



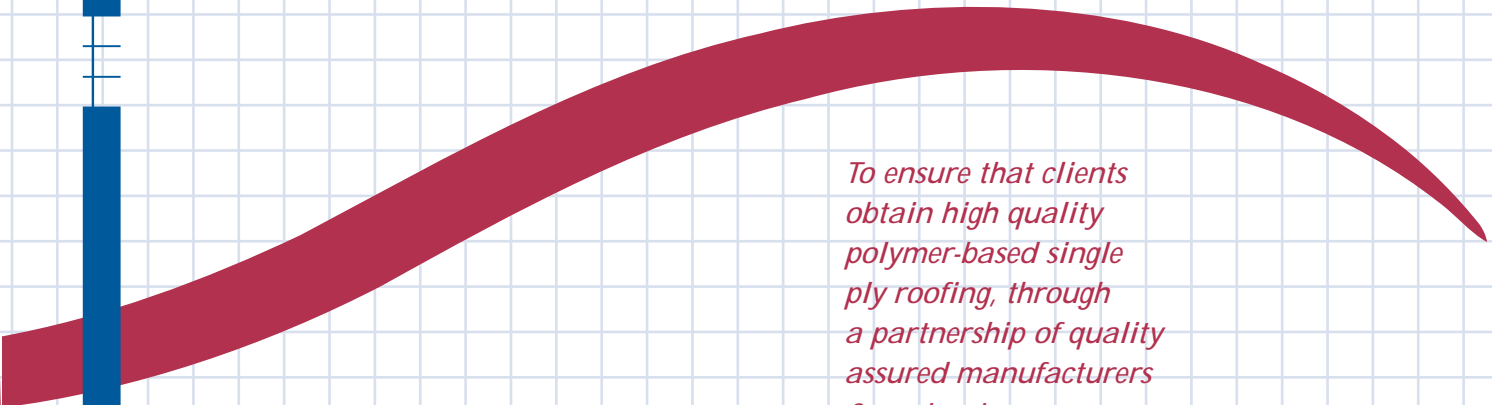
SPRA



We've Got It Covered

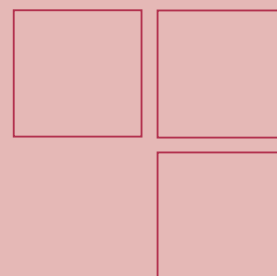
Single Ply
Roofing
Association

**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.*





CONTENTS

1. OBJECTIVES AND SCOPE

2. PERFORMANCE TARGETS AND CONSTRAINTS

- 2.1 Introduction p 4
- 2.2 Durability p 4
- 2.3 Appearance p 5
- 2.4 Thermal performance p 5
- 2.5 Resistance to solar radiation p 5
- 2.6 Control of condensation p 5
- 2.7 Control of air leakage p 5
- 2.8 Acoustic performance p 5
- 2.9 Resistance to loading p 5
- 2.10 External fire performance p 5
- 2.11 Transmission of daylight p 6
- 2.12 Lightning protection p 6
- 2.13 Environmental impact p 6
- 2.14 Security p 6
- 2.15 Supplementary uses p 6
- 2.16 Maintenance frequency and cost p 6
- 2.17 Safety during construction and use p 6

3. DESIGN CONSIDERATIONS

- 3.1 Introduction p 7
- 3.2 Types of roof system p 7
 - 3.2.1 The warm roof p 7
 - 3.2.2 The inverted warm roof p 7
 - 3.2.3 The cold roof p 8
 - 3.2.4 Roof gardens or 'green' roofs p 8
- 3.3 Falls p 8-9
- 3.4 Drainage p 9
- 3.5 Thermal insulation p 9
 - 3.5.1 Selection criteria p 9
- 3.6 Solar radiation p 9
- 3.7 Control of condensation p 9-10
- 3.8 Control of air leakage p 10
- 3.9 Acoustic insulation p 10
- 3.10 Compatibility p 10
- 3.11 Loads p 10
 - 3.11.1 Wind p 10
 - 3.11.2 Foot traffic p 11
 - 3.11.3 Plant and equipment p 11
- 3.12 External fire performance p 11
- 3.13 Lightning protection p 11
- 3.14 Methods of attachment p 12
 - 3.14.1 Introduction p 12
 - 3.14.2 Mechanical fastening p 12-13
 - 3.14.3 Adhesion p 13
 - 3.14.4 Ballast p 13
- 3.15 Detailing p 14-15
- 3.16 Safety during construction and use p 15

4. MATERIALS

- 4.1 Deck p 15
 - 4.1.1 Introduction p 15
 - 4.1.2 Profiled metal sheet p 15-16
 - 4.1.3 Timber p 16
 - 4.1.4 Concrete p 16
- 4.2 Vapour control layer p 16
 - 4.2.1 Classification p 16
 - 4.2.2 Cellular materials p 17
 - 4.2.3 Fibrous materials p 17
- 4.3 Waterproof membrane p 17
 - 4.3.1 Introduction p 17
 - 4.3.2 Product certification p 17
 - 4.3.3 Product standards p 17-18
 - 4.3.4 Generic types of membrane p 18

- 4.5 Ancillary components p 18
 - 4.5.1 Introduction p 18
 - 4.5.2 Mechanical fasteners p 18
 - 4.5.3 Adhesives p 19
 - 4.5.4 Pre-formed details p 19
 - 4.5.5 Rainwater outlets p 19
 - 4.5.6 Fall-arrest anchorages p 19
 - 4.5.7 Lightning conductor pads p 19

5. WORKMANSHIP

- 5.1 Training certification p 19
- 5.2 Programme p 19
- 5.3 Storage and handling of materials p 19
- 5.4 Health and Safety; COSHH Regulations p 20
- 5.5 Existing substrate (refurbishment only) p 20
- 5.6 Deck p 20
- 5.7 Vapour control layer p 20
- 5.8 Thermal insulation p 20
 - 5.8.1 Mechanical fastening p 20
 - 5.8.2 Adhesion p 21
- 5.9 Waterproof membrane p 21
 - 5.9.1 Mechanical fastening p 21
 - 5.9.2 Adhesion p 21
 - 5.9.3 Ballast p 22
- 5.10 Temporary protection of roof system p 22
- 5.11 Inspection p 22
- 5.12 Integrity testing p 22-23

6. MAINTENANCE

7. REFURBISHMENT

- 7.1 Introduction p 23
- 7.2 Removal or overlay of existing system p 23
- 7.3 Change of use p 23
- 7.4 Existing deck p 23
- 7.5 Insulation p 23

8. REFERENCES

- 8.1 Regulations p 24
- 8.2 Normative references p 24
- 8.3 Informative references p 24
- 8.4 Other references p 24



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.

As such it represents the current industry view of best practice in the design, installation and maintenance of single ply roofing systems and includes reference to all relevant European and British Standards as appropriate. Since European and British Standards and Regulations are under continuous review, the reader should confirm their status with the appropriate institutions before referring to them in specifications.

In the absence of a British Standard for single ply roofing, a British Board of Agrément or WIMLAS Certificate is required to satisfy The Building Regulations in respect of fitness for purpose.

In addition, certain projects may be subject to material approvals to Factory Mutual Research (FM - an affiliate of FM Global) standards, which set loss prevention standards specified world-wide.

