Case Study

July 2012

5. Vacuum Insulated Panels (VIPs)

Table of Contents

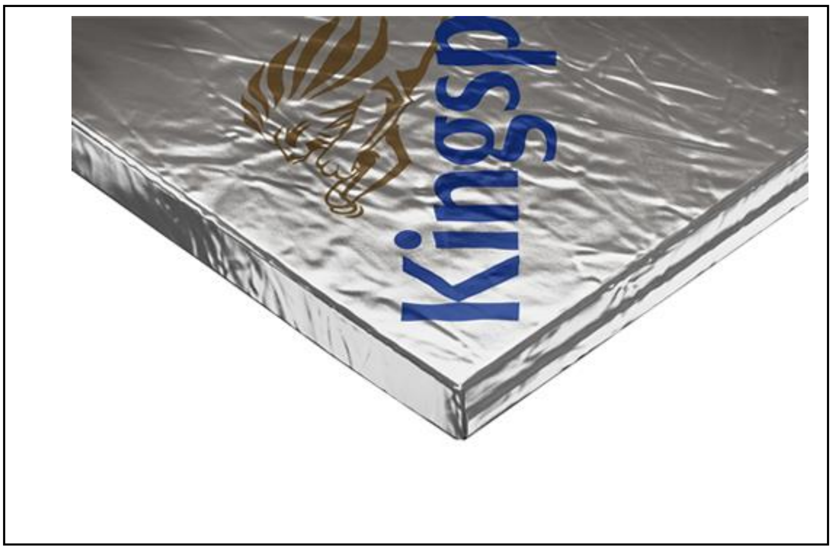
5.1 Introduction to the technology

Vacuum insulated panels (VIPs) are aimed at providing solutions to problem areas where space or technical detailing is an issue.

VIPs are made from a rigid, micro-porous core encased in a thin, gas-tight envelope (metal foil or metallised laminated plastic such as mylar). The package is evacuated and then sealed during manufacture. Creating a partial vacuum practically eliminates convection, since this relies on the presence of gas molecules to transfer heat energy by bulk movement through the insulator. Evacuation also greatly reduces conduction across the insulator, and the addition of infrared opacifiers in the core material can also reduce radiation. The resulting panels can provide an insulating performance five to ten times better than other commonly available insulation materials.

The panel has to be capable of withstanding atmospheric pressure without collapsing, and of maintaining the partial vacuum over time. Chemicals known as ‘getters’ are sometimes incorporated in the core, to collect gases leaked through the membrane or off-gassed from the membrane materials. These gases may be emitted throughout the lifetime of the product.

VIPs have long been used in fridges, freezers and mobile refrigeration applications, but are a new technology for construction in most of the EU. VIPs are becoming increasingly common in Germany and Switzerland in particular.



5.2 Available types of this technology

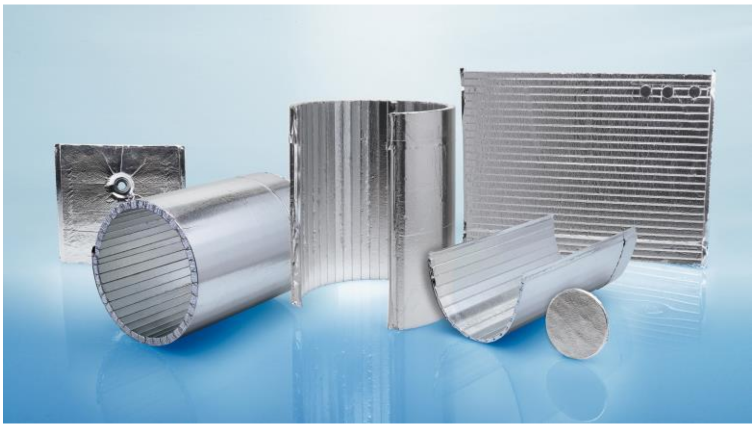
VIPs are distinguished predominantly by their core type, and also by their outer covering.

Common core types, all of which are designed to support the membrane walls against atmospheric pressure once the air is evacuated, are as follows:

- Fumed silica/titania (which is essentially fine sand)
- Carbon aerogel (a highly porous solid with extremely low density.)
- Glass fibre board
- Polystyrene foam
- Polyurethane foam

Getters (eg. calcium oxide) tend to be added to VIPs with glass fibre or foam cores, because their bigger pore size requires a higher vacuum during the planned service life.

