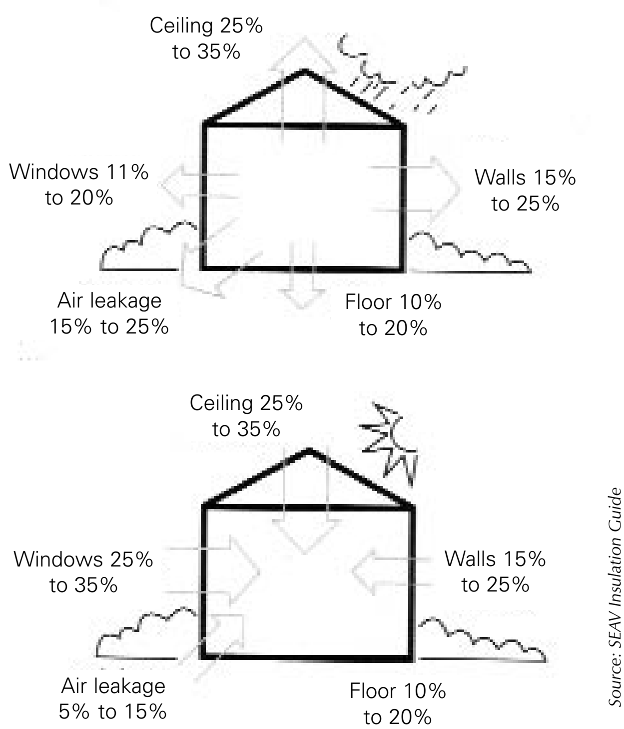
Insulation acts as a barrier to heat flow and is essential to keep your home warm in winter and cool in summer. A well insulated and well designed home will provide year-round comfort, cutting cooling and heating bills by up to half. This, in turn, will reduce greenhouse emissions.

Climatic conditions will influence the appropriate level and type of insulation. Establish whether the insulation will be predominantly needed to keep heat out or in (or both). Insulation must cater for seasonal as well as daily variations in temperature, see "Insulation levels for your Climate", page 3.



Typical heat gains and losses in a temperate climate

Passive design techniques should be used in conjunction with insulation. For example, if insulation is installed but the house is not properly shaded, built up heat can be kept in by the insulation creating an 'oven' effect. Draught sealing is important, as draughts can account for up to 25 percent of heat loss from a home in winter. **[See: Passive Solar Heating; Passive Cooling]**

Insulation can assist with weatherproofing and eliminate moisture problems such as condensation. Some types of insulation also have soundproofing qualities.

The most economical time to install insulation is during construction. For information on retro-fitting insulation, see the section headed "Adding insulation to existing buildings" on page 5.

There is little insulating value in most common construction materials, but there are some exceptions where little or no additional insulation may be required. Suitable materials include aerated concrete blocks, hollow expanded polystyrene blocks, straw bales and rendered extruded polystyrene sheets. Check with your local building information centre for more details.

CHOOSING INSULATION- WHERE TO START

Insulation products come in 2 main categories - bulk and reflective. These are sometimes combined into a composite material. There are many different products available. See the section headed "Insulation types and their applications" on page 2 for further information.

To compare the insulating ability of the products available look at their R-value, which measures resistance to heat flow. The higher the *R-value* the higher the level of insulation. Products with the same R-value will provide the same insulating performance if installed as specified.

Check the information supplied on the product, including the R-value, the price per square metre and whether it must be installed professionally or can be DIY. Ensure that it suits your particular application and will fit within the space available. *Ask if performance guarantees or test certificates are available.*

Compare the environmental benefits of different products. Ask about recycled content and how easily the product can be recycled after use. For example, glass fibre insulation contains up to 60 percent recycled glass. Currently some brands of polyester insulation contain up to 80 percent recycled *PET* (the plastic commonly used in drink bottles). Some brands of cellulose fibre contain up to 100 percent recycled paper.

[See: Embodied Energy; Waste Minimisation]

These bio-soluble batts are manufactured from around 30 percent recycled glass

insulation

overview

The appropriate degree of insulation will depend on climate, building construction type, and whether auxiliary heating and/or cooling is to be used. Refer to the section headed "Insulation levels for your climate", page 3.

