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From: Dr. Raffaele Cammarano B.E. PhD
Consulting Services,
6, Barnett St.
Freemantle WA 6160
Ph: (09) 3352940
Fax: (09) 3304501

To: Insultec Liquid Insulation
P.O. Box 873
DUBBO NSW 2830

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REPORT: INSULTEC LIQUID INSULATION

The following is a review of previous experimental work conducted on establishing the efficacy of “Insultec” Liquid Insulation as a heat rejecting medium. The report includes a summary of comparative experiments and research carried out to determine the fundamental properties of Insultec. A preliminary suggestion for further experimental work is also provide.

1. COMPARATIVE EXPERIMENTS.

I have examined numerous test results in which experiments were conducted to compare the heat rejecting properties of Insultec to other materials, including ordinary paints, and fiberglass insulating batts. These experiments were carried out in order to examine the hypothesis that

> “ if the outside walls and roofs of buildings were coated with Insultec, then the interior of those buildings remained much cooler than a similar uncoated building”

Extensive independent testing (1-3) has been performed on a variety of enclosures over a number of years (including galvanized steel sheds and 300 mm3 boxes) to examine this hypothesis.

A common experimental procedure was used for all tests: the enclosures were completely exposed to full sunlight and the ambient and internal air temperature was monitored. Of particular interest was the maximum air temperature within the enclosure, which of course affects the comforts and cooling (air conditioning) costs when the enclosure happens to be an occupied building.

All results indicate that an enclosure coated with Insultec was significantly cooler, of the order of 5-15^{0}C (approximately 20-40%) cooler, than an identical uncoated enclosure. The variation in temperature difference is dependent on ambient air temperature and climatic conditions. For example, on hot clear days the temperature difference between coated and uncoated enclosures is greatest. It should be noted that experiments ran for extended periods of time, sometimes up to several months and in fact some field trials have been subjectively monitored for several years.

The astonishing results suggested that Insultec maybe more effective than conventional insulation such as fiberglass, to minimize internal air temperatures. Again, independent experimental results (1-2) verified this claim. An experiment performed under guidance of Professor H.J. Goldsmid (Emeritus Professor of Physics, University New South Wales) whilst he was the Professor in charge of experimental physics, provides an indicative example (1). The test comprised of recording the maximum temperature inside two identical steel sheds, one completely insulated with conventional fiberglass batts, the other coated externally with Insultec. It was found that the Insultec coated shed was 10% (+/- 4%) cooler than the fiberglass batt insulated shed. The experiment ran for 4 months and daily maximum temperatures varied from 14^{0}C to 32^{0}C, daily minimums from 3^{0}C to 16^{0}C.

Significantly, Insultec users have also conducted comparative examinations of he efficacy of coated buildings with Insulted and have also verified the original supposition that the internal temperature would be greatly reduced.

2. FUNDAMENTAL PROPERTIES OF INSULTEC.

The extensive independent experimental results and practical experiments conclusively verify the claim that the coating of a building with Insultec will significantly reduce the interior temperature of the building compared to an identical uncoated building. The obvious question then arises, “ how does Insultec work?”

It is well known that the heat transfers from one region to another by three primary mechanisms, namely radiation, conduction and convection. Few people are more qualified than Professor H J Goldsmid in providing an explanation of how Insultec is such an effective heat rejecting coating. The following is quoted directly from a recent report that he wrote (6):

“ Insultec, when applied to he roof and walls of a building or other enclosure, reduces the temperature inside that enclosure by the following means:

(1) Due to the specially selected pigments in the membrane, the surface becomes a good reflector of solar radiation (visible and near infra red) and a good radiator of terrestrial radiation (far infra red). This enables the building to radiate heat effectively while at the same time minimizing the influx of heat from the sun.

(2) The selective radiative and reflective properties of Insultec explain no more than a fraction of its beneficial properties. Accordingly, I presume that, in spite of being relatively thin, an Insultec coating offers significant resistance to heat conduction. I understand that the constituents of Insultec were selected in the firs place so that the membrane would offer substantial thermal resistance.

(3) It is difficult to see any way in which Insultec could modify thermal convection through the surrounding air. Nevertheless, in the light of the outstanding behaviour of Insultec as a heat rejecting medium, I cannot dismiss the possibility that the enhanced thermal convection may be playing some part.”

Typical measurements used to characterize the radiative heat transfer process of a material are the “Solar Absorptance and Reflective” and the Infra-red Emissivity”. The Solar Absorptance and Reflectance were measured most recently by Vipac Engineers and Scientists Ltd., (7). Their figures of 15% Solar Absorptance and 85% Solar Reflectance are identical to previous measurements obtained by the Solar Materials Testing Laboratory, Department of Mechanical Engineering at the University of Western Australia (8). That is, 85% of incoming solar radiation, (covering the full spectrum from ultra-violet to visible to near infra-red), is reflected back into the atmosphere by Insultec. Only 15% of solar radiation is absorbed. It is this absorbed solar energy which leads to the heating of the interior of an opaque enclosure. This should be compared to the values of solar absorptance measure for a typical commercial white paint and galvanised steel of 25% and 29% respectively (7). Thus, in terms of “Solar Heat Gained”, Insultec coated enclosures would be 40% better than an enclosure coated with commercial white paint and 48 % better than a simple galvanized steel enclosure.