It is essential that the integrity of the membrane is maintained in order to preserve the thermal performance of the panel. Various grades of protective cover can therefore be incorporated to suit different applications. These range from simple fabric covers for interstitial insulation, to glass facades on external surfaces and even galvanized flooring.



5.3 Strengths, weaknesses, opportunities and threats

This section outlines a discussion of the key drivers affecting vacuum insulated panels.

Strengths

- Much lower thermal conductivity (k- or lambda- value) than conventional insulation
- Thermal resistance per unit thickness is typically ten times that of conventional insulation in the centre of the panel (or five if edge effects are taken into account).
- Useful in situations where either strict insulation requirements or space constraints make traditional insulation impractical.

Weaknesses

- Cost -conventional products with an equivalent thermal performance are between two and four times cheaper (UK, 2012).
- VIPs cannot be cut to fit as with conventional insulation; VIPs in non-standard sizes must be made to order.
- Thermal bridging by the membrane at panel edges. Particularly significant where an array of panels is installed in a larger building element.
- Air will gradually enter panels over time, and their thermal resistance deteriorates as a result.
- Strict quality control of manufacture of the membranes and sealing joins is necessary if a panel is to maintain its vacuum over a suitably long period of time.
- Aerogels are more difficult to manufacture than polyurethane foams or mineral wools.

Opportunities

- VIPs can be manufactured to any shape or size.
- Particularly suited to curved surfaces – eg. pipework insulation.
- Landfill benefits – glass fibre cores can be reused, while fumed silica and carbon aerogels are essentially dirt (with a very low mass and volume).
- VIPs are a new building technology, so new applications will continue to be found for some time.

Threats

- Post-occupancy modifications/additions to a building may cause puncturing of VIPs; even the hanging of pictures can be a problem if the presence of VIPs is unknown.
- Conventional insulation does not depend on the evacuation of air for its thermal performance, and is therefore not susceptible to this form of deterioration.
- Relatively high cost has generally kept VIPs out of traditional construction situations to date.
- The cost of alternative products may reduce at a faster rate.

5.4 Building pathology, defects, and what can go wrong

5.4.1 Invitations to complete questionnaire

An invitation to complete the online version of the Elios II questionnaire was sent to 374 individuals in the following industry sectors:

TABLE 5.1 – Invitations to complete questionnaire

Sector	***Number sent***
Insurance	64
Certification Bodies	10
Accreditation Organisations	4
Builders/Installers	55
Manufacturers	74
Trade Associations	27
Professional Institutes	19
Architects	14
Quantity Surveyors	2
Other	4
Building Inspection Services	13
Government Organisation	22
Housing Associations/Commissioner	16
Consultancies	15
Merchant/retailer	5
Unknown	30
Total	374

In total 70 respondents completed some or all of the questionnaire. This is an 18% response rate.

5.4.2 Responses received

At the closing date of 1st October 2012, 3 responses had been received which related specifically to Vacuum Insulated Panels (VIP). This is 4% of the received questionnaires. The industry sectors of the respondents were as follows:

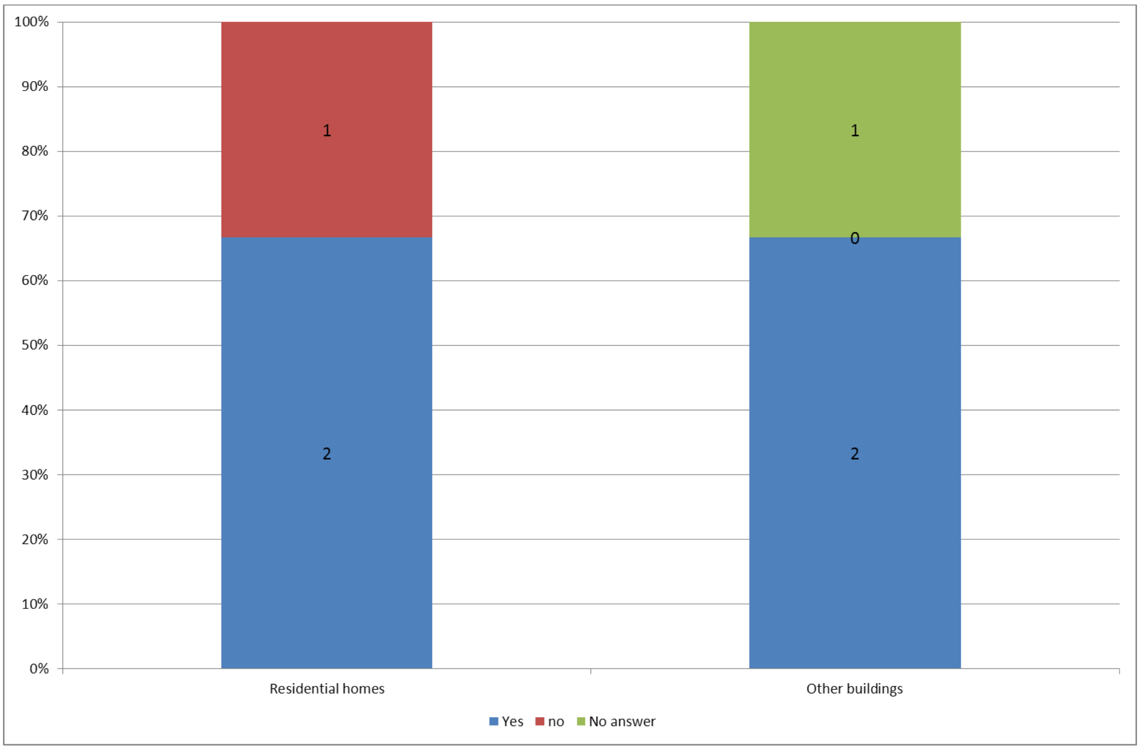
TABLE 5.2 – Responses

Sector	***Responses received***
Government organisation	0
Architectural practice	1
Housing organisation	0
Manufacturer	3
Retailer/merchant	1
Construction company	1
Installer	1
Building inspection service	0
Certification organisation	0
Insurance company	0
Trade association	0
Professional institution	0
Other (please specify)	2
Business in more than one	2
Total	***3***

The respondents collectively claimed to have data relating to 15 installations of the technology, of which 3 (20%) were said to have experienced failures or defects.

The following graphs and charts only relate to the people who responded about this technology.

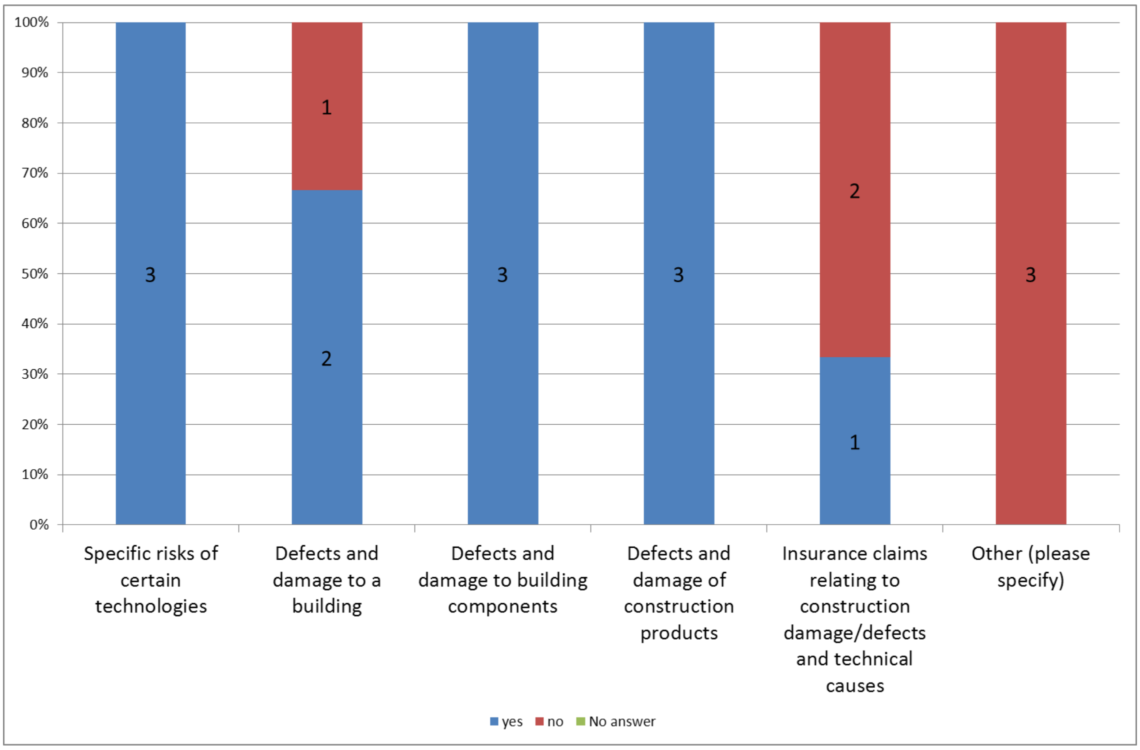
CHART 5.3
Question asked – "Does your organisation collect or collate its own data on these types of buildings?"