The Australian Standard AS2627.1 sets out minimum requirements for R-values for buildings heated and refigeratively cooled. It is generally advisable to exceed these for greater comfort and energy savings. This standard is not relevant where houses are evaporatively cooled.

The higher the R-value the better the thermal performance.

Material R-values are supplied with bulk insulation and refer to the insulating value of the product alone. The higher the R-value the better the thermal performance.

System R-values are supplied with reflective insulation and depend on the product being installed as specified.

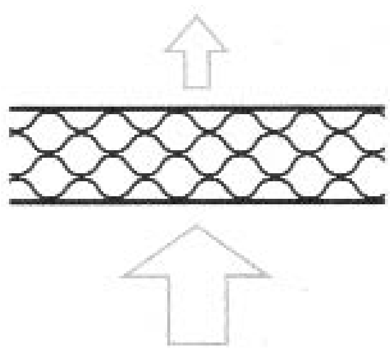
R-values can differ depending on the direction of heat flow through the product. The difference is generally marginal for bulk insulation but can be pronounced for reflective insulation.

> Up R values describe resistance to heat flow upwards (sometimes known as 'winter' R values).

> Down R values describe resistance to heat flow downwards (sometimes known as 'summer' R values).

Up and *down* R values should be quoted when installing insulation in roofs, ceilings and floors.

INSULATION TYPES & THEIR APPLICATIONS

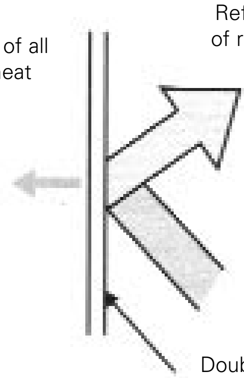


Source: SEAV Insulation Guide

Bulk insulation mainly resists the transfer of conducted and convected heat, relying on pockets of trapped air within its structure. Its thermal resistance is essentially the same regardless of the direction of heat flow through it.

Bulk insulation includes materials such as glass fibre, wool, cellulose fibre, polyester and polystyrene. All products come with one *material* R-value for a given thickness.

Reflective insulation mainly resists radiant heat flow due to its high reflectivity and low *emissivity* (ability to re-radiate heat). It relies on the presence of an air layer of at least 25mm next to the shiny surface. The thermal resistance of reflective insulation varies with the direction of heat flow through it.



Source: SEAV Insulation Guide

Reflective insulation is usually shiny aluminium foil laminated onto paper or plastic and is available as sheets (sarking), concertina-type batts and multi-cell batts. Together these products are known as reflective foil laminates or 'RFL'.

Dust settling on the reflective surface will greatly reduce performance. Face reflective surfaces downwards or keep them vertical. The 'anti-glare' surface of single sided foil sarking should always face up.

The system R values for reflective insulation are supplied as up and down values. System values depend on where and how the reflective insulation is installed. Ensure system values provided by the manufacturer relate to your particular installation situation.

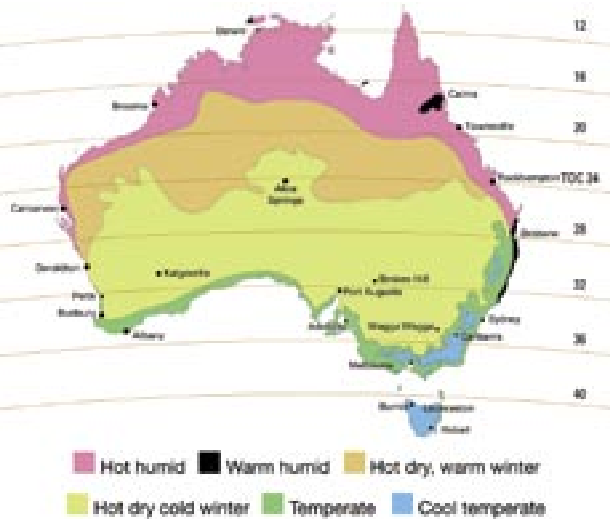
Composite bulk and reflective materials are available that combine some features of both types. Examples include foil backed blankets, foil backed batts and foil faced boards.

