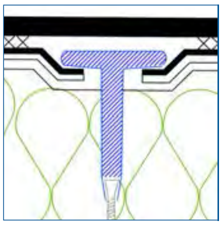
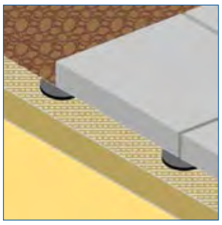
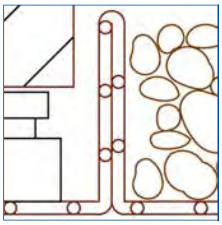
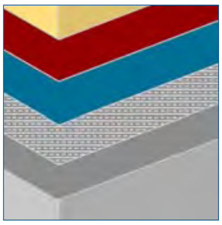
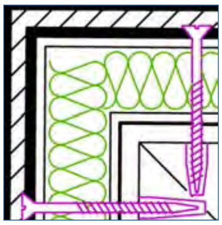
2012

Design Guide

for Single Ply Roofing

To ensure that clients obtain high quality polymer-based single ply roofing, through a partnership of quality assured manufacturers & contractors.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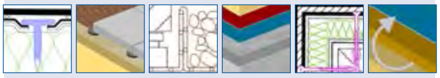

Design Guide for Single Ply Roofing

This design guide has been prepared by the Technical Committee of the Single Ply Roofing Association (SPRA) which comprises representation from all membership categories (Membrane manufacturer, Associate manufacturer and Contractor).

Based on extensive research and over thirty-five years' experience in the UK, it is the current industry view of best practice in the design, selection of materials, installation and maintenance of single ply roofing systems and includes reference to all relevant European and British Standards as appropriate. Since Regulations and European and British Standards are under continuous review, the reader should confirm their status with the appropriate institutions before referring to them in specifications.

A national or European certificate issued by a European Technical Approvals issuing body is one method to satisfy The Building Regulations in respect of the fitness for purpose of a single ply roofing membrane (so long as the conditions of use are in accordance with the terms of the certificate). This can also be demonstrated by a manufacturer's declaration of conformity with the new harmonised European Standard BS EN 13956.

In addition, certain projects may be subject to higher requirements specified by insurance companies for the purposes of property protection (e.g. material approvals to Loss Prevention Certification Board (LPCB) or full roof system approvals issued by FM Approvals (an affiliate of FM Global).

1. OBJECTIVES AND SCOPE

1.1. OBJECTIVES

This Guide is intended to:

- Set a standard for the single ply roofing industry.
- Encourage the client to set performance criteria against which the design can be assessed and reviewed.
- Assist the decision-making process in the design of a roof system based upon polymeric single ply water-proofing membranes.
- Provide the designer with technical information which, together with manufacturers' advice and published Regulations and Standards will be sufficient for the design of a single ply roof.

1.2. SCOPE

The recommendations given in this Guide are applicable to all roof forms in new construction and refurbishment, non-dwellings and dwellings. They do not cover all aspects of single ply roofing but feature those design aspects believed to be important for optimum performance.

Section 5 'Workmanship' is intended to inform the designer of those aspects which will be of relevance to the design and supervision functions; it is not an installation manual for the contractor.

In all instances it has been assumed in drafting this Guide that construction will be carried out by operatives who have passed the relevant SPRA manufacturers' certified training course, under the direction of qualified supervisors as required by the SPRA Criteria for Membership.

This document takes the form of guidance and recommendations. It should not be quoted as if it is a specification and particular care should be taken to ensure that claims of compliance are not misleading. SPRA publishes a generic specification for single ply roofing which can be used to set criteria for performance, product support and training in accordance with the SPRA Criteria for Membership and Code of Conduct.

Compliance with this Guide does not in itself confer immunity from legal obligations.

2. THE CLIENT BRIEF - SETTING PERFORMANCE TARGETS AND CONSTRAINTS

2.1. INTRODUCTION

This section lists those aspects of performance together with any constraints, which should be considered in the client's brief to the designer.

At the earliest possible stage and with the early involvement of the membrane manufacturer, these targets and constraints should be identified by the client and designer, together with the priority of each. This will enable effective review and modification as the design develops.

Fundamentally, a single ply roof system must provide protection from all weather conditions likely to be experienced during its design life. Such protection may be required before building completion to facilitate rapid fit-out of the interior. The roof system must also perform satisfactorily against a wide range of other targets and constraints as required by legislation, by the client, by the building insurer, and by the design of the substructure and services.

Since the priority order of performance is unique to each design, the following performance criteria are not ranked in order of importance.

2.2. SUSTAINABILITY *(for Design see section 3.5)*

2.2.1. Environmental impact

Environmental impact ranges from consumption of natural resources and energy during manufacture and installation to removal, recycling, reuse and disposal. Realistic durability and maintenance input estimates are an essential pre-requisite of impact studies.

Thermal insulation performance also has a major positive effect on the environmental impact of any roofing proposal.

The environmental impact of a particular design is specific to that design. Many simplistic impact ratings for individual materials are available, but in reality, the impact of a design is dependent upon the complete system and the client's selection of which environmental issues are most important.

Therefore, it is recommended that the client's priorities for environmental assessment are established at an early stage.

Single ply roofing is fully represented in the various levels of environmental assessment now recognised by UK construction:

- *Individual product assessments*: SPRA members can provide information on individual product environmental profiles of the materials they supply, including the provision of recycled products.
- *Generic assessments for component types*: SPRA assisted the BRE with providing information on single ply membranes for production of the BRE Green Guide to Specification 2008.
- *Generic assessments for total roof systems* (BRE Green Guide to Specification): ratings for typical single ply systems can be found at www.bre.co.uk/greenguide
- *Generic assessments for whole-buildings* (BRE BREEAM ratings and Code for Sustainable Homes): further information available at www.breeam.org and www.planningportal.gov.uk

BREEAM is the BRE's Environmental Assessment Method for the performance of entire buildings. Credits are awarded according to the performance of the building using the following factors - Management, Health & Wellbeing, Energy, Transport, Water, Materials, Land use/Ecology & Pollution. These credits are then added together to produce one of the five overall ratings: Outstanding, Excellent, Very Good, Good or Pass.

2.2.2. Durability

Durability is derived from artificial ageing and long-term experience in the construction. It usually refers to individual components. It should not be confused with the term of any warranty (see 2.13). Service life is generally applied to systems of components and assumes that normal maintenance procedures have been followed. In financial terms, service life is the period over which the depreciated initial capital cost and annual maintenance cost does not exceed the annualised cost of a replacement roof system.

The British Board of Agrément (BBA) assesses the durability of single ply roofing membranes as part of the Agrément Certification process. The durability of single ply membranes supplied by members of SPRA is typically in excess of 30 years and Membrane manufacturers must hold current British Board of Agrément Certificates. Check these at www.bbacerts.co.uk

2.2.3. Renewables

Single ply roof systems are fully compatible with roof-level renewable technologies such as photovoltaic (PV) solar water heating (RH) and wind turbines. Some single ply membranes can be used to improve the efficiency of photovoltaic systems as compared with other roof coverings. Subject to certification, single ply roofing systems are also fully compatible with a range of green roof finishes.

2.2.4. Rainwater harvesting

Single ply roof systems are fully compatible with systems for the storage of rainwater, either at roof, ground or basement level. Both gravity and siphonic drainage systems can be used for collection.

2.3. THERMAL PERFORMANCE
(for Design see section 3.6)

2.3.1. Building Regulations

England & Wales – Building Regulations Part L 2010, Conservation of fuel and power

New Build

Part L1A (new dwellings) and Part L2A (new buildings other than dwellings) (extracts):

New buildings - Regulation 17C

'Where a building is erected, it shall not exceed the target CO_2 emission rate for the building that has been approved;..'

Energy performance certificates - Regulation 17E

'The person carrying out the work shall –

- *Give an energy performance certificate for the building to the owner of the building; and*
- *Provide the Local Authority with the reference number for the certificate.'*

Schedule 1 – Part L Conservation of fuel and power

'L1. Reasonable provision shall be made for the conservation of fuel and power in buildings by:

a) limiting heat gains and losses -

(i) through thermal elements and other parts of the building fabric;…'

Refurbishment

Part L2B (existing dwellings) & Part L2B (existing buildings other than dwellings) (extracts):

Requirements relating to thermal elements - Regulation 4A

(1) 'Where a person intends to renovate a thermal element, such work shall be carried out as is necessary to ensure that the whole thermal element complies with the requirements of paragraph L1(a)(i) Schedule 1' (See above).

(2) 'Where a new thermal element is replaced, the new thermal element shall comply with the requirements of L1(a)(i) of Schedule 1' (See above).

Scotland - Scottish Building Standards Agency (SBSA) Technical Handbooks – Section 6 Energy (extracts):

Standard 6.1 - 'Every building must be designed and constructed in such a way that:

(a) the energy performance is estimated in accordance with a methodology of calculation approved under regulation 7(a) of the Energy Performance of Buildings (Scotland) Regulations 2008; and

(b) the energy performance of the building is capable of reducing carbon dioxide emissions.'

Standard 6.2 - *'Every building must be designed and constructed in such a way that an insulation envelope is provided which reduces heat loss.'*

2.3.2. Control of condensation

Satisfactory performance in respect of the control of condensation both on the surface of and within the roof system is essential if thermal and durability targets are to be realised. All designs should be checked in terms of condensation risk for the intended building function (and any future change of use).

The Building Regulations Approved Documents C (AD C) sets mandatory requirements in respect of the control of condensation, which should be designed and constructed in accordance with BS 5250 and BS EN ISO 13788.

The requirement for ventilation of cold roofs is also covered within BS 5250.

