Restraint of the membrane at the perimeter

Whatever the means of attachment, mechanical restraint is always required at the roof perimeter, at changes of slope and around details. This ensures that any tension in the membrane in the roof field or upstand is not transferred to the other as a peeling action. Perimeter restraint is achieved by several methods, depending upon the manufacturer:

(g) Individual fasteners, protected by a flashing.

(h) A linear bar, protected by a flashing.

(i) Welding the field sheet to a membrane-coated metal trim secured to the deck (with thermal break fasteners where appropriate).

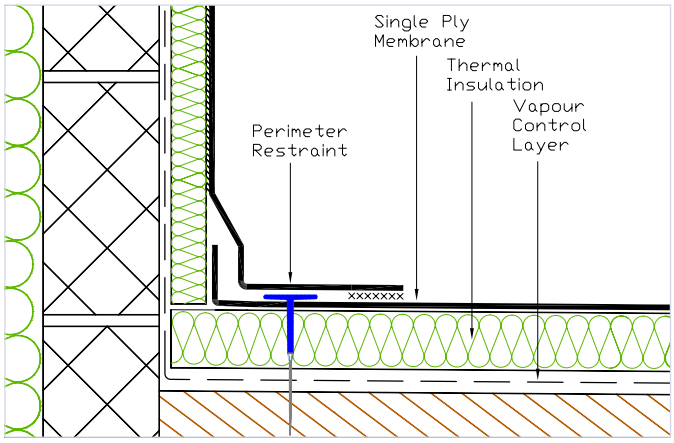


Fig.11 Restraint of membrane by mechanical fastening at perimeter (example)

If the remainder of the roof system is to be bonded it is essential that the design resistance to wind load is also achieved for the attachment of these components.

Irrespective of the wind uplift considerations or distribution requirements for securing the membrane, the fixing of the insulation boards should always be considered separately, unless specifically sanctioned by the membrane manufacturer. Refer to the insulation/membrane manufacturer for advice.

The number and distribution of mechanical fasteners required to fix the insulation boards may vary with the insulation type, geographical location of the building, topographical data and the height of the roof concerned. See Table 4.

Separating layer

On some substrates where no insulation is included in the specification and on inverted roofs, a protection layer (normally polyester or polypropylene fleece) may be required beneath the waterproof membrane.

A separation layer may be required between profiled steel decking and the insulation material. Normally, the vapour control layer will perform this function but if a vapour control layer is not required by calculation or vapour control is achieved by a sealed deck, the insulation manufacturer should be consulted with regard to recommended practice.

Fastening to metal decks

All fixing to profiled metal deck should be to the crown (top) of the deck only and the penetration length should not be greater than the depth of the deck.

Similarly, fasteners through washers will be nominated and the frequency of fixing calculated. Single point fastening to profiled metal decking is usually required to be at right angles to the direction of the deck profile in order that wind load is well distributed. If situations arise where this requirement cannot be met, it is essential that the approval of the deck and membrane manufacturer is obtained.

3.15.3. Adhesion

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

A system whereby the membrane is bonded to the substrate using a proprietary cold adhesive. Systems can be either fully or partially bonded depending on the manufacturer. Allowance should be made for the fact that a full bond is rarely achieved and that an even distribution of bond is the critical factor.

Bonding may be achieved by the use of a proprietary adhesive or (very rarely) hot bonding compound, depending on the specification and compatibility of the membrane. Hot bonding is rare because few single ply membranes are compatible with this method and because of general health and safety concerns.

If the remainder of the roof system is to be bonded, it is essential that the design resistance to wind load is achieved at all interfaces in the system.

Adhered membranes may be laid over insulation boards specifically manufactured for adhesive bonding.

Taping of the board joints may be required whenever solvents or solvent-based adhesives are employed in the roof construction, to stop the solvent eroding the cut edge of the insulation product. The requirements of the SPRA insulation manufacturer must be followed in this respect.

Whatever the means of attachment, mechanical restraint is always required at the roof perimeter, at changes of slope and around details. This ensures that any tension in the membrane in the roof field or upstand is not transferred to the other as a peeling action.

3.15.4. Ballast

This is a system whereby the membrane is loosely laid on the substrate and restrained by weight. The weight is supplied typically either by round washed ballast, paving slabs or soil and planting (green roof systems).

Where loose-laid membranes are secured against wind uplift by ballast, the areas of the membrane beneath the ballast may require different properties from the exposed areas. The covered membrane will need to be resistant to bacterial attack but will not need resistance to ultra violet light, whilst the reverse is true for the exposed membrane. Thus different products may be required. Some manufacturers identify each by different colours. To avoid UV degradation, care must be taken to ensure that the correct membrane is used on exposed areas such as upstands.

Timber promenade decking is a popular finish on residential projects but requires care in design, as follows:

- The decking should not be taken to be ballast for resistance to wind load.
- The waterproof membrane should be adhered or mechanically fixed.
- Decking should be secured against displacement under wind load.
- The attachment of the decking should be removable and the deck sections of manageable size to allow cleaning of debris, leaves etc. from beneath the decking.

A separate sheet overlay to the waterproof membrane may be required to protect it from movement of the decking, spillages and timber treatment fluids. Manufacturers' advice should be sought.

Whatever the means of attachment, mechanical restraint is always required at the roof perimeter, at changes of slope and around details. This ensures that any tension in the membrane in the roof field or upstand is not transferred to the other as a peeling action.

3.16. DETAILING

3.16.1. General principles

At an early stage in the design process an audit of roof geometry should be carried out to establish what types of details will be required and whether they are to be weatherproof (incorporating an upstand/cover flashing arrangement) or waterproof (providing continuous waterproofing across the detail). The following key principles should be followed in design of all details:

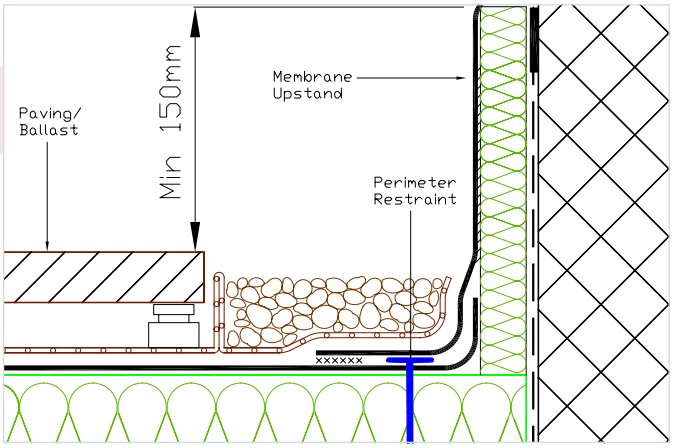
- Upstands to extend 150mm above finished roof level.
- Downstands (of separate metal flashings) should lap the upstand by min. 75mm
- Construction should achieve independence between different elements and trades.
- Thermal* and fire performance should be maintained.
- A continuous barrier to air leakage should be maintained.
- Reliance on sealant as the sole means of protection should be avoided.

** 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.

The total roof zone depth should be assessed at critical points, such as the top of drainage slopes to ensure that there is enough free upstand available to create the minimum required 150mm of waterproofing protection above finished roof level. It is important that this minimum 150mm upstand is maintained at all points around the waterproofed area, including patios, terraces etc. except at continuous water checks and verges. Balconies are a frequent exception due to the need for level or unobstructed access. Designers should carefully consider the risks of any departure from this criterion. Special design features are essential. NHBC and Premier Guarantee publish specific guidance on the design of balconies.

NHBC link Premier link



Detail 1 Upstand – minimum height

Where a surface finish, ballast, paving slabs, or decking is applied to the roof, this minimum height is to be measured from the finished roof surface, not from the waterproof membrane. This applies to both warm and inverted roof construction.

Typical classes of detail are given below together with the design principles to be followed.

Important note: *the illustrations are schematic, to illustrate principles. They are not intended to represent any or all manufacturers' specific requirements.*

3.16.2. Specific types

(a) Upstands - waterproof

Flashings and upstands to perimeters, (and penetrations through the roof), can be formed from the membrane itself or from membrane faced metal–strictly in accordance with each manufacturer's recommendations.

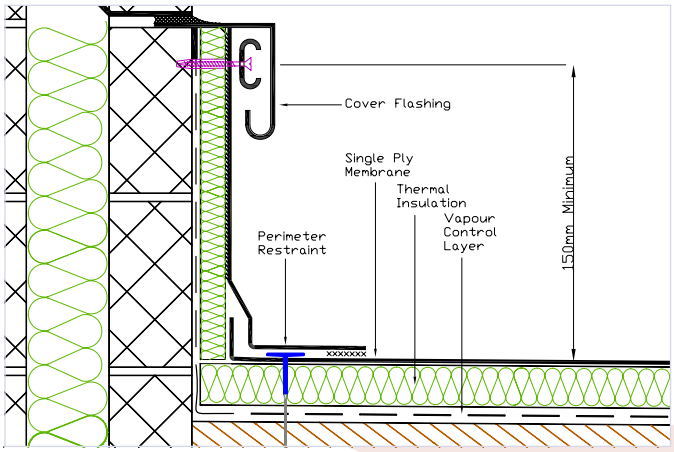
It is recommended that the upper termination be formed by turning the membrane (or membrane-metal profile) into a suitable chase. Only if no alternatives exist (for example, on reinforced concrete panels) should face-fixed termination be considered. In this case, the termination bar should be sufficiently rigid to avoid distortion between fixings and should provide a trough for filling with high durability flexible sealant. See SPRA SGD4/06 - Use of Sealants.

