Design Guide for Tropical Conditions

TASMAN INSULATION NEW ZEALAND LIMITED

Contents.

Introduction.

Tasman Insulation New Zealand (TINZ) is a part of the Fletcher Building Group. TINZ manufactures and markets a comprehensive range of insulation products offering outstanding thermal and acoustic properties for use in all residential, commercial and industrial applications.

Insulation materials can be divided into two groups **glasswool** 'bulk' insulation used predominantly as thermal or acoustic insulation. And **Building Foils** and laminates which are used as radiant heat barriers and/or vapour barrier when installed in conjunction with bulk insulation.

Both product types are available in various grades whose requirement is dependant on local environmental conditions. It is recognised the that extreme conditions of tropical environments creates a requirement for products which adhere to stringent quality control standards to ensure long lasting functionality of the materials.

Tasman Insulation New Zealand Ltd. is dedicated to the manufacture of high quality insulation products suitable for use in the various climatic conditions where they are used.

Tasman Insulation realises that just as important as the quality of the insulation materials, is the use of appropriate installation techniques. This Design Guide has been developed to address an inconsistencies in the quality of materials and the installation methods throughout the Pacific Region.

If you have any further queries or concerns regarding the appropriate use of insulation in tropical environments please feel free to contact Tasman Insulation New Zealand directly.

The Benefits of Insulation in Buildings.

Improved Thermal Comfort and a Healthier living environment.

Insulation can significantly reduce heat gain in summer as well as heat loss in winter. A layer of Pink® Batts® insulation resists the flow of heat in and out of your house or building helping your home remain at a more comfortable temperature.

Wrapping your home in a Building Foil provides protective envelope helps defend against radiant heat, water, humidity and air infiltration. A properly installed insulation system will help to create a drier, cooler and healthier home.

Condensation Control

Water stains or mould on the ceiling and walls are two of the obvious signs of condensation. These early signs often indicate that major damage is being caused to the buildings structure. Condensation forms when the outer surfaces of a buildings linings, is cooled by air conditioning to a temperature below the dew-point of the air in contact with it.

Any air-conditioned building requires Pink® Batts® Glasswool bulk insulation to provide an insulated surface which is above the dew-point temperature, but glasswool alone will not stop the passage of the hot humid air through to the cool surfaces. A fire retardant building foil must be installed over the Pink® Batts® insulation to form a protective vapour barrier 'envelope' around the insulation layer.

Reduce Noise Levels

Strategic use of acoustic insulation is an essential part of modern construction. As the best chance to insulate correctly is at the building stage, it is important to choose materials that will perform well, not just initially, but in the long term.

Glasswool is an excellent sound absorber and there are specific products for each application; reducing noise transmission through walls, ceilings, and floors making the home or work environment quieter.

Even the noise of rain through metal deck roofing is significantly reduced by installations of specialised glasswool blanket as a part of the roof system.

Saving on Energy Costs

By reducing summer heat gain and winter heat loss air-conditioning and heating requirements are significantly reduced and can potentially save you 30-50% on electricity bills. A well thought out insulation system can pay itself back in electricity savings in as little as 2-3 years.

Importantly this will enhance energy efficiency and help reduce greenhouse gas emissions.

Helping the Environment

Sustainable practices… are the measures that satisfy the needs of people today while enhancing the quality of life for future generations.

The demands on non-renewable resources for the production of energy are not sustainable without compromising the environment.

Insulation, correctly specified and installed, is one of the most critical products in improving energy efficiency and reducing the levels of greenhouse gas emissions.

Tasman Insulation New Zealand is environmentally friendly and utilises up to 70% recycled waste glass in the production of glasswool Insulation.

Design Considerations for Tropical Environments.

When considering the level of insulation required in a residential or commercial building in a tropical climate there are several factors which should be taken into account to ensure the performance requirements are met.

Comfort Level of Building Interior

You can't control the weather, but you can control your internal environment. There are many factors of the external environment which effect our comfort levels;

- Air Temperature
- Level of Solar Radiation
- Air Movement
- Humidity

Tropical climates generate the most extreme and powerful examples of each of these factors, therefore it is important that we design a buildings protective envelope taking these extreme environmental factors into consideration. The building envelope should give us better control of internal conditions, or if controlled by air-conditioned the buildings thermal envelope will greatly reduce the cost of achieving temperature control.

As the use of lightweight construction materials becomes more common due to factors of cost and speed of construction the requirements for insulation are increasing. The use of insulation materials is the only way to achieve the ever increasing comfort levels now demanded by building occupants. A greater understanding of the products available and their appropriate application the designer can find a balance which optimises the investment in insulation with the reduction in air-conditioning operating costs which insulation provides.

Effects of Solar Radiation

In tropical climates it is necessary to understand the various methods in which heat transfers through the building's envelope:

Radiation: solar radiation arriving from the sun striking the buildings exterior heating up surfaces which in turn emit heat radiation towards the interior.

Conduction: due to differences in the ambient temperature inside and outside of a building.

Convection: heat transfer from warm/cold air currents within a building.

Solar radiation contributes significantly to the total heat gain experienced in a building. Up to 97% of total heat gain is due to radiation coming into contact with the buildings exterior.

Solar radiation affects different building material surfaces in different ways. Each and every type of building material reflects [away] and emits [toward the interior] radiated heat at different levels. The ideal barriers to radiated heat are products which reflect a lot and emit very little radiation. The following table indicates the level of reflection and emission of radiated heat by various building materials:

TABLE 1. SOLAR RADIATION ABSORBTION LEVELS OF VARIOUS BUILDING MATERIALS.

