Department for
Business, Energy
& Industrial Strategy

Retrofit Room in Roof Insulation

Guide to best practice

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Glossary

Air barrier - A building material with properties that aim to prevent the passage of air through it. An air barrier may also be a VCL or a vapour barrier, but it may be specified to have a very low resistance to the passage of vapour.

Hygrothermal movement - Refers to the movement of moisture and heat through buildings and building materials.

Interstitial Condensation - This is a type of condensation that may occur on relatively colder surfaces within an enclosed wall, roof or floor structure.

IWI - Internal wall insulation. Insulation that is installed on the warm side of a wall.

PAS 2030 - The specification for installation of energy efficiency measures in existing buildings - for installers.

PAS 2035 - Retrofitting Buildings for Energy Efficiency - Specification and Guidance - Assessors Designers and Retrofit Coordinators.

RIRI - Room in the Roof Insulation. Insulation in a pre-existing room in a roof space.

Skeiling - Pitched roof section in room in a roof.

Thermal bridge - area of the building envelope where the insulation is:

a) discontinuous or thinner than the adjacent insulation;

b) has higher thermal conductivity than the adjacent insulation; or

c) has reduced effectiveness due to the building geometry;

leading to locally increased heat loss and therefore locally reduced internal surface temperature.

Thermal bypass - Unintended penetration or circulation of external air on the warm side of the insulation layer in a construction, rendering the insulation ineffective.

Vapour barrier - A building material (usually a membrane) with properties that <u>prevents</u> the passage of moisture through it.

Vapour impermeable - prevents the passage of water vapour by diffusion.

Vapour permeable - allows the passage of water vapour by diffusion.

VCL - Vapour Control Layer - A building material (usually a membrane) with properties that <u>controls</u> the passage of vapour through it.

1. Introduction

The built environment is one of the biggest carbon dioxide emitters, with space heating being a large proportion of this. To meet UK´s 2050 emissions targets, it is necessary to reduce carbon dioxide emissions of the existing building stock. Retrofit not only reduces operational emissions, but also avoids replacing the embodied carbon of demolition and rebuilding. By installing insulation, thermal performance and comfort levels are improved and there is a corresponding reduction in energy costs for the householder and in carbon dioxide emissions.

Improving the building energy efficiency with insulation measures and the use of efficient systems and sources of renewable energy are necessary. However, a fabric first approach to domestic energy saving is very important, as it reduces the overall demand for heating, the size of the heating system and the demands on the renewable energy supply.

Retrofit insulation, whilst conferring great benefits, also carries risks if not fitted in a considered and careful manner and can lead to unintended consequences as outlined in section 5. Good design based on the thorough understanding of the principles of safe retrofit AND the building being worked on, is vital to successful and long-lasting outcomes.

Unlike retrofitting other dwelling elements, room in roof insulation (RIRI) is more likely to be adding to and combining with previously installed insulation.

For the purpose of this guide a room in roof is defined as any pre-existing room in which all or part of the ceilings follow the rafter line of the roof.

Rooms in roofs come in many shapes, forms and parts, and with different construction histories and consequent risk profiles. Therefore, this guide will only cover those most common room in the roof insulation scenarios.

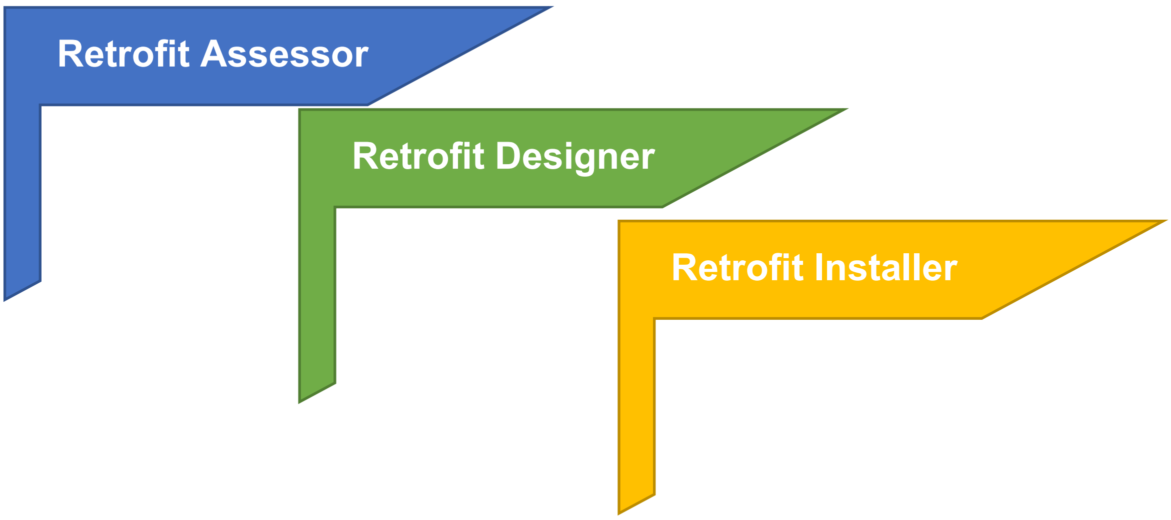
With special thanks to Norfolk Building and Energy Services and Enhabit for producing this guide, and to Peter Rickaby, AECB, Green Building Store, Ofgem, GDGC, the IAA, ATMA, Trustmark, Carbon Co-op, Retrofitworks, Saint-Gobain Insulation UK, BBA, MIMA, Bierce Surveying, Insulation Manufacturer Association, ScottishPower, EDF Energy and relevant system designers and installers for their input and support during the production of this guide.

2. Scope

The aim of this guide is to provide clear reference for designers, surveyors and installers considering the suitability of roofs to receive internal thermal upgrades to:

- assess the viability of insulations and systems for scenarios they might encounter,
- select materials based on hygrothermal understanding and installation best practice, and
- steer designers, surveyors, and installers towards safe methods of achieving the best possible solutions.

The whole guide is recommended reading for any parties undertaking room in roof insulation. However, some sections have been written specifically with PAS 2035 in mind - for the retrofit assessor or surveyor, the retrofit designer or the retrofit installer, and these are labelled, and colour coded at the beginning of the chapters. Chapters that are applicable to all audiences have no colour coding.



This guide may also be relevant to the insulation requirements of loft conversions. However, when converting an existing roof space into a room or rooms or subdividing roof rooms, there are provisions for fire, structural changes and means of escape that need to be considered and are not covered here. The focus of this guide is the insulation of existing rooms in roofs.

This guide does not cover the insulation of roofs externally (‘over rafter’ warm roof).

It is very important that external and other exposed walls are insulated at the same time as other room in roof surfaces, but the installation of internal wall insulation (IWI), external wall insulation and cavity wall insulation that might form a part of RIRI is fully dealt with in other publications which should be referred to when undertaking RIRI[1]. Dwarf and other timber framed walls that are unique to RIRI projects are included within this guidance.

Drawings or images in this guide are for general illustration, and not prescriptive guidance.

PAS 2035/2030 ‘Retrofitting dwellings for improved energy efficiency. Specification and guidance’ is sponsored by the UK Government’s Department for Business, Energy and Industrial Strategy (BEIS). It is a key document in a framework of new and existing standards on how to conduct effective energy retrofits of existing buildings. PAS 2035 covers how to assess dwellings for retrofit, identify improvement options, design and specify Energy Efficiency Measures (EEM) and monitor retrofit projects. Meanwhile PAS 2030, which was redeveloped in conjunction with PAS 2035, covers the installation, commissioning and handover of retrofit projects. Organizations which trade using the Trustmark Government endorsed Quality scheme are required to comply with PAS 2035. The principles and guidance within PAS 2035/2030 are recommended for all retrofit projects.

The basic approach to assessment and installation can be summarised as follows:

RIRI Assessment & Design process

Pre-design retrofit assessment
↓
Identification of remedial works
↓
Health and Safety Risk Assessment
↓
Implementation of remedial works (allowing time for drying if damp was present)
↓
Develop insulation strategy (including mitigation of risks such as moisture, fire, flood & overheating)
↓
Develop detailed design

RIRI installation process

Pre-installation building inspection & verification retrofit assessment and design
↓
Health and Safety Risk Assessment
↓
Installation Considerations and Method Statement
↓
Carry out installation
↓
Making Good
↓
Post installation Checks
↓
Handover
↓
Monitoring

[1] Understanding Best Practice in Deploying External Solid-Wall Insulation in the UK, UCL
Guide to Best Practice, Retrofit Internal Wall Insulation, BEIS, 2021

3. Room in Roof identification: Context, scenarios, elements and junctions

1. In planning Room in Roof Insulation (RIRI) it is helpful to understand the historical and building context of the proposed work.

Structure

2. Cut roofs: Hand cut timber roofs predominated until the middle of the 20th century. Economy often determined the design, to minimise the amount and size of timbers used.
3. Large roofs generally had some combination of beams, trusses and purlins (see Figure 1) to support rafters allowing the timbers to be smaller in section. The trusses came in different degrees of complexity depending on the span of the roof and, where applicable, the aesthetics.