1. OBJECTIVES AND SCOPE

This Guide is intended to:

- 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.

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.

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

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 were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

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

2. PERFORMANCE TARGETS AND CONSTRAINTS

2.1 Introduction

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.

In addition, the roof system must perform satisfactorily against a wide range of constraints and targets required by legislation, by the client and by the design of the substructure and services.

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.

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

2.2 Durability

Durability is expressed in terms of anticipated life to renewal. In financial terms, it is the period over which the depreciated initial capital cost and annual maintenance cost does not exceed the annual cost of a replacement roof.

The British Board of Agrément (BBA) assesses the durability of single ply roofing membranes as part of the Agrément Certification process. Single ply membranes are typically given a life expectancy of between "at least 20 years" and "in excess of 25 years".

2.3 Aesthetic appearance

The overall appearance of the finished roof with its necessary details, plus any decorative surface finish. The durability of the appearance should also be considered.

2.4 Thermal performance

Wherever possible, targets should exceed those required by current legislation in anticipation of higher standards being set during the life of the building. Initial investment in high standards will be readily offset by reduced heating and cooling loads and by the building's capacity for adaptation to future change or intensity of use. Such targets should consider heat loss, heat gain, and the impact of change (for example, increased use of IT equipment internally). The roofs of all heated buildings are required by building legislation to be thermally insulated. The Approved Document Part L (2001 Edition) of the Building Regulations (England & Wales), and Part J (Scotland) implemented in 2002, define the maximum permitted Elemental U-value of flat roofs as:

Dwellings, commercial, industrial & retail

- 0.25 W/m².K

Alternative methods of compliance with the Building Regulations include:

Dwellings

- Target U-value approach.
- Carbon index method (dwellings).

Commercial, industrial & retail

- Whole building method.
- Carbon emissions calculation method.

Further guidance on these methods is provided within the Approved Document Parts L1 (Dwellings) and L2, (England & Wales), and Part J (Scotland).

2.5 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 also 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.

2.6 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 Document sets mandatory requirements in respect of the control of condensation.

2.7 Control of air leakage

Approved Document L of the Building Regulations has introduced the requirement that the roof and those elements which penetrate it, should be suitably airtight. It is anticipated that with effect from October 2003, the roof of a building with a gross floor area in excess of 1000m² will comply with the requirement if the permeability to air of the roof is tested to the procedures defined in CIBSE TM23. It should achieve permeability to air not exceeding 10m³/h/m² at a reference pressure of 50Pa.

Buildings of less than 1000m² gross floor area require a certificate of conformity indicating that appropriate design details and building techniques have been used.

2.8 Acoustic performance

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 the deck and thermal insulation) early identification of the requirement may assist the design selection process.

On lightweight, wide-span structures, noise from heavy rain is often overlooked in design. However, the inherent flexibility of single ply membranes provides for good attenuation when compared with rigid sheet systems.

Advice with regards to individual constructions is available from SPRA insulation manufacturer members (see 3.9).

2.9 Resistance to loading

2.9.1 Resistance to 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 3.11.1).

2.9.2 Roof traffic

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.

2.10 External fire performance

The Building Regulations Approved Document B: 2000 requires that roofs of certain buildings meet specified performance levels for exposure to fire from external sources. This is expressed as a requirement for the whole roof construction, including deck and covering, characterised by penetration of fire and spread of flame. Classification ranges from Ext. FAA (External, Flat, Penetration rating A, spread of flame rating A) to Ext. FCD (lowest) when tested in accordance with BS 476 Part 3: 1958.

Approved document B is under review pending the confirmation of a new classification system based on a new European test for resistance to fire. BS476 Part 3 will be withdrawn following a transition period. Further information should be obtained from British Standards Institution and the Department of Trade and Industry.

Performance in excess of the mandatory requirement may be specified by insurance loss prevention consortia such as Loss Prevention Council (LPC) or Factory Mutual (FM). Currently, certification to LPC is by testing to the British Standard; to FM it is by testing to an American standard.

2.11 Transmission of daylight

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.

2.12 Lightning protection

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.

2.13 Environmental impact

Environmental impact ranges from consumption of natural resources and energy during manufacture and installation to removal, recycling 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 be established at an early stage.

SPRA members can provide a variety of information regarding the environmental profiles of the materials they supply, including the provision of recycled products. The Association will base these profiles upon agreed national and international protocols, as they develop.

2.14 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.

2.15 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 avoid complex detailing or difficult sequencing during construction.

2.16 Maintenance frequency and cost

Single ply roofing systems require no maintenance in themselves but it is established good practice to check roofs at least once per year and preferably in early Spring and late Autumn (see 6.0 Maintenance).

2.17 Safety during construction and use

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

The Construction Safety and Welfare Regulations 1966, statutory no.1592 Regulation 6, states that it is the responsibility of the employer to ensure that any employee required to work at a height of 2 metres or more must be suitably protected from any potential fall hazards.

The Construction Design and Management Regulations 1994 (CDM) extend the responsibility for Health & Safety to the designer. The designer must ensure that the design is such that it minimises risk during construction, maintenance and repair. Failure to comply with these requirements could ultimately lead to criminal as well as civil prosecution.

Working with its Associate members, SPRA has developed a classification system for assessing risk associated with fall protection.

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

Table 2.1: Fall protection for workers with basic fall protection training

*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.

3. DESIGN CONSIDERATIONS

3.1 Introduction

The head code of practice for the design of single ply roof systems is BS 6229 : 1982 Code of practice for flat roofs with continuously supported coverings. This version is subject to a major review including the incorporation of single ply technology within its scope.

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 and other British Standards, as follows:

- BS 6339 Part 1: 1984 'Code of Practice for Dead and Imposed Loads'.
- BS 6399 Part 2: 1997 'Code of Practice for Wind Loads' (replaces BS CP3 Chapter V Part 2 : 1972 which was withdrawn in June 2001).
- BS EN 12056 3: 2000 'Gravity Drainage Systems inside buildings. Part 3 Roof drainage, layout and calculation'.
- Building Research Establishment Digest No. 346 : 1989 'Assessment of Wind Loads'.
- Building Research Establishment BR262 'Thermal insulation: avoiding risks' 2002 edition.

3.2 Types of roof system

A typical single ply roof system comprises:

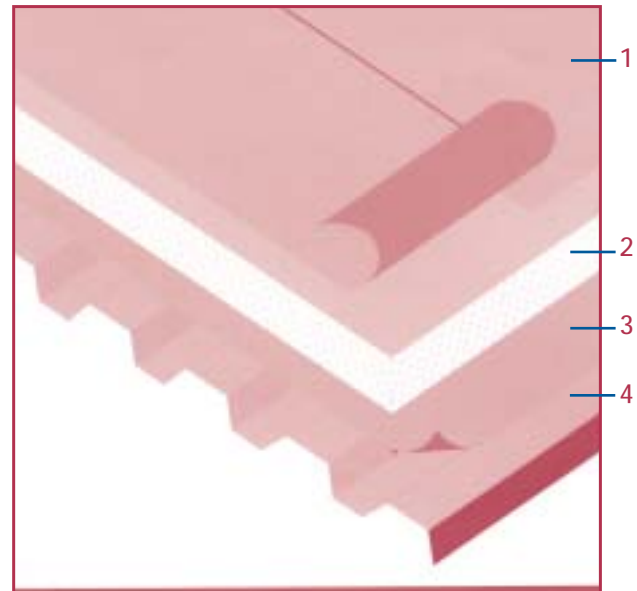
- Structural support (generally not installed by the roofing contractor).
- Deck providing continuous support.
- Vapour control layer (if required).
- Thermal insulation (if required).
- Waterproof membrane.
- Traffic or load resistant finish (if required for functional and/or aesthetic reasons).