	Rate (%) of	
Material	Reflection	Emittance
Aluminium Paint	.82	0.18
Aluminium - Pure	.97	0.03
Asphalt	.14	0.86
Brickwork - Red Common	.32	0.68
Brickwork - Glazed White	.74	0.26
Concrete	.35	0.65
Fibre Cement (new)	.55	0.45
Fibre Cement (old)	.25	0.75
Galvanised Steel (dull)	.45	0.55
Steel Roof (red/brown)	.25	0.75
Steel Roof (white)	.60	0.40
Glass	.17	0.83
Granite	.45	0.55
Marble - White	.66	0.44
Roofing Felt - Bituminised	.22	0.88
Slate (Dark Grey)	.10	0.90
Tiles (Red)	.40	0.60
Timber (Smooth Planed)	.22	0.78
White Enamel Paint on Steel	.47	0.63
Zinc Oxide oil paint	.70	0.30

Energy Conservation

Energy efficiency keeps you power and gas bills down, and puts less strain on the country's natural resources.

An important part of having an energy efficient home or building is the thermal integrity of its shell (how well a comfortable internal temperature can be maintained). The use of thermal insulation will reduce the penetration of heat into the building, therefore reducing the demand on air-conditioning.

Condensation Control

When building in warm humid environments three is a much greater requirement to consider condensation when specifying insulation requirements.

Condensation occurs when water vapour in the aid comes into contact with a cool surface at or below the "dew point". The dew point is the temperature at which the water vapour reaches saturation, or 100% humidity.

Condensation becomes a problem when it occurs either:

(a) On interior surfaces of walls, ceilings, windows etc.

(b) On the interior of building cavities, in roof or attic spaces etc.

The consequences of condensation vary with its severity and other factors, but include:

- Staining of pointed surfaces by dust, mould and mildew,
- Corrosion of fixing screws, cladding, or structural steels.
- Rotting of timber,
- Water damage to stock and equipment.

The short and the long term costs of damage caused by condensation justify consideration of means of avoiding it.

In tropical climates air-conditioning which cools interior linings combined with the warm humid air outside creates a situation with a high risk of condensation. The solution to the problem of condensation in tropical environments is ensuring that warm moist air outside the building cannot come into contact with the cold surfaces of the interior where they will condense.

The danger of condensation can be minimised by the use of an appropriate and adequate insulation system. The system incorporates a bulk glasswool insulation which raises the temperature of the surface above dew point, and a fire retardant Building Foil (see Table C1) to act as a vapour barrier installed on the warm side of the insulation, which will ensure the humid air cannot penetrate the insulation system.

In building structures such as walls, roof/ceiling etc. the vapour barriers should be continuous and always installed on the warmer side of the appropriate level of bulk insulation (See Table C2). A self adhesive aluminium tape should be used to seal all vapour barrier laps and penetrations.

In temperate climates the installation of the vapour barrier should be reversed and therefore a vapour barrier is placed on the inside of the insulation.

Radiant Barriers versus Bulk Insulation

The determination of the requirement for bulk insulation is the following:

If a building will have, or could potentially have at any stage in the future, air conditioning, an adequate thickness of glasswool insulation must be installed together with a suitable vapour barrier. With out the appropriate Pink Batts insulation with a vapour barrier it is very likely condensation will occur.

The only feasible time to install the appropriate insulation for air conditioned buildings is during construction, this means that consideration for the most appropriate insulation system needs to be made during the design phase.

Pink Batts insulation is also appropriate when it is required for acoustic purposes. i.e. Noise Control Blanket installed under metal deck roofing to reduce rain drum or reverberation caused by rain and airborne sound and the transfer of unwanted noise can be greatly reduced by the insulation of internal walls with Pink Batts Silencer.

Noise Control

"Today, houses and commercial centres are being built to higher levels of quality and comfort. A sign of this trend is a greater awareness of the sounds around us, those that we want and those that we don't."

A modern well designed and constructed building will take acoustics into account, and will typically include insulation materials such as Pink Batts Silencer in interior wall cavities and between floor and ceiling linings. Because there is only one chance to insulate correctly, at building stage, it is important to choose materials that will perform well, not just initially, but in the long term also.

Effective acoustic insulation, such as Pink Batts Silencer, is not only necessary in offices and commercial areas, it also helps to ensure that people can find peace and privacy within their own home. In particular, bedrooms, entertainment and service areas benefit from extra sound control.

Flat sheet roofing is often the source of noisy "rain drum", a simple consideration to acoustics during the design phase would include the installation of Noise Control Blanket directly under the roofing iron providing a high level of both acoustic and thermal insulation.

Fire Protection

It is strongly recommended that all pliable building membranes be of low flammability (i.e. fire retardant).

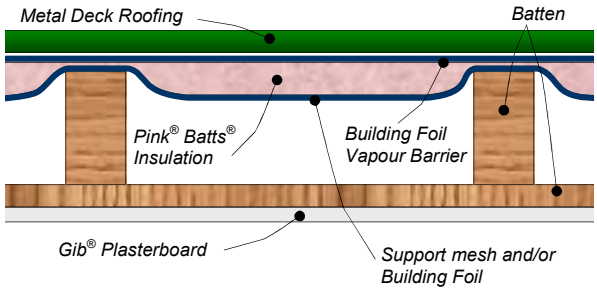
According to AS/NZS4200.1 a material may be classified as *low* if its flammability index is not greater than 5 when tested to AS1530.2. Please consult Table C1 for a list of available products with low flammability according to AS1530.2.