If there is a damp proof course in the abutment construction it must be set to discharge above the upper termination of the waterproofing.

(b) Upstands – weatherproof

Weatherproof upstands have the advantage that the membrane upstand is independent of whatever rigid material is used to form the cover-flashing. Thus repair of either does not involve multiple trades. They are also appropriate where membrane-metal profiles are not available for the membrane product or where differential movement is anticipated. However they may be slower to construct. The effect of the detail on thermal properties and air sealing should always be considered.

If there is a damp proof course in the abutment construction it must be set to discharge above the cover flashing.



Detail 2 Weatherproof upstand - principles

(c) Upstand-Parapet

Parapets are a special form of upstand in which the capping to the elevation forms either:

- *Weatherproof* protection with the roof system (membrane, insulation, VCL-if required) terminated on the upstand and protected by a separate weathered or flat capping or coping.
- *Waterproof* protection with the roof system taken up the upstand, over a supporting deck covering the elevation and terminated at a drip edge on the exterior.

(d) Waterproof eaves and verges

Drip details at eaves and verges are generally formed from a preformed trim of membrane coated metal secured to a hard edge or through the insulation to the deck. This saves time, improves appearance and reduces variability through pre-fabrication. Separate lengths of this trim are required to accommodate thermal movement, the joint being sealed by a membrane 'butt strap'. In addition, where appearance is important, sheet metal plates may be available for fixing under the trim to ensure that adjacent lengths of trim follow a consistent line.

Where membrane coated metal is not available for the membrane product a non-ferrous edge profile may be part-covered by a membrane flashing.

Membrane manufacturers should be consulted regarding the need for face fixing of deep eaves or verge profiles.

(e) Gutter

As stated in section 3.4, internal box gutters should be avoided wherever possible. Where unavoidable, they can be lined using the roofing membrane to achieve a uniform finish. Membrane coated metal is used frequently to form gutters because:

- It provides continuous support to the gutter sides.
- It provides protection at the upper edge of the gutter walls.

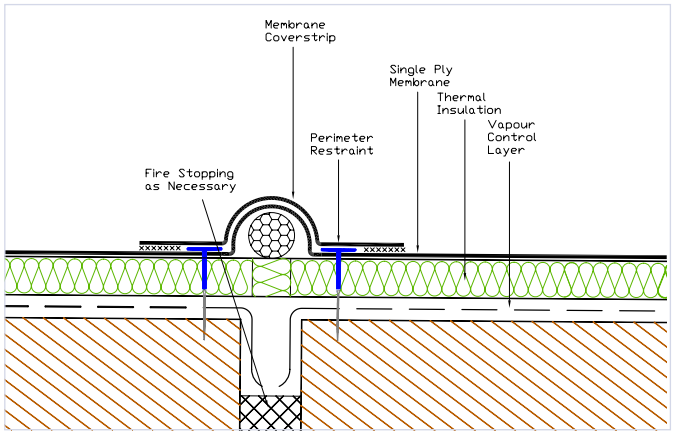
If unavoidable, gutters should be designed in accordance with BS EN 12056: Part 3 and SPRA Component Quality Standard - Membrane-lined gutters.

(f) Rainwater outlet

Rainwater outlets must be situated at low points and their location changed in the event that the drainage layout is changed. The area surrounding the outlet must fall to the outlet without obstruction. In an inverted roof the high water resistance filter layer must fall continuously to the outlet without obstruction. All rainwater outlets should be designed so as to enable simple visual access for checking and clearing as necessary.

(g) Movement joint – waterproof

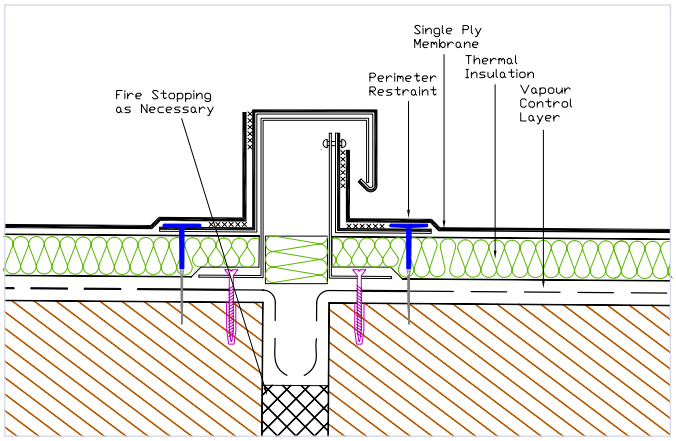
Where a building requires structural expansion joints the membrane may have sufficient elasticity to accommodate minor movement within the plain of the waterproofing.



Detail 3 Movement joint – waterproof - principles

(h) Movement joint – weatherproof

In other situations, where movement may be multi-directional and of large amplitude, a weatherproof detail is required. This detail is inherently reliable because movement is isolated from the waterproofing but it does form an obstruction to drainage if the joint runs across the line of fall and it may be difficult to eliminate cold-bridging.



Detail 4 Movement joint – weatherproof - principles

(i) Abutment to masonry - weatherproof

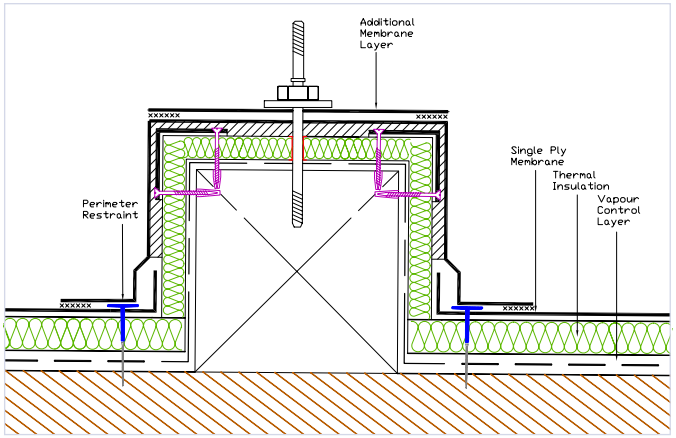
Any abutment to masonry which incorporates a damp proof course (DPC) must be detailed such that the latter discharges above the point of attachment of the upstand flashing to the wall. If not, rain driven into the cavity may pass into the roof system.

(j) Load-bearing plinth for services

In the absence of a load-bearing structure set above the roof field, independent plinths may be required.

The design of the plinth should allow for:

- Equipment to be demounted without affecting the integrity of the waterproofing.
- Protection of exposed edges and corners from accidental damage.
- Sufficient height to allow installation and inspection of the roof membrane adjacent.
- Avoidance of cold bridging into the structure.



Detail 5 Load-bearing plinth for plant - principles

(k) Pipe penetration

The approach to waterproofing of pipe penetrations is heavily dependant upon membrane type.

The design of penetrations should allow for:

- Isolation of the waterproofing from hot flues.
- Differential movement as required between the penetration and roof system.
- Mechanical clamping or apron flashing at the upper termination of the pipe collar.
- Control of air leakage.

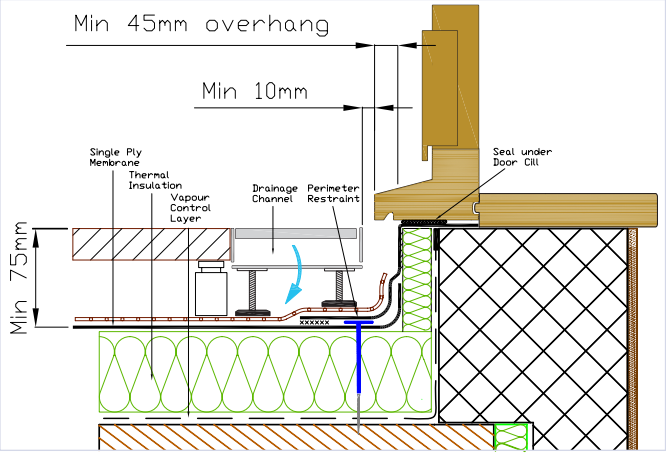
Multiple pipe penetrations should be set in a raised plinth with either a purpose-made cover to fall (preferred) or adequate space between each pipe to enable effective seams to be formed.

(l) Access to balcony or terrace

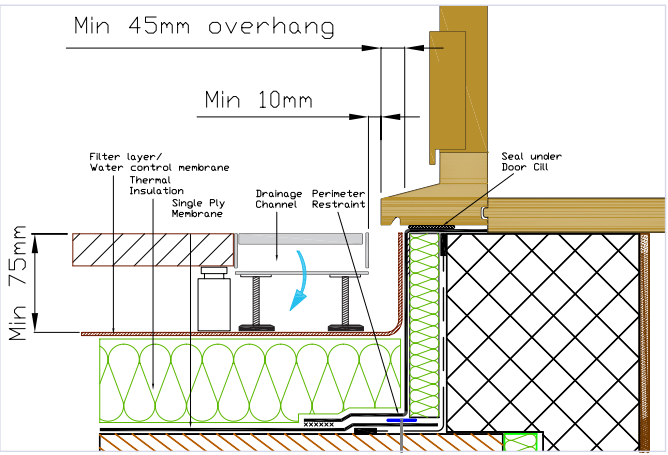
The requirement of a 150mm waterproofing upstand is fundamental to reliable detailing. However, working with building insurers and the residential sector, SPRA is aware of the requirement for unimpeded access to balconies and roof-level terraces in many designs. In this situation only, the requirement has been reduced to 75mm at the opening, provided that the following conditions are met:

- Rapid removal or rainwater across the width of the opening, by including a proprietary drainage channel in front of the threshold.
- The waterproof membrane extends 150mm height in the door reveal and roof/abutment wall adjacent.
- The waterproof membrane flashing extends fully below the door frame bottom rail and is sealed to it.
- A horizontal gap of minimum 10mm between frame front edge and drainage channel.