Membrane roof systems are generally divided into the following types, according to the position in which the principal thermal insulation is placed.

3.2.1 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.

Fig. 3.1 Warm Roof (section)



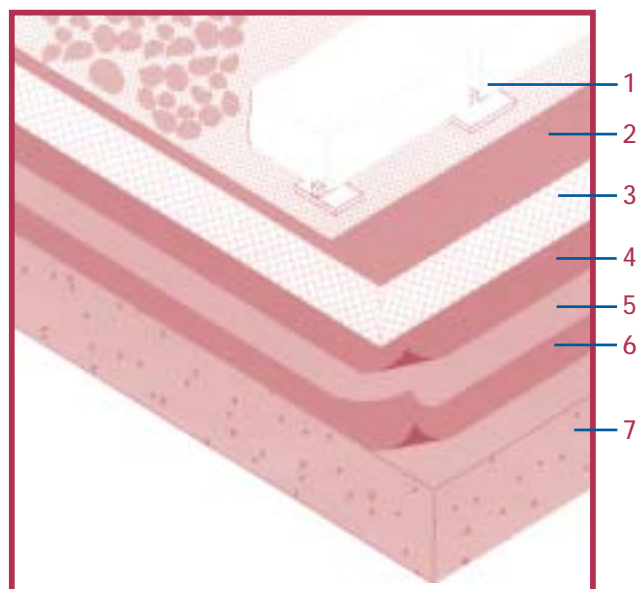
1. Waterproof membrane
2. Thermal insulation
3. Vapour control layer
4. Deck

Note: the section shows a typical system with a metal profile deck. The basic configuration would be unchanged with other deck types.

3.2.2 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 ballast, however proprietary lightweight systems are available comprising of insulation/balrest composite, which do not rely on separate ballast in the roof field.

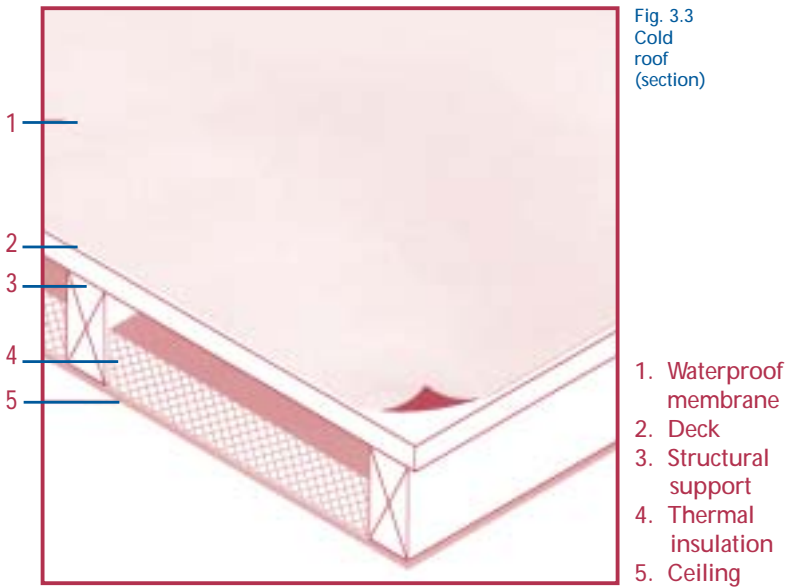
Fig. 3.2 Inverted Warm Roof (section)



1. Ballast
2. Filter layer
3. Thermal insulation
4. Separation layer (some products)
5. Waterproof membrane
6. Separation layer (some products)
7. Deck

3.2.3 The cold roof

The principal thermal insulation is placed at or immediately above the ceiling, resulting in the roof covering and structural deck being substantially colder in winter than the interior of the building. The structural support will typically 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 increasing the risk of condensation accumulation within the system. In addition, the requirement for uninterrupted external air circulation limits the application of the system where abutting elevations or changes in building geometry occur. Therefore, it is not a recommended option. 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.



Many roofs combine the features of two or more of the roof types described above. 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.

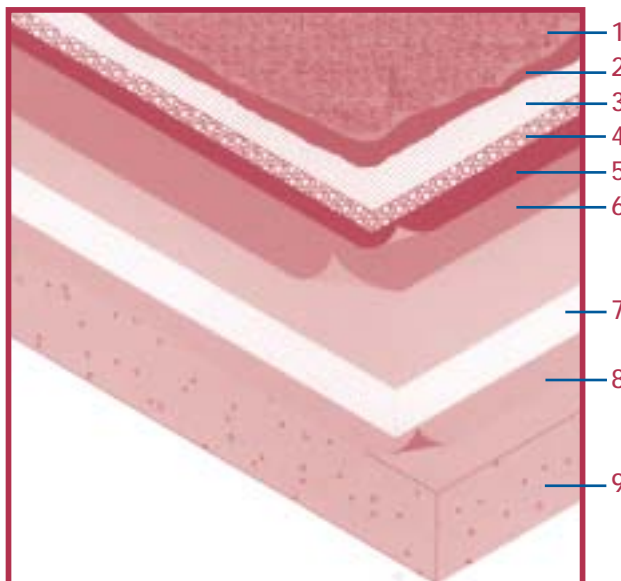
In some constructions the waterproofing layer is placed between two layers of insulation, combining the properties of warm roof and inverted warm roof construction. This form of construction is generally known as a 'duo roof'.

3.2.4 Roof gardens or 'green' roofs

Roof gardens or 'green roofs' typically comprise a roof system of either warm deck or inverted warm deck construction with drainage, reservoir, filter and growing medium layers placed above.

Fig. 3.4 Green roof - (Warm roof type) (section)

1. Grass, low-level plant species
2. Growing medium
3. Filter layer
4. Drainage/reservoir layer
5. Protection layer
6. Waterproof membrane
7. Thermal insulation
8. Vapour control layer
9. Deck



3.3 Falls

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 a greater water ingress.
- It may cause progressive deflection of the deck.
- Ice may be a slip or wind hazard.

Independent research (see footnote) has shown that roofs with extensive ponding require increased maintenance input.

Because polymeric single ply membranes are not affected directly by standing water, the avoidance of ponding is not a material-related issue. 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 second line of defence to water ingress both during construction and in service.

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.

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

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 zone 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.

3.4 Drainage

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 and downpipes.

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 plain falls to an abutment. Box gutters are slow and difficult to construct and the requirement to maintain a fall in them may call for complex design.

3.5 Thermal insulation

3.5.1 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 or equipment will be applied directly onto the roof surface).
- Compatibility with other roofing components.
- Required fire resistance.
- Acoustic performance (profiled metal decks only).
- Cantilever capability.

