

## Fact Sheet

### Insulation

We use nothing less than 50mm foil coated dense foam board insulation (coated on both sides) as standard construction as it has the best heat retention properties. It helps distribute heat evenly and the pods never have any 'heat spots'. All joints are fully bonded with fibreglass matt and resin throughout to keep any heat loss to an absolute minimum – in turn giving customers the maximum heat retention and absolute minimum running costs.

There are many types of insulation on the market from reflective foil, bubble wrap, rockwool (fibreglass wool) foam panels and so forth.

Below shows the R-Value (insulation efficiency) of our foam fibreglass method in comparison to the rockwool, used in most wooden pods.

**50mm Rockwool = R 2.5      50mm standard foam board = R 4.0      50mm Our foam boards = R 5.2**

### Fibreglass Matt & Resin

We take fibreglass woven strand matt and mix with a high-grade resin, then infuse onto both sides of our foam boards creating a very versatile, durable and strong structure, If more strength is required we just add more fibreglass matt as the more layers we add, the stronger the product.

There is nothing on the market that can offer such an adaptable structure with the same heat retention properties, quality and strength. The materials we use are of the highest quality and give our customers an excellent value for money.

### Making A Structure

We take the required amount of foam board, shape it into the required style and then infuse all the panels together with fibreglass matt and resin, inside and out to create a strong, fully bonded watertight unit with no air gaps to allow heat loss. Then to finish, we add a thick high-grade topcoat both inside and out, creating a long lasting and durable egg shell finish.

### Product Testing & Certification

In January 2017 we collaborated with Lancaster University Engineering Department for them to carry out a research project to ascertain the exact insulation and stress values of our products. The findings were that we have the highest insulation value of any other insulation product on the market, and that our structures can comfortably accommodate a weight of approximately 1.5 tonnes on the roof. By burying our structures in embankments, this not only adds to the structural strength of the pod, but also significantly adds to the thermal values.

### Case studies      **Lancaster University Engineering Department, March 2017**

Statements made by the university whilst carrying out studies on our foam/fibreglass infused panel.

1. The fibreglass-backed foam gives outstanding thermal insulation properties. In addition, it is able to withstand harsh environments without the risk of rot or mould, giving a lifespan of 50-60 years. These characteristics ensure the final product is a sound financial investment.
2. The portfolio of products manufactured by Pennine Pods Ltd includes highly insulated sectional buildings and floating homes as well as Eco-homes and structures with the ability to integrate solar power systems and other forward-thinking energy solutions. The fibreglass backed foam can also be implemented in subterranean structures, increasing the thermal mass and lowering the visual impact on Areas of Outstanding Natural Beauty. This is made possible by the completely sealed nature of the building material.

3. Following the initial meeting with the client, this brief was expanded to include strength testing on the material examining a standard pod roof under a **1250kg load** (equivalent to burying a pod under soil deep enough to mask the construction). Therefore, the aims of the project are to provide customer with analysis to be used when marketing their products showing the thermal properties and strength of the design.
4. The validation of the estimated loading value on the roof of such units opens the possibility of new designs. One area which could be investigated is the embedding of pods into hillsides and embankments. This could be especially beneficial in many popular camping sites classed as areas of outstanding natural beauty; making them appear part of the landscape. Up to **1.50 tonnes** of soil, grass and flowers could be planted on the roof of the pod.
5. Insulating foam is a commonly used material in building services due to its low weight and low thermal conductivity. Dense foam board is a high-quality material used by Pennine Pods; the material's excellent ability to resist heat transfer via conduction makes it ideal for use in pod structures. Convection is a form of heat transfer where a heated section of fluent gas or liquid travels to cooler areas, causing convection currents and heat loss. This phenomenon is especially prevalent in wall cavities; where the cool exterior of the house draws heat through the cavity from the warm interior (engineeringtoolbox.com, 2017). By filling wall and roof cavities with a lightweight solid such as foam, heat loss through convection is prevented, as the heat has no medium in which to flow.
6. The effectiveness of such insulating materials is primarily measured by thermal conductivity (R) and thermal resistance (R-value). The thermal resistance can be used to determine the optimal material thickness for minimal heat transfer. It is calculated by dividing the material thickness by the thermal conductivity, giving an R-value in  $m^2 K/W$ . As this value uses the inverse of the thermal conductivity, the higher the value the better the insulating properties. For insulation comprised of multiple layers of material, such as that used by Pennine Pods, the U-value is calculated. This is the sum of the R-value of all layers, which is indicative of the composites ability to transmit heat from a warm to a cool area:
7. Another advantage of Pennine Pods foam fibreglass panel is the ability to remove all potential air gaps from the building. The elimination of thermal bridges not only prevents heat from escaping, but also condensation from forming from such gaps.
8. The considered design required by Pennine Pods Ltd makes the mechanical properties offered being excellent.
9. The environmental resistance offered by the outer fibreglass layers is far superior to that offered by most natural materials (including woods and metals). Fibreglass resins are suitable for use in a wide range of industries and environments, including the harsh marine and aerospace industries facing exposure to high temperature ranges and constant corrosive action.
10. The heat retention tests concluded that the fibreglass-backed foam was a composite panel with incredible insulating properties and is ideal for use in construction.
11. For outdoor construction such as the Hobbit House, the heat loss would be so minute that a person's body heat alone would be enough to keep the interior at a comfortable temperature.

12. The results comparing the **R value** for the two wall materials examined (composite and standard) show the established trend that the composite material, with the addition of fibreglass, is an improvement over standard material in both calculated and actual results from practical testing.

	Rth Calculated (K/W)	Rth Actual (K/W)
Unit		
Pennine Pods Composite wall	34.08	23.73
Standard Foam Board	32.95	20.08