New Zealand and Australian Building Standards

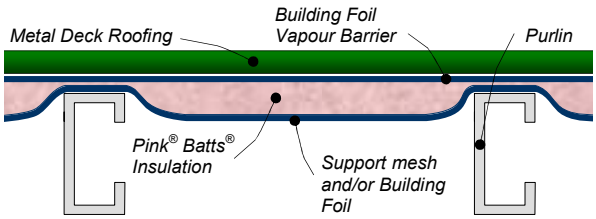
For Building Foil Duty classifications refer to AS/NZS 4200.1:1994 Pliable Building Membranes and Underlays - Materials.

The installation methods outlined in this booklet comply with AS/NZS 4200.2:1994 Pliable Building Membranes and Underlays - Installation requirements.

FLAT METAL DECK WITH CEILING LINING.



FLAT METAL DECK WITH NO CEILING LINING.

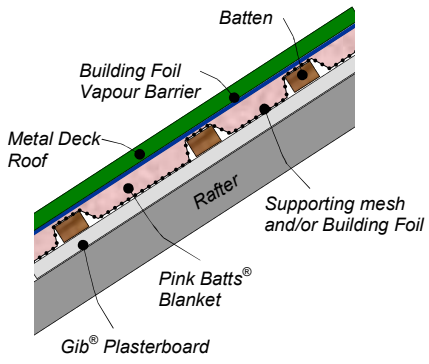


Insulation of Commercial and Industrial Buildings.

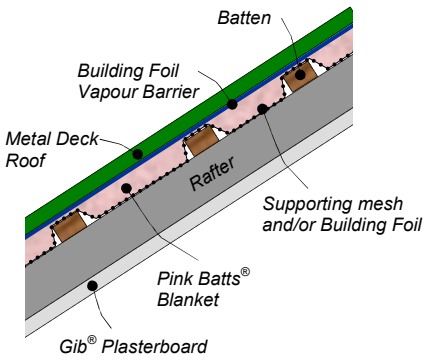
In tropical climates it is essential to use glasswool insulation in situations where the building is air-conditioned; where acoustic performance is required; and/or greater thermal performance is required. In other situations correctly installed building foils will provide excellent insulation against excessive heat gain within the building.

1. Where glasswool is required the material shall be *Pink® Batts® Blanket R1.9, R2.6 or Noise Control Blanket 75mm, 100mm* suspended on suitable Building Foil and/or supporting wire mesh.
2. Where Building Foil is used as the standalone insulation material use only fire retardant laminates. Heavy Duty laminates do not require a supporting mesh for spans up to 1200mm, medium duty laminates and for spans greater than 1200mm a wire supporting mesh is to be installed.
3. Install Building Foil starting at eaves and overlapping each layer minimum 150mm. Install in accordance with AS/NZS4200.2.
4. Where required install wire safety mesh across purlins. Wire mesh shall be dished to maintain the insulation thickness and air gap to ensure insulation performance. The wire mesh shall be dished and fixed between purlins in accordance with the following:
   Building Foil - dish minimum 50mm
   R1.9 - dish minimum 75mm;
   R2.6 - dish minimum 100mm
1. Roll out glasswool insulation material over the wire mesh, butt edges together ensuring there are no air gaps.
2. Install Building Foil as the anti-condensation vapour barrier on warmer side of insulation (i.e. in tropical climates on upper side and in temperate climates on underside of glasswool.)
3. In areas of high humidity and where the building is air-conditioned the vapour barrier shall be made vapour proof by sealing the 150mm overlaps with pressure sensitive aluminium tape.
4. If glasswool installation is exposed as ceiling an additional layer of Building Foil can be installed below insulation to provide additional thermal insulation and/ or an aesthetic finish, (i.e. White Faced Building Foil).

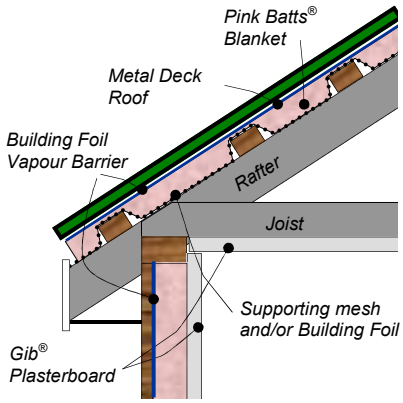
METAL DECK WITH CATHEDRAL (OR RAKED) CEILING AND FULLY EXPOSED RAFTERS.



METAL DECK WITH CATHEDRAL (OR RAKED) CEILING AND FULLY ENCLOSED RAFTERS



PITCHED METAL DECK WITH HORIZONTAL CEILING (NO INSULATION IN CEILING)



NOTE: Building Foil Vapour Barrier is shown on upper side for tropical climates. Foil to be located on underside for cold and temperate climates.

Insulation of Residential Houses with Pitched Roof.

1. The insulation material shall be *Pink® Batts® R2.6, R3.6, or R4.0 Ceiling Batts.*
2. A reinforced, fire retardant Building Foil (medium or heavy duty) shall be installed directly beneath the tile battens so as to provide protection against the penetration of radiated heat and water. The Building Foil shall comply with AS/NZ4200.
3. When installed in tiled roofing the Building Foil shall be draped across the rafters or trusses and fixed under the battens with a sag sufficient to allow water flow but not more than the depth of the supporting battens.
4. When installing the building foil begin at eaves extending 25mm over the facing ensuring that any water will flow into the gutter and no ponding will occur.
5. Each successive layer of Building Foil shall overlap the lower by no less than 150mm, fasten each layer of the membrane securely to the rafters.
6. Building Foil should be installed in such a way as to ensure that no ponding will occur around the perimeter of the roof or at valleys, for detailed information consult AS/NZS 4200.2:1994.
7. Where required by AS4200.1 the Building Foil shall be supported below by mesh or strapping.
8. In new and existing constructions it is important to provide adequate space for the insulation material to fully recover to its manufactured thickness and allow no less than 25mm ventilation space between the top of the Pink® Batts® and the underside of the Building Foil.
9. For tropical climates a building foil shall be positioned against the outer (warmer) side of the insulation material so as to provide an ***anti-condensation vapour barrier.*** For cold and temperate climates a vapour barrier is recommended to be installed underneath the insulation.
10. In areas of high humidity and where the building is air-conditioned the vapour barrier shall be made vapour proof by sealing the 150mm overlaps with pressure sensitive aluminium tape.
11. Provide adequate ventilation at eaves and ridges of all sections of the roof to ensure air circulation.
12. The insulation material shall be cut where necessary to ensure 'friction fit'. All joins will be butted together to eliminate the potential for air gaps in the insulation envelope.
13. The insulation material shall be installed to the outer edge of wall plates around the perimeter of the building.

