SPRA
Single Ply Roofing Association

## SPRA TECHNICAL GUIDANCE S23/24

# *PASSIVHAUS*: CONSIDERATIONS FOR SINGLE PLY ROOFING

### WHAT IS *PASSIVHAUS*?

Buildings are a significant culprit of carbon emissions, accountable for 35% of total global energy consumption. Backed by over 30 years of international evidence, *Passivhaus* is a tried-and-tested solution that provides a range of proven approaches to deliver net-zero-ready new and existing buildings optimised for a decarbonised grid and augmented for occupant health and wellbeing. *Passivhaus* buildings provide a high level of occupant comfort using very little energy for heating and cooling.

*Passivhaus* adopts a whole-building approach with clear, measured targets focused on high-quality construction, certified through an exacting quality assurance process.

To contribute to the achievement of the *Passivhaus* Standard in the United Kingdom, flat roofs can form part of an airtight building fabric and incorporate very high levels of thermal insulation.

### THERMAL BYPASS RISKS

One of the major contributors to the energy performance gap in buildings is faulty, ill-considered design and construction that can result in thermal bypass. This is caused by a combination of conductive and radiative heat loss mechanisms, which result in uncontrolled air movement.

By addressing thermal bypass, heat loss can be reduced; thermal comfort can be improved; the building fabric can be protected; performance gaps can be mitigated against or avoided; carbon emissions and fuel poverty can be reduced; and health, well-being and energy security can be improved.

### DEFINITIONS

**Thermal Bypass** Heat loss that bypasses the thermal insulation layer between two areas of a construction.
**Air Gap** An air gap located on the warm side of the thermal insulation.
**Joint** An interface/abutment between two pieces of thermal insulation.
**Air Barrier** An air barrier inhibits the passage of air and moisture through the assembly of materials in a wall or flat roof construction.
**Wind Barrier** A wind barrier inhibits pressure differences that drive air movement across, through or behind thermal insulation.

### AIR GAPS AND JOINTS

The lower (better) the design U-value, the greater the need to design, specify and install insulation systems in a manner that eliminates air gaps on the warm side of – and gaps in vertical joints between – thermal insulation boards. Thermal Bypass Risks | A Technical Review (*Passivhaus Trust*, September 2022) states that, *'continuous air gaps adjacent to the warm side of the insulation should not be tolerated.'*

With the agreement of the relevant Passivhaus designer(s) and certifier(s), however, the following tolerances may be acceptable—

- **Horizontal air gaps** on the warm side of thermal insulation boards should be ≤2mm wide.
- **Gaps in vertical joints** between thermal insulation boards should be ≤3mm wide and ≤600mm long.

### CONSIDERATIONS FOR SINGLE PLY ROOFING

#### Flat Roof Construction

A cold, flat roof construction is not recommended by BS 5250 *Management of moisture in buildings. Code of practice* nor BS 6229 *Flat roofs with continuously supported flexible waterproof coverings. Code of practice.* This is due to the high risk of harmful interstitial and surface condensation on the underside of the supporting structure/deck or the upper surface of the insulation; the difficulty of forming and maintaining an effective Air and Vapour Control Layer (AVCL) below the insulation; and the difficulty of providing sufficient cross ventilation above the insulation. Cold, flat roofs should be avoided.

While it is possible to construct an inverted, flat roof in accordance with the *Passivhaus* Standard, the practical experience of members of the *Single Ply Roofing Association* (SPRA) dictates that it is difficult to achieve. This is especially so where the waterproof layer is ≥2mm thick, which can create unacceptably large air gaps on the warm side of thermal insulation boards where they span laps in the waterproof layer.

A warm, flat roof construction (typically a structural deck or slab; AVCL; thermal insulation; and waterproof layer) should be the preferred option for the purposes of *Passivhaus* design, as the AVCL constitutes an air barrier; the waterproof layer constitutes a wind barrier; and the thermal insulation can be encapsulated to minimise thermal bypass. The following guidance is written on this basis.

#### Structural Flat Roof Deck or Slab

A structural flat roof deck or slab should have a regular surface – including at all joints – to allow intimate contact with the Air and Vapour Control Layer (AVCL) and prevent potential air gaps. It should be swept clean of debris to avoid puncturing the AVCL.

The troughs of a profiled metal deck do not constitute an air gap. Indeed, as Conventions for U-Value Calculations (*BRE*, 2019) states, *'Profiled metal sheets used for roofing decks usually result in small airspaces between the insulation and the metal sheet at each profiled section. The effect of these airspaces on the U-value of an insulated roof is very small because of lateral heat conduction in the metal sheets. No allowance for them should be made in U-value calculations.'* Moreover, a lapped and sealed AVCL (see below) would perform the function of an air barrier and prevent the passage of air to weak joints between thermal insulation boards.

Reinforced concrete slabs should have a surface regularity class 2 (SR2) finish. SR2 represents a maximum 5mm departure from a 2m straight edge in accordance with BS 8204-2 *Screeds, bases and in situ floorings. Concrete wearing surfaces. Code of practice.* Localised low points should be made good using a proprietary levelling screed.

#### Air and Vapour Control Layer

An Air and Vapour Control Layer (AVCL) should be lapped and sealed to the substrate around the flat roof perimeter and at penetrations in accordance with manufacturers' instructions to perform the function of an air barrier.

Where possible, for example where a flat roof abuts an external wall with a rainscreen cladding system, the flat roof AVCL should be lapped with the external wall AVCL to create a continuous air barrier.

