULATION SYSTEM

When installed correctly, insulation reduces heat transfer through the envelope of a building. Whenever there is a temperature difference, heat flows naturally from a warmer to a cooler space. To maintain comfort in the winter, the heat lost must be replaced by your heating system. In the summer, the heat gained must be removed by your air conditioner.

Heat moves across empty wall cavities or between roofs and attic floors by radiation, conduction and convection. A reflective insulation reduces heat transfer by radiation to a very low level, and most products also reduce heat transfer by convection. Mass insulations reduce the convection part to a low level and slow down the conduction mode. However, reflective reduction is achieved by absorption of heat rather than reflecting it. Both types involve placing a solid material between the warm and the cool regions to reduce heat flow across the insulation region.

The benefits of insulating all cavities within the building envelope are many. A few Are:

1. It supports the individual and national economic and energy conservation goals,
2. Provides a much more livable structure. Well-insulated buildings, where effects of moisture condensation and air movement are minimized, require less maintenance, plus they deteriorate move slowly. Various forms of thermal insulation exist and one of the better ones is the reflective system.

The building envelope consists of five main elements which are : the weather barrier, the air barrier, the insulation, the **vapor barrier** and the interior finish. These must fulfill the following **critical functions** :

- Provide the minimum thermal insulation as required by the building code applicable.
- Restrict the flow of house air through the building envelope.
- Restrict the passage of interior **water vapor** by diffusion into the exterior shell.

- Allow moisture trapped within the exterior shell to breath to the outside**.**
- Provide the minimum fire retardant, flame spread and smoke development ratings.

3-VAPOR BARRIER AND CONDENSATION

Why is a vapor retardant necessary? During the heating months, humidity contained in the inside air is much higher than in the outside air. The inside air loaded with moisture will naturally move toward colder surfaces such as ceilings and exterior walls. If water vapor penetrates the wall or ceiling and condenses on cold surfaces, it may cause discoloration, mildew, or even structural damage. This will also decrease significantly the thermal resistance of this assembly. Therefore **it's vital to install a vapor retardant** between the inside air and the insulation. Humid air can go through any hole, gap or crack in the vapor retardant. **It is very important to install an efficient and solid barrier and to take the time to be sure warm inside air stays where it should**, **inside.**

The insulating capability of fibrous and rigid insulation comes mostly from the dry air cells in it and not from the material itself. For example, fiberglass insulates 30 times more than glass by itself. It's because of the air trapped in the fiberglass. That shows all the importance of an efficient vapor barrier preventing the moisture to migrate and condense in the insulation and lowered dramatically its thermal efficiency.

* For more details on condensation and dew point; see "Physics of foil".

4-REFLECTIVE INSULATION BASICS

It is not rare in construction to find some materials or methods that, for some reason, had been forgotten. The principle of reflectivity to prevent heat transfer through radiation has been used since the dawn of time. Romans were already using it during Antiquity.

To understand the principles of reflective insulation, we need to understand well how heat is transferred and the basic modes of energy transmission.

HOW HEAT IS TRANSFERRED

Since 50% to 70% of the energy used in the average home in North America is for heating and cooling. It makes sense to use thermal insulation to reduce the energy consumed and increase com-fort and save money.

The performance of any thermal insulation system depends on how well it reduces heat flow. Heat moves from warm locations to cool locations in three ways:

* By radiation from surface to surface through an air space,
* By conduction through solid or fluid materials,
* By convection which involves the physical movement of the air.

BASIC MODES OF HEAT TRANSMISSION

A. RADIATION from heat source is transmitted through air or vacuum to a cold surface at 186,000 miles per second.

B. CONDUCTION through a solid material is caused by fast moving molecules on the hot side colliding with and transferring energy to slower moving molecules on the cold side.

C. CONVECTION occurs when air or fluid moves. Warm air rises and cold air falls to create a convection loop. The moving air infiltrates or leaves your building during this process.

Modern construction these days demands high performance insulation systems that have the capability to prevent heat loss by conduction, convection and radiation. The systems must also stop air infiltration and be 100% vapor barrier.

How is it possible to create a thin insulation that would meet the criteria?

The principle is simple:

1. Air that does not move is one of the best insulation against heat transfer by conduction.
2. Reflecting colors act like a mirror and reflects exterior energy toward the exterior and interior energy toward the interior.

The principle of reflective insulation is the result of studies done on different kind of insulation worldwide. It had been shown that there was an undeveloped market to fulfill. Therefore, it was appropriate to innovate and bring a new multi-purpose product to give end users a new solution.

It is as simple as that, just like a survival blanket. The technique is based on those two essential elements; trapped air against heat transfer by conduction and a good reflector (like aluminum) against heat transfer by radiation.