- Suitability for roof traffic both during and after construction.

Additionally for inverted warm roofs:

- Water absorption.
- 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 or WIMLAS.

3.6 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. Manufacturers can provide specific data as required.

It should be noted that ponding on light coloured membranes will inevitably cause dark areas which will be subject to increased heat gain.

3.7 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 lower 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 uses such as kitchens, swimming pools or shower rooms are at particularly high risk. Buildings such as school classrooms or community centres that are heated intermittently and then closed for security reasons are also at significant risk.

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.

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.

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.

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

Guidance is available in Building Research Establishment BR262, BS 5250, and the Chartered Institute of Building Services Engineers (CIBSE) Guide - Volume A – Design Data.

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 BS6229, which additionally advises maximum levels of annual accumulation in Kg.m².

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.

Particular consideration should be given to the following:

Warm roofs

- Avoidance of cold-bridging across components with high thermal resistance.
- Avoidance of areas with reduced thermal resistance (e.g box gutters).
- Avoidance of air movement through and across the roof system.
- Continuity of vapour control layer at upstands and details generally.
- The effect of penetrations through the vapour control layer.

Inverted warm roofs

- Avoidance of surface condensation on lightweight decks.
- Maximum possible drainage above insulation.
- Avoidance of cold bridging due to gaps in loose-laid insulation.

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.

3.8 Control of air leakage

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)

- *A vapour control layer* which, if properly sealed to the building perimeter and all penetrations should provide a satisfactory seal. It is anticipated 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 the current requirement is not onerous and is easy to achieve, it will become steadily more onerous with each revision of the Building Regulations.

3.9 Acoustic insulation

Acoustic insulation 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 insulation boards in combination with increasing the unit mass of the roof construction.

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

A single ply membrane will not itself provide significant acoustic performance; however, when used in the correct roof construction almost any acoustic requirements can be met without compromising the integrity of the waterproofing system.

It is generally not advisable to place external air handling plant directly on the roof surface for reasons of satisfactory weatherproofing (see section 3.15). In lightweight construction this may also contribute to sound transmission. However the ease with which single ply membranes can be detailed around vibration - absorbent mountings should eliminate the need for such practices.

3.10 Compatibility of components

The selection of components within the roofing system should be discussed in detail with the manufacturer of the membrane to ensure complete compatibility between components as the incorrect specification of incompatible components will lead to premature failure of the roofing system. The correct choice of insulation (where applicable) is important when fully adhering the waterproofing, especially when solvent based adhesives are being used and the membrane and insulation manufacturer should always be consulted when selecting the insulation.

3.11 Loads

3.11.1 Wind

At the earliest possible stage, the wind load acting on the roof should be calculated as recommended in BS 6399 : Part 2 1997. 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.

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 3.14).

It has been established from experience and confirmed in relevant British and industry standards that a partial bond of bitumen, applied consistently, can resist a maximum design load of 2.4kN.m². The equivalent for a full bond is taken as 3.6kN.m². However, caution must be applied where a nominally full bond is used to secure a semi-rigid sheet such an insulation board because a full bond is rarely achievable in practice.

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.

3.11.2 Foot traffic and construction process

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 or maintenance, a handrail or fall arrest system may be a requirement.

Even on non-access roofs, the construction process itself places demands upon the resistance of the system to repeated loads.

Considerations include:

- The distribution of roof access points and the effect of repeated loads on the system nearby; load-spreading protection will usually be required.
- The location of plant and the provision of heavy-duty walkway sheets to protect the waterproof membrane.
- Provision of load-spreading sheets below the waterproof membrane in situations where materials may be stored or heavy equipment used, for example to service roof-mounted equipment.

During construction, the most effective protection is timber panels such as plywood or oriented strand board with taped or linked joints. The construction sequence should be reviewed to ensure that heavy deliveries (for example, a pallet of coping stones or atrium glazing units) are not placed on the roof without special bearers to transfer their load to the structure. Membrane and insulation manufacturers should be consulted in such cases.

3.11.3 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. In the latter case, the pier section must facilitate the waterproofing process or be constructed with an integral flashing. For example, it is very difficult and therefore costly, to waterproof an I - section effectively. If equipment dead load is to be applied to the roof system the advice of the membrane manufacturer should be sought regarding compression resistance of insulation, and requirements for separating layers.

3.12 External fire performance

External fire performance of roof systems is assessed according to BS 476 Part 3 : 1958, where the roofing system is subjected to fire exposure from a simulated external burning brand comprising a gas flame. The external fire performance is expressed as a requirement for the whole roof construction including deck and covering, characterised by penetration of fire and spread of flame. Classification ranges from (highest) Ext. FAA (external flat, penetration rating A, spread of flame rating A) to Ext. FCD (lowest). Note that the minimum guidance of the Approved Document still relates to the 1958 test, and not the 1975 version, which has not been adopted by the regulators.

Note 2. European tests and fire classification systems are expected to be introduced as supplements to Approved Document B, and Technical Standards in Scotland, from 2002 – 2003.

It is anticipated that the new European Standard (ENV 1187 : 2002) for external fire exposure of roofs will be implemented during the life of this Guide. This test is in three parts as follows:

- *Part 1* To simulate a burning brand without wind.
- *Part 2* To simulate a burning brand with wind.
- *Part 3* To simulate a burning brand with wind and radiation from an adjoining burning building.

The Building Regulations will be amended to incorporate one or more of these tests based on a new European classification document for external fire performance, currently EN 13501-2 (expected 2002).

The existing BS476 reference will then be withdrawn. A 'transitional period' during which fire test certificates for existing products based upon BS476 will be allowed but all new systems are likely to require assessment to the new tests with immediate effect.

The Building Regulations Approved Document B also makes fire resistance provisions for where fire exposure to the underside of the roof needs to be considered. These are listed in Table A1 of the approved document and apply: -

- When the roof and its support structure are part of an escape route, including any opening within 3m of the escape route.
- When the roof performs the function of a floor.

Building designers should ensure that the client is aware of the Fire precautions (Workplace) Regulations:1997 (As amended), wherein the employer is required to undertake the continually review a risk assessment to ensure that employees are not placed at risk from fire. It is recommended that a fire expert be consulted as part of this process.

3.13 Lightning protection

The installation of a well-designed lightning protection system on a structure will collect the strike itself and dissipate it safely to earth. The design of a lightning protection system for installation in the United Kingdom should be in accordance with BS6651 : 1991. A harmonised European Standard is anticipated shortly.

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

Note: the 'Consultants Handbook' was available free of charge from W.J. Furse, Wilford Road, Nottingham NG2 1EB at the time this Guide went to press.

3.14 Methods of attachment

3.14.1 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 6399: Part 2 1997. 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.

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

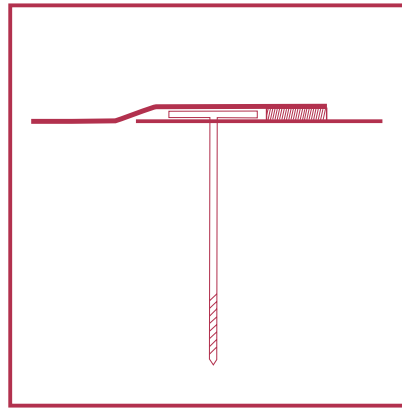
- Calculated wind load.
- The suitability of the deck to receive mechanical fasteners.
- The internal relative humidity.
- The extent and complexity of roof detailing.
- Aesthetic considerations.
- (*refurbishment*) The condition of the existing system.

