Department for
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Solid floor 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.

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

Moisture balanced - A term used to describe a moisture open building construction that does not get wet for prolonged periods and does not have any moisture related issues such as mould or fungus growth or spalling (ice damage of brickwork).

Moisture closed - A building construction that prevents moisture (vapour & liquid) from moving in an out of it.

Moisture open - A building construction that allows moisture (vapour & liquid) to move freely in an out of it.

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.

Solid Floor – A floor directly in contact with the ground (i.e. no air cavity)

SFI – Solid floor insulation

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.

Upstand – a thin strip of insulation that is taller than it is wide that usually installed around the perimeter of a floor.

Vapour barrier - A building material (usually a membrane) with properties that prevent 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 control 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 greenhouse gas emissions targets, it is necessary to reduce carbon dioxide emissions of the existing building stock. Retrofit not only reduces operational emissions, but also avoids the carbon emissions associated with 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.

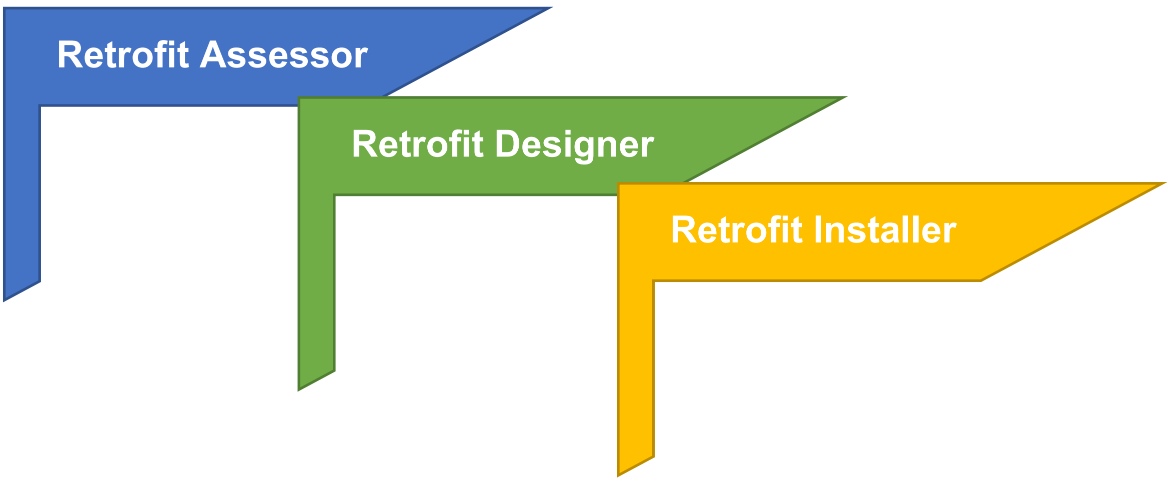
Improving the building energy efficiency with insulation measures and the use of efficient systems and sources of renewable energy are necessary. However, a fabric first approach to domestic energy saving is very important, as it reduces the overall demand for heating, the size of the heating system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

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

- assess the technical 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 solid floor 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 does not cover the installation of timber suspended floor insulation which is dealt with in another guide. All possible steps should be taken to assess whether a floor is solid or suspended or has insulation already installed, including, where appropriate, intrusive works to understand the structure. Where it is not possible to assess it, all available evidence should be retained to demonstrate why this was not possible. Similarly, the floor should be assessed to ensure that it is in a suitable condition to receive solid floor insulation, or whether it might be appropriate to dig out the floor to install insulation.

Any drawings or images in this guide are for general use and not prescriptive guidance.

It is recommended, and mandatory for Government-funded or promoted schemes, that assessment and design in accordance with the latest version of PAS 2035 is undertaken before any solid floor insulation measure is installed. The assessment must be specific to that property and the type of insulation being considered for its suitability; or as a minimum (i.e. before the adoption of PAS 2035), an assessment in line with the requirements of the relevant version of PAS 2030.

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

SFI 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

SFI 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

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2. Benefits

Thermal comfort can be significantly improved by solid floor insulation (SFI). SFI can help increase and maintain the internal temperature as well as providing a higher surface temperature at floor level of the room, both of which contribute to an improved comfort.