2.3.3. Control of air leakage

(for Design see section 3.6.3)

Approved Document L of the Building Regulations states the relevant requirements for air tightness in buildings. The roof and those elements which penetrate it should be suitably airtight and must comply when tested with the minimum requirements as defined in the Approved Document.

2.3.4. Resistance to solar radiation

Resistance to solar radiation concerns issues of durability and of heat absorption and radiation. Infrared solar radiation has the potential to increase significantly summer cooling loads, even on well-insulated roofs. Its ultra-violet component is a major determinant in the ageing of construction materials.

Heat absorption is a function of colour and texture. Dark membranes not only absorb more solar radiation and transmit it to the rest of the roof system; they also radiate heat at night at a greater rate thereby cooling the roof surface. Heat absorption has become more important in roof design. It may affect the performance of energy capture equipment, but it is not currently included in the SAP and SBEM calculation methods for AD L1 and AD L2 respectively.

2.4. ACOUSTIC PERFORMANCE

(for Design see section 3.7)

SGD7/10 - Acoustic control within buildings

All likely sources of external and internal noise should be identified in order to establish the degree of attenuation required to suit the building function. Because acoustic performance is heavily dependent upon the selection of materials (especially any ceilings, the deck and the thermal insulation) early identification of the requirement may assist the design selection process.

Impact noise from rain must be considered at an early part in the roof design, due to the fact that this can significantly increase the indoor noise level.

Building Bulletin 93 (BB93) outlines the methods of compliance for Educational facilities. Health Technical Memorandum 08-01 (HTM 08-01) sets out the methods for compliance for Healthcare facilities. Both of these guidance documents include a requirement to minimise the noise of rainfall on lightweight roofs and whilst no limit is set, methods of control must be included and justified to Building Control.

The inherent flexibility of single ply membranes combined with appropriate insulation and fastening systems can offer a significantly improved acoustic performance when compared with rigid metal composite roofing systems.

Advice with regards to individual constructions is available from SPRA insulation manufacturer members (see 3.7).

2.5. LOADS *(for Design see section 3.8)*

2.5.1. Wind load

Wind load is established by calculation in which site topography and location are major determinants but its level is also influenced by the building design as a whole. It is therefore advisable to estimate wind load at an early stage. Detailed calculation can then follow when the design is more developed (see 3.8.1).

2.5.2. Roof traffic *(for Design see section 3.8.2)*

Consideration should be given to the suitability for roof traffic both during and after construction. Areas that will sustain heavy foot traffic after installation but prior to completion should be adequately protected.

Suitable provision should be made for maintenance access to plant and any other areas requiring regular access. SPRA manufacturers offer guidance in the treatment of such areas including, in some cases, materials for walkways and load spreading. Extra provision should be considered where additional plant is expected in the future (e.g. as units are let).

Where single ply roofing systems are incorporated in balconies and podia accessible to the disabled, the construction must comply with the requirements of the Building Regulations Approved Document M.

2.5.3. Plant and equipment *(for Design see section 3.8.3)*

SGD9/11 Wind load design requirements

Flat roofs are ideal locations for plant and equipment. At the earliest possible stage, the type, location, support and frequency of access to plant and weathering of services' access points should be agreed. This will inform later decisions on roof system type and selection of components. It is recognised that late changes are often necessary to plant both in terms of location and type. If this is likely, selection of a suitable support arrangement will help to reduce risk of damage to the roof covering or delays to programme.

2.6. FIRE PERFORMANCE *(for Design see section 3.9)*

2.6.1. Building Regulations

Approved Document B (AD B) 'Fire Safety' to the Building Regulations 2010 (England & Wales), contains minimum guidance for demonstrating the fire performance of roofs when the fire source is either external or internal to the roof construction. AD B is in two volumes: Volume 1 "Dwelling houses" (e.g. residential construction) and Volume 2 "Buildings other than Dwelling houses" (e.g. commercial construction).

2.6.2. External Fire Source (AD B)

Performance in terms of the resistance of single ply roofs to external fire exposure is determined by reference to either the national test BS 476-3 or European test method 't4' specified in ENV 1187:2002.

The European 't4' method is effectively the BS 476-3 method minus the requirement to test for flame spread.

All roof coverings require either a national classification (e.g. 'AA' , 'AB', 'AC') in accordance with BS 476-3 etc or a European classification (e.g. 'BROOF t4', 'CROOF t4', etc) in accordance with BS EN 13501-5.

For 'dwelling houses' Table 5 in Section 10 of AD B Volume 1 defines limitations of use on roof coverings based on national or European classification.

For 'buildings other than dwelling houses' Table 16 in Section 14 of AD B Volume 2 defines limitations of use on roof coverings based on national or European classification.

2.6.3. Fire Resistance (AD B)

In some circumstances the roof, or part of the roof, may also need to demonstrate a minimum period of fire resistance when tested to either national or European standards (for example if used as an escape route or if the roof performs the function of a floor in terms of the buildings overall stability). In these situations, the guidance of Table A1 to Appendix A of AD B should be followed to determine the minimum fire resistance period required.

2.6.4. Insurers Requirements

Building Regulations are intended to ensure that a reasonable standard of life safety is provided in case of fire. The protection of property, including the building itself, often requires additional measures and insurers will, in general, seek their own higher standards before accepting the risk.

The insurance company FM Global recommends the use of FM Approved roof assemblies as listed at www.roofnav.com and installed in accordance with their Loss Prevention Data Sheets (www.fmglobaldatasheets.com). Specimens of the full roof construction (from deck through to roof membrane) are subject to both external and internal fire test.

The Loss Prevention Certification Board (LPCB) operates an alternative certification scheme (www.redbooklive.com).

2.7. TRANSMISSION OF DAYLIGHT *(for Design see section 3.10)*

Rooflights can provide very durable and effective glare-free natural lighting in deep plan buildings. Since their size and position has a significant effect upon drainage and thermal design, it is important to establish the performance requirement at an early stage. Solar gain must now be considered.

2.8. LIGHTNING PROTECTION
(for Design see section 3.11)

Lightning protection is a function of building location, design, materials and internal use. Since lightning protection works are usually part of the electrical contract package, effective integration of the roofing and electrical design is important at an early stage.

2.9. APPEARANCE *(for Design see section 3.12)*

The overall appearance of the finished roof with its necessary details, plus any decorative surface finish. The durability of the appearance and retention of colour should also be considered. Where the roof is a visible feature, client expectations should be matched with system performance by reference to similar projects and sample panels, as appropriate.

2.10. SECURITY

Required performance in respect of security against access to and through the roof should be established at an early stage as this can influence the selection of roof type and detailing. Buildings such as data centres require this special consideration.

2.11. SUPPLEMENTARY USES

Mechanical and electrical services are often subject to location and capacity change during a building project and during service. Single ply roof systems are unique in their adaptability to such change. However, the extent of design flexibility likely to be required should be established, to inform appropriate detailing or and to avoid difficult sequencing during construction.

2.12. MAINTENANCE FREQUENCY AND COST

Single ply roofing membranes require no maintenance but it is established good practice to check roofs for damage or debris at least twice per year (preferably in early spring and late autumn) (see 6.0 Maintenance).

2.13. WARRANTY

S4/08 Guarantees – a checklist for clients & designers

SPRA requires that its membrane and associate component manufacturers offer a minimum ten year product warranty. Longer product guarantee periods may be available as may additional guarantees for workmanship, from either the sub-contractor or via third-party products which include protection from insolvency.

2.14. SAFETY DURING CONSTRUCTION AND USE
(for Design see section 3.17)

In addition to the safe methods of working with materials there is a requirement to protect workers from falls.

The Work at Height Regulations became effective in April 2005 as a result of a European Directive.

Because much of Section 6 of the Construction Health Safety & Welfare Regulations has now been absorbed into these Regulations, activities in compliance with Section 6 will generally be in compliance with the Work at Height Regulations.

The need to provide protection and preventative measures to stop persons falling during the construction phase would be covered and included in the contractors Risk Assessment.

Consideration must also be given to the prevention of falls during the in-service phase of the roof, such as guard rails, safety restraint systems, designated walkways etc, to ensure the reasonable safety of persons who may need to access the roof for inspection of plant, equipment, roof lights etc. These considerations and requirements should be brought to the attention of the CDM coordinator for inclusion in the Health and Safety file.

Risk avoidance is paramount. The new Regulations mark a change of approach from prescriptive requirements to hazard determination by risk assessment on a job-by-job basis, leading to more consideration of the actions required for every different activity where someone is liable to be harmed as a result of a fall, irrespective of height. It is no longer acceptable to assume that there is no risk if the fall is from less than 2 metres. The scope of 'work at height' is that if measures required by the Regulations were not taken, then a person could fall a distance liable to cause personal injury.

Collective + protection		Individual protection + (of a small number of workers)			
Category A1	**Category A2**	**Category B1**	**Category B2**	**Category B3**	**Category C**
Permanent structural barriers	Guard rails for occasional access	Fall restraint No PPE* adjustment required (perimeter system)	Fall arrest No PPE* adjustment required (perimeter system with fall hazards)	Fall arrest PPE* adjustment required (ridge system)	Roped access (abseiling) specialist techniques
Risk factor* for a basic trained worker 1	Risk factor* for a basic trained worker 1	Risk factor* for a basic trained worker 2	Risk factor* for a basic trained worker 3	Risk factor* for a basic trained worker 6	Risk factor* for a basic trained worker 10
Worker training to control risk **NONE**	Worker training to control risk **NONE**	Worker training to control risk **BASIC**	Worker training to control risk **BASIC**	Worker training to control risk **ADVANCED**	Worker training to control risk **SPECIALIST**

* **Notes**
PPE: Personal Protective Equipment
Risk factor: 1 = low risk, 10 = high risk

\+ **Definitions**
Collective protection: systems which protect an area, allowing work to take place safely, without the necessity for any direct action by the worker in order to protect himself.
Individual protection: systems which require direct action by each worker in order to ensure that he is protected. The level of worker competency required to safely use different categories of system will vary.

