DESIGN GUIDE FOR SPECIFIERS
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Liquid Applied Waterproofing Systems for Roofs and Balconies

FOREWORD

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Foreword

Through this Design Guide, the Liquid Roofing and Waterproofing Association (LRWA) aims to provide the building owner, specifier, main contractor and roofing contractor with guidance on selecting the right quality products, and how to ensure the correct specification and application for each individual project.

During recent years, liquid applied systems have made huge strides in providing solutions to the practical problems within the flat roofing and waterproofing industry. Changing circumstances within the market, health and safety concerns and technical advances have made it possible for liquid applied waterproofing systems not only to become part and parcel of what is perceived as the traditional answer to flat roofing problems, but to become the leading solution to solving these challenges.

The fact that liquid applications are totally seamless - and in many cases can be cold-applied - has not been overlooked by the roofing industry. Many liquid-applied waterproofing membrane manufacturers also provide complete insulated warm roof solutions for the new build and refurbishment sectors, many of which are completely cold-applied.

The versatile nature of liquid applied systems means it is now perceived as the perfect waterproofing solution for anyone who wishes to utilise a roof area as a green roof terrace or a pedestrian trafficked podium roof, many of which are found within shopping centre type projects.

In this guide, you will also find suggestions on how to carry out details with liquid applied membranes - but it is important to remember that every project is different and all details should be completed in accordance with the specified manufacturer's instructions.

Please note that this Design Guide is aimed to help you with providing nothing but the best quality waterproofing system for your project. However, because of the differing types of liquid membranes available, the manufacturer's specification must be strictly adhered to.

The information contained in this document may be freely used by any interested parties.

This Design Guide has been prepared by the Technical Committee of the Liquid Roofing & Waterproofing Association (LRWA), which comprises of the representation from all membership categories – manufacturers, contractors and associate members. Based on extensive research and with more than forty years' experience in the UK, it is the current industry view of best practice in the design, selection of materials, installation and maintenance of liquid roofing systems, and includes reference to all relevant European and British Standards as appropriate.

The main way to verify the performance of a liquid waterproofing product or system is via third party certifications, including European Technical Approval (ETA) certificates, British Board of Agrément (BBA) certificates and BDA certificates (issued by KIWA). These contain data that will confirm whether the waterproofing system will meet specified requirements - so long as the conditions of use are in accordance with the terms of the certificate - and/or satisfy The Building Regulations.

Since European and British Regulations, and product certifications, are under continuous review, the reader should confirm their status with the appropriate institutions before referring to them in specifications.

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1. OBJECTIVES AND SCOPE

1. Objectives

The liquid waterproofing sector offers a variety of durable and versatile systems. This Design Guide, prepared by the Liquid Roofing and Waterproofing Association (LRWA), gives advice and recommendations on the specification and use of liquid applied waterproofing systems. The Guide has been structured in order to achieve the following:

- Set a standard for the liquid roofing and waterproofing industry
- Describe performance criteria that a client may wish their system to achieve, in order for a design and specification to be prepared accordingly
- Set out aspects of design that need to be considered, and assist the decision-making process when meeting the client brief using a liquid applied waterproofing system, including relevant standards and regulations
- Provide technical information about liquid waterproofing applications, and aid understanding of materials that may be used in them, so that appropriate specifications can be prepared
- Describe aspects of workmanship relevant to design and supervision roles
- Give advice on appropriate inspection and maintenance schedules

1.1. Scope

The Guide covers the waterproofing of roofs, balconies and walkways (including associated fittings and constructions) using systems manufactured by LRWA members. It applies to domestic and non-domestic buildings, and its primary areas of focus are:

- Replacement systems for existing roofs requiring a thermal upgrade
- Product life extension systems for refurbishment projects requiring no thermal upgrade
- New build projects

The intended readership includes:

- Building surveyors
- Facilities managers
- Building owners
- Local government bodies, including local authorities, and health and education trusts
- Architects, specifiers and other design professionals
- Building inspectors
- Contractors

Householders do not form part of the intended readership. The LRWA collaborated with the National Federation of Roofing Contractors (NFRC) and the Single Ply Roofing Association (SPRA) to produce The Householder's Guide to Flat Roofing, which any homeowner looking for advice on domestic roofing should consult instead. **It is available via the NFRC website (www.nfrc.co.uk).**

Separate codes of practice, also published by the LRWA, are available covering hot melt systems and car park applications.

The Guide is not an installation manual, and does not replace LRWA training courses and qualifications. Nor does it replace technical literature, installation instructions, and/or design details provided by individual system manufacturers. System-specific instructions provided by manufacturers should be followed carefully at all times in order to ensure correct performance.

As it gives advice and recommendations only, the Guide should not be quoted as if it is a specification, and particular care should be taken to ensure that claims of compliance are not misleading. Compliance with this Guide does not in itself confer immunity from legal obligations.

The principles described in this guide should reflect the majority of circumstances encountered on roof, balcony and walkway projects, though site specific challenges can never be ruled out. Nevertheless, for properly maintained structures, the information described in this Guide can be expected to help achieve satisfactory performance.

It is assumed that all construction work and system installation relating to topics covered by this Guide are carried out by suitably qualified operatives.

2. CLIENT BRIEF

2. Overview

This section describes criteria that form part of a client brief, and which inform subsequent design decisions.

They are presented in no particular order of priority. That priority should be agreed between the client and designer, and preferably in consultation with the waterproofing system manufacturer. Identifying and agreeing the performance criteria for a project at an early stage allows them to be reviewed and adjusted as the design progresses.

The role of a liquid applied waterproofing system is to prevent water ingress. The chosen system must therefore be capable of providing the necessary protection, taking into account year-round weather conditions, the building's location and exposure, and foot traffic across the roof during construction and once the building is in service.

Other project-specific performance criteria are imposed by standards and regulations, the client's requirements, the design of the building structure and services, and project timescales for making the shell watertight.

Underpinning this section is the aim of reducing risk. For example, on many projects, hot works are inappropriate. Buildings also need to remain open and accessible, and waterproofing detailing is a challenge.

Liquid applied waterproofing systems lend themselves to overcoming these challenges. Most systems are cold-applied, eliminating fire risk on the roofs of occupied buildings. Meanwhile, fast-curing solutions minimise disruption, and the seamless application of liquid systems reduces the risk of leaks, thereby reducing the frequency with which operatives need to access the roof for maintenance.

2.1. Refurbishment projects and roof investigations

Existing buildings provide challenges not encountered in the design of new buildings. In order to be able to establish the performance criteria for a refurbishment project, it is first necessary to establish the construction and condition of the existing roof through a site survey. Once that has been done, design work can be carried out as described in section 3.1.

Even where a flat roof construction has not undergone significant modification since it was first constructed, a building owner may be unaware of the exact nature of its make-up. Previous attempts at refurbishment or repair can easily hide unfamiliar materials or existing problems that could jeopardise the longevity of a newly-applied waterproofing system.

The following investigations should be used to help establish the construction of an existing flat roof prior to design and specification.

Substrate

The successful application and performance of liquid applied waterproofing systems largely depends on the suitability and preparation of the substrate. A system can be applied to the substrate directly, or may be part of a build-up including insulation and ancillary materials.

In either case, the procedures and recommendations of the system manufacturer should be followed at all stages of installation - including substrate suitability and preparation.

For built-up systems, the insulation or carrier membrane is the substrate for the application of the waterproofing system, but the 'structural substrate' (the roof deck) may also require preparation prior to the installation of the insulation system.

It is preferable to choose a system where a single manufacturer either supplies or has approved the components for use within the system, this is to ensure compatibility and performance. However, this does not exclude the use of materials from different sources.

For the purpose of this Guide, substrates can broadly be categorised as follows:

(a) Substrates suitable for direct treatment

These are substrates which, when correctly prepared, provide a suitable base for the direct application of a liquid applied waterproofing system. These substrates may require pre-treatments, treatment and removal of biological growths, priming systems and joint treatments.

(b) Substrates requiring more detailed examination

These are substrates which require a detailed investigation before a waterproofing system can be selected. The investigation may include:

- Visual inspection of poorly-described existing substrates
- Core sample to determine or confirm the structure, and any insulation requirements
- Carrying out adhesion tests
- Moisture content measurement
- Substrate surface finish assessment

(c) Substrates unsuitable for liquid applied waterproofing systems treatment

Substrates unsuitable for direct treatment either need to be removed, or require the application of a carrier membrane over the complete roof area to provide a suitable base.

Thanks to the wide variety of liquid applied waterproofing systems available, a solution exists for most scenarios likely to be encountered. LRWA Guidance Note No. 3 lists the most commonly encountered substrates, together with explanatory notes, and represents the current knowledge of LRWA member companies.

Preliminary inspection

It is important to identify the correct roof construction and specification of the existing build-up in order to assess the work required. Waterproofing treatment should only be carried out on structures that are sound.

A full inspection of the existing construction and waterproofing system, including internal and external visual assessment, should be carried out in accordance with health and safety criteria (see Section 4). Pre-inspection guides the specifier toward the most suitable system, noting the needs for preparation and any other associated work described in this section of the Guide.

Incorrect identification could result in an inappropriate specification or application method. It may also lead to a dangerous situation for operatives working on the roof. Consider the following non-exhaustive list in each case:

- Flat, pitched or curved roof
- Cold or inverted roof
- Presence of, or requirement for, roof void ventilation
- Solar reflective or painted surface
- Slip resistance
- Insulation type
- Position of rainwater outlets, gutters or rainwater pipes
- Flashings and trims
- Penetrations
- Rooflights
- Ponding

Common misconceptions connected with identification include:

- All profiled or corrugated sheeting is fibre cement. It may be coated steel, aluminium or other composite material
- All materials that are black are asphalt. They can also be bituminous felt or a polymeric single ply membrane
- That all built-up felt is made up of three layers. The number of layers is often more or less than three. Bituminous felt is also confused with black coloured polymer layers, often laid as a single sheet
- That all flat metal sheet is lead. It is frequently zinc, aluminium, zinc-coated steel, copper or stainless steel
- That all fibrous decking materials are wood wool. They are frequently compressed strawboards

Condition surveys

A survey inspection must assess the condition of the supports, the roof deck, the insulation and the existing waterproofing, taking into account moisture, condensation and the possible requirement for ventilation or vapour control measures. A full examination is particularly critical for timber and other degradable or non-durable decks.

In many cases core sampling is the most effective method, however visual surveys and other non-destructive testing such as thermal imaging and moisture mapping may also be used where appropriate. In some cases a condition report may comprise one or more of these survey methods.

Core sampling

Core samples should generally be taken to assess the condition of the existing construction, and identify areas of concern such as damp insulation (whether from leaks or interstitial condensation). If a roof deck cannot be inspected from below, core samples should be taken through to the deck to assess its condition.

2.2. Substrates and investigations for new-build projects

The categories applied to refurbishment projects can also apply to new-build construction. The advice in the 'suitable for direct treatment' category, for example, can be applied to substrates of known manufactured quality, such as plywood.

Where it is possible for substrates to be more variable, such as cast in situ concrete decks, the recommendations given in the 'requiring detailed examination' category can apply.

Guidance on roof structure design for new-build projects is contained in section 3.3.

The waterproofing system for a new-build project is usually specified before the roof is constructed. It is still good practice, however, to inspect the roof deck prior to installing the system. In particular, the inspection should ensure the roof deck achieves the required falls for adequate drainage - see sections 3.11 and 3.12 for guidance.

2.3. Insurers' requirements

Since the disaster at Grenfell Tower in 2017, the construction industry has come under greater scrutiny both internally and externally. Building a Safer Future, the independent review by Dame Judith Hackitt, set out a range of recommendations that are gradually being implemented by the UK Government.

At the heart of those recommendations is a change of culture, away from 'business as usual' and 'we've always done it this way'. While the majority of the construction industry undergoes that cultural shift, in some sectors a more risk averse approach has been adopted in an effort to deal with a lack of certainty surrounding updates to regulatory requirements.

Arguably, such an approach is underpinned by a lack of understanding when it comes to how materials perform as part of the system in which they are used, leading perfectly suitable construction products to be ruled out from being used on projects. This is particularly the case when it comes to fire performance.

Insurers, especially those who deal with commercial and industrial properties, are mandating performance standards that exceed national building regulations in many circumstances. Consultation with the building insurer is recommended at an early stage to ensure their requirements form part of the client brief.

Even without the effect of the events at Grenfell, insurers have their own expectations for building performance. While national building regulations are concerned only with the safety of building users, insurers are also concerned with the protection of the property, so have traditionally placed greater demands on building fabric performance anyway.

FM Global is a US-based insurance company. 'FM approved' roof assemblies can be configured using their online RoofNav tool, which also offers related installation guidance from relevant FM Global Property Loss Prevention Data Sheets. Roof assembly tests are based on research and analysis of actual losses caused by roof fires on commercial and industrial properties.

An alternative certification scheme is operated by the Loss Prevention Certification Board (LPCB), which lists tested assemblies in the Red Book, both online and in print.

2.4. Fire performance

Solutions for achieving fire safety in buildings vary depending on a range of factors, such as the use of the building (i.e. what purpose group(s) it falls into), its occupancy, the height of the building, and other protection methods. Guidance on design for fire performance is contained in section 3.15.

Requirements for internal fire spread tend to put the onus on ceiling and deck specification, but may take into account other parts of the roof system (especially where compartment walls are concerned).

2.5. Thermal performance

'Energy efficiency' is a broad phrase, but serves as a useful catch-all term. The fundamental aim is to limit the carbon dioxide emissions from buildings; achieve a reasonable standard of building fabric performance; limit heat gains and losses more generally; and provide efficient and effective building service installations.

Assessment of energy efficiency changes depending on whether a project is the refurbishment of an existing building, or the construction of a new building. Guidance on design for thermal performance is contained in section 3.16, while a broader view of sustainability is offered in section 2.9 below.

Renovation of existing roof constructions

A key aspect of setting the brief for a refurbishment project is understanding whether the thermal performance of the roof needs to be upgraded as part of the works. A failure to address it early in the process risks leading to a compromised solution and/or non-compliance at a later date.

Airtightness / control of air leakage

Better levels of airtightness reduce the leakage of warm air from the building, reducing heating system demand in the process.

New airtightness measures in existing buildings must be designed with care so as to ensure they do not upset the moisture balance of the building fabric. This is more of an issue with walls than with flat roofs, but should be kept in mind when considering the building as a whole.

The airtightness of a building has a significant impact on the effectiveness of the chosen ventilation system and the availability of fresh air for building occupants. It is recommended that the desired airtightness rate and the ventilation system both be established from an early stage.

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Control of condensation

It is important that any roof design not only meets thermal performance standards in terms of U-value targets, but is also designed correctly as to avoid the risk of surface and interstitial condensation. Guidance on correct roof design can be found in BS 6229 and also in section 3 of this guide. Guidance on condensation risk may be found in BS 5250 in section 3.1. It is recommended that a U-Value Calculation and Condensation risk analysis are be carried out at design stage to ensure correct compliance. In refurbishment situations where all or part of the existing build up may be is retained, care should be taken to take into account the existing retained build up in any calculations.

Solar radiation and solar reflectivity of coatings

Solar radiation can negatively impact the durability of flat roof coverings, and alter the thermal performance of roofs as a whole. The infrared component of solar radiation can significantly increase summer cooling loads, even on well-insulated roofs. The ultra-violet (UV) component, meanwhile, is a determining factor in the ageing of building materials and construction products.

Solar gain

Roof glazing helps bring a high quality of natural light deeper into a building. While glazing achieves a worse thermal performance than a surrounding insulated roof build-up, solar gains and a reduction in energy use (through lower reliance on artificial lighting) offset the slightly increased heat loss, improving overall energy efficiency.

Solar gains form part of compliance calculations, so it is advisable to undertake daylighting design calculations at an early stage to gain an appreciation of the overall area of roof glazing required. The paragraphs about rooflights in section 3.18 offer some further guidance on daylighting.'

2.6. Roof loads - access

A flat roof construction and its waterproofing covering, including any surface protection, are influenced by the regularity with which the roof will be accessed.

Access and traffic during construction should be considered, in addition to the expected traffic once the building is occupied. Where substantial traffic is expected after the liquid waterproofing system is installed, but before the works are completed, suitable protection will be required.

Plant on a roof introduces a range of factors to keep in mind when setting a brief:

- The dead loads imposed by the plant
- The type of plant, how it is supported, and the implications for waterproofing around it
- How often access will be required
- Whether additional plant will be required/installed in future

For refurbishment projects, existing plant arrangements can be complex and make roof waterproofing difficult. The seamless nature of liquid applied waterproofing systems makes them a popular choice. Even so, the challenges posed by any existing plant arrangements should be fully assessed. For new-build projects, the type and location of plant should be agreed as early as possible to help with the specification of the most appropriate waterproofing system.

Flat roofs intended as amenity space, or which form part of escape routes in the event of fire, need to meet the appropriate requirements in terms of inclusive access and fire safety.

Guidance on design for roof loads relating to access is contained in section 3.9.

2.7. Roof loads - environmental

Site location and topography have the biggest influence on what scale of wind loading a flat roof is subjected to. In addition, the building design itself, and its relationship to neighbouring buildings, should also be factored in. An estimate of wind loads at an early stage of the project is advisable.

Snow loads should be factored into calculations as specified in the relevant standards for structural loads.

For further guidance on environmental roof loads, see section 3.10.

2.8. Acoustic requirements

Good acoustic design in buildings plays a significant role in occupant comfort and wellbeing. This is relatively easy to design into a new building, given sufficiently early consideration. For an existing building, improving acoustic performance may only be achieved by a wider-scale refurbishment of the existing build-up.

Establishing the likely acoustic requirements for a project at an early stage means they can be taken into account during design and specification. Impact noise from rain is particularly critical to the design solution employed. Control of noise generated inside the building puts the onus on ceiling and deck specification.

Guidance on design for acoustics is contained in section 3.17.

2.9. Sustainability

There are many facets to what is considered 'sustainable'. Where clients, architects, specifiers and contractors share a common vision of sustainability for a project, then all can work together in pursuit of that goal.

Where 'greenwash' (the practice of making something sound more 'eco-friendly' than it is) comes into conflict with values that prioritise minimal impact in the sourcing of materials, the end result is likely to be compromised.

Energy efficiency - as described in section 2.5 above, and section 3.16 - is a cornerstone of minimising the environmental impact of a building. Reducing the energy demand of a building means less carbon dioxide emitted to the atmosphere. But the materials used to construct the building can require huge volumes of carbon to be emitted in their production. This is the delicate balance that must be struck.

Then there is the disposal of materials at the end of a building's life, and whether materials and components can be recycled or reused. With climate breakdown now a common part of everyday conversation, it should come as no surprise if project briefs demand greater depth and understanding of sustainability issues. Guidance on waste management is contained in section 4.6.

Environmental Product Declarations

At the individual product level, an Environmental Product Declaration (EPD) - prepared in accordance with EN 15804 - is a document giving independently assessed and verified life cycle analysis. Information about a product or service is collected relating to five modules: production, construction, use, end of life, and reuse, recycle, recovery.

The 'production' module covers 'cradle to gate'; the next three cover 'gate to grave'. The final module is viewed as 'future benefits'. Results do not have to be declared in every module. An EPD is a standalone document, designed to allow similar products to be compared to one another objectively.

Traditionally, the BRE Green Guide to Specification has been the 'go to' source of environmental ratings for products. As life cycle analysis improves, however, more sophisticated tools like EPDs have become available, reducing the relevance of the Green Guide.

Starting with the 2018 version, Green guide ratings are no longer recognised by BREEAM. As long as projects are still being completed under BREEAM 2014 then existing Green Guide ratings remain available, but no new ratings are being assessed.

BREEAM

Attempting to assess the environmental impact of a building using life cycle analysis (such as EPDs) for each individual component is impossible. Whole-building assessment methods developed out of the need for a more holistic view of sustainability, since the true impact of a design can only be established when looking at everything working together.

The BRE's Environmental Assessment Method (BREEAM) is arguably the most well-known whole-building assessment scheme. There are five different BREEAM standards; New Construction is probably the most well known, while the others include Refurbishment & Fit-Out (for homes and commercial buildings) and In-Use (for commercial buildings).

A BREEAM assessment gives a project a star rating, measured against BREEAM benchmarks (which include Energy, Health & Wellbeing, and Materials). The star rating corresponds to a rating system which, from best to worst, consists of Outstanding, Excellent, Very Good, Good, and Pass. There is also an Acceptable rating, but this is only a feature of In-Use assessments.

Durability

Where sustainability is concerned, getting the expected life from a specified product is an important part of using resources responsibly.

Different building materials have different natural lifespans, so expectations for durability cannot be applied equally. Nevertheless, developments in material technology, together with improved understanding of how products should be installed and maintained, means the minimum expectation should be to meet a system manufacturer's claimed durability.

The durability of a material by itself, and the guarantee offered by a manufacturer on a system build-up, are not the same and should not be confused. The durability of an installed material relies on installation and maintenance procedures being followed in order for it to continue achieving its performance.

Durability often involves the question of economics versus sustainability. Doing the bare minimum to maintain the waterproofing of an existing roof that otherwise performs poorly should be viewed as nothing but a short term cost saving. In the long term, refurbishing a roof to achieve better thermal and acoustic performance achieves savings through energy use and reduced maintenance.

