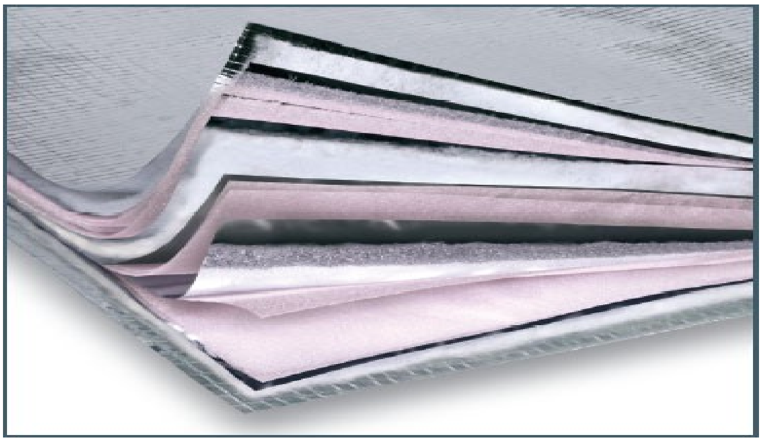
Peter Linnell, B3 Essay;
If something looks too good to be true, it probably is...

Being an examination of the claims for performance of Actis Triso Super 10(TM) multi layer thermal insulation, and various counter claims made against it.

Introduction.

As a contractor working in conversion and refurbishment of traditional buildings I have used this material where specified by others and have specified it as a best solution to achieving high insulation value without excess loss of internal space and where clients have demanded no risk of chemical outgassing. Previously I have accepted in good faith the manufacturers claims for the thermal insulation properties of this material and have defended it's use on this basis to Building Control Officers. However fresh evidence recently led me to question the validity of the claims made. I have here set out to examine the claims in the context of independent testing and regulated standards and also in the context of actual applications.



Actis-insulation.com

The claims made

The principal claim under examination here is the thermal insulation performance of the material, TRISO-SUPER10 for which the makers, Actis SA, claim a u value of

u = 0.19 W/m^{2}K

along with the associated claim that this is equivalent to 210mm of mineral wool quilt insulation. They do make clear that this value is not measured directly, but that it is derived from a testing method using actual buildings, and is dependant on rigorous installation. Secondarily, they claim that TRISO-SUPER10;

“*Meets 04/2006 Part L Building Regulations* ***for refurbishment*** *for England and Wales.”*
(Emphasis mine)

Both these claims appear on current web pages as at 16.3.09. (Actis-insulation.co.uk) The technical specification sheet and installation guide available from the site emphasise the test method used as

“*measured under real conditions”*   (ACTIS 2008)

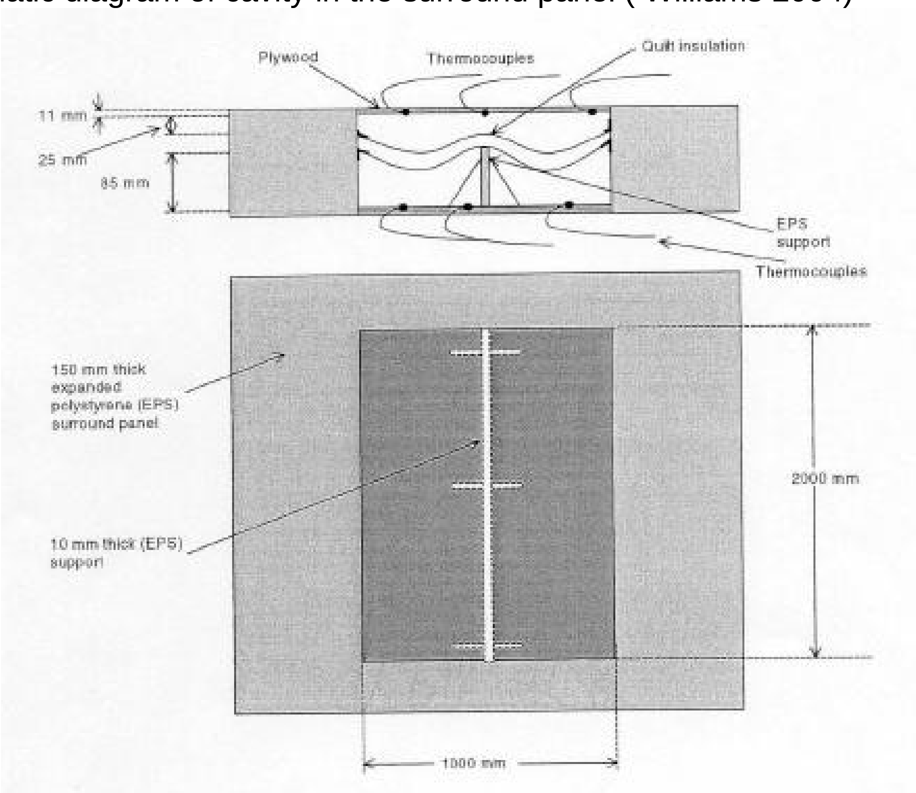
To verify the first claim would appear a simple matter of examining the reported performance of the material tested according to BS EN ISO 8990 :1996. However the manufacturers do not publish such a value. Instead their claim is based on a comparative test carried out across a range of sites in the UK and France details of which are not published. Because of the potential benefits from using this material, saving headroom in interiors and time on site it represents a real challenge to the market for more conventional insulation materials. No surprise therefore that a legal challenge to the claims was mounted through the Advertising Standards Authority. This brought the matter into the realm of adversarial legalistic dispute, rather than scientific debate which muddied the issue considerably.

