



Thermal insulation



the invisible



energy saver



The Guide
to
Energy Efficient
Thermal Insulation
in Buildings

Endorsed by



Administered by



August 2010

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- Sustainable Energy Authority Victoria -Energy Smart Housing Manual 2002
- Insulation Manufacturers Association of Australia
- Building Code of Australia (BCA) 2007
- NOVA Project – Authors; D Holm, HM Murray, CJ Pauw, AS van Niekerk
- Standards Australia, AS 2627.1-1993 Thermal Insulation of Dwellings - *Thermal insulation of roofs/ceilings and walls in dwellings*
- Standards Australia, AS 3999 *Thermal Insulation of Dwellings- Bulk Insulation Installation Requirements*
- Standards Australia, AS/ NZ 4200.2-1994 *Pliable building membranes and under lays Part 2: Installation Requirements*
- TIASA Technical Committee
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FOREWORD

South Africa is facing an energy crisis. The electricity emergency cannot be solved by government alone, but will have to be a collective effort by all South Africans in general.

Interventions that will provide South Africa with immediate relief will be on the demand side management and energy efficiency.

Eskom's Demand Side Management (DSM) plan was established to reduce the growth in the country's electricity demands. The DSM plan is aimed at managing the residential energy load and encouraging people to use energy-efficient equipment, which reduces energy usage.

The installation of thermal insulation will reduce the energy required for electrical heating or cooling, thus supporting Eskom's Demand Side Management.

Major energy savings can be achieved through changes in people's attitude and behaviour which depends on informed professionals, designers and consumers as to what options exist. The Building Sector has great potential for energy savings since building design is a major factor determining the energy efficiency of a building.

Eskom supports TIASA's initiative to create awareness of energy efficiency by providing information and the dissemination thereof to promote and achieve constructive changes in the Thermal Insulation Industry and Building Sector.

OBJECTIVE

The objective of this Guide is to disseminate the performance requirements of SANS 204 Energy Efficiency in Buildings, in respect of energy efficient thermal insulation.

This guide compliments our Thermal Insulation Handbook on industrial thermal insulation.

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CHAPTER 1

1.1 INTRODUCING TIASA

TIASA (Thermal Insulation Association of Southern Africa) promotes the benefits of insulation.

The initiative of the Residential Demand Side Management (RDSM) Department of Eskom and a broad spectrum of concerned parties from government, NGOs and industry resulted in the establishment of TIASA.

TIASA embraces the entire thermal insulation marketplace, including manufacturers, distributors, contractors, specifiers, consultants, designers, architects, energy service companies, government, utilities and end users.

Although providing a service to all industries, TIASA will initially focus the development of its products and services for the building and construction industry with specific attention being paid to sustainable energy efficient affordable homes and buildings by:

- Promoting greater understanding and co-operation among all segments of the insulation industry.
- Capacity building through education and training on the correct selection and installation of energy saving thermal insulation.
- Developing a database of all products, suppliers, contractors, and interested parties in thermal insulation and appropriate dissemination of information.
- Participating in technical, legislative and regulative committees on insulation.
- Developing international relationships.
- Enlisting the resources and support of government agencies, utilities, academic and professional societies.

1.2 BACKGROUND

Thermal insulation materials, have been neglected or ignored for their thermal and acoustic values, in the design and function of a building and has had limited use in the construction industry, despite being available in South Africa for decades. This is due to the misconception that insulation is regarded as a non essential or luxury item.

With the introduction of Energy Efficiency Standards and Regulations to intervene to reduce peak electricity demand usage, together with excessive high cost, thermal insulation will play an integral part in the future design of buildings.

1.3 MISSION

The mission of TIASA is to improve the environment, and the social and economic wellbeing of Southern Africans through the greater use, and better application of thermal insulation.

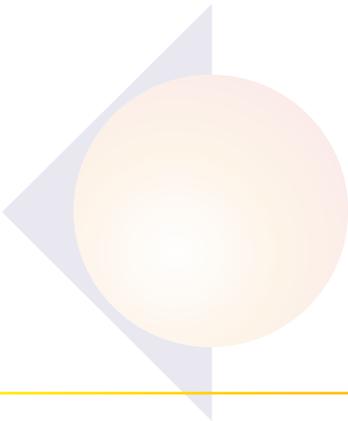
Insulation has proved to be effective and beneficial in the following:

- Reducing energy costs
- Safety of personnel working in “hot” or “cold” applications
- Home comfort control
- Temperature control in processing equipment
- Assisting in the reduction of environmental pollution
- Increasing the manufacturing competitiveness of companies
- Reducing the consumption of natural resources
- Reducing noise pollution
- Increasing the productivity of workers in factories, commercial buildings etc. to comfortable working conditions.

Southern Africa can no longer afford to disregard these benefits and ignore the advantages of a carefully and clearly defined policy on thermal insulation application.

1.4 CODE OF CONDUCT

TIASA members will not engage in any activities that would undermine the integrity of the Association and will conduct their business fairly, impartially and ethically.



CHAPTER 2

DEFINITIONS, INTERPRETATIONS & TERMINOLOGY

The following section includes definitions, interpretations and terminology which are relevant to energy efficiency and would benefit the reader in general.

Absorbance

Symbol "a"

The ratio of the radiant, or luminous, flux absorbed by a body to the flux falling on it. The absorbance of a black surface or body is by definition "1"

Absorption

The take-up of heat, especially radiant heat, by a surface of mass or membrane barrier, which contributes to the heat gain and loss through a wall or roof construction (system)

Added R-Value

The added R-Value is the value of the insulating material added to achieve a certain value required.

Building component

Part of a building other than a building element

Building element

Wall, floor, foundation or roof of a building

Building envelope

The elements of a building that separate a habitable room from the exterior of a building or a garage or storage area.

Note: The envelope controls heat gain in summer and heat loss in winter. Well-designed envelopes maximize cooling air movement and limits exposure to direct sunlight in summer. In winter, they trap and store heat from the sun and minimize heat loss to the external environment. The fundamental principles of passive design should be applied to a vast range of building types and construction systems in the various South African climates.

Bulk insulation

Materials of low thermal conductivity, that mainly resists (slows) the transfer of conducted and convected heat, relying on pockets of trapped air or low conductive gasses within its structure. Its thermal resistance is essentially the same regardless of the direction of heat flow through it and is proportional to its thickness, density and upper & lower operating temperature.

Ceiling area

The area is measured in square metres, measured to the inside of outerwalls.

Climate zone

Region in which the climatic conditions are similar.

Note: The zones have been adjusted to simplify use of the energy efficiency measures. A map of South Africa indicating the various climatic zones and a table specifying the zones for major cities and towns are given in SANS 10400-XA

Composite insulation

Two or more types of material combined to achieve a required level of performance, example: bulk insulation and reflective insulation used in combination.

Competent person

A person who is qualified, by virtue of his education, training, experience and contextual knowledge, to make a determination regarding the performance of a building or part thereof in relation to a functional regulation

Condensation

The change of a vapour or gas into a liquid. The change of phase is accompanied by the evolution of heat.

Continuous insulation

Insulation that is continuous across all structural members without any thermal bridges, excluding fasteners and service openings

Note: It is