FIG 9. PITCHED ROOF WITH HORIZONTAL CEILING.

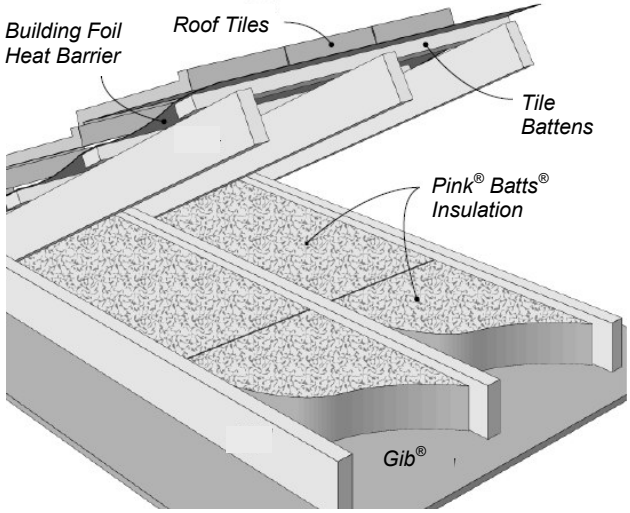


FIG 10. PITCHED ROOF WITH RAKED CEILING AND EXPOSED RAFTERS.

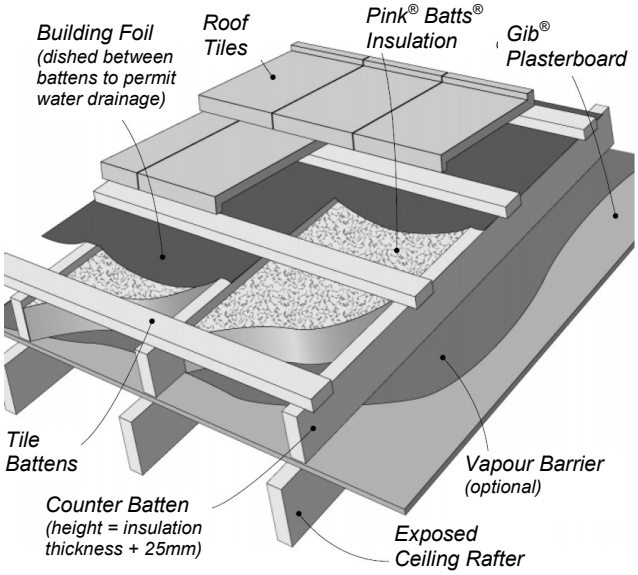
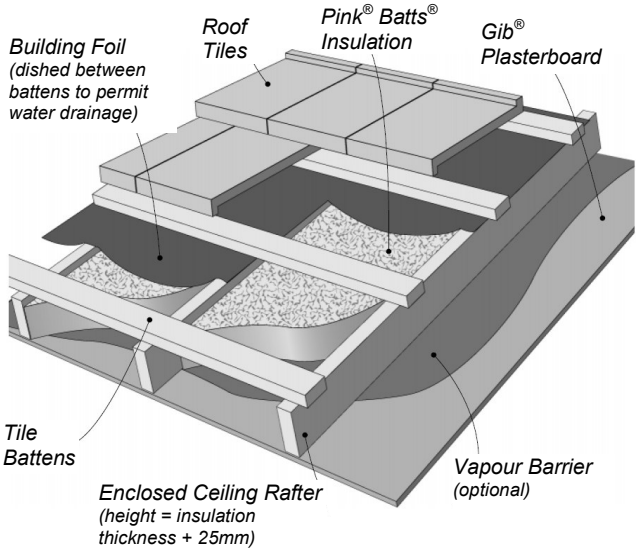


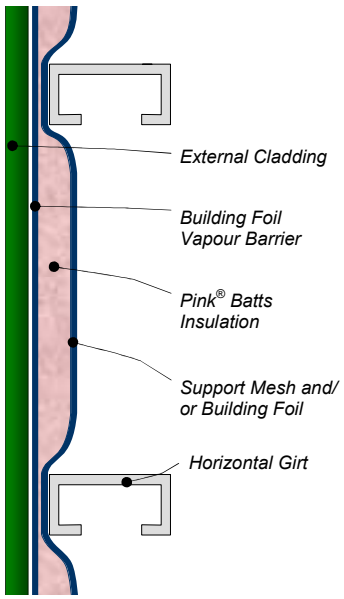
FIG 11. PITCHED ROOF WITH RAKED CEILING AND ENCLOSED RAFTERS.



Insulation of External Walls - Commercial.