- A horizontal gap of minimum 10mm between frame front edge and drainage channel.



Detail 6 Level threshold – warm roof – principles



Detail 7 Level threshold – inverted warm roof - principles

3.17. SAFETY DURING CONSTRUCTION AND USE

Safe methods of access and working should be used for the roof installation and ongoing maintenance of the roof and any equipment on it. Prevention of falls is a major consideration and may require the use of edge protection or a safety cable system. If a safety cable restraint or fall arrest system is installed it should have been type tested to BS EN 795 and carry the CE mark. The support posts for the system should be of suitable design to withstand the high potential loads and to allow adequate weathering.

SPRA supports and participates in the Advisory Committee for Roof Safety www.roofworkadvice.info and was a contributor to the 'Magenta Scheme' for safety lines Part 1 Best practice for use of horizontal safety lines in Roofwork and Part 2 (test methods).

4. MATERIALS

4.1. STRUCTURAL DECK

4.1.1. Introduction

Structural decks can be classified as:

- Panel or sheet (pre-formed, supplied and fixed).
- Cast in-situ.
- Existing (refurbishment).

This section defines the types of structural roof deck generally available in the context of new roof construction where the designer or roofing contractor is responsible for selection.

4.1.2. Profiled metal sheet

Profiled metal decking typically consists of galvanised steel, coated steel or aluminium that is profiled to provide the necessary strength to suit the span and load requirements. These materials are generally used for lightweight roof systems where rapid installation is required.

When considering the deck profile and the necessity for side lap stitching and metal deck closures reference should be made to the manufacturers of the deck, insulation and membrane.

To provide a sound base for the insulation and waterproofing system and to avoid reduced drainage performance, the mid-span deflection of the metal deck should not exceed 1/200 of the span under uniformly distributed design loads.

The choice of thickness, profile, acoustic perforation and finish of the decking will be dependent on the required span, roof construction, imposed dead and live loading and any aesthetic consideration such as requiring a decorative exposed underside.

Material specifications in the UK are defined in the following documents;

(a) Galvanised steel

Minimum recommended thickness 0.7mm to BS EN 10346 Fe E280G Z275. Typical gauge range 0.7-1.2mm.

(b) Coated galvanised steel

Minimum recommended thickness 0.7mm to BS EN 10346 Fe E220G Z275. Typical gauge range 0.7-1.2mm.

(c) Plain aluminium

Minimum recommended thickness 0.9mm to BS EN 485-2 AA3004 H34. Reference should also be made to BS EN 1396 as appropriate. For mechanically fastened roof systems peel rivets or expanding fasteners, which provide a positive clamping action, should be used.

(d) Coloured aluminium

Minimum recommended thickness 0.9mm to BS EN 485-2 AA3004 H34 and BS EN 485-2 AA3105 H25. For mechanically fastened roof systems peel rivets or expanding fasteners, which provide a positive clamping action, should be used.

4.1.3. Timber

SPRA recommends that all timber products are responsibly sourced. Timber decking of all types should be specified to suit the load and span capability of the joists and purlins. Timber decking is generally classified into pre-formed sheets and timber boarding. Modern roof construction typically utilises sheets but it is not uncommon in re-roofing situations to identify traditional timber boarding.

(a) Sheet Boarding - orientated strand board (O. S. B.)

A wood panel composed of timber strands orientated in cross directional layers, the choice of thickness is dependant on the span, type of insulation and membrane. For details of design criteria and installation please refer to the panel manufacturer.

Roofing grade OSB should be manufactured to BS EN300 grade OSB/3 and be certificated by the British Board of Agrément or BRE Certification. The minimum recommended thickness is 18mm.

(b) Plywood

Plywood should be minimum 18mm thickness and certificated to conform to BS EN 1995-1-1 Eurocode 5. Design of timber structures and to BS EN 636 Plywood, specifications minimum Service class 2 – 'humid conditions' or where required Service class 3 – 'Exterior conditions'.

(c) Timber boarding

New timber boarding should be a minimum 25mm thick and, ideally, tongued and grooved because this maintains its resistance to deflection after natural shrinkage.

(d) Woodwool cement slab

A rigid timber and cement based medium weight panel, which may be reinforced with steel edge channel for longer spans. Woodwool cement slabs should conform to BS EN 13168.

The minimum required thickness is 50mm. The choice of thickness is dependent on the span, type of insulation and membrane. For details on design criteria and installation please refer to the panel manufacturer.

If the panel is to be designed as a contributor to roof system thermal performance then the effect of any metal channel (edge) support should be considered.

Woodwool is very rarely used in new construction. If encountered during refurbishment, specific advice must be obtained from the membrane manufacturer regarding attachment to resist wind loading.

4.1.4. Concrete

Structural concrete decks can be classified as either reinforced (cast in-situ), precast, pre-stressed or lightweight aerated. Each will have a different effect upon cost, contract period and performance. Since concrete decks are installed by roofing contractors only in specific and very rare instances, their inspection and material specifications are not covered in this guide.

Information on span capability and installation requirements of precast panels can be obtained from manufacturers.

Information on the location of required movement joints should be obtained early in the design process as they have implications for drainage layout and detailing.

Precast panels installed to a fall can provide a simple layout but without cross-falls. In-situ concrete is more difficult to lay to a fall and it is more common to create falls in the insulation (warm roofs only) or by use of an additional screed. Bitumen-bound screeds are not generally suitable for single ply roof systems.

Information on compressive strength, resistance to point load and drying periods of wet screeds can be obtained from suppliers and relevant trade associations.

4.1.5. Composite metal decks

Composite decks comprise a polyisocyanurate (PIR) insulation core factory-adhered onto a suitable profiled steel liner sheet. Panels are generally available with the following top sheet options:

- Insulated panel with a membrane top sheet; waterproof membrane factory-applied.
- Insulated panel supplied with a 50micron foil top sheet; waterproof membrane mechanically fastened on site.
- Insulated panel supplied with a polyester/cellulose mat reinforced with glass fibre; waterproof membrane adhered on site.
- Insulated panel with plain galvanised steel top sheet; waterproof membrane mechanically fastened or adhered on site.
- Insulated panel with plastisol/polyester coated steel top sheet; waterproof membrane mechanically fastened or adhered on site (seek advice from the membrane manufacturer). A separation layer may also be required.

Some composite panels are also available with deep deck profiled liner sheets suitable for larger spans and extensive or intensive green roof solutions.

4.1.6. Structural insulated panel systems

Pre-fabricated structural insulated panels systems (SIPS) generally comprise an insulated core of polyisocyanurate (PIR) or Polystyrene (EPS) sandwiched between two skins of plywood (to BS EN 636 Service Class 2 minimum, higher Service Class plywood may be required,

depending on climatic conditions, and should be defined by the specifier) or Orientated Strand Board (to BS EN 300 OSB3).

Membrane can be adhered on site or may be mechanically fastened to the panel. Suitability for mechanical fixing depends on deck thickness and quality and is subject to confirmation of the suitability of attachment by both the panel and membrane manufacturers.

As it is likely to be impractical to install a vapour control layer on the warm side of the insulated panel, the designer should seek the manufacturer's advice on how to prevent vapour transmission. Special attention should be given to the long term sealing of all the panel joints, abutments and penetrations. Reliance on site-applied foams is not recommended.

4.2. VAPOUR CONTROL LAYER (VCL)

Where a vapour control layer (VCL) has been shown by calculation to be necessary then this could consist of a polyethylene membrane, reinforced bitumen sheet or polymeric/foil self-adhesive sheet. In either case, the inclusion of metal foil laminate greatly increases the water vapour resistance of the product and may be required for high humidity applications.

Independently certified test data for the product should verify that is has adequate performance against the following criteria:

- Resistance to heat ageing.
- Resistance to UV (during construction and storage).
- Tear resistance.
- Consistent vapour resistance.
- Tensile strength.

Polymeric vapour control layers such as polyethylene are generally laid loose and restrained by the mechanical fasteners for the insulation or by the ballast on the system as a whole. Side and head laps are sealed with a non-setting adhesive once the sheets have been set out.

Bituminous vapour control layers are bonded in hot bitumen and may be fully or partially bonded. Side and head laps are sealed with hot bitumen during the laying process. There are also bitumen sheet products available for application by proprietary adhesive, gas torch or by self-adhesion. Both require skill and appropriate site cleanliness and safety conditions. Manufacturers' advice should be sought.

When using torch-on bitumen products consult guidance published by the National Federation of roofing Contractors.

4.3. THERMAL INSULATION

4.3.1. Classification

Thermal insulation products for single ply roofing are classified generically in terms of their behaviour as follows:

- Cellular materials which derive their performance from the thermal resistance of gas(es) trapped in the cell structure and from the thermal resistance of the cell walls.
- Fibrous materials which derive their performance from air trapped between fibres laid perpendicular to the direction of heat flow.

For application in warm roof and inverted warm roof systems, thermal insulation is manufactured and supplied as a rigid board because it must be capable of withstanding loads during construction and service. Boards range in size from 600 x1200mm to 1200 x 2400mm for flat boards or 1200 x 1200mm for tapered products.