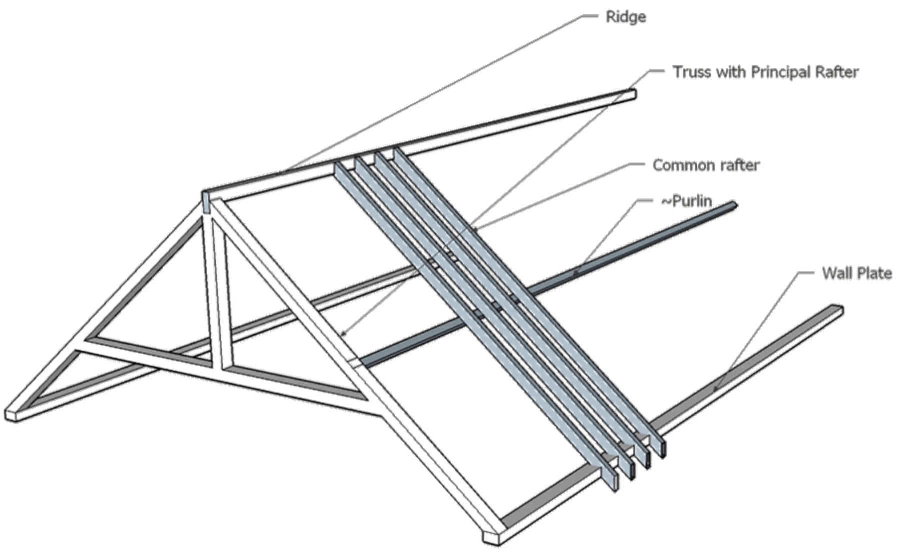


Figure 1: Typical configuration of timbers in roofs

4. Roof timbers in older houses are often ‘wany’ edged and irregular. Regularized timber arrived towards the end of the 19th century.
5. Roof rooms are most often found in hand cut rafter roofs. These roofs were not designed with insulation in mind. The contextual challenges they often present are these:
   - The shape and contortion of older timbers and roofs.
   - The depth of the rafters giving inadequate space for insulation and ventilation.
   - Trusses, purlins and other downward intrusions from the line of the roof.

6. In the 1940s, shortages of timber encouraged the development of the engineered or trussed roofs using ever lighter (mostly thinner) timbers. These were mostly for 'cold' unoccupied roof spaces, but the trussed rafter system developed into accommodating rooms in roofs in their design, and more often than not, safe and replicable (if minimal) insulation and ventilation were accommodated at the time.

Roof coverings, sarking and membranes

7. Outer roof coverings (with the possible qualification of thatch) have always sought to exclude water from the timbers and roof space entirely. However, they are not always completely watertight and often have gaps where wind and wind driven weather can reach.
8. The traditional response to this was typically an application of lath and plaster, reeds, or wattle and daub. This 'buffering' layer allowed moisture from the outside and inside to be absorbed and then to dry out, and it provided a small degree of insulation and draught proofing internally.
9. Then, from around the 1930s, this vapour permeable buffering layer was replaced, in repairs and new builds, with impermeable roofing felts – bituminous felt being the most common. These were impermeable to moisture and long lasting, but susceptible to impact, animal and UV damage. Timbers in these kinds of roofs are at higher risk of moisture problems because the impervious roofing felt traps moisture which can accumulate if the roof space is not properly ventilated.
10. In the 1970s plastic felts were introduced which were lighter, more convenient to apply, stronger and completely impermeable.
11. The introduction of impermeable bituminised and plastic felts coincided with the growing spread of central heating and insulation and the corresponding increasing moisture content of the internal environment.
12. It soon became evident that 'through' ventilation had become necessary to avoid condensation (and consequential problems) on the cold felt surfaces.
13. In the 1990s new vapour permeable roofing membranes appeared that in some ways reproduced the characteristics of the pre bituminised coverings.
14. Vapour permeable membranes have developed since their introduction from not very vapour permeable to very vapour permeable and 'intelligent' one-way membranes.
15. Vapour permeable membranes do not all have the same ability to deal with air borne moisture, the successful use of different types being dependent on different arrangements for internal ventilation, outer battening and membrane laying.
16. The type of membrane present may affect the choice of type and method of insulation.

Scenarios

17. There are a variety of scenarios to be found in the way a RIR is constructed and lined that raise questions that will influence the risk assessment and approach to the retrofit insulation.
18. Retrofit Assessors, Designers and Installers must do the necessary and sometimes destructive investigation work to ascertain the current position and answer the following

questions:

- Do and will timbers penetrate the insulation layer?
- Are there pipes, cables, appliances, flues or other fittings and fixtures that will be in contact with or otherwise be affected by the work?
- Do and should the insulation, airtightness and VCL line follow the room shape or the roof shape?
- How much of what type of insulation is already present?
- Can the existing insulation be over-insulated, or will it have to be replaced?
- How are the roof timbers ventilated – if at all?
- What kind of roof membrane is there?

Dormers and flat roofs present slightly different challenges

- How are they built?
- Do the relative positions of dormer cheeks, roofs and windows mean that there are space limitations on the potential thickness of the proposed insulation.

Is there a loft space – and is this used for storage?

19. Roof spaces above flat ceilings and behind dwarf walls have long been used for storage.
20. A loft hatch or access door to the storage space are often unwelcome breaks in the (ideally continuous) insulation layer and are weaknesses in the air tightness and VCL layers.
21. Whilst it might be sensible to design, these storage spaces out of roofs they are often valued by householder, so may need to be accommodated.

Room in Roof Elements

22. For the purposes of this guide the room in roof is divided into the most commonly found elements.
    - Sloping ceilings – Skeilings
    - Flat ceilings
    - Dwarf stud walls – insulated or uninsulated
    - Dormer cheeks
    - Dormer flat roofs
    - Dormer pitched roofs
    - Gable walls
    - External walls: these are dealt with in other Guides

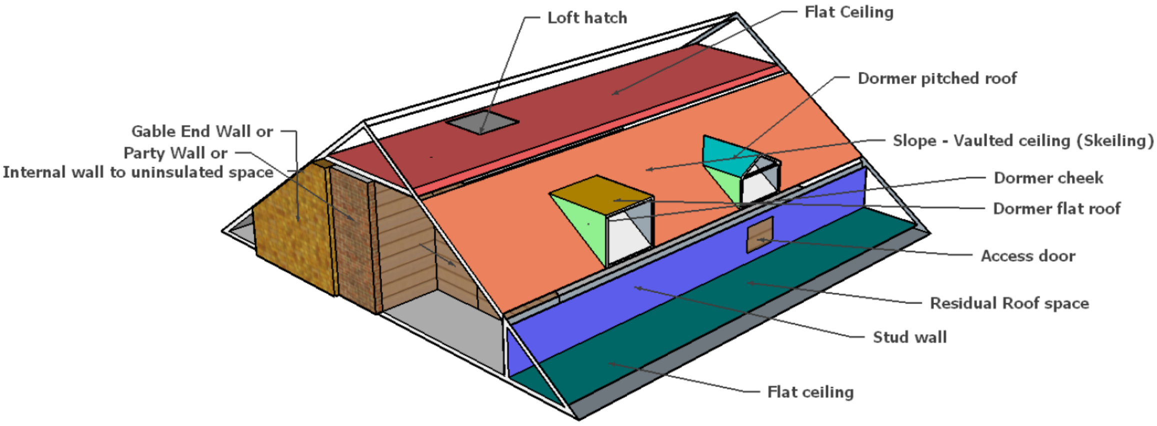


Figure 2: Room in roof elements

4. Benefits

23. Thermal comfort can be significantly improved with RIRI measures. Heat loss through roofs accounts for a significant proportion of heat loss from dwellings.

24. RIRI helps increase and maintain the internal temperature as well as providing a higher surface temperature, both of which contribute to improved comfort.

25. Properly installed RIR insulation will improve thermal comfort and reduce energy bills for occupants and contribute towards the national policy objectives of greenhouse gas emissions reduction and the alleviation of fuel poverty.

26. The main sources of heat loss in relation to roofs are:

    - conductive heat loss through the fabric of the roof
    - conductive heat losses through thermal bridging and junctions of roof sections
    - convective heat losses through poor airtightness
    - convective heat losses from draughts from roof penetrations

27. Conductive heat losses will be improved in proportion to the choice and thickness of material used. Convective heat losses will be improved by good workmanship and detailing addressing air tightness in the installation

28. Insulating the RIR from the inside can be done without the use of scaffolding and in any weather and avoids a change in the roof line and some other technical difficulties where insulation is applied over the roof structure.

29. The level of airtightness of a building should improve when installing RIRI. It is essential to have good airtightness in building construction as it protects existing construction elements and seals uncontrolled air leakage pathways at junctions and edges. Good airtightness reduces heat loss and helps to avoid unintended consequences such as interstitial condensation.

30. Although internally applied RIRI can be more disruptive for the occupants than externally applied insulation, it does allow the opportunity for a room by room approach to retrofit, taking advantage of opportunities and reducing constraints around budget and scale.

5. Unintended consequences

31. Whilst a room by room approach presents some advantages to occupants and owners, understanding the whole roof and building context of the work is vital, as insulating rooms in roofs can bring unintended and potentially unwelcome consequences.

32. Improving insulation and airtightness in one area of a building affects the conditions in the whole building, so RIRI should always be seen in the context of a whole building approach to retrofit, and ideally as part of a medium-term plan for the dwelling – all as described in PAS 2035.

33. It is common that ventilation systems in existing dwellings are not adequate and rely on a leaky building fabric to provide sufficient ventilation. When undertaking retrofit, ventilation design must therefore be addressed such that it can extract and supply

sufficient air through safe, and correctly sized supply and extract points, to avoid excess humidity and poor indoor air quality throughout the building.

34. The designer and installer must always check that there is adequate ventilation in the rest of the house (in accordance with PAS 2035 and Building Regulations, see Section 9 Design Principles for more information) and advise and remediate as appropriate before the retrofit insulation takes place.

35. Overheating represents another significant post RIRI risk - particularly for rooms in roof. Heat from the house itself and from solar gain is less likely to dissipate after retrofit insulation is installed.

6. Building Regulations

36. It is the responsibility of the assessor, designer and installer to consider whether the works being undertaken would be considered “Building Works” as defined by the Building Regulations.

37. For clarity, an internal partition wall separating one heated room or space from another (including party walls) and not forming part of an external wall is not considered a heat loss perimeter. Any such type of construction is excluded from this guidance.

38. The Fire Safety Bill published in March 2020 places beyond doubt that external wall systems that form part of a room in the roof retrofit, fall within the scope of the Regulatory Reform (Fire Safety) Order 2005. Designers and installers need to follow current Regulations in England and the devolved nations[2] for high-rise buildings (Note: the definition of a high-rise building varies between the devolved nations).