The Infra-red emissivity was most recently measure to be 89% (8) and previously measure to be 95% (1). The difference is not significant, considering the difficulty of measurement and that the actual wavelengths at which the emissivity was determined was not specified. In any case these figures indicate that Insultec is an efficient emitter (radiator) of far infra red.

All the aforementioned figures reinforce the statements made by Emeritus Professor H J Goldsmid in his statement (1) above. However as he noted, “ the selective and radiative and reflective properties of Insultec explain no more than a fraction of it’s beneficial properties”. It must therefore be logically assumed that Insultec provides considerable resistance to heat conduction.

Heat flow due to conduction is usually characterized by the thermal conductivity, K of the material. The thermal resistance R (commonly referred to as the R-value) is then related to the thickness, T of the material by R = t/k. That is, materials with high conductivity have low thermal resistance and vice versa. Also, the thicker the material, the higher it’s thermal resistance.

Enormous experimental errors of the order of 30% occur in the measurement of k (9). This is due to the inherent difficulties involved in its measurement. It is notable that, to the authors knowledge, no Australian standard exists for the measurement of the thermal conductivity of paints. Also, to date, no attempt has been made to characterize thermal convection.

Regardless of this, it would be completely inappropriate to describe Insultec by the conventional R-value, as this thermal resistance is based purely on the thermal conductivity. No account is taken on the surface properties of the material, which could significantly affect heat transfer due to radiation and convection. This is particularly important for highly selective reflective materials such as Insultec. Thus, the ‘overall’ R-value of such a material may be appreciably larger than that due to taking account of only heat flow by conduction. In this respect, one should particularly note the following statements taken from Australian Standard AS2464 – methods of testing of thermal insulation (1981). (10).

“ The thermal resistance of a material is know to depend on the relative magnitudes of the heat transfer process involved. Thermal conduction, radiation, and convection are the primary mechanisms. Of these, only conduction is linearly dependent on <T (“the temperature difference across the specimens”). These processes are well researched, but they can combine, or couple, to produce non-linear effects that are difficult to analyse, and even more difficult to measure.”

It is the author’s belief that the overall thermal resistance of Insultec is in fact a result of complex non-linear coupling between the heat transfer mechanisms, predominantly radiation and conduction. Insultec is an example of “the whole is greater than the sum of the separate components”, as often occurs in non-linear systems. That is, any attempt to characterize Insultec by separating the radiative and conductive heat transfer mechanisms will grossly underestimate it’s effectiveness, as demonstrated by the extensive comparative (i.e., before and after) experiments and in-use experience.

Only further fundamental research will elucidate the true thermal and optical properties of Insultec. However, just because one does not understand how Insultec is such an effective solar heat insulator, does not preclude the fact that it does indeed work. One could take the example that gravity existed long before it was understood – but it is still not fully known.

3. PROPOSAL FOR FURTHER EXPERIMENTAL WORK

The difficulty at present in the utilization of Insultec as a heat rejecting medium is that it is complicated to model it's insulating effects when applied to buildings. This complication arises from the fact that traditionally, engineers, architects, designers etc have relied on design concepts relating to the determination of the insulation properties of composite structures based on the R-value of the individual components. As previously explained, it has not been possible to obtain from the "first principles" an equivalent R-value for Insultec because of the extremely complex nature of coupled heat transfer mechanisms. Continued fundamental research may, eventually provided a greater understanding of the heat transfer processes involved in Insultec. However, the author believes that work conducted in this area would be costly and should be viewed as an ongoing, long term, academic programme.

(1) Numerous reports, Dept. of Physics, University of NSW, Australia.

(2) Exposure report. Allunga Exposure Lab. Qld. Australia.

(3) Testing report no.53249, National Chemical Building Materials Laboratory, Beijing, China.

(4) Correspondence, Dept. Road Transport, South Aust.

(5) Correspondence, A.E. Smith, Westair Group of Companies Mechanical Engineers and Contractors, WA, Australia

(6) " Performance of Insultec Membranes as Heat Rejecting Coatings" Emeritus Professor H J Goldsmid, NSW Australia.

(7) "Insultec Coatings: Measurement of Solar Heat Gain Properties", Vipac Engineers and Scientists Ltd., Victoria, Australia.

(8) "Emissivity and Optical properties Measurements, Ref. 18/92" Solar Materials Testing Laboratory. Department of Mechanical Engineering, University of W.A.

(9) "K factor of Insultec", Unisearch Limited, NSW , Australia

(10) Australian Standard AS2464.5 Steady State Thermal Transmission Properties by means of the Guarded Hotplate page 18, appendix C Section 4.1 1983

Dr. Raffaele Cammarano B.E., Ph.D.