Table 1: Categories of individual and collective fall protection

3. DESIGN

3.1. INTRODUCTION

The principal code of practice for the design of single ply roof systems is BS 6229 *'Code of practice for flat roofs with continuously supported coverings'.*

This Standard cross-refers to various other more specific Standards and Codes of Practice; these are set out under the relevant design criterion.

Other relevant sources of best practice advice include *Flat Roofing – Design and Good Practice'* (BFRC/CIRIA 1993), Digests and Reports of the Building Research Establishment, SPRA Technical Guidance Documents and other British Standards, as follows:

SPRA Technical Guidance Documents

SGD2/04 - Safety - Design considerations for reduced risk

SGD4/06 - Use of Sealants

SGD5/07- Non-destructive Testing of Single Ply Membranes

SGD6/08 - Quality control and use of adhesives for the attachment of vapour control layers, insulation and single ply membranes in flat roofing

SGD7/10 - Acoustic control within buildings

SGD8a/10 - Falls and Drainage for single ply roofs – Part 1

SGD 9/11 - Protection of roofs

British Standards

- BS EN 1991-1-1: Eurocode 1. Actions on Structures. General Actions. Densities, self-weight imposed loadings for buildings. BS EN 12056–3 and the Building Regulations Approved document Part H contain relevant design information to enable precipitation and run-off rates to be assessed and give design principles for gutters.
- BS EN 1991-1-7: Eurocode 1. Actions on Structures. General Actions. Accidental Actions.
- BS EN 1991-1-4 + A1: Eurocode 1. Actions on Structures. General Actions. Wind Actions.
- National Annex to BS EN 1991-1-4 + A1: UK National Annex to Eurocode 1. Actions on Structures. General Actions. Wind Actions.
- BS EN 12056: 'Gravity Drainage Systems inside buildings. Part 3 Roof drainage, layout and calculation'.

Other References

- Building Research Establishment Digest No. 346: 1989 'Assessment of Wind Loads'.
- Building Research Establishment BR262 'Thermal insulation: avoiding risks' 2002 edition.
- The Loss Prevention Certification Board – List of Approved Fire and Security Products and Services. This is known within the industry as the 'red book'. This can be viewed free of charge on the internet at www.redbooklive.com

Specifically Section 2.5.1 refers to 'Roofing products: protection against fire from outside the building. Section 2.5.2 refers to 'Roofing products: protection against fire from inside the building.

- The LPC Design Guide for the Fire Protection of Buildings – A code of Practice for the protection of business. Published by The Fire Protection Association with supporting documents, including 'Essential Principles'. Both documents are published by The Fire Protection Association.
- FM Approvals Standard 4470 for roof assemblies and www.roofnav.com
- FM Global Data Sheets (www.fmglobaldatasheets.com)

3.2. TYPES OF ROOF SYSTEM

3.2.1. Components

A typical single ply roof system comprises:

- Traffic or load resistant finish (if required for functional and/or aesthetic reasons).
- A filter or water control membrane (inverted roofs only).
- Waterproof membrane.
- Thermal insulation (if required).
- Vapour control layer (VCL, if insulation required).
- Deck providing continuous support (may be installed by the roofing contractor).
- Structural support (generally not installed by the roofing contractor).

Roof systems based on continuous waterproofing are generally divided into the following types, according to the position of the principal thermal insulation (and therefore the temperature of the deck during service).

3.2.2. The warm roof

The principal thermal insulation is placed immediately below the roof covering, resulting in the structural deck and support being at a temperature close to that of the interior of the building. The design should ensure that the deck is maintained at a temperature above that which could cause condensation to occur at this level during service.

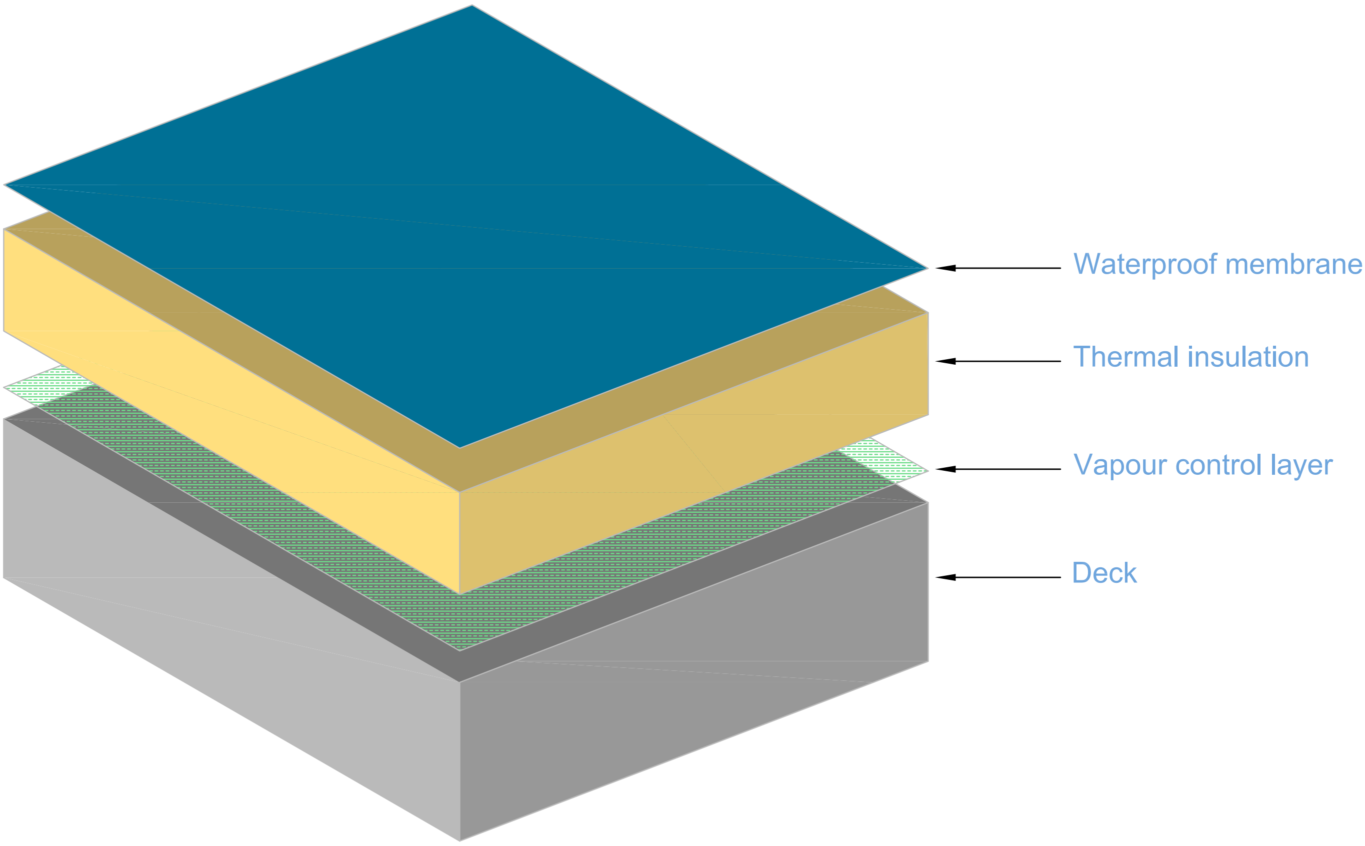

Fig. 1 Warm roof (section)

3.2.3. The inverted warm roof

This is a variant of the warm deck roof in which the principal thermal insulation is placed above the roof covering, resulting in the roof covering, structural deck and structural support being at a temperature close to that of the interior of the building. Generally the principal insulation is secured by separate ballast (paving or stone). However for low wind loading situations proprietary lightweight systems are available comprising of an insulation/ballast composite, which do not rely on separate ballast in the roof field.

A filter layer is required to stop mineral fines passing into and below the insulation joints, to improve rainwater run-off and to reduce the effect of wind uplift on the ballast. Conventional low water resistance geotextiles necessitate a 20% increase in insulation thickness to compensate for losses due to cold bridging by drainage. More recent high water-resistance products (with suitable performance certification) allow a much lower penalty of approximately 3% (depending on the product). By reducing insulation flotation loads, these products may also allow reduced ballast depth (and therefore load) to be used. It is essential that the drainage design facilitates the rapid transfer of rainwater across these products and to rainwater outlets.