Other benefits that are harder to quantify centre on improved occupant comfort and wellbeing. Depending on the use of the building in question, this could mean reduced absence through sickness and better productivity, for example.

It is therefore recommended that product life extension systems offered by liquid waterproofing manufacturers should be considered for flat roofs that already demonstrate an acceptable level of performance in other areas.

Design considerations relating to durability are discussed in section 3.14.

Renewables

Renewable technology can help meet the heating and hot water needs of a building. However, it should complement good building fabric performance, rather than being relied upon to offset poor thermal performance and airtightness standards.

The potential for installing roof-level renewable technology, such as photovoltaic (PV) solar panels, should be discussed at an early stage of the project and the manufacturer/supplier consulted accordingly. The liquid waterproofing system manufacturer can advise on the use of their product in conjunction with renewables to ensure correct installation and to meet guarantee requirements.

Rainwater harvesting and attenuation

Generally speaking, a flat roof should be designed to shed rainwater quickly and effectively (see sections 3.11 and 3.12). Doing so avoids imposing unwanted and unexpected additional loads on the structure, especially if there would otherwise be a risk of ponding.

Rainwater storage (harvesting) systems can be located at roof level. Alternatively, they may be at ground or below-ground level. The United Kingdom does not provide an ideal climate for rainwater harvesting - there tends to be either too much or too little rainfall at any one time, rather than enough for the system to be consistently useful.

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If rainwater storage is to be a feature of a flat roof then the structure designed accordingly, and the storage system manufacturer consulted from an early stage to establish the potential impact on the choice of liquid applied waterproofing system.

Due to the inconsistency of rainfall volumes, and the increasing severity of extreme weather events, storm drainage in urban areas is frequently overcome by water volumes. Rooftop rainwater attenuation solutions are designed to form the basis of sustainable urban drainage systems SuDS, especially on buildings with a tight site footprint.

Rainwater attenuation, such as offered by a blue roof, is not rainwater storage. Rooftop drainage is slowed to avoid overwhelming the storm drainage on and away from the site, but designed in such a way that it takes no more than 24 hours to leave the roof (that being the design rate for the most extreme weather event).

Blue roofs are specialist systems that rely on void formers to temporarily hold rainwater. A green roof build-up (see section 3.7) can also provide a 'buffer' function, delivering some attenuation at the same time as irrigating the rooftop planting. Roof structures should be designed with the structural loads of a blue or green roof taken into account. Guidance on blue roof design, including relevant standards and publications, is contained in section 3.8.

2.10. BIM

The acronym 'BIM' can be interpreted a number of different ways. Arguably the most common is Building Information Modelling, which we will use for the purposes of this Guide.

Due to the visual nature of 3D modelling and rendering realistic virtual walkthroughs, the temptation may be to assume that modelling is the key function of BIM. Primarily, however, it should be seen as an information sharing platform, allowing greater collaboration from an earlier stage of the design process. This information sharing can continue post-construction, through the operation and maintenance phases, right through to end-of-life and even re-use of materials.

The use of BIM on a project might be mandated as a result of public funding. In other cases, the level of BIM adoption is more likely to be due to how forward-thinking the client is, together with the BIM-readiness and capability of other members of the project team.

Where BIM is to be used on a project, it is much more likely to be for new-build. It would be a particularly forward-thinking client who chose the time and expense of capturing an existing building in BIM - but that is not to say that some projects would not benefit from it. Contracts specify what information should be provided, and in what format(s), to achieve the employer's requirements.

There is an ongoing initiative to codify data for construction products, mainly through the use of Product Data Templates (PDTs). Historically, there has been little agreement on the content of product data files, which has been one hurdle to widespread adoption of Level 2 BIM.

An initiative called LEXiCON is in development to provide an industry-wide system for PDTs. Organisations and individuals with the appropriate sector-specific experience have been named as "relevant authorities" to ensure the suitability of PDTs within LEXiCON. The LRWA is the relevant authority for the liquid waterproofing sector.

3. DESIGN

3. Overview

The primary objective for a liquid applied waterproofing system is to waterproof, for the minimum period of time required by the client, the substrate to which it is applied. In achieving this, it must also allow the application in which it is used to function as intended.

Used on a flat roof, the liquid waterproofing system must allow the roof to act as an area for plant, equipment and other services, or as a leisure space. The chosen roof system build-up must be capable of allowing safe access to users and bearing the associated volume of foot traffic. It must also contribute to the other functional areas of building performance.

For balconies, terraces and walkways, access is equally critical, but other functional requirements - such as thermal performance - may not apply.

Design is likely to be subject to constraints, especially in refurbishment projects where thorough site surveys should be used to inform the choices made.

Constraints also exist in new-build projects, especially where changes are made, or issues come to light, late in a project. The liquid waterproofing system supplier should be engaged from an early stage to help ensure all aspects of the design are compatible.

This section builds on the elements of the client brief already discussed. Understanding these performance requirements can inform the aesthetic design of a proposal, as well as informing the materials specification discussed in the section after.

3.1. BS 6229 and BS 5250

A substantially revised version of BS 6229 Flat roofs with continuously supported flexible waterproof coverings. Code of practice was published at the end of 2018.

It sets out guidance and recommendations regarding what is considered to be current best practice in the design, construction and maintenance of "roofs with a flat or curved surface, at a pitch not greater than 10 degrees to the horizontal". The principles may be applied to roofs with a pitch greater than 10 degrees to the horizontal, provided the design conditions are similar.

It is recommended to read the relevant sections of BS 6229:2018 in conjunction with the guidance set out in corresponding sections of this Design Guide.

The previous version of BS 6229 (published in 2003) featured advice on designing to avoid condensation risk. That information has been removed from the 2018 version, as it has been covered by revisions to other standards in the intervening time - namely BS 5250:2011 + A1:2016 Code of practice for control of condensation in buildings.

BS 5250 gives detailed information about design for condensation risk, appropriate risk assessment methods for different construction types, and ventilation provision (where appropriate). It provides design guidance on managing moisture risk, taking into account that "occupants often fail to use buildings in the manner intended, be it by choice, lack of understanding or force of circumstance".

The standard therefore advises designers "to err on the side of caution and adopt robust fail-safe solutions."

3.2. Design constraints in refurbishment projects

The results of roof surveys, carried out as described in section 2.1, should inform the design of solutions for refurbishment projects. The surveys will indicate any constraints that are present. Only once all the facts have been gathered can a comprehensive design be undertaken. Those constraints may include some or all of the following non-exhaustive list:

- Flat, pitched or curved roof
- Cold or inverted roof
- Presence of, or requirement for, roof void ventilation
- Solar reflective or painted surface
- Slip resistance
- Insulation type
- Position of rainwater outlets, gutters or rainwater pipes
- Flashings and trims
- Penetrations
- Rooflights
- Ponding

3.3. New-build projects - flat, pitched or curved substrates

The term 'flat roof' is defined by the roofing industry in general, and refers to a roof with an angle of slope (or pitch) of no more than 10 degrees to the horizontal, acting as a barrier to climatic conditions. Many designers of liquid applied waterproofing systems, however, regard a flat roof as the plane or substrate carrying the waterproofing system. This substrate may be flat horizontal, flat sloping, or a plane of curvature. The weathering surface is continuous or made from large components, in contrast to a tiled or slated roof.

Flat roofs

Flat roof construction may be of in-situ or precast concrete (with or without an overlayer of concrete screed), metal decking, or timber or steel rafters supporting a structural deck. Any of these may support other materials, including any of the following that may be present below the weather-proofing system:

- Concrete or concrete screed (normal or lightweight)
- Plywood, oriented strand board (OSB), or softwood timber boarding
- Chipboard (no longer used for new construction, but may be found in refurbishment work and their structural integrity must be ascertained by a competent person)
- Plastic-based rigid foam insulation board (polystyrene or polyurethane-type products
- Fibreboard (various soft fibrous materials for insulation, in board form)
- Wood wool (wood fibres held by cement in an open celled board; no longer used for new construction, but may be found in refurbishment work and their structural integrity must be ascertained by a competent person)
- Strawboard (compressed straw, resin bonded; no longer used for new construction, but may be found in refurbishment work and their structural integrity must be ascertained by a competent person)

Where an existing roof is to be refurbished, the following covering materials are commonly found in UK construction:

- Mastic asphalt
- Built-up bituminous felt
- Flat metal sheets (e.g. lead, zinc, aluminium, copper, stainless steel)
- Polymer sheeting (laid as one layer)
- Fibre cement promenade tiles
- Liquid applied waterproofing systems

Pitched roofs

It follows that the industry definition of a pitched roof is one with an angle of slope (or pitch) greater than 10 degrees to the horizontal (usually to a limit of 70 to the horizontal), acting as a barrier to climatic conditions.

Pitched roofs are typically constructed from structural timber rafters and purlins, or timber trusses. Timber battens support tiles or slates that act as the primary covering.

Where larger spans are required (e.g. industrial buildings), steel or precast concrete roof trusses are covered with larger panels or sheet materials, such as profiled fibre/cement or metal sheets.

In the UK, the following materials are commonly found covering existing pitched roofs:

- Concrete tiles (single or double lap)
- Clay tiles (single or double lap, glazed or unglazed)
- Slates (natural, fibre cement and simulated resin-based; single or double lap)
- Profiled sheet (galvanised or coated steel, uncoated or coated aluminium, fibre cement or bitumen)
- Shingles (timber or reinforced bitumen)

Fully supported finishes are less likely to be used on pitched roofs compared to flat roofs, but may be used in certain applications such as north lights, dormers or mansards. They are laid over flat board materials and the finish may be:

- Mastic asphalt
- Built-up roofing felt
- Polymer sheeting
- Flat metal sheeting (e.g. lead, zinc, copper, aluminium)
- Liquid applied waterproofing systems

Curved Roofs

The surface materials used on curved roofs may be any of those used on flat or pitched roofs.

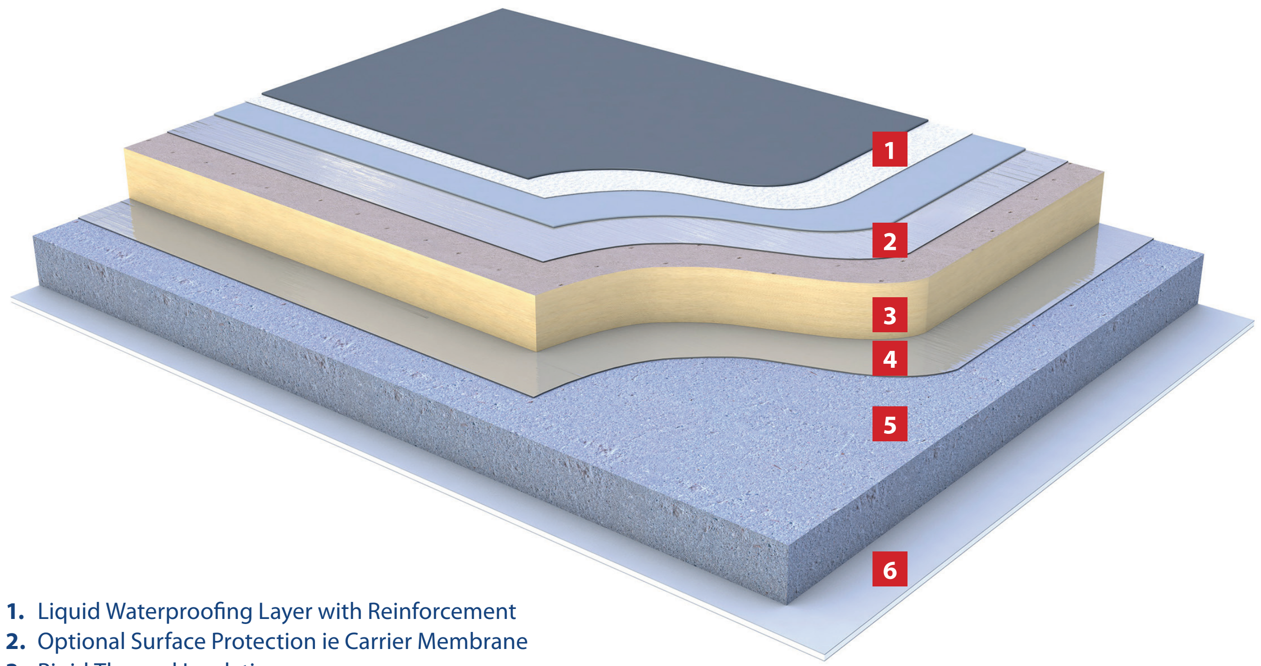
3.4. Types of flat roof construction

Roof constructions are typically categorised by the position of the thermal insulation relative to the structural deck.

Warm roof

Thermal insulation is installed over the structural roof deck and the AVCL, and immediately below the weatherproof covering. The roof deck is maintained at or close to the building's internal temperature throughout the year, and liquid applied waterproofing systems often act as the external finish.

Warm Roof Build-up

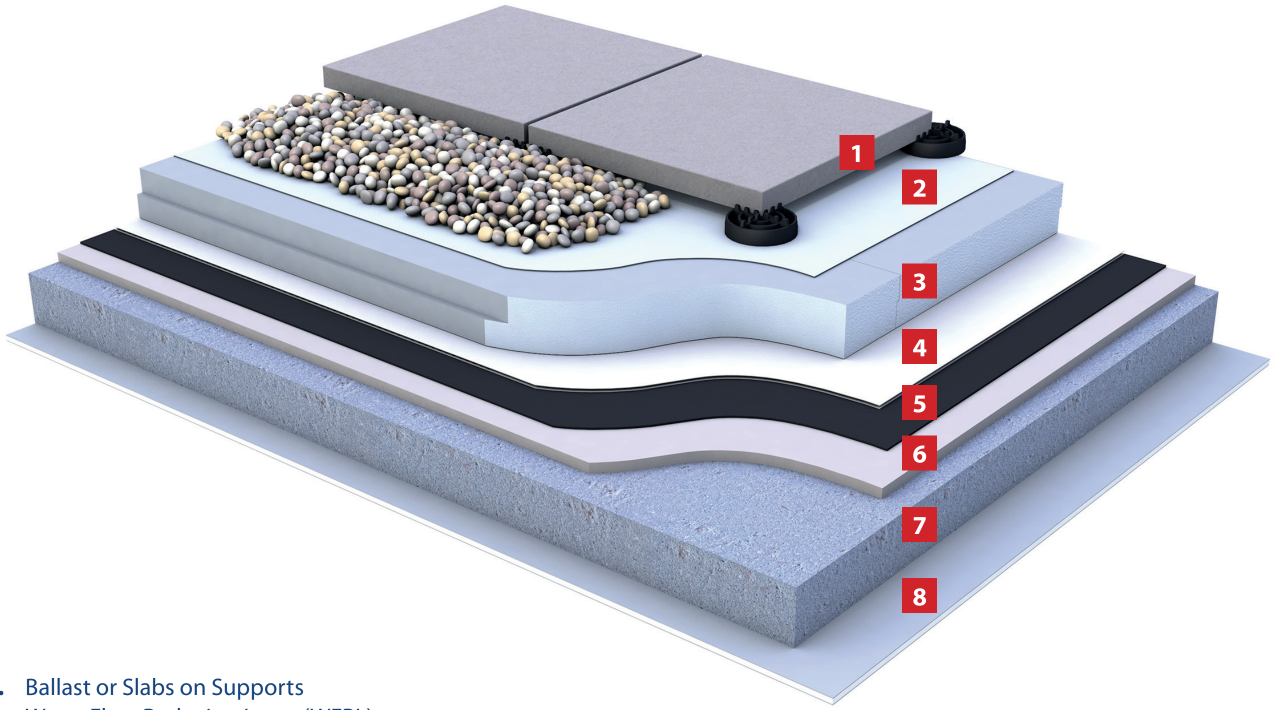


1. Liquid Waterproofing Layer with Reinforcement
2. Optional Surface Protection ie Carrier Membrane
3. Rigid Thermal Insulation
4. Air and Vapour Control Layer (AVCL)
5. Structural Slab/Deck
6. Internal Finish

Inverted roof

A type of roof, also called an upside down roof or protected membrane roof. The structural roof deck is waterproofed, prior to installing loose-laid thermal insulation (with a water flow reducing layer, WFRL, to restrict the flow of water into the system) and ballast. The roof deck and waterproofing are maintained at or close to the building's internal temperature, and the waterproofing is protected from ultraviolet exposure and seasonal temperature fluctuations. Liquid applied waterproofing systems are well-suited to inverted roof constructions.

Inverted Roof Build-up



1. Ballast or Slabs on Supports
2. Water Flow Reducing Layer (WFRL)
3. Rigid Thermal Insulation
4. Drainage Layer (Optional)
5. Liquid Waterproofing Layer
6. Screed to Falls
7. Structural slab/deck
8. Internal Finish

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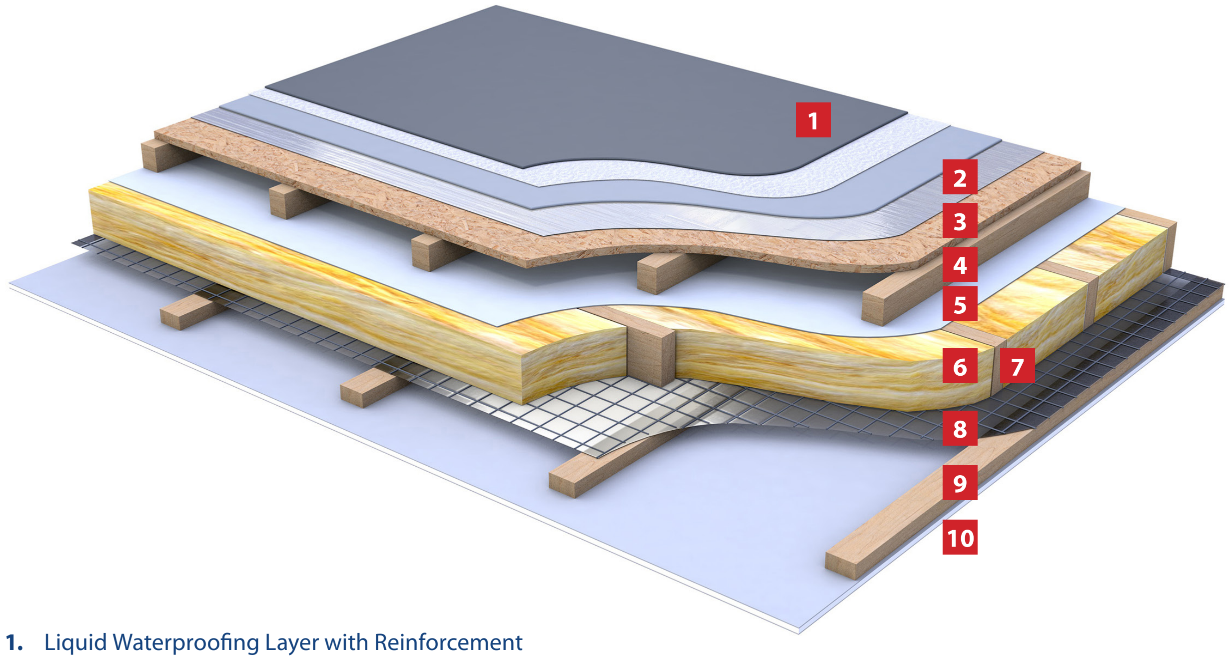
Cold roof

Thermal insulation is below the roof deck, usually at ceiling level. The roof deck is therefore at the external air temperature, and a well ventilated airspace is required between the insulation and roof deck to limit the risk of condensation. Liquid applied waterproofing systems are used as the roof deck's external waterproofing finish.

Effective ventilation is difficult to achieve, for which reason new-build cold roofs are extremely rare. Refurbishment of an existing cold roof must pay attention to the ventilation provision.

Cold Roof Build-up



1. Liquid Waterproofing Layer with Reinforcement
2. Optional Surface Protection ie. Carrier Membrane
3. Supporting Structure/Deck
4. Fixtures to Provide Vented Void (Min 50mm Deep)
5. Breather Membrane
6. Thermal Insulation
7. Structural Frame
8. Air and Vapour Control Layer (AVCL)
9. Furrings to Provide Service Void (min 25mm deep)
10. Internal Finish

3.5. Other roof types

Not all methods of roof construction fit neatly into the categories described above. Failure to recognise where exceptions occur can lead to incorrect assumptions about how a roof will perform.

Insulated decks

Some structural decks also provide thermal performance. Where an existing roof features a wood wool deck, for example, the build-up is not easily categorised. For new-build construction, structural insulated panels (SIPs) sandwich insulation between two sheet materials, and the manufacturer's advice and guidance should be followed at all times.

Hybrid roofs

A hybrid roof construction is one where constraints on build-up height lead to warm roofs failing to achieve the required U-value target. Insulation that cannot be accommodated above the deck is proposed below the deck instead - and therefore usually below the air and vapour control layer.

Hybrid roof constructions are not recognised by BS 5250 (see section 3.1) and are generally not recommended. They increase the risk of interstitial condensation, and can potentially introduce workmanship issues where it proves difficult to fix the insulation below the roof deck. U-value calculations and condensation risk analyses for hybrid roofs must therefore be treated with caution.