#### Thermal Insulation

Increasing thicknesses of thermal insulation in flat roofs to comply with the provisions of national building regulations has led to a greater proportion of thermal bypass through gaps in joints between thernal insulation boards. The larger the flat roof area, the larger the number of joints between boards, the greater the potential for thermal bypass.

To minimise air movement through the flat roof construction, edges of thermal insulation boards should

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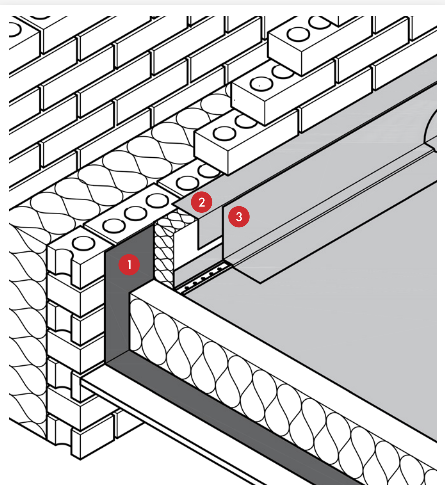
be rebated or tongued-and-grooved; multiple layers (instead of one thick board) should be installed, with the thinnest layer at the bottom of the build-up; and joints between boards should be staggered. Thinner boards have the added benefit of increased flexibility, which can help to minimise air gaps.

When modelling the energy performance of a flat roof, thermal bypass can be more prominent through gaps around the perimeter. Where practical, thermal insulation boards should be installed from the perimeter of a flat roof towards the centre to avoid cuts around the perimeter. Where boards must be cut, correct equipment – such as a proprietary, cordless insulating material saw with guide rail for polyisocyanurate (PIR) and stone mineral wool, or a hot wire cutter for expanded polystyrene (EPS) and extruded polystyrene (XPS) – should be used to leave a straight, square edge. Handsaws with flexible blades should not be used. Incorrect cuts should not be hidden by installing boards upside down, but filled as below.

Gaps in vertical joints should be ≤3mm wide and ≤600mm long. Gaps larger than this should be filled using a compressible material such as stone mineral wool, a proprietary low-expanding foam, or a compressible tape – with consideration of any potential impact on the single ply roofing system's external fire performance.



1. Air and Vapour Control Layer
2. Membrane-laminated metal angle
3. Single ply membrane abutment flashing

**Waterproof Layer**

The seam welding of single ply membrane sheets creates a homogenous waterproof layer, which performs as a wind barrier for the purposes of *Passivhaus* design.

For single ply membranes that are incompatible with bitumen, it is not possible to seal them to bituminous AVCLs. Nonetheless, at details it is possible to independently seal the AVCL (behind the thermal insulation) and single ply membrane to the substrate (via a chase, weld and/or proprietary sealant) to create an airtight construction. Refer to the example of an abutment in the diagram.

**Methods of Attachment**

In a mechanically fastened single ply roofing system, thermally broken telescopic tube washers should be used instead of stress plates to eliminate thermal bridging through the flat roof construction. The void within a telescopic tube washer is not considered to be an air gap, as it is encapsulated within a sealed system. Mechanically fastened thermal insulation boards should be installed in accordance with relevant manufacturers' and trade association guidance to prevent movement and any potential distortion of the boards, which could create air gaps. Mechanically fastened single ply membranes should be pulled taut to minimise the potential for movement due to wind uplift. This would reduce the effect of the membrane (wind barrier) acting like a diaphragm, whereby warm internal air could be drawn into the depth of the flat roof construction, assisting heat loss and thus increasing the U-value. Consider installing additional rows of fasteners along the centre of wider sheets, or reduce the widths of the sheets from, for example, two metres to one metre.

In fully adhered systems, a low-foaming adhesive should be used to install thermal insulation boards to minimise air gaps between the boards and the AVCL. For bituminous AVCLs, which are typically ≥2mm thick, applying a bead of adhesive along the leading edges of end and side laps can help to fill air gaps where thermal insulation boards span the laps.

A fully adhered single ply membrane effectively eliminates the potential for air movement underneath, though care should be taken during installation to avoid blisters and wrinkles in the sheets.

In warm, ballasted systems, the mass of the ballast (typically cast stone or mineral slabs of at least 40mm thickness; or loose laid gravel with a thickness of at least 50mm or a mass ≥80kg/m²) can compress horizontal air gaps between layers.

## PROJECT MANAGEMENT

The single ply roofing contractor should operate a strict system of quality control in conjunction with the single ply roofing system manufacturer, *Passivhaus* designer, and *Passivhaus* certifier throughout a *Passivhaus* project.

Prior to works starting on site, it is good practice to build samples of the single ply roofing system to demonstrate how air gaps will be minimised and *Passivhaus* requirements will be achieved. This can be reviewed and signed off by the *Passivhaus* designer and certifier.

During construction, the contractor and single ply roofing system manufacturer should collate photographic evidence of the installation of each layer of the system, including the installation of each layer of thermal insulation. It is advisible to arrange a benchmark inspection of the first layer of thermal insulation to show 'what a good one looks like' before progressing to additional layers.

Upon completion of the project, the single ply roofing contractor, single ply roofing system manufacturer, *Passivhaus* designer, and *Passivhaus* certifier should perform a thorough review to learn lessons and drive continuous improvement.

## CONSULT A *PASSIVHAUS* DESIGNER

Consult a *Passivhaus* designer before and during construction to clarify their requirements; ensure that the requirements are met; and avoid having to complete potentially expensive remedial works at a later date.

## FURTHER READING

- **Good Practice Guide to Insulation** Passivhaus Trust, September 2017
- **Thermal bypass risks | A technical review** Passivhaus Trust, September 2022

## ACKNOWLEDGMENTS

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