This chart shows the number of reporting organisations that collect data on each type of property. This is only for this eco-technology. Organisations may collect data on more than one type of property.

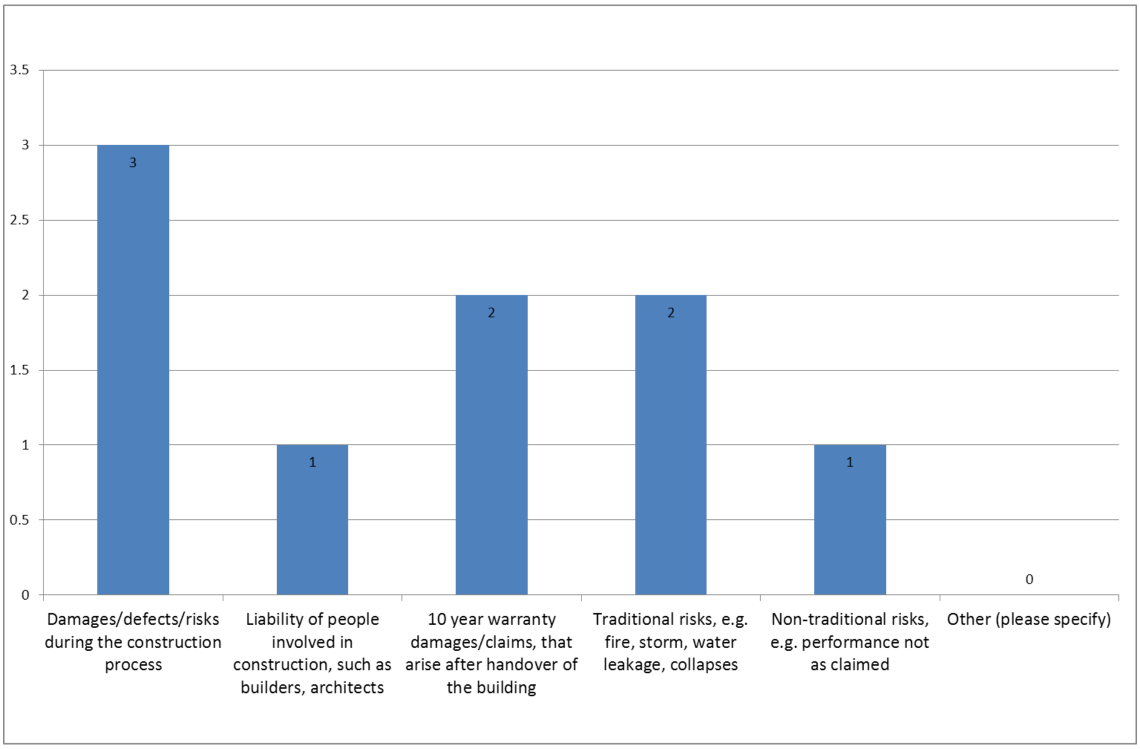
CHART 5.4

Question asked –*"Does your organisation collect its own data on these issues (please tick all that* apply*)?"*



This chart shows the various reasons that the reporting organisations collect data, and the number of organisations that gave each reason. This is only for this eco-technology, and not for all 10 technologies. Organisations may collect data for more than one reason.