The properties and uses of some common insulation materials are shown in the table at the end of this sheet.

INSULATION LEVELS FOR YOUR CLIMATE

Recommendations for best practice.

The following figures represent currently recommended industry best practice and are drawn from various guide books and Australian Standards.



Australian Bureau of Meteorology

HOT HUMID (TROPICAL) CLIMATES
HOT DRY CLIMATES WITH WARM WINTERS

Reducing heat gain is the critical priority
Naturally ventilated/ evaporatively cooled houses
Reduce heat gain without unduly restricting heat loss (high down values and lower up values).

Air conditioned houses
Reduce heat gain and keep cooled air inside (high up and down values, well sealed building).

Roof
Use RFL insulation under the roof with an air gap of at least 25mm minimum. Check manufacturers specifications.

Ceiling
Naturally ventilated/ evaporatively cooled houses
Use insulation with high down and lower up values.
Air conditioned houses
Use a minimum of R 3.5 insulation.

Walls
Naturally ventilated/ evaporatively cooled houses
Insulate walls not in permanent shade to a minimum of R1.0 *total* (see Installing Insulation).
Air conditioned houses
Use a minimum of R1.5 insulation.

Floor
Naturally ventilated/ evaporatively cooled houses
Do not insulate floors.
Air conditioned houses
R1.0 insulation is recommended under suspended floors (timber or concrete).

COOL TEMPERATE CLIMATES
ALPINE CLIMATES

Reducing heat loss is the main priority.
Reducing summer heat gain is also an issue.

Roof
Use RFL insulation under the roof with an air gap of 25mm minimum.

Ceiling
Use a minimum of R3 insulation.
Higher minimums are recommended for:

> Alpine areas.
> Homes with central heating or cooling.
> Homes with ceilings higher than 3m.

Walls
Use a minimum of R1.5 insulation.
Use R2.0 or more where space permits.

Floor
R1.0 is adequate for most homes.
Use higher levels in alpine climates, or where:

> Slab heating is used.
> The underfloor space is ventilated.
> There is no covering to timber floors.

TEMPERATE CLIMATES
WARM HUMID (SUB-TROPICAL) CLIMATES
HOT DRY CLIMATES WITH COLD WINTERS

Reducing heat loss and heat gain are equally important.

Roof
Use RFL insulation under the roof with an air gap of 25mm minimum.

Ceiling
In naturally ventilated houses
Use a minimum of R 1.5 insulation.

Centrally heated or air conditioned houses
Use a minimum of R 3.0 insulation.

Walls
Use a minimum of R1.5 insulation.

Floor
R1.0 is recommended under suspended floors if:

> Slab heating is used.
> The underfloor space is ventilated.
> There is no covering to timber floors.
> Air conditioning is used.

If you are unsure about which climate type you live in consult your local energy advice or building information centre. [See: Energy Use Introduction]

The following table gives recommended insulation levels for best practice in a range of locations.

The lowest figure in each range indicates the minimum level of insulation recommended for houses using occasional or no heating.

The highest figure indicates the minimum level of insulation recommended for houses using central heating and/or cooling.

The table does not distinguish between directional R values for roofs and ceilings. The most important thing to remember is that in hot humid climates where houses are naturally ventilated, high down values and lower up values are appropriate for roofs and ceilings.

CLIMATE TYPE AND EXAMPLE LOCATIONS	RECOMMENDED INSULATION LEVELS *(material or system R values)*	
	ROOF/CEILING	WALL
Cool Temperate & Alpine		
Melbourne, Vic	3.0	1.5
Canberra, ACT	3.5	1.5 - 2.0
Hobart, Tas	3.5	1.5 - 2.0
Mt Gambier, SA	3.0	1.5 - 2.0
Ballarat, Vic	3.5	1.5 - 2.0
Thredbo, NSW	4.0	1.5 - 2.0
Hot Humid & Hot Dry		
Darwin, NT	0* -4	0* - 2
Cairns, Qld	0* -3.5	0* - 1.5
Broome, WA	0* -4	0* - 2
Marble Bar, WA	0* -4	0* - 2
Mt Isa, QLD	0* -4	0* - 2
Tennant Creek, NT	0* -4	0* - 2
Townsville, QLD	0* -3.5	0* -1.5
Temperate & Warm Humid		
Brisbane, QLD	1.5 - 2.5	1.0
Perth, WA	1.5 - 3.0	1.5
Alice Springs, NT	1.5 - 4.0	1.5 - 2.0
Bourke, NSW	1.5 - 4.0	1.5 - 2.0
Sydney, NSW	1.5 - 3.0	1.5
Adelaide, SA	2.0 - 3.0	1.5
Katoomba, NSW	4.0	1.5 - 2.0