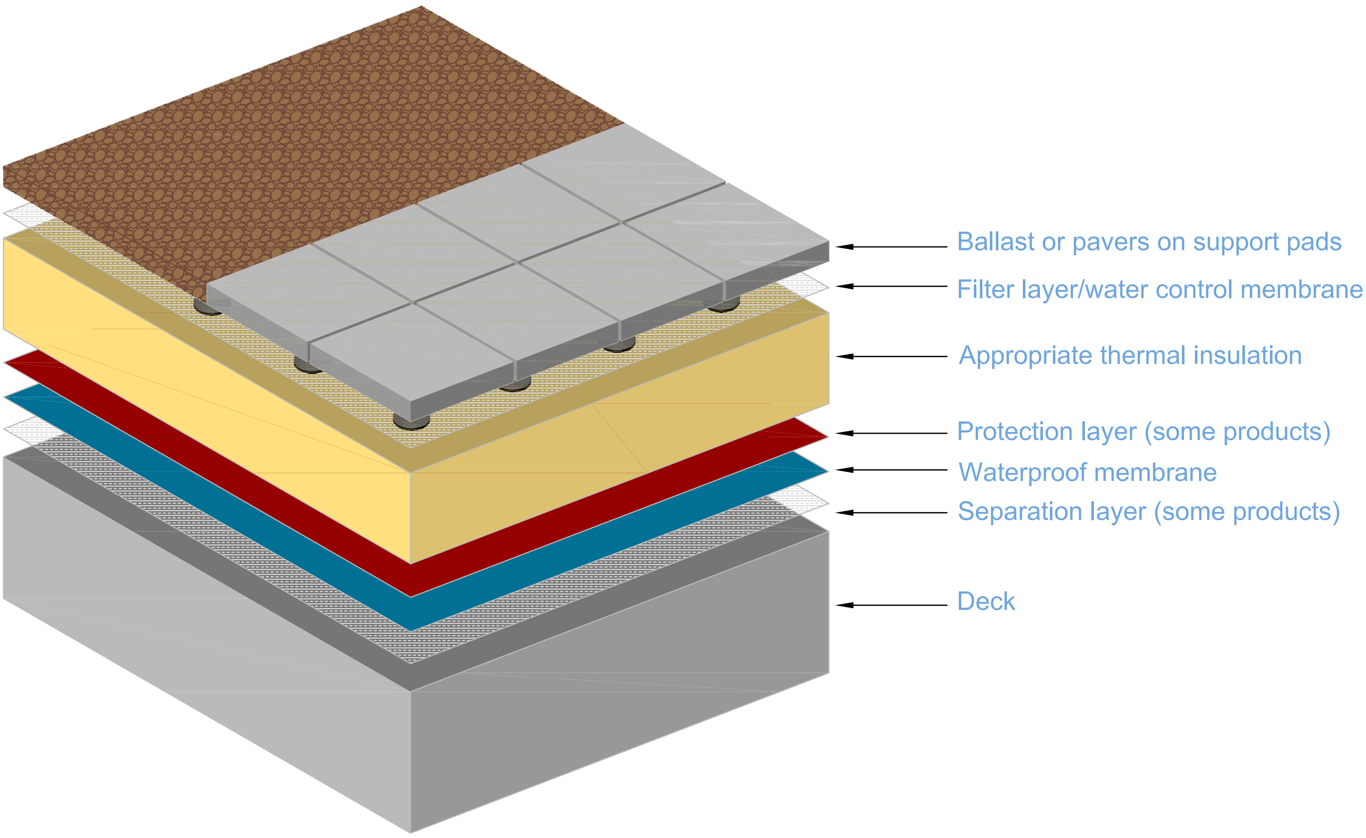

Fig. 2 Inverted warm roof (section)

3.2.4. Roof gardens or 'green/living roofs'

Green Roof Organisation (GRO)

There are four discernable types of green roof construction:

- **Intensive** – Roof gardens designed for mainly recreational use, comprising both hard and soft landscaping. These could include for example, ground level podia, plazas, terraces, lawns, flower-beds and raised planters. Normally constructed on concrete decks due to the imposed loading to the structure, design considerations must include saturated load, upstand height, irrigation, maintenance and safe access.
- **Simple-Intensive** – low maintenance planting with pedestrian access. Typical planting would include lavender or heathers that would still require some irrigation and maintenance. Access provided by paved walkways.
- **Extensive** – low growing, drought tolerant planting cultivated in lightweight substrate growing medium. Available as pre-cultivated vegetation blankets or selected plants either manually plug-planted or hydro-planted, where the seeds/cuttings are sprayed on to the growing medium. Planting generally consists of alpine species such as sedum, together with herbs, grasses and moss. Irrigation only required on steep slopes and/or exposed locations.
- **Brown/Bio-diverse** – designed to replicate natural habitats for endangered wildlife using materials reclaimed from the site being developed. For example, materials from building demolition might be used as a substrate and left to see what planting develops naturally. Surface features may include dead tree branches, coiled rope, large and small boulders etc. No maintenance or irrigation required.

All waterproofing membranes used for green roofs should be independently certificated for such use and demonstrate long term resistance to root penetration and micro-organisms. The current recognised standard in Europe is the German 'FLL' and the UK guide published by the Green Roof Organisation (GRO) (see references). Green roof design requires early and close coordination between those providing the roof and the landscaping.

Insurers will also often have additional requirements for green roofs in respect of property protection. One example being FM Approvals standard 4477.

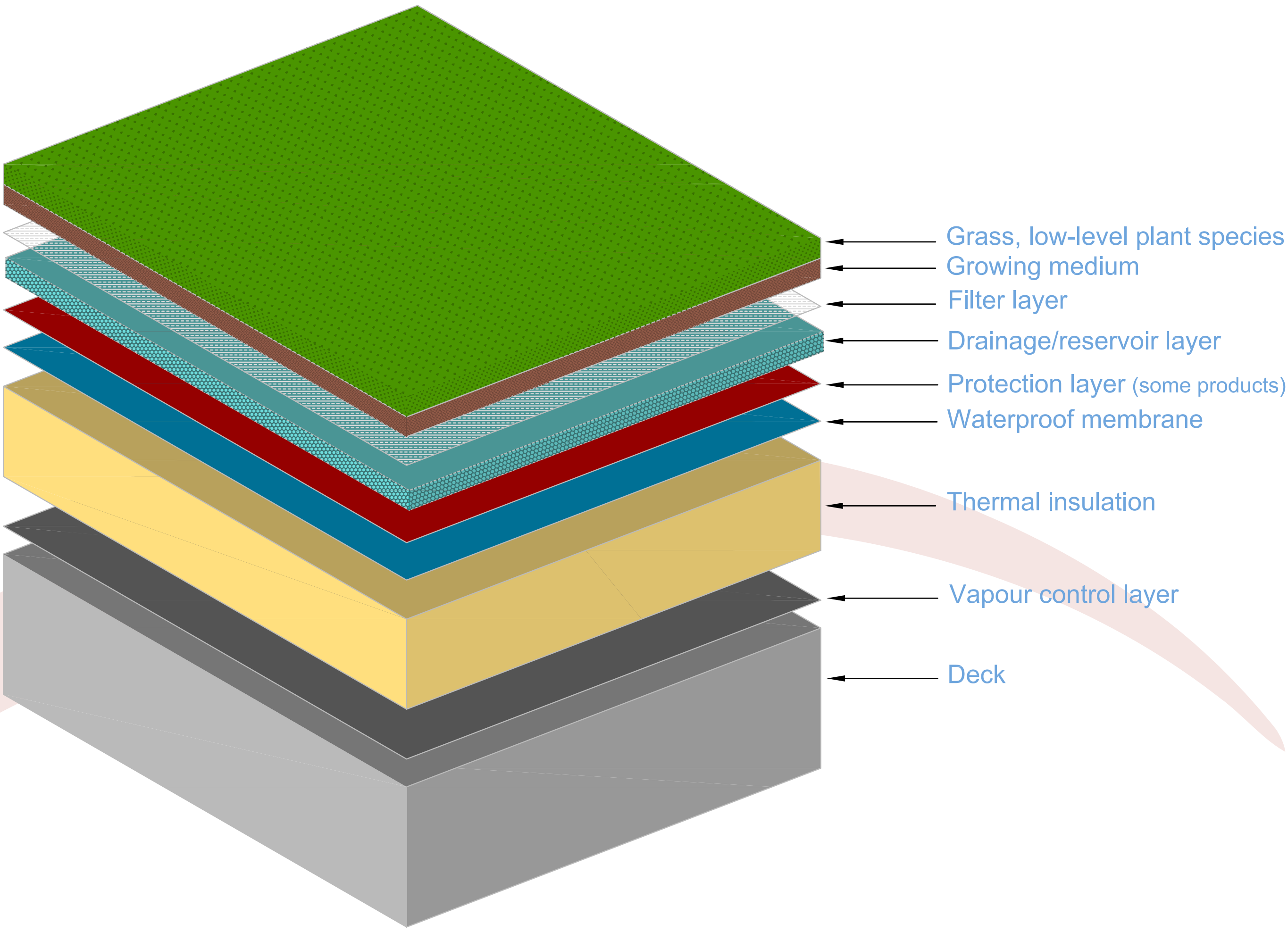

Fig. 3 Green roof - (Warm roof type) (section)

3.2.5. The cold roof

The principal thermal insulation is placed at or immediately above the ceiling (i.e. below the deck), resulting in the roof covering and structural deck being substantially colder in winter than the interior of the building. The structural support will typically form a 'cold bridge' between the high and low temperature zones of the construction. It is very difficult to insulate a cold roof system to current mandatory levels without introducing cold bridges and/or increasing the risk of condensation accumulation within the system. In addition, the mandatory requirement for uninterrupted external air circulation limits the application of the system where abutting elevations or changes in building geometry occur. Therefore, it is very unlikely to be a feasible option and is not recommended.

If an existing cold deck roof is refurbished, it is important to ensure that the ventilation requirement is achieved, whether or not the level of insulation is to be increased. It is also not feasible to introduce vapour control and insulation below an existing structural deck, of concrete for example. If, during refurbishment, a cold deck roof is converted to a warm deck roof (by placing insulation above the deck and closing off the ventilation) it is necessary to provide at least as much thermal resistance above the deck as was previously provided below the deck. A condensation risk calculation should always be carried out in such circumstances to ensure that the deck is above dew point during service.