The ASA upheld the complaint, challenging the claimed performance (equivalent to 200mm mineral wool) on the basis that the elements of the test chalets did not truly recreate real building elements, missing internal plaster-boarding and outer under batten membrane. (ASA 2008). As the TRISO-SUPER9 was installed strictly according to directions including overlaps and tape sealing of joints, effectively making it an airtight envelope, this massively favoured this material in a comparison test. No recognised laboratory test results were offered to substantiate the claimed U value. (ASA 2008). Since the adjudication the product has been "improved" and renamed as Triso Super 10; but David Curtis of Actis UK described the alterations to the material as minor. (Pers. comm. 25.3.09)

Another insulation manufacturer Celotex Ltd. commissioned a laboratory test, through National Physical Laboratory. (Williams 2004) This test was conducted according to BS EN ISO 8990, using a hot box apparatus and measuring energy inputs to maintain a steady state heat flow through the sample. The measured thermal resistance of the insulated cavity was

$R = 1.71\ m^2 K/W$ indicating $U = 0.58\ W/m2K$

Fig 1:Schematic diagram of cavity in the surround panel (Williams 2004)



It must be noted however that the physical construction of the test sample in the apparatus differs from any real application. The sample is draped loosely over a support element and taped in place at edges; rather than pulled level (as it would be over rafters). Perhaps more importantly the cold side void is fully ventilated with air movement at 4m/s.

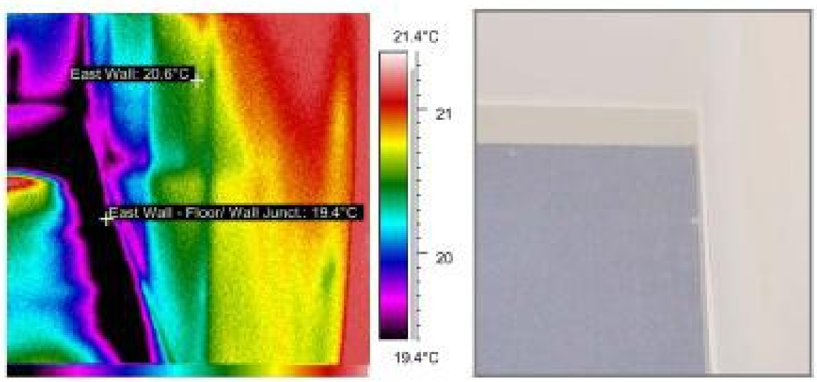
In addition, a study by Building Research Establishment (Ward and Doran 2005) tested in situ thermal performance of this material in a refurbishment of granite built accommodation. The wall construction consisted of duplex plasterboard, 25mm unvented void, Tri-Iso Super 9, unvented void, masonry. The measurements (of four walls) yielded u values for the construction (including the unvented voids) between 0.45 and 0.52 W/m2K. Tests on roofs and floors were conducted at another site.

Actis UK subsequently engaged Alba Building Sciences Ltd. to carry out a thermographic survey of the same properties, which revealed anomalies in the surface temperature of wall to floor junctions; suggested to indicate air flow from outside into the supposedly unvented voids. (Rooney 2006) Subsequent destructive inspection of the wall revealed that poor construction detailing had left paths for cold air from the underfloor space into voids forming essential parts of the insulation system. It was found that the insulation had no taping of joints; in direct contradiction of installation instructions. Whilst the project design called for removal of the original lath and plaster from the granite walls before dry-lining, it was found that in some areas this had not been done, also compromising air tightness. (Rooney pers.com.26.3.09). (For drawings see appendix 1). For these reasons, the Ward and Doran examination is flawed and cannot be relied upon.

Fig 2 An example of the thermal anomalies revealed by imaging. (Rooney 2006)