***The zero figure does not suggest that no insulation is required.** It indicates that insulation to reduce heat loss may not be cost effective and can even contribute to overheating in homes without adequate sun control. In these situations use insulation that prevents heat gain without unduly restricting heat loss (high down values, low up values).

WHERE TO INSTALL INSULATION

Roofs and ceilings work in conjunction when it comes to insulation.

> Install insulation under the roofing material to reduce radiant heat gain.

> Install insulation in the ceiling to reduce heat gain and loss. In most cases ceiling insulation is installed between the joists.

Verandah roofs should be insulated in hot climates where outdoor living spaces are used extensively, to reduce radiant heat gain. Heat build up under verandahs not only affects the space below but can affect conditions inside the house.

Bulkheads (wall sections between ceilings of different heights) must be insulated to the same level as the ceiling, as they are subjected to the same temperature extremes.

Save up to 45 percent on heating and cooling energy with roof and ceiling insulation.

External walls should be insulated to reduce radiant, conducted and convected heat transfer. Wall insulation can be installed:

> Within cavities.

> Within stud frames.

> On the outside of stud frames.

> On the inside or outside of solid walls.

Depending on the particular situation, some forms of insulation can double as a vapour or moisture barrier.

Save up to an additional 15 percent of heating and cooling energy with wall insulation.

Floors require insulation in cool climates and often in other climates. Insulate:

The underside of suspended floors

> In cool temperate and alpine climates.

> In temperate climates in some cases (see previous section).

> In hot humid and hot dry climates where air conditioning is used.

The edge of ground slabs

> In cool temperate and alpine climates.

> In temperate climates where slab heating is used.

The underside of ground slabs

> In alpine climates.

> Where groundwater is present.

Enclosing sub-floor spaces in mixed climates may be sufficient to reduce heat loss.

Save up to 5 percent on winter energy costs with appropriate floor insulation.

[See Insulation Installation]

Insulation Solutions

ADDING INSULATION TO EXISTING BUILDINGS

Insulation can be added to existing buildings with varying effectiveness and cost depending on the construction type and where the insulation is being placed.

Ceilings and suspended floors with easy access are relatively simple to insulate post-construction.

Insulation board can be laid beneath floor finishes if there is no under-floor access.

Walls and skillion roofs are the hardest to insulate post-construction, as the internal or external lining must be removed. A good time to insulate walls is during re-cladding or re-plastering. Specialised products are available to insulate existing walls. Check with your local building information centre. External insulation or (if local building regulations permit) cavity fill are often appropriate solutions for double brick walls.

RETROFITS AND RENOVATIONS

Adding (or 'retrofitting') insulation to existing buildings provides a major opportunity to increase comfort and reduce energy costs and greenhouse gas emissions. An ideal time for doing this is during renovations.

This section explains how to retrofit insulation to various construction types. Refer to the previous sections of this sheet to determine the appropriate type and level of insulation for your climate.

WALLS

Most walls will benefit from added insulation, and it is possible to add insulation to most construction types used in Australia. Autoclaved aerated concrete (AAC) already has a reasonable degree of insulation built into the blocks themselves, and straw bale is an extremely highly insulated system.

Apart from these exceptions, added wall insulation is essential in all climates. If it is not already fitted, or if existing insulation levels are not high enough, there are ways of installing it as a retrofit.