3.14.2 Mechanical fastening

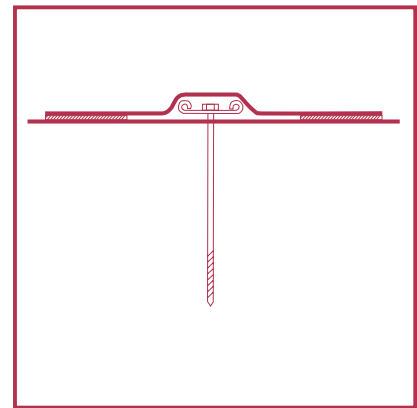
A system whereby the membrane is loosely laid and fastened to the substrate using either metal or plastic pressure plates/washers or a linear bar with a suitable mechanical fastener.

Mechanical attachment may also be achieved by the use of special discs (or strips) of membrane or membrane coated metal mechanically fastened to the deck in a predetermined pattern (over a separation layer if specified). The waterproofing membrane is then heat welded or chemically welded to the discs or strips.

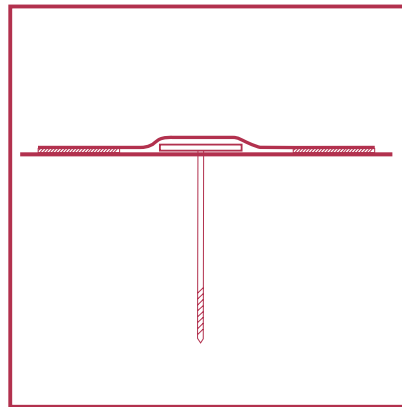
Seam fastening (schematic)



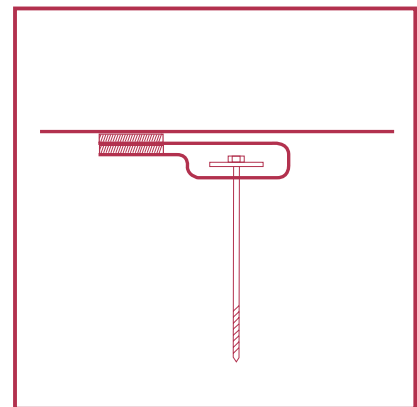
Linear bar fastening (schematic)



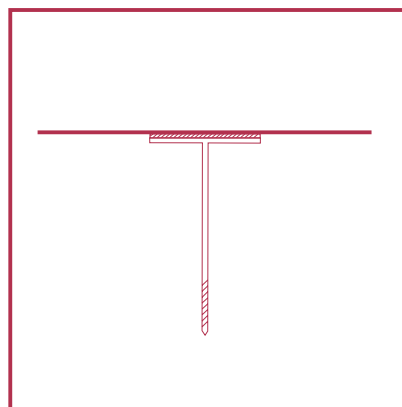
Field fastening (schematic)



Membrane pocket fastening (schematic)



Disk fastening (schematic)



Stud and cap fastening (elastomeric membranes) (schematic)

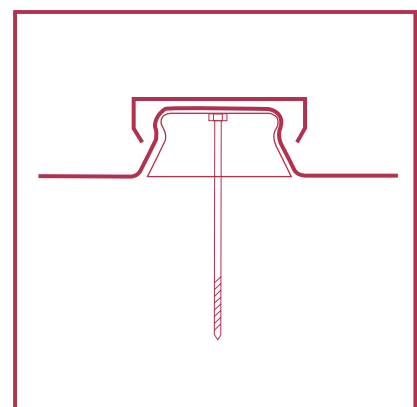


Fig 3.5 Methods of mechanical fastening (schematic)

Mechanical fasteners should not create significant cold bridge effects and should be compatible with other components.

If the remainder of the roof system is to be bonded it is essential that the design resistance to wind load is achieved.

Additional fixings are required around the roof perimeter at details and around large penetrations.

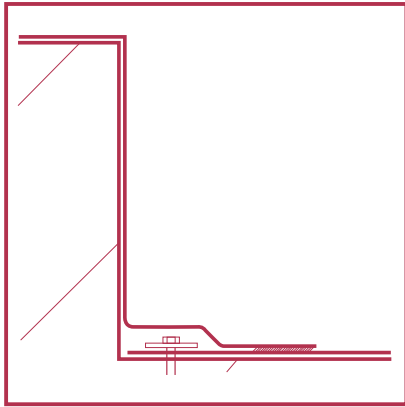


Fig 3.6 Typical perimeter restraint (schematic)

Irrespective of the wind uplift considerations or distribution requirements for securing the membrane, the fixing of the roof insulation boards should always be considered separately. Special fasteners and washers may be necessary to secure insulation boards to decks. Refer to the insulation board manufacturer for advice.

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

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. The insulation manufacturer should be consulted with regard to recommended practice.

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, the bars should be applied at right angles to the direction of the decking unless otherwise specified.

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 manufacturers are obtained.

On pitched roofs, adequate provision should be made for mechanical fixing of the waterproofing layer and insulation boards, to prevent slippage.

3.14.3 Adhesion

A system whereby the membrane is bonded to the substrate using a proprietary adhesive. Systems can be either fully or partially bonded depending on the manufacturer.

Full bonding may be achieved by the use of a proprietary adhesive or 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.

In this case, bitumen compound of a given grade is poured or mopped onto the substrate and the sheet is then rolled into it. The full sequence of work relating to hot bitumen bonding should be as described in BS 8217: 1994 (under review).

If the remainder of the roof system is to be bonded, it is essential that the design resistance to wind load is achieved at the vapour control layer.

Adhered membranes may be laid over 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 SPRA roofing membrane supplier should be contacted as regards the recommended installation practice.

3.14.4 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, it is likely that the areas of the membrane beneath the ballast will 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.

3.15 Detailing

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).

Wherever possible, thermal performance should be maintained across a detail to avoid creation of a cold bridge. Restraint against wind load and design fire resistance must also be maintained across 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, balconies etc.

In situations where uninterrupted access/egress (disabled/fire) is required, this is best achieved by use of localised ramps, preferably with some form of open grating at the abutment to the elevation to ensure effective weatherproofing.

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.

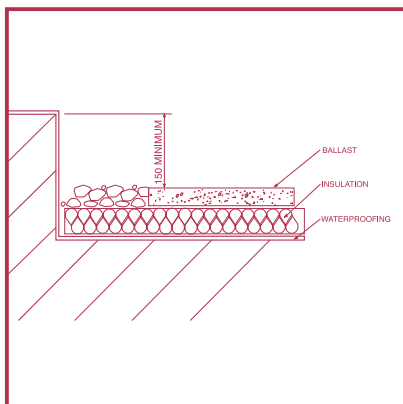


Fig 3.7 Upstand - inverted roof (schematic) (Perimeter restraints not shown)

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.

(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.

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. However they may be slower to construct.