Properly installed floor 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.

Floor insulation can usually be installed without impacting on the building’s external aesthetics and appearance.

On listed buildings SFI can sometimes be installed carefully without harm to sensitive internal features.

SFI is one of the more disruptive insulation measures for occupants, and in most cases will require that the occupants move out for the duration of the work. However, when combining SFI with other measures, it can be included within a medium term improvement plan to align with the client’s expectations, budget and timescales.

A key early decision in planning SFI is whether the insulation can be included in a floating floor OVER the existing floor. This will have a big impact on the level of disruption. The decision will depend on ceiling heights, stair treads, and the condition of the existing floor.

The level of airtightness of a building may improve when installing SFI as it seals floor edge junctions. 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.

SFI may offer the opportunity to improve or rectify damp issues in existing floors.

SFI may offer the opportunity to install underfloor heating which would suit the installation of lower carbon heating solutions (such as heat pumps).

3. Unintended consequences

In most cases solid floor insulation carries fewer risks than other retrofit insulation works. Care is nevertheless needed to avoid adverse unintended consequences.

However, improving insulation and airtightness in one area of a building affects the conditions in the whole building, so SFI insulation 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.

Traditional (and typically moisture open) floors can sometimes be contributing to the diffusion of moisture in walls and be affecting humidity levels.

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.

The designer and installer must always check that there is adequate ventilation in the whole of the dwelling (in accordance with PAS 2035 and Building Regulations, see Section 5 Design Principles for more information) and advise and remediate as appropriate before the retrofit insulation takes place.

4. Building Regulations

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.

In England and 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 devolved administrations.

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.

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

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;
    - 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.

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.

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.

Because this advice deals with whole floors, it is safest to assume that Building Regulations Approved Document L1b applies to the work.

An assessment of the adequacy of the existing ventilation and if necessary, a ventilation upgrade must be undertaken in accordance with the requirements set out in the latest version of PAS 2035.

5. Building suitability assessment & risks

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

A retrofit assessment should include correct identification of the different construction types, materials and ventilation strategies present in the floor to be insulated, as this will have a significant impact upon the retrofit design.

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

When assessing the suitability of a solid floor for retrofit insulation, a Retrofit Assessor should undertake a whole building assessment as outlined in PAS 2035. Table 1 below describes areas of risk associated with SFI which should also be included in the retrofit assessment.

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

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 SFI. The building should then be re-assessed to ensure it is in a suitable condition for SFI.

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.

Table 1 Pre-installation suitability and risks

Action	Assessing	Methodology and mitigation	Risk
HISTORICAL SIGNIFICANCE			
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 "Traditional"?	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 SFI will have an impact upon the heritage significance. [For consideration by Retrofit Designer] Take heritage significance into consideration when developing the retrofit design. Property may not be suitable for SFI.	Non-compliance with PAS 2035, and negative impact on the significance of the building.
CONTEXT STRUCTURE AND CONDITION			
Is the external ground level higher than the internal finish floor level?	Relationships of the internal floor to the potential risk of water penetration	Visual inspection and measurement of internal and external finish floor level. [For consideration by Retrofit Designer] If floors are below external ground level then follow guidance in BS 8102:2009 Code of practice for protection of below ground structures against water from the ground.	High external ground levels may prevent solid floors from draining properly and may be introducing moisture into the construction.
Is the property located in a high radon area?	Reference to the Radon Maps, and possible radon measurement.	Consider radon maps, https://www.ukradon.org/information/ukmaps	Exposure of occupants to the health risks of radon.