Cavity Brick Walls

Cavity brick walls have high thermal mass, but without insulation are usually too cold in winter, and often too hot in summer if exposed to prolonged heat wave conditions. If the cavity is insulated, the internal thermal mass (ie. the internal brick skin) is protected from external temperature changes, and becomes highly effective at regulating temperatures within the home.

Insulate existing cavities by sealing the bottom of the cavity if it is open to the subfloor, and pumping in loose bulk material to a measured density. This has been common practice in the UK and Europe for many years, and is becoming available in Australia, usually in one of the following forms:

Small polystyrene balls (produced with CO_2) coated in a non-toxic bonding agent are pumped in at regular points around the building. The bonding agent solidifies and locks all the balls in place.

Mineral fibres can be blown into the cavity either through a series of small holes as above, or into the top of the cavity if it is accessible. This material is gypsum isover mineral wool, commonly known as Isowool, and is moisture repellent, keeping the cavity dry.

It is important that such materials are installed by reputable manufacturers whose products meet either the Australian, UK or European standards.

Brick Veneer, Reverse Brick Veneer & Timber Framed Walls

Brick Veneer (BV) walls have the brick skin on the outside, which is not the ideal location for thermal mass. The bricks heat up in summer and radiate heat late into the evening, while in winter they stay cold and absorb heat from the house. Insulation is essential to protect the occupants from external temperature extremes that are exacerbated by the external brick skin.

Reverse Brick Veneer (RBV) is much more thermally efficient because the thermal mass is on the inside, however good insulation is still important. [See: Thermal Mass]

Timber framed walls are low mass construction, and rely entirely upon insulation to maintain thermal comfort.

The two cavity fill methods previously described (polystyrene balls or mineral fibres) can be used to insulate these wall types if the lining or cladding is not being removed. More material may be required, as it will fill up not only the cavity but the width of the wall frame (BV & RBV). Note that the effectiveness of existing sarking is greatly diminished by replacing the airspace with fill material. For timber frame walls, insulation is pumped into the voids between studs and noggings, but this can be labour intensive.

The ideal option, if the scope of the renovation permits, is to remove the internal plasterboard linings or external cladding and fit insulation to the stud frame.

Reflective insulation can be retro-fitted to existing wall frames by either cutting up a roll and fitting the pieces between each wall stud, or by using a factory prepared product like concertina or multi-cell foil batts, which are easy to install and expand or fold into place. Reflective foil-backed plasterboard is also a useful material.

There is usually sufficient depth in a wall frame to add more than one layer of reflective insulation, including the necessary air gap between layers. When used for this purpose the foil should not have an antiglare coating on it.

Bulk insulation can be fitted between studs in the conventional manner, and depending on the thickness of the studs and the selected R value, may or may not fill the entire wall frame width. Do not compress bulk insulation. When used in conjunction with a layer of foil, ensure there is an air space of at least 25mm between the batt and the foil. [See: Insulation Installation]

Other Wall Types

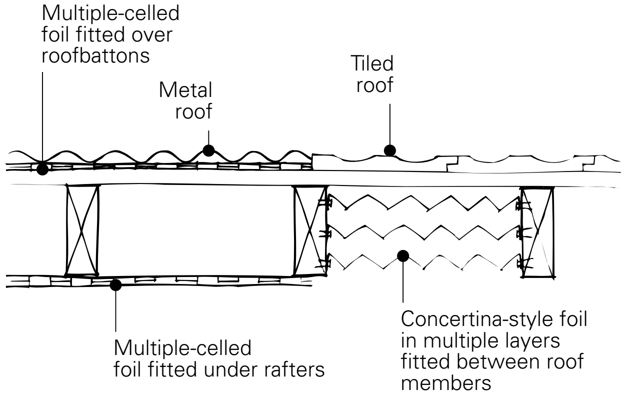
Single skin high mass walls such as concrete block, rammed earth or mud brick can have their thermal performance radically improved by installing insulation on the wall exterior. The simplest method is to use polystyrene board with an external render, or batts fixed between battens at around 600mm centres, covered with a waterproof cladding. [See: Insulation Installation, Thermal Mass]