39. In England and in Wales, the Building Regulations apply to most buildings and alterations to existing buildings. They contain a range of requirements in respect of how a building is designed or constructed. Similar regulations apply in the other devolved administrations.

40. In Scotland, reference should be made to Schedule 3 Descriptions of Building of the Scottish Building Standards, and work including the provision of services, fittings and equipment, not requiring a warrant. Unless the work is more extensive and may require an application for a Building Warrant to be made to the Local Authority.

41. In Northern Ireland reference should be made to the Building Regulations and specifically Part F (Conservation of Fuel and Power).

42. The Building Regulations in England 2010 provide that “building work” shall be carried out so that it complies with the requirements contained in Schedule 1. The definition of “building work” includes, but is not limited to:

    - the erection or extension of a building (which would cover new builds);
    - the material alteration of a building, which is either;

[2] At the time of publication the Building Regulations Approved Documents for the devolved nations can be found at the following links:
http://www.buildingcontrol-ni.com/regulations
https://www.gov.scot/policies/building-standards/monitoring-improving-building-regulations/
https://www.gov.uk/government/collections/approved-documents
https://gov.wales/building-regulations-approved-documents

    - where the work would result in the building no longer complying with a previous requirement when it once did; or
    - a building, which before the work did not comply with a relevant requirement, being more unsatisfactory in relation to such requirements.
- the insertion of insulation into the cavity wall of a building; and
- certain other specific work which relates to energy efficiency requirements, including the renovation of individual thermal elements or change in the energy status of the building.

43. Schedule 1 Part B of the Buildings Regulations 2010 contains requirements for fire safety, which includes requirement B3, relating to internal fire spread (structure). This provides that the building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period, as referenced in Schedule 1 Part B of the Building Regulations 2010. In other words, if the project is “building work” for the purposes of the Building Regulations, the fire resistance requirements apply. Specific fire requirements also apply where the wall is adjacent to an attached or integral garage.

44. If there is any doubt over the compliance and handover (as specified in the latest version of PAS 2030) of the installation, or whether Building Regulations apply, an independent report from Building Control confirming that they are content with the approach taken should be obtained, and this must be undertaken on a property specific basis.

45. An assessment of the ventilation requirement for the property must be undertaken in accordance with the requirements set out in the latest version of PAS 2035. Part F of the Building Regulations requires that the building works (when completed) should not demonstrate a worse level of compliance with other applicable requirements of Schedule 1 than before the work commenced. i.e. “make it no worse”. This is often not adequate for situations where room in roof insulation is being installed and therefore the process in PAS 2035 Annex C should be followed.

46. Because this advice deals with whole room insulation at a minimum, it is safest to assume that Building Regulations Approved Document L1b applies to the work.

47. For internal solid wall insulation (IWI) installers and designers should refer to the previously referenced BEIS *Guide to Internal Wall Insulation.*

7. Building suitability assessment & risks

48. Retrofit Assessment, Design and Coordination are terms drawn from PAS 2035 and are best understood in that context.

49. A retrofit assessment should include correct identification of the different construction types, materials and ventilation strategies present in the room to be insulated, as this will have a significant impact upon the retrofit design. Guidance can be found in the section above: - *Room in Roof identification: Context, scenarios, elements and junctions.*

50. A retrofit assessment shall include evidence such as photographs or drawings which have suitable referencing to identify the precise spatial area of the RIRI that it relates to.

51. Further information on construction types can be obtained by undertaking Retrofit Assessor training, Retrofit Coordinator training, or the AECB Carbonlite Retrofit course.

52. When assessing the suitability of a roof room for retrofit insulation, a Retrofit Assessor should undertake a whole building assessment as outlined in PAS 2035.

53. Table 1 below describes areas of risk associated with RIRI which should also be included in the retrofit assessment. These risks should be reviewed throughout the project. These and further risks may be uncovered during the initial assessment, design and/or installation processes.

54. Assessors should be aware that some elements of the roof construction may not be accessible to them at the time of the assessment and should include these limitations in their report.

55. For all actions and risks associated with existing moisture, remedial action may be required to remove or reduce the source of moisture. Any damp sections of the existing construction should be allowed to dry thoroughly prior to installation of RIRI. The building should then be re-assessed to ensure it is in a suitable condition for RIRI.

56. Some risks identified in the table below are mitigated in the retrofit design and are for the consideration of the Retrofit Designer. These are in green text. Note that this table is unlikely to be exhaustive and that other risks may be identified by the Retrofit Assessor or Designer.

Table 1: Pre-installation suitability and risks

Historical Significance

Action	Assessing	Methodology and mitigation	Risk
Has an assessment been undertaken of how the measure may affect the significance of the building after installation, particularly if the building is defined as traditionally constructed?	Impact of the measure that may have a detrimental effect on the significance of the building.	Completing a Heritage Significance Assessment based upon BS7913 as described in PAS 2035. (Note: PAS 2035 allows the use of a simplified checklist for some buildings) Identify whether the RIRI will have an impact upon the heritage significance. Retrofit designer: Take heritage significance into consideration when developing the retrofit design. Property may not be suitable for RIRI (Refer to BS7913)	Non-compliance with PAS 2035, and negative impact on the significance of the building.

Context, structure and condition

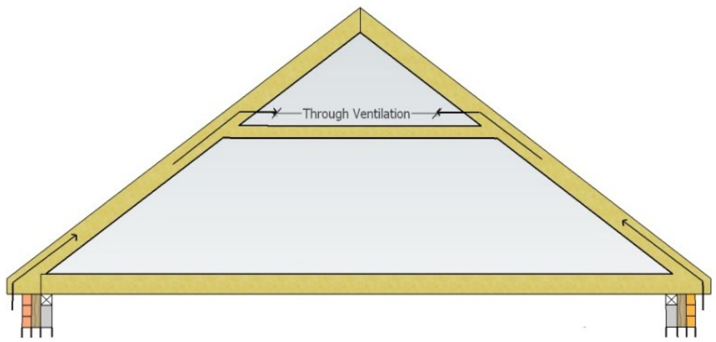
Action	Assessing	Methodology and mitigation	Risk
External Roof survey	Whether the condition of the roof can be assessed without access equipment.	If external inspection is not possible and there is no way to establish that the roof surfaces are in good condition, then consider employing specialist equipment for survey. Visual inspection of external finish of roofs.	Rot or decay of rafters, wall plates, bargeboards and fascias. Water penetration into insulation.

Action	Assessing	Methodology and mitigation	Risk
Are external roof coverings in good condition and an effective barrier to wind and rain?	Whether external roof coverings need repairing or cleaning prior to installation of RIRI to prevent rain penetration.	Identify any loose, damaged or missing tiles or slates. Check condition of coping stones on parapets. If possible, identify flat roof defects through external and internal inspections. Retrofit designer: Spot repair roof coverings where feasible. Otherwise recommend reroofing and delay RIRI work. If reroofing, different insulation strategies may be possible. Repair or replace damaged coping stones and allow time for wet elements to dry.	Further damage to fabric by preventing drying to inside due to RIRI installation. Damp timbers need to dry out before RIRI is installed.
Are gutters, flashings and external pipework in good condition?	If remedial works are required to repair external guttering, flashings and pipe work to avoid water leaking into building fabric.	Visual inspection of guttering, flashing, pipes and external walls for signs of leaks. Damp patches may be visible in brickwork. Use hose or other water source to check for leaks in external drainage. Retrofit designer: Repair all guttering, flashing, pipes or services so that water is taken away from the fabric of the building efficiently.	Rot or decay of roof timbers. Water penetration into roof structure.
Are the roofs and the proposed works covered by the	Suitability to use this guide and methodology.	Establish the existing construction and suitability of proposed insulation for the context.	Potential for rot and decay in roof timbers.

Action	Assessing	Methodology and mitigation	Risk
definitions in this guide?			
Are there any structural defects in the roof?	If the roof timbers need strengthening prior to installation of RIRI. Bear in mind that they may be carrying an additional load from the RIRI work.	Visual inspection. May require structural engineer and/or invasive investigations. Retrofit designer: Reinforce the roof timbers using structural engineer's instructions. Consider structural limitations when selecting insulation materials. Dense mineral wools can add significant loading.	Further structural deterioration and collapse.
Is there any evidence of damp, surface condensation, salts, fungus on roof timbers- or roofing felts?	If remedial works need to be done to improve ventilation in roof/ rafter space.	Visual inspection of all accessible roof areas. Mould growth or condensation indicates inadequate ventilation. Focused areas of fungus or mould growth may indicate water ingress from elsewhere.	Further mould growth and timber decay through rot or infestation.