Action	Assessing	Methodology and mitigation	Risk
		and whether radon levels are likely to be above the 'Action level'. Measurements may need to be taken to confirm radon levels. [For consideration by Retrofit Designer] If high levels of radon are evident, take expert advice, and consider installation of a radon barrier and/or sump as part of the SFI work.	
Is there any evidence of damp, surface condensation, salts, fungus or mould growth on solid floors?	If remedial works need to be done to remove/reduce water source. If the SFI can be fitted over the existing floor.	Visual inspection of all solid floors. Damp, mould growth or condensation on the floors or lower walls may be indicative of rising damp, water leaks, or condensation arising from poor ventilation, and/or underheating. Any doubts arising from the visual inspection should be followed by a damp survey from a specialist. The cause should be investigated, and remedial work undertaken prior to or during the SFI installation to clean, dry and seal the floor and to resolve air quality issues. [For consideration by Retrofit Designer] Retrofit designs should include upgrading ventilation if it is not adequate as per PAS 2035 Annex C.	Water penetration into solid floor insulation. Poor indoor air quality.
Is the existing solid floor level and free from dust and loose materials?	If solid floor insulation can be fitted over the existing floor and that any adhesives will be able to fully bond to it.	Visual inspection of solid floor finish, (this may require some section of the floor finish layer e.g. carpet/vinyl/laminate to be removed). Remove loose materials, clean and repair such that the surface is flat and smooth for installation of the SFI. Loose materials or uneven solid floors can also indicate structural defects (see below).	Risk of air pockets forming on cold side of insulation which increases risk of interstitial condensation and thermal bypass.

Action	Assessing	Methodology and mitigation	Risk
Are there any structural defects in the solid floor or wall bases?	If the insulation can be fitted over the existing floor. If solid floors or wall bases need strengthening or re-building prior to installation of solid floor insulation.	Visual inspection. May require structural engineer and/or invasive investigations. Signs of sinking or bulging anywhere on the floor may indicate structural problems with the floor. Undertake remedial work as advised by structural engineer.	Risk of further structural deterioration. Damp.
Are there any fixings or penetrations that currently exist in solid floor?	The potential for thermal bridging and non-continuous air barrier.	Identify and mark up all fixings and penetrations in existing floor. These are usually associated with services or kitchens & bathrooms. [For consideration by Retrofit Designer] Ensure that a suitable design for the air barrier is available for all types of penetration.	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 floor insulation.
Is the current construction moisture open or moisture closed?	Potential for solid floor insulation to upset the moisture balance of the existing building.	Most solid domestic floors are designed and bult with damp proof membranes and concrete.	Risk of increasing moisture levels in existing construction.

Action	Assessing	Methodology and mitigation	Risk
		Some traditional floors such as lime and stone floors may be moisture open and moisture balanced. Other floors may be moisture open and contributing to damp problems in the building. Visual inspection of existing floor. May require invasive inspections to investigate the depth of the solid floor and types of materials used underneath. [For consideration by Retrofit Designer] Ensure that moisture strategy design of solid floor insulation is sympathetic to the moisture strategy of the existing floor (see Design section for more information).	
What is the maximum height of the water table?	Potential for water damage to traditional moisture open floors	Evaluate height of water table for property in relation to current ground floor level. For traditional floors consider the impact of water table height on moisture open designs, especially those that involve digging out of the existing floor.	Water logging and reduced thermal performance of insulation.
Has the building ever been flooded?	Potential for moisture related issues and high moisture content in existing fabric.	Inspection of River or coastal flood maps available from the Environment Agency. Interview with occupant on history of building. Evidence of flooding related moisture in construction. High salt levels on wall bases and floors. [For consideration by Retrofit Designer] If there is evidence of flooding, or evidence of future flood risk (due to climate change) then the solid floor insulation retrofit design should be capable of withstanding flooding without detriment to the floor.	Risk of high moisture levels in construction that may be trapped when floor insulation is installed.
What are the limiting factors for increasing the	Ceiling heights, stair tread heights, threshold heights.	Record ceiling heights in all rooms. Record all steps on ground floor and height of treads. Record all door thresholds on ground floor and height of these above floor level. Record any permanent fixtures that	SFI installation creates impractical or hazardous

Action	Assessing	Methodology and mitigation	Risk
ground floor level?		are within 200mm of the current finished floor level, including but not limited to • fitted kitchen units, • bathrooms fittings, • risers or other service boxing, • internal doors (including internal door heights), • radiators • electrical sockets • hot & cold water pipework • fireplaces Record any tall furniture that is less than 200mm from the ceiling. [For consideration by Retrofit Designer] Consider whether it is practical to increase floor height, and if so, by how much. Consider if floor should be dug out to accommodate insulation. Often in older properties there are very shallow foundations and digging down could undermine the wall. Underpinning might be necessary. [For consideration by Retrofit Designer] Building regulations do not allow different height stair risers. A typical solution might be to design a platform to the level of the first riser, with step(s) up to the platform from other rooms or in a different area of the hall. [For consideration by Retrofit Designer] In the Retrofit Design, provide a schedule of items that will require alteration if floor is insulated.	feature in the home due to change in floor level.