CEILINGS & ROOFS

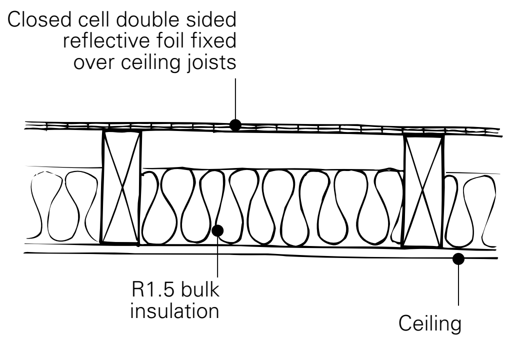
It is possible to add insulation to all roof types common in Australia, and even if some effort is required to lift roofing, the benefit is well worth it.

Tiled roofs without sarking can have it added easily if the roof is being re-tiled. If the tiles are to remain in place and access is available to the roofspace, double sided foil or foil batts can be added between the rafters or trusses, directly under the tile battens.

Metal roofs need a condensation barrier directly beneath them: a layer of reflective foil sarking is an effective membrane and barrier to radiant heat, thus doing two jobs at once. It is usually necessary to remove the roofing to install this, but most metal roofing can be removed and reinstalled easily, without damage.



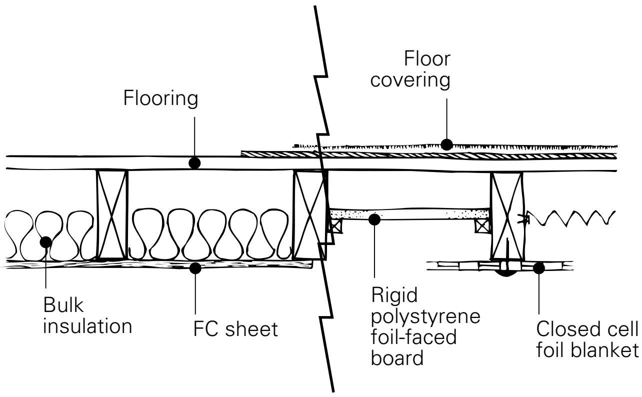
If sarking has been fitted it may still be necessary to fit extra layer/s of foil beneath it. A minimum air gap of 25mm should always be maintained between layers. If the roof is being painted to restore colour, select the lightest permissible colour (heat-reflective roof paints are also an option), and then match the remaining colour scheme to it.



Ceiling insulation is simple to fit if the roof space is accessible. If the house has a flat roof or raked ceilings, there will be no access into the space except by removing and reinstalling the roofing or the ceiling lining. If the ceiling is being replaced, it's a simple job to install insulation from below. Reflective foil backed plasterboard is a useful material in this situation. [See: Insulation Installation]

FLOORS

Floors do not always require insulation. Refer to the previous sections of this sheet to determine whether floor insulation is required for your situation.



Exposed subfloor (Pole home)

Enclosed or ventilated subfloor (brick, brick veneer, timber frame)

Raised timber floors should have subfloor access, with soil clearance of around 400mm below the lowest timbers. This provides sufficient access to install insulation. Foil or bulk insulation will work well, but in either case care must be taken to ensure it is well supported and will not sag or fall down in time. Vermin also need to be accounted for. Insulation board can be laid beneath floor finishes if there is no subfloor access.

Concrete slabs are either suspended or slab on ground. Suspended slabs can be insulated in a similar way to raised timber floors.

Slabs on ground can have edge insulation installed if the climate requires it. Excavate a shallow trench around the slab edge (avoid excavating right down to the bottom of the slab, as destabilisation of the foundation may occur).