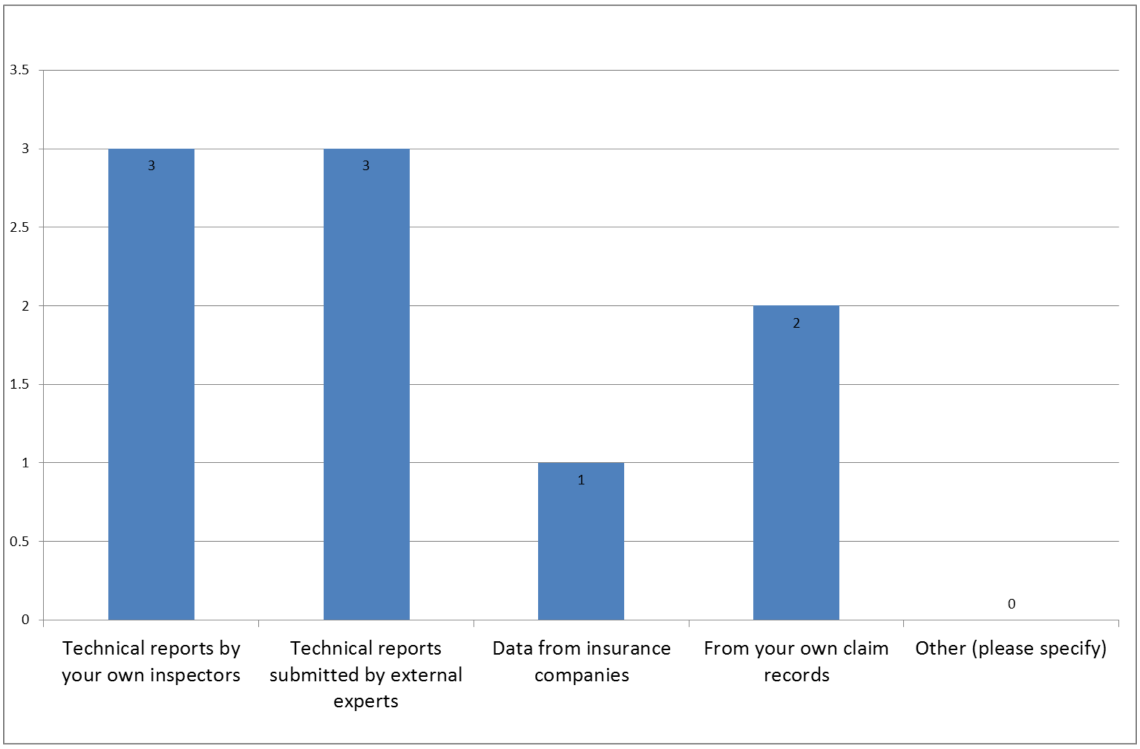
CHART 5.5
Question asked – "What kind of damages/defects do the data refer to (please tick all that apply)?"



This chart shows the number of organisations that reported each kind of damage on which they collect data. Each column represents a different type of damage. This is only for this specific eco-technology, not overall. Organisations may collect data for more than one reason.