Action	Assessing	Methodology and mitigation	Risk
		 **Figure 3: Mould on roof felt**	
Are 100% of externally facing RIR surfaces to be insulated?	Extent of external facing surfaces. The presence of obstructions and permanent features on surfaces inhibiting proposals.	Visual inspection of ability to access every relevant surface. Assessment of plans to remove relevant fixtures, fittings and other permanent features. Retrofit designer: Follow guidance in Section 9. Design Principles, for less than 100%.	Increased risk of surface condensation in uninsulated areas adjacent to insulated areas.
Identifying the continuous thermal	Which walls and ceilings constitute the thermal barrier?	Visual inspection of the existing arrangement and how it is compromised, if at all, by the use of uninsulated spaces for storage, timbers and other intrusions.	Discontinuity of insulation, thermal

Action	Assessing	Methodology and mitigation	Risk
and air tightness and VCL line.	Storage hatches into uninsulated spaces.	Consider that the thermal envelope, the air barrier and the VCL may not follow the exact same lines and will have different joining and edge details. Ensure measured survey is produced to allow retrofit designer to visualise roof in 3 dimensions. Check and record whether there are roof areas that are not part of the room in roof but may require insulation from it and the rest of the dwelling.	bridges, loss of air tightness. Losing storage space leading to customer dissatisfaction.
What type of roofing membrane and roofing finish is installed?	Is there a membrane? If so, how vapour permeable is the membrane?	Investigate as necessary to determine the resistance of the roof finish or membrane to moisture. (See notes above about membrane types and their properties). Moisture needs to have a means to escape from roof constructions, and this will be affected by the type of membrane installed. Retrofit designer: If there is no membrane, it should be considered whether insulation works should proceed. The Retrofit Designer should consider all risks and may propose different insulation strategies to be adopted. Take into account existing membrane hygrothermal properties when specifying retrofit solutions. If this cannot be established the lowest risk approach should be adopted.	Condensation, damp and rot in the roof timbers

Action	Assessing	Methodology and mitigation	Risk
What arrangement is there to ventilate the roof space and in between the rafters?	The type of ventilation and whether it is and/ or might be compromised by the proposed insulation.	Investigate as necessary to establish the inlets and outlets for air passing between the rafters and through the roof space. Measure rafter depths and note ventilation space between felt and insulation where present. Note whether ventilation is continuous between rafters. It is common for pitched roofs to be ventilated, and 'cold' flat roofs are ventilated in the same way.  **Figure 4: Typical through ventilation of rafters and roof void** Retrofit designer: A minimum of 50mm ventilation gap should be retained between insulation and membrane which would then mean that a vapour permeable wind-tight membrane may be required to protect some insulation products to avoid thermal bypass from the ventilated cavity. The only exception	Condensation, damp and rot in the roof timbers.

Action	Assessing	Methodology and mitigation	Risk
		is warm flat roofs where the insulation is over the joists, these do not require ventilation. Inspect eaves ventilation, roof ridge and tile ventilation and take photos to establish total ventilation sizes. Where access is constrained, make the necessary limitations statement to the designer.	
Is the loft hatch (where installed) insulated and airtight?	Continuity of VCL and air tightness layer.	Check loft hatches and storage doors to uninsulated spaces are properly insulated and airtight Airtightness will require more than single point locking. Retrofit designer: Design to include insulated and airtight loft hatch and storage doors where access is required.	Large cold bridge risking condensation if the loft hatch is not properly insulated. Where the loft hatch is not sealed there may be leakage from the house to the roof space via convection or suction of air from the house into the roof space - wasting heat and bringing moisture with it - which could condense in the roof space if it is not properly ventilated.

Action	Assessing	Methodology and mitigation	Risk
Are there any timber roof members that protrude through the roof line?	Potential for thermal bridging and air leakage	Identify and mark up all timber penetrations through the roof/ceiling line (the boundary of the room). Retrofit designer: Assess whether these can and should be boxed and insulated or left protruding.	Creation of a thermal bridge and air leakage, leading to heat loss and increased risk of surface condensation and mould growth. Non-continuous air barrier leading to increased risk of thermal bypass (air leakage) and moisture penetration into the internal wall insulation.
Are there any other fixings or penetrations that currently go through the roof/ceiling line?	Potential for thermal bridging and non-continuous air barrier and VCL.	Identify and mark up all fixings and penetrations. Retrofit designer: Ensure that a suitable design for the air barrier is available for all types of penetration. Ensure that fixings specified do not incur unacceptable thermal bridging (e.g. large metal brackets for radiators, or numerous metal fixings).	As above.

Action	Assessing	Methodology and mitigation	Risk
Is there insulation in the existing roof?	Potential for integration into new RIRI design.	Assess all existing roof constructions, the type and condition of the insulation, wind barrier and airtightness barrier (if these are present). Retrofit Designer: Consider whether the existing insulation installation is appropriate for the RIRI design and whether it requires removal, remedial work or could remain as part of the RIRI design.	Thermal bridging, thermal bypass, interstitial condensation, poor airtightness.

Services

Action	Assessing	Methodology and Mitigation	Risk
Are there any penetrations from hot appliances going through the roof that carry the risk of fire?	RIRI may increase temperatures around flues and chimneys.	Inspect and record any flue penetrations, or in-use chimneys. Retrofit designer: Take into account chimneys and flue penetrations when designing the room-in-the-roof insulation.	Fire
Do any appliances in the room use combustion?	If any RIR wall or roof ventilation present or is required for combustion devices.	Visual inspection of combustion devices and any wall ventilation. Assessor should take expert advice.	Carbon monoxide risk or failure of the appliance to operate effectively.

Action	Assessing	Methodology and Mitigation	Risk
		Retrofit design should allow for adequate ventilation for combustion devices without compromising the performance of the insulation.	
Are there any electrical installations or wiring on/within RIR elements?	Potential for electrical fittings to be covered up during installation.	Identify and mark up any light fittings or electrical connections that will need protecting or moving during the installation phase. Retrofit designer: Take expert advice and follow existing guidance on the potential impact of the works on electrical installations. Where electrics are moved or otherwise affected by the works, the design and installation should always be checked by a qualified electrician. For example: • Ensure that the design has incorporated the safe operation of light switches, sockets etc. • The sizing of the cables may be critical and they may need derating. • Beware of insulating over electric cables as this can cause overheating. • Consider designing in a service cavity.	That the previously adequate electrical installation will no longer be safe. Overheating of fitting and fire risk. Adverse reactions between cables and insulation. As above - potential thermal bridge and compromising the air tightness/VCL layer.
Are there any penetrations from light fittings going	Are recessed light fittings airtight insulation compatible (IC) rated?	Inspect type and model of recessed light fittings. Record number and position. Retrofit designer: Take expert advice on the potential impact of the works on light fittings. Where lights are moved or	Smouldering and fire.

Action	Assessing	Methodology and Mitigation	Risk
through the roof/ceiling line?		otherwise affected by the works, the design and installation should always be checked by a qualified electrician. For Example: • If non-IC (insulation compatible) light fittings will penetrate the insulation layer then they should be replaced with insulation contact and air tight (ICAT) light fittings.	Thermal bridge around non-IC light fittings. Air leakage around non-ICAT light fittings leading to moisture build-up in loft space.
Are there other electrical items in or over the roof space?	The presence of Solar PV, inverters, extract fans or any other electrical items.	Inspect and record all electric items. Retrofit designer: Take appropriate advice on the potential effect of the insulation on these items.	That the previously adequate electrical installation will no longer be safe. Overheating of fitting and fire risk. As above - potential thermal bridge and compromising the air tightness/VCL layer.
Are there and will there be tanks and pipes, or other building services in	Type and number of building services in unheated spaces surrounding the room in the roof.	Inspect and record positions of pipes, tanks, ventilation, ducts and insulation around them. Can these be moved or removed? Take expert advice where necessary.	Burst pipes and tanks. Maintenance access post retrofit.

Action	Assessing	Methodology and Mitigation	Risk
uninsulated roof spaces?		Retrofit designer: Water tanks and pipes must be properly insulated (following existing regulations and guidance) in cold roof spaces that will be made colder once the room in the roof is well insulated.	Reduced efficiency of ventilation systems.
Is there sufficient ventilation in the property?	Potential for high relative humidity levels after RIRI is installed.	Assess ventilation system in accordance with PAS 2035 Annex C. Record details and pass on to Retrofit Designer. Retrofit designer: If ventilation system is not adequate, then include a ventilation upgrade in retrofit design.	Increased risk of condensation and poor air quality.

Wildlife

Action	Assessing	Methodology and Mitigation	Risk
Is there any evidence of wildlife in the roof space?	Presence of protected species. Presence of desirable and undesirable wildlife.	Look for nests, animal droppings. Take necessary advice from experts on what should be done and advise Designer.	Illegal disturbance to protected species. Physical damage to structure and services from undesirable wildlife. Risk to installers.

Overheating

Action	Assessing	Methodology and Mitigation	Risk
Is there an overheating risk in the existing room in the roof?	Risk of overheating and evidence for overheating.	Record size, orientation and type of glazing. Record any existing shading from eaves overhangs, trees or otherwise. Record any evidence of overheating from occupant's perspective. Retrofit designer: Evaluate overheating risk using an appropriate tool, such as the Good Homes Alliance or the Passivhaus Trust overheating risk tools. Ensure modelling undertaken is appropriate to overheating risk. Ensure overheating risk is reduced to a minimum with appropriate design, following the guidance in PAS 2035. Consider using insulation materials with higher thermal mass to help mitigate overheating. Consider the use of secure night-time ventilation in reducing overheating.	Overheating, uninhabitable space in a future climate.

8. Materials

57. To improve the thermal performance of a roof area by adding extra insulation, it will need to comply with the current relevant national building regulations.

58. Currently, in England, Wales and Northern Ireland a vaulted or flat roof should achieve an ‘improved’ thermal transmittance (U-value) of 0.18 W/m^2K, and a roof insulated at ceiling level should achieve an ‘improved’ thermal transmittance (U-value) of 0.16 W/m^2K. Where this is not technically or functionally feasible, then the roofs should be upgraded to the best U-value possible. In all circumstances, the U-value must be calculated in accordance with the conventions in the current version of BR443 conventions for calculating U-values.

59. In Scotland a roof should be upgraded to meet a U-value of no worse than 0.35 W/m^2K, and the area weighted average for all roof elements should be no worse than 0.25 W/m^2K.

    Important note: These U values will change, and readers should refer to the current Building Regulation Guidance Documents for the devolved nations.

60. There is some latitude in the Building Regulations to lower these standards for technical and cost reasons in the case of roof insulation at ceiling level and rafter level. However, it would usually be reasonable to adhere to these standards or better them.

61. Different types of insulating material will be appropriate for different roof areas. It is important that manufacturers’ technical information is checked to see if the materials are appropriate for the situation where they are to be installed, and this could be verified by a Retrofit Designer or by referring to details of Technical Approvals such as an Agrément Certificate for specific applications.