Insulating screeds on concrete decks can also contribute to overall thermal resistance. However, their contribution is limited unless an impractical thickness of screed is proposed. In addition, the effect of a further wet process on construction time has reduced its popularity.

4.3.2. Cellular materials

Cellular thermal insulation materials are composed of materials of polymeric and mineral origin.

Polymeric materials

- Polyurethane PUR
- Polyisocyanurate PIR
- Polystyrene - expanded EPS
- Polystyrene - extruded XPS

Mineral materials

- Cellular glass CG

(a) Polyisocyanurate foam (PUR/PIR)

SPRA Component Quality Standard – Rigid Urethane Foam

Rigid urethane foam comprises a combination of polyurethane (PUR) and polyisocyanurate (PIR) thermoset foams with closed cell structures, produced by a chemical reaction during which a blowing agent is added.

Rigid urethane foam roofboard should comply with BS 4841: Part 4. Part of this Standard is replaced by EN 13165 Thermal insulation products for buildings - factory made rigid polyurethane products.

(b) Polystyrene – Expanded

SPRA Component Quality Standard – Expanded Polystyrene – Warm deck roofs

SPRA Component Quality Standard – Expanded Polystyrene – Inverted warm deck roofs

Expanded polystyrene is produced by fusing together expanded beads of polystyrene in a high pressure steam environment.

Boards should comply with BS EN 13163 Thermal insulation products for buildings - factory made expanded polystyrene products. Expanded polystyrene is not compatible with PVC membranes. Either a fleece-backed membrane or a separation layer will be required in warm roofs. Special products are available for use in inverted roof applications, subject to appropriate certification.

(c) Polystyrene – Extruded

SPRA Component Quality Standard – Extruded Polystyrene

Extruded polystyrene is produced by an extrusion process to create a closed cell structure, which offers a wide range of compressive strengths. Boards should comply with BS EN 13164 Thermal insulation products for buildings - factory made extruded polystyrene products. Extruded polystyrene is not compatible with PVC membranes. For warm roofs, either a fleece-backed membrane or a separation layer will be required. For inverted roofs a separation layer may be required.

(d) Cellular glass

Cellular glass is manufactured from glass which is crushed to a powder, mixed with carbon and melted at very high temperature to convert the carbon to carbon dioxide which is trapped in the cell structure.

Cellular glass should comply with BS EN 13167 Thermal insulation products for buildings - factory made cellular glass products. The membrane manufacturer should be consulted to ensure that the insulation product is compatible with the other components in the specification.

Insulation type	Minimum size of fastener stress plate	Minimum no. of fasteners per board	Position of fasteners
PIR (see note 1)	Mechanically fastened waterproof membrane: Minimum 50 x 50mm or 50mm dia. (based on minimum surface area of 1963mm^2) Adhered waterproof membrane: Minimum 70 x 70mm or 75mm dia. (based on minimum surface area of 4400mm^2)	4 per 0.6 x 1.2m board (5.55 fixings/m^2) (see note 1) 4 per 1.2 x 1.2m board (2.77 fixings/m^2) (see note 1) 6 per 2.4 x 1.2m board (2.08 fixings/m^2) (see note 1) 8 per 3.0 x 1.2m board (2.22 fixings/m^2) (see note 1)	Pattern to be as per BRUFMA Guidance (see references Section 8.4)
EPS (see note 1)	Minimum 70 x 70mm or 75mm dia. (based on minimum surface area of 4400mm^2)	4 or 5 per board for most board sizes - consult manufacturer 1.2 x 2.4m require min 6 per board or above - consult manufacturer (see note 1)	One per corner (fifth in centre, if required)
XPS (see notes 1)	Minimum 70 x 70mm or 75mm dia. (based on minimum surface area of 4400mm^2)	4 per 0.6 x 1.25m board (see note 1)	One per corner
MW (see note 2)	Minimum 70 x 70mm or 75mm dia. (based on minimum surface area of 4400mm^2)	1 per 1.2 x 1.0m board 1 per 1.8 x 0.6m board (see note 2)	Centre of board

Notes

1. *The required number of fasteners shown is the minimum only. Regardless of the membrane attachment method, wind load calculations should be undertaken in order to determine actual fastener requirements in corner, perimeter and field roof areas. These areas should be clearly defined, especially where different numbers of fasteners are required for each zone.*
2. *The number of fasteners required for mineral wool products is subject to individual membrane manufacturer approval, which should be based on wind uplift testing undertaken by the same. The required number of fasteners may increase for membrane systems bonded to the insulation with adhesive because wind loading acting on the membrane is transferred to the insulation fasteners.*

Table 4 Insulation fasteners - minimum area of stress plate, number of fixings and layout.

4.3.3. Fibrous materials

Fibrous materials are composed of materials of mineral or organic origin.

- Mineral Wool MW.
- Mineral Wool (low density quilt) cold roofs only.

(a) Mineral wool

SPRA Component Quality Standard – Mineral Wool

Mineral wool manufacturing processes involve the fusion of the constituent minerals at high temperatures (1,100-1,500°C). The result is a vitreous melt, which is spun or pulled into fibres. Immediately following their formation the fibres are compressed to a predetermined density, bonded together with binding agent and cured to form rigid boards, slabs or roll products non combustible according to EN 13501 Part 1 & BS EN ISO 1182.

Roofing boards are available as either mono-density or dual density products, the latter with increased compression resistance.

Boards should comply with BS EN 13162 Thermal insulation products for buildings - factory made mineral wool (MW) products.

4.3.4. Composite Insulation

One insulation material may be combined with another or with another component in order to achieve an optimum performance in a single product. Examples include:

- Polyisocyanurate insulation with an upper surface of plywood: for use where a very smooth finish is required for enhanced appearance or for improved resistance to point loads.
- Polyisocyanurate insulation with an upper surface of plywood and lower surface of metal foil: a single product providing deck, insulation and vapour control. Special measures are required to achieve continuous vapour control between boards.
- Mineral wool on expanded polystyrene: to achieve thermal resistance at low cost but with improved acoustic or fire resistance.

4.3.5. Other insulation types

The following types of insulation are not currently in use alone with single ply membrane systems, either because they lack the necessary compressive strength or because their thermal performance is insufficient for modern applications:

- Granulated cork.
- Phenolic foam (PF).
- Expanded Perlite (EP).

4.4. WATERPROOF MEMBRANES

4.4.1. Introduction

Several generic classes of polymeric materials have emerged, all of which are suited to the exposure conditions for roofing. However, because of the nature of the material, each has a different spectrum of properties that the manufacturer can modify by changing the formulation, reinforcement/carrier (if any) and production process.

Even within the same class of materials, manufacturers will adopt different approaches to exploit whichever balance of properties meets general requirements or specific market conditions. In these latter cases, a particular material can, for example, be complimentary to the type of roof construction, the attachment method or the required performance.

The nature of single ply material ensures satisfactory physical properties over a working temperature range of below -30°C to above 80°C, which exceeds all UK environmental conditions including allowance for solar radiation and cooling. Single ply membranes can be jointed by hot air, solvent welding, or adhesive tapes depending upon material type and manufacturers' preferences.

4.4.2. Product certification

The British Board of Agrément certificate single ply material and systems, based upon test methods that have a commonality throughout the EEC. Their investigations focus on the confirmation of a manufacturer's own test data, with limited testing conducted independently. On the basis of this and independent test data and the as-built history of the product, certification bodies will provide a statement of the anticipated durability of the product provided it is installed in accordance with the manufacturer's instructions.

4.4.3. Product standards

The harmonised European Standard BS EN 13956 describes the protocol for declaration of product characteristics when tested to a wide range of European Standard test methods. In recognition of the wide range of potential applications of these products, BS EN 13956 sets few requirements as such (other than for fire performance - a roof system test - and watertightness, the latter of which is a pass/fail test). Thus whilst the Standard can be used to compare the characteristics of products, the designer must set their own requirements as relevant to the particular project conditions (see 4.4.5).

4.4.4. Generic types of membrane

Polymers suitable for roofing applications are usefully classified according to the extent of cross-linking between the polymer chains because this determines many of their characteristics and the method of forming seams.

These range from thermoplastics to elastomers, with some materials displaying features of both:

Thermoplastic

a. Polyvinylchloride PVC-p

b. Flexible Polyolefin FPO

c. Chlorinated Polyethylene CPE

d. Vinyl Ethylene Terpolymer VET

e. Thermoplastic Polyolefin Elastomer TPE

Elastomeric

f. Polyisobutylene PIB

g. Ethylene Propylene Diene Monomer EPDM

A general guide to the generic material types supplied by SPRA members is as follows;

(a) Polyvinylchloride

PVC-p is a flexible form of PVC due to the addition of high molecular weight plasticizers, which can be heat or solvent welded (depending upon the product). PVC-p-based membranes are generally not suitable for direct contact with bitumen unless a suitable weight of fleece backing is incorporated to separate the two. Generally, such membranes can be recycled back into new roofing product or for re-use in a range of other applications.

(b) Flexible polyolefin

FPO is a large family of heat-weldable polyolefin based upon polyethylene or polypropylene. Preparation of the lap prior to welding may be required. FPO-based membranes are generally suitable for direct contact with aged bitumen. Generally FPO based membranes can be recycled back into themselves or another product.

(d) Chlorinated polyethylene

Polyethylene is made flexible by chlorination and can be heat or solvent welded. Generally, CPE is compatible with bitumen.