Install a 40mm polystyrene board and fibre cement cover board around the entire slab edge, up to the height of the wall cladding. Ensure the termite barrier remains intact. For more effective performance (if needed) an additional fin of polystyrene board can be laid horizontally from the slab edge underneath paving, extending about 1-1.5m. [See: Insulation Installation]

ADDITIONAL KEY REFERENCES

Woolley, Kimmins, Harrison and Harrison, *The Green Building Handbook*, E & FN Spon 1997

Standards Australia, AS 2627.1-1993 *Thermal Insulation of Dwellings*

Standards Australia, AS 4859, *Insulation Product Standard*

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PATHE, *Insulation Management Guide for Residential Building*

Willrath, H, *Energy Efficient Building Design Resource Book*, Renewable Energy Centre, Brisbane Institute of TAFE, 2000

BDP *Environment Design Guide, PRO7 & PRO8 Thermal Insulation in domestic buildings for temperate climates*

PROPERTIES AND USES OF COMMON INSULATION TYPES

Common types of Reflective Insulation

MATERIAL	DESCRIPTION	Flat ceilings Pitched roof	Cathedral or raked ceilings	Timber floors	Framed walls
Reflective Foil Laminate [RFL sarking	Aluminium foil laminated with glass fibre reinforcement Requires a sealed air space of at least 25mm between foil and solid surface to provide full insulation Useful as a barrier against moisture Dust build up on foil reduces performance Available in rolls, often with one side painted with anti-glare paint	✔	✔	✔	✔
Multi-cell Foil Batts	Batts made from layers of RFL with enclosed air cavities between the layers Other characteristics identical to RFL sarking Double or triple cell batts available	✔	✔	✔	✔
Concertina –type Foil Batts	Concertina-folded foil/ paper laminate Expandable, and can be adjusted to suit varying gaps Other characteristics identical to RFL	✔	✔	✔	✔

Common types of Bulk Insulation

MATERIAL	DESCRIPTION	Flat ceilings Pitched roof	Cathedral or raked ceilings	Timber floors	Suspended slabs	Slab edges	Full masonry walls	Framed walls
Glass Fibre	Made from melted glass spun into a mat of fine fibres Easy to cut and install, commonly sold in DIY packs as rolls or batts Should not be compressed or moistened Can cause irritation, wear protective clothing during installation	✔	✔	✔				✔
Rockwool Batts	Made from melted volcanic rock spun into a mat of fine fibres Higher R values than glass fibre per unit thickness Good sound absorption properties Other characteristics- see glass fibre	✔	✔	✔				✔
Rockwool Loose-fill	Supplied as granules, properties as for Rockwool batts Can be difficult to install in weatherboard walls Treat with water repellent & install evenly Should not be compressed or moistened	✔	✔*					✔
Polyester	Made from polyester threads spun into a mat, produced in rolls and batts Similar physical properties to fibreglass and rockwool Should not be compressed or moistened	✔	✔	✔				✔
Wool Batts	Made from spun sheep's wool, treated against vermin and rot Available with polyester blend to reduce settling & compression Check the quality and fire resistance of the product	✔	✔	✔				✔
Wool Loose-fill	Properties as for wool batts, but quality and density can vary and affect the R-value	✔	✔*					
Cellulose Fibre Loose-fill	Made from pulverised recycled paper Borax & boracic acid are added as fire retardant and to deter vermin Usually pumped into ceiling, must be a consistent density and thickness Should not be compressed or exposed to moisture Some settling may occur, decreasing performance	✔	✔*					
Extruded polystyrene [styrofoam]	Rigid boards that retain air but exclude water High R-value per unit thickness, suitable where space is limited Easy to cut and install & can be rendered Greater structural strength & moisture resistance than EPS		✔	✔	✔	✔	✔	✔
Expanded polystyrene[EPS]	Semi-rigid boards of polystyrene beads Easy to cut and install & can be rendered Available as pre-clad panels		✔	✔	✔	✔	✔	✔

Consult manufacturers for maximum roof slope to which loose fill insulation can be installed

Composite insulation combines the benefits of bulk and reflective insulation

MATERIAL	DESCRIPTION	Flat ceilings Pitched roof	Cathedral or raked ceilings	Timber floors	Suspended slabs	Slab edges	Full masonry walls	Framed walls
Fibreglass or Rockwool Batts & blankets with RFL	Reflective foil is bonded to one side of the batt Characteristics as for batts, plus: Higher 'down' R-values due to foil Increased moisture resistance due to foil	✔	✔	✔	✔			
Expanded polystyrene with foil	Expanded polystyrene boards sandwiched between reflective foil Characteristics as for EPS, plus: higher 'down' R-values due to foil		✔	✔	✔			✔

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