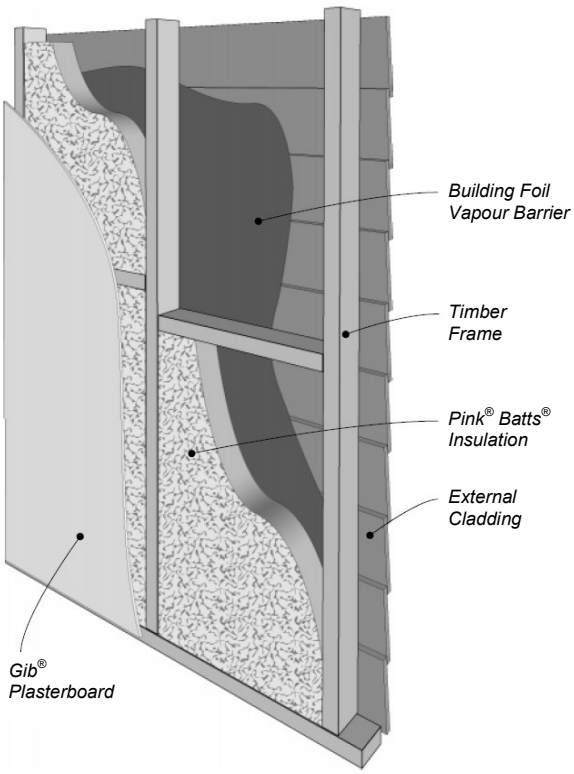
1. Where used glasswool insulation shall be minimum Pink® Batts® Blanket R1.9 faced with a suitable fire retardant vapour barrier and supported internally by supporting mesh and/or fire retardant Building Foil.
2. Where an aesthetic finish is desirable use white faced building foil as internal lining, installed with white facing towards the interior.
3. The supporting wire mesh and/or Building Foil shall be installed against the outside of the girts allowing sufficient slack to accommodate the thickness of the glasswool insulation (see Insulation of Commercial Buildings Note 4. for allowances).
4. The glasswool insulation shall be rolled out over the outside of the wire mesh with all edges firmly butted together.
5. The Building Foil Vapour Barrier shall be installed on the outside of the glasswool insulation in tropical climates and on the inside for temperate climates. Where maximum vapour barrier protection is sought the 150mm Building Foil overlaps shall be sealed with aluminium tape.
6. The external cladding shall them be installed over the insulation and secured to the girts in accordance with the manufacturers directions.

EXTERNAL WALL WITHOUT INTERNAL LINING.



Insulation of External Walls - Residential.

1. The glasswool insulation shall be *Pink® Batts® R2.2 or R2.6 Wall Batts.*
2. With all types of external cladding the Building Foil shall be wrapped around the outside of the timber frame and fixed at 450mm centres. Where Pink® Batts® glasswool insulation is installed the Building foil will act as a vapour barrier (in tropical environments only) where glasswool is not installed the Building Foil will act as a radiant heat barrier. (See Appendix A for the R-Values of alternate installation methods)
3. All steps shall be taken to ensure that the Building Foils are not be installed in contact with concrete or mortar.
4. Batts shall be friction fitted between studs ensuring there are no gaps between the insulation and studs or between adjoining edges of insulation the installed. The installed Building Foil will ensure batts are held firmly within the cavity.
5. External cladding/brickwork and internal lining can then be installed in accordance with the manufacturers directions.



Acoustics Under Consideration

While all Pink Batts glasswool products provide a level of acoustic insulation for any specific acoustic requirements it is recommend to use the specialised range of acoustic materials such as Noise Control Blanket and Pink Batts Silencer.

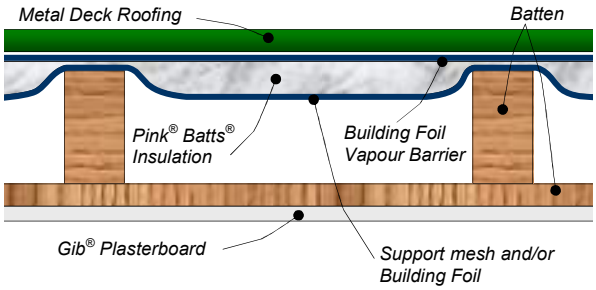
Roof Structure "Rain Drum"

1. In metal deck roofing to protect against the noise of "rain drum" the product used shall be Noise Control Blanket 75mm, or 100mm supported by a supporting wire mesh and an appropriate Building Foil if a radiant barrier is required.
2. Noise Control Blankets also provide a level of Thermal Insulation and can substitute the requirement for thermal insulation:

   Noise Control Blanket 75mm: R-Value 2.3
   Noise Control Blanket 100mm: R-Value 3.1

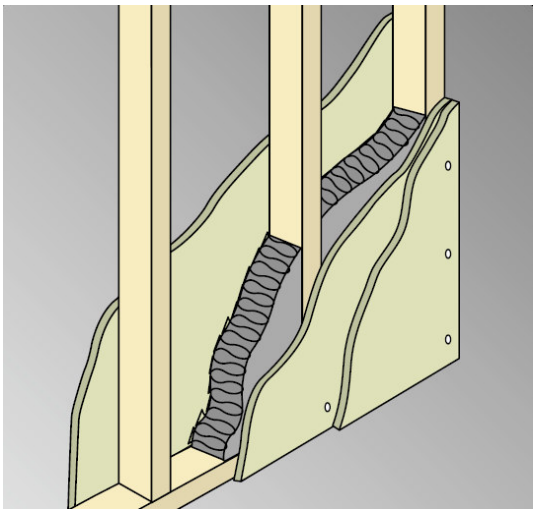
   IMPORTANT: When considering R-Values please consider that the Noise Control Blanket must be held firmly against the metal deck roofing so as to deaden the rain drum, this may result in a loss of material thickness and as a result R-Values may diminish.