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

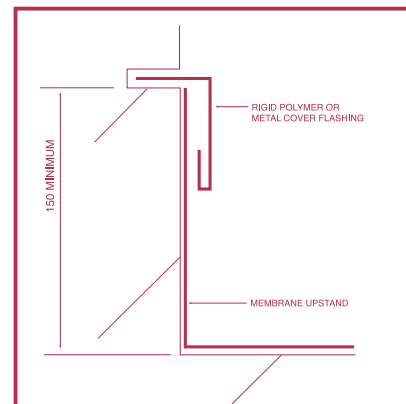


Fig 3.8 Upstand - weatherproof (height in mm) (schematic)

(c) Waterproof eaves and verges

Drip details at eaves and verges are generally formed from a preformed section of membrane coated metal. This saves time, improves appearance and reduces variability through pre-fabrication. Where membrane coated metal is not available for the membrane product a non-ferrous edge profile may be part-covered by a membrane flashing.

(d) Gutter

Gutters can be lined using the roofing membrane to achieve a completely 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.

Gutters should be designed in accordance with BS EN 12056: Part3.

(e) Rainwater outlet

Rainwater outlets can be either:

- Made of lightweight, compatible material and set at the level of the waterproof membrane.
- or
- Clamp ring type of alloy construction and generally set below the level of the roof surface or on spacers. The underside of the membrane situated beneath the clamp ring should be sealed to the outlet body with an appropriate mastic sealant.

(f) Movement joint - waterproof

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

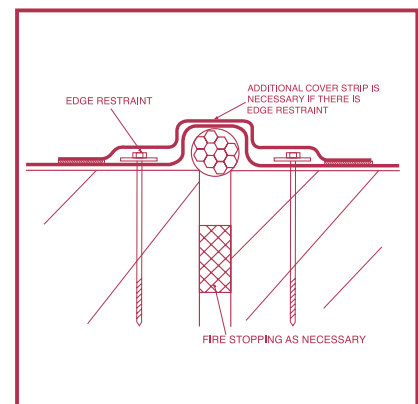


Fig 3.9 Movement joint - waterproof (schematic)

(g) 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.

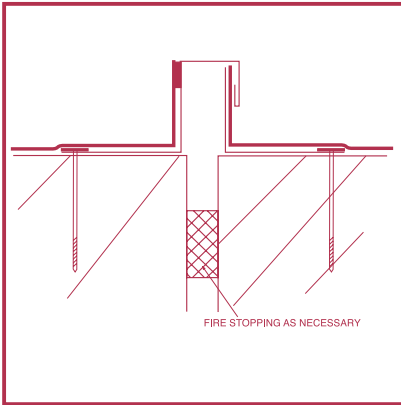


Fig 3.10 Movement joint - weatherproof (schematic)

(h) 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.

(i) Load-bearing plinth for services
In the absence of a load-bearing structure set above the roof field, independent plinths may be required.

The plinth design of 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.

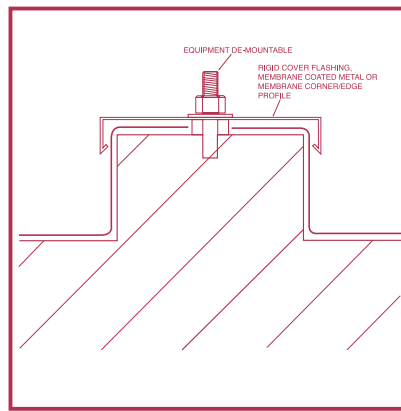


Fig 3.11 Load bearing plinth for services (schematic)

(j) 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.

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.

3.16 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 EN795 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.

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 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 1/250 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 10147:2000 Fe E280G Z275. Typical gauge range 0.7-1.2mm.

(b) Coated galvanised steel

Minimum recommended thickness 0.7mm to BS EN 10147:2000 Fe E220G Z275. Typical gauge range 0.7 - 1.2mm.

(c) Plain aluminium

Minimum recommended thickness 0.9 to 1.2mm to BS EN 485-2 : 1995 AA3004 H34. Reference should also be made to BS EN 1396 : 1997 as appropriate. Special fasteners may be required in mechanically fastened applications.

(d) Coloured aluminium

Minimum recommended thickness 0.9mm to BS EN 485-2 : 1995 AA3004 H34 and BS EN 485-2 : 1995 AA3105 H25. Special fasteners may be required in mechanically fastened applications.

4.1.3 Timber

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 on design criteria and installation please refer to the panel manufacturer.

Roofing grade OSB should be manufactured to BS EN300 1997 grade OSB/3 (formerly F2 of BS5669 Part 3.) and be certificated by the British Board of Agrément or WIMLAS. The minimum recommended thickness is 18mm.

(b) Plywood

Plywood should be minimum 18mm thickness and certificated to conform to BS5268 Part 2 and to BS EN 636 Part 3.

SPRA has researched the certification of plywood for roofing use and concluded that not all supply is suitably identified as conforming to a Standard. In these circumstances it has concluded that one option is to specify to the American Plywood Association certification scheme. In this case grades C-D and C-C would apply.

(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 : 2001.

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 support should be considered.

The minimum required thickness is 50mm.

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.

4.2 Vapour control layer

Where a vapour control layer has been shown by calculation to be necessary then this could consist of a polyethylene membrane or reinforced bitumen sheet. In either case, the inclusion of metal foil laminate greatly increases the water vapour resistance of the product.

Independently certified test data for the product should verify that it 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 are generally loose laid 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.

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 x 1200mm to 1200 x 2400mm.

Composite products for warm and inverted roof applications comprise a base board with an overlay factory-bonded to it. Composites combine the thermal performance advantages of cellular or fibrous insulants with the load-resistant and/or fire-resistant properties of the dense overlay.

Some composite products are available which combine a plywood overlay with a cellular insulation and metal foil vapour control layer bonded to the underside. These composites combine deck, thermal insulation and vapour control layer in a single product but are suitable only for certain applications. They must be carefully sealed at joints to prevent loss of vapour control performance.

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 |
| • Rigid urethane foam | (PUR/PIR) RUF |
| • Phenolic foam | PF |
| • Polystyrene - expanded | EPS |
| • Polystyrene - expanded - extruded | XPS |

Mineral materials

- | | |
|------------------|----|
| • Cellular glass | CG |
|------------------|----|

(a) Rigid urethane foam (PUR/PIR)

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 to BS 4841: Part 3. Part of this Standard is replaced by EN 13165 Thermal Insulation products for buildings - factory made rigid urethane products.

Note: SPRA is working with the British Rigid Urethane Foam Manufacturers Association (BRUFMA) to develop production quality control procedures to complement the requirements of British and European Standards. A new BS4841 Part 4 with specific requirements in respect of rigid urethane foam products for use with single ply membranes is anticipated.

(b) Phenolic foam

Closed cell phenolic foam is produced from phenolic resin by a polymerisation reaction incorporating a low thermal conductivity-blowing agent. Phenolic foam should comply to BS EN 13166.

(c) Polystyrene - expanded

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

Expanded polystyrene board should comply with BS 3837: Part 1. Part of this Standard is replaced by BS EN 13163.

(d) Polystyrene - extruded

Extruded polystyrene is produced by an extrusion process to create a closed cell structure, which offers a wide range of compressive strengths.

Extruded polystyrene should comply to BS 3837 : Part 2. Part of this Standard is replaced by BS EN 13164 Thermal Insulation products for buildings - factory made extruded polystyrene products.