Action	Assessing	Methodology and mitigation	Risk
SERVICES			
Is there sufficient ventilation in the property?	Potential for changed humidity levels after solid floor insulation is installed.	Assess ventilation system in accordance with PAS 2035 Annex C. [For consideration by Retrofit Designer] If ventilation system is not appropriate, then include a ventilation upgrade in the retrofit design.	Increased risk of condensation.
Is there pipework, drains or other services embedded in the solid floor and what condition are they in?	Potential for leakage and heat loss into colder floor.	Inspect and record pipework and services entering and leaving the floor slab. Identify type of material used for pipework. Identify any leaking pipes entering and leaving the floor. Identify any damp patches on the floor where pipes are likely to be embedded. [For consideration by Retrofit Designer] Consider bringing embedded pipework (or services) above the ground floor level. This will avoid heat loss into the cold floor, reduce the risk of leaks, and allow for easier maintenance of the pipes.	Risk of moisture source into slab and further heat loss from hot water systems.

6. Materials

Improving the thermal performance of a solid floor by adding extra insulation will need to comply with the current relevant national building regulations. Currently, in England, Wales, Northern Ireland the floors should achieve an ‘improved’ thermal transmittance (U-value) of 0.25 W/m2K, or where this is not technically or functionally feasible, then the floors 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, making sure to include the ratio of the exposed floor perimeter to the floor area.

In Scotland a floor being upgraded should meet a U-value of no worse than 0.18 W/m2K.

These values will change, and readers should refer to the current Building Regulations Guidance for the devolved nations.

To achieve an optimum U-value there are a range of materials available on the market that are appropriately certified for use as solid floor insulation. It is important that manufacturer’s technical information is checked to see if the materials are appropriate for the situation where they are to be installed, and for details of Technical Approvals such as an Agrément Certificate for specific applications.

Material Conformity

When assessing any material for use as solid floor 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 as SFI?	Consider if the material is suitable for use as solid floor insulation of the type being considered for the installation.	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

		UKCA or CE Marking with manufacturers Declaration of Performance and data sheet. OR UK Technical Approval or European Technical Assessments, OR 3rd Party Certification of material for specific applications such as BBA or KIWA Certificate of Agrement.
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.

7. Design Principles

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 solid floor insulation. These should be readily available on site.

An airtightness and moisture strategy summary should be recorded and be available onsite for quick reference.

Where possible, reuse existing floor finishes to reduce emissions associated with new floor finish materials. Make sure they are compatible with the moisture strategy for the SFI.

Thermal bridging

Solid floor insulation may be installed as a single energy efficiency measure or as part of a package of measures. Even as a single energy efficiency measure, thermal bridging is still important, and designs should show how insulation can be continuous around junctions, edges and corners. If this is not possible then thermal bridges should be minimised. All thermal bridges should be considered and assessed when installing solid floor insulation. The following are examples of thermal bridge junctions that might occur in solid floor insulation projects:

- Where solid floor insulation is interrupted by internal walls, party walls[1], stairs, chimney breasts or other permanent structures where they meet the ground floor.
- Where solid floor insulation meets external walls.
- Door thresholds
- Where solid floors meet external walls.

Much of the heat loss through a solid floor in contact with the ground, is at the exposed perimeter, and so these thermal bridges become especially important.

All thermal bridges should be minimised 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 Information Paper 1/06[2] and the detail improved until it does meet this target.

Solid floor insulation can work well when installed with either external or internal wall insulation. It can connect directly with internal wall insulation to create a continuous thermal envelope,

[1] Care needs to be taken at party walls if returning insulation up the party wall to mitigate against 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.