Thermogram 5

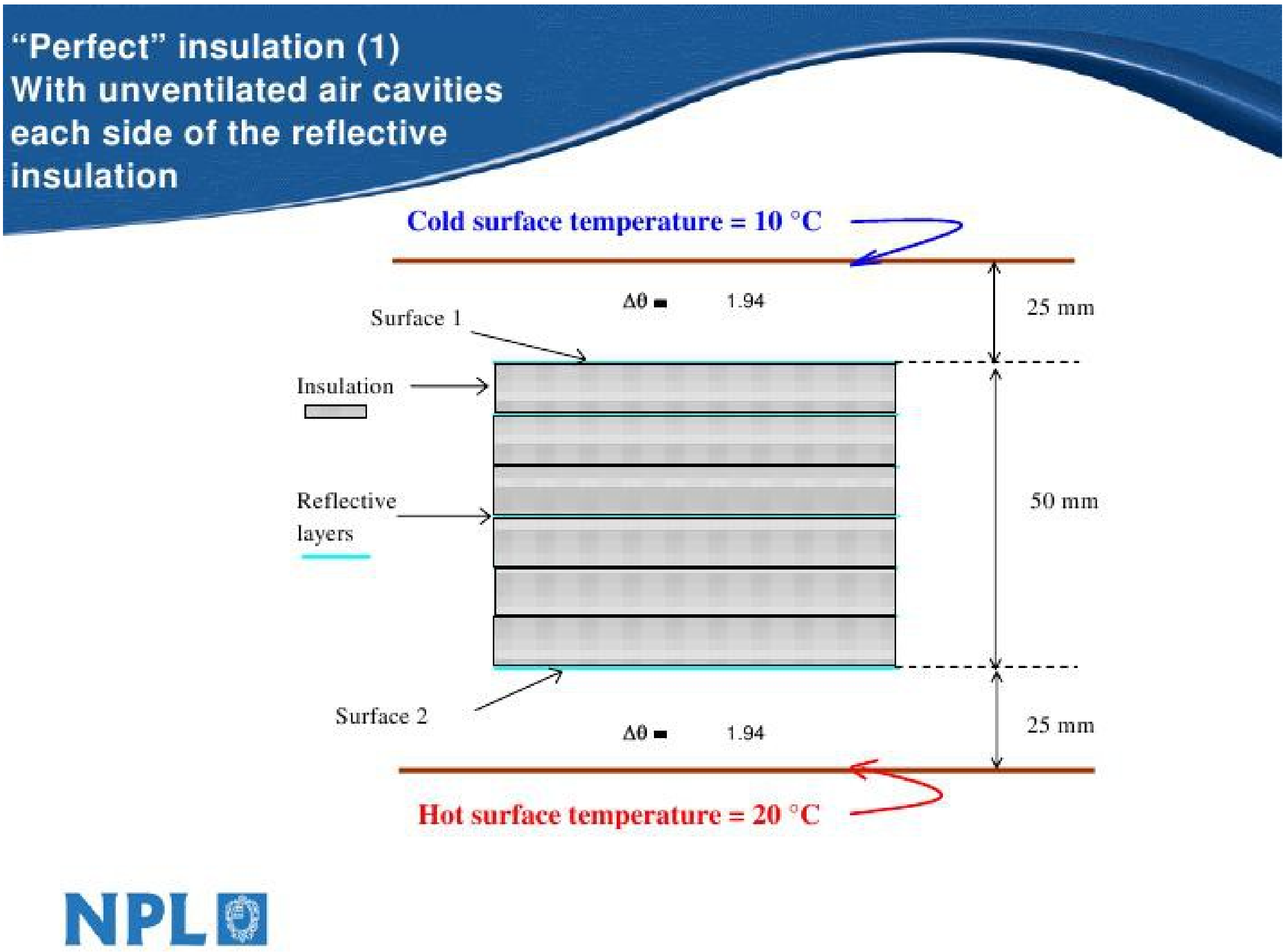
East Return Wall – Floor / Wall Junction



Location	Spot Temperature Reading
East Wall	20.6°C
East Wall – Floor / Wall Junction	19.4°C

In an attempt to share a better understanding of the basic physics involved in this matter Williams (Williams 2005) created a thought experiment proposing a “ perfect insulator” and using established standard calculation methods to determine it's performance in suggested real building elements.

Fig 3 Williams' perfect insulator thought experiment



By assuming that the reflective layers are 100% effective, that no quilting compression occurs and assigning a thermal conductivity to the insulation the same as *still air* (no convection) and using standard values (EN 673 ; E = 0.05 @ 45 degrees pitch.)for heat transfer across the adjoining cavities;

Total resistance, including unvented voids R = 3.3 m^2K/W

u = 0.30 W/mK (Williams 2005)

This demonstrates from basic principles that any insulation material claiming a higher resistance from less thickness in a real life situation is seriously challenged. It must be offered against TRISO-SUPER10 that there are no innovative materials used in it's manufacture which could give it any new unique ability to resist heat transfer better than still trapped air, and it's claim to work by reflecting Infra red radiation is dealt with by the model at 100% reflective efficiency.

Comparative testing

The original, (continuing) claims made for TRISO-SUPER10 are based on a testing regime characterised as comparative in situ testing. Apart from the considerations above, this basis of claim needs examination. According to the certification for the material; BM TRADA Building Insulation Products Certificate No. 0102 (BM TRADA 2006) (See appendix 2)

> "*Two identical chalets of a total uninsulated roof surface of approximately* $41m^2$ *(* $26m^2$ *on the two slopes plus* $15m^2$ *on the two gable walls were lined with TRISO SUPER 10 and mineral wool (glass) of 200 mm in thickness respectively and were heated and maintained at an average temperature of* $23\,^oC$*. The energy consumption for heating each chalet was recorded and results compared. Temperature and humidity conditions inside each chalet were continuously monitored and weather conditions at each site were also recorded."*

Data from test sites in UK and France were used to calibrate an unidentified mathematical model of thermal behaviour of structures for the test site conditions and was found to be able to predict power consumption of the chalets under different weather conditions. The model was applied to theoretical test chalets at sites representative of the UK as a whole, followed by an "assessment" based on results of modelling to derive relative performance of the materials under different conditions.

