INSULTEC – What does it do and why?

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Introduction

I first came across the concept of special membranes for heat control in the late 1980's. I was then Professor of Experimental Physics at the University of New South Wales and Head of the Department of Applied Physics. One of my colleagues and I were asked to write a report on a new product which, it was claimed, was remarkably effective in preventing heat from entering buildings. The inventor of this product, Mr. Raymond Brooks, who was known to be a well established and highly regarded paint manufacturer, told us that it was essentially a high quality white paint to which had been added a special filler. He thought that the membrane, which was a few tenths of a millimeter in thickness, was acting as a thermal insulator and that it was just as effective for this purpose as an insulating batt of several centimeters thickness.

My colleagues and I were, at first, merely presented with data that had been obtained by other people, but we felt that we could not write our report without carrying out some tests of our own. It so happened that I had a Ph.D. student who had developed a thermal conductivity apparatus that was most suitable for use with the new membrane. Accordingly I asked her to measure its thermal resistance. She found that the material did indeed have a rather low *thermal conductivity* but, since the membrane was relative thin, its *thermal resistance* was not particularly large. There was no way we could explain, in terms of thermal resistance, the claim, made by Mr. Brooks, that his product kept the inside of a building cool on hot days, and we began to doubt that it was of any use for its designated purpose.

However, Mr. Brooks insisted that his product really did work and we were left with the problem of reconciling his claims with our measurements.

Modes of Heat Transfer

Most people known that heat can be transferred from one point to another by more than one mechanism. Heat can actually be carried in three different ways:

conduction, radiation and convection.

Let us look at a common system aimed at keeping the interior of a building cool in summer. In this system, insulating batts, made out of fiberglass, rockwool or similar open-structured material, are placed behind a painted roof. Although the roof reflects some of the heat radiation from the sun and sky, it becomes heated by both the non-reflected potion of the radiation and also by the conduction and convection from the surrounding air. As its temperature rises, the roof loses some heat back to the surroundings and some into the building, via the insulation. If there is no other source of heating or cooling, the temperature inside the building will eventually rise to that of the hot roof. Of course, if the batts are thick enough, this state of affairs may not be fully reached by the end of the day. Nevertheless, it is worth remembering that roof insulation not only impedes the entry of heat but also traps it once it has got inside.

A relatively cheap alternative system uses metallic reflective paint on the roof instead of insulating batts. This prevents most of the radiant energy from the sun and sky from entering the building but does nothing to reduce heating from the air and it is found, in practice, that roofs painted with metallic paints still become very hot.

What one would really like is a roof coating that reflects the incoming radiation but which, at the same time, emits heat strongly. Such a coating is even more desirable when substantial generation of heat takes place inside the building, as would normally be the case if it is used to house manufacturing plant.

Any surfaces is characterized by two quantities, the reflectivity, R, and the emissivity, E. One would like R to be as large as possible (it cannot be greater than 100%) and E also to be as large as possible (again the limiting value is 100%). Now there is a simple law of physics that states, *for any given wavelength* of heat or light rays,

$$R + E = 100\%$$

Thus, it would seem that we can make R large and E small or vice versa but we cannot, apparently, make both R and E large at the same time.

However, we must remember that sunlight consists mostly of the visible radiation centered at the wavelength of green light, whereas the radiation from a hot roof is at a quite different wavelength, far out in the infra-red region of the spectrum. It is theoretically possible for a surface to be a good reflector of visible light and a good emitter (poor reflector) of infra-red radiation. Could it be, then, that the new membrane, which was the forerunner of what is now know as INSULTEC, might be combining these two favourable properties? In other words, might it be what we call a selective reflector?

Thermal Insulators versus Selective Reflectors.

It cannot be emphasized too strongly that thermal insulators and selective reflectors are not substitutes for one another. If one's aim is to keep a house warm in cold weather, then there is no doubt that a thermal insulator is a sensible choice. However, it has disadvantages if one's object is to keep the building cool in hot weather. Let us then compare some of the features of thermal insulators and selective reflectors:

1a. Thermal insulators can delay the influx of heat into a building but eventually the inside temperature will approach that of the roof.

1b. On the other hand, selective reflectors keep the roof cool so that the inside temperature will never become high.

2a. If heat is generated inside a building, a thermal insulator will trap this heat.

2b. A selective reflector will emit the extra heat to the surroundings.

3a. For a well-insulated building, the only way to keep cool when there is a long period of hot weather is to install an air conditioner.

3b. If a selective reflector is applied, an air conditioner may not be necessary or, if a thermal insulator is installed, air conditioning can be operated at a lower power level

Experimental Observations

Theory is a most useful tool for physicist but, if there is a disagreement between theory and experiment, then it is the experimental observations that one must trust. Consequently, although at first we had our doubts about the new membrane, we though that the very least we could do was to check on the validity of the claims that Mr. Brooks had made. He had suggested that he set up two small sheds in the open air with a thermometer in each. One shed was to be coated with the new membrane and the other was to be left uncoated or coated with ordinary paint. I made suggestions about the location of the sheds and the standardization of the thermometers so that there could be no doubt about the meaning of the results.

Within a day or two, I became convinced that the new coating conferred all the benefits that Mr. Brooks claimed for it. Under virtually all conditions, the shed covered with the special membrane was many degrees cooler than the other shed. There was absolutely no doubt that the new system worked. However, being a scientist, I had to satisfy myself as to why this was so.

Some of my colleagues were working on the utilization of solar energy and I was able to use their equipment to show that the new product was an excellent reflector of sunlight, with a reflectivity of about 80%. I also had a laser that operated in the same region of the spectrum as the heat coming off a hot roof. Using the laser, I found that the infra-red emissivity had the high value of 95%. I was, therefore, able to explain why the new membrane was so effective.

Later on, I was able to replace the metal sheds, on which the original experiments had been carried out, by more sophisticated experimental arrangement. This confirmed the original claims but also showed that the cooling is much greater under some conditions than others. I understand that, under a cloudless sky and with clear air, the internal temperature can be as much as 15 degrees below that of the surrounding air.

Practical Considerations.

As a physicist, I could probably design a surface that would be effective in keeping heat out of a building. However, my surface would probably be very expensive and would be unlikely to last for very long on a roof that was exposed to the elements 24 hours a day. It is doubtful if it would protect the roof from degradation over the years. In other words, it might do the job for a short time after installation but it would be quite uneconomical and, in the long run, ineffective.

The original membrane that I tested for Mr. Brooks was much more practical than my imagined material but it was by no means perfect. However, its shortcomings have been eliminated over time so that the present day product, INSULTEC, not only performs well immediately after installation but continues to do so, without degradation, as the years go by.

How has Mr. Brooks been able to achieve this result?

It is because he is not a scientist but a paint technologist who has specialized in the development of long-life coatings. Thus, he has been able to ensure that INSULTEC provides maintenance-free roof protection for decades rather than years. Much of this benefit is due to the fact that INSULTEC is much thicker than ordinary roof paint. Of course, it is necessary that the coating should be well bonded to the roof but there are, in fact, different versions of INSULTEC that allow good adhesion to be achieved under various conditions. All versions have the same heat rejecting properties.

Conclusions

In summary, I was at first reluctant to accept the claim that buildings could be kept cool by a membrane of less than a millimeter thickness but tests that I supervised showed the claim to be true. I was able to explain the behaviour of the new membrane in terms of selective reflectivity and emissivity in the visible and infra-red parts of the spectrum. I have also been convinced of the excellent protective properties of the membrane, which in its development form is know as INSULTEC.

It is my considered opinion that INSULTEC is an excellent product and that it deserves the success that it is achieving.