Material Conformity

62. When assessing any material for use as RIRI insulation, there are a number of factors that should be considered. These are set out in Table 2 below.

Table 2: Material Conformity

Assessment	Requirement	Evidence
Are the materials suitable for the selected use?	Consider if the material is suitable for use for the location chosen.	Appropriate hygrothermal assessment (see BS 5250 for more guidance) of the specific situation in which it is being installed. OR Case studies with monitoring of the same situations. OR

Assessment	Requirement	Evidence
		UKCA or CE Marking with manufacturers Declaration of Performance and data sheet. OR UK Technical Approval or European Technical Approval. OR 3rd Party Certification of material for specific applications such as BBA or KIWA Certificate of Agrément.
Does the construction meet fire regulatory requirements?	The materials must have the correct fire classification to follow current legislation.	Reference to the Declaration of Performance and assessment of the characteristics and location of the materials to be used.

9. Design Principles

63. Architectural junction details, showing airtightness layers, vapour control layers (VCLs) (if needed), insulation materials and structures should be provided for all relevant junctions, edges and corners associated with the RIRI. These should be readily available on site.

64. An airtightness and moisture strategy summary should be recorded and be available on site for quick reference.

65. A ventilation design for the roof space and roof timbers should be provided based on the findings of the retrofit assessor.

66. Consideration should be given as to whether the roof timbers and spaces are adequately ventilated pre-retrofit and whether the ventilation provision could be adversely affected by the proposed retrofit works.

67. The appropriate allowances should be made for the type of roof membrane in place and its hygrothermal properties.

68. A services design should define how lights and services are to be fitted safely.

69. A ventilation design for the dwelling should be provided to ensure moisture balance is achieved in the long run.

70. Room in the roof insulation schemes should be assessed individually on a property specific basis. The Retrofit Designer may then adopt a RIRI system, design it themselves or combine the two approaches.

Thermal bridging

71. Depending on the geometry of the roof, RIR insulation may be installed on its own or as part of a package of measures. Even as a single energy efficiency measure, thermal bridging is important and designs shall show how insulation can be continuous around junctions, edges and corners. If this is not possible then thermal bridges should be mitigated. An example of thermal bridge mitigation that may be used by a Retrofit Designer, might be to return insulation along thermal bridge junctions by a minimum of 400mm, although care should be taken to consider the moisture risk of the surface along which insulation is returned. All thermal bridges should be considered and assessed when installing RIRI, the following are examples of thermal bridge junctions that might occur in RIRI projects (Figure 5 can help to visualise these junctions):

    - Around window and door reveals and dormer walls. Using a thin insulation (<15mm) returned into the reveals or dormer walls is a good way to reduce thermal bridging. Figure 6 shows how window or door reveals may be insulated to reduce thermal bridging.
    - Where dormer walls meet pitched roof or dwarf walls.

- Where wall or roof insulation is interrupted by internal walls, party walls[3], intermediate floors, stairs or other permanent structures where they meet external walls or roofs.
- Where ceiling and roof insulation meets all external walls.
- Where dwarf walls meet roof insulation.
- Where dwarf walls meet pitched roof insulation.
- Where the pitch of the roof changes, and at roof ridges.

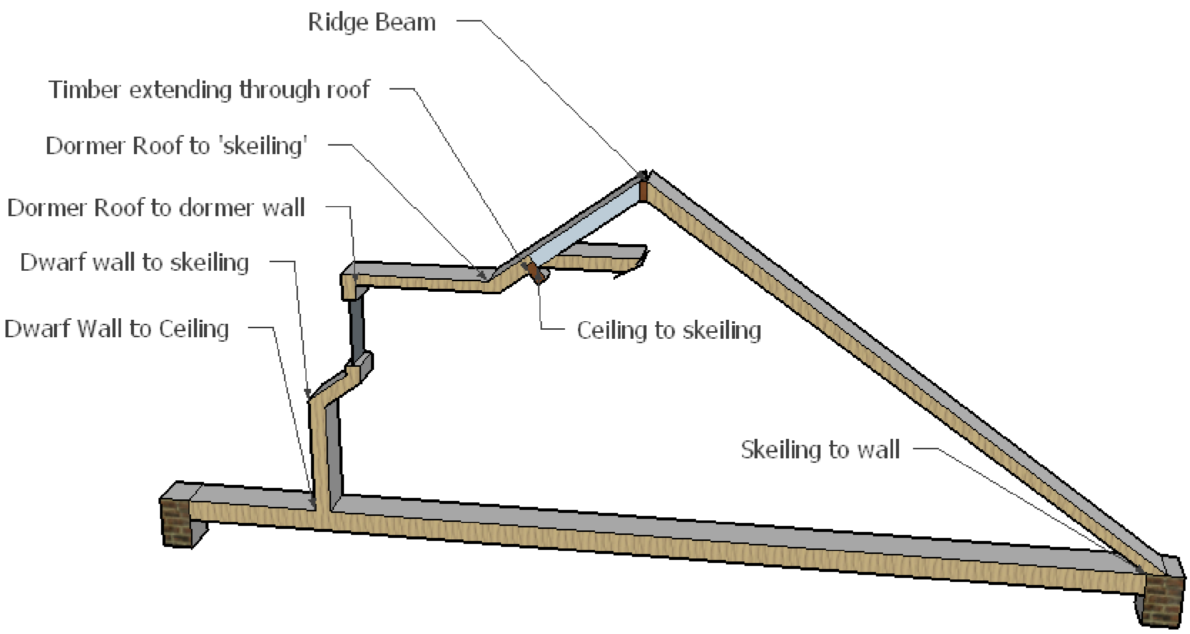


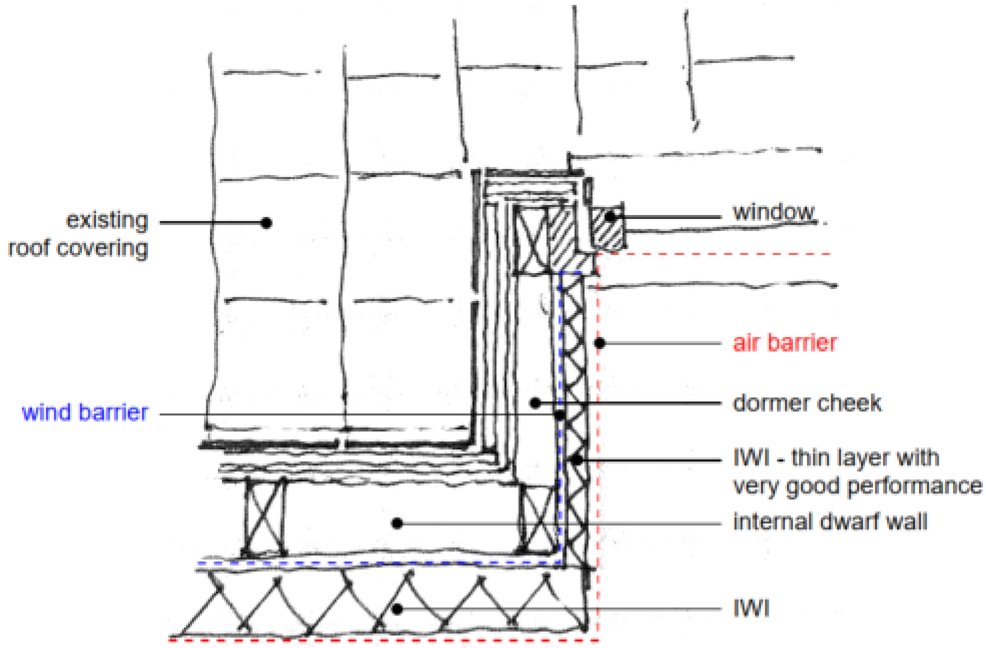
Figure 5: Section showing some typical thermal bridging locations and vulnerable junctions.

72. All thermal bridges should be mitigated to ensure a surface temperature factor (fRsi) > 0.75. If there is any doubt that the thermal bridge design will achieve this target, then the surface temperature factor should be calculated in accordance with BRE's IP 1/06[4].

73. When targeting very low U-values such as those required in roof insulation for building regulations compliance, it becomes increasingly important to consider the impacts of thermal bridging and how well they can be managed.

[3] Care needs to be taken at party walls when returning insulation along the party wall to mitigate thermal bridging. Installing insulation on party walls can make the party wall colder and therefore increase the risk of condensation and mould growth in the neighbouring property if it is not suitably heated or ventilated.

[4] IP 1/06 Assessing the effects of thermal bridging at junctions and around openings, BRE, 2006.



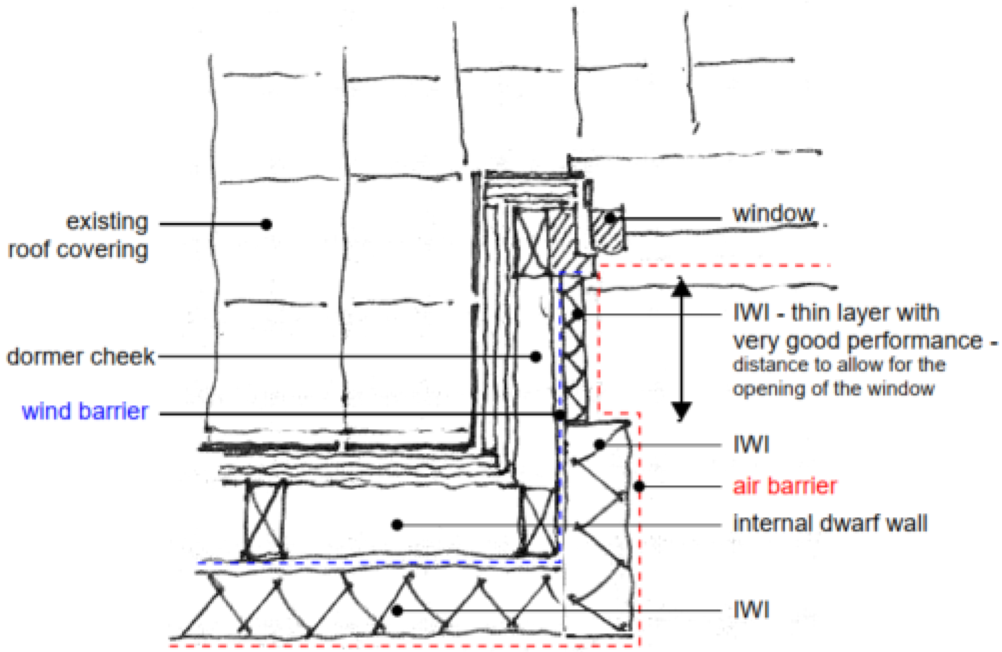


Figure 6: Dormer wall insulation retrofit options, plan view of dormer window.