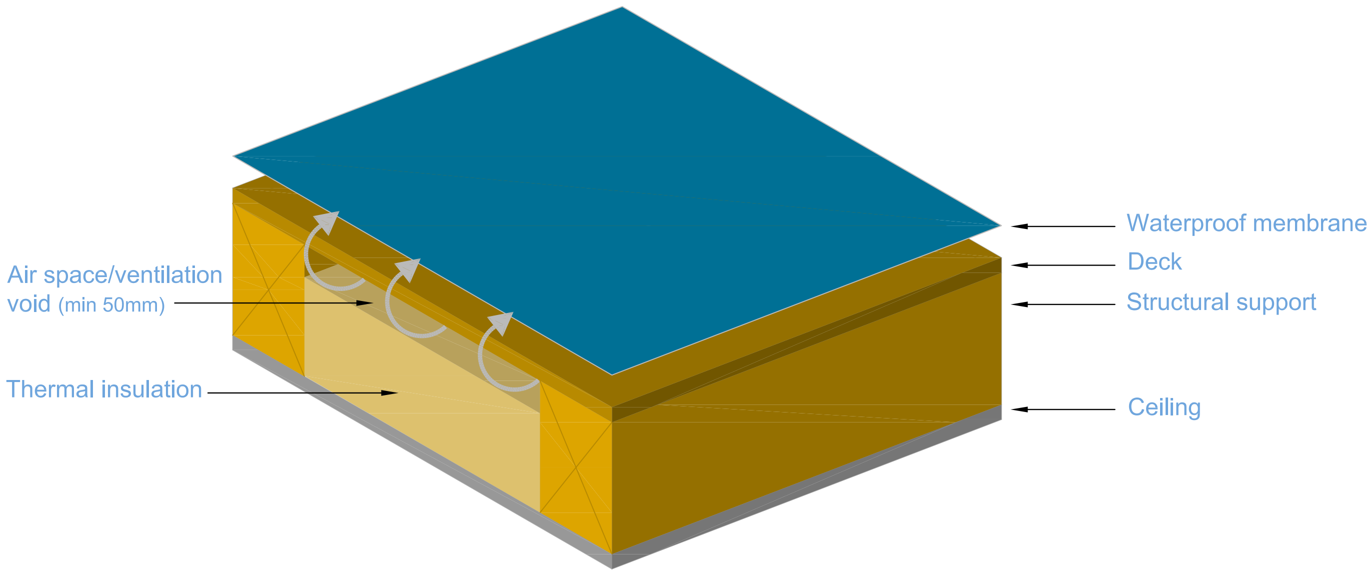

Fig. 4 Cold roof (section)

Many roofs combine the features of two or more of the roof types previously described. Examples include structural decks of high thermal resistance combined with additional insulation and existing roofs to which thermal insulation is added. Once assessed in terms of their thermal and water vapour transmission characteristics, such roofs will generally fall into one of the categories described.

In some constructions the waterproofing layer is placed between two layers of insulation, combining the properties of warm roof and inverted warm roof construction. This form of construction is generally known as a 'duo roof '.

3.3. FALLS

SGD8a/10 - Falls and Drainage for single ply roofs – Part 1

Since the primary function of the roof is to exclude water, it is important to consider how best to direct this into the drainage system. Ponding on membrane roofs should be avoided because:

- It encourages the deposition of dirt and leaves which can be unsightly, may obstruct outlets and/or become a slip hazard.
- In the event of damage, the interior will suffer increased water ingress.
- The load may cause progressive deflection of the deck.
- Ice or algae may create a slip or wind hazard, particularly on walkways.

Independent research has shown that roofs with extensive ponding require increased maintenance input.

Membranes are tested for water absorption and watertightness at seams as part of third party certification. However the construction process, including the laying of components and the forming of seams is clearly facilitated in dry, well drained conditions.

Roof falls may be created either during the construction of the deck or alternatively by the use of tapered insulation systems. The former has the advantage that the vapour control layer will also be to fall and will act as a temporary line of defence to water ingress during construction.

BS 6229 states that a minimum finished fall at any point of 1:80 (1.25%) should be achieved. Since adjoining roof planes at 1:80 will meet at a mitre of less than 1:80, the intended finished fall at such intersections should be considered at an early stage.

Design falls should take account of any potential deflection and construction tolerances. In the absence of detailed calculation this may necessitate design falls of twice the minimum finished falls (1:40 or 2.5%). Cut-to-falls systems are often produced to a 1:60 (1.7%) fall or 1:40 (2.5%) fall to ensure that deflection of the deck and/or construction tolerances are overcome.

Consideration should also be given to:

- The available upstand height at the high end of the falls. This may be a limiting factor on the length/size of the roof area to be drained.
- Avoidance of ponding behind wide obstructions to the drained slope such as plant plinths or rooflights.
- Avoidance of gutters by designing with intersecting roof planes.
- Falls between rainwater outlets along a perimeter.

For further information, see SGD8a/10 - Falls and drainage for single ply roofs – Part 1

3.4. DRAINAGE

SGD8a/10 - Falls and drainage for single ply roofs – Part 1

Drainage design should be based upon calculation given a design head of water (typically 30mm). Rainwater outlet capacity should be taken from properly certificated information provided by manufacturers and the resulting number and layout of outlets should allow for obstruction and drag due to any additional surface finishes such as walkways.

It is not generally necessary to provide separate box gutters where two planes of roofing intersect, or where a single plane falls to an abutment. In the latter case, there will be no fall between outlets so consideration should be given to creating these in the structure or insulation. Box gutters are slow, difficult to construct and introduce unnecessary complexity. The need to maintain a fall in gutters and to comply with Building Regulations may be difficult to achieve.

Single ply membranes are fully compatible with siphonic roof drainage systems. For larger roofs, siphonic drainage offers many advantages:

- Very high capacity, enabling fewer outlets and so less detailing work on site.
- Smaller bore horizontal collector pipework, enabling reduced roof void depth.
- Self-cleaning in many situations.

For further information, see www.siphonic-roof-drainage.co.uk

3.5. SUSTAINABILITY

3.5.1. Environmental Impact

An Ecopoint® assessment was developed by BRE for generic (Polyvinyl Chloride) and FPO (Flexible Polyolefin) in 2008, based on manufacturing data supplied by SPRA members. When set against eleven criteria of environmental impact this produced scores of 14.33 for PVC and 11.35 for FPO. When these ratings were combined with impact data for other parts of the roof assembly (e.g. deck and insulation) they produced the following ratings (irrespective of whether the waterproof membrane was PVC or FPO):

Example - Warm roof

	Commercial/ industrial	Dwellings
Steel deck	A+	A+
Timber deck	A+	A+
Concrete deck – insitu	C	C
Concrete - precast	B	B

Table 2: Green Guide to Specification – Typical ratings for warm roof systems

3.5.2. Durability

Because the sustainability of a roof system depends to a large extent upon its durability, expected durability has been factored into the ratings in Table 2 (above). Single ply membranes supplied by SPRA manufacturer members have independently certificated durability in the range 25-40 years depending on product type and maintenance regime. A single ply roof system should be designed to a service life defined by the client, taking into account such factors as building lifespan likelihood of change-of-use and secondary uses of the roof.

The actual service life will depend on many factors relating to design and maintenance including the following:

- Provision of drainage falls.
- Appropriate design to resist the effects of foot traffic.
- Isolation of building and thermal movement from the waterproof membrane.
- Selection of membrane product type to suit any local airborne contamination.
- Prompt attention to repairs.

3.5.3. Renewables

Cost-effective integration of energy capture equipment with single ply membranes is straightforward, but simplified by early consultation. The following should be considered:

- Careful design if self-ballasted equipment is placed on the roof system.
- Transfer loads to deck directly via structural support or via a framework set on supports.
- Consider the sound transmission effects of turbines and panel arrays.
- Arrange safe and protected access routes to all equipment.
- Provide weathered services access points to avoid late-stage use of sealed collars or pipes.
- Agree minimum access space requirements for repairing equipment of roof covering.

3.5.4. Design to reduce waste

SPRA is committed to the objective of zero waste to landfill. Other parties' commitments to the Waste Resource Action Plan (WRAP) are increasingly precluding the generation of waste on modern sites. Manufacturer recovery of packaging and waste and removal of site waste by the roofing contractor are increasingly common against a background of steeply rising landfill disposal costs. Early consultation between client, designer and roofing contractor is essential for waste minimisation.

Examples include:

- Dimensioning to suit the deck and insulation panel size.
- Off-site preparation of steel decking for roofs of irregular or curved plan.
- Specification of single ply membrane to enable use of field area off-cuts for detailing.
- Avoidance of unnecessary details such as plinths and box gutters.

3.6. THERMAL INSULATION

3.6.1. Building Regulations

England & Wales

Building Regulations Part L implemented in October 2010 consists of the following approved documents:

- L1A (new dwellings)
- L1B (existing dwellings)
- L2A (new buildings other than dwellings)
- L2B (existing buildings other than dwellings)

<u>New build</u>

The 2010 revision to Part L1A of the Building Regulations is tailored to give a 25% reduction in CO_2 emissions on new dwellings, from the 2006 Regulations.

Part L2A is slightly different, in that the total reduction in CO_2 emissions across buildings other than dwellings, follows an aggregate approach, with some building types requiring less than a 25% reduction and some requiring more.

The above documents define the following mandatory limiting backstop fabric U-Values for flat roofs:

- For Part L1A (new dwellings) - Area weighted average 0.20W/m^{2}k
- For Part L2A (new buildings other than dwellings) - Area weighted average 0.25W/m^{2}k

<u>However in practice, achievement of the overall carbon reduction target will require a lower U-value (e.g. 0.18 – 0.12W/m^{2}k).</u>

<u>Refurbishment</u>

Approved documents Part L1B & Part L2B apply to the refurbishment of existing buildings.