(e) Vinyl ethylene terpolymer

VET consists of PVC made flexible by blending with Ethylene Vinyl Acetate (EVA). VET can be heat or solvent welded and is compatible with bitumen.

(f) Thermoplastic Polyolefin Elastomer

A particular group of polyolefins with the basic properties of elastomers but which can be processed as thermoplastics. They exhibit a high resistance to UV/Ozone exposure and do not absorb moisture. Laps are heat welded.

(g) Polyisobutylene

PIB incorporates carbon black to provide good physical properties. PIB products available on the UK market are generally solvent welded using tape systems. PIB is compatible with bitumen.

(h) Ethylene propylene diene monomer

EPDM is a naturally flexible material to which carbon black is added for stability. Jointing is normally carried out with tape bonding using a special primer but adhesives can also be used. EPDM is compatible with bitumen.

4.4.5. Selection criteria for single ply membrane

Technical criteria for the selection of a single ply membrane product must be related to the performance objectives, which will in turn reflect the client brief established in Section 2. These will include:

- Colour and reflectivity.
- Appearance as-built.
- Durability.
- Suitability for method of attachment.
- Suitability of accessories for termination and other details.
- Chemical compatibility.

SPRA publishes two guides:

- S3/09 SPRA Membrane product evaluation checklist is an aid to the comparison of different products against criteria of technical performance and certification criteria, product support, training and quality control.
- SGD11/11 Single ply membranes - a guide to specification using BSEN 13956 takes the test methods specified in the harmonised European product standard, explains each, its relevance to system types and provides a table of recommended maximum and minimum values.

4.5. ANCILLARY COMPONENTS

4.5.1. Introduction

The design selection process should include due consideration of requirements for the following:

- Mechanical fasteners
- Lightning conductor pads
- Adhesives
- Fall-arrest anchorages
- Pre-formed details
- Rainwater outlets

4.5.2. Mechanical fasteners

SPRA Component Quality Standard - Mechanical fasteners

The correct fastener for the particular substrate will be recommended by the insulation/membrane manufacturer and/or fastener supplier. SPRA requires a minimum resistance to corrosion defined by Clause 2, UEAtc directive; “Supplementary Guide for the Assessment of

Mechanically Fastened Waterproofing" (less than 15% corrosion after 15 cycles in a Kesternich cabinet). When using dissimilar metals the risk of galvanic corrosion must also be assessed.

Table 4 below shows the minimum standards for thermal insulation pressure plates have been agreed by SPRA.

4.5.3. Adhesives

The range of adhesives for single ply membranes continues to increase. The generic types are:

- Water-based: compatible with a wide range of insulation materials including polystyrene. May be slower to use at low temperature and may take longer to achieve their design bond strength than solvent-based products.
- Solvent based: suitable tackiness achieved rapidly in normal working conditions. Where not compatible with certain cellular plastic insulation materials, taping of joints is required. These products are likely to have a high volatile organic compound (VOC) content.
- Polyurethanes: products available for securing insulation and membranes. Some are effective in damp (NOT wet) conditions. In recent years, polyurethane moisture curing adhesives have become very popular for bonding insulation boards, in preference to hot bitumen. Experience in the use of these newer adhesives is not as extensive; for its correct use and to achieve design resistance to wind load it is essential that the correct coverage rate is maintained, to a pattern or application method recommended by the insulation and/or membrane manufacturer (as appropriate).
- Hot bitumen: this should be prepared and applied in accordance with BS 8217 and the instructions of the membrane manufacturer.

The type of substrate, roof access and ambient temperature during application are crucial for the adhesive selection process.

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

4.5.4. Pre-formed details

Many membranes are available with compatible factory-made three-dimensional mouldings, which may increase productivity and/or improve the protection afforded to the detail. They include internal and external corners and nosings. It is usual practice to partially or fully form the detail in the sheet membrane and then heat or solvent weld the moulding to provide added protection. Corners can also be made up on site from sheet material.

4.5.5. Membrane-lined gutters

SPRA Component Quality Standard - Membrane-lined gutters

Industrial roofing applications call for the use of prefabricated gutters linking large pitched roofs areas with coverings steel or single ply composite panels (see 4.1.5 and 4.1.6). Galvanised steel sheet with a factory-applied covering of thermoplastic single ply membrane can be sealed effectively at joints by a membrane strap and welded to rainwater outlets.

4.5.6. Rainwater outlets

Rainwater outlets suitable for single ply roofing are of three generic types:

- **Gravity - lightweight:** SPRA membrane manufacturers can supply compatible polymeric outlets designed for direct heat or solvent welding of the field membrane to the outlet flange. These are placed at membrane level, thereby speeding up installation and avoiding creation of a cold bridge. They are generally not suitable for inverted roofs and are available plain or tapered (the latter being more efficient).
- **Gravity - heavyweight:** alloy rainwater outlets are generally of tapered design. The membrane is dressed onto the tapered section, sealed, and restrained by a clamp ring secured by screws or bolts, then sealed to the outlet body with an appropriate mastic sealant. The mastic seal is generally a maintenance item which may need repair or replacement as the joints fatigue or weather.

  High-efficiency refurbishment products are available which can be sealed into the bore of an existing downpipe whilst still improving upon the performance of an original plain outlet. Heavyweight, two-level outlets are suitable for public access areas, ballast and garden roofs.
- **Siphonic** - siphonic drainage uses the weight of water in the downpipe system to pull water from the roof thereby achieving very high capacity. Unless the head of water at the outlet is sufficient, the outlet will perform as a gravity outlet so it is important to design a drainage layout, which creates the necessary head of water. SPRA is working with the Siphonic Roof Drainage Association to develop specific guidance and performance standards for these products.

4.5.7. Fall-arrest anchorages

Due to the high loads exerted during a fall, traditional 'through the roof' anchorages for fall-arrest lines require to be tied directly back to the structure of the building. However, over the last decade, 'top fixed' energy absorbing anchorages have been developed that are able to dissipate such loads and, consequently, are installed directly onto the single ply membrane (warm roof) systems. Where such 'top fixed' anchorages are

intended for use it is imperative to obtain full test data in accordance with the recommendations of ACR [M] 002:2009 Testing of roof anchors on roof systems.

4.5.8. Lightning conductor pads

The practice of securing lightning conductor tape with membrane flaps is no longer necessary or desirable. Compatible polymeric mouldings are available and approved for use with a wide range of membrane products. These products are attached to the membrane surfaces by solvent welding or heat welding and the conductor is secured by a clip such that the conductor is held clear of the roof surface. Attachment by self-adhesive pads has been found to be unreliable and is not recommended. 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, thereby avoiding the need for welding.

4.5.9. Rooflights

There are numerous glazing materials used in rooflights, however care should be taken to ensure correct specification, particularly in relation to non fragility and fire performance; polycarbonate, GRP or glass are the options acceptable in the UK.

Kerb materials should be sufficiently mechanically and thermally robust so as to not to detract from the overall performance of the building envelope.

Cellular PVC kerbs or similar low conductivity in situ details are available as alternatives to the traditional insulated metal upstands.

4.5.10. Decorative profiles

A wide range of profiles is available to replicate the appearance of metal standing seam coverings. It is also possible to use a timber batten roll and single ply membrane cover strip - or a large pre-formed profile - to replicate lead roll details. Designers are recommended to set out profiles to the same dimensional disciplines as the materials they replicate and to ensure that their effect upon drainage is checked.

4.5.11. Paving support pads

A wide variety of paving support products is available to facilitate levelling up a pedestrian surface. All such products include vertical nibs which set a consistent gap between the slabs and all products provide for vertical adjustment. Some products reduce installation time by allowing such adjustment after the slabs are laid. Since the available height and vertical adjustment limit varies with product, the design should take account of the maximum change in roof level and the tolerance in the paving thickness that must be accommodated.

4.5.12. Ballast

Many types and grades of stone are unsuitable for single ply roofing because they contain fines or sharp edges. Washed, rounded 20-40mm stone is required.

5. WORKMANSHIP

5.1. CERTIFICATION OF TRAINING

The material differences of the various single ply membranes with respect to fixing and jointing demand that the contractor is fully experienced and conversant in the handling and installation of the various products.

SPRA manufacturer members ensure that the contractors to whom they supply membrane have this relevant experience through extensive in-house training backed up by monitored post-training sitework and these processes are audited independently. Whilst some trained contractors can consequently handle several of the range of single ply materials available, the majority of general roofing contractors will have had no such experience and should not therefore handle single ply materials.

A Vocational Qualification (NVQ - England, Wales and Northern Ireland, SVQ - Scotland) is also available at level 2 ('Applied Waterproof Membranes - Single Ply Roofing'). SPRA encourages its membrane manufacturers to ensure filed inspection and training staff are qualified NVQ/SVQ assessors.

SPRA recognises this qualification as evidence of specific skills in installation of single ply systems. However, it must be complemented by manufacturer training in the particular product being laid.

A two-year Specialist Apprenticeship Programme for single ply roofing.

SPRA fully supports the Construction Skills Certification Scheme (CSCS) and expects the site staff of its member companies to hold a current, appropriate card.

5.2. PROGRAMME, SEQUENCING AND INTERRUPTIONS

SGD2/04 Safety – design considerations for reduced risk

Rapid construction necessitates the sequencing of many diverse trades on the building envelope. To speed up internal fit-out, the roof is frequently completed before many potentially disruptive wet and mechanical trades have been completed. Other examples include rendering of elevations above roof level, scabbling of concrete surfaces adjacent or over the roof and installation of atria and air conditioning systems. Early consultation between the designer, membrane manufacturer and roofing contractor will assist the selection of an appropriate specification and details to avoid difficulties. For example, it may be possible to install single ply flashings before other trades commence and later to install the field membrane and weld it to the flashings. If work on a finished roof cannot be avoided, it is essential to protect the roof against loading, impact, abrasion, heat and other damage during the work.