FLAT METAL DECK WITH NOISE CONTROL BLANKET INSTALLED



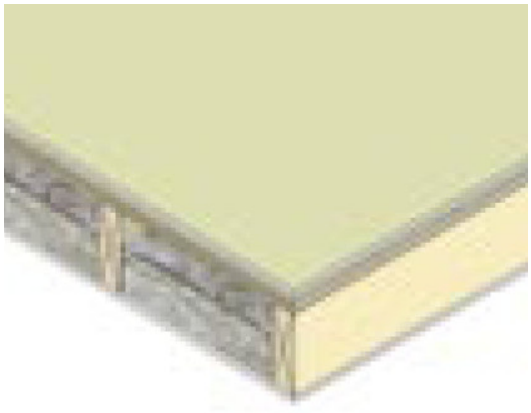
Internal Partitions and Walls

1. The product used shall be Pink Batts Silencer 75mm or 100mm installed to completely fill the walls internal cavity.
2. If additional acoustic insulation is required use Gib Noiseline installing 2 layers on one side and a single layer on the other side of the wall or partition.
3. Fd



Between Floors

Pink®Batts® Silencer® Midfloor is fitted in between the floor joists in multi-storey homes to help reduce airborne noise transmission between levels. To achieve significant reduction in the transmission of airborne and impact noise use Pink®Batts® Silencer® Midfloor as part of the GIB Quiet Zone® floor/ceiling solution. See the GIB Living Solutions® 'Your New Home' guide for specification details.



APPENDIX A.

R Value Calculations for Typical Assemblies

The following examples are a guide to the thermal insulation performance of typical applications using insulation materials. In practice slight variations can occur depending on the product and installation practices. Certain assumptions have been made in the following calculations and while the accuracy of the values are sufficient for most purposes if greater accuracy is required calculations should be based on data listed in Appendix B.

TABLE A1.

WALL - TIMBER FRAMING - LIGHTWEIGHT CLADDING

	No Insulation	Building Foil Only	R1.9 Insulation
1. Outside Air Film	0.03	0.03	0.03
2. Weatherboard 12mm (or Metal Deck)	0.09	0.09	0.09
3. Airspace	0.16	0.61	0.61
4. Insulation R1.9	**n/a**	**n/a**	**1.9**
5. Gib® Plasterboard 10mm	0.06	0.06	0.06
6. Inside Air Film	0.12	0.12	0.12
Total R-Value (m^2K/W)	**0.46**	**0.91**	**2.81**

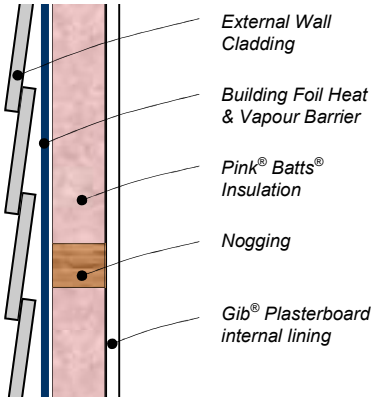


TABLE A2.

WALL - CONCRETE/BRICK - WITH INTERIOR LINING

	No Insulation	Building Foil Only	R1.3 Insulation
1. Outside Air Film	0.03	0.03	0.03
2. Concrete/Brick Exterior	0.08	0.08	0.08
3. Airspace	0.16	0.61	n/a
4. Insulation R1.3	**n/a**	**n/a**	**1.3**
5. Gib® Plasterboard 10mm	0.06	0.06	0.06
6. Inside Air Film	0.12	0.12	0.12
Total R-Value (m^2K/W)	**0.45**	**0.9**	**1.59**

NOTES TO TABLES A1 AND A2: Where a vapour barrier is considered necessary fire retardant aluminium laminates are the recommended type. Vapour barriers should always be installed on the warmer side of glass wool insulation.

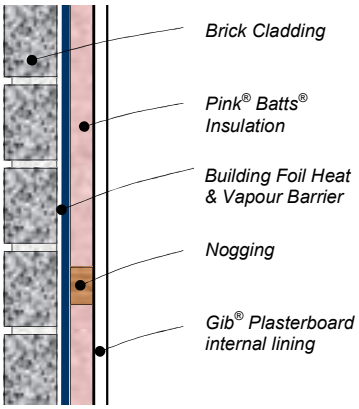


TABLE A3.

ROOF - TILED - WITH CEILING

	No Insulation		Building Foil Only		R2.6 Insulation	
	Wint.	Summ.	Wint.	Summ.	Wint.	Summ.
1. Outside Air Film	0.03	0.04	0.03	0.04	0.03	0.04
2. Roof Tiles (or Metal Deck)	0.02	0.02	0.02	0.02	0.02	0.02
3. Attic Space*		0.46	0.34	1.36	0.34	1.36
4. Insulation R2.6	**n/a**	**n/a**	**n/a**	**n/a**	**2.6**	**2.6**
5. Gib® Plasterboard 10mm	0.06	0.06	0.06	0.06	0.06	0.06
6. Inside Air Film	0.11	0.16	0.11	0.16	0.11	0.16
Total R-Value (m^2K/W)	**0.22**	**0.74**	**0.56**	**1.64**	**3.16**	**4.24**

NOTES: Normal pitched roof of clay tiles with horizontal ceiling of 10mm Gib® plasterboard, roof space ventilated.
For air-conditioned houses a suitable fire retardant vapour barrier should be used on the warmer side of glass-wool insulation.
*Values are theoretical only and assume radiant barrier is correctly installed without damage.