[2] Information Paper 1/06 Assessing the effects of thermal bridging at junctions and around openings, BRE, 2006

and with external wall insulation, this can be bought down below the level of the solid floor to reduce the perimeter thermal bridge.

An insulated perimeter upstand should be considered to improve the surface temperature factor and reduce the thermal bridge. This same detail can be used at junctions where internal walls, chimney breasts, stairs, or other structures meet the solid ground floor. Where floor insulation is very thin (<25mm), although possibly counter-intuitive but confirmed by modelling, the perimeter upstands become more important to maintain a good internal surface temperature at the junction between the wall and the floor.

Using a perimeter upstand is not possible at door thresholds, and therefore other design solutions need to be considered. If the door needs to be removed and replaced due to the increase in floor height, then a structural insulating product can be placed under the door threshold to reduce the thermal bridge.

When targeting very low U-values (0.3 W/m2K down to 0.1 W/m2K) it becomes increasingly important to consider the impacts of thermal bridging and how well it can be managed.

Airtightness layer

Air leakage into solid floors is possible and carries a high amount of moisture and increases the risk of interstitial condensation. An air barrier should be installed in all solid floor systems on the warm side of the insulation. This is not the same as a vapour control layer (VCL), although some VCLs can double up as air barriers. Screed may be airtight but may be prone to cracking in the long term and is not a vapour control layer.

Air barriers shall be designed to continue around junctions, edges and corners which includes those junctions listed in clause 31. At these junctions between potentially different air barrier materials, proprietary airtightness tapes, adhesives or paints should 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, gaffa tape, aluminium foil tape, expanding foam, silicon sealant, decorators caulk, dot & dab plasterboard, skim finish, vinyl, plywood, flooring and masking tape.[3] However, many building materials are airtight and can double up as air barriers if they are on the warm side of the insulation, such as:

- Concrete cast in situ
- Precast concrete – with care at edges and joints
- Screed (although this is susceptible to cracking)
- Vapour control membranes (taped at joints with airtightness tapes)
- 18mm OSB board (taped at joints with airtightness tapes)

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

Moisture management

Solid floors tend to be moisture closed and a damp proof membrane should be introduced on the existing solid floor, prior to the installation of any insulation. The type of insulation that is installed onto solid floors is also usually rigid and vapour impermeable. Therefore, a moisture closed strategy should be chosen. This will include installing a vapour control layer on the warm side of the insulation.

Where installed as part of the SFI installation, damp proof membranes should be lapped up the walls to overlap the damp proof course.

Vapour control layers (which may double as the air barrier) should be sealed at junctions and edges, to ensure a continuous barrier.

In traditional buildings, some solid floors may be of compacted earth or lime screed which is a moisture open construction. In this case, careful consideration needs to be given to the type of insulation, the thickness and the floor finish as well as the floor will be dug out or insulated on top. In general, it is advisable to design a moisture strategy for the new SFI that complements the existing moisture strategy. Guidance from Historic England on Insulation of Solid Floors is available[4].

BS5250 Management of Moisture in Buildings: Code of practice should be adhered to in the assessment, design and implementation of solid floor insulation.

Installing OSB or plywood boards beneath tiles may result in water being trapped in the OSB or plywood layer and could lead to rotting. Water ingress may be as a result of leakage from an appliance, pipework, or flooding. Any materials liable to decay within the floor should be able to dry after wetting.

Ventilation

In accordance with PAS 2035 no insulation should be installed without assessing, and if necessary, upgrading the ventilation system. A fully functioning, and preferably continuous ventilation system[5] should be in operation upon completion of the SFI.

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[4] Energy Efficiency and Historic Buildings: Insulating Solid Ground Floors, Historic England, https://historicengland.org.uk/images-books/publications/eehb-insulating-solid-ground-floors/heag087-solid-floors/

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

Interaction with other measures

Where other insulation measures are installed at the same time as the SFI, special attention should be given to thermal bridging, air tightness and moisture at junctions with other measures as outlined in the previous sections.

Thermal capacity

Insulating an existing solid floor in connection with the ground will mean that the effects of the thermal capacity of the floor will be changed. Thermal capacity can reduce the risk of overheating and helps stabilise the internal temperature. Consideration should therefore be given where appropriate to reintroducing thermal capacity by specifying a dense material such as a screed floor finish where possible.