(e) 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. It is used very rarely with single ply membranes.

Cellular glass should comply to BS EN 13167 Thermal Insulation products for buildings - factory made cellular glass products.

4.3.3 Fibrous materials

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

- Mineral wool MW
- Perlite EP
- Granulated corkboard C
- Mineral wool (low density quilt) cold roofs only.

(a) 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.

Roofing boards are available as either mono density or dual density products.

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

(b) Perlite

Manufactured from a volcanic mineral which is subsequently expanded and combined with mineral fibres and binders. Boards should comply with BS EN 13169.

(c) Granulated corkboard

Produced by compressing granulated cork bark which is then held together by the natural cork gum.

In the absence of a British Standard, an industry standard has been published by the Cork Industry Federation.

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 and WIMLAS 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

Currently SPRA is actively involved with the British Standards Institute (BSI), the European Committee for Standardisation (CEN) and the British Board of Agrément (BBA) to ensure that authorised minimum standards exist throughout Europe for single ply roofing materials. The harmonised European Standard EN13956 is due for implementation in 2003. This standard will set rules for the declaration of product characteristics against a list of pan-European Standard test methods. This will facilitate the comparison between products of different national origin. However, this Standard will set requirements only in respect of fire performance (a full system test - see 3.12 above) and watertightness.

The designer should consult manufacturers and SPRA for advice on the relevance of different product characteristics to a particular project.

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

Polyvinylchloride	PVC
Chlorosulphonated Polyethylene	CSM
Chlorinated Polyethylene	CPE
Flexible Polyolefin	FPO
Vinyl ethylene terpolymer	VET
Polyisobutylene	PIB

Elastomeric

Ethylene propylene diene monomer EPDM

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

(a) Polyvinylchloride

PVC is made flexible by the addition of plasticisers. PVC can be heat or solvent welded but is generally not suitable for direct contact with bitumen.

(b) Chlorinated polyethylene

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

(c) Vinyl ethylene terpolymer

VET is made flexible by blending Ethylene Vinyl Acetate (EVA) with PVC, the EVA acting as a plasticiser. VET can be heat or solvent welded and is compatible with bitumen.

(d) Chlorosulphonated polyethylene

Polyethylene is made flexible by chlorosulphonation and can be solvent or heat welded. After external exposure CSM's properties are modified to produce a partially vulcanised membrane that improves weather resistance but impairs the weldability. CSM is compatible with bitumen.

(e) Flexible polyolefin

FPO membranes consist of a composition based on internally plasticised polyolefines. FPO can only be heat welded.

(f) Polyisobutylene

PIB incorporates carbon black to provide good physical properties. PIB products available on the UK market are suitable for solvent welding by tape systems.

(g) Ethylene propylene diene monomer

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

4.5 Ancillary components

4.5.1 Introduction

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

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

4.5.2 Mechanical fasteners

The correct fastener for the particular substrate will be recommended by the insulation/membrane manufacturer and/or fastener supplier and should comply with 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.

Minimum recommendations for thermal insulation pressure plates have been agreed within SPRA and are tabled below:

Thermal insulation	Minimum No. of fasteners per board	Position of fasteners
PUR/PIR & PF	11 per 2.4m x 1.2m board (3.8 fixings/m ²) 4 per 0.6 x 1.2m board (5.55 fixings/m ²)	Pattern to be as per BRUFMA Guide (see references 8.4)
EPS	4 or 5 per board of any size (consult manufacturer)	one per corner (fifth in centre, if required)
XPS	2 or 3 per board - (usually 0.6 x 2.4m - consult manufacturer)	Along centre line of long dimension
MW	1 per 1.0m x 0.6m board 1 per 1.2m x 0.6m board 1 per 2.0m x 0.6m board 1 per 2.0m x 1.2m board	Centre of board

Table 4.1 Minimum numbers of insulation fasteners and their layout.

Notes

1. All insulation fastener stress plates are to be of minimum dimension 70 x 70mm or 75mm diameter
2. The fastener requirement will increase for membrane systems bonded with adhesive
3. 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

4.5.3 Adhesives

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

- Water-based: compatible with a wide range of insulation materials including polystyrene. May be slower to use at low temperature 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.
- Polyurethanes: products available for securing insulation and membranes. Some are effective in damp (NOT wet) conditions.

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

4.5.4 Pre-formed details

Many membranes are available with compatible factory-made three-dimensional mouldings. These include internal and external corners and nosings. It is usual practice to 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 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 - heavy weight: 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. 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.

- Syphonic: syphonic 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.

4.5.6 Fall-arrest anchorages

Because of the high loads exerted during a fall, conventional anchorages for fall-arrest lines must be tied directly to structure on single ply roofs. However energy absorbing anchorage posts are available which dissipate such loads whilst maintaining tension in the line. These are becoming available for application directly onto single ply membrane (warm roof) systems.

4.5.7 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 are welded to the membrane surface and the tape is secured by a clamp such that the tape is held clear of the roof surface.

5. WORKMANSHIP

5.1 Training certification

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 they recommend have this relevant experience, which involves extensive in-house and on site training. 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.

Working with SPRA, the Construction Industry Training board (CITB) has developed a training resource for introductory training. A Vocational Qualification (NVQ-England, Wales and Northern Ireland, SVQ - Scotland) is available at levels 1 and 2 ('Applied Waterproof Membranes - Single Ply Roofing').

SPRA members are already adopting this certification for their trained contractors. The inherent advantages of single ply can only be fully exploited and demonstrated when installed by contractors who are adequately trained in their specific use.

5.2 Programme

Rapid construction necessitates the sequencing of many disparate 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. Examples include rendering of elevations above roof level, scabbling of concrete surfaces adjacent or over the roof and installation of atrium systems. When such work cannot be avoided, it is essential to protect the finished single ply roof against potential damage by other trades.

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 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 on a clean, dry and level surface. The rolls are usually wrapped individually with protective film and may be stacked on pallets 3-4 rolls high. This wrapping is for protection in transit and handling of individual rolls. It is not a suitable weather protection.

Insulation boards must be protected from weather, (preferably by dry storage) on the site 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.

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 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 1994 (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 may impair the integrity of the roof and should be checked prior to installation.

5.6 Deck

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 woodwool are typically installed by the general contractor.

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.

An indication of how slow the process is can be gained from BS8203: 2001, 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.

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

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 with a moisture content in excess of 18%. Panels should be fastened securely to joists with ring shank nails or screws at 300mm centres.

Woodwool 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 have adequately sealed side and end laps. Where possible all penetrations of the vapour control layer should be sealed as appropriate to the use of the system.

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.

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 or steps or gaps and should be graded to provide the correct falls to rainwater outlets. Where appropriate it should be primed to accept bitumen or adhesive bonding of the VCL. The roof insulation boards should be laid break-bonded 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 adhesive and insulation are compatible and tape insulation board joints as necessary.

5.8.1 Mechanically fastened

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

Fasteners should be placed within the area of the individual board as recommended by the insulation manufacturer. Additional fasteners needed to meet the design loading conditions should be evenly distributed over the full area of the board. Each fastener should incorporate a washer, having a minimum surface area of not less than 4400 mm (see 4.5.2 Table 4.1) 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.

