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THINSULEX[®] :

Report on the comparative performance of different insulation materials using insulated structures within a controlled temperature environment.

September 2005

1) Executive Summary

The School of Mechanical Aerospace and Construction Engineering (MACE) was commissioned by Web Dynamics Ltd to evaluate the thermal performance of Thinsulex[®] in comparison with other insulation products by means of monitoring test cells in a controlled temperature environment. This report summarises the methodology used and the results obtained.

2) Objective

To measure the comparative performance of different insulation materials using insulated structures within a controlled temperature environment.

3) Methodology

Background

The essential components of an experiment to measure the steady state heat loss are as follows:

- A test cell constructed from a known surface area of the material under test in conjunction with a known surface area of other materials of established thermal resistance
- A means of providing a constant rate of heat input into the test cell
- A controlled temperature environmental chamber external to the test cell, thermostatically maintained at a lower temperature than the inside of the test cell so as to induce a flow of heat outwards from the external surfaces of the cell.
- A means of measuring temperatures within and external to the test cell.

These components will be dealt with in turn.

Test cell

The test cell is shown in Figure 1. The pitched surfaces, gable ends and the walls are made from the material under test. The material is affixed to a frame made from mild steel rod. The floor plate is made from 90mm Kooltherm K8 rigid insulation board. The test cell is held clear of the floor of the test chamber by means of polystyrene blocks.

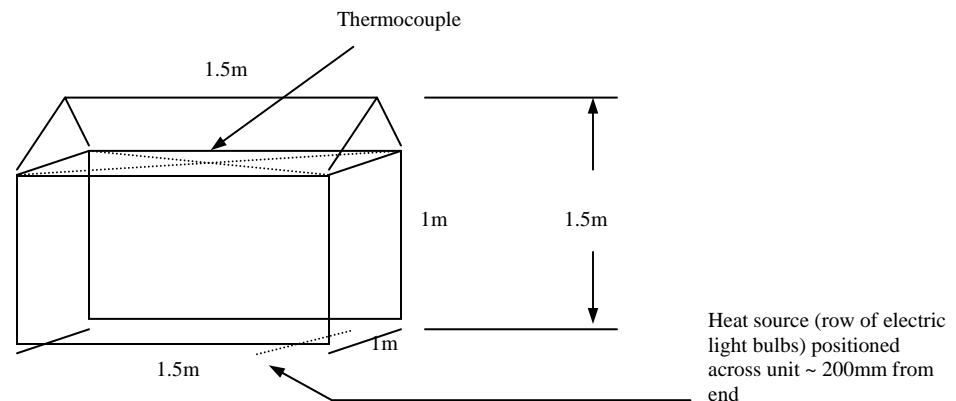


Figure 1: Test Cell showing heat source and thermocouple location

Controlled environment chamber.

Controlled environment chambers with extremely accurate temperature control are extremely expensive to construct. In view of the stated objective of this investigation, it was inappropriate to construct such a facility. Rather, it was decided to use a more convenient piece of equipment. A refrigerated trailer was rented for the duration of the tests. The temperature control was adequate for the methodology being used, and the volume of the trailer meant that it would be possible to house no less than three test cells of identical volume.

The use of the trailer introduces one potential source of experimental error which would have to be minimized. Within a refrigerated trailer, cooling is achieved by the chilling of recirculating air. Air flow might produce heat exchange by forced convection over the external surfaces of the test cells: furthermore, the rates of forced convection might be different for each of the test cells. It was therefore decided to minimize air flow over the test cells by means of a series of baffle plates. These are shown in Figure 2.