Reflective insulation is a combination of aluminum foil and air spaces to provide reflective cavities which have low values of radiant energy emission (emittance). These cavities may have low emittance surfaces (foil) or encapsulated air spates within the layers of foil such as the bubble pack product.

Reflective insulation has been used in both residential and commercial applications for over forty years. These products provide a proven, reliable alternative or **supplement** to mass insulations.

Reflective insulation effectiveness depends on its ability to reduce each of the three modes of heat transfer. For example, a typical multi-layer reflective insulation divides a cavity into a set of smaller air spaces with parallel high reflectance and low emittance surfaces (A good insulation

technique.). For a cavity, the cell dimensions are designed to minimize air movement and reduce convection. The low emittance of the facing surfaces minimizes direct radiative heat transfer across the cells.

The reflectivity being function of the surface finish, it is obtained from a thin sheet of 99% pure aluminum. Also, the aluminum is so thin that it does not retain the energy in its mass. The ability of the foil to reflect the energy and not conduct it in its mass allows the people to quickly feel comfortable inside their home. This will also allow to bring back the temperature to a comfortable degree much faster when thermostats are lowered at night. Another way to save energy.

To obtain maximum efficiency , it is always better to have, on each side of the reflector a trapped air space (minimum of 16mm). It is essential to seal all the seams with a vapor barrier tape to insure perfect tightness.

Radiation is also heat losses

Authorities agree that 65% to 80% of all energy that goes from the warm side to the cold side of a wall assembly, summer and winter, is radiant heat; depending upon the direction of the heat flow (because of the varying role convection plays in the transfer of heat across buildings spaces). Of the remainder of the heat transfer, convection is responsible for 15% to 28%, and conduction is responsible for between 3% and 7% (see document "Physics of foil").

And more, the air volume facing the aluminum foil restricts the heat loss by conduction considering that **stagnant air is a better insulation** on that account than any solid material.

Reflective insulation materials work on a different concept than conventional thermal insulation like foam or mineral wool. In order to understand reflective insulation capabilities, one must be aware that the radiant heat rays of the sun do not become heat until they strike an object such as a home or everything that is in it. Thus, radiant heat rays must be kept out in warm weather; while in the cold weather, warmth must be kept in.

Conventional thermal insulation **does not stop** those heat rays; but rather, will absorb them and transfer heat. Thus, mineral wool and other thermal insulation will only **« slow down »** the transfer of heat. Reflective products, on the other hand, **stop** approximately 70 % of all radiant heat by reflecting up to 97% of the radiant heat rays. What **this means is that only 30% of this heat remains**, in some cases to be handled by conventional thermal insulation used **in conjunction** with the reflective insulation products.

The end result is that reflective insulation products are installed in conjunction with conventional insulation, the optimum energy can be experienced.

For reflective insulation materials, if air spaces are left out in the construction plan, the reflective insulation material will still provide excellent vapor barrier and air-infiltration benefits, but will give a lower R-value, and system performance **will be affected.**

Since there are built in air spaces inside walls and roofs, **it makes sense** that installing a material capable of reflecting large percentages of radiant heat it would thus provide a **highly effective insulating material.**

However, by creating a space which is bounded by at least one surface which is highly reflective of heat rays (as aluminum foil), a reflective space is created which can effectively **stop** the transfer of a majority of the heat.

Experts agree that as far as the rate of heat transfer is concerned, it makes only little difference whether the reflective surface is on the cooler or warmer side of the space.

5-R-VALUE

R values are commonly used to show the thermal value of insulating material. But it is important to know that R-value is just a measure of heat transfer by conduction and does not apply for other heat transfer ways. The R-value has no utility to measure the capability of a material to reflect the energy. Even if reflective insulation materials have a respectable R-value, their first quality is to stop heat transfer through radiation. Those products can stop up to 97% of heat transfer through radiation and provide an excellent temperature control method.

R-value is a measure of resistance to direct conduction of heat, and is a good measure of the effectiveness of mass insulation. The greater the mass, the higher the R-value, therefore the more effective most insulating materials become. Properly installed foil insulation, however **reflects 97% of the radiant heat** to which it is exposed…a factor not matched by common mass insulation…**nor measured directly by R-values.**

Therefore, while reflectivity remains constant, this insulation provides a secondary benefit of resistance to conduction (lost of heat through absorption) to varying degrees of effectiveness depending on whether its placement would be affected by **Down, Up or Side Heat Flow.** That's why this product has three R-values.

Reflective Insulation Thermal Performance Value:

Heat flow direction	Thermal resistance – R value (Hr ft^2 _F/ Btu)
Horizontal	**R6.70**
Heat flow up (ceiling)	**R5.4**
Heat flow down (floor)	**R14.6**

Once again, it is very important to understand that the benefits brought by reflective insulation materials can go way beyond the R values indicated in this chart. The energy savings will be much superior in many applications.