> *" The overall conclusion of the assessment is that when TRISO SUPER 10 is used as specified in the manufacturers' Fixing instructions it has insulating properties equivalent to mineral wool (glass) of 210mm in thickness."*

BM TRADA were asked to supply detailed information about the testing procedure; but could not without client consent. (V. Kearley, BM TRADA; pers. comm.22.3.09). They state that test chalets were now constructed using plasterboard finishes and under batten membranes; overcoming the objections of unequal comparison referred to in the ASA adjudication. However, when asked for a copy of the test reports Actis UK were unable to release this without director level approval. (D.Curtis; Actis UK Ltd; pers. comm. 25.3.09). This was not given.

Some information can be gleaned from various web pages posted by Actis SA in support of their product, such as this photograph of a test site; Limoux;France.

These chalets must be experiencing different exposures to weather by virtue of their close proximity, linear plot layout and nearby vegetation. Also these buildings include elements other than those included in the testing, walls which are not tested gables and of course floors. Another Actis document, "Exclusive Technology Thermal reference guide 2" (Actis 2006) offers this illustration;

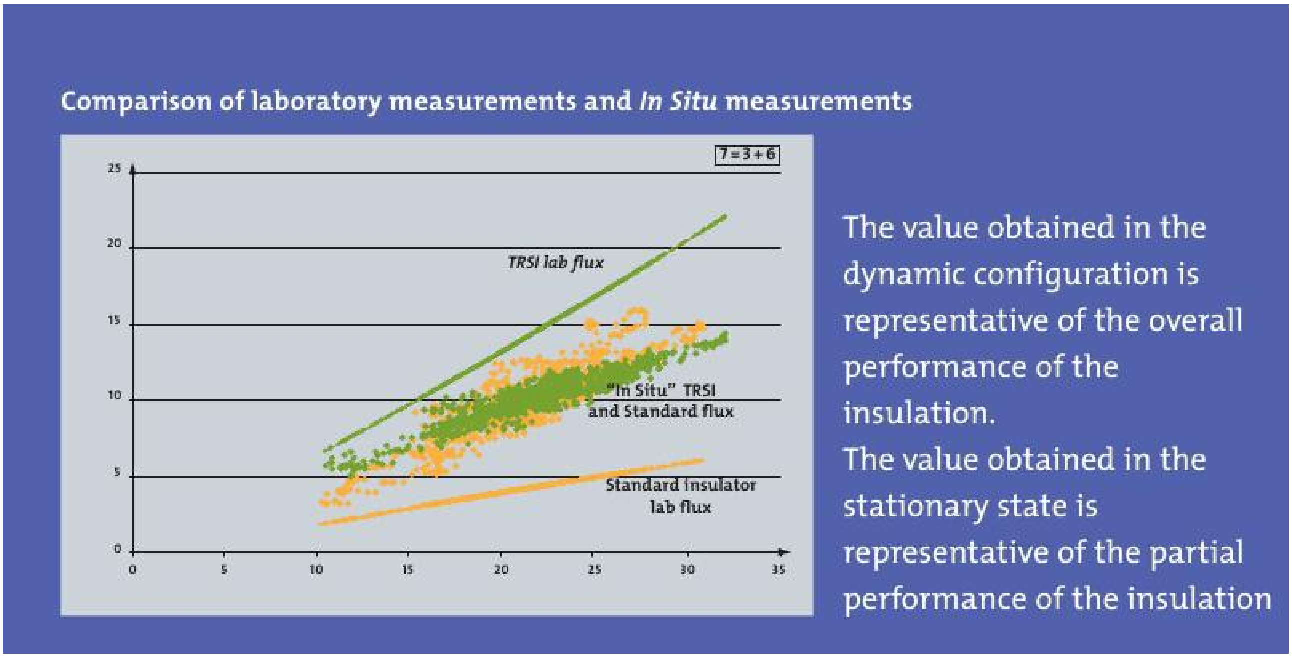
Again the micro climatic conditions around these buildings cannot be identical simply because of their mutual proximity. In addition it can clearly be seen that lean-to type extensions are on opposite sides of the structures and that some materials are stacked against the right hand building. All these differences could contribute to differences in heat transfer through the building fabric. In the absence of test data the impact of these is impossible to estimate.

There is a simple way to overcome these objections; which is to repeat the same tests with the standard and test materials installed in opposite structures. It would also be instructive to repeat these tests for other common insulation materials, as suggested in a summary paper by Williams and Ballard. (Williams and Ballard 2007).

Another criticism to which these test buildings are vulnerable is the proportion of potential heat loss through elements which are not part of the test . No mention is made in the Certification schedule of thermal separation between the test roof/gable components and lower walls and floors. From dimensions supplied (Actis 2009) these chalets include 88 m^2 of walls and 28m^2 of floor through which heat loss can occur. A rough test of area weighted average u values for such a chalet indicates considerable sensitivity to potential heat loss through the walls. (Appendix 3) Absence of such data from the report diminishes it's value.