Air barrier

74. Air leakage into roof voids can carry a high amount of moisture and significantly increases the risk of condensation on timbers and the underside of roofing membranes. An air barrier should form part of all RIRI construction on the warm side. This is not the

same as a vapour control layer (VCL) or a wind barrier, although some VCLs can double up as air barriers.

75. Any air barrier shall be specified such that it is consistent with the moisture strategy as outlined in the following sections.

76. Air barriers shall be designed to continue around junctions, edges and corners. At these junctions between potentially different air barrier materials, proprietary airtightness tapes, adhesives or paints shall be specified that are appropriate to the situation. Products that are commonly used but do not form robust and reliable air barriers are duct tape, gaffer tape, aluminium foil tape, expanding foam, silicon sealant, decorators caulk, dot & dab plasterboard, skim finish, vinyl, plywood, flooring and masking tape.[5]

77. Many building materials are airtight and can double up as air barriers, such as:

- Wet plaster (or lime render) >5mm thick
- Vapour control layers
- Some closed cell insulation products

78. Wind barriers are an important part of the RIRI design and help to reduce the risk of thermal bypass. Wind barriers installed on the cold side of the insulation are particularly important where there are ventilated cavities.

79. Where existing cavities cannot be proven to be airtight it is unadvisable to assume that they are airtight for the purpose of either thermal or hygroscopic performance where a newly installed product may rely upon this. Existing buildings will often have minor defects in construction and not designing with this consideration could lead to unintended consequences.

Moisture management

80. The best way to develop a robust moisture strategy for RIRI is to design from first principles. This means that the designer should have a good understanding of moisture sources, storage and movement in building materials.

81. The RIRI design must consider the current moisture strategy of the building as well as the

- exposure,
- external weather finish,
- the roof construction,
- internal moisture loads (occupancy and activities).

82. Of primary importance is that it is verified that the roof structure is dry before proceeding with RIRI.

83. Appropriate ventilation of enclosed loft spaces surrounding the RIR is critical to managing moisture in these spaces and this should be included in the retrofit design where necessary.

[5] For more information on airtightness, refer to the Passivhaus Trust Guide ‘Demystifying Airtightness: Good Practice Guide, June 2020’.

84. For RIRI constructions, it is advisable to prevent moisture from entering the construction from the warm side (usually by the use of a VCL or vapour barrier and a well-designed and implemented air barrier, these may be the same thing) and to allow removal of moisture to the outside (usually by the use of a vapour permeable wind barrier in contact with the insulation) and a ventilated cavity.

85. Constructions that fully insulate between rafters need a carefully considered moisture strategy since there is unlikely to be a ventilated cavity. There is a high potential for moisture to become trapped within the construction causing rotting of the timbers.

86. If a ventilated cavity is required as part of the design, then it should be verified that any product between the rafters does not block any part of the ventilated cavity. Insulation is often pushed too far in and may cause this scenario.

87. BS 5250:2021 Management of Moisture in Buildings should be adhered to in the assessment, design and implementation of RIRI.

Ventilation

88. No retrofit should be undertaken without assessing the internal ventilation system and its adequacy for dealing with internal moisture loads and air quality. A fully functioning, and preferably continuous ventilation system[6] should be in operation upon completion of the works.

89. The ventilation assessment, design and installation (both controlled and via window opening) should provide for the risk of overheating and err on the side of caution to take account of the warming climate.

Overheating

90. Rooms in roofs are particularly susceptible to overheating from internal and solar gains, especially if there are south facing windows or roof lights. Being higher in the building, there tends to be less external shading of the windows. Openable windows may address this potential in part but should not be relied upon particularly if noise and security are also considerations.

91. The Good Homes Alliance overheating guidance tool, or the Passivhaus Trust overheating assessment tool are recommended for a preliminary assessment of overheating risk.

92. Overheating risk should be mitigated following the principles laid out in PAS 2035. External shading, whether that be permanent or automated, is the most effective way to reduce solar gains in a room and should be considered first and foremost.

Interaction with other measures

93. Where other insulation measures are installed at the same time as the RIRI, special

[6] Intermittent mechanical extract systems should not be relied upon for buildings with an air permeability of < 5 m^3/m^2hr.

attention should be given to thermal bridging, air tightness and moisture at junctions with others measures as outlined in the previous sections.

Less than 100% of the room insulated

94. There is an increased surface condensation risk if RIRI is installed on only part of the external surface area of a room in roof. This is because the uninsulated surfaces will be relatively colder and hence more susceptible to condensation. Therefore, you should insulate all of the external elements in a RIRI project.

95. Some RIRI projects have multiple rooms, and in this instance every effort should be made to insulate all rooms. However, if this is not possible, then the guidance in the BEIS IWI guide for <100% IWI insulation may be followed.

Choosing and designing for continuity in the thermal envelope and air barrier

96. Roof rooms come in many shapes and sizes, but in every case it is crucial to design a continuous thermal envelope around the roof rooms and connecting with the rest of the dwelling. For example, this may follow the roof line, or the roof line and the ceiling line, or the roof line and a dwarf stud wall.

97. There may be storage space on the cold side of the envelope which could be designed out, but which the client may depend on.

98. Party walls should be insulated as part of the RIRI design, where the neighbouring property's roof space has not been converted to a heated RIR. Care should be taken if neighbouring property's RIR is converted and occupied, as insulating the party wall could lead to increased risk of condensation and moisture issues in the neighbouring property.

99. Roof rooms may not always occupy the whole of the potential floor area, and it may be necessary to insulate internal walls and floors/ceilings to allow for this.

100. Decommissioned masonry chimneys on gable ends or party walls should generally be insulated in line with the guidance in the BEIS IWI guide, but should be checked and repaired first. In use masonry chimneys on gable or party walls should not be insulated.

Services and penetrations

101. Ensure that all the services (plug sockets, light switches, pipes, radiators, etc.) and fittings (skirtings, covings, shelves, cabinets, fitted wardrobes, etc.) accommodated on the surface to be insulated are considered. A qualified electrician should be employed to review the design and reinstatement (See Table 1: Services - above).

102. Depending on the installation method selected, the services may penetrate the insulation layer, the VCL and/or the air barrier. These penetrations should be kept to a minimum and be properly sealed. If possible, a separate service cavity should be provided in front of the insulation, air barrier and VCL to eliminate the penetrations.

103. A schedule of penetrations should be provided, along with the appropriate sealing products for air tightness and/or vapour control.

104. Provisions should be made for the installation of heavier items where necessary. Timber battens for instance could be installed in the relevant areas to accept the load of any heavy fittings.

105. Recessed lights present fire and air leakage risks in roof insulation systems and will need particular consideration in RIRI design.

106. Avoiding the use of recessed lights will remove these risks but where installed, recessed lights should be recorded and proper allowances made for fire safety (fire rated hood or using airtight and insulation contact resistant fitting for example) and to prevent air leakage carrying heat and moisture into the uninsulated spaces above.

Hatches and Storage Spaces

107. The information provided by the assessor regarding the needs of the client and the current design and ventilation provision to the roof voids will help the designer to determine the thermal and air tightness line to be incorporated in the design of the RIRI.

108. The designer may need to accommodate storage on the cold side of the air tightness and insulation line in which case designs for sealable, insulated and airtight doors and/or hatches should be provided for the installer. An airtight loft hatch is shown in Figure 7.

Figure 7: Loft hatch fitted with Brighton latches and rubber strip to make an airtight seal.

109. Where new access hatches are installed, they should be compliant with Approved Documents B (Fire) and L of the Building Regulations[7].

[7] For further guidance for loft hatches and Part B please refer to the NHBC Guide 7.2/18 Loft Hatches and Fire Resistance.

10. Installation

Pre-installation building inspection and risks

110. Upon receiving the retrofit design, the installer should satisfy themselves that the design is suitable for the building by undertaking a pre-installation building inspection (PIBI) by an appropriately qualified independent person as outlined in PAS 2030. The inspections need to be independently checked on plan with one in ten being checked in the field. They should also check the information from the retrofit assessment, and that it has identified all the risks as laid out in Section 7 Building Suitability Assessment & Risk, in this guide. The installer should be satisfied that any remedial works have been carried out and that the roof is in a suitable condition for the proposed works.

111. The table below describes **some** of the major considerations for the installer upon receiving a retrofit design for RIRI, Installers are advised to consider these items but not to take this as a checklist, as every RIRI project will pose different questions.

Action	Assessing	Methodology	Risk
Are the works to be undertaken defined as **"Building Works"** **according to the current** **Building Regulations?**	The Building Regulations 2010 provide that "building work" shall be carried out so that it complies with the requirements contained in Schedule 1.	Consider if the works entail: 1. the erection or extension of a building (which would cover new builds); 2. the material alteration of a building. This is either: a. Where the work would result in the building no longer complying with a previous requirement when it once did; or	Works being undertaken without correct permissions or approvals in place.