Services and penetrations

Ensure that all the services (pipes, radiators, etc.) and fittings (skirtings, stairs, cupboards etc.) situated on the floor-to-be-insulated are considered. Post-installation works will be necessary to reinstate them.

Service penetrations through SFI should be kept to a minimum and be properly sealed where they penetrate the insulation layer, the VCL and/or the air barrier.

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

When installing solid floor insulation in a replacement floor, consideration should be given to installing underfloor heating pipes either as part of a new heating system or to future proof against the installation of heat pumps and other low temperature heating installations. Heating pipes should be installed above the SFI.

If installing underfloor heating with solid floor insulation, the position of the insulation is important. If height is restricted then choose an underfloor heating system with integrated insulation that allows the thickness of solid floor insulation to be maximised. Check new floor finish is robust enough to protect underfloor heating systems.

8. Installation

Pre-installation survey and risks

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 as required by PAS 2030. They should also check the information from the retrofit assessment, and that it has identified all the risks as laid out in Section 3 Building Suitability Assessment & Risk, in this guide. The installer should be satisfied that any remedial works have been carried out and that the floor is in a suitable condition for the type of SFI to be installed.

The table below describes some of the major considerations for the installer upon receiving a retrofit design for SFI.

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 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	Works being undertaken without correct permissions or approvals in place.
Has an assessment been	If the installation to be undertaken will result in	Review of the scope of works to assess suitability in relation to:	Installation of the measure contravenes or results in the

Action	Assessing	Methodology	Risk
undertaken for compliance with the Building Regulations?	non-compliance with the Building Regulations.	• workmanship, • materials, • structural stability, • fire safety, • management of moisture, • ventilation, • overheating, • thermal performance, and • protection from falling, collision and impact.	building becoming non-compliant with the Building Regulations.
Have the risks identified in the retrofit assessment been mitigated by the remedial work or in a retrofit design?	If remedial work has been undertaken or if the retrofit design has mitigated any risks identified.	Review the retrofit assessment and identified risks. 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.	Potential for structural or moisture risks due to 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 solid ground floor junctions with	Review of the Whole House Retrofit Plan and/or design package. Visual and potential invasive inspection (if appropriate) of: • the existing wall conditions. Including any internal or external wall insulation that has been installed anywhere in the property; • The window and door installation situations close to the ground;	Creation of a thermal bridge, leading to heat loss and increased risk of surface condensation and mould growth.

Action	Assessing	Methodology	Risk
	• external walls • internal walls • party walls • stairs • door thresholds • chimney breasts	• The extent of internal walls, stairs and external walls and other structures joining ground floors; to assess how these junctions will/can be resolved to avoid thermal bridging and install a continuous air barrier[6]. 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.	Non-continuous air barrier leading to increased risk of thermal bypass and moisture penetration into the solid floor insulation.
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; • 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 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 or disturbances that may occur) and ongoing maintenance needs for solid floors and ventilation systems.	Customer unhappy with disruption Customer unable to maintain retrofit system, know how to make changes

[6] 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
			to their home or use new ventilation controls.
Does the retrofit design include upgrade of the ventilation system?	If ventilation is appropriate for improved air tightness associated with SFI.	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

In accordance with PAS 2035/2030 a Retrofit Installer should be able to 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 solid floor insulation.

Minimising thermal bridging

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.

SFI will inherently have thermal bridges due to internal and external walls, party walls, chimney breasts, stairs and other structures in contact with the ground. However, these can be mitigated, usually with a small perimeter upstand against the wall or structure 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 at door thresholds, but there are other design solutions that could reduce the thermal bridge.

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.

Air barriers, vapour barrier and vapour control layers

An air barrier is a building material with properties that aim to 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 be installed on all construction types to protect insulation and the building fabric from moisture carried in the air.

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.

The moisture strategy describes how water vapour is controlled within the SFI system. The moisture strategy tends to fall into one of two categories; those that try to control the passage of water vapour (known as moisture closed), and those that allow and manage the passage of water vapour (known as moisture open). Note that moisture closed is not the same as airtight.