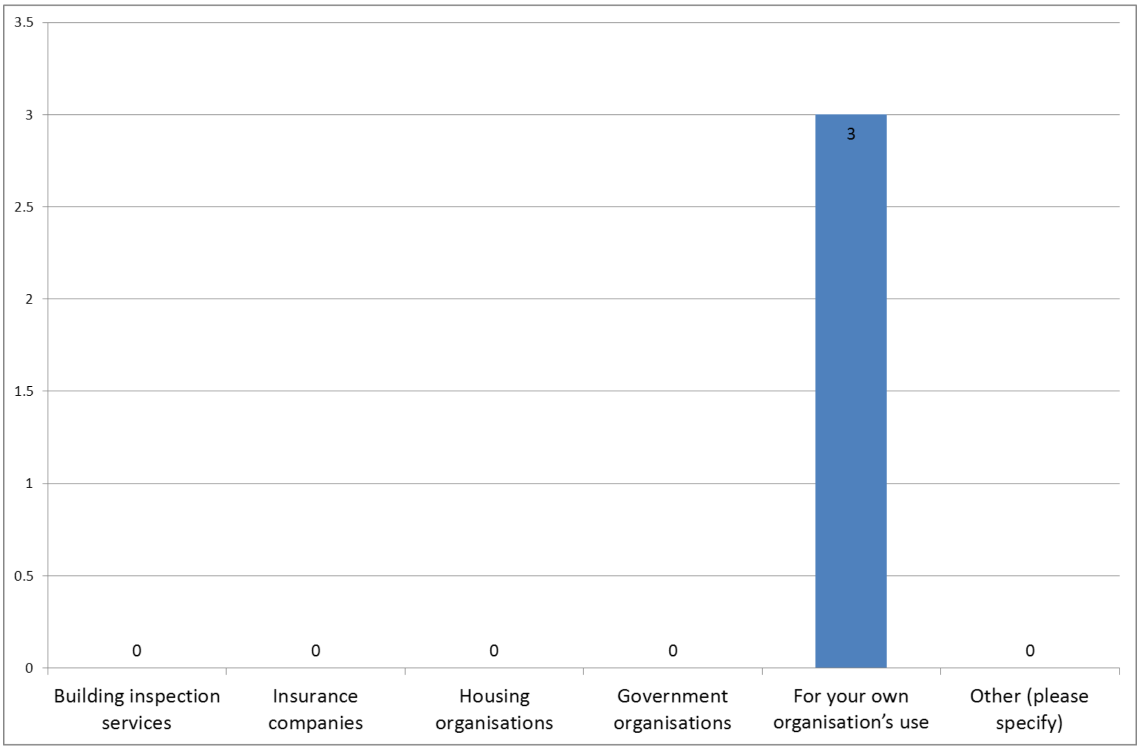
CHART 5.6

Question asked – "How do you collect the data (please tick all that apply) ?"



This chart shows the method by which each organisation collects data; each column represents a different method of data collection. This is only for this eco-technology, not overall. Organisations may collect data for more than one reason.

CHART 5.7
Question asked "For whom do you collect the data (please tick all that apply)?"



This chart shows the number and type of organisations that reported that they collect data about this eco-technology. Organisations may collect data for more than one type of organisation.

5.4.3 Summary of responses about databases

About their database:

- 1 have a database, all responded;
- 1 provided a date when data collection started – 2007;
- 3 carry out statistical analysis of the data;

About data publication:

- 2 make data available on the web;
- 2 in newsletters;
- 2 in other publications;

About the availability of data, of these respondents:

- 1 publish summary data only;
- 1 publish raw data in any form;
- 1 publish raw data, even anonymously;

1 comment was passed, as follows:

- *"Where we have research projects funded by third parties, there is often a requirement to disseminate findings, under controlled know how and IP[1], with commercially sensitive information removed."*

Finally, note that this question was answered in general about all 10 eco-technologies and may not apply to the specific technology.

[1] IP – Intellectual Property

5.4.4 Reasons for failures and defects

The reported reasons for the failures and defects were as follows:

TABLE 5.8

Reason for failure/defect	**Number**	**% of total**
Requirement management		
Change in client's requirements	0	0.0%
Misunderstanding of the effectiveness of the technology	3	20.0%
Poor project management	0	0.0%
Inaccurate engineering or architectural data	0	0.0%
Delivery		
Late delivery	0	0.0%
Storage issues	0	0.0%
Awkward packaging	0	0.0%
Poor transport of product	0	0.0%
Installation		
Incorrect design for installation	1	6.7%
Incorrect installation documentation	0	0.0%
Failure in installation	1	6.7%
Commissioning failure	0	0.0%
Operational failure		
Product failure once installed	0	0.0%
Incorrect user documentation	0	0.0%
Misuse of product by end-user	0	0.0%
Performance not as claimed	0	0.0%
Other		
No other reasons were given for failure		
Total		

Note that an installation may have had more than one reason to fail.

5.4.5 Failures/defects commentary

The respondents offered the following general comments and suggestions on the ways in which the failures and defects might be avoided in future:

TABLE 5.9

Reason for failure/defect	Commentary
Requirement management	
Change in client's requirements	
Misunderstanding of the effectiveness of the technology	vacuum has been lost over a short period
Poor project management	
Inaccurate engineering or architectural data	
Delivery	
Late delivery	
Storage issues	
Awkward packaging	
Poor transport of product	

Installation	
Incorrect design for installation	
Incorrect installation documentation	
Failure in installation	
Commissioning failure	
Operational failure	
Product failure once installed	
Incorrect user documentation	
Misuse of product by end-user	
Performance not as claimed	
Other (specified)	

1 comment was passed:

- We assessed this product through the AIMC4[2] project. We felt it was not commercially viable and had significant practical issues regarding puncturing and damage. It also lacked a track record with many < … > options claiming poorer than expected performance. It had potential for limited and very specific focus use, where product was perhaps more likely to be used - i.e. door insulation, foundation insulation.

[2] AIMC4 is a partnership pioneering the volume production of low carbon future homes.

5.4.6 Key findings

In summary:

- Small sample size
- Fear about risk of puncturing
- Claimed loss of vacuum in practice

Lessons:

- Increase awareness of suitable applications and need to avoid puncturing,