The Actis document “Thermal reference Guide 2” (Actis 2006) sets out to present a “novel” testing method to determine the thermal performance of their product by combining lab data with data collected in situ. The document lays out some equations which bear some resemblance to artificial neural net diagrams but there is no mention of this technique being employed and there is no glossary linking the equations to data sources or weighting evaluations without which they are meaningless. (Appendix 4) The document does clearly show the use of a specific model of hot box apparatus, Fox 600, to produce the laboratory values. There is a graph combining lab values for heat flux against temperature gradient with field data;(fig 4)

Fig.4 Combining lab results with in situ data (Actis 2006)



The accompanying rubric describes lab values for TRISO-SUPER10 as **maximum;** for Standard insulation as **minimum** without supplying supporting evidence for this . Despite the legend accompanying this graph no explanation is offered why the product should only perform partially in the lab test. Without the full trial report to explain the data points this graph has little use.

Testing realistic building elements.

Following the thought experiment described above Williams and Ballard (Williams and Ballard 2007) conducted tests on fully detailed sections of roof elements using four different insulation systems. The sections were tested at horizontal aspect with heat flow up and down as well as vertical and 45 degrees. In addition dynamic tests examined the responses of the test elements to variations in heat flow as well as conventional steady state test.. This is probably the most comprehensive study of it's kind yet undertaken.

It's most significant finding is that an improvised insulation system comprising a series of aluminium coated cardboard sections separated by 25mm airgaps matched closely standard glass fibre insulation (at test depth) and out performed the Actis product. In all cases theoretical u value calculations confirm the test results.

Fig.5; Cardboard insulation test cell construction (Williams and Ballard 2007)

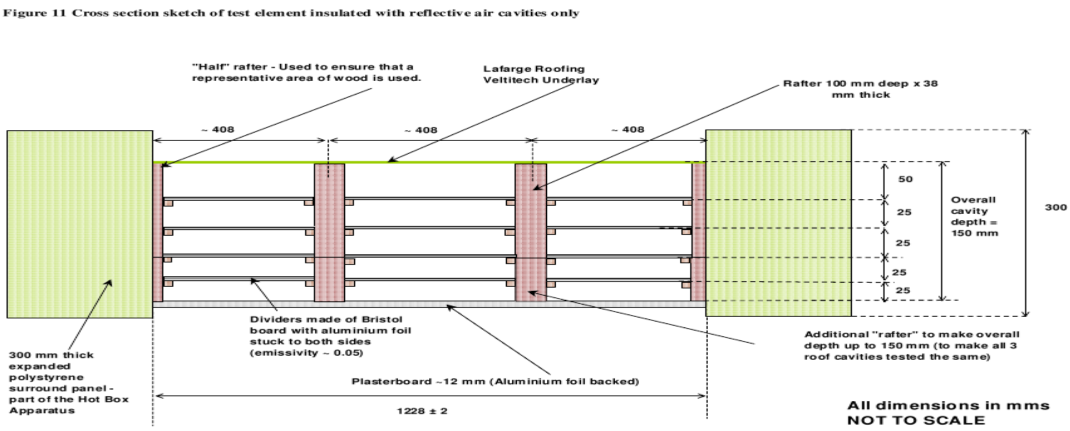


Table 1; Measured and theoretical u values of the four insulated roof systems (Williams and Ballard 2007)

Hot Box test number	NPL Specimen number	Description of test element	Heat flow direction	Environmental [1] temperature difference (°C)	Measured standardised thermal transmittance ($W/m^2.K$)	Calculated thermal transmittance - (using THERM & ISO 15099) ($W/m^2.K$)	Assumptions made in calculating the U-value
1	R058A	Triso-Super 10 - Vertical - Air vent closed	Horizontal	19.14	0.489		
2	R058B	Triso-Super 10 - 45 degrees - Air vent closed	Up	19.14	0.514	0.53	* Triso-Super 10 assumed to be a uniform slab of insulation 23 mm thick with a λ of 0.033 W/m.K * It's outer surfaces were assumed to have emittances of 0.05
3	R058D	Triso-Super 10 - Horizontal - Air vent closed	Up	19.31	0.529		
4	R058E	Triso-Super 10 - 45 degrees - Air vent open	Up	19.10	0.559		
5	R058F	Triso-Super 10 - Horizontal - Air vent closed	Down	19.00	0.347		
6	R059A	Celotex - Vertical - Air vent closed	Horizontal	19.33	0.256		* The emittance of the foil covering of the insulation was assumed to be 0.2.
7	R059B	Celotex - 45 degrees - Air vent closed	Up	19.33	0.260	0.27	* λ of the insulation was assumed to be 0.023 W/m.K. * Thickness of the insulation was taken as 100 mm
8	R059C	Celotex - Horizontal - Air vent closed	Up	19.59	0.261		
9	R059D	Celotex - 45 degrees - Air vent open	Up	19.25	0.269		
10	R059E	Celotex - Horizontal - Air vent closed	Down	19.12	0.232		
11	R060A	Air cavity - Vertical - Air vent closed	Horizontal	19.31	0.334		
12	R060B	Air cavity - 45 degrees - Air vent closed	Up	19.30	0.357	0.36	
13	R060C	Air cavity - Horizontal - Air vent closed	Up	19.63	0.417		* The emittance of the aluminium foil was asumed to be 0.05
14	R060D	Air cavity - 45 degrees - Air vent open	Up	19.36	0.392		
15	R060E	Air cavity - Horizontal - Air vent closed	Down	19.17	0.268		
16	R061A	Glass fibre - 45 degrees - Air vent closed	Up	19.42	0.333	0.35	* λ of the glass fibre was assumed to be 0.034 W/m.K
17	R061B	Glass fibre - 45 degrees - Air vent open	Up	19.38	0.341		