When a thermal element is subject to renovation, the whole element should be improved to achieve or better the relevant U- value set out below (for full details see table 3 and table 5 of L1B & L2B respectively), provided the area to be renovated is greater than 50% of the surface of the individual element, or 25% of the total building envelope (When assessing this area proportion, the area of the element should be taken as that of the individual element, not all the elements of that type in the building).

Flat roof or roof with integral insulation: improved U-value - Area weighted average 0.18W/m²k

Reasonable provision would be to upgrade those thermal elements whose U-value is worse than the maximum threshold value of 0.35W/m²k (for full details see table 3 and table 5 of L1B & L2B respectively) to achieve the improved U-value previously stated above.

Insulated upstands

Section 5 of Part L of the Building Regulations refers specifically to *'the building fabric'* and states that it *'should be constructed so that there are no reasonably avoidable thermal bridges in the insulation layers, caused by gaps within the various elements, at the joints between elements and at the edges of elements…..'*

This section provides guidance to the industry on ways to construct best practice details, to ensure a reduction of heat loss through typical roof and wall junctions, e.g. insulated upstands. Where an approved accredited construction detail (ACD) scheme is available, it may be possible for calculated thermal transmittance values to be used directly into the SBEM/SAP calculations for the building. These can have a significant affect on improving the thermal performance of a building and where ACD's are not used, generic values must be used. Refer to the relevant section of Part L for details.

Scotland

Building Regulations Section 6 (Energy) implemented in October 2010 consists of the following standards:-

- Section 6 (Domestic Energy)
- Section 6 (Non Domestic Energy)

New build

The 2010 revision to Section 6 (Energy) of the SBSA Technical Handbooks is tailored to give a 30% reduction in CO_2 emissions on new buildings (dwellings and non-dwellings) from previous regulations.

The above documents define the following mandatory limiting backstop fabric U-Values for flat roofs.

New dwellings – Area weighted average 0.18 W/m².K.

New buildings other than dwellings – Area weighted average 0.20 W/m².K.

New buildings other than dwellings (shell and fit out buildings) – Area weighted average U-Value 0.15 W/m².K.

However in practice, achievement of the overall carbon reduction target will require a lower U-Value (e.g. 0.18 W/m².K – 0.12 W/m².K).

Refurbishment – Dwellings - New thermal elements (extensions).

There is one of two levels for the new building fabric depending on the thermal efficiency of the existing building, where a building has external walls with a U-Value poorer than 0.7 W/m²k and a roof with a U-Value poorer than 0.25 W/m².K then a U-Value of 0.15 W/m².K is required for the flat roof. Where the existing wall and roof elements already meet or, as part of the works will be upgraded to meet the U-Values of 0.7 W/m².K and 0.25 W/m².K respectively a U-Value of 0.18 W/m².K is required for the flat roof.

Refurbishment – Dwellings - Reconstruction of elements.

Where the build up of the flat roof element forming the fabric is to be altered or dismantled and rebuilt an opportunity exists to improve the level of insulation. If there is no technical risk or other reason which prevents this then the U-Value of 0.18 W/m².K is to be used as the benchmark. If however it is deemed not reasonably practicable at least a U-Value of 0.35 W/m².K for the flat roof is to be achieved.

Buildings other than dwellings - New thermal elements (extensions).

Where the insulation envelope of a building is extended, the new building fabric flat roof element should be designed to a U-Value of 0.15 W/m².K.

Buildings other than dwellings - Reconstruction of elements.

Where the build up of the flat roof element forming the fabric is to be altered or dismantled and rebuilt an opportunity exists to improve the level of insulation. If there is no technical risk or other reason which prevents this then the U-Value of 0.15 W/m².K is to be used as the benchmark. If however it is deemed not reasonably practicable at least a U-Value of 0.35 W/m².K for the flat roof is to be achieved.

3.6.2. Control of condensation

Condensation in a roof construction occurs when moist air is cooled below its dew point. The greater the moisture content of the air (relative humidity, RH), the higher the dew point temperature.

In cold external conditions, as moisture vapour from a heated interior moves upwards through a typical roof system, its temperature drops. Correct design against interstitial (within the system) condensation ensures that either a vapour control layer (warm roofs) or ventilation (cold roofs) is provided to control this process. The former works by acting as a barrier, the latter by dispersal.

Building types

Building uses such as kitchens, swimming pools or shower rooms are at particularly high risk because of high internal RH. Buildings such as school classrooms or community centres that may be heated intermittently and then poorly ventilated because they are closed for security reasons are also at significant risk. See BS 5250 fig B.1 and table B.5.

Conversely, low RH buildings such as warehouses with only background heating or offices with air management systems are at very low risk.

Cold stores can be assessed in similar ways but in reverse, with the external waterproofing also being required to control effectively moisture vapour transmission into the roof system from the exterior.

Increased thickness of insulation in roofs helps to reduce the risk of surface condensation on ceilings but it does not in itself reduce the risk of interstitial condensation. Indeed it may increase that risk. The correct design of vapour control is therefore vital for effective roof performance.

Vapour control

In a warm roof the vapour control layer (VCL) is placed on the underside of the insulation. However, the VCL is never totally resistant to moisture vapour transmission or air convection. A small quantity of water vapour passing through the membrane itself or at joints will pass through the insulation system and condense on the cold underside of the waterproof membrane.

Design calculation takes account of this process by ensuring that there is no significant accumulation of condensate within the system over a complete annual cycle of winter condensation and summer evaporation.

Advice regarding the requirement for a vapour control layer should be sought from insulation and membrane manufacturers.

Calculation

BS 5250 describes a method of quantifying the accumulation and removal of condensate during hypothetical winter and summer conditions respectively. This method of calculation has also been adopted for all roof coverings within the scope of BS 6229, which additionally advises maximum levels of annual accumulation in kg/m^2. All SPRA insulation manufacturer members offer a calculation service in respect of both U-values and condensation risk. However such calculation is theoretical because it is based upon steady state conditions and nominal performance data for roof components.

Guidance is available in Building Research Establishment BR262, BS 5250, and the Chartered Institute of Building Services Engineers (CIBSE) Guide - Volume A – Design Data. Calculation may indicate that a VCL is not required for certain low-risk buildings. In this situation, an unsealed metal deck may provide sufficient control. However, such a roof may not provide sufficient resistance to air leakage, thus still necessitating a VCL.

All SPRA Associate members supplying insulation are committed to the TIMSA/BBA *Competent Persons Scheme for the calculation of U-value and condensation risk analysis.* www.bbacerts.co.uk

Reducing risk

Particular consideration should be given to the following:

(a) Warm roofs

- Avoidance of cold-bridging across components with high thermal resistance.
- Avoidance of cold bridging due to gaps in insulation.
- Avoidance of areas with reduced thermal resistance (e.g. box gutters must achieve a minimum U-value of 0.35W/m^2.K unless it can be demonstrated by reference to BS5250 that condensation will not occur during service).
- Avoidance of air movement through and across the roof system.
- Continuity and termination of vapour control layer at upstands and details generally.
- The effect of penetrations through the vapour control layer.

(b) Inverted warm roofs

- Avoidance of surface condensation on lightweight decks.
- Maximum possible drainage above insulation by designing the deck to a fall.
- Use of a water control membrane beneath ballast.
- Avoidance of cold bridging due to gaps in loose-laid insulation.

(c) Cold deck roofs

- Clear routes for through-ventilation.
- A minimum 50mm gap between the underside of the deck and the top of the insulation.
- Adequate openings for ventilation at each end of the roof.

3.6.3. Control of air leakage

The air tightness of the building fabric should meet the requirements set out in the Building Regulations Approved Documents L1A and L2A (England & Wales) and SBSA Section 6 (Scotland).

The measured air permeability should generally be no worse than the *limiting air permeability* value of *10m^3/h.m^2 at 50 Pa*, however the design air permeability value required for each individual building will be set at design stage and may well be lower in order to achieve the TER (target emission rate) for the building. In order to demonstrate that acceptable figures have been achieved, the Building Regulations impose a requirement for pressure testing. Refer to the appropriate Approved Document for guidance.

In a single ply roofing system, effective sealing against air leakage is achieved by either:

- A sealed deck (concrete or steel, with appropriate sealing at perimeters and penetrations by incorporating sealant in the side and head stitching of the steel decks), or (more commonly and easily, but also vulnerable to damage during the construction process).
- A vapour control layer which, if properly sealed to the building perimeter and all penetrations should provide a satisfactory seal.

Tests have shown that mechanical fasteners driven through the vapour control layer will not affect permeability significantly because the insulation is compressed onto the vapour control layer at each fastening point.

It is anticipated that whilst it is relatively easy (with sound design and construction) to achieve less than the current mandatory maximum permeability, the requirement is expected to become more onerous with future revisions of the Building Regulations.

3.6.4. Resistance to solar radiation

Depending upon the membrane selected, solar heat gain may significantly affect the performance of the roof system. Polymeric single ply membranes designed for exposed applications are available with high reflectivity and resistance to UV ageing. The very slow degradation process is such that a high proportion of initial reflectivity is maintained during long service, depending on the local environment and cleaning regime. Manufacturers can provide specific data as required.

Ponding on light coloured membranes will inevitably cause dark areas which will be subject to increased heat gain. These may reduce the efficiency of some photovoltaic systems. Similarly, dark coloured membranes will transmit more heat to the roof system than those with increased reflectivity.

Insurers will also often have additional requirements for roofs incorporating photovoltaic systems in respect of property protection.

3.6.5. Selection criteria

The designer should determine the type and thickness of the insulation and any integral or separate overlay by reference to the performance criteria listed below.