For solid floor insulation, the most common moisture strategy is moisture closed. However, there are exceptions for traditional lime based or rammed earth floors.

Air barriers 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 should 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, gaffa tape, aluminium foil tape, expanding foam, silicon sealant, decorators caulk, dot & dab plasterboard, skim finish, vinyl, plywood, flooring and masking tape.[7]

For moisture closed systems a vapour barrier or vapour control layer is used, and this must be sealed at all junctions, edges and corners using proprietary vapour control tapes or sealants.

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.

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.

The vapour control layer and the air barrier may be the same in moisture closed designs.

Installation principles

Products & thermal bridging

Ensure that the correct insulation products are used in each situation. Some insulation products have much better insulating properties, and others are structural. All components of solid floor insulation should match the retrofit design, including surface finishes and adhesives. If looking to propose alternative products, ensure these are checked with the Retrofit Designer and/or Retrofit Coordinator as being appropriate for the situation they are to be used, and that they are consistent with the retrofit design.

Eliminating thermal bypass

One of the biggest risks to reducing the effectiveness of insulation when it is installed is allowing gaps within and through the insulation layer. This is known as thermal bypass, and it can increase heat loss through an insulated wall by up to 300%. A robust and continuous air

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

barrier on the warm side of the insulation will help to reduce the risk of thermal bypass, but it is also important to avoid gaps between insulation layers or between insulation boards or batts.

If installing rigid insulation board, as is commonly used in solid floor insulation, the joints between the boards should be ideally tongue and grooved/lapped joints to fit in corners, around edges and with each other. All joints must be staggered. Before finishing, the installation of the boards should be inspected. Any gaps between the board connections and at the perimeter of the insulation should be properly packed out and sealed. Some rigid boards (e.g. PIR) may also be taped, especially if their surface forms the vapour control layer and/or air barrier.

Sealing is also important around the perimeter of the SFI boards, ensuring that the air barrier, vapour control layer and damp proof membrane is continuous at the perimeter of the floor and connects to the relevant layer in the wall.

Eliminating interstitial condensation

Interstitial condensation is a type of condensation that may occur within an enclosed wall, roof or floor structure, which can create moisture issues. It can only form on surfaces where there is an air gap. Some of the risk of interstitial condensation can be mitigated in choosing an appropriate retrofit design. Good installation practice is also important in reducing risk and all the points in the section Avoiding Thermal Bypass will also help to reduce the risk of interstitial condensation.

Services in relation with SFI

Any holes and gaps in the VCL and/or air barrier should be properly sealed with appropriate tape. If wiring is encapsulated in, or directly under the insulation, an electrician should be consulted on the need to replace or derate the cable.

Any penetrations of the air barrier or the vapour control layer that cannot be avoided should be sealed appropriately. These penetrations may include:

- Waste pipes & SVPS
- Incoming water, gas, oil, electricity, data, and district heating, as applicable
- Hot water heating pipes

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. 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.

9. Mid- and post- installation checks

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.

Many serious moisture-related problems may be hidden from view for some time prior to their effects being felt (for example in slowly accumulating levels of mould, moisture 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.

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.

PAS 2030 requires date-stamped and geo-located photographs to be taken of all work that is covered up without inspection. It is recommended that photographs are taken before and during installation to evidence the following:

- Existing stripped back solid floor.
- Installation of appropriate vapour control barrier (if needed) in accordance with the design and manufacturer’s instructions.
- Installation of appropriate damp proof membrane 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 SFI in good condition.

Maintenance

Although SFI itself requires little or no maintenance, other works associated with a SFI installation will inevitably require maintenance to avoid potential problems. Examples include installation & maintenance of ventilation systems or replacement or repair of external drainage systems.

Handover of buildings should include clear and informative maintenance manuals and web-based information. If possible, maintenance programmes should be established, 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

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

10. Health & Safety

The surveyor or 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

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.

When digging out floors, ensure appropriate edge protection to avoid falling.

Insulation materials

Some insulation materials may be hazardous to health, particularly when cut. 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.

Ensure floor finish protects occupants from any insulation dust released when floor is in use. The air barrier will often form this protective layer.