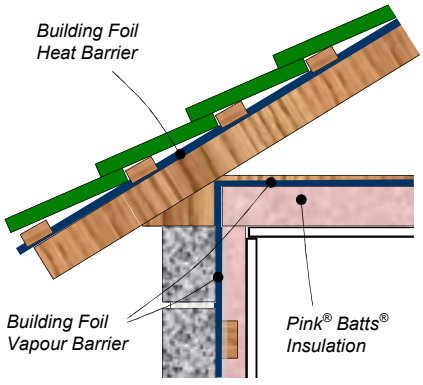
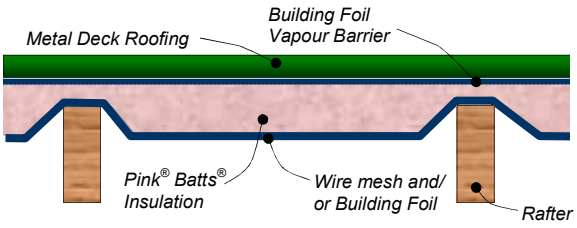


TABLE A4.
ROOF - METAL DECK - WITHOUT CEILING

	No Insulation	Radiant Barrier only		R1.9 insulation		Acoustic Blanket-75mm	
		Winter	Summer	Winter	Summer	Winter	Summer
1. Outside Air Film	0.03	0.03	0.04	0.03	0.04	0.03	0.04
2. Metal Deck							
3. Air Space (100mm)		0.48	1.08				
4. Insulation				1.7	1.7	2.1	2.1
5. Inside Air Film (reflective)		0.20	0.60	0.20	0.6	0.20	0.60
6. Inside Air Film	0.16						
Total R-Value (m^2K/W)	**0.19**	**0.71**	**1.72**	**1.93**	**2.34**	**2.33**	**2.74**



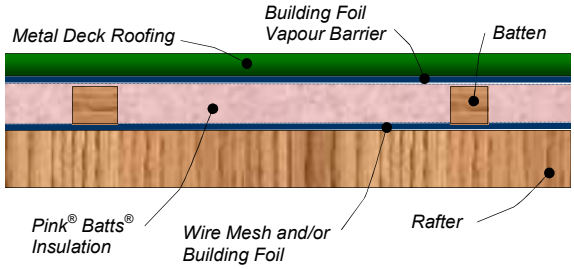
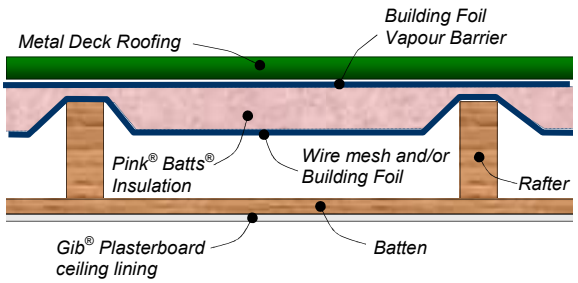
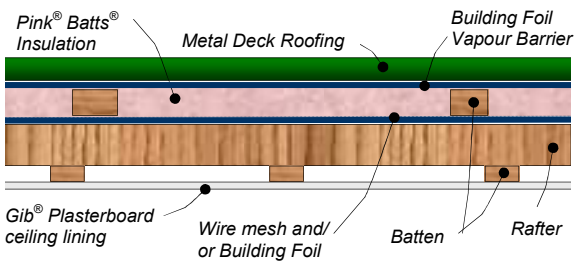


TABLE A5.
ROOF - METAL DECK - WITH CEILING

	No Insulation	Radiant Barrier only		R1.9 insulation		Acoustic Blanket-75mm	
		Winter	Summer	Winter	Summer	Winter	Summer
1. Outside Air Film	0.03	0.03	0.04	0.03	0.04	0.03	0.04
2. Metal Deck							
3. Air Space*:100mm (Reflective)		0.48	1.08				
4. Insulation				1.7	1.7	2.1	2.1
5. Air Space*:100mm (Reflective)	0.17 (Non)	0.48	1.08	0.48	1.08	0.48	1.08
6. Gib® Plasterboard 10mm	0.06	0.06	0.06	0.06	0.06	0.06	0.06
6. Inside Air Film	0.16	0.11	0.16	0.11	0.16	0.11	0.16
Total R-Value (m^2K/W)	**0.19**	**1.16**	**2.42**	**2.38**	**3.04**	**2.78**	**3.44**





NOTES FOR TABLES A4 and A5:
Roof space classed as non-ventilated for heat transfer calculations.
Where necessary install a suitable fire retardant vapour barrier. In tropical conditions vapour barrier should be on inside of glasswool insulaiton, where winter conditions dominate on outside.
*Values are theoretical only and assume building foil is correctly installed without damage. Resistance of reflective airspace assumes a 2-23 degree roof pitch, which will increase for horizontal roofs. See Table B1.

APPENDIX B.

Design Tables

TABLE B1. THERMAL RESISTANCE OF SURFACE AIR FILMS

For orientations appropriate for buildings with high and low emittance surfaces (0.9 to 0.05)

Wind Speed (m/s)	Position of Surface	Direction of Heat Flow	Thermal Resistance (m^2K/W) High Emittance Surface (Non-Reflective)	Low Emittance Surface (Reflective)
Still Air	Horizontal	Up	0.11	0.23
		Down	0.16	0.80
	45° Slope	Up	0.11	0.24
		Down	0.13	0.39
	22.25° Slope	Up	0.11	0.24
		Down	0.15	0.60
	Vertical	Horizontal	0.12	0.30
6 (winter)	Any Position	Any Direction	0.03	
3 (summer)	Any Position	Any Direction	0.04	
0.5 (internal movement of air)	Any Position	Any Direction	0.08	

Source: AIRAH Design Data Manual

TABLE B2. THERMAL RESISTANCE OF AIRSPACE

Values of resistance for situations commonly encountered in buildings with various combinations of boundary surfaces of high and low emittance (0.9 and0.05 respectively)