Action	Assessing	Methodology	Risk
		b. In a building which before the work did not comply with a relevant requirement, being more unsatisfactory in relation to such requirement. 3. the insertion of insulation into the cavity wall of a building; and 4. certain other specific work which relates to energy efficiency requirements, including the renovation of individual thermal elements or change in the energy status of the building.	
Has an assessment been undertaken for compliance with the Building Regulations?	If the installation to be undertaken will result in non-compliance with the Building Regulations.	Review of the scope of works to assess suitability in relation to: • workmanship, • materials, • structural stability, • fire safety, • management of moisture, • ventilation, • overheating, and • thermal performance.	Installation of the measure contravenes or results in the building no longer complying with the Building Regulations.
Have the risks identified in the	If remedial work has been undertaken or if	Review the retrofit assessment and identified risks.	Potential for structural or moisture risks due to

Action	Assessing	Methodology	Risk
retrofit assessment been mitigated by the remedial work or in a retrofit design?	the retrofit design has mitigated any risks identified.	Establish if any remedial work has been undertaken and that sufficient time has been allowed for the building to dry if any moisture issues were identified. Establish if the retrofit design has accounted for the risks identified in the retrofit assessment, and that they are not exacerbated by the retrofit design.	existing condition of building.
Has there been an assessment of junctions with other insulation or construction elements?	Potential for thermal bridging and discontinuous air barrier at external wall or roof junctions with, • ceilings/roofs • window/doors • internal walls • intermediate floors • stairs OR • at change in roof pitch,	Review of the Whole House Retrofit Plan and/or design package. Visual and potential invasive inspection (if appropriate) of: • the existing wall and roof conditions. Including any wall, loft, pitched or flat roof insulation that has been installed anywhere in the property; • The window and door installation situations; • The extent of internal walls, stairs and intermediate floors joining external walls and roofs; • The thermal line of the existing RIR to assess how these junctions will/can be resolved to avoid thermal bridging and install a continuous air barrier[8].	Creation of a thermal bridge, leading to heat loss and increased risk of surface condensation and mould growth. Non-continuous air barrier leading to increased risk of thermal bypass and moisture penetration into roof voids and structures. Increased risk of rotting in roof timbers

[8] Note that an air barrier may be the same as a vapour control layer (VCL). However, an air barrier is always required, where a vapour control layer may not be. For example, in a moisture open internal wall insulation system design, an air barrier is required but the design is not likely to incorporate a vapour control layer. A vapour permeable air barrier should be selected in this case.

Action	Assessing	Methodology	Risk
	• where a dwarf wall meets a pitched roof or insulated loft space • Where dormer walls meet pitched roof or dwarf walls.	If the design does not include continuous insulation or an air barrier, the contractor should raise this with the Retrofit Designer or Retrofit Coordinator to see if this was intentional.	
Is the installation acceptable and appropriate?	Suitability of design and appropriateness to ascertain if the installation is suitable for the building.	Consider whether the installation would; • be non-compliant with any requirement stated by the designer/specifier; • compromise the functionality of existing air supply/extract ventilation/duct systems; and • be suitable for the building (as outlined in PAS 2030); and Consider if the site layout or conditions will impair the execution of the works in relation to appropriate access to the property and to the walls/roof to be insulated;	Lack of ventilation to habitable spaces. Risks to safe working practices. Risk to the appropriateness of the building. Proximity of stored items that may result in damage.
Has the customer been given appropriate retrofit advice?	Suitability of design and appropriateness for customer.	Check whether the customer has been made aware of the level of disruption during works (including timescales and any furniture displacement or disturbances that may occur) and ongoing maintenance needs for roofs, walls and ventilation systems.	Customer unhappy with disruption. Customer unable to maintain retrofit system, know how to make changes to their home or

Action	Assessing	Methodology	Risk
			use new ventilation controls.
Does the retrofit design include upgrade of the ventilation system?	If ventilation is appropriate for improved air tightness associated with RIRI.	If ventilation improvements are not included within the retrofit design, check that this was intentional and that the retrofit ventilation assessment indicated a fully functioning and correctly sized ventilation system.	The ventilation is not sufficient for property, risk of condensation and mould growth.

Design principles for installers

112. In accordance with PAS 2035/2030 a Retrofit Installer should be able satisfy themselves that a retrofit design is complete and suitable for the building(s) in question. Therefore, it is important to understand some design principles of RIRI.

Minimising thermal bridging

113. A thermal bridge is defined as an area of the building envelope where the insulation is:

a) discontinuous or thinner than the adjacent insulation and/or,

b) has higher thermal conductivity than the adjacent insulation and/or,

c) has reduced effectiveness due to the building geometry.

Thermal bridges can lead to locally increased heat loss and therefore a locally reduced surface temperature. This in turn can lead to surface condensation and mould growth.

114. Roofs that have multiple rooms will inherently have thermal bridges due to internal walls. However, these can be mitigated, usually by returning a layer of insulation along the wall or floor that is causing the thermal bridge. This reduces the pathway for heat to escape to the outside. There are a few situations where this may not be recommended, or possible. One example might be on party walls next to a heated space. Insulating these party walls may increase the risk of moisture issues in the neighbouring property.

115. If there are thermal bridges that haven't been mitigated in the retrofit design, the retrofit installer should raise this with the Retrofit Designer or Retrofit Coordinator to understand if this was intentional. Thermal bridges may have been modelled at the design stage to help design appropriate details and choose the right thickness and type of insulation to help mitigate the thermal bridge.

116. Thermal bridging can also occur within a construction build-up as a repeated thermal bridge. For example, when timber or metal framework interrupts the insulation. Metal is extremely good at conducting heat and therefore will have a big impact on the performance of the system. Where possible, a layer of continuous insulation should be installed across the studwork to reduce the impact of the repeated thermal bridging.

Air barriers, vapour barrier and vapour control layers

117. An air barrier is a building material with properties that prevent the passage of air through it. An air barrier may also be a vapour control layer or a vapour barrier, but it may be specified to have a very low resistance to the passage of vapour. Air barriers should form part of all construction types to protect insulation and the building fabric from moisture carried in the air.

118. If there is no air barrier marked on the retrofit design, the retrofit installer should raise this with the retrofit designer and retrofit coordinator who should provide guidance as to what materials form the air barrier in their design.

119. Any air barrier that is specified should be consistent with the moisture strategy of the RIRI system. Vapour permeable and airtight air barriers are available, these could be membranes, appropriate rigid boards or finishes such as lime render.

120. The moisture strategy describes how water vapour is controlled within the construction

build-up.

121. For RIRI, often the lowest risk approach is to prevent moisture entering the construction from the inside, but to allow drying to the outside.

122. Air barriers are always required, and shall be designed to continue around junctions, edges and corners and at these junctions between potentially different air barrier materials. Proprietary airtightness tapes, adhesives or paints shall be specified that are appropriate to the situation. Products that are commonly used but do not form robust and reliable air barriers are duct tape, gaffer tape, aluminium foil tape, expanding foam, silicon sealant, decorators caulk, dot & dab plasterboard, skim finish, vinyl, plywood, flooring and masking tape.[9]

123. To prevent moisture from entering into a construction, a vapour barrier or vapour control layer is used (which may also be an air barrier), and this must be sealed at all junctions, edges and corners using proprietary vapour control tapes or sealants.

124. If vapour control layers or vapour barriers are specified, then these should be on the warm side of the insulation. If this is not the case, this should be raised with the Retrofit Designer or Retrofit Coordinator to see if this was intentional as there may be a risk of interstitial condensation.

125. Air barriers should also be installed on the warm side of the insulation. If this is not the case, this should be raised with the Retrofit Designer or Retrofit Coordinator to see if this was intentional as there may be a risk of interstitial condensation and/or thermal bypass.

Installation principles

Products & thermal bridging

126. Ensure that the correct insulation products are used in each situation. Some insulation products have a much better thermal performance. For example, aerogel is a very good insulating material even in thin layers (<20mm), and it is often used in window reveals and dormer cheeks where space is limited. Some products have specific moisture properties which may be essential to reducing the impact of moisture risks. All components of an RIRI should match the retrofit design, including surface finishes and adhesives. If looking to propose alternative products, ensure that the Retrofit Designer and/or Retrofit Coordinator approves them as being appropriate for the situation they are to be used, and that they are consistent with the retrofit design.

Eliminating thermal bypass

127. One of the biggest risks to reducing the effectiveness of insulation when it is installed is allowing the movement of air in gaps within and through the insulation layer. This is known as thermal bypass. It is important to avoid gaps between insulation layers or between insulation boards or batts.

128. If installing rigid insulation board, the joints between the boards should be tightly butted (and /or tongued and grooved/lapped) to fit in corners, around doors and windows, and with each other. Vertical joints between layers and courses must be staggered. Before finishing, the installation of the boards should be inspected. Gaps between the board

[9] For more information on airtightness, refer to the Passivhaus Trust Guide ‘Demystifying Airtightness: Good Practice Guide, June 2020’.

connections and at the perimeter of the insulation should be properly filled. Some rigid boards (e.g. PIR/PUR) should also be taped (or sealed with an appropriate airtightness bonding product), especially if their surface forms the vapour control layer and/or air barrier.

129. If installing flexible insulation in timber work, a friction fit will help to ensure no gaps are formed. If the insulation requires cutting, it should be cut slightly wider than the space it is intended to fill to ensure that friction fitting is achieved in installation.

130. Sealing is also important around the perimeter of the RIRI boards. If the retrofit design shows RIRI boards meeting the floor, ceiling or other edges, then this should be adhered to.

Services in relation with retrofit insulation

131. Where space allows a service cavity can be provided. This isolates small services from the unheated spaces in the ideal way. This will not always be feasible and where services do penetrate the VCL and/or air barrier all holes and gaps around cables, pipes and other services should be properly sealed with grommets and/or appropriate tape.

132. If wiring is encapsulated in, or directly behind insulation, there can be a risk of overheating. An electrician should be consulted on the need to replace or derate the cable.