Asbestos

Asbestos, particularly in floor tiles and coverings may be found in floors. Any materials suspected of containing asbestos should be tested by an appropriately qualified person and appropriate removal techniques adopted.

11. Training and Vocational Competence

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

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.

For all retrofit professionals, the level 5 Retrofit Coordinator qualification (required for PAS 2035 /2030) is recommended as it offers an overview of retrofit systems & technologies and their associated risks.

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 tool and can be useful in communications with the client.

For all retrofit professionals working with traditional buildings, the Level 3 qualification in Energy Efficiency and Retrofit of Traditional Buildings is recommended.[8]

Competencies for Retrofit Installers for SFI can be found in PAS 2030 (B.6. Floor insulation) 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/).

[8] 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 – Floor construction and Identification

Ground floors come in two basic types. Solid and suspended.

Suspended timber floors (which are included in the BEIS Guide to Best Practice Retrofit Floor Insulation – Suspended Timber Floors) can usually be identified by sound and feeling if the floor is jumped on and by the presence of air bricks in the outside walls.

Concrete block and beam floors (which are not covered in this guide, but will be included in the BEIS Guide to Best practice Retrofit Floor Insulation - Suspended Timber Floors Guide at the next update) can be hard to distinguish from traditional solid floors, but the age of the dwelling, presence of air bricks in the external walls and the height of the floor above the ground can be good indicators for these.

Solid floors are defined as being built directly on the ground. These floors come in many forms and with many different surfaces and this raises a variety of design and installation issues for the insulation.

Period homes often consist of lime-based ground floor slabs, flagged-stone or tiles laid straight onto soil (rammed earth). This form of construction allows moisture from the ground to permeate through the floor and evaporate.

In Victorian times, suspended timbers tended to be installed in most rooms, but solid floors were still popular in areas such as kitchens and hallways.

By the 1930s, solid concrete floors became the norm. In the early days these concrete floors had no damp proof course.

Damp-proof membranes (DPMs) embedded within solid floors did not become a Building Regulations requirement until the 1960s.

Before that, it was common to apply a bitumen coating to the surface of concrete floors to serve as a damp proof course and an adhesive for floorboards or tiles. These damp proof courses often failed because nails holding the floorboards down perforated the bitumen and were prone to rust.

In the 1980’s concrete beam and block floors were introduced in situations where the ground was not obviously suitable for an economic installation of a ground floor slab.

Insulation became a standard requirement in solid floors in the 1990’s. There has been a steady increase in the required performance of the insulation since.

Today, new solid floors are more substantial, typically comprising 150mm of compacted hardcore, 50mm of sand, a polythene sheet DPM, 100mm of concrete, then around 100mm of insulation and a 60mm screed.

Floors may have been changed over time, usually from suspended to solid floors. Houses may be a mixture of floor types. A typical layout might be a solid floor to the rear of the house where a new extension has been built, with suspended timber to the front.

Annex B – Customer Care & handover

Installing SFI (Solid floor Insulation) is disruptive to the residents and the properties involved. It is therefore essential that thorough discussions with the resident and and/or building owner take place before during and after the work.

The installer shall advise clearly, as a minimum, the following aspects of the works:

- the extent of any disruption that may be caused by the chosen installation method (removal of fittings and or fixtures, skirtings, floor finishes and coverings, removal of furniture)
- any additional works that may be required to facilitate the installation of insulation (lighting rigs, 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; and
- the extent of any making good that is included in the work being carried out (redecoration etc); and
- where relevant, safe and secure storage of materials on site; and
- the cost of the works, and any deviation from this during the works caused by unforeseen issues; and
- the contracts that the customer is expected to sign up to with the installer; and
- 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 insulation 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, coordinator, 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 are likely to be whole rooms, 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 SFI associated measures (e.g. new ventilation systems, new floor finishes)
- Operation manuals for SFI associated measures (e.g. new ventilation systems)
- Physical inspection of installed SFI and associated measures
- Visual check that consumer is able to operate SFI associated measures (e.g. ventilation system)
- 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 SFI associated measures (e.g. ventilation system)

This publication is available from: www.gov.uk/government/publications/solid-floor-insulation-sfi-best-practice

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