Note [1] For the definition of environmental temperatures see BS EN ISO 8990 Annex A

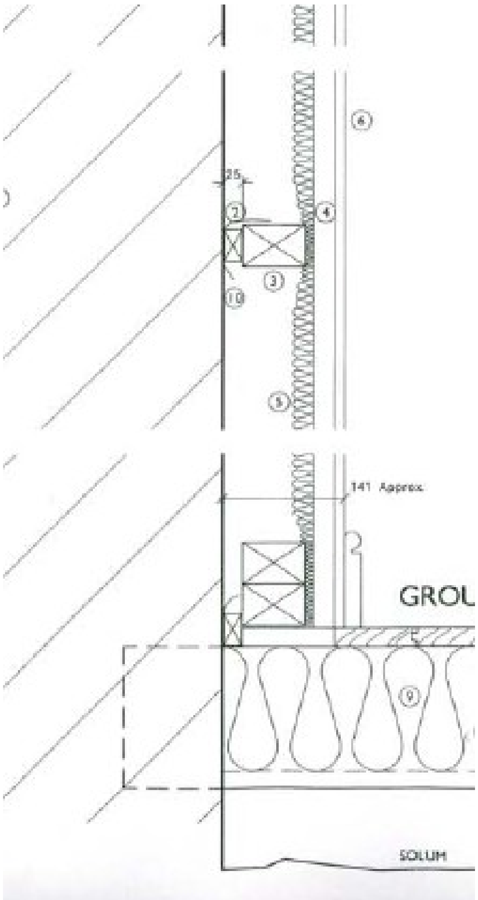
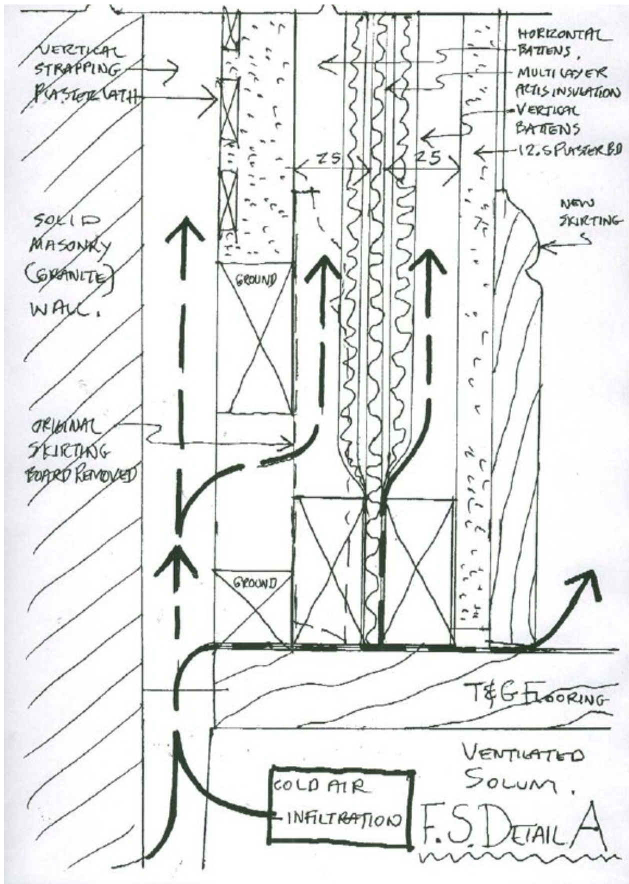
Conclusions

Given the Williams and Ballard study the use of Triso Super 10 as a roof insulation system with a u value of 0.19 is invalid. It's use in insulating dry lined walls cannot meet the demands of Approved Document L 2006. The thought experiment of the R value of a perfect insulator provides the theoretical basis for understanding why something too good to be true probably is. There may be a place for this material in conjunction with other insulants to create building elements which meet Part L requirements. This then raises issues of cost effectiveness which have not been considered here. (For a real example see Appendix 5.)

Actis SA and it's UK arm could improve presentation of their test results and other materials, missing rudimentary essentials such as units and glossaries from scientific explanations is confusing. It may be the case that they have developed an artificial neural net or fuzzy logic methodology for evaluating building element thermal performance; if so they are not alone in this work; perhaps they would care to publish it ?

The industry awaits the outcome of a cross Europe working group (Workshop 36) into finding methods of testing and certificating multi-layer foil insulation products such as Triso Super 10. It's workings are presently confidential but some participants expect at least a preliminary output by autumn 2009.

Appendix 1. Construction details of property tested by Ward and Doran, subsequently thermographically surveyed by Alba Building Science Ltd. and then destructively inspected.