133. Any penetrations that necessarily pass right through the roof or walls, and that cannot be avoided should be sealed appropriately (see section on air barriers). These penetrations could include:

- Waste pipes & SVPS
- MVHR ducts
- Incoming water, gas, oil, electricity, data, and district heating, as applicable
- Flues, including air supplies to wood burning stoves or similar, where other precautions including fire risk need to be considered.
- Connections to external services, such as entry phones, outside lights, security cameras, satellite dishes

134. A schedule of penetrations, their dimensions, orientation, and the applicable sealing method should be provided as part of the retrofit design. Sequencing is important since a number of items e.g., EPDM (rubber) gaskets, may need to be fitted prior to the installation of the penetration. Ideally, the gasket is fitted loosely around the penetration (e.g., ductwork, plumbing or electrical services) whilst it is being installed, and once the ductwork or other services are fixed in place, then the gasket can be taped back to the air barrier. This prevents any off centre stretching of the gaskets which can cause air leakages. For existing services, gaskets may not be suitable and therefore other airtightness products should be considered. All service alterations should be carried out by a suitably qualified person.

11. Mid- and Post- Installation checks

135. Monitoring the hygrothermal performance of the RIRI system post retrofit and examining the temperature/relative humidity levels in locations within the build-up that are considered high-risk (e.g. embedded timbers) is good practice.

136. It is essential that any issues or special considerations that were identified at the assessment stage are carefully considered and appropriately addressed in accordance with the relevant standard.

137. Many serious moisture-related problems may be hidden from view for some time prior to their effects being felt (for example when there is interstitial moisture build-up, or in slowly accumulating levels of mould or dust mites).Therefore, completion of a building project should not be considered to occur at practical completion of works, but when the building is in equilibrium (after the input of new materials and systems) and when it has been shown to be operating safely for the long term. In some situations, this will mean that completion is after two years, but in others with less certainty and higher risks, this may be considerably longer.

138. All post installation checks should be evidenced by survey notes and supported by photographic evidence at mid and post-installation stage. Such evidence must include suitable referencing to identify the precise spatial area of the work that it relates to.

139. It is recommended that photographs are taken before and during installation to evidence the following:

- Existing stripped back roof lining, ventilation provision and insulation.
- Installation of appropriate vapour control barrier (if needed) in accordance with the design and manufacturer’s instructions.
- Installation of an appropriate air barrier in accordance with the design and manufacturer’s instructions.
- Taping or sealing of air barrier and/or vapour control layer at junctions, edges and corners.
- Installation of insulation product to thickness specified in the design, with no gaps.
- Services passing through RIRI in good condition.
- Treatment of awkward spaces and junctions where future access will be difficult.

Maintenance

140. Although RIRI itself requires little or no maintenance, other works associated with a RIRI installation will inevitably require maintenance to avoid potential problems. Examples include installation & maintenance of ventilation systems, gutter & RWG clearing and replacement or repair of external roof coverings.

141. Handover of buildings should include clear and informative maintenance manuals and web-based information. If possible, maintenance programmes should be provided, and where owners or occupiers cannot maintain their fabric and services themselves, options for external assistance and contracts should be provided. Automated reminders about maintenance may be advisable.

Customer care and handover

142. It is the responsibility of the Retrofit Installer to ensure that the appropriate information is provided to the Retrofit Coordinator, or directly to the customer at handover. Further guidance on customer care is given in Annex B Customer Care & Handover, of this guide.

12. Health & Safety

143. The assessor and installer should be mindful of the Health and Safety at Work Act and follow all guidance and specific requirements of this regulation, and in particular the requirements of the Work at Height Regulations 2005. Further guidance is available from the Health and Safety Executive website: www.hse.gov.uk

144. The Construction Design and Management Regulations (2015) applies to all construction projects and defines Health and Safety responsibilities throughout a construction project, including the roles of principal designer and principal contractor.

145. Health and safety concerns particular to Room in Roof insulation are these:

Insulation materials

146. Some insulation materials are hazardous to health, particularly when cut. PIR, stonewool and fibreglass insulation for instance can be irritants during fabrication. Masks and goggles are usually considered the minimum personal protective equipment for undertaking insulation works with these materials.

147. In every case, designers and installers should read the product health and safety data sheets and take the appropriate precautions to protect themselves, their operatives and present and future occupants of the house.

Confined spaces

148. RIRI can require some work in tight and confined spaces. Appropriate guidance and procedures must be understood and followed. This includes checking that the sizes of entrance points are sufficient and ensuring that there is provision for ventilation in the space in which persons will be working.

Asbestos

149. Asbestos, particularly in plumbing and electrical systems, fire proofing and artex coatings may be found in roofs. Any materials suspected of containing asbestos should be tested by an appropriately qualified person and appropriate removal techniques adopted.

Electrical installations

150. Electrical installations in roof spaces can be dangerous. Care should be taken when surveying and working, as open junction boxes and unterminated cables may be encountered. If old or potentially unsafe electrical items are present, a qualified electrician should be instructed to assess and make them safe.

13. Training and Vocational Competence

151. All competence requirements for the surveying, assessment, installation and checking shall be in strict compliance with the relevant Building Regulations.

152. For retrofit designers, the Carbonlite Retrofit course offered by the AECB is recommended as it offers a high level of detail and in-depth evaluation of retrofit risks.

153. For all retrofit professionals, the level 5 Retrofit Coordinator qualification is recommended as it offers an overview of retrofit systems & technologies and their associated risks.

154. For traditional buildings, the retrofit guidance wheel, developed by the Sustainable Traditional Buildings Association (STBA) gives high level guidance on retrofit risks in traditional buildings. This is a highly visual online tool and can be useful in communications with the client.

155. For all retrofit professionals working with traditional buildings, the Level 3 qualification in Energy Efficiency and Retrofit of Traditional Buildings is recommended.[10]

156. For vocational competence of RIRI installers, refer to PAS 2030 Annex B.12, or online via the Scottish Installer Skills Matrix. (Note this link is due to go live in early 2022 https://esp-scotland.ac.uk/scottish-installer-skills-matrix/)

[10] This qualification varies in the devolved nations: the Level 3 Award in Energy Efficiency and Retrofit of Traditional Buildings, Scottish Level 6 Award in Energy Efficiency Measures for Older and Traditional Buildings; and the Welsh Level 3 Award in Energy Efficiency Measures for Older and Traditional Buildings

Annex A – Customer Care & handover

157. Installing RIRI can be disruptive to the residents and the properties involved. It is therefore essential that thorough discussions with the resident and/or building owner take place before during and after the work.

158. The following items of Customer Care and advice are particular to this type of work:

- the extent of any disruption that may be caused by the chosen installation method (removal of fittings and or fixtures, floor covering and/or floorboards, wall and ceiling finishes),
- any additional works that may be required to facilitate the installation of insulation (movement of services, repair of defects, additional ventilation etc),
- the time anticipated to undertake the works, and any deviation from this during the works caused by unforeseen issues,
- the extent of any making good that is included in the work being carried out (redecoration etc),
- the health and safety implications of the work,
- where relevant, safe and secure storage of materials on site,
- the cost of the works, and any deviation of costs during the works caused by unforeseen issues,
- the contracts that the customer is expected to sign up to with the installer,
- any warranties that will be made available to the customer on completion of the works and how to redeem these,
- the potential implications of this work on future indoor air quality and relative humidity and how this should be addressed,
- the potential implications of the RIRI on other matters affecting the structure and future maintenance and repairs, and
- the potential implications for heating, ventilation and overheating post retrofit.

The following general customer care guidelines should also be followed:

- Verify that the address for installation is correct, and the assessor, designer and installer identify their credentials to the customer.
- Explain to the customer the purpose of the visit and what they can expect.
- Use shoe protectors/covers when entering the property and conduct themselves appropriately.
- Advise the customer of any precautions needed e.g. removal of materials or possessions that restrict access to the wall prior to assessment or installation.

- With the customers permission, remove and protect materials and possessions if the customer is unable to do so.
- Put down dust sheets where required, to protect the customer's property.
- Following completion of the works all packaging/waste materials must be removed from site and properly disposed of.
- Clear up any mess as soon as possible and dispose of waste in the appropriate manner.
- Ask for permission if the customer's toilet facilities are needed.
- Avoid disputes with the customer or responding negatively to any complaints or criticism.
- Carry out a check of any pre-existing problems or defects, repair any defects that require attention and declare them to the customer before starting work and report on the pre-installation check sheet.
- If any damage is caused, however small, the customer should be informed, and the matter subsequently reported to the organisation responsible for carrying out the work. The customer should be informed that the matter will be dealt with appropriately and quickly.
- The customer should be fully informed of the work being carried out, including explanation of any areas that are not accessible (these may be whole rooms for RIRI projects, or where there are dangerous structures such as scaffold towers, scissor lifts, or lighting rigs and transformers). Additionally, any openings or hazards should be appropriately cordoned/barriered or hazard tapes applied.
- Any specific safety considerations as recommended by the manufacturer of the product or system utilised should also be followed.

A customer handover checklist may be used as follows:

- [ ] Maintenance manuals for RIRI associated measures (e.g. new ventilation systems, external wall finishes)
- [ ] Operation manuals for RIRI associated measures (e.g. new ventilation systems)
- [ ] Physical inspection of installed RIRI and associated measures
- [ ] Visual check that consumer is able to operate RIRI associated measures (e.g. ventilation system)
- [ ] Simple explanation of 'less than 100%' RIRI risks where wet rooms may have been uninsulated, and instructions on how to manage these risks.
- [ ] As-built construction details, specifications, and designs.
- [ ] Relevant warranties, insurances and/or guarantees.

- ☐ Information about the importance of ventilation and the implications of turning any ventilation off or down
- ☐ Commissioning records for any RIRI associated measures (e.g. ventilation system)
- ☐ Guidance on the air barrier, what it is, where it is, and how to fix through it if necessary.

This publication is available from: www.gov.uk/government/publications/room-in-roof-insulation-riri-best-practice