- Required thermal transmittance ('U-value') of the roof.
- Compressive strength (where permanent plant, equipment or loads from roof traffic will be applied directly onto the roof surface).
- Compatibility with other roofing components.
- Required fire resistance.
- Acoustic performance.
- Cantilever capability.
- Free span capability.
- Suitability for roof traffic both during and after construction.
- Suitability for proposed method of attachment.

Additionally for inverted warm roofs:

- Water absorption.
- Correction factors for the cold bridge effect of drainage (rainwater cooling)
- Effect of wind uplift/flotation
- Resistance to freeze/thaw.

SPRA requires that its membrane manufacturers provide product only in systems where the insulation selected conforms to the relevant British Standard or European Standard or is certified by the British Board of Agrément.

3.7. ACOUSTIC DESIGN

SGD7/10 - Acoustic control within buildings

Design of the roof structure should take into account the type of acoustic control required.

Sound absorption within buildings is important for building categories including manufacturing plants, offices, convention and sports halls where sound reflection may become a problem following occupancy. This may be achieved using a combination of insulation boards in conjunction with perforated decking, acoustic ceilings or other sound reduction measures.

The roof structure may alternatively be required to provide sound reduction from external sources such as, heavy traffic or aircraft, which can be accommodated through the use of acoustic materials of appropriate compressive strength in combination with increasing the unit mass of the roof construction, for example by using a mass layer.

Approved Document E – Resistance to the passage of sound, 2004 Edition, requires the construction of new school buildings to meet appropriate acoustic standards. Building Bulletin 93 'The Acoustic Design of Schools' produced by DfES, outlines the methods of compliance. Section 3 of BB93 requires designers to consider the effect of impact noise from rain on the roof. With regards to Health Facilities, in 2008, Health Memorandum HTM 08-01 set out targets for designers to deal with rain noise. Excessive noise from rain on the roof can occur in buildings where the roof is made from profiled metal cladding and there is no sealed roof space below the roof to attenuate the noise.

Lightweight roof construction including single ply membrane in combination with acoustic material or alternatively acoustic ceilings, will offer significant sound attenuation and thereby assist in meeting the necessary requirements determined by an acoustic consultant.

It is generally not advisable to place external air handling plant directly on the roof surface for reasons of satisfactory weatherproofing (see section 3.16); in lightweight construction this may also contribute to sound transmission. However this should not be necessary given the ease with which single ply membranes can be detailed around vibration-absorbent mountings.

Advice with regards individual constructions is available from SPRA insulation manufacturer members.

3.8. RESISTANCE TO LOADING

3.8.1. Live loading - Wind

At the earliest possible stage, the wind load acting on the roof should be calculated as recommended in BS EN 1991-1-4 and the UK National Annex. Calculation should be based upon building height, site elevation above sea level, site topography, distance from hills and urban areas, building design life and roof design. Separate calculations for different wind directions may be necessary.

The effect of openings in the building such as warehouse doors must also be considered. Complexities such as canopies, barrel vaults and the effect of shadow zones must also be considered.

The roof and membrane attachment design will respond to this design load with appropriate safety factors.

Once design wind load has been established, the attachment method for each impermeable layer in the roof system must be selected to exceed this load (see 3.15.1).

Manufacturers should be consulted on a job-specific basis to establish the bond strength of adhesives used to secure the insulation and/or single ply membrane. This should make allowance for the fact that a full bond is rarely achieved between a flat deck and a rigid insulation. An even distribution of bond is the critical factor.

In designs with high wind load, supplementary mechanical fasteners may be required. Special consideration of design against wind load should also be applied where a bitumen sheet vapour control layer is bonded to the crowns of a metal deck in a fully adhered design. The minimum contact area recommended on a profiled metal deck for bonding should be >49%.

FM Approved roof assemblies require additional consideration due to property protection considerations. Calculations in accordance with BS EN 1991-1-4 are permitted so long as they are supplemented by certain conditions specified in FM Global Data Sheet 1-28.

3.8.2. Live loading - Access, foot traffic and construction process

SGD 9/11 - Protection of roofs

All materials developed for single ply roofs are capable of withstanding occasional, light, foot traffic for inspection purposes.

Where walkways are to be provided for servicing roof top equipment, the obvious direct route should be protected since this is the route that will be taken. The route should be well clear of areas which might be prone to temporary ponding and be finished with a non-slip surface. A handrail or fall arrest system may be an additional requirement SGD2/04 - Safety - Design considerations for reduced risk. The membrane and insulation manufacturers should be consulted for advice on supplementary load-spreading sheets below the waterproofing where traffic is frequent.

Balconies and podia require special consideration regarding access for the elderly, partially sighted or disabled. For example, level access may be required from external doors, requiring special detailing. Pebble or soft margins at the perimeter of paved areas must be protected from wheeled equipment by a suitable kerb. SGD8a/10 - Falls and Drainage for single ply roofs

During construction considerations include:

- The distribution of roof access points and the effect of repeated loads on the system at the stepping on/off location.
- Load-spreading protection will usually be required. The most effective protection is timber panels such as plywood or oriented strand board with taped or linked joints, laid on a geotextile fleece. Re-usable, rolled reinforced mats are available and are recommended since they reduce waste and cost but their suitability/compatibility should be checked with the membrane manufacturer.
- The location of plant and the provision of heavy-duty walkway sheets to protect the waterproof membrane.

Even on non-access roofs, the construction process itself places demands upon the resistance of the system to repeated loads; it should be a major consideration in design and product selection.

3.8.3. Dead loading - Plant and equipment

The design objective should be the transfer of loads from permanent plant and equipment directly to structure either through a bridging structure taken to elevations or by piers penetrating the roof system (with appropriate measures to avoid cold bridging).

In the latter case, the pier section must facilitate the waterproofing process or be constructed with an integral flashing. It is very difficult and therefore costly to waterproof an I-section effectively, but a circular section is simple. If equipment dead load is to be applied to the roof system the supports should be demountable and advice of the membrane manufacturer should be sought regarding compression resistance of insulation, and requirements for protection layers.

3.9. FIRE PERFORMANCE

3.9.1. Building Regulations

Single ply membranes produced by SPRA members are generally self extinguishing and, depending on the nature of the roof build up as a whole, can typically achieve an AB or AC national rating when tested to BS 476 – 3 in a warm deck roof system. Ballasted membranes can generally achieve the highest national rating of AA. In all cases, users are advised to request from the manufacturer official test and classification reports from a recognised test and certification laboratory in order to validate performance.

Demonstration of fire performance through European test methods and fire classification systems is allowed by the current AD B (volumes 1 and 2).

There are a number of different fire classification systems described in the various parts of BS EN 13501 *Fire classification of construction products and building elements*. These include:

BS EN 13501-1 *Classification using test data from reaction to fire tests*. This enables classification of each roof component or lining into one of seven Euroclasses (A1, A2, B, C, D, E or F) for Reaction to Fire Performance. Currently BS EN 13956 for single ply covers limits reaction to fire performance to Euroclass E.

BS EN 13501-2 'Classification using data from EN fire resistance tests for systems in the fully developed stages of a fire. For roofs this includes EN 1363, which will eventually replace test method BS 476 Part 22:1987.

BS EN 13501-5 - See section 2.6

Building designers should ensure that the client is aware of interaction with all other relevant legislation. For example, compliance with The Regulatory Reform (Fire Safety) Order 2005 relating to fire safety in non domestic premises. It imposes a general duty to take such fire precautions as may be reasonably required to ensure that premises are safe for the occupants and those in the immediate vicinity.

3.9.2. Insurers requirements

See section 2.6.4.

3.10. ROOFLIGHTS

Consultation on daylight design should be carried out at the earliest stage possible taking into account, building type and use, rooflight type and lighting levels, non fragility, thermal performance, security and aesthetics. Advice should also be sought on the detail and material compatibility for the roof light/roof system interface.

Independent guidance on rooflight design and selection can be obtained through the National Association of Rooflight Manufactures (NARM) www.narm.org.uk

3.11. LIGHTNING PROTECTION

The installation of a well designed lightning protection system on a structure will collect the lightning strike and dissipate it safely to earth. Such design for installations in the United Kingdom should be in accordance with BS EN 62305.

The design process uses a defined formula to establish the need for protection based on the building size, building location, construction materials and the building use. If protection is required, early communication to the lightning protection supplier and/or contractor of the roof system components and proposed method of attachment will avoid sequencing difficulties as the project proceeds.

Care should be taken that:

- The detailing of waterproofing at entry points of the conductor(s) into the roof is weatherproof and durable.
- The conductor is visible for inspection purposes and not hidden by details or plant installations.
- Clips used to secure the conductor tape to the roof should be approved by the membrane manufacturer.

Adoption of BS EN 62305 has lead to increased use of finials with wire connections in place of tape. These are secured by gravity, using concrete weights set in compatible thermoplastic trays. The advice of the membrane manufacturers should be sought if these are used on mechanically fastened membranes as they can affect the behaviour of the membrane during strong winds.

Note: At the time this Guide went to press 'A Guide to BS EN 62305:2006 Protection against lightning' is available free of charge from Furse, Wilford Road, Nottingham NG2 1EB or via www.furse.com

3.12. APPEARANCE

Where the roof is a visible feature, client expectations should be matched to the capabilities of the specification by reference to similar, completed projects and/or sample panels. This is particularly important where the roof surface is subject to a low angle of incidence of sunlight. If special measures such as timber panel overlays to insulation are required, membrane manufacturers' advice should be sought.

3.13. SECURITY

Single ply roof systems can be designed to include special security measures to protect against entry or electromagnetic radiation. For example, earthed steel mesh can be incorporated between layers of insulation in warm roof systems.

3.14. COMPATIBILITY OF COMPONENTS

The selection of components within the roofing system should be discussed in detail with the membrane manufacturers to ensure complete compatibility between components, as the incorrect specification may lead to reduced performance or premature failure of the roofing system. The correct choice of insulation is important when fully adhering the waterproofing, especially when solvent based adhesives are being used. The insulation manufacturer or relevant trade association should always be consulted.

3.15. METHODS OF ATTACHMENT

3.15.1. Introduction

The means of attaching the waterproof membrane and thermal insulation to the substrate must be selected only after calculation of wind uplift forces as recommended in BS EN 1991-1-4 & the UK National Annex. If using this documentation for projects outside the UK, national codes of practice must be taken into consideration.

The three principal options for attachment of single ply membranes are:

- Mechanical fastening.
- Adhesion.
- Ballast.

In warm roofs, the thermal insulation may be attached by the same or by a different method from the waterproof membrane. Insulation for inverted warm roofs is restrained by the ballast overlay. Some typical combinations of attachment are shown in Table 3 (below). Selection is based on project-specific factors, taking membrane manufacturer's advice into account.

	VCL	Insulation	Waterproof membrane
1	Laid loose	Mechanically fixed	Adhered
2	Laid loose	Mechanically fixed	Mechanically fixed
3	Adhered	Adhered	Adhered
4	Laid loose	Laid loose*	Ballasted

** The manufacturer may have specific requirements for attachment if the ballast components are not to be laid immediately.*

Table 3 Options for attachment of roof system components

The selection of the appropriate method should be on the basis of the following criteria:

- Calculated wind loads.
- The suitability of the deck to receive mechanical fasteners.
- The suitability of the deck to receive adhesive.
- The internal relative humidity.
- The extent and complexity of roof detailing.
- Aesthetic considerations.
- Noise transmission during construction
- Roof slope
- (refurbishment only) The condition of the existing system.

Whatever the means of attachment, mechanical restraint of the single ply membrane is always required at the roof perimeter, at changes of slope and around details. This can be achieved by one of the following:

- A continuous bar secured to the deck or upstand and covered with a flashing.
- A row of individual fasteners secured to the deck or upstand and covered with a flashing.
- Welding the field and vertical membrane to a membrane/metal profile secured to the deck.

3.15.2. Mechanical fastening

A system whereby the membrane is fastened to the deck using a variety of methods which incorporate a thermal break (if insulation is present).

The following methods are available, depending upon the manufacturer:

(a) In-seam fastening: fasteners are placed in the overlap between adjacent sheets and protected by the welded seam.

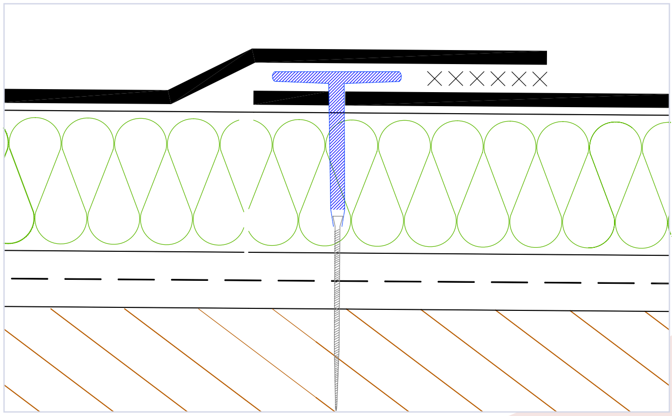

Fig.5 Mechanical fastening – in-seam fastening of membrane

(b) Linear bar fastening: a galvanised steel bar is placed across the width of the sheet and secured with thermal break fasteners before being protected by a cover strip.

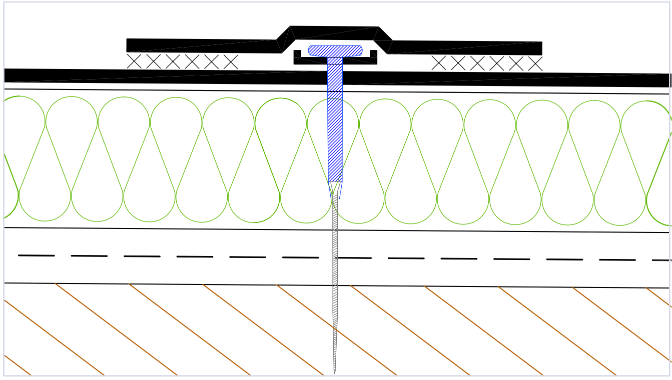

Fig.6 Mechanical fastening – linear bar fastening of membrane

(c) Field fastening: a method of providing supplementary attachment to in-seam or linear bar fastening.

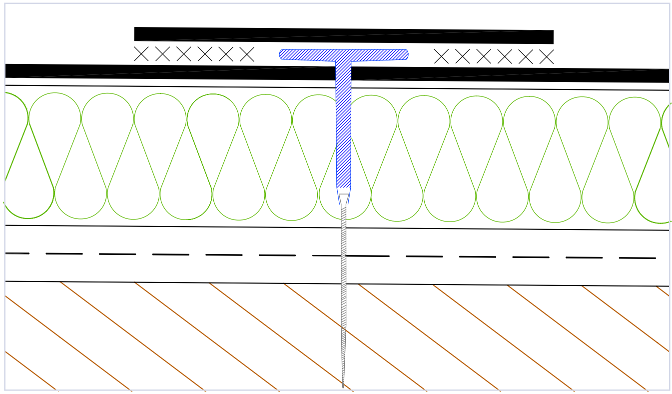

Fig.7 Mechanical fastening – field fastening of membrane

(d) Disc fastening: the field sheet is adhered to a membrane coated steel plate secured to the deck. Equipment is also available for creating this weld by electrical induction.

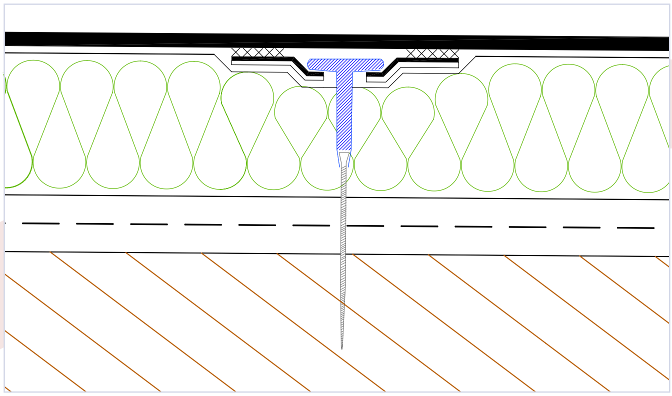

Fig.8 Mechanical fastening – disc fastening of membrane

(e) Secret fix fastening: the field sheet is welded to a narrow strip of membrane secured to the deck.

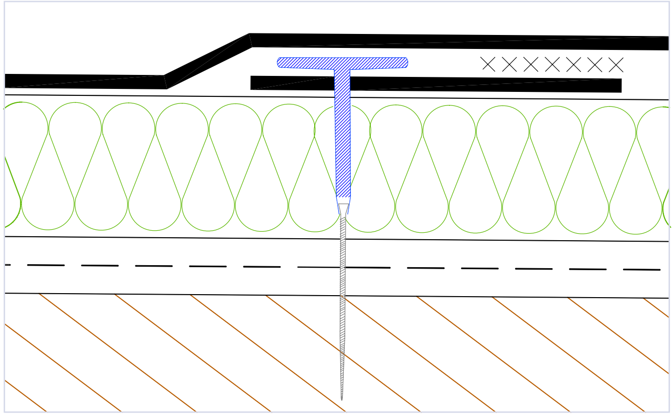

Fig.9 Mechanical fastening: secret fix fastening of membrane

(f) Vacuum vent attachment: vents around the roof perimeter equalise the pressure above and below the membrane, obviating the need for attachment other than at the perimeter.

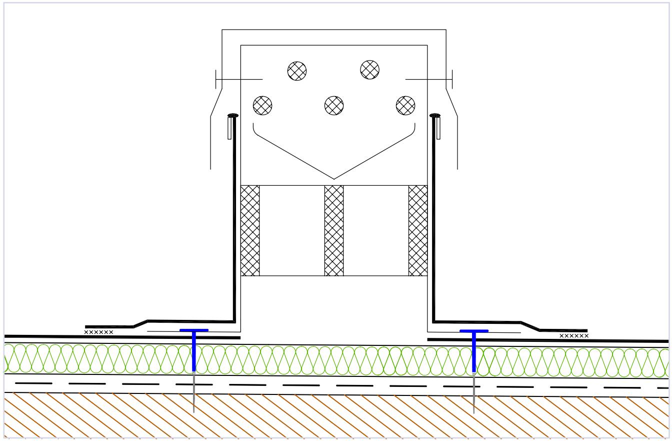

Fig.10 Mechanical fastening – vacuum vent attachment of membrane

Linear bar fastening

Where the specification calls for metal bars to be fastened through the membrane to the deck as the main method of attachment, the manufacturer will normally supply pre-drilled metal bars and will either supply or nominate the fasteners required. These will have been selected for their resistance to pull-out on the deck and their compatibility with the decking material.

The bars and the fastenings should be installed at the specified intervals with additional fixings at perimeters and penetrations and then weathered as recommended by the membrane manufacturer (normally by covering with detailing strips of the main roof membrane). On metal decks, bars should be applied at right angles to the direction of the decking. If situations arise where this requirement cannot be met, it is essential that the approval of the deck and membrane manufacturers is obtained.