On completion of each day's work, or whenever work is interrupted, the roof must be made secure and a 'day' joint made in order to prevent water penetration of the roof construction and/or wind damage. This procedure is facilitated if work proceeds along as narrow a working front as possible, from roof high-points and towards low-points.

5.3. STORAGE AND HANDLING OF MATERIALS

All rolls of single ply membrane and components must be placed carefully and stored horizontally on a clean, dry and flat surface above ground level. The rolls are usually wrapped individually with protective film and may be stacked on pallets 3-4 rolls high but this wrapping is only for protection in transit and handling of individual rolls. If internal storage is not possible, rolls must be protected by waterproof sheeting secured against wind load and fitted such that some air movement below is possible to avoid accumulation of condensate.

Insulation boards must be protected from weather whilst stored and during installation. The wrapping on boards as delivered is not a suitable weather protection. If internal storage is not possible, boards must be protected by waterproof sheeting secured against wind load and fitted such that some air movement below is possible to avoid accumulation of condensate.

Single ply membranes are tough and resistant to damage but delay and expense can be avoided by clear contractual terms, appropriate methods and careful planning of protection throughout the period when uncontrolled access is available to the roof. Routine good site practices should be observed at all times including care in the handling of scaffolding and other builders' plant, by avoiding the mixing of cement or mortar on the roof surface and by avoiding storing material of any kind directly on the surface.

5.4. HEALTH AND SAFETY REGULATIONS

No special scaffolding is required for single ply roofing other than that which permits ready access and complies with current safety regulations.

Facilities for hoisting should be provided and space arranged for the positioning of material on a clean, dry and level surface.

All SPRA members publish material safety data sheets giving full details of the safe use of their products and on any precautions that are necessary in accordance with the Control of Substances Hazardous to Health Regulations (COSHH).

5.5. EXISTING SUBSTRATE *(REFURBISHMENT ONLY)*

Before laying single ply membrane, ensure that the condition of the existing roof is suitable to receive the proposed roofing system. The moisture content and stability of existing materials should be checked prior to installation as it may impair the integrity of the roof. Overlays to wet roofs should be avoided.

5.6. DECK

Steel

Profiled metal decking will generally be installed by the single ply roofing contractor and should be secured against wind uplift in accordance with the deck manufacturer's requirements.

Most other forms of decking, such as concrete, timber and wood wool are typically installed by the general contractor.

Concrete

Concrete deck should be finished with a smooth, nib-free float finish. Permanent formwork is used frequently in rapid construction. If such an in-situ concrete deck is then overlaid with a waterproof membrane or vapour control layer, any excess construction water will effectively be trapped in the deck. Provided the concrete is gauged and poured correctly, this does not have significance for the strength of the concrete, nor for the single ply roof system laid over it.

However it is significant in the following situations:

- Where a bitumen sheet vapour control layer is to be applied by conventional hot pour or torch methods. In these situations, adhesion will not be achieved unless the deck is properly dry.
- Where mechanical fasteners are to be used. The advice of the membrane and/or fastener manufacturer should be sought.
- It may result in slow seepage of construction water through day joints or discontinuities in the formwork.

Drying process

An indication of how slow the drying out process is can be gained from BS 8203, which uses the rule of thumb that a screed will dry at approximately 1mm per day (from one face) in well ventilated conditions with reduced drying rates as the process continues, such that a 50mm screed will take some two months. The equivalent times for structural slabs is expected to be much slower and may be nearer one year for a 150mm slab to dry.

Therefore, rapid construction with in-situ concrete on permanent formwork should be avoided, the preferred options being use of perforated formwork or (as recommended in BS 6229) by temporary facilities above the roof to enable full drying out of the deck.

Timber

Timber decking should be installed with no gaps at butt joints and securely fastened to joists with ring shank nails or screws.

Plywood

Plywood decking should be installed at a moisture content of 14 -18% and laid with a gap between boards of 1mm per metre of panel size. Boards should not be laid at a moisture content in excess of 18%. Panels should be fastened securely to joists with ring shank nails or screws at 300mm centres.

Wood Wool

Wood wool slabs should be installed in accordance with the manufacturer's requirement.

5.7. VAPOUR CONTROL LAYER *(warm roofs only)*

The specified vapour control layer (VCL) should be adequately sealed at side and end laps. On metal decks with polyethylene VCL, bitumastic tape should be used and all joints should be supported during the sealing process.

The VCL should be turned up to all vertical surfaces by the thickness of the insulation. Where applicable, sufficient additional material should be retained at the perimeter to enable it to be sealed to a suitable surface of the perimeter to form an air and moisture vapour seal. Where possible, all penetrations of the vapour control layer should be sealed as appropriate to the use of the system.

5.8. THERMAL INSULATION

Before installing thermal insulation, ensure that the surfaces to be covered are firmly fixed, clean, dry, smooth and free from frost, contaminants, voids and protrusions.

All preliminary work including formation of upstands, kerbs box gutters, sumps, grooves, chases, expansion joints, etc. and fixing of battens, fillets, anchoring plugs/strips, etc. is complete and satisfactory.

The supporting deck should be clean, dry, without large projections, steps or gaps and should be graded to provide the correct falls to rainwater outlets.

The roof insulation boards should be laid break-bonded (with the exception of tapered boards) and installed strictly in accordance with the manufacturer's recommendations.

Where appropriate the manufacturer should be consulted regarding the spanning, cantilever capability and installation technique of the insulation board.

Where membranes are to be fully adhered to the face of the insulation board check that:

- The boards are to a level consistent with building and product tolerances. This will improve appearance and reduce voids under the membrane that could reduce resistance to wind load.
- The adhesive and insulation are compatible.
- Board joints have been taped (if necessary).
- Board facings are designed to withstand the design wind load.

5.8.1. Mechanically fastened

SPRA insulation manufacturer members will provide minimum requirements for fastener quantity and layout.

Fasteners used to secure the insulation should be placed within the area of the individual board and not at joints. Fasteners required to meet the design loading conditions should be evenly distributed over the full area of the board in the pattern proscribed by the manufacturer. Each fastener should incorporate a washer, having a minimum surface area as per 4.5.2 Table 4 and be placed so that it is in contact with one board only.

When using mechanically fastened insulation board beneath a fully adhered single ply membrane the insulation must have sufficient fasteners to resist wind uplift. The membrane manufacturer will generally provide this information.

When using mechanically fastened insulation below a mechanically fastened waterproof membrane, the recommendations of the insulation manufacturer should be followed and the insulation fastenings should not generally be considered as contributing to the securing of the waterproofing membrane.

5.8.2. Adhesion

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

Thermal insulation boards should be adhered directly to the substrate/vapour control layer using a synthetic bonding adhesive or bitumen bonding compound. Different products are suited to each insulation and membrane product.

Bonding the larger 1200 x 2400mm boards should be avoided. Always establish the application rate required from the adhesive supplier, including the extra required in roof perimeters. One rate will not suit all roofs because the exposure to wind uplift is unique to each building. Check who is responsible for the job-specific application rate and ensure it is achieved.

On metal decks lay boards with long edges at 90° to the troughs with end joints fully supported on crowns.

Once boards are laid, ensure that they are in good condition, well fitting and with no springing, flexing or rocking.

5.9. WATERPROOF MEMBRANE

The three principal methods for securing the waterproofing layer to the substrate are:

- Mechanical attachment.
- Adhesion.
- Ballast.

The sheets of waterproofing membrane should be rolled out (over the separation layer if applicable) onto the substrate and where required by the manufacturer, allowed to relax.

The sheets should be inspected for defects prior to being correctly aligned (allowing for the correct overlap with adjacent sheets) before attachment to the substrate.

When the waterproof membrane has been installed, it is important to seal the laps as quickly as possible. There are rarely situations where delay is advantageous.

Single ply membranes can be laid with the line of fall or across it; the orientation of seams in relation to the fall is also of no significance for performance. Rather, setting out should be planned taking into consideration the following:

- Point of access.
- Temporary drainage.
- Formation of effective day joints.
- Sequencing of other trades.
- Minimising waste.

Close adherence to the specification is critical, particularly in the case of mechanically/partially attached systems where precise calculations will have been carried out to ensure the system is secured against wind uplift.

5.9.1. Mechanical fastening

There are three commonly employed methods of mechanically fastening single ply membranes: seam/spot fastening, linear bar fastening and disc fastening (see 3.15.2). The membrane manufacturer will advise on the most suitable method for their system or the application.

Screw fasteners should be properly driven home at the appropriate torque. Care must be taken so as not to over tighten screws as this may reduce resistance to pull-out or cause subsequent failure of the fastener. On profiled metal decks, fasteners should be driven into the deck crowns only.

In-seam fastening

The membrane is laid perpendicular to the deck direction (if metal) and then mechanically fastened in the sheet overlap area. The washers/pressure plates should be positioned at the required centres and the fasteners installed through the washers (and insulation where applicable) and secured into the deck. When correctly installed, the washers should be in a line, resist rotation by hand and be set inside the membrane lap rather than overlapping an edge. Weathering is normally achieved by sealing the laps over the top of the fastenings. Fastenings at intermediate locations are weathered in the same manner as linear bar fastenings.