From the Architects drawing (as included in Rooney 2006)	From Alba B.S. Ltd report (Rooney 2006)
	

The details sketched by Alba Building Services Ltd. (Rooney 2006) on the basis of their thermographic survey of the premises were entirely confirmed by later destructive inspection of the dry lining. These findings, along with discovery that the Triso Super 10 insulation had not been jointed and taped to the makers directions invalidate the Ward and Doran work as a true test of this material. They also confirm the critical role that education and training; coupled with rigorous on site supervision have in attempting to reduce heat loss in buildings by retro fitting insulation.

Appendix 2 BM TRADA certification;

BM TRADA Certification is recognised by UK Acreditation Scheme for the testing and certification of many construction materials, notably timber and timber derived products such as composite structural elements. However the certificate granted to Actis SA for their product is under another scheme, BM TRADA Building Insulation Products Scheme, which is not accredited by UKAS. The testing method, comparative in situ measurement, is not recognised by any current UK , European or ISO standard. Actis claim that their product cannot be tested by standard techniques. Work is presently underway to find an agreed standard procedure for evaluation and certification of this type of insulating material.

Appendix 3 Sensitivity of test chalet to performance of walls and floor.

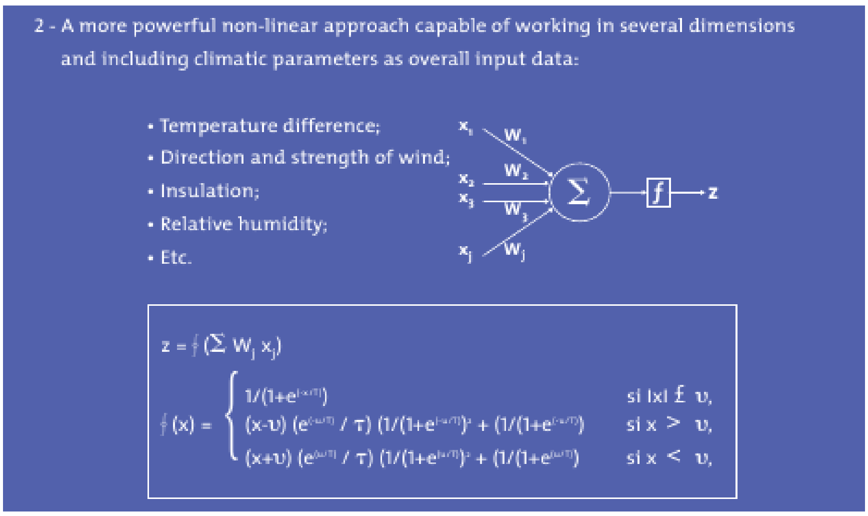
Table 2 Comparing Area weighted average u values for test chalets

	Area m2	**Part L 2006**	Chalet with TS10 NPL test value	Area x u	Chalet with mineral wool Standard	Area x u	Chalet with "perfect insulator" Calculated	
Roof including gables	41		0.58	23.78	0.2	8.2	0.33	13.53
Walls	88	0.35		30.8		30.8		22.4
Floor	28	0.25		7		7		4
Total	157			61.58		46		39.93
Area weighted Av u				**0.39**		**0.29**		**0.25**

	Area	**McMullen**	Chalet with TS10 NPL test value	Area x u	Chalet with mineral wool Standard	Area x u	Chalet with "perfect insulator" Calculated	
Roof including gables	41		0.58	23.78	0.2	8.2	0.33	13.53
Walls	88	0.25		22		22		16
Floor	28	0.22		6.16		6.16		4
Total	157			51.94		36.36		33.53
Area weighted Av u				**0.33**		**0.23**		**0.21**

In this model the walls and floor are assigned u values taken from Approved Document L 2006, and from "long term values" according to McMullen (McMullen 2007). The variation in the area weighted average u value for the whole structure between these results shows sensitivity to this value and demonstrates the importance of including data on such matters in a comparative testing of in situ materials. The roof u values used are for Triso Super 10 as lab tested by Williams and Ballard, 2007; the standard value for 200mm of mineral wool, and theoretical "perfect insulator" as described by Williams, 2005. The impact of failure to account for the losses from these elements will be directly dependent on their construction/ insulation method and their actual area.

Appendix 4; Is this part of an Artificial Neural Net ? (Actis 2006)



Use of Artificial Neural Nets and other decision support tools is an emerging method for attempts to evaluate the energy performance of buildings from limited or incomplete data sets. This graphic from the Actis document may represent such a tool in use; it is clearly meant to, but no mention of the underlying mathematical toolset is given. Note also that the weighting given to each input stream remains subjective, according to the experimenters preference. Only examination of the full test report and it's methodology would permit proper evaluation of the merits of it's use and validity of the results.

Appendix 5; Impact on a real project of using a “tested” u value for TRISO-SUPER10

This example concerns a re-roof job on a Snowdonia slate house. The roof has an existing loft conversion carried out in the 1970's, so insulation is poor to the slopes and absent from the walls. The original scheme proposed the use of TRISO-SUPER10 to insulate the slopes and small walls at the eaves; using the claimed u value it would have passed Part L 2006.