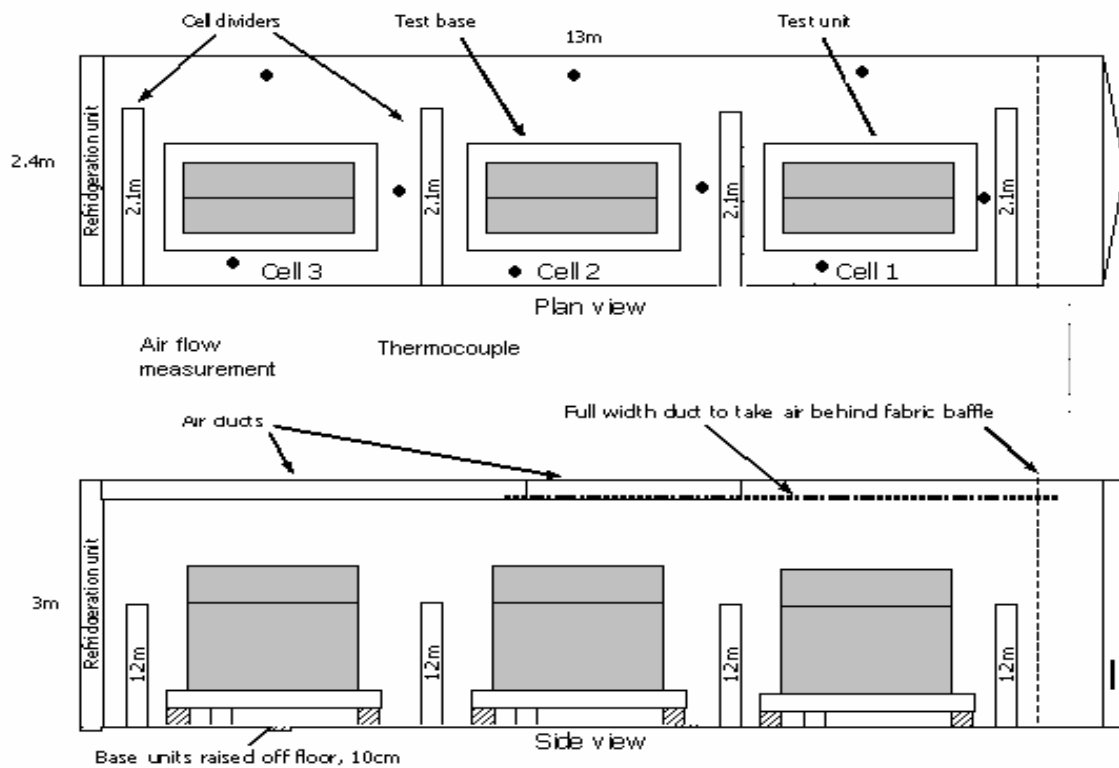


Figure 2: Test Cells in Trailer

Air velocities were measured at a number of locations within the trailer, as shown in Figure 2, with all three test cells in position. The results are summarized in Figure 3. These indicate that forced convection is not likely to be a significant source of error.

	Cell 1 (Door end of test room)			Cell 2			Cell 3 (Refrigeration unit end of test room)		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
By the wall opposite test cell	0.500	0.300	0.040	0.720	0.570	0.340	0.690	0.410	0.480
Mid-way across the width of the test cell	0.040	0.150	0.130	0.012	0.015	0.060	0.160	0.090	0.120
By the wall within the test cell	0.010	0.350	0.090	0.300	0.100	0.060	0.060	0.300	0.180

Figure 3: air velocities around the test cells (all in metres per second)

Temperature measurement

Temperatures were measured by means of type K thermocouples. The locations of these are shown on figure 2. The thermocouples were shielded from convection and radiation. Temperatures were recorded continuously on chart recorders. For purposes of analysis, data was read off the chart paper at one hourly intervals.

Test Schedule and data analysis

Two phases of measurements were undertaken. The test methodology was the same in each phase. The materials tested may be subdivided into two sub groups, namely standard fibre based products and multi layer products.

Fibre products:

200mm glass fibre roll	(Phase 1)
25mm Xtratherm board	(Phase 2)

Multi layer products:

Thinsulex [®]	(Phases 1 and 2)
Actis Tri Iso Super 9	(Phase 1)
YBS SuperQuilt 14	(Phase 2)

For each test, cells were set up using the material as the wall and roof material of the cells in question. It should be remembered that 90mm thick Kingspan Kooltherm 8 was used as the floor material in each case.

In each test, the test cells were allowed to come to equilibrium. Overall heat losses from the test material were fixed at 82W, and hence thermal losses per square metre of material could be calculated. Readings of internal and external temperature were taken from the chart rolls at 1 hour intervals (Phase 1) and 2 hour intervals (phase 2). Using these, thermal transmittance values (W/m^2K) were calculated. Implied thermal resistance values (m^2K/W) were calculated. It should be noted that in view of the multi faceted nature of the test cells, it was felt that it would be unsound to attempt to correct these results for surface resistance effects.

4) Results and Discussion

The mean results for the tests are summarized in Figure 4.

Phase 1

	200mm glass fibre	Thinsulex®	Tri Iso Super 9	
THERMAL TRANSMITTANCE	0.513	0.488	0.555	W/m²K (mean of means)
IMPLIED THERMAL RESISTANCE	1.949	2.049	1.801	m²K/W

Phase 2

	25mm Xtratherm	Thinsulex®	SuperQuilt 14	
THERMAL TRANSMITTANCE	0.565	0.493	0.632	W/m²K (mean of means)
IMPLIED THERMAL RESISTANCE	1.770	2.028	1.508	m²K/W

Figure 4: Results summary

Several points of interest arise. Firstly, the result for glass fibre is more than double what might have been expected on the basis of the widely accepted typical U value for a 200mm layer of about 0.22W/m²K. It could reasonably be argued that this test is inappropriate for this material, as glass fibre is rarely used in isolation. By contrast, 25mm Xtratherm loses only 10% more heat than the glass fibre, reinforcing the view that the performance of the glass fibre is being severely compromised.

Of the multilayer materials, Thinsulex® clearly gives the best performance, being over 12% better than Actis Tri Iso Super 9 and nearly 23% better than SuperQuilt 14. These two latter products both use stitching to hold the layers together, whilst Thinsulex® does not. Tri Iso Super 9 has straight stitching, whilst SuperQuilt 14 has a more complex pattern. This could well explain some of the difference between these two.

5) Conclusions

- i. Foil insulation systems do provide high level of thermal resistance. Of these, Thinsulex® was shown to have the best thermal transmittance properties. Thinsulex® also demonstrated better thermal values than PUR rigid foam at the same nominal thickness.
- ii. The test methodology was probably unfair on glass fibre. However, the results suggest that the in situ thermal performance of glass fibre may be inferior to that obtained by laboratory tests.
- iii. The results suggest that stitching of multi layer insulation products may affect thermal transmittance.
- iv. Although beyond the scope of this study, it is suggested by the author that multi layer insulation products may exhibit different thermal transmittance values according to its fixing orientation. This would be worthy of further investigation.
- v. For low surface emissivity multi-layer insulation products the in-use test method, when conducted in controlled conditions, probably produces more realistic thermal resistance figures than those generated by the guarded hot plate method.
- vi. It is noted that Thinsulex® only just fell short of the currently required U value of $0.3 \text{ W/m}^2\text{K}$ for a refurbished roof. It might well be that when tested in a full sized structure that Thinsulex® combined with the other structural components might achieve the required value.

6) Recommendation

Web Dynamics is of the opinion that there is an urgent need for an industry wide consensus on the development of a full scale in-use, thermal insulation test.