Where it is necessary to mechanically fasten the insulation, 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

Adhere the thermal insulation directly to the substrate/vapour control layer using a synthetic bonding adhesive, hot, or cold bitumen bonding compound.

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

On completion of laying, ensure that boards 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 roof membrane has been installed, it is important to seal the laps as quickly as possible. There are rarely situations where delay is advantageous.

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. The membrane manufacturer will advise on the most suitable method for their system or the application.

Screw fasteners should be properly driven home taking care not to over tighten any of the screws as this may reduce resistance to pull-out or cause subsequent failure of the fastener.

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 manufacturers specified intervals with additional fixings at perimeters and penetrations. The linear bars are then weathered as recommended by the membrane manufacturer (normally by covering with detailing strips of the main roof membrane). On metal decks, the bars should be applied perpendicular to the direction of the decking unless otherwise specified.

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 washer should resist rotation by hand. 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.

Where it is necessary to mechanically fasten the insulation, 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.

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

Care should be taken to apply the waterproofing sheet in a manner that minimises voids and wrinkles and ensuring that the entire sheet is fully adhered. Puddles or blobs of adhesive should be avoided as these may lead to punctures or poor adhesion. 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 as required by the membrane manufacturer.

Where a contact adhesive is utilised, the sheets of membrane should be rolled out and positioned with correct overlaps. Each sheet should be folded back in half length-wise 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 effected. Once the sheet has been installed, a water filled roller should be used to ensure intimate adhesion between the two adhered surfaces.

Full bonding utilising a proprietary adhesive should be achieved by following the recommendations of the manufacturer (paying close attention to the Health & Safety precautions).

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.

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 for 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.

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. This is to prevent mineral fines from becoming trapped in the interstices of the insulation joints or at membrane level.

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 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 in a forward direction, working from the roof access point to minimise trafficking on the unprotected membrane.

Slabs should be laid on specified protection layers and corner supports may additionally be specified to facilitate levelling up a pedestrian surface. They should not be tightly butted to the upstand because allowance must be made for thermal expansion. This can be achieved by either a 50mm margin of washed and rounded stone or by a proprietary compressible sealing strip.

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.

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, cementitious 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 Code of Practice requires that manufacturers also make recorded inspections before a guarantee is issued and may make inspections of other work as appropriate.

5.12 Integrity testing

The roofing contractor should carry out mechanical integrity testing of jointed seams on a daily basis. Additional random mechanical checking of joints will be carried 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 testing vary with the roof type and objective. Electrical resistance (pulse) testing is suitable for proving waterproofing integrity or for locating known water ingress. It is not suitable for EPDM or electrically conductive membranes 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 not suitable for EPDM or electrically conductive membranes 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 is required.

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 at least annually and 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 co-ordinates, 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.

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 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 will 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 due to be refurbished. 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.

If the existing drainage layout is poor and ponding widespread, retention of an existing deck will restrict the range of design options because only a warm roof system with cut-to-falls insulation will be feasible.

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 Document B (2000 edition) Fire safety (new guidance expected 12/02)

The Building Regulations Approved Documents F Ventilation (1995 Edition, amended 2000) (F1-Means of ventilation, F-2 Condensation in roofs)

The Building Regulations Approved Document Part H (2002 Edition) Drainage and waste disposal

The Building Regulations Approved Document Part L1 (2002 Edition) Conservation of fuel and power in dwellings

The Building Regulations 2001 Approved Document Part L2 (2002 Edition) Conservation of fuel and power in buildings other than dwellings

The Building Standards (Scotland) Regulations 1990 (sixth amendment) Part J Conservation of fuel and power

The Construction Safety and Welfare Regulations 1966 statutory no.1592 Regulation 6

The Construction Design and Management Regulations 1994 (CDM)

Fire Precautions (Workplace) Regulations:1997 (As amended)

Control of Substances Hazardous to Health Regulations 1994 (COSHH)

8.2 Normative references

BS 476 Part 3 : 1958 External fire exposure roof test

BS 5268 Part 2 : Structural use of timber - Code of practice for permissible stress design, materials and workmanship

BS 1105 : 1981 Specification for woodwool cement slabs up to 125mm thick (proposed for deletion)

BS 3837 Part 1 : 1986 Expanded polystyrene boards. Specification for boards manufactured from expandable beads

BS 3837 Part 2: 1990 Expanded polystyrene boards. Specification for extruded boards

BS 4841 Part 3 : 1994 Rigid polyurethane (PUR) and polyisocyanurate (PIR) foam for building applications.

Specification for two types of laminated board (roofboards) with auto-adhesively bonded reinforcing facings for use as roofboard thermal insulation for built-up roofs. (New part 4 for single ply roofing under development)

BS EN 300 : 1997 Oriented strand boards (OSB). Definitions, classification and specifications

BS EN 485-2 : 1995 Aluminium and aluminium alloys. Sheet, strip and plate. Mechanical properties

BS EN 636-3 : 1997 Plywood. Specifications. Requirements for plywood for use in exterior conditions

BS EN 795 : 1997 Protection against falls from a height

BS EN 1396 : 1997 Aluminium and aluminium alloys. Coil coated sheet and strip for general applications. Specification

BS EN 10147 : 1992 Continuously hot-dip 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 : 2001 Thermal insulation 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 : 2001 Thermal insulation products for buildings. Factory made rigid urethane foam (PUR) products. Specification

BS EN 13166 : 2001 Thermal insulation products for buildings. Factory made products of phenolic foam. Specification

BS EN 13167 : 2001 Thermal insulation products for buildings. Factory made cellular glass (CG) products. Specification

BS EN 13168 : 2001 Thermal insulation products for buildings. Factory made woodwool (WW) products. Specification

BS EN 13169 : 2001 Thermal insulation products for buildings. Factory made products of expanded perlite (EPB). Specification

BS EN 13501-2 Classification for fire resistance

BS EN 13956 (Draft European Standard - implementation expected 2003) Flexible sheets for waterproofing. Plastic and rubber sheets for roof waterproofing. Definitions and characteristics

8.3 Informative references

BS 6229 : 1982 (under review) Code of practice for flat roofs with continuous supported coverings

BS 6339 Part 1 : 1984 Code of practice for dead and imposed loads

BS 5250 : 1989 Code of practice for control of condensation in buildings (currently under review)

BS 6399 Part 2: 1997 Code of practice for wind loads

BS 6651 : 1991 Code of practice for protection of structures against lightning

BS 8217 : 1994 (under review) Code of Practice for built-up felt roofing

BS8203 : 2001 Code of practice for installation of resilient floor coverings

BS EN 12056 – 3 : 2000 Gravity drainage Systems inside buildings. Part 3 Roof drainage, layout and calculation

8.4 Other references

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

British Urethane Foam Manufacturers Association Information document 1/2001, published by BRUFMA
Tel: 0161 236 7575

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

Building Research Establishment BR262 Thermal insulation: avoiding risks 2002 edition

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

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

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



Design Guide for Single Ply Roofing

Single Ply Roofing
Association

The Building Centre,
26 Store Street,
London WC1E 7BT
Tel: 0115 914 4445
Fax: 0115 974 9827
Email: enquires@spra.co.uk
Website: www.spra.co.uk