Correcting the u value for that found by Williams and Ballard leads to a demand for additional insulation in the roof, but inter rafter space is only 100mm deep. To maintain effectiveness of the TRISO-SUPER10 demands that 25mm of unvented air gap be left between it and the foam insulation. Together, 75mm of foam and a layer of TRISO-SUPER10 do NOT meet the part L requirements. At this point it becomes easier and cheaper to abandon TRISO-SUPER10 and use 100mm of foam in between the rafters and and additional 25mm across the inside face, resulting in no overall loss of headroom compared to using TRISO-SUPER10. A solution using a bulk fibre insulant is most suitable for the eaves walls, as these are below useable height and loss of internal space is not at issue.

Table 3 Attempting to use TRISO-SUPER10 in conjunction with other materials.

U Values foıTan y Bryn ***Minimum suggested***
<u>Recalculated u value for Tri-Iso</u>

Element	Component	Thickness m	Conductivity W/mK	R value	1/(y/T)	Area m2	Area x U	
Roof (ignores rafters)								
	Kingspan	0.07500	0.02500	3.00000	3.00000			
	Triso 10	From NPL data			1.71000			
	Gyproc	0.01200	0.25000	0.04800	0.04800			
	Skim	0.00300	0.18000	0.01667	0.01667			
	Int.Res				0.13000			
					4.90467			
	NOT Part L comliant			u value	**0.20389**	95.24300	19.41885	
Rooflights	Velux	From manufacturers data			**2.00000**	2.65700	5.31400	
Wall (Gable)	Ext. Res				0.06000			
	Slate wall	0.60000	2.70000	0.22222	0.22222			
	UF foam	0.07500	0.02500	3.00000	3.00000			
	Gyproc	0.01200	0.25000	0.04800	0.04800			
	Skim	0.03000	0.18000	0.16667	0.16667			
	Int.Res				0.13000			
					3.43689			
					0.29096	11.58500	3.37078	
Wall (Eaves)	Ext.Res				0.06000			
	Slate wall	0.60000	2.70000	0.22222	0.22222			
	Triso 10	From NPL data			1.71000			
	Gyproc	0.01200	0.25000	0.04800	0.04800			
	Skim	0.00300	0.18000	0.01667	0.01667			
	Int.Res.				0.13000			
					2.18689			
	NB This is NOT Part L compliant				**0.45727**	10.68000	4.88365	
Windows	Single (as is)				**4.80000**	2.59000	12.43200	
							122.75500	45.41928
					<u>Area weighted average U value</u>			***0.37000***

lifespacedesign client project 2009.

References

Advertising Standards Authority ASA Adjudications,23 April 2008 Advertising Standards Authority, Mid City Place, 71 High Holborn, London, WC1V 6QT. UK http://www.asa.org.uk/asa/adjudications/Public/TF_ADJ_44335.htm (22.3.09)

Actis (2009) . http://www.insulation-actis.com/mesurea.php?p=6&l=3&rub=2&vert=1&blanc=3 (22.3.09)

ACTIS INSULATION Ltd. (2008) Triso_Super 10 Data Sheet Edition 2008 Ref PZ177 (07/2008) - RCS Paris 333 296 887 Publicis Dialog http://www.insulation-actis.com/documentations.php?p=6&l=3&rub=6&vert=5 (22.3.09)

ACTIS (2006) Exclusive Technology Thermal Reference Guide 2. 2006 Longine +33 490 848 - Ref PZ120 - 04/2006 (873 1) http://www.insulation-actis.com/mesurea.php?p=6&l=3&rub=2&vert=1&blanc=3 (22.3.09)

BM TRADA Certification Ltd. Registration Certificate (BM TRADA Building Insulation Products) Certificate No. 0102. Date of issue 03 April 2006.
BM TRADA Certification Ltd. Chiltern House, Stocking Lane, Hughenden Valley, High Wycombe Buckinghamshire, HP14 4NR, UK
http://www.insulation-actis.com/pdf/13pdf13.pdf (16.3.09)

McMULLEN R. (2007) *Environmental Science in Building* (sixth ed.) Basingstoke, Palgrave Macmillan P 20 fig 2.1

ROONEY G (2006) *Report No 25035 Thermal Insulation Performance Appraisal 139b and 141b Victoria Road, Torry, Aberdeen*. Alba Building Sciences Ltd. Norham, Perth Rd, Blairgowrie PH10 6EJ

WARD T.I. & DORAN S.M. (2005) *The Thermal Performance of Multi-foil Insulation* BRE, Scottish Enterprise Technology Park, East Kilbride, Glasgow, G75 0RZ

WILLIAMS R August 2004 Measurement of the thermal resistance of an air cavity insulated with ACTIS TRI-ISO Super 9 National Physical Laboratory, Teddington, Middlesex, UK. TW11 0LW.

WILLIAMS R, (2005),” Evaluating the thermal performance of reflective insulation systems.” *Thermal Imaging for Building Fabric Insulation Compliance* TMAN Meeting Feb 2005 (location not known)

WILLIAMS R & BALLARD G; (2007); *NPL Report MAT 8 Evaluation of the thermal performance of insulation systems used in roof structures*. National Physical Laboratory, Teddington, Middlesex, UK. TW11 0LW.