Linear (bar) fastening

The membrane is laid perpendicular to the fixing direction and all joints are welded. The linear bars and fasteners are then installed at the manufacturer's specified intervals with additional fixings at perimeters and penetrations. Bars are generally laid perpendicular to the longitudinal axis of profiled metal decks in order to distribute wind load across the deck crowns. Linear bars are then weathered as recommended by the membrane manufacturer (normally by covering with detailing strips of the main roof membrane).

Disc fastening

Discs are set out at a rate per unit area related to design wind load and the fastener transfers this load to the deck. Thus the number may vary across the roof field. Adhesive is applied to the face of the discs and the field membrane is then rolled out over them. Seams are welded as a separate operation.

Where the insulation is mechanically fastened, the recommendations of the insulation manufacturer should be followed and the insulation fastenings should not generally be considered as contributing to the securing of the waterproofing membrane. Likewise, unless specifically permitted by the membrane manufacturer, membrane fasteners should not be considered as contributing to the attachment of any mechanically-fixed insulation in the roof system.

The installed membrane must be adequately protected against damage during completion of the roofing works and from following trades. Point loading should be avoided.

5.9.2. Adhesion

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

Procedures may vary according to whether the membrane is plain or fleece-backed.

Care should be taken to apply the waterproofing sheet in a manner that minimises voids and wrinkles and ensures that the entire sheet is fully adhered. Puddles or blobs of adhesive should be avoided as these may lead to punctures or poor adhesion, or collapsed insulation. Entrapped air should also be minimised to avoid later punctures. On systems that require the lap to be sealed by an alternative method (e.g. welding or with an alternative adhesive), measures should be taken to avoid spillage of adhesive onto the lap joint area. All membrane perimeters should be mechanically fastened by a method

defined by the membrane manufacturer.

Where a contact adhesive is used, the sheets of membrane should be rolled out and positioned with correct overlaps. Each sheet should be folded back in half and the adhesive should be applied to the substrate and to the back of the membrane in accordance with the manufacturers recommendations, before being allowed to partially dry as required. Drying times will vary, according to the weather conditions. The membrane is then unfolded onto the prepared substrate. This operation should then be repeated on the other half of the sheet, positioning the membrane accurately, as the bond is difficult to break once contact between the two surfaces has been affected. Once the sheet has been installed, a water filled roller (a hand roller for vertical or slopes) should be used to ensure intimate adhesion between the two adhered surfaces.

Full bonding using a proprietary adhesive should be achieved by following the recommendations of the manufacturer (paying close attention to the Health & Safety precautions). Partial bonding, whether by use of strips of adhesive or some other pattern must be strictly in accordance with the membrane manufacturers instructions.

Where the membrane is to be laid into wet adhesive, a coat of adhesive or special primer is applied to the substrate, which is allowed to dry thoroughly. The sheet should be positioned with correct overlaps and rolled back from either end to the centre of the roll. The bonding adhesive is then applied to the substrate with a brush, roller, trowel or spray and the membrane is laid into the wet adhesive. With fleece-backed products, two coats of adhesive may be required by the membrane manufacturer, each applied to the substrate, not the fleece.

The same process should be repeated for the second half of the roll. Pressure should then be applied (with a water filled roller, for example) to ensure maximum contact with the adhesive.

Where the membrane is bonded in an area where there is a change of direction (e.g. where it meets perimeter upstands) ensure that the membrane is mechanically secured to prevent bridging.

Overlaps should be jointed as recommended by the membrane manufacturer.

5.9.3. Ballast

Ballast may be used to restrain the components of both warm roof and inverted roof systems.

Warm roof application

The sequence of installation is as follows:

- Single ply membrane is laid loose over the insulation in accordance with the membrane manufacturer's recommendations.
- A compatible polymeric protection layer is laid loose over the single ply membrane. This layer serves to protect the waterproofing from abrasion.
- Gauge boards should be laid to set a depth for the ballast.
- Ballast is then applied as evenly as possible, to avoid large accumulations of material.
- Ballast is levelled off carefully with a straight edge.

For Polyisocyanurate insulation there is an Information Document ID3/2009 published by the British Rigid Urethane Foam Manufacturers Association.

Inverted warm roof application

The membrane should be applied over any specified protection layer and the laps sealed in the manner specified. Any mechanical or adhesive restraint at perimeters and details should be installed as recommended.

When the membrane manufacturer has supplied two different membranes of different formulation for exposed and covered applications on the same roof area, the specification should be followed carefully, paying special attention to the interface detailing.

A separation layer may be specified over the waterproof membrane. Insulation is then laid loose above the waterproofing membrane/separation layer, ensuring that joints are tight and rebates engaged wherever practical. Care should be taken to ensure that the separation layer is applied in all areas where an interface may occur between the insulation and the waterproofing membrane. This is normally achieved by turning the separation layer up at all perimeter edges of the insulation boards and at all roof penetrations.

A suitable non-woven filtration layer should be laid over the insulation with side and head laps as specified and extended vertically at upstands and details such that ballast is not in direct contact with the waterproof membrane. Where a water control membrane is specified, this must be fully supported, lapped in accordance with manufacturer's instructions and dressed at details so as to ensure maximum movement of water towards the rainwater outlets and not through the insulation.

The roof should always be ballasted, with the specified aggregate or paving. The ballasting should be sufficient to resist wind uplift and flotation and should be applied as soon as practicable to prevent wind damage to the single ply system, but after the checking of all seam joints and/or integrity testing.

Gravel guards should be in place on all roof outlets before stone ballast is laid.

Gauge boards should be placed to match the specified depth and ballast should be spread between them. The correct depth of ballast should be levelled off with a straight edge and the gauge boards moved on. Paving slabs should be set out to minimise cutting.

Slabs should be laid from the roof access point to minimise trafficking on the unprotected membrane. Slabs should be laid on the filter layer (or on any specified additional protection layer). They should not be tightly butted to the upstand because allowance must be made for thermal movement. This can be achieved by either a 150mm margin of washed and rounded stone or by a proprietary compressible margin of bonded granulated rubber. If paving support pads are used, care should be taken to avoid damaging vertical nibs and manufacturers' instructions should be followed in respect of the maximum vertical adjustment or stacking of supports.

Care should be taken not to exceed the limitations on roof loading.

If there is to be any delay in applying the finishing ballast, then a temporary ballast should be applied (e.g. sand or gravel, wrapped in bags, to prevent damage to the system) being strategically placed across the finished roofing. It may also be a requirement to attach the insulation by either bonding or mechanically fixing. Refer to the insulation manufacturer for guidance.

5.10. TEMPORARY PROTECTION OF ROOF SYSTEM

Full temporary protection of the roofing is essential if following trades are to use the finished roof as a working platform or access walkway. The responsibility for ensuring this must be agreed between relevant parties during the course of the building operations.

In general, no building work should be carried out from a completed roof. Paint, cementicious materials, plaster and solvents should not be allowed to come into contact with the completed roof surfacing.

The complete roof should NOT be used as a working platform.

5.11. INSPECTION

During the course of construction, routine interim and final inspections should be carried out in accordance with specific manufacturer's instructions. This is the primary responsibility of the roofing contractor. However, the client and/or main contractor (if any) should be aware that the SPRA Bylaws require that manufacturers also make a recorded inspection before a guarantee is issued and may additionally make interim inspections.

5.12. TESTING FOR INTEGRITY

SGD5/07- Non-destructive testing of single ply membranes

The roofing contractor should carry out mechanical integrity testing of jointed seams on a daily basis using a probe, or where doubt persists, with a random peel test. Additional random mechanical checking of joints will be carried out by the manufacturer during inspections. Prior to hand-over, all seams should be checked visually (and with a probe if recommended by the manufacturer) and made good as necessary.

If following trades are to use the finished roof covering as a working platform or for access, it is recommended that integrity testing be carried out and the results notified to the main contractor (as appropriate) prior to any other trades having access. It may then be necessary to re-test affected areas after the other works are complete.

Appropriate methods of test vary with the roof type and the objective.

Low voltage electrical resistance (pulse) testing is suitable for proving waterproofing integrity or for locating known water ingress. It is not suitable for EPDM and other electrically conductive membranes or for electrically insulating decks and it requires a wet roof surface.

Electrical capacitance testing is suitable for locating areas of water ingress and for assessment of existing roofs for water entrapment. It can be used to give an approximate location of points of ingress but tends not to be as accurate as resistance testing. It is also not suitable for EPDM and other electrically conductive membranes or for electrically insulating decks and it requires a dry roof surface.

Vacuum testing is suitable for testing the integrity of small areas of membrane such as seams. It is slow, cumbersome, and unlikely ever to be economically feasible for the roof field as a whole.

Thermal imaging is most suitable for strategic assessment of existing structures for thermal integrity and moisture ingress into insulation or heavyweight decks. It is not generally suitable for proving the integrity of a waterproof membrane. It is generally necessary to test at night when thermal conditions are stable. A heated building interior may be required to create the necessary temperature difference across the roof cross-section.

Flood testing is not recommended unless the nature of the roof or building function demands this direct method. It should never be chosen unless a thorough assessment of its implications has been made.

- The weight of water stored must not exceed the structural limits of the construction.
- The effect of water ingress and water entrapment within the roof system must be considered.
- Rainwater outlets must not be covered in case rain occurs during testing and weight limits are exceeded. Bunds should be formed around outlets and to define the area of test.