If a hybrid roof is completely unavoidable then, as a starting point, it is important to ensure that the thermal resistance of the insulation above the deck is greater than the thermal resistance of the insulation below the deck.

Fixing insulation in a hybrid arrangement does not change the ability of liquid applied waterproofing to be used as the roof deck's external finish, but manufacturers may be reluctant to support the proposed design.

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3.6. Balconies, terraces and walkways

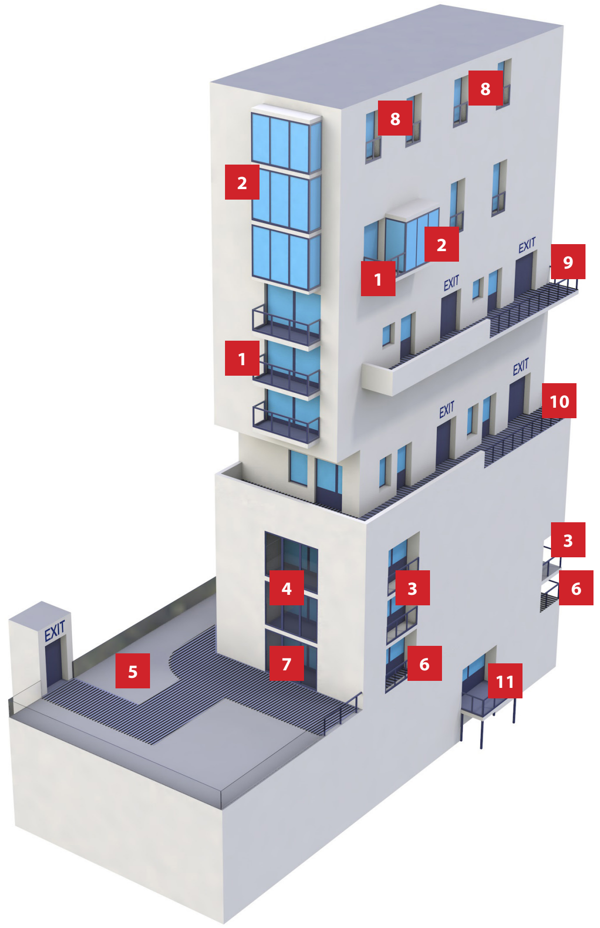
Liquid applied waterproofing systems lend themselves to applications other than the traditional flat roof constructions described above.

A balcony is an accessible external amenity platform above ground level exterior to and with direct access from a building. A balcony is formed above an external space that is not a habitable room. Balconies are typically of concrete construction. Existing balconies may be left exposed, waterproofed with asphalt, or receive an aesthetic coating.

Balconies often have a wearing surface as part of the liquid applied system, or can be finished with bonded tiles, loose laid tiles or decking. This Design Guide only covers waterproofing applications. Similar guidance can apply to aesthetic coating systems, but they should be installed in accordance with the manufacturer's instructions.

A flat roof used as amenity space is typically referred to as a terrace, and can also be described as a podium deck. Terraces tend be waterproofed, then receive separate finishes capable of resisting the wear and tear of public access (such as tiles, paving slabs or timber decking boards).

Walkways are areas of communal access to flats and can have a wearing surface as part of the liquid applied system or can be finished with bonded tiles.



At the time of writing this Design Guide a new British Standard has been drafted called BS 8579:2020: Guide to the design of balconies and terraces which is aiming to clarify the definition of all the various balcony types, terraces and walkways. See key below:

Disclaimer: Please refer to BS 8579:2020 as information may change upon publication.

Key

1. Projecting open balcony
2. Projecting enclosed balcony
3. Recessed open balcony
4. Recessed enclosed balcony
5. Terrace
6. Recessed open terrace
7. Recessed enclosed terrace
8. Juliet guarding
9. Access balcony [can be referred to as 'access deck' (see 3.1) or 'walkway'
10. Access terrace [can be referred to as 'access deck' (see 3.1) or 'walkway'
11. Free-standing balcony

- Terrace, access terrace and access balcony surfaces with fire performance BROOF (t4) or better (see Clause 12).
- Imperforate (as BS 9991) guarding materials reaction to fire class as in Clause 12
- Other guarding materials reaction to fire class as in Clause 12
- Other guarding

3.7. Green roofs

By their seamless nature, liquid applied waterproofing systems are suitable for use in green roof build-ups. Root resistant grades are also available, negating the need for a separate root resistant membrane. Four main types of green roof construction are generally defined:

Types of green roof	
Intensive	A rooftop garden, designed to be fully accessible and enjoyed as a usable space. Requires irrigation, a relatively deep layer of growing medium, and a regular programme of maintenance to ensure it remains a healthy and usable public space
Semi-intensive	Falls somewhere in the middle between intensive and extensive roofs, in terms of cost, thickness of growing medium, and amount of maintenance required. Can also incorporate elements of both, as well as featuring a greater range of planting
Extensive	Featuring a thin layer of growing medium, an extensive green roof is generally lighter and requires less maintenance than an intensive or semi-intensive roof. Sedum mats are an example of an extensive roof covering, and irrigation is not normally required once established
Biodiverse	Shares similarities to an extensive roof, but designed specifically to attract bird and insect life, using plants that create a specific habitat. Brown roofs are a type of biodiverse roof, but have fallen out of favour and a biodiverse green roof is seen as more effective

It is beyond the remit of this Design Guide to provide a detailed explanation of green roof construction. For further advice, consult with the green roof system supplier, and the Code of Practice for Green Roofs published by the Green Roof Organisation (GRO). Insurers are likely to have their own requirements for green roofs in terms of property protection.

3.8. Blue roofs

Currently, no British or European standard exists for blue roof water attenuation solutions. Liquid applied waterproofing systems can be used with blue roof solutions, provided the requirements of both the liquid waterproofing supplier and the manufacturer of the relevant blue roof components are met.

Typically, blue roof systems should be capable of attenuating rainwater drainage from a 100 year storm event, without impact on the rest of the roof construction, and draining the water completely within a 24 hour period.

Guidance on current best practice with regard to blue roofs may also be sought from BS 6229:2018 and the relevant NFRC Technical Guidance Note produced by the NFRC Joint Flat Roofing Technical Committee.

3.9. Roof loads - access

Flat roofs are an ideal location for plant or equipment, which requires suitable maintenance access. Podium decks are a type of flat roof where the space is used for leisure and amenity, while roofs can also form part of a means of escape in the event of fire.

Even where a roof is not designed to be accessed with any regularity, routine inspections and maintenance are still necessary to keep a roof in good working order and to prolong its useful life. The roof should therefore be designed with foot traffic loads in mind, including anticipating future requirements (especially if more plant may be installed at a later date).

Construction loads

On all roof types, the construction process places demands on the load resistance of the system. Particular consideration should be given to roof access points and the effect of repeated loads at the stepping on/off location. Similarly, the location of plant will have an impact on which areas of the roof are most frequently trafficked, and the provision of load-spreading protection may be required.

Categorisation of user loads

The following extract from the 'European Technical Approvals – General' PART 1 Standard describes selecting an appropriate liquid applied waterproofing system:

"The 'systems', including its support and protection (if any), shall be capable of withstanding mechanical damage due to the user loads likely to occur during its working life. The risk of mechanical damage will depend on the accessibility of the roof and the frequency of the traffic envisaged. Table 1 gives the appropriate categories of user loads and examples of the related accessibility."

Table 1 - Categorisation according to user loads

Category	User load	Examples of accessibility
P1	Low	Non-accessible
P2	Moderate	Accessible for maintenance of the roofing only
P3	Normal	Accessible for maintenance of plant and equipment, and to pedestrian traffic
P4	Special	Roof gardens, inverted roofs, green roofs

Dead loads

The dead load of roof top plant and equipment, including any renewable technology, should be effectively transferred to the load-bearing structure below. The method of support that helps to transfer the load should be taken into account when selecting the liquid applied waterproofing system, so as to ensure there is no weakness in the penetration/flashing detailing.

Any dead load applied directly to the liquid applied waterproofing system should be done with the agreement of the system manufacturer and the project's structural engineer, to avoid anything that might damage or reduce the effectiveness of the system.

The Eurocode for the structural design of buildings gives design loadings for different applications, including roof terraces. Concentrated loads imposed on thermal insulation through paving support pads must be allowed for. Standard compressive strength/compressive stress at 10% compression declarations may not be appropriate. Compressive creep declarations, based on long term compression of up to 2%, should be used instead.

Slip resistance

Different grades of liquid waterproofing can be specified according to the level of foot traffic expected on different parts of the roof. Walkways for access and maintenance should not cross areas that might be subject to temporary ponding. By contrast, roofs providing amenity space may be frequently used in wet conditions.

In all cases, appropriate slip resistance should be provided. A liquid applied waterproofing system usually achieves slip resistance through the use of a suitable aggregate with a bonding coat, or within the final layer of liquid in a multi-layer system. Alternatively, promenade tiles are capable of providing a safe surface upon which to walk.

Slip resistance is measured by a Pendulum Test Value (PTV), in accordance with the method prescribed by the Health and Safety Executive (HSE). The lower the value achieved, the higher the slip potential. Results are categorised as follows for people walking in a straight line on a level surface:

Pendulum Test Value (PTV)	Slip potential
24 or lower	High slip potential
25 to 35	Moderate slip potential
36 or higher	Low slip potential

Tests are carried out for dry and wet conditions, with worse results understandably achieved in a wet test. Handrails and/or fall arrest systems may also be necessary.

Surface protection

Most liquid applied waterproofing systems can be used as the final finish to the roof system. On occasion it is necessary to protect the system from exposure to ultraviolet light, roof traffic or fire spread. Suitable protection methods in these cases can include:

- Promenade tiles
- Aggregates
- GRP/GRC terrace tiles
- Concrete paviours
- Rubber granule extended coatings

Level access

Where a level threshold is provided between the inside of the building and a roof, special detailing may be required to meet access requirements. Pebble or soft margins at the perimeter of paved areas must be protected from wheeled equipment by a suitable kerb.

Stairways

Related to access for all building users, where waterproofing is applied on external or semi-external stairs, the liquid applied waterproofing systems can also be used to create a contrasting or reflective stair nosing.

3.10. Roof loads - environmental

Wind loads acting on a roof should be calculated in accordance with BS EN 1991-1-4 (which forms part of 'Eurocode 1') and the UK National Annex. Separate calculations for different wind directions may be necessary. Factors influencing the calculation include:

- Site location
- Building height
- Site elevation above sea level
- Site topography
- Distance from hills and urban areas
- Building design life
- Roof design

Various building design features introduce complexity in the behaviour of wind and should be accounted for accordingly; e.g. large openings, canopies, barrel vaults, and the effect of shadow zones.

The attachment of the complete roof build-up must be designed to exceed the design wind loads, including safety factors as deemed appropriate by the party carrying out the calculations. On inverted roof constructions, gravel ballast must be specified to resist wind scour as far as possible. If roof ballast is displaced, it must be reinstated to ensure appropriate restraint to the whole roof area.

The weight of timber decking will generally be insufficient load to resist calculated wind load and

so additional loading measures, or attachment of the roof system by adhesion or mechanical fastening will be necessary.

FM Approved roof assemblies require additional consideration due to property protection considerations. Calculations in accordance with BS EN 1991-1-4 are permitted so long as they are supplemented by certain conditions specified in FM Global Data Sheet 1-28. In order for any roof assembly (system) to become FM Approved it must obtain a minimum wind uplift rating of 2.87kPa (60psf) when tested to the method described in Standard 4470.

Design loads for snow are also given in BS EN 1991-1-4 and should be factored into calculations accordingly.

3.11. Falls

Flat roofs are usually constructed with slight falls to allow effective drainage. However, minor variations in the surface once installed allow water to collect with no way of draining. It is therefore advisable to design roof falls greater than the required finished falls to allow for construction tolerances and dead and imposed loads. In minor cases, water disappears within a few hours. On poorly constructed roofs, or old roofs where the structure has moved or sagged, water can remain for days or weeks. In these circumstances, the condition is called ponding. Many modern high -performance liquid applied waterproofing membranes are more than capable of accommodating ponding without detriment to the integrity of the waterproofing system. Certain systems are specifically designed for permanently submerged applications (including water features, fountains etc).

However, it is the opinion of LRWA that zero falls are not acceptable in an exposed roof situation and that ponding water should ideally be avoided because; it introduces greater potential for water penetration (and subsequent damage) if the roof finish suffers mechanical damage in a ponded area. A flat roof deck may suffer from progressive deflection due to the repeated increased loading caused by ponding. The more this happens, the greater the depth of water - which increases the load to which the deck is subjected. thus increasing the load on the structure, causing further deflection. Water on roofs increases the slip hazard, especially where algae occurs, and particularly when ice forms in cold weather. Build ups of dirt, leaves and algae are also unsightly and unhygienic. The following advice is given for specific applications and project types. LRWA Guidance Note No.7 includes further guidance.

Flat roofs are often subjected to standing water, or ponding, especially during or following heavy rain. Many modern high-performance liquid applied waterproofing membranes are more than capable of accommodating ponding without detriment to the integrity of the waterproofing system. Small areas of ponding water for example held behind field membrane seams or underlying laps in the waterproofing that do not remain for long and do not grow in size over time are unlikely to lead to the issues described above.

Creating falls on existing roofs

Ponding on an existing roof cannot be addressed by a new waterproofing finish alone. However, the seamless finish of a correctly installed liquid applied system should not increase the risk of standing water or ponding. The potential consequences of inadequate falls and ponding on an existing roof deck should inform the scale of refurbishment works, including whether to improve the falls and/or drainage. This can be achieved with a tapered insulation system for warm roof overlays, and/or additional outlets. Advice provided should always be based on a comprehensive site investigation report, i.e. if the roof is clearly not free draining then the degree of falls should be accurately assessed by taking levels. Any height increase to an existing roof should take into account the existing upstands, and ensure that the minimum upstand height is achieved.

Creating falls on new-build roofs

Reference should be made to BS 6229:2018 Flat roofs with continuously supported coverings, Code of practice, BS 8217:2005 Reinforced bitumen membranes for roofing, Code of practice and NHBC Standards. Adequate finished falls to aid effective drainage should be achieved either in the deck or by using tapered insulation. BS 6229 describes the minimum falls to which a roof should be designed in order to achieve the necessary falls on site, once construction tolerances, deviations and deflections have been taken into account. To achieve the necessary falls for drainage, a minimum fall of 1:80 is recommended, meaning the roof and gutter beds should be designed with a fall of 1:40. Falls may be achieved either through sloping the roof structure, or designing it to be flat and achieving the falls through the use of sloping screed, a tapered insulation layer, or firrings. The above applies to the use of liquid waterproofing systems in an exposed waterproofing application. Systems particularly designed for inverted roof construction - carry third-party certification stating their suitability for use with zero falls. BS 6229 recommends that to achieve a level surface, a fall of 1:80 should be designed It is essential that back falls (negative falls) are avoided, and local application of self-levelling screed can correct points of deflection that would otherwise hold water. Alternatively, positioning outlets at low points identified by a deflection analysis can also be an effective strategy. BBA Information Bulletin No.4 Inverted roofs – Drainage and U value corrections offers additional guidance on 'zero falls roofs.

Balconies and walkways

As applications designed for access, balconies and walkways are more at risk of slip hazards under standing water conditions. Ice is a particular risk for trafficked areas. For small or low risk areas it may be possible to design to falls of less than 1:80, provided that the area is completely free draining and there are no back-falls or hollows. The designer or client should be made aware of the risks if the area is not freely draining. Where flush access is required at door thresholds, attention should be given to allow adequate detailing. Please refer to BS6229:2018 section 4.5 Rainwater Disposal for guidance on level access.

3.12. Drainage

Roof drainage systems - including the number, size and location of outlets - should be designed in accordance with BS EN 12056-3:2000. Drainage can be via either direct discharge or siphonic drainage.

For direct discharge, rainwater outlet capacity should be taken from manufacturers' certified performance information. The number and layout of outlets should allow for obstruction and drag due to any additional surface finishes such as walkways.

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Siphonic drainage offers a high capacity, meaning fewer outlets, fewer downpipes and less detailing work on site. Its smaller bore horizontal collector pipework enables reduced roof void depth, and it is self-cleaning in many situations. For more information, see www.siphonic-roof-drainage.co.uk

Inverted roof constructions drain at two levels - the level of the water flow reducing layer (WFRL) and the waterproofing level (i.e. the structural deck).

3.13. Gutters

Gutters are usually constructed as part of the flat roof deck construction. In warm roof constructions, they may also be designed as part of the insulation system - especially in tapered insulation schemes. Gutter linings generally use materials that are the same as the main roof area.

Some internal gutters may not have a separate lining material as the main roof but be semi-structural self finished material such as galvanised or plain steel, cast iron or asbestos cement. These are usually included in liquid applied waterproofing system treatments.

3.14. Durability

Liquid applied waterproofing systems can offer durability from 5 to 25 years. The durability of products and systems is tested by artificial ageing, often as part of third party verification and certification.

Selected liquid waterproofing systems should hold a current European Technical Approval (ETA), British Board of Agrément (BBA) certificate or BDA Agrément certificate (KIWA), all of which assess fitness for purpose.

The following extract (including table) from the 'European Technical Approvals – General' PART 1 Standard indicates how categories are assigned to the working life of liquid applied waterproofing systems:

"The estimated working life of 'systems' for the intended use is 10 years. In special circumstances, where indicated by the applicant, this may be modified to 5 or 25 years.

"An estimated working life of 'systems' of 5 years shall only be assumed in the case of liquid applied waterproofing systems intended for use as a repair, renovation or maintenance medium only, or for use solely in construction works which have a limited intended life.

Specifiers should satisfy themselves before accepting quoted life expectancies of materials that are new to the market and have no track record.

The table gives the categories according to working life.

Category	Expected working life (years)
W1	5
W2	10
W3	25

"The indication given on the working life of 'system(s)' cannot be interpreted as a guarantee by the applicant (or the approval body) but is regarded only as a means of choosing the right products in relation to the expected economically reasonable working life of the works."

The above is not exclusive. Systems for 15, 20 and possibly in excess of 30 years may be offered. Fully protected liquid applied waterproofing systems may have working lives comparable to the structure itself.

The actual service life of a liquid applied waterproofing system depends on a variety of factors relating to design and maintenance, including:

- Achieving correct drainage falls
- Designing according to anticipated roof traffic
- Appropriate maintenance schedules and prompt attention to repairs

3.15. Fire performance

As with any aspect of national building regulations, the requirements for fire safety and performance represent a minimum standard that must be achieved. Guidance on complying with regulatory requirements for fire safety is contained in the following publications: n England - Approved Document B, volumes 1 and 2 n Wales - Approved Document B, volumes 1 and 2 n Scotland - Technical Handbooks, section 2 n Northern Ireland - Technical Booklet E Fire safety solutions vary from project to project depending on the building type, its use and occupancy, layout, height and construction, as well as the distance from surrounding buildings. Design solutions should take into account the fire performance of individual products and/or complete systems as required. The more complex the building, the more specific the requirements in terms of fire safety and performance. Applying general principles to buildings where specific provisions are required risks compromising fire safety. BS 6229:2018 provides useful guidance. Depending on the project's complexity, advice may also be sought from a fire engineer or other specialist. Some projects require consultation directly with the local fire service.

The Regulatory Reform (Fire Safety) Order 2005 relating to fire safety in non domestic premises imposes a general duty to take fire precautions as may reasonably be required to ensure that premises are safe for the occupants and those in the immediate vicinity.

Reaction to fire

Reaction fire measures how a product behaves when exposed to fire, and how the product continues to contribute to a fire as it decomposes as a result of that exposure. Products are classified according to BS EN 13501-1. From best to worst, the classifications are: A1, A2, B, C, D, E and F. A designation of NPD means 'no performance determined', as the product has not been tested. Classifications A2 to E have a designation for the production of smoke and/or flaming particles added.

Fire resistance

Three different aspects of fire resistance are all measured by the number of minutes that elapse during standard tests. 'Resistance to collapse' (R) applies to load-bearing elements only. 'Resistance to fire penetration' (E) is also called integrity. 'Resistance to the transfer of excessive heat' (I) is insulation. A construction element may need to meet all three aspects, in which case the performance would be written REI 30 (or 60, 90 or 120, depending on the period of resistance achieved/required). EI relates to an element that is not load-bearing, and sometimes only E is necessary. Again, they are followed by the number of minutes.

Fire performance of roofs

Among the requirements of fire safety regulations, it is necessary to ensure that a roof achieves sufficient resistance to external fire exposure, in terms of both penetration of fire and spread of flame. Depending on the rating achieved by a roof covering, there may be limitations on its use relative to the distance to site boundaries and adjacent buildings. That rating should be in accordance with the classifications in BS EN 13501-5, and established based on test 4 (t4) of Technical Specification TS 1187. Ratings range from Broof(t4) to Froof(t4), where Broof(t4) is the best. Used as part of tested roof constructions, liquid applied waterproofing systems are generally capable of contributing to a Broof(t4) rating. For inverted roof constructions, certain inorganic roof coverings acting as ballast meet the necessary standard for fire spread without testing, as allowed by European Commission Directive 2000/553/EC. The following feature in the majority of specifications, and drive the design of most inverted roof systems: loose laid gravel at least 50mm thick, or with a mass greater than 80 kg/m^2 (subject to maximum and minimum aggregate sizes, to resist wind scour); sand cement screed at least 30mm thick and cast stone or mineral paving slabs at least 40mm thick. Roof coverings outside of this will require to be tested to TS 1187 test method 4, regardless of whether they are non-combustible or not.