Nature of Bounding Surfaces	Position of Airspace	Direction of Heat	Thermal Resistance (m^2K/W) 20mm Width	100mm Width
High Emittance Surfaces (non-reflective)	Horizontal	Up	0.15	0.17
	Horizontal	Down	0.15	0.17
	45° Slope	Up	0.17	0.17
	45° Slope	Down	0.15	0.16
	Vertical	Horizontal	0.15*	0.16
One Surface of Low Emittance (reflective)	Horizontal	Up	0.39	0.48
	Horizontal	Down	0.57	1.42
	45° Slope	Up	0.49	0.53
	45° Slope	Down	0.57	0.77
	Vertical	Horizontal	0.58*	0.61
Two Surfaces of Low Emittance (reflective)	Horizontal	Up	0.41	0.51
	Horizontal	Down	0.63	1.75
	45° Slope	Up	0.52	0.56
	45° Slope	Down	0.62	0.85
	Vertical	Horizontal	0.62*	0.66

*For vertical air spaces greater than 20mm, with horizontal heat flow, the value of resistance for 100mm should be used. Source: AIRAH Handbook

TABLE B2. THERMAL RESISTANCE OF PITCHED ROOF SPACE.

Typical U-values for roof spaces for four cases, namely ventilated and non-ventilated spaces for:
(a) High emittance surfaces; and
(b) Low emittance Building Foil beneath the roofing material.

		Thermal Resistance (m^2K/W)	
	Direction of Heat Flow	High Emittance Surfaces (non-reflective)	Low Emittance Building Foil (reflective)
Ventilated Roof Space	Up	Nil	0.34
	Down	0.46	1.36
Non Ventilated Roof Space	Up	0.18	0.56
	Down	0.28	1.09

Source: AIRAH Handbook

TABLE B3. THERMAL RESISTANCE OF TYPICAL BUILDING MATERIALS

Material	**Density Kg/m^3**	**K W//m K**	**L mm**	**R-Value M^2 K/W**
Fibre-Cement Sheet	1488	0.317	5	0.02
			6	0.02
Brick: (a) Dry	1760	0.807	100	0.018
(b) 6 % moisture	1872	1.211	100	0.08
(c) Common Brick Wall		1.154	100	0.09
Concrete	2400	1.442	60	0.04
			75	0.05
			100	0.07
			150	0.10
Concrete - Lightweight (3% moisture)	64	0.144	100	0.69
	960	0.303	100	.33
	1120	0.346	100	0.29
	1280	0.476	100	0.21
Fibre board	264	0.052	12	0.23
Fibre Glass Insulation (Pink® Batts®)	10	0.0397	50	1.26
	12	0.366	50	1.37
	24	0.304	50	1.64
	32	0.290	50	1.72
Gib® Plaster Board	880	0.170	12	0.07
Hard Board: (a) Standard	1024	0.216	4.5	0.02
			6.0	0.03
(b) Medium	640	0.123	4.5	0.04
			6.0	0.05
Metals: (a) Aluminium Alloy (typical)	2672	211	1.0	0.00
(b) Copper (Commercial)	8784	385	0.5	0.00
(c) Steel	7840	47.6	0.5	0.00
Polystyrene – Expanded	16	0.035	50	1.43
Polyurethane - Foam	24	0.024	50	2.08
Tile Roof	1890	0.836	12	0.01
Timber Across Grain (a) Softwood	608	0.125	20	0.16
(b) Hardwood	720	0.138	20	0.14
(c) Plywood	528	0.138	3	0.02
			4.5	0.03
			6	0.04
			7.5	0.05
			10	0.07

Source: Tidman 4

TABLE C1. FIRE RETARDANT PLIABLE MEMBRANES

The following products are considered of low flammability according to AS1530.2 and are readily available throughout the Pacific Region.

	Roll Size	Flammability*	Duty*	Self Supporting*	Distributor
Antiblaze® 990	1350mm x 56m	Low	Heavy	Yes	Tropex Exports
Antiblaze® Whitecap®	1350mm x 56m	Low	Heavy	Yes	Tropex Exports
Antiblaze® 760	1350mm x 56m	Low	Medium	No	Tropex Exports
Flamestop® 525	1250mm x 60m	Low	Heavy	Yes	Tasman Insulation New Zealand
Flamestop® 516 (white faced)	1350mm x 56m	Low	Heavy	Yes	Tasman Insulation New Zealand
Flamestop® 524	1250mm x 60m	Low	Medium	No	Tasman Insulation New Zealand

NOTE: If in doubt always request a copy of the current test certificate from the distributor.
*Flammability, Duty and Self Supporting classification as defined by AS/ NZS 4200.1:1994 Pliable Membranes and Underlays. Part 1: Materials.

TABLE C2. RECOMMENDED INSULATION R-VALUES FOR RESIDENTIAL AND COMMERCIAL APPLICAITONS IN PACIFIC ISLAND NATIONS.

Recommended minimum additional thermal resistance requirements for Pacific Nations.
Note: If roof construction is metal deck with ceiling space, then insulation should also be installed on the ceiling.

	Ceiling	Walls
Cook Islands		
Fiji	2.6	2.2
Guam	3.6	2.6
Hawaii	3.6	2.6
New Caledonia	2.6	2.2
Norfolk Island	2.6	2.2
Papua New Guinea	3.2	2.2
Samoa	2.6	2.2
Tahiti	2.6	2.2
Tonga	2.6	2.2
Vanuatu	2.6	2.2

NOTE: The above values are minimum recommendations based on average temperatures throughout the year. Electricity prices have not been taken into account, often high electricity costs make installing higher R-Values economically viable due to faster payback periods.
The above values are determined with the aim of a total payback of 3-5 years. i.e. the total savings achieved though a reduction in the use of air conditioning will be greater than the initial investment in insulation within 3-5 years.