6. MAINTENANCE

Routine maintenance of the membrane is not normally required but regular inspection of the roof should be carried out twice per year preferably in early spring and late autumn. The purpose of this inspection is to:

- Check for damage.
- Ensure rainwater outlets are not obstructed.
- Check that materials from other trades have not been left on roof.
- Check lightning and fall arrest equipment.

If ponding causes accumulation of silt or algae on exposed membranes this can be removed by brushing when wet with a soft bristle brush and removed by water spray. Proprietary fungicides or cleaners are not necessary and may not be compatible with the waterproofing; they should not be used.

It is recommended that a standard format roof plan, marked with coordinates, be used to record the findings of a planned inspection. This will avoid confusion with instructions to contractors and provide an ongoing record of roof performance, which can be compared year-on-year.

Timber roof decking should be set aside to allow removal of debris that could otherwise obstruct drainage. This is particularly important on buildings near trees.

7. ROOF REFURBISHMENT

7.1. INTRODUCTION

Because it is lightweight, easy to detail and available in a range of attachment options, single ply technology is well suited to roof refurbishment. The same evaluation process in respect of performance criteria (Section 2) should be followed as for new construction, but with the constraints imposed by the existing construction fully understood.

If refurbishment is required due to failure of the existing, the cause should be fully investigated. For example, cracking of an old bituminous system due to building movement may necessitate revised detailing.

7.2. REMOVAL OR OVERLAY OF EXISTING SYSTEM

A major decision concerns whether to remove existing components or to overlay them.

Overlay has the following advantages:

- The interior is at minimal risk of water ingress throughout the works.
- Waste removal and disposal cost is minimised.
- Contract period can be minimised.

Overlay also has the following disadvantages:

- Roof loading may exceed the capacity of the structure.
- Any entrapped moisture due to past water ingress must be dissipated effectively.
- Details may be compromised by increased finished roof height.
- Options for improving drainage will be restricted.
- Options for attachment of the new system may be restricted.

Removal of the existing system provides maximum scope for correction of deficiencies in the existing design and for thermal upgrading. It also widens the choice of attachment methods.

7.3. CHANGE OF USE

Refurbishment dictated by change of use will require special consideration of the following:

- Imposed loads may change, due to roof-mounted plant or access arrangements.
- Mandatory resistance to external fire may change.
- Internal relative humidity may change, requiring modified thermal design.
- Aesthetic considerations may restrict choice, for example with rainwater goods.

7.4. EXISTING DECK

A wide range of deck materials may be encountered on existing buildings. In addition to the above, these may include timber boarding, aerated concrete and soft boards.

On no account should strawboard, softboard or chipboard be considered as suitable materials for mechanical attachment. It is likely that their replacement will be required in any case, due to deflection and/or softening.

Due to potential deterioration from moisture, and the difficulties of determining the nature of an existing deck, advice should be sought from membrane and fastener manufacturers.

Where mechanical attachment is proposed, the fastener manufacturer must undertake pullout tests to establish the level and consistency of restraint provided by the existing deck (at the crowns if metal deck).

If the existing drainage layout is poor and ponding widespread, retention of an existing deck will restrict the range of design options; only a warm roof system with tapered insulation will be suitable.

7.5. INSULATION

When upgrading thermal insulation or installing a tapered insulation scheme, consideration should be given to the effect upon finished roof height especially at points furthest from rainwater outlets. It may be necessary to raise upstand heights to achieve a minimum 150mm height above finished waterproofing level.

8. REFERENCES

Note: the following key references appear in the text of the Design Guide. All are subject to change and their accuracy is not guaranteed.

8.1. REGULATIONS

The Building Regulations Approved Documents can be found and downloaded at www.planningportal.gov.uk

The Building Regulations Approved Document B - Fire safety

The Building Regulations Approved Documents F - Ventilation

The Building Regulations Approved Document Part H - Drainage and waste disposal

The Building Regulations Approved Document Part L (L1A, L1B, L2A & L2B) - Conservation of fuel and power in dwellings

The Building Regulations Approved Document Part M - Access to and Use of Buildings

The Scottish Building Standards Agency – Technical Handbooks Section 6 - Energy

The Construction Design and Management Regulations (CDM)

Fire Precautions (Workplace) Regulations

Control of Substances Hazardous to Health Regulations (COSHH)

Work at Height Regulations

8.2. NORMATIVE REFERENCES

BS 476 Part 3 External fire exposure roof test

BS 3837-1: Expanded polystyrene boards. Boards and blocks manufactured from expandable beads. Requirements and test methods

BS 4841-4: Rigid polyurethane (PUR) and polyisocyanurate (PIR) foam for building end-use applications Specification for laminated board (roofboards) with auto-adhesively or separately bonded facings for use as roofboard thermal insulation under non-bituminous single ply membranes

BS EN 1995-1-1:2004+A1: Eurocode 5. Design of timber structures. General. Common rules and rules for buildings.

BS EN 300: Oriented strand boards (OSB). Definitions, classification and specifications

BS EN 485-2: Aluminium and aluminium alloys. Sheet, strip and plate. Mechanical properties

BS EN 636-2: Plywood. Specifications. Requirements for plywood for use in humid conditions.

BS EN 636-3: Plywood. Specifications. Requirements for plywood for use in exterior conditions.

BS EN ISO 6946: Building components and building elements. Thermal resistance and thermal transmittance. Calculation method.

BS EN 795: Protection against falls from a height. Anchor devices. Requirements and testing

BS EN 1396: Aluminium and aluminium alloys. Coil coated sheet and strip for general applications. Specifications

BS EN 10147: Continuously hot-dip zinc coated structural steels strip and sheet. Technical delivery conditions

BS EN 13162: Thermal insulation products for buildings. Factory made mineral wool (MW) products. Specification

BS EN 13163: Thermal insulation products for buildings. Factory made products of expanded polystyrene. Specification

BS EN 13164: Thermal insulation products for buildings. Factory made products of extruded polystyrene foam (XPS). Specification

BS EN 13165: Thermal insulation products for buildings. Factory made rigid polyurethane foam (PUR) products. Specification

BS EN 13166: Thermal insulation products for buildings. Factory made products of phenolic foam (PF). Specification

BS EN 13167: Thermal insulation products for buildings. Factory made cellular glass (CG) products. Specification

BS EN 13168: Thermal insulation products for buildings. Factory made wood wool (WW) products. Specification

BS EN 13169: Thermal insulation products for buildings. Factory made products of expanded perlite (EPB). Specification

BS EN 13501-2: Fire classification of construction products and building elements. Classification using data from fire resistance tests, excluding ventilation services

BS EN 13956: Flexible sheets for waterproofing - Plastic and rubber sheets for roof waterproofing - Definitions and characteristics

8.3. INFORMATIVE REFERENCES

BS 5250: Code of practice for control of condensation in buildings

BS 6229: Code of practice for flat roofs with continuous supported Coverings

BS EN 1991-1-1: Eurocode 1. Actions on structures. General actions. Densities, self-weight, imposed loads for buildings.

BS EN 1991-1-4 + A1. Eurocode 1. Actions on structures. General actions. Wind actions

NA to BS EN 1991-1-4 + A1. UK National Annex to Eurocode 1. Actions on structures. General actions. Wind actions

BS EN 1991-1-7: Eurocode 1. Actions on structures. General actions. Accidental actions.

BS EN 62305: Protection against lightning.

BS 8217: Reinforced bitumen membranes for roofing. Code of practice.

BS EN 12056 - 3: Gravity drainage Systems inside buildings. Roof drainage, layout and calculation.

8.4. OTHER REFERENCES

British Flat Roofing Council (BFRC)/CIRIA 'Flat Roofing - Design and Good Practice' 1993

BFRC & Napier University 'The Assessment of Lifespan Characteristics and As-built Performance of Flat Roofing Systems: A summary and recommendations for construction professionals' 1994

British Urethane Foam Manufacturers Association Information document ID/1/2009, published by BRUFMA tel. 0161 236 7575 www.brufma.co.uk

Building Research Establishment Digest No. 346: 1989 Assessment of Wind Loads

Building Research Establishment BR262 Thermal insulation: avoiding risks 2002 edition

Chartered Institute of Building Services Engineers Guide: Volume A – Design Data

CITB Construction Skills – Training resource pack for single ply roofing.

FM Approvals standard 4470 Approvals standard for Single Ply Roof Assemblies for use in Class 1 or Non Combustible Roof Deck Construction. www.roofnav.com

FM Global Loss Prevention Data Sheets (www.fmglobaldatasheets.com and www.roofnav.com)

Green Roof Organisation (GRO) www.livingroofs.org

- GRO Guidelines 2010
- Green Roof Code of Practice 2011

National Association of Rooflight Manufactures (NARM) www.narm.org.uk

Siphonic Roof Drainage Association www.siphonic-roof-drainage.co.uk

- An introduction to siphonic drainage
- The Siphonic Guide
- Model specification for siphonic drainage

SPRA

Documents available from www.spra.co.uk – 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
- SGD9/11 – Wind load design requirements

Guides and checklists

- S3/05 – SPRA Membrane product evaluation checklist
- S4/08 – Guarantees for materials and workmanship

Component Quality Standards

- Insulation – Expanded polystyrene
- Insulation – Extruded polystyrene
- Insulation – Mineral wool insulation
- Insulation – Rigid urethane insulation
- Insulation – Expanded polystyrene for inverted roofs
- Mechanical fasteners
- Membrane – lined gutters
- Rooflights

UEAtc directive; 'Supplementary Guide for the Assessment of Mechanically Fastened Waterproofing'

SPRA

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