Roofs performing the function of a floor

Flat roofs are not generally classed as 'load-bearing elements of structure' by national building regulations. That is, they generally do not contribute to the building's structural stability by bearing the load of other parts of the building. The exception is when it performs 'the function of a floor'. Where a flat roof is part of an escape route from or across the building, it typically needs to achieve a fire resistance rating of REI 30 when measured from the underside.

Balconies and fire spread across external walls Liquid waterproofing systems are commonly used on balconies

Updates to fire safety regulations, particularly in England, since the events at Grenfell Tower have caused some confusion over the way that balconies should be treated. The Building Regulations in England were initially amended at the end of 2018. A fire at a block of flats in Barking in June 2019, where fire spread seemed to occur due to timber cladding on balconies that were outside the thermal envelope of the building, resulted in the issue of a further advice note. Paragraph 1.4 of the advice note says: "The view of the Expert Panel is that the removal and replacement of any combustible material used in balcony construction is the clearest way to prevent external fire spread from balconies and therefore to meet the intention of building regulation requirements…" Paragraph 2.1 of the advice note goes on to say: "Balcony fires can spread to the adjacent balconies or into the building. If combustible materials have been used in the balcony or external wall system, it is possible that fire may spread rapidly across the façade. The risk is increased if combustible materials are used extensively (i.e. in floors and facades of balconies and in certain geometries)." The use of the word "extensively" in connection to floors may lead to an interpretation that waterproofing systems comprising combustible material are unacceptable. Further clarification is needed on this topic, and consulting the appropriate authorities is essential when setting a brief and considering a design solution. Appropriate authorities could be fire engineers, the local fire service, or the Building Control Body carrying out inspection and approval work. It is anticipated that the new BS8579:2020 will clarify the definitions of balcony types, but it is worth bearing in mind the distinction between a balcony that is outside the building's thermal envelope, and one that forms part of the thermal envelope. An external amenity space marked as a 'Balcony' on an architectural drawing might be over a heated space. In those circumstances, it is part of the thermal envelope (commonly referred to as a roof terrace) and a thermal element in its own right.

As a flat roof, it is subject to all the normal provisions of the Building Regulations, including standards of fire safety and fire spread. Not only that but, as a flat roof, it is not part of the external wall construction, nor is it a 'specified attachment' as defined in the amended Building Regulations.

The waterproofing on a balcony which is normally covered by an inorganic roof covering is exempt under regulation 7 and is not covered by approved document B4 clause 10.15 (v1) as it does not refer to "specified attachments". For trafficable liquid applied roof and balcony waterproofing membranes this would also be the case.

LRWA and NHBC would classify liquid applied waterproofing systems as a membrane in its finished form.

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3.16. Thermal performance

Determining the requirement for the thermal upgrade of an existing structure is vital from the outset of a project to help establish the scope of the work.

In England and Wales replacement of more than 50% of an existing roof's area requires the whole of the roof to be thermally upgraded, as long as it is technically, functionally and economically feasible to do so. Refurbishment of an existing roof can simply involve the removal and replacement of the waterproofing membrane. Where this work affects at least 50% of the surface area of the individual roof (or where it constitutes more than 25% of the entire building envelope), the roof's thermal performance should be improved.

See below for further explanation:

1. Strip off more than 50% of the roof (or where it constitutes more than 25% of the entire building envelope):
   a. **Full Strip Off** (i.e. Replacing the existing insulated roof system to the structural roof deck) – this would mean that a new insulated roof would have to be re-installed to the whole area to meet the current building regulations
   b. **Partial Strip Off** (i.e. replacing the waterproofing membrane of a flat roof) - this would mean that the roof should be thermally upgraded across the whole area to meet the current building regulations
2. Strip off less than and including 50% of the roof (or where it constitutes less than 25% of the entire building envelope):
   a. There is no requirement to thermally upgrade the roof ie a waterproofing overlay is acceptable

The U-value target specified in the Approved Documents should be achieved, again where it is technically, functionally and economically feasible to do so (otherwise the aim should be the best improvement possible within the constraints).

A retained thermal element is an existing element in a building that is subject to a material change of use, or that becomes part of the thermal envelope when it was not before. Where a roof falls under this definition, it should be upgraded in accordance with the threshold and improved U-values specified in the Approved Documents, or as far as possible within given constraints.

The guidance in the Approved Documents also describes simple payback periods for renovated and retained thermal elements, as well as detailing situations in which consequential improvements apply. The summary given here should be read in conjunction with the relevant Approved Document.

In Scotland, the U-value requirement for refurbishment work depends on the building use, the size of the building and proposed extension, the extent of renovation or refurbishment, and the existing adjoining building. See section 6 of the relevant Technical Handbook for a more detailed description.

For dwellings, the thermal performance of new elements in an extension depends on the existing and (where applicable) proposed U-values of the walls and roof of the existing building. Where an existing roof is altered or reconstructed, it should meet a specified target if practical to do (otherwise, a less stringent target applies).

For buildings other than dwellings, thermal elements of extensions must meet a specified U-value target. Where an existing roof is altered or reconstructed, it should meet a specified target if practical to do (otherwise, a less stringent target applies).

In Northern Ireland, renovation of a thermal element means the addition of a new layer, or the replacement of an existing layer, and work to improve the thermal performance of the entire element. Patch repair of a flat roof is not considered to be renovation, but replacement of a waterproofing membrane is.

When it comes to improving the whole of a flat roof to meet the U-values specified in the technical guidance, the same 50% of the thermal element / 25% of the entire building fabric threshold applies as in England and Wales. Again, the area is taken as that of the individual element, not all elements of that type in a building. The area depends on whether the renovation is being carried out from the inside or the outside.

If in doubt refer to Local Authority Building Control for advice.

New-build compliance calculations

Where new-build construction is concerned, national building regulations across the UK use a whole-building method of assessment to determine overall energy efficiency and carbon emissions. The U-values of individual building elements are entered into approved calculation methods, along with numerous other characteristics of the building design, to determine the design's performance relative to a 'notional building'.

For domestic buildings, the Standard Assessment Procedure (SAP) is the calculation methodology used. For non-domestic buildings, the Simplified Building Energy Model (SBEM) performs a similar function.

Generally speaking, the notional building sets a Target Emission Rate (TER), which must be improved upon in order to demonstrate compliance. The nature of a whole-building assessment means some trade-offs are possible in the design. However, current versions of the regulations ensure that low values must be achieved as part of the design.

In England, this is done through Target Fabric Energy Efficiency (TFEE), and additional measure to the TER that must also be improved upon. Everywhere else, technical guidance to the different regulations simply specifies tighter threshold U-values that cannot be exceeded.

Thermal insulation to achieve U-values

Depending on the type of warm roof specified, a liquid applied waterproofing system can either be applied onto thermal insulation (a 'conventional' warm roof), or the insulation can be installed over the system (as is the case in an inverted roof). Suitability of an insulation product for either application should be confirmed with the insulation manufacturer, unless the insulation (and ancillary products) are being supplied by the liquid applied waterproofing system manufacturer.

Thermal performance of inverted roofs

Installing thermal insulation over the waterproofing places specific demands on the design and performance of the roof and its insulation. Moisture has two effects on thermal performance in inverted roofs:

1. Reduction in thermal performance of the insulation material due to moisture absorption.

Moisture absorption by insulation materials is addressed through the use of a moisture correction factor. The factor is applied to the declared thermal conductivity (λD) of the insulation, giving a design thermal conductivity (λU) that must be used in the calculation for thermal transmittance (U-value).

Always refer to the insulation manufacturer's datasheet for further information about declared and design thermal conductivities.

2. Cooling effect of rainwater reaching the waterproofed roof deck.

The rainwater cooling effect must be accounted for in U-value calculations, and is dependent on the volume of rainwater that reaches the waterproofed deck. To restrict how much water can pass through the system, a membrane called a water flow reducing layer (WFRL) is loose laid over the thermal insulation prior to installation of the chosen surface finish.

Insulation systems, including a WFRL, are tested according to a method in ETAG 031, to establish the percentage of rainfall that is able to enter into the system. This value (known as 'f') is used with the local average rainfall for the building location ('p') to establish a correction to the U-value for the effect of rainwater cooling.

Best practice for the installation of WFRLs is covered in detail by LRWA Guidance Note No.14. If manufacturers' installation instructions are followed, and site management restricts access to the roof until such time as finishes are applied, the WFRL will perform as intended and the roof will deliver the expected in-service thermal performance.

Where inverted roofs are designed and installed to achieve zero falls, the roof should be constructed so as to avoid backfalls or ponding and promote free drainage.

BS 6229:2018 identifies construction quality - and the installation of the WFRL in particular - as a reason for inverted roofs potentially under-performing and achieving a worse-than-expected in-service thermal performance. The standard attempts to mitigate against higher volumes of water reaching the roof deck than were designed for by proposing a 10% increase in the insulation thickness.

This increase is compared to the thickness established by the uncorrected U-value calculation (i.e. prior to calculating and applying the rainwater cooling correction).

The suggestion of a 10% increase in insulation thickness is contained within a note to the text of the standard, and as such is not part of the formal recommendations. The foreword of BS 6229:2018 is clear that: "Notes give references and additional information that are important but do not form part of the recommendations."

The note has caused confusion within the construction industry, because many specifiers view it as compulsory and are unaware of its status in the standard. In the main text, BS 6229:2018 is clear that U-value calculations should continue to be carried out in accordance with the combined method detailed in BS EN ISO 6946:2017. The combined method for calculating U-values includes the procedure for calculating the rainwater cooling correction for inverted roofs.

In product certification for inverted roof systems featuring thermal insulation and a WFRL, the British Board of Agrément (BBA) have chosen not to implement the suggested 10% insulation thickness increase. Doing so fails to take into account the variance in the rainwater cooling effect, which depends on project location.

Since rainfall volumes vary significantly across the UK, the magnitude of the U value correction (and consequent increase in insulation thickness) needed to compensate for it also varies. For the purposes of product certification, the BBA applies a minimum 'f' value of 2.5% to account for rainfall entering the system.

It is acknowledged that both a 10% increase in insulation thickness (BS 6229:2018) and a minimum f value of 2.5% (BBA) are arbitrary. The note in BS 6229:2018 makes reference to 'until further evidence and test data is made available', and an LRWA specialist technical group is currently working with the BBA to develop an updated system test.

The testing will assist the BBA approach of using a minimum value for f, and what that percentage should be, in order to calculate a consistent rainwater cooling effect across all roofs.

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In the meantime, it is prudent to consult with the thermal insulation manufacturer regarding the values used in U-value calculations. Where an inverted roof is being designed to act as a blue roof as well, consultation with the insulation manufacturer and the blue roof system supplier is recommended.

Thermal bridging and upstands

As part of achieving a high level of whole-building thermal efficiency, national building regulations require thermal insulation to be 'reasonably continuous' across the building envelope, with no avoidable thermal bridges.

Linear thermal bridges mostly occur at junctions between building elements, such as where a roof meets an external wall. For flat roof constructions, an insulated upstand is the typical solution for achieving some overlap with the external wall insulation and lengthening the path by which heat energy flows out through the construction.

The use of a load-bearing insulation block, especially in masonry construction, can help to achieve continuity of insulation between the wall and roof insulation as part of the wall construction. The subsequent upstand detail to the roof therefore requires no insulation.

Various schemes featuring accredited construction details, and providing psi values for use in compliance calculations, are available. Alternatively, some thermal insulation manufacturers offer calculated details featuring their own solutions.

If calculated psi values are not used in compliance calculations, generic values are used instead which heavily penalise the calculations and require significant improvements in performance elsewhere.

Airtightness, vapour control and condensation

Guidance on complying with regulatory requirements for moisture and condensation risk is contained in the following publications:

- England - Approved Document C
- Wales - Approved Document C
- Scotland - Technical Handbooks, section 3
- Northern Ireland - Technical Booklet C

Condensation occurs when the air temperature cools to the point that it can no longer hold its moisture content. When the temperature falls below the dew point, the excess moisture is deposited as condensation.

The likelihood of condensation occurring is based on the relationship between temperature and humidity (the actual moisture content of the air compared to its capacity, which alters with temperature), and how these parameters change throughout the layers of a construction - specifically between the warm (internal) side of the thermal insulation layer, and the cold (external) side.

Moisture content of the air is affected by airtightness and vapour control measures. Modern construction methods and improved understanding of building physics increasingly encourages airtight construction. The idea is to keep warm air in the building, rather than allowing it to leak through the building fabric.

Airtightness standards are set by national building regulations, and included in compliance calculations. Where a particularly high standard of airtightness is required, designing to keep the number of penetrations through the building fabric - including a flat roof - to a minimum is essential.

Voluntary standards, such as the Passivhaus standard, aim for much stricter performance levels. Ventilation design for the building, appropriate to the level of airtightness, is essential for the health and comfort of building occupants, but is beyond the scope of this Guide.

Ventilation of the roof structure - i.e. a flow of external air through the construction, but isolated from the internal climate of the building - should only be a feature of cold roof constructions.

Restricting the passage of warm air into the building fabric reduces the quantity of moisture vapour available to potentially form as condensation when the warm air comes into contact with colder surfaces. Vapour control layers (VCLs) are common terminology in construction, being positioned on the warm side of the thermal insulation layer.

Airtightness and vapour control measures can be separate, but are often achieved at the same layer of a building element, especially in flat roofs. This has been recognised through the adoption of the term 'air and vapour control layer' (AVCL) in BS 6229:2018.

The term 'breathability' might arise during discussions about vapour control, though this should generally be avoided. Breathability refers to a variety of moisture transfer processes that can occur in building materials. It is perfectly possible to construct buildings using breathable materials, and such buildings can also be airtight (since breathability and airtightness are not the same thing). Given the nature of the materials and constructions discussed in this Design Guide, however, breathability is unlikely to be a consideration.

Building occupancy and use has an impact on the risk of condensation. High humidity occupancies such as swimming pools, kitchens and laundry introduce much greater quantities of moisture vapour into the air. Buildings with a low humidity, such as warehouses, represent a lower risk of condensation.

National building regulations, backed up by third-party certification documents (such as BBA or BDA Agrément certificates) specify threshold U-values that a construction must achieve in order to avoid surface condensation on the inside of a building. Thermal performance therefore has a direct correlation with condensation risk.

Insulation specification helps to achieve target U-values for the project and contributes to avoiding surface condensation. It is not a guarantee against interstitial condensation, however. Whatever the design and specification, poorly constructed building fabric can allow warm, moist air into the structure, and condensation can occur unseen within the layers of the roof build-up.

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Roof design and construction should follow the principles of BS 5250. It is generally sufficient for condensation risk analyses for flat roofs to be carried out in accordance with the Glaser method, specified in BS EN ISO 13788. Most insulation manufacturers providing a U-value calculation service also supply a condensation risk analysis, carried out to this standard.

Such analysis does not excuse poor construction quality, especially as it is very much a simplified calculation model based on steady state conditions and nominal performance data for many roof components.

Assessments of condensation risk for flat roofs should take into account clear sky radiative cooling during the heating season (i.e. winter) as described in BS 6229.

Applying airtightness and vapour control principles is easier for new-build construction than it is for existing buildings. Traditional construction methods and materials, some of which may no longer be appropriate, should be full investigated prior to the commencement of design and specification.

To help with reducing the risk of condensation, the following principles should be kept in mind:

Warm roofs

- Avoid thermal bridging across components with high thermal resistance.
- Avoid thermal bridging due to gaps in insulation.
- Avoid areas with reduced thermal resistance (e.g. box gutters) unless it can be demonstrated by reference to BS 5250 that condensation will not occur during service.
- Avoid air movement through and across the roof system
- Continuity and termination of AVCL at upstands and details generally
- The effect of penetrations through the AVCL

Inverted roofs

- Avoid surface condensation on lightweight decks
- Maximum possible drainage above insulation by designing the deck to correct falls
- Correct specification and installation of a WFRL
- Avoid thermal bridging due to gaps in loose laid insulation

Cold deck roofs

- Clear routes for through ventilation
- 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 (openings at one end only are not sufficient)

Climate effects

The following extract from the 'European Technical Approvals - General' PART 1 Standard indicates how categories are assigned to two European Climate zones:

"The 'system', including its support and protection (if any) shall be resistant to the solar exposure effects (solar energy, temperature etc) occurring during its expected working life, which will depend on the geographical location of use. Two categories of climatic zone have been established (Moderate and Severe) and a table defines the limiting values for mean annual radiant exposure and the mean air temperature during the warmest month. The UK comes into the Moderate zone."

Solar reflectivity

The colour of a roof covering material alters the extent to which heat is absorbed. Reduced heat build up is desirable since it reduces the rate of degradation which can occur within the coating, and also presents the possibility of a more equitable environment within the building structure.

Dark colours absorb more solar radiation and transmit it to the rest of the roof system. At night, they radiate heat at a greater rate, cooling the roof surface in the process. While this 'cool roof' concept is recognised, it is not currently accounted for in calculation methodologies for building regulation compliance.

Light coloured finishes - typically white, light grey, obtained either by overcoating or by self colour, reflect a greater proportion of the sun's radiated energy compared with dark or black finishes. Light finishes therefore benefit from a lower level of heat build up within the roof deck and the building.

Liquid applied waterproofing systems may be applied onto existing solar reflective finishes after suitable preparation and/or priming. Consult the system manufacturer for further advice.

3.17. Acoustics

Guidance on complying with regulatory requirements for the passage of sound is contained in the following publications:

- England - Approved Document E
- Wales - Approved Document E
- Scotland - Technical Handbooks, section 5
- Northern Ireland - Technical Booklet G

Sector-specific guidance on acoustic performance should also be consulted where necessary. Building Bulletin (BB) 93 describes performance standards for schools; Health Technical Memorandum (HTM) 08-01 does the same for healthcare premises.

Sports facilities funded by Sport England, Sport Wales or Sport Scotland should follow the design guidance published by the respective body.

Acoustic performance is heavily dependent on material and product specification. As a general rule, more density equates to better acoustic performance (hence a concrete deck achieves a better acoustic performance than a timber or metal deck).

Fig. 1 - Warm Roof - Minimum 300mm Insulated Upstand

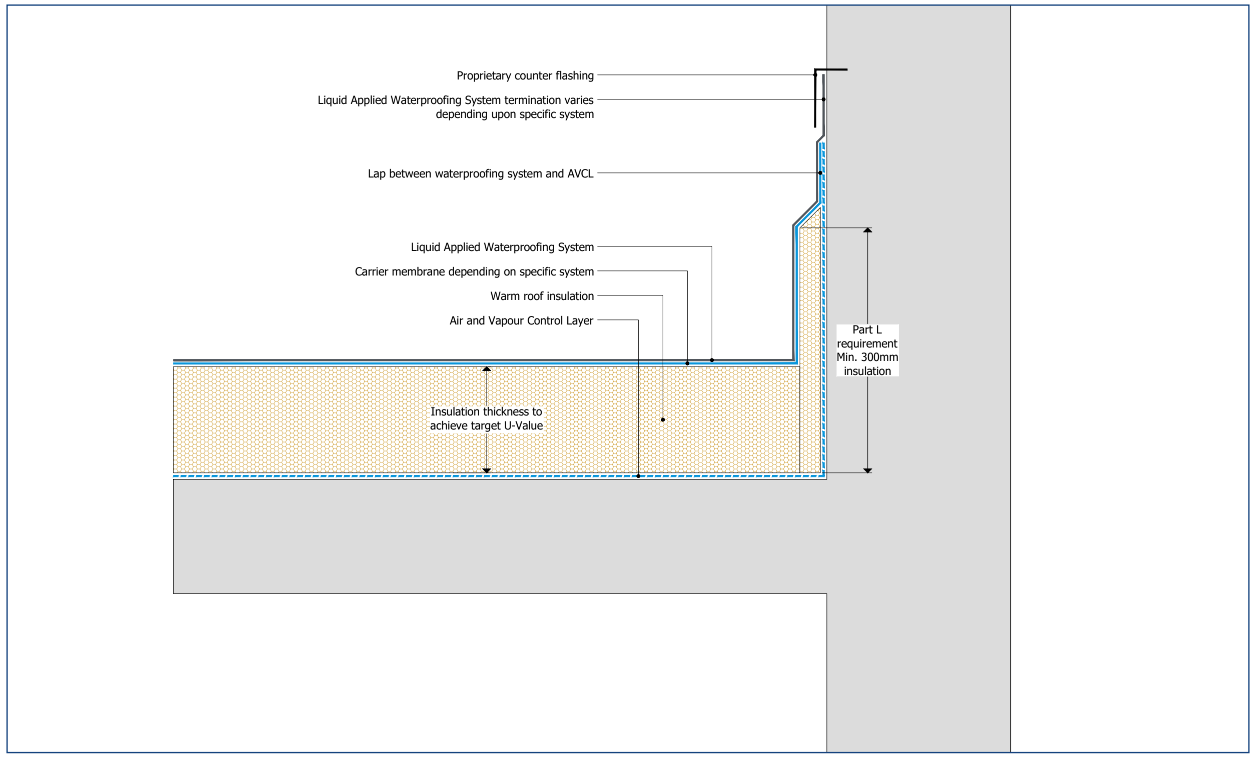

Fig. 2 - Warm Roof - Typical External Gutter

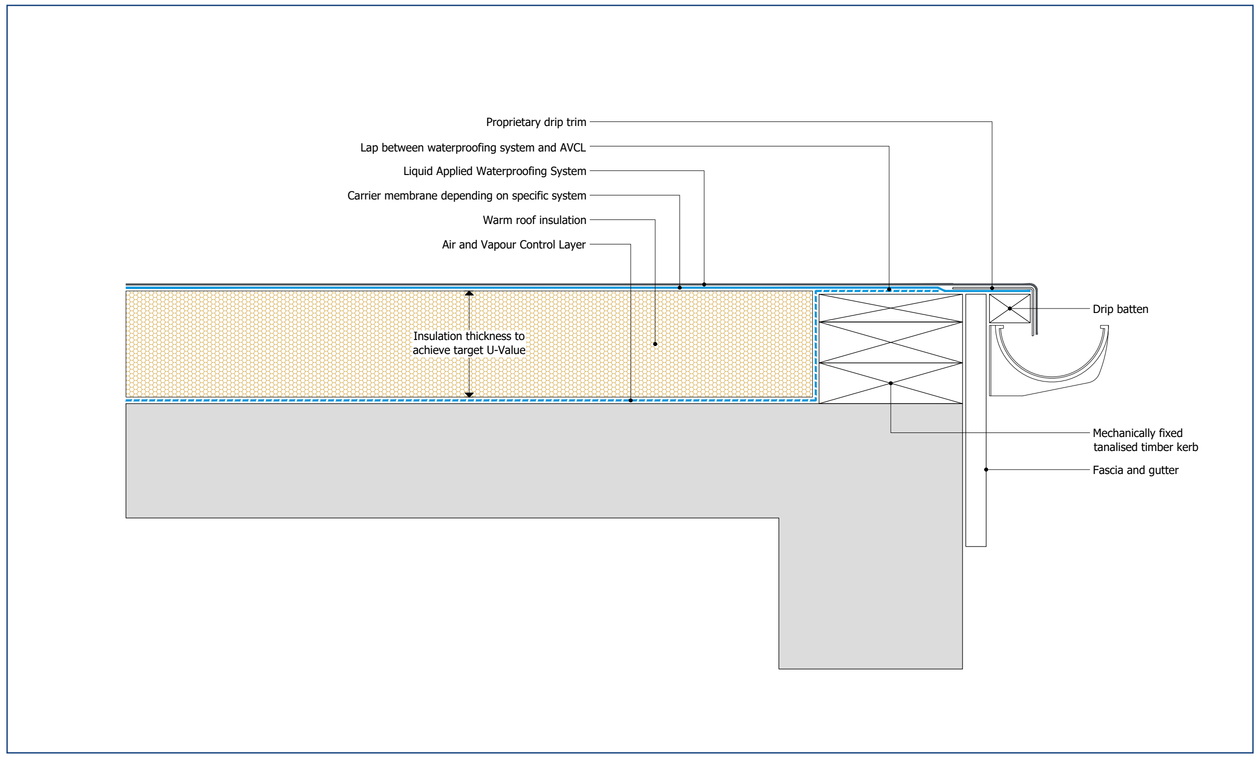

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Fig. 3 - Warm Roof - Typical Movement Joint with Raised Kerbs

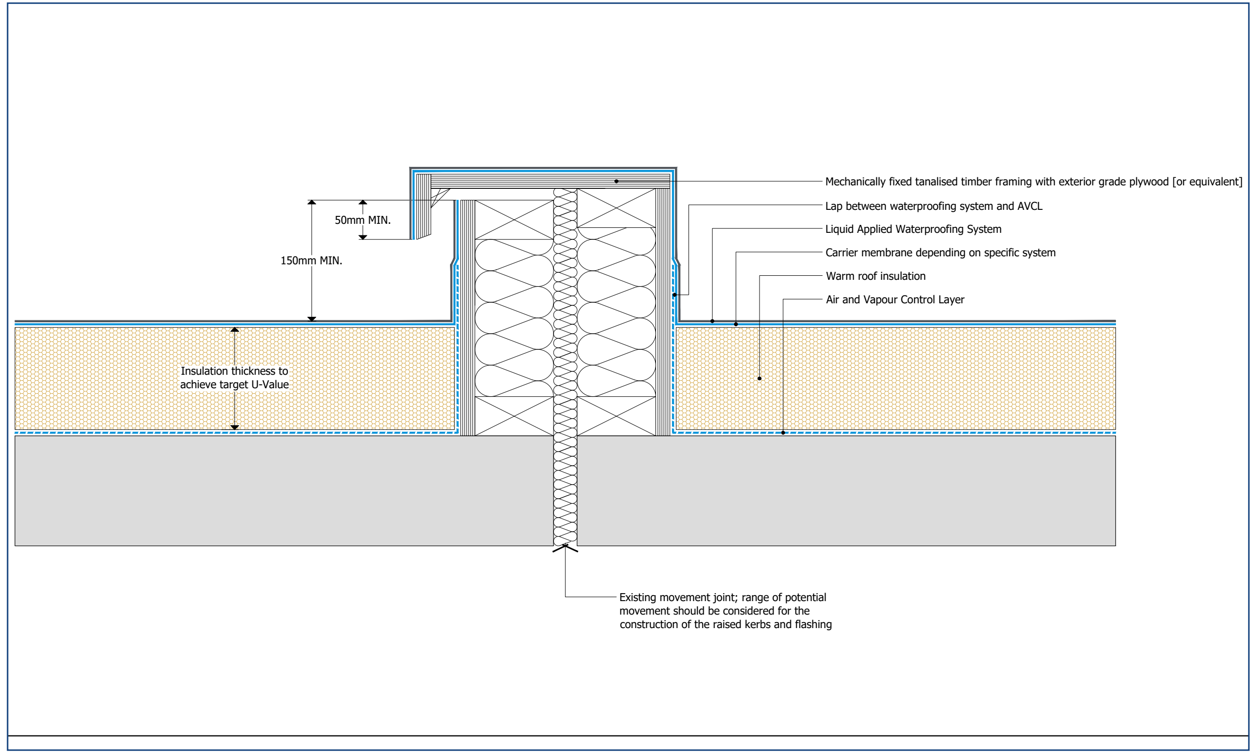

Fig. 4 - Warm Roof - Typical Pipe Penetration

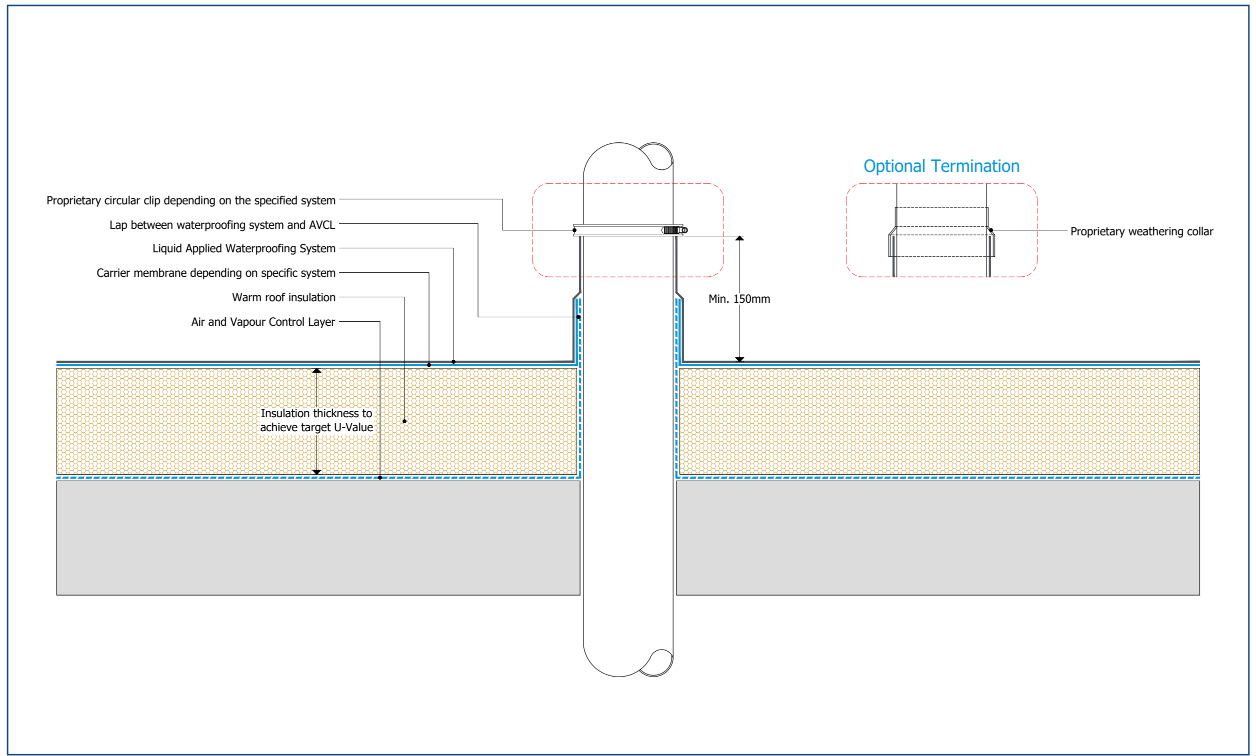

Fig. 5 - Warm Roof - Typical Rooflight or Access Hatch

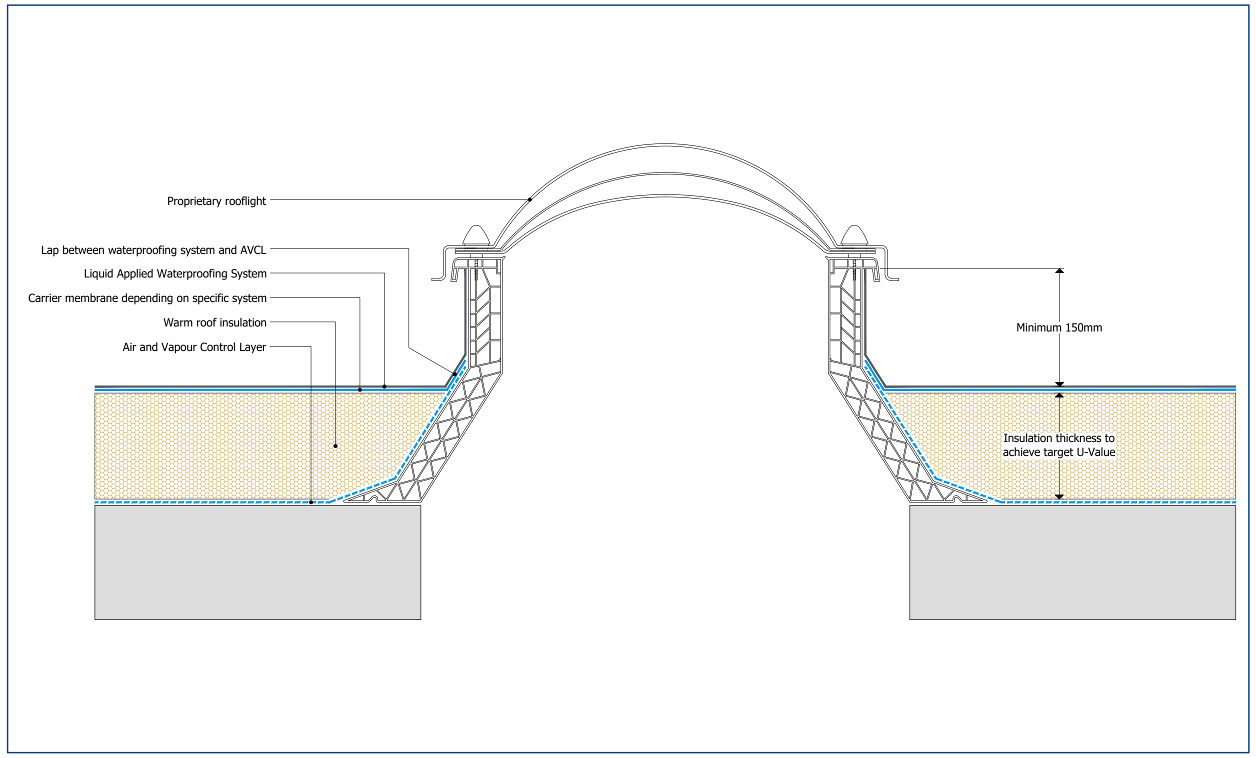

Fig. 6 - Warm Roof - Typical Sumped Internal Outlet

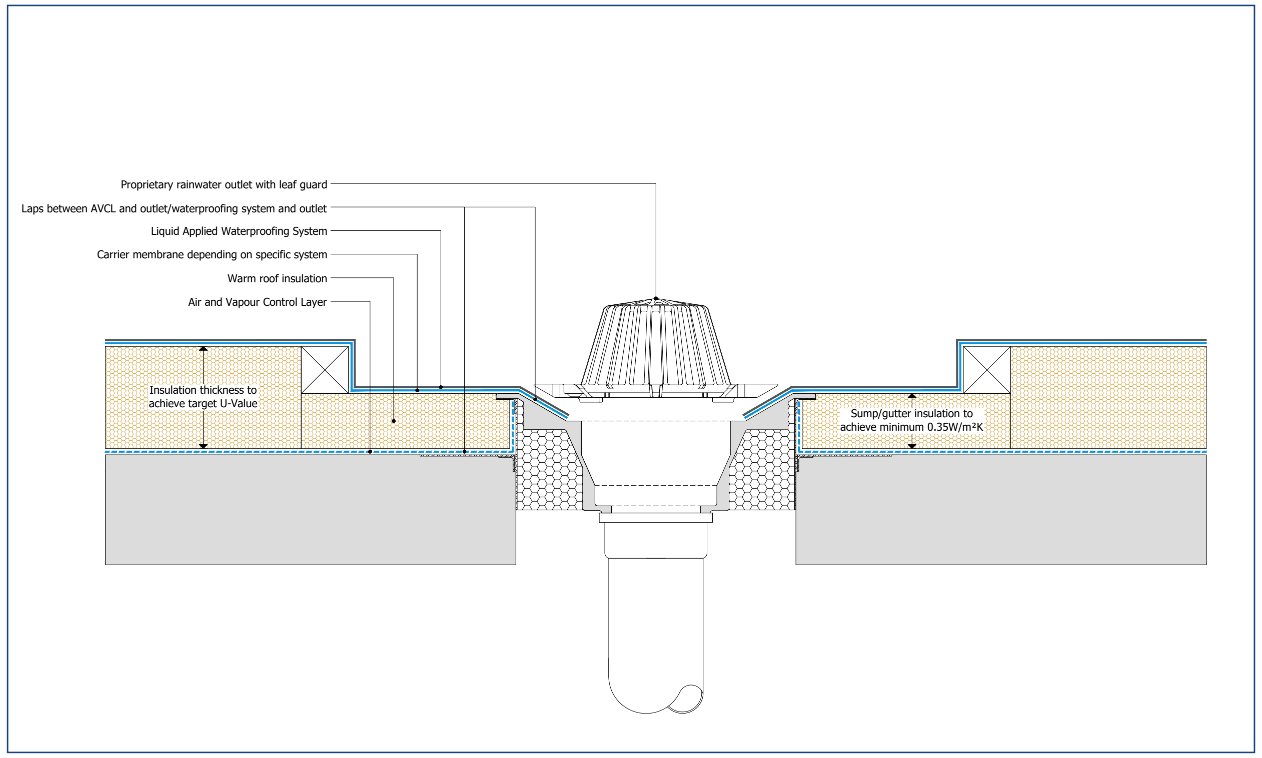

Fig. 7 - Warm Roof - Typical Watercheck

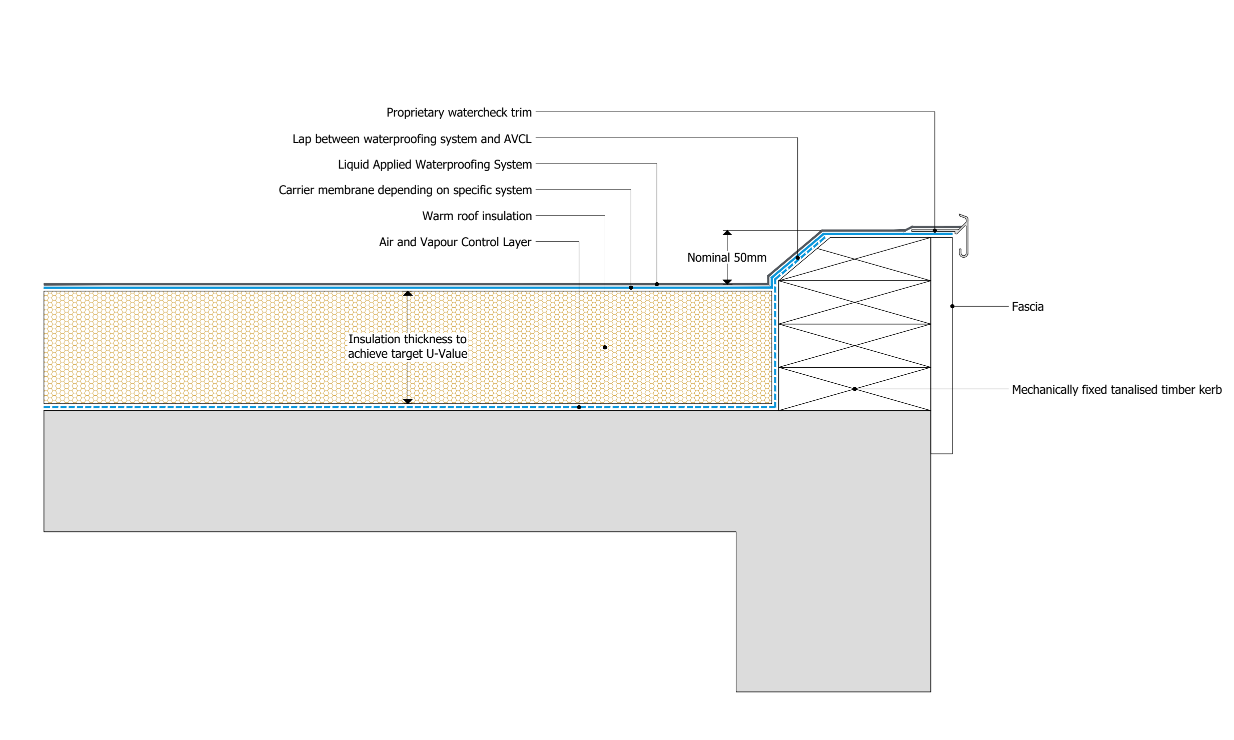

Fig. 8 - Inverted Roof - Typical Balcony with Low Level Threshold

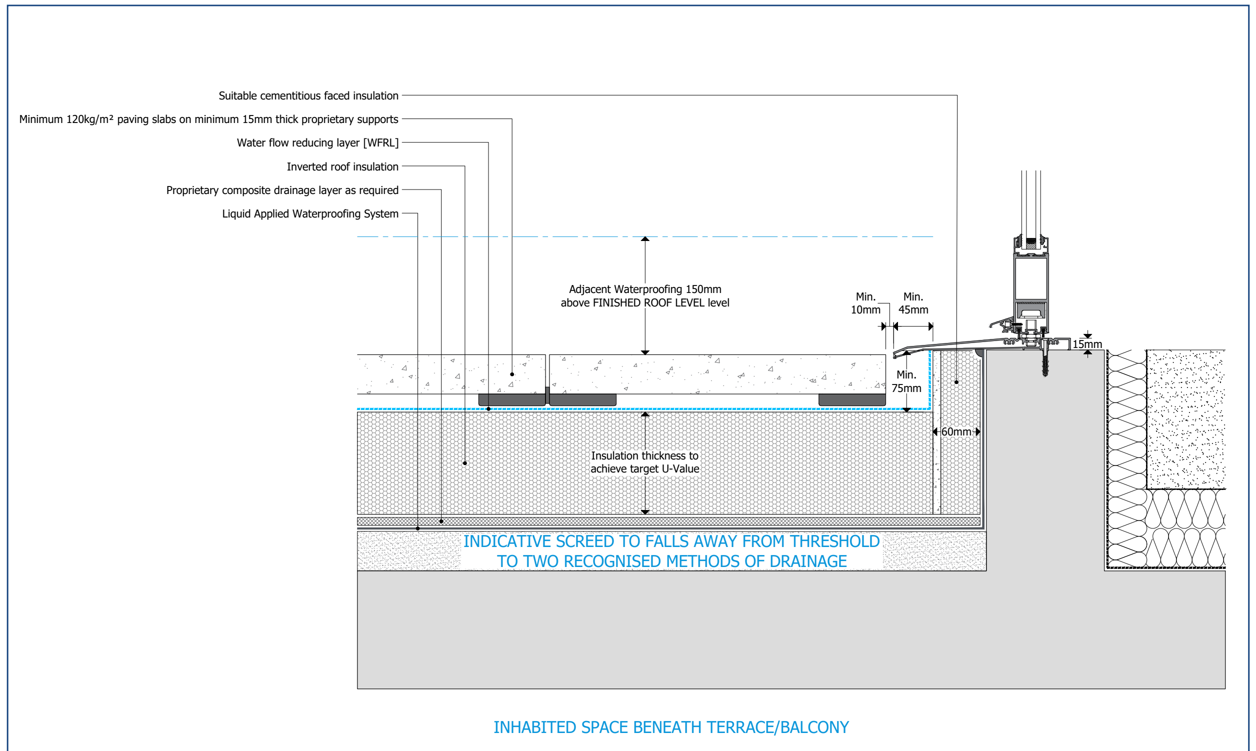

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Fig. 9 - Inverted Roof - Typical Insulated Parapet

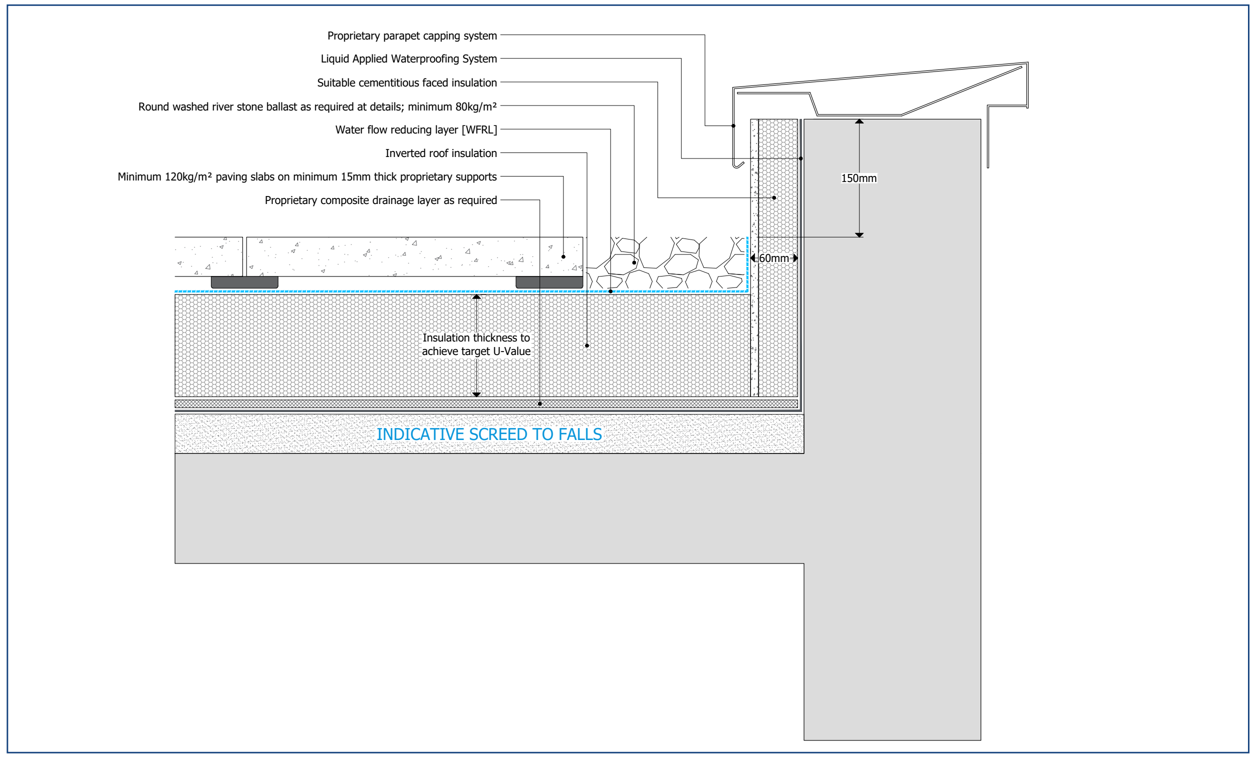
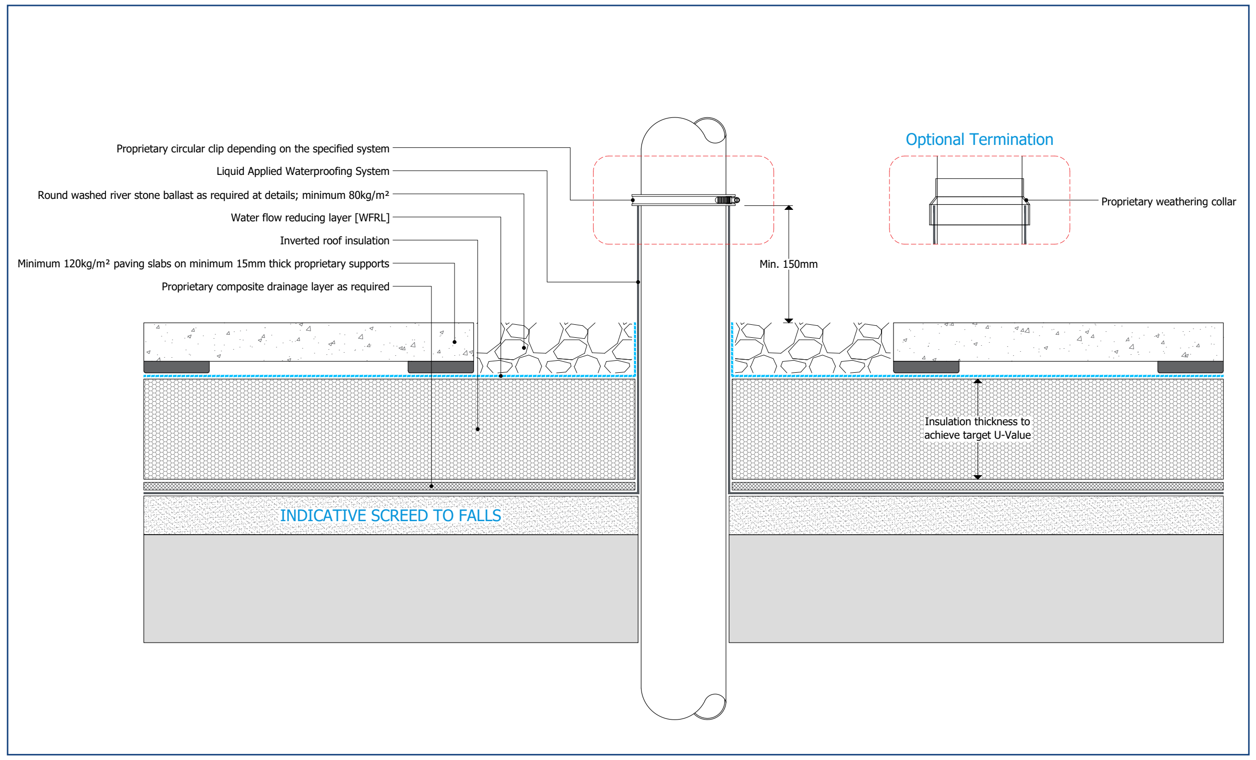


Fig. 10 - Inverted Roof - Typical Pipe Penetration



3.18. Details and terminations

Flashings and trims

Flashings are generally required on upstand details unless the detail is otherwise suitably protected. For refurbishment work, flashings can be made of flexible sheet materials such as lead, aluminium, copper, zinc, asphalt, bituminous felt, PVC, self-adhesive flashing tapes or lead.

Some liquid applied waterproofing systems can be self-flashing with suitable termination details. The manufacturer's recommendations should be sought.

Trims are generally of pre-formed or extruded aluminium or GRP.

Rooflights

For all flat roof systems, out of plane rooflights are the norm; they comprise an upstand kerb and a glazing element. The upstand kerb is waterproofed to a suitably protected termination.

Rooflights of all types may be broken or cracked, so should normally be replaced. Sheet glass may have slipped down the roof within their frames; these should be repositioned or otherwise replaced. Where side joints of patent glazing are leaking they should be waterproofed as part of the liquid applied waterproofing systems treatment. The manufacturer's guidance must be sought.

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

Common details

The following typical details demonstrate general principles behind and are not intended to be used as construction details. System-specific guidance should be provided by liquid applied waterproofing system manufacturers.

- Fig. 1 - Warm Roof - Minimum 300mm Insulated Upstand
- Fig. 2 - Warm Roof - Typical External Gutter
- Fig. 3 - Warm Roof - Typical Movement Joint with Raised Kerbs
- Fig. 4 - Warm Roof - Typical Pipe Penetration
- Fig. 5 - Warm Roof - Typical Rooflight or Access Hatch
- Fig. 6 - Warm Roof - Typical Sumped Internal Outlet
- Fig. 7 - Warm Roof - Typical Watercheck
- Fig. 8 - Inverted Roof - Typical Balcony with Low Level Threshold
- Fig. 9 - Inverted Roof - Typical Insulated Parapet
- Fig. 10 - Inverted Roof - Typical Pipe Penetration

4. Overview

The construction build-up chosen to meet the client brief and technical design must be capable of meeting the national building regulation requirements for the country in which the project is located. Selecting materials as part of the chosen solution means taking into account their individual performance, as well as how they work together as a system.

National buildings regulations include a regulation relating to materials and workmanship. Separate technical guidance - such as Approved Document 7 in England and Wales, supporting regulation 7 - is published to help designers, specifiers and installers understand how materials can be judged in terms of fitness for purpose, and the minimum level of quality that should be achieved on site.

Generally speaking, materials should be 'adequate and proper', and be:

- Appropriate for the circumstances in which they are used,
- Adequately mixed or prepared, and
- Applied, used or fixed in a workmanlike manner, so as to adequately perform the functions for which they are designed.

Building materials and construction products should meet the standards which cover their production/manufacture. Relevant codes of practice are a useful source of information about these standards; the materials section of BS 6229:2018 describes different material standards for roofing, for example.

In addition to product standards and technical approvals at the European level, independent third-party certification at the national level also helps to establish fitness for purpose. In the UK, BBA or BDA Agrément certification assesses products against relevant parts of the national building regulations.

They also include statements on non-regulatory requirements, standards, design and installation details, and durability.

4.1. Deck types

In refurbishment projects, the structural deck is the existing construction. For new-build projects, a structural deck can be a factory-made panel or sheet construction that is supplied to site ready for fixing, or it can be cast in-situ.

The 'Client Brief' section of this Design Guide goes into detail about inspecting and preparing existing decks ready for refurbishment. For new structural decks, the following information should be read in conjunction with the materials section of BS 6229:2018.

Metal decks / profiled metal sheets

Metal decking typically consists of galvanised steel, coated steel or aluminium. The deck is profiled to provide strength, with different profiles to suit a variety of span and load requirements. A metal deck suits a lightweight roof system where rapid installation is required.

The choice of deck thickness, profile, any acoustic perforation, and finish depends on the underlying roof structure, the required span, the system build-up intended to go on the deck, and the imposed dead and live loading. If the underside of the deck will be exposed, aesthetics may also be a factor.

Consultation with the deck manufacturer is essential, including the necessity for side lap stitching and metal deck closures. Material specifications in the UK are defined in the following documents:

Galvanised steel: minimum recommended thickness 0.7mm, to BS EN 10346 Fe E280G Z275. Typical gauge range 0.7 to 1.2mm.

Coated galvanised steel: minimum recommended thickness 0.7mm, to BS EN 10346 Fe E220G Z275. Typical gauge range 0.7 to 1.2mm.

Plain aluminium: minimum recommended thickness 0.9mm, to BS EN 485-2 AA3004 H34. Reference should also be made to BS EN 1396 as appropriate.

Coloured aluminium: minimum recommended thickness 0.9mm, to BS EN 485-2 AA3004 H34 and BS EN 485-2 AA3105 H25.

Timber

Any timber product used on a building project should be responsibly sourced, demonstrated through chain of custody certification through either the Programme for the Endorsement of Forest Certification (PEFC) or the Forest Stewardship Council (FSC).

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 new timber deck should be specified to suit the load and span capability of the joists and purlins.

Oriented Strand Board (OSB): a wood panel composed of timber strands oriented in cross directional layers. The choice of thickness depends on the span, as well as the intended insulation and waterproofing. Roofing grade OSB should be manufactured to BS EN 300, grade OSB/3, and carry third-party certification. The minimum recommended thickness is 18mm.

Plywood: minimum thickness of 18mm, certified as conforming to BS EN 1995-1-1:2004 Eurocode 5 Design of timber structures. General. Common rules and rules for buildings and BS EN 636:2003 Plywood. Specifications, minimum 'Service class 2 - humid conditions' or, where required, 'Service class 3 - Exterior conditions'.

Timber boarding: new timber boarding should be a minimum 25mm thick, ideally with a tongue and groove edge profile to maintain deflection resistance after natural shrinkage.

Woodwool: rarely used in new construction, woodwool is a rigid, medium weight, timber and cement-based panel, which may be reinforced with steel edge channel for longer spans. When encountered during refurbishment, obtain advice from the liquid applied waterproofing system manufacturer about resisting wind loading.

Cement-bonded particle (CP) board: it is not recommended to use cement particle board as a structural flat roof deck as CP board has insufficient inherent strength to provide adequate structural support. In warm roof construction it is not recommended to use CP board as a panel substrate for parapet wall details as the wind load is transferred directly from the liquid applied membrane layer to the CP board, which has insufficient inherent strength to provide adequate structural support. CP board is recommended in construction as a panel substrate for parapet wall details in inverted roof where the Liquid Applied Waterproofing is covered with a full height insulation board suitable for exposure to the environment.

CP board is recommended for use as a supported mass layer for the provision of additional acoustic performance on flat roofs with Liquid Applied Membranes.

Concrete

Structural concrete decks can be classified as either reinforced (cast in-situ), precast, pre-stressed or lightweight aerated. Each has a different effect upon cost, contract period and performance.

The location of required movement joints should be obtained early in the design process as they have implications for drainage layout and detailing. Information on span capability and installation requirements of precast panels can be obtained from manufacturers.

Since concrete decks are rarely installed by roofing contractors, their inspection and material specifications are not covered in this Design Guide. Guidance on the drainage falls that should be achieved by the deck is contained in section 3.11.

Structural insulated panel systems (SIPS)

Prefabricated SIPS generally comprise an insulated core of polyisocyanurate (PIR), expanded polystyrene (EPS) or mineral wool (MW) sandwiched between two skins of plywood to BS EN 636, minimum 'Service Class 2' (or higher, depending on climatic conditions - should be defined by the specifier) or OSB to BS EN 300, minimum OSB3.

Installing an air and vapour control layer on the warm side of a panel is usually impractical. The designer should seek the manufacturer's advice on how to prevent vapour transmission. A ventilation void between the panel and the roof covering may be required in some cases.

Special attention should be given to the long term sealing of all the panel joints, abutments and penetrations. Reliance on site-applied foams is not recommended.

4.2. Air and vapour control layers (AVCLs)

If condensation risk analysis shows an air and vapour control layer (AVCL) to be necessary, it may be provided by a polyethylene (polythene) membrane, reinforced bitumen membrane or self-adhesive polymeric/foil membrane. For an inverted flat roof, the waterproofing layer also performs the function of the AVCL.

Inclusion of a metal foil laminate greatly increases the water vapour resistance of an AVCL, and is more likely to be required for high humidity applications.

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 (while stored and during construction)
- Tear resistance
- Consistent vapour resistance
- Tensile strength

Polymeric AVCLs, such as polythene, are generally laid loose and restrained by the mechanical fixing or ballast used to secure the system as a whole. Side and head laps are sealed with a non-setting adhesive once the sheets have been set out.

Bituminous AVCLs are bonded in hot bitumen and may be fully or partially bonded. Side and head laps are sealed with hot bitumen during laying. Reinforced bitumen membranes can be applied either by gas torch or self-adhesion. Both require skill and the appropriate site cleanliness and safety conditions. Advice of the manufacturer should be followed.

When using torch-on bitumen products, consider the NFRC's Safe2Torch guidance. See section 5.1.

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4.3. Thermal insulation

There are many different ways of categorising thermal insulation materials. For the purposes of typical liquid applied waterproofing system applications - and inverted flat roof applications particularly (including inverted roofs) - categorising them by the material structure makes most sense.

- Fibrous materials, such as mineral or stone wool, derive their thermal performance from air trapped between the fibres
- Cellular materials, which include most plastic-based rigid foams such as PIR and extruded polystyrene (XPS), derive their thermal resistance from the gas trapped in the cell structure

Insulation products manufactured as rigid boards are best placed to bear the loads imposed during construction and in service. Boards vary in size depending on intended application and waterproofing, but typical sizes include 600 x 1200mm, 1200 x 1200mm and 1200 x 2400mm.

Factors influencing the selection of the type and thickness of insulation are:

- Details, upstand and threshold heights
- The required U-value
- Compressive strength and suitability for foot traffic
- Fire resistance (as part of the system)
- Acoustic performance
- Cantilever and free span capability
- Suitability for intended method of attachment
- Compatibility with other roofing components.
- Aesthetics and quality of finish

The insulation must obviously be compatible with the application method for the liquid waterproofing system. Principally, this is a matter of whether the waterproofing can be applied directly to the insulation product, or whether a carrier membrane is required.

For inverted flat roofs, a suitable insulation product must have low water absorption, freeze/thaw resistance and, ideally, an interlocking edge profile to further limit the infiltration of rainwater into the roof construction. Typically, this restricts the choice of suitable materials to extruded and expanded polystyrene (XPS and EPS respectively), as described in ETAG 031.

Expanded polystyrene (EPS)

Expanded polystyrene should be manufactured to the EN 13163 harmonised product standard. It is produced by fusing beads of polystyrene that are expanded in a high pressure steam environment.

Extruded polystyrene (XPS)

Extruded polystyrene should be manufactured to the EN 13164 harmonised product standard. It is produced by an extrusion process to create a closed cell structure, and offers a range of compressive strengths.

Polyisocyanurate (PIR)

Rigid PIR foam boards should be manufactured to the EN 13165 harmonised product standard. PIR is a development of polyurethane (PUR). It is a closed cell material, produced by a chemical reaction to which a blowing agent is added.

Cellular glass (CG)

Although less common than the materials listed above, cellular glass has flat roofing applications. The manufacturer should be consulted regarding compatibility with liquid applied waterproofing systems. Cellular glass products should be manufactured to the EN 13167 harmonised product standard. It is manufactured from (mainly recycled) glass, which is crushed with carbon powder and put into a mould. The moulds then pass into a foaming oven.

Mineral and stone wool

Being inherently flexible and compressible, mineral wool and rock fibre products are not an automatic first choice for roofing applications. However, dual density (DD) products with a higher compressive strength are more suitable and offer good acoustic performance. Products should be manufactured to the EN 13162 harmonised product standard.

Vacuum insulated panels (VIP)

Vacuum insulated panels (VIP) have a very low thermal conductivity, and are at least three times more thermally efficient than the materials listed above. However, they cannot be adapted on site, or damaged during use, or their performance is ruined. The panels have to be installed to a precise scheme design, with infills of 'standard' insulation.

Increasingly, VIP products encased in PIR foam are being developed to aid their use in roofing applications. Combining insulation materials is a common approach where different performance characteristics are beneficial.

Other insulation types

Composite products can also be formed using insulation and other materials. For example, PIR insulation can be bonded to plywood. The plywood provides a smoother, more robust surface, as well as greater versatility in the choice of waterproofing.

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4.4. Liquid applied waterproofing systems

Liquid applied products are robust, versatile waterproofing solutions, and their applications extend beyond the roofs, balconies and walkways that are the focus of this Design Guide. Separate guidance is available for liquid waterproofing used in car parks, for example.

The range of available systems covers everything from gutters and small domestic flat roofs, to large commercial and industrial buildings. Liquid applied waterproofing systems also come into their own in helping to preserve historic buildings, allowing existing structures to be made watertight in a comprehensive and sympathetic manner.

As well as achieving the right aesthetic for prestigious or sensitive projects, the liquid waterproofing sector has also developed solutions for buried applications. Hot melt is a popular solution for new-build inverted flat roofs - it too has its own code of practice.

Encapsulation is a particular benefit of liquid applied systems. Their ability to waterproof vertical surfaces as well as horizontal, quickly and with relative ease, makes them well suited to other applications such as parapet walls and water treatment works.

Elements of liquid applied waterproofing systems

Every liquid applied waterproofing system is different, and specific guidance from individual manufacturers should be followed for the specific application at all times. The following, however, provides some guidance on the generic elements of systems.

Substrate: any surface which forms the basis of the roof structure - concrete, timber, metal, insulation etc. - together with existing waterproofing systems where relevant.

Primer (or stabiliser): usually a low viscosity product which is applied to the substrate to improve the adhesion of a liquid applied waterproofing system. A primer does not replace the need for adequate surface preparation such as brushing or cleaning, but will on occasions help to consolidate a friable or porous layer. System manufacturers will advise on the correct priming regime for their product.

Liquid waterproofing: a liquid applied product which, once applied to the substrate and allowed to cure, provides protection against water ingress. The range of coatings are discussed in more detail below, but systems may be categorised as emulsions, or chemically-curing single or two pack systems.

Reinforcement: Many liquid applied waterproofing systems need strengthening by suitable reinforcement, which is wetted between successive coats. Reinforcement types include glass cloth, chopped glass mat and needled polyester fleece. Areas of concentrated stress which are in particular need of reinforcement include upstands, movement cracks and expansion joints. Consult the system manufacturer for their recommendations.

Product standards and certification

The Construction Products Regulation (CPR) was fully introduced into the UK in July 2013, Like the Construction Products Directive it replaced, the CPR removes technical barriers to the trade of construction products between EU member states. Features of the CPR include:

- CE marking for construction products
- Declarations of Performance (DoPs)
- A framework for harmonised technical specifications, through harmonised standards (hENs) and European Assessment Documents (EADs)

The CPR applies automatically and equally across all member states. Using a common technical language and uniform assessment methods, it acts as a means by which the CE mark can be applied to construction products.

Construction products can be individual products, or a kit of at least two separate components that need to be put together but are supplied by a single manufacturer or system-holder. Declaring compliance with EU legislation through the use of a CE mark is solely the responsibility of the product manufacturer or system-holder.

CE marking does not indicate whether a product is fit for a given application. It does not declare any conformity to national building regulations (so does not replace BBA or BDA Agrément certificates), nor is it a quality mark. Where other standards set out what products and solutions are suitable, however, the CE mark is a presumption of conformity with the standards to which the product should be manufactured.

In the context of roofing, the following products have hENs, and it is therefore mandatory for the CE mark to be affixed to the product label, and for the manufacturer to make available a Declaration of Performance:

- AVCLs
- Carrier membranes
- Thermal insulation
- Rooflights

Harmonised standards and EADs are both routes by which a construction product can be CE marked. Liquid applied waterproofing products do not have a hEN, however, so manufacturers have pursued the voluntary route of a European Technical Assessment (ETA), which follows the testing and assessment procedure set out in an EAD.

Where a hEN exists, CE marking is mandatory; where system holders obtain an ETA voluntarily, they must then CE mark the product. If they choose not to obtain an ETA then they must not CE mark the product. Either way, the manufacturer is free to pursue national certification as they see fit.

EADs are developed by the European Organisation for Technical Assessment (EOTA), who have undertaken the coordination work to produce harmonised technical standards for liquid applied waterproofing systems.

A variety of systems exist and it was recognised that ETAs should accommodate the different types in a formal structure. As a result, seven generic types of liquid waterproofing are recognised.

Generic types of liquid waterproofing

A European Technical Approval Guideline (ETAG) is used by recognised assessment bodies to issue ETAs. ETAG 005 is the test standard for liquid waterproofing 'kits', and it's first part gives overall guidance on assessment of fitness for use, including methods of verification and attestation of conformity.

The remaining seven parts deal with specific requirements for families of liquid product based on the following:

- Part 2: Polymer modified bitumen
- Part 3: Glass reinforced resilient unsaturated polyester resin
- Part 4: Flexible unsaturated polyester
- Part 5: Hot applied polymer modified bitumen
- Part 6: Polyurethane
- Part 7: Bitumen emulsions and solutions
- Part 8: Water dispersible polymers

A range of resins for Liquid Applied Waterproofing Systems has evolved over the years, which are not covered by the existing ETAG (parts 2-8):

Methacrylates

Sometimes described as Acrylics, MMA or PMMA, these products are formulated to achieve the required physical performance by using various polymers dissolved in reactive methacrylate and acrylate monomers. These two-component, solvent-free products are generally applied by spray, although they can be formulated for roller, brush, trowel or squeegee applications.

They cure by an extremely rapid in-situ polymerisation, which is activated by the addition of a catalyst. This curing proceeds rapidly even at temperatures around 0°C. All methacrylate coats chemically react with each other to produce a fully-bonded composite.

The systems incorporate primers to ensure adhesion on a variety of substrates and reinforcement can be incorporated if required. The use of Bond Coats can allow them to be overlaid with asphaltic surfacing. On exposure to UV light, they display very good retention of physical properties.

Although not specifically covered by the ETAG, some manufacturers have tested their roofing products against Part 4.

Acrylic Roof Coating Systems (Solvent Based)

A one component polymeric composition for use in repairing and coating leaking roofs, gutters and similar structures. They are particularly useful in an emergency repair situation in adverse weather conditions and will cure under water.

Applied by roller or brush direct onto a clean, dust-free surface with any wide gaps being reinforced with glass-fibre tape. Most sound surfaces are suitable without a priming coat but priming is required on fresh bitumen, metal or asbestos.

Thermoplastic Block Copolymers (S-EB-S),(S-EP-S)(Solvent Based)

These are flexible single component systems which are applied to produce multilayer coatings. They can be spray, roller or brush applied. Internal reinforcement layers can be incorporated to increase the lifetime of the coating. Most sound surfaces are suitable without a priming coat but priming is required on fresh bitumen, metal or asbestos.

LRWA requirements and recommendations

It is criterion of LRWA membership that products hold either ETA certification and/or national certification (BBA or KIWA BDA certificate). LRWA advises specifiers to select only products that have third party accreditation to verify product performance claims.

Where UK manufacturers of liquid waterproofing systems only supply their products to the UK market, the LRWA does not expect those products to be CE marked.

Clients should not wholly rely on CE marking as a form of differentiation between liquid waterproofing systems, or different types of waterproofing. Other criteria should be considered relating to product quality, durability and regulatory compliance.

More information is available in LRWA Guidance Notes No.3 and No.8.

4.5. Ancillary components

Adhesives

System build-ups featuring liquid waterproofing solutions are often secured by adhesive. The application and performance of adhesives is therefore critical to the working life of a system. The roofing market uses a wide range of cold applied liquid adhesive technologies, including:

- Solvent-free moisture-curing polyurethane (MCPU) adhesives
- Solvent-based MCPU adhesives
- Solvent-free two-component PU adhesives
- Tacky two-component PU adhesives
- Gel PU adhesives
- Solvent-based contact adhesives
- Water-based adhesives

Polyurethane adhesives are the most proven and effective cold applied solutions. They are simple to apply and suitable for all project types and most warm roof applications.

Solvent-free adhesives provide non-flammable and low-odour solutions, and can be used on a wide range of buildings, including odour-sensitive environments (such as hospitals and schools). They are also more pleasant for the contractor to work with.

When adhesive is used to secure all the layers of a system (including the AVCL and thermal insulation), best practice is to specify adhesives that have been independently tested for resistance to wind uplift pressure.

For wind loads up to 2.4 kPa, it is considered good roofing practice to design the roof construction allowing for a safety factor of 2. For wind loads greater than 2.4 kPa, additional measures such as mechanical fixing or ballasting may be required.

Before applying any adhesives, the substrate should be checked and suitably prepared. More information, including guidance on applying adhesives, is available in LRWA Guidance Note No.11.

Mechanical fixings

Increasingly being used as part of liquid applied waterproofing systems, mechanical fixings are available for use in both new build and refurbishment applications.

New build applications

Mechanical fixings are used for the securement of insulation and AVCL layers for steel, timber and concrete decks. For profiled steel decks the AVCL contact with the deck is not 100% and in some instances may be less than 50% which could effectively rule out the use on an insulation adhesive in exposed locations. Mechanical fixings in this instance will provide a secure connection to the deck. For concrete decks, installing the AVCL and insulation with mechanical fasteners will be effective where drying out of concrete decks is a concern in respect to the use of self adhered or torched on AVCL's, particularly during winter months.

Refurbishment applications

The use of mechanical fasteners effectively secures existing insulation and membrane layers and protects against the possibility of wind uplift. Where required, new insulation layers can also be effectively be installed as part of the build up prior to the application of the liquid membrane waterproofing layer. Fasteners are available in carbon steel or alternatively in austenitic stainless steel for long life warranties.

High exposure zones

For high exposure areas, mechanical fasteners are an effective means of securing new insulation and AVCL and any existing layers from wind uplift. A wind load calculation is necessary for every project to determine the wind suction load at corner perimeter and field roof zones.

Site Pull-outs

Site pull-out testing is recommended particularly for refurbishment and new build concrete decks. When used in conjunction with the wind load calculation, this data will assist determine the fastener design load and also the minimum number of fasteners required per square metre of roof area.

Fixing guidance

The correct fixing type and frequency for each roof zone should be recommended by the insulation manufacturer, fixing supplier and / or liquid applied waterproofing systems supplier. For PIR insulation guidance is provided by the Insulation Manufacturers Association (IMA). Specific reference should be made to the IMA document ID/1/ October2016 version.

For the fixing of insulation boards it is important that the washers or stress plates should be a minimum of 75mm diameter or 70x70mm in order to provide sufficient pull-through resistance.

When used with Mineral Wool Insulation it is essential that the fasteners used have an in-built telescopic or treadfast arrangement to allow for trafficking over the membrane.

Lightning conductor pads

Traditional methods of securing lightning conductor tape are no longer necessary or desirable. Compatible polymeric mouldings are available and approved for use with a range of waterproofing solutions. Attachment by self-adhesive pads has been found to be unreliable and is not recommended, therefore lightning conductor pads can usually be bonded with a suitable adhesive that is compatible with the waterproofing membrane and the pad base.

Adoption of BS EN 62305 Protection against lightning has led to increased use of finials with wire connections in place of tape. These are secured by gravity, using concrete weights set in compatible thermoplastic trays, thereby avoiding the need for bonding.

Fall protection systems

Falls from height exert high loads. As such, traditional 'through the roof' anchor devices for fall protection systems must be tied back to the building structure directly.

'Top fixed' energy absorbing anchor devices dissipate those same loads and can therefore be installed directly onto the roof system build-up. The specification and use of 'top fixed' anchor devices should be in accordance with the recommendations of the Advisory Committee for Roofsafety (ACR) Magenta Book (ACR (M) 002:2015 Rev 2 - (Part 2) Testing of roof anchors on roof systems).

Personal fall protection equipment should be fully compliant with;

- BS EN 795:2012 Personal fall protection equipment. Anchor devices (Type A - single user)
- CEN/TS 16415:2013 - Personal fall protection equipment. Anchor devices. Recommendations for anchor devices for use by more than one person simultaneously (Type C - multi user)

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The above should be evidenced by a Declaration of Conformity detailing the product, the European Standard, the name of the independent Notified Body and the date.

Although tested for fall arrest, systems should, wherever possible, be designed in fall restraint.

Periodic examination of all equipment shall take place at least every 12 months by a competent person and strictly in accordance with the manufacturer's periodic examination procedures.

Rainwater outlets

Consultation with the rainwater outlet manufacturer is recommended, both in terms of the most appropriate type of outlet and the number required (which must be determined by calculation).

For direct discharge/gravity drainage, outlets may be lightweight or heavyweight. Detailing of the liquid waterproofing at the outlet should be in accordance with the system supplier's instructions and details. Where siphonic drainage is specified, the drainage layout should create a suitable head of water for the system to be effective.

Where dual-level drainage is present in an inverted flat roof construction, the water flow reducing layer (WFRL) membrane should be installed in accordance with the system supplier's instructions to ensure it drapes into the outlet and achieves the intended drainage performance.

Rooflights

Glass, polycarbonate and GRP are all rooflight material options in UK construction, depending on the type of building and the performance required. Specification is particularly critical in terms of safety (especially where there is any risk of a person falling onto a rooflight), fire performance and, of course, thermal performance.

Kerb materials should be sufficiently strong and thermally insulated to not to detract from the overall performance of the building envelope. Cellular PVC kerbs or similar low conductivity in-situ details are available as alternatives to traditional insulated metal upstands.

The National Association of Rooflight Manufacturers (NARM) publish a comprehensive range of guidance documents concerning rooflight types, their specification, and how they perform - both in isolation and as part of the complete building fabric: **https://www.narm.org.uk/**

Standing Seams

To give the appearance of metal standing seam coverings, liquid applied waterproofing systems are coated over timber battens or pre-formed GRP profiles can be used. Follow the advice and instructions of the waterproofing system supplier.

Ballast and paving support pads

Aggregate used as ballast should be specified based on the building's height and location, in order to resist 'wind scour' (movement of the ballast by wind) and maintain consistent coverage. Aggregate specifications are based on wind tunnel test results in BRE Digest 311.

A typical specification would be for washed, rounded, low-fines aggregate, and generally a size ranging from 16 to 40mm is adequate for most applications. Minimum depth (i.e. the weight needed to resist wind uplift) is based on the building location and height.

The aggregate depth should also meet the requirements of Commission Decision 2000/553/EC to ensure the expected standard of fire resistance is met.

Commission Decision 2000/553/EC also specifies a minimum specification for paving slabs to provide the expected standard of fire resistance when used as the final roof covering. Paving slabs require paving support pads, and a wide variety of products are available. All allow for vertical adjustment to create a consistent level in the finished surface, and to allow water to drain through and underneath.

Some products reduce installation time by allowing such adjustment after the slabs are laid. Since the available height and vertical adjustment limit varies with product, the design should take account of the maximum change in roof level and the tolerance in the paving thickness that must be accommodated.

4.6. Waste Management

Resource Efficiency Action Plans (REAP) increasingly preclude the generation of waste on modern sites. Early consultation between client, designer and roofing contractor is essential for keeping waste to a minimum.

Contractors are legally obliged to correctly classify waste and ensure it is stored and handled safely and securely - evidence of which may be requested by Environment Agency inspectors or waste handlers.

Manufacturers and suppliers also have a duty of care towards the health and safety of those further along the waste chain. Products must be appropriately classified, labelled and packaged to reflect a chemical's possible hazards. Information is also made available on the safety data sheet (SDS) of products.

Further guidance is available from the industry guidance document The assessment and classification of waste packaging. The document complements the Environment Agency's WM3 technical guidance, and includes a flowchart to help companies assess whether packaging to be taken off site actually constitutes as waste, and whether it should be classified as hazardous or not.

An LRWA technical article on waste disposal offers further advice on how to classify used containers.

5. Training

The range of liquid applied waterproofing systems available means a wide variety of application techniques. To ensure that materials applied to a roof are able to function as intended, it is essential that all persons concerned with the operation, from the estimator to the operative applying the material, receive training in the activities involved.

For any person asked to work on a roof, training is a prerequisite. Training should cover identification and correction of roof faults prior to installing materials, as well as application of the roof coating itself.

Safety training is also of paramount importance. Operatives must work in a safe manner at all times, ensuring that neither operatives nor the general public are put at risk during preliminary work or during the roof coating operations.

Responsibility for training the workforce falls fairly and squarely upon the employing company. Many manufacturers organise courses for operatives in the application of coating materials, often with subsequent on site training and inspection of installed systems. General roofing contractors lacking relevant system-specific experience should not be engaged on projects using those systems.

Training schemes include:

- Vocational Qualifications (VQs) for liquid applied waterproofing systems (complemented by manufacturer-specific programmes)
- Specialist Applied-skills Programme (SAP)
- Experienced Worker Practical Assessment The Institute of Roofing (EWPA)
- Supplier training schemes for approved contractors

To help operatives achieve a Level 2 Vocational Qualification in Liquid Roofing, the LRWA has developed a Basic Competency Programme (BCP), which is delivered in conjunction with leading manufacturers. The BCP is the first stage. The second stage offers three options depending on experience:

- Specialist Applied-skills Programme (SAP) (No experience)
- On-site Assessment Training (OSAT) (four/five years' experience)

More information is available at **http://www.lrwa.org.uk/training/**

Safety training for operatives can be conducted in-house or by an outside organisation. The LRWA supports the Construction Skills Certification Scheme (CSCS). Successful completion of the Level 2 VQ sees the trained operative issued with a CSCS card.

5.1. Preparation

Liquid applied waterproofing systems are only as good as the substrate condition allows. Thorough preparation is essential to the long term performance of the waterproofing system. The following guidelines do not replace manufacturers' specific instructions regarding their products.

Drying

In the event of a roof becoming wet it is important to ensure drying out is done safely. The most common method is still by use of a propane gas torch, but there are a range of alternatives which do not involve hot works. Planning is key, especially in winter. Thirty minutes at the end of the day spent laying temporary cover sheets can help work commence promptly the following day, rather than drying off moisture or melting frost and ice.

Common sense must be applied with regard to weather conditions and the weighting of temporary sheets, as well as the potential for polythene sheets to become slippery in wet or frosty conditions.

For daily drying off, the following methods may be considered:

- Rags, mops and squeegees
- Bowdry roller
- Roof pumps
- Hot air blower
- Leaf blower

More information is available in LRWA Guidance Note No.13.

Safe2Torch

As well as drying, preparation of the existing substrate is another area where hot works are often deemed to be the most effective option. However, other, safer methods should be exhausted first.

Preparing existing roofing felt: remove local areas of badly cracked, degraded or blistered felt, going back to a sound, straight cut with a well-adhered edge. Replace with a suitable self-adhesive felt or similar, ensuring it is firmly adhered and checking for any peel back. Alternatively, blisters can be star cut to release any moisture, dried out using a rag and re-adhered to the substrate using a suitable cold applied glue. Ensure the repaired and remaining felt is correctly laid and/or suitably adhered to provide a smooth and level surface for treatment. Exercise all necessary care when cutting, and brush away excess grit from mineral surfaces.

Preparing existing asphalt: remove any gas blisters, slump or sag, or damaged asphalt. Fill any significant cracks using an appropriate polymer modified mortar or other compatible material approved for repairing these areas. Allow repairs to cure prior to application. Ensure the repaired and remaining asphalt is correctly laid and/or suitably adhered to provide a smooth and level surface for treatment. Exercise all necessary care when cutting.

If use of a naked flame is unavoidable: all gas torch operatives should be familiar with, and understand the principles of, the NFRC's Safe2Torch conditions. For more information, see **https://www.nfrc.co.uk/safe2torch**

Cleaning

Remove all dust or loose material. Inspect, repair, prepare, make clean and dry, noting the following:

- Remove chippings where possible using a stiff bristle broom. If chippings are embedded (e.g. in asphalt) they may be removed with a suitable scabbling machine or power grinder. Take care where chippings (and the bitumen layer they are in) is over thermal insulation as the insulation may be damaged. It may be more economical to remove the existing waterproofing and/or insulation layer, applying a carrier membrane prior to installing a new liquid applied waterproofing system
- Use a stiff bristle broom to remove all moss, lichen, leaves, silt and other debris, particularly in corners and at eaves, joints, gutters and areas susceptible to ponding. Existing substrates are generally power washed but must be at least washed with clean water prior to inspection and repair
- High pressure water cleaning is very effective on most substrates, but may pump water into the building through defective joints. Prior inspection is essential to avoid damage to thermal insulation or plaster at ceiling level that can be soaked. Pressure water cleaning is not recommended for asbestos cement (see below)
- Ensure no debris can block rainwater downpipes. Downpipes and gutters can be cleaned by rodding, with access obtained around bends through detachable access plates
- Where asbestos is present, or even suspected of being present, cleaning fibre cement roofs must be done in accordance with Health and Safety Regulations. Advice is given in HSG 33, published by the Health and Safety Executive (HSE). Specifiers and contractors are also referred to the Control of Asbestos Regulations: EH10, EH35, EH36, EH41, MDHS 39/2 and EH71. Ensure that no debris/swarf can escape into rainwater downpipes; if this happens they must be washed out and the debris/swarf caught in suitable filters for disposal. Open high pressure water cleaning is not recommended. All washings must be collected, and marked with appropriate hazard label for suitable disposal. If the debris does contain asbestos it will need to be treated as "special waste" under the Control of Pollution (Special Wastes) Regulations

Repair

- Blisters in built-up felt should be star cut and the four corners folded back. Dry out any moisture and re-bed the felt using the liquid applied waterproofing system, or a suitable adhesive where appropriate. Ensure the adhesive closely seals the cut lines, indicated by a continuous line of adhesive exuding from the cut joint. Badly damaged felt should be replaced
- Asphalt cracks should be resealed to ensure substrate continuity. Ruckles and slumps should be inspected and, if necessary, smoothed out and made good. This is particularly important where reinforcement will be added to the liquid applied waterproofing system to ensure good substrate contact
- Existing single ply membranes must be correctly laid and securely mechanically fixed. Any defects must be repaired with compatible materials. Where extensive damage is evident (such as splits or embrittlement) the membrane should be removed and a carrier membrane used instead
- Inspect concrete and screeds for soundness. Any live cracks should be noted for special consideration. Repairs can range from sand and cement to polymer modified speciality repair mortars and screeds
- Other substrates are subject to general inspection and repairs appropriate to that material
- Where the deck or insulation below the existing waterproofing layer is suspected of being wet, take core samples and determine moisture presence or otherwise. Water can track extensively under mechanically fixed or partially bonded systems. Not all damp material will need replacing as long as it will still perform as required and can be suitably dried out. Replace rotten wood or fibre based materials and any other affected materials. Cut out damaged areas back to sound dry material and replace with new material of correct thickness. A proprietary venting system may be required where general dampness requires drying out in parallel to the application of the liquid applied waterproofing system (the guidance of the system manufacturer should be sought, as some systems are vapour permeable)

- Repair can also include the replacement of non-desirable decks such as chipboard or strawboard with a new material that is not susceptible to moisture
- Ensure repaired areas are clean and thoroughly dry before applying the liquid applied waterproofing system

Other general preparation items

- Inspect rainwater outlets to ensure they are not blocked, and that they are sound and free draining. Water should not be impeded by the build up of previously applied systems. Clean and inspect gutters
- Agree arrangements for making good to penetrations such as pipes, vents, flues, handrails, etc. Add or renew collars and flashings
- Fixed items which are not included in the coating schedule - including wires, cables, etc. - must either be totally removed or, in order to allow access, be suspended from the surfaces to be coated. Such items should only be removed with prior agreement
- Only lift lightning conductors, cables etc. by prior arrangement and DO NOT COAT WITH liquid applied waterproofing systems
- Lift metal flashings to enable installation of the liquid applied waterproofing system below
- Inspect skirtings and make good if necessary. Provision for re-installation must be made if missing or inadequately formed
- Ensure rooflights, vents, gutters and other fittings are capable of being treated or lapped onto
- Increase heights if necessary where insulation is being added or falls being changed
- On masonry upstands, the liquid applied waterproofing system may be finished into a suitable chase cut and subsequently sealed. Alternatively, termination bars or surface-mounted cover flashings may be used in accordance with the system manufacturer's instructions
- Inspect for fire risk particularly if torches or solvent based materials are being used. Check to ensure that adequate appropriate fire fighting equipment is available. Hot work permits must be obtained
- Agree access and safety requirements

Treatments prior to liquid applied waterproofing systems

- Anti-fungal treatments may be applied after cleaning and should be allowed to dry (see manufacturer's methods of application and usage).
- Some substrates may require specific pre-treatments such as an etch primer for aluminium or galvanized steel.
- Generally consider the elements of the surfaces to be treated for those items which may require specific pre-treatments apart from general priming and application of the liquid applied waterproofing system.

5.2. Application

The choice of liquid system should be made referencing the 'Materials' section of this Design Guide. Application methods for liquid applied waterproofing systems are typically brush, roller, airless spray, and squeegee. Others are defined by manufacturers' specific method statements.

Good site practice should be observed at all times, including care in the handling of scaffolding and other builders' plant, avoiding mixing cement or mortar on the roof surface, and avoiding material storage directly on the roof surface.

Achieving correct coverage of the liquid system is critical to the validity of any guarantee subsequently issued. Taking the time to plan how the system will be protected during periods of uncontrolled access on a roof can avoid the expense and delays associated with damaged installations.

5.3. Accessories and ancillary items

Items, such as trims, vents, rooflights, sealants etc. must be compatible with the liquid applied waterproofing system. Most system manufacturers either supply these items or have recommended suppliers, and the manufacturer's guidance must be followed.

5.4. Storage

Carefully store all materials in accordance with the manufacturers' instructions. Proper site storage must be arranged by the contractor.

5.5. Quality control

General

Selecting a suitable specification based on the particular circumstances of the roof, balcony or walkway is the first stage of a quality programme to provide a durable system. Particular attention should be paid to the following in regard of existing roofs, balconies and walkways:

- The way in which they have failed
- Access
- Structural integrity
- Provision of damp courses on parapets
- Roof level equipment
- Any other client requirements

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The proposed specification should take account of the application requirement, health and safety needs, and the practicality of installation on each site. Quality control should be considered from the design stage and a feasible programme established covering all aspects of the proposed work.

Scheduled quality control should include every stage of application, including the preparation phase as post-installation inspection is often difficult (if not impossible). Quality control should be part of a full programme of organised work, rather than being isolated to completion of the project.

Unlike other membrane types, which are produced under factory conditions, liquid applied waterproofing systems are formulated for application on site. Installation should therefore be thought of as a succession of stages, each of which require a quality control procedure. The process should include the following items:

1. Initial site survey and development of specification.
2. Provision of suitably trained labour and supervision.
3. Preparation of the substrate(s).
4. Acknowledgement of surface profile and how it is to be dealt with.
5. Detail work involving the liquid applied waterproofing system, e.g. around outlets, upstands etc. and work in relation to flashings, gutters and minor building work.
6. Primers and successive coats, including formation of the wearing layer.
7. Reinforcement within the system (overall or localised), and expansion joints where necessary.
8. Coating thickness control measures for all 'layers'.
9. Evaluation of site applied check samples.
10. Site monitoring provisions by the contractor or manufacturer during all stages of application, including any testing deemed appropriate to the stages of installation.
11. Site inspection by the joint manufacturer or contractor for guarantee purposes.

Particular note should be made of the prevailing weather during application, and the effects of any interruptions to application caused by inclement weather.

Once substrates are covered it is not easy to establish such things as preparation, insulation and material usage. Reviewing these items at all stages is essential.

On completion of each day's work, or whenever work is interrupted, secure the roof to prevent water penetration and/or wind damage. Full temporary protection of the roof is essential if following trades intend to use the finished roof as a working platform or access walkway. Responsibility for this must be agreed between relevant parties during the course of the building operations.

Completion

Completion should be considered as the final stage of the organised work programme, and not as a remote item at the end of the project. It is the final check in a series of quality control and procedural processes, and should cover the following items:

1. Adherence to the manufacturer's or specifier's specification.
2. Logging of all material batch data obtained from packaging e.g. numbers, dates etc.
3. Execution of detail work, e.g. flashings, walkways, gutters, minor building work.
4. Film thickness may require checking. This is best established by material usage at all stages of application. Take account of surface profile. Site applied check samples may require less evaluation. Wet film gauges can be used where appropriate.
5. Reinforcement. Usage and overlap are best checked at appropriate stage.
6. Film conditions during installation, i.e. freedom from pinholes, cure, and general appearance. All may be corrected at the appropriate time during system installation or by a final site snagging.
7. The use of different colours in a multi-coat system helps in avoiding uneven membrane thickness, achieving the required film build overall, and showing adherence to the specification.
8. Guarantees will likely require inspection by both the manufacturer and the contractor, as well as the client or their agent.
9. The site should be left clean and tidy. All cans, packaging, and equipment should be removed together with scaffold.
10. If scaffold is tied with 'Hilti' bolts or similar, these may require removal and the holes plugged as the scaffold is removed.
11. Scaffold may be left in place if required for final snagging inspection. It may be necessary to carry out a final check for scaffold damage once it is removed.
12. All rainwater goods and roof-situated equipment, e.g. lightning conductors, power lines etc. should be left in appropriate working order. Such items should be checked by a competent person.
13. Manufacturer and contractor guarantees should be sought for the liquid applied waterproofing system.
14. Update and complete the Operation and Maintenance Manual prior to passing to the client for their retention.

No building work should be carried out from a completed roof. No paint, cementitious materials, plaster or solvents should be allowed to come into contact with the completed roof surface, and the completed roof should NOT be used as a working platform. If work on a finished roof cannot be avoided, it is essential to protect the roof against loading, impact, abrasion, heat and other damage.

Post-completion inspection

In addition to any routine interim inspections required by the system manufacturer, a post-completion inspection should be carried out on all work featuring a liquid applied waterproofing systems. Post application inspection can cover such items as:

- Application rate - film thickness
- Reinforcement
- Minor building works
- Reinstatement of flashings
- Adherence to the design specification
- Film condition (especially for products which cure)
- Detailing and other related matters

5.6. Health and safety

The Health and Safety at Work Act deals with fundamental working practices. Other legislation contributes to the welfare of those undertaking the work and those in the vicinity of the work. It is important to gather as much health and safety information about a project and the site before work begins. A survey of the site should be made by a competent qualified person.

While the Construction (Design and Management) Regulations (CDM regulations) may not be a legal requirement on short term contracts, it is good practice to apply the principles to all roof, balcony and walkway projects.

Safety data sheets

Safety data sheets provide information on chemical products that help users of those chemicals to make a risk assessment. They are issued by product manufacturers and are essential reading prior to handling any materials. They contain information under 16 primary headings, which are as follows:

1. Product and company identification
2. Composition/information on ingredients
3. Hazard identification
4. First aid measures
5. Fire fighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure control/personal protection.
9. Physical and chemical properties.
10. Stability and reactivity.
11. Toxicological information.
12. Ecological information.
13. Disposal considerations.
14. Transport information.
15. Regulatory information.
16. Other information.

Reference checklist

The following non-exclusive list should be considered in relation to safety:

- CDM - relationship at time of quote
- Contact with the client's Principal Designer or safety officer
- Safety during initial site visit by installing contractor
- Scaffold erection and removal
- Delivery, unloading, lifting and storage of materials
- Provision of edge protection

Access for inspection purposes. Specific assessment of:

- materials containing asbestos
- fragility classification of the roof (ACR Red and Green books)
- rooflights
- vents with fumes (prevention of taking in fumes, and discharges)
- birds (especially sea)
- unstable parapets
- safety lines (recently tested and certified)
- harnesses/fall restraint
- condition of gutters

Note: If the roof or any part of it cannot be assessed beyond all doubt as non- fragile, then it must be treated as fragile and the roof must be accessed in accordance with the guidance given in the ACR Green Book.

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5. WORKMANSHIP

Decisions relating to specification, e.g. will it be possible to transport equipment, raw materials etc

- Health and safety cost implication - adequate funding should be provided
- Risk assessments should be provided and work methods agreed with the Principal Designer or safety officer prior to commencement on site
- Special client requirements for work area, i.e. site health and safety requirements, personal protection equipment (PPE), working hours, etc
- Specification, COSHH, working environment, training, site supervision, method of work, waste regulations, disposal of containers
- Safety during final quality check
- Removal of site waste

Health and safety in roof work

Falls from height account for half of accidental deaths in the construction industry. Compliance with current Working at Height (WAH) Regulations and HSE guidance on scaffolding etc. helps to reduce falls, as well as injuries to others caused by materials falling from a roof.

'Health and safety in roof work' published by the HSE (known as HSG33) is essential reading for all concerned with the commissioning, design or execution of roof work, or with responsibility for those who work on any new, repair or refurbishment site.

'Working on Roofs' (leaflet INDG284) published by the HSE, and Guidance Note 7 published by the Work at Height Safety Association (WHSA), are also recommended. The Advisory Committee for Roofwork (ACR) has produced several useful roof safety publications that are available to download from **www.roofworkadvice.info**

More information is available in LRWA Guidance Notes No.5 and No.6.

CDM regulations

The main purpose of the Construction (Design and Management) Regulations 2015 is to establish a safety management network at all stages of a construction project. Obligations are imposed on all parties, but mainly the Principal Designer and Principal Contractor. A safety plan must combat risks at source, and involve a method statement based on their own health and safety plans.

Liquid applied waterproofing system manufacturers and LRWA members comply with these aims.

COSHH regulations

The Control of Substances Hazardous to Health Regulations 2002 (as amended) protect workers against the risk of exposure to substances considered to be hazardous to health. The use of such substances arises out of or in connection with work undertaken under the control of the employer.

The hazards that may be associated with the chemicals used in liquid applied waterproofing systems are shown in the Safety Data Sheets issued by the system supplier. Under the regulations, the contractors must prepare and submit a suitable COSHH assessment to the client/contract administrator for all materials falling under the regulations.

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6. MAINTENANCE

6. Overview

In normal use, liquid applied waterproofing systems require no routine maintenance. Periodic inspections should be scheduled to check for damage by accidental impact, or as a result of building modifications involving the roof.

Balconies and walkways have a greater degree of foot traffic. The degree of wear, and the maintenance required, differs depending on the usage.

Waterproofing system guarantees or warranties may last for many years. Appropriate maintenance schedules should be adopted, following appropriate guidelines - this may be stipulated in the terms of the guarantee.

6.1. Inspections

Inspections should be carried out twice-yearly inspections as per BS 6229:2018 - one in spring to check for winter damage, and one in autumn to clear any leaves and other debris.

Roofs, balconies and walkways in close proximity to trees, subject to large quantities of dust or other pollutants, or in other high risk locations should be inspected more frequently.

The following is a list of typical roof details, although each individual roof, balcony or walkway may have other areas that require inspection. Where sealants are used they may require a separate maintenance cycle.

- General areas: remove leaves, paper, silt and any other extraneous debris. Cut back overhanging tree limbs
- Sharp objects such as screws, stones, broken glass and other material should be removed from the surface to minimise the chances of accidental damage by subsequent foot traffic
- Upstands, flashings, cappings, expansion joint covers and copings: check exposed membrane for any damage and ensure the components themselves, sealants, mastics and pointing are all in good condition and effective
- Edge details, drips and water checks: check that edge details are properly secured to provide protection against wind uplift
- Upstand flashings at walls, kerbs and gutters: check exposed membrane for any damage and ensure flashings, termination bars, sealants, mastics and pointing are in good condition and effective
- Penetrations and protrusions, pipes, rooflights and plinths: check exposed membrane for any damage and ensure sealants, mastics and clips are in good condition and effective
- Outlets, gutters and rainwater pipes: check for free flow of rainwater and remove any debris or other extraneous items. If grates are missing they should be replaced

The requirements for inverted roof maintenance are generally limited to inspecting exposed details and surfacing, as the waterproofing is protected by the insulation and ballast.

In order to prevent damage by excessive localised loading, planks or other load spreading devices should be placed under ladders or the supports of free standing structures.

6.2. Repairs

In the event of localised damage, or to reinstate a completely seamless barrier following structural modifications, repairs can be made quickly and easily by applying more of the appropriate coating to the affected areas.

If treating small punctures, the surrounding membrane should be cleaned, primed if necessary, and repaired by the application of additional material (usually by brush or roller). In all cases, care should be taken to restore the dry film thickness of the original membrane.

Application should be in accordance with the manufacturer's specification and instructions.

6.3. Long term maintenance

The in-service durability of a roof, balcony or walkway system typically exceeds the quoted lifespan. Maintenance will not strictly be necessary for several years after the termination of the stated period. Nevertheless, towards the end of its anticipated design life, the system should be inspected and any maintenance works agreed accordingly.

Not all roof, balcony and walkway systems need to be replaced at the end of their initial design lives. Their durability can be extended through the use of a product life extension system, which provides a significantly more cost effective alternative, as per section 2.9.

Application of any liquid applied product or system should be in accordance with the manufacturer's specification and instructions. If the present top coat was applied in a different colour to the underlying coat, the coating underneath will begin to show through as the top coat wears.

Ongoing inspections should be carried out at agreed regular intervals to check for signs of wear or excessive weathering.

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7. REFERENCES

7. References

The LRWA recognises and acknowledges the contribution of the Single Ply Roofing Association (SPRA) in the creation of this Design Guide, not least the inspiration provided by the SPRA Design Guide. The collaborative approach displayed by SPRA means our industry can speak about our respective areas of expertise with a consistent voice.

The following is a list of all references that appear in this LRWA Design Guide. It is not intended to be an exhaustive list of references relating to the design, specification and installation of liquid applied waterproofing systems on roofs, balconies and walkways.

7.1 LRWA documents

Guidance Notes

- Guidance Note No. 1: Roof, balcony and walkway inspection for the specification of liquid applied waterproofing systems
- Guidance Note No. 2: Substrates for liquid applied waterproofing systems for roofs, balconies and walkways
- Guidance Note No. 3: Generic types of liquid applied waterproofing systems for roofs, balconies and walkways
- Guidance Note No. 4: Roof, balcony and walkway refurbishment using liquid applied waterproofing systems
- Guidance Note No. 5: Health and safety provision for liquid applied waterproofing systems on roofs, balconies and walkways
- Guidance Note No. 6: Safe use of liquid applied waterproofing systems
- Guidance Note No. 7: Specifier guidance for flat roof falls
- Guidance Note No. 8: CE Marking of liquid applied waterproofing kits
- Guidance Note No. 11: Use of adhesives for liquid flat roof systems
- Guidance Note No. 12: Termination of waterproofing at cills and thresholds
- Guidance Note No. 13: Drying of existing roof substrates prior to installation of liquid applied waterproofing systems
- Guidance Note No. 14: Best practice for the installation of water flow reducing layers in inverted roofs
- Guidance Note No. 15: Clarification of BS 6229:2018 regarding the thermal performance of inverted roofs and inverted blue roofs
- Hot Melt Code of Practice
- Code of Practice: Specification and Use of Liquid Applied Car Park Deck Systems
- The Householder's Guide to Flat Roofing (collaboration with NFRC and SPRA)
- Training courses and qualifications
  - Basic Competency Programme (BCP)
  - Specialist Applied-skills Programme (SAP)
  - On-site Assessment Training (OSAT)
- Technical article on waste disposal

7.2 National building regulations and associated documents

- England - Approved Documents
- Wales - Approved Documents
- Scotland - Technical Handbooks
- Northern Ireland - Technical Booklets
- Building a Safer Future, the independent review by Dame Judith Hackitt
- Building Bulletin 93 (BB93) Acoustic design of schools - performance standards
- Health Technical Memorandum (HTM) 08-01 Acoustics
- Sport England, Sport Wales or Sport Scotland design guidance

Regulations

- The Construction (Design and Management) Regulations 2015
- The Construction Products Regulations 2013
- Control of Asbestos Regulations 2012
- The Control of Substances Hazardous to Health Regulations 2002
- The Control of Pollution (Special Waste) Regulations 1980
- Health and Safety at Work etc. Act 1974
- The Regulatory Reform (Fire Safety) Order 2005
- The Work at Height Regulations 2005

7. REFERENCES

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7. REFERENCES

Standards

- BS EN 300:2006 Oriented strand boards (OSB). Definitions, classification and specifications
- BS EN 485-2:2016+A1:2018 Aluminium and aluminium alloys. Sheet, strip and plate. Mechanical properties
- BS EN 636:2012+A1:2015 Plywood. Specifications
- BS EN 795:2012 Personal fall protection equipment. Anchor devices
- BS EN 1991 Eurocode 1: Actions on structures
- BS EN 1995 Eurocode 5: Design of timber structures
- BS EN 1396:2015 Aluminium and aluminium alloys. Coil coated sheet and strip for general applications. Specifications
- BS 5250:2011 + A1:2016 Code of practice for control of condensation in buildings
- BS 6229:2018 Flat roofs with continuously supported flexible waterproof coverings. Code of practice
- BS EN ISO 6946:2017 Building components and building elements. Thermal resistance and thermal transmittance. Calculation method
- BS 8217:2005 Reinforced bitumen membranes for roofing. Code of practice
- BS 8579:2020: Guide to the design of balconies and terraces
- BS EN 10346:2009 Continuously hot-dip coated steel flat products. Technical delivery conditions
- BS EN 12056-3:2000 Gravity drainage systems inside buildings. Roof drainage, layout and calculation
- BS EN 13162:2012+A1:2015 Thermal insulation products for buildings. Factory made mineral wool (MW) products. Specification
- BS EN 13163:2012+A2:2016 Thermal insulation products for buildings. Factory made expanded polystyrene (EPS) products. Specification
- BS EN 13164:2012+A1:2015 Thermal insulation products for buildings. Factory made extruded polystyrene foam (XPS) products. Specification
- BS EN 13165:2012+A2:2016 Thermal insulation products for buildings. Factory made rigid polyurethane foam (PU) products. Specification
- BS EN 13167:2012+A1:2015 Thermal insulation products for buildings. Factory made cellular glass (CG) products. Specification
- BS EN 13501-1:2018 Fire classification of construction products and building elements. Classification using data from reaction to fire tests
- BS EN 13501-5:2005+A1:2009 Fire classification of construction products and building elements. Classification using data from external fire exposure to roofs tests
- BS EN ISO 13788:2012 Hygrothermal performance of building components and building elements. Internal surface temperature to avoid critical surface humidity and interstitial condensation. Calculation methods
- BS EN 15804:2012+A2:2019 Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products
- BS EN 17037:2019 Daylight in buildings
- BS EN 62305-3:2011 Protection against lightning. Physical damage to structures and life hazard

Other References

- Advisory Committee for Roofsafety (ACR) books
  - Green Book - Fragile roof guide
  - Magenta Book - Safety lines
  - Red Book - Test for non-fragility of large element roofing assemblies
- BBA or BDA Agrément certificates
- BBA Information Bulletin No.4
- BRE Digest 311 Wind scour of gravel ballast on roofs
- BRE Environmental Assessment Method (BREEAM)
- BRE Green Guide to Specification
- CEN Technical Specification (TS) 1187:2012 Test methods for external fire exposure to roofs
- CEN Technical Specification (TS) 16415:2013 Personal fall protection equipment. Anchor devices. Recommendations for anchor devices for use by more than one person simultaneously
- CHIP (Chemical Hazard Information and Packaging) Safety Data Sheets
- Commission Decision 2000/553/EC External fire performance of roof coverings
- ETAG 005 Liquid applied roof waterproofing kits
- ETAG 031 Inverted roofs insulation kits
- Environment Agency WM3 technical guidance
- FM Global Property Loss Prevention Data Sheets
- Forest Stewardship Council (FSC)
- GRO Code of Practice for Green Roofs
- HSE leaflet INDG284 Working on roofs
- HSG33 Health and safety in roof work
- LPCB Red Book
- NARM guidance documents
- NFRC Technical Guidance Notes
- NFRC Safe2Torch guidance
- NHBC Standards
- Programme for the Endorsement of Forest Certification (PEFC)
- The assessment and classification of waste packaging
- WHSA Guidance Note 7

7. References

LRWA

Liquid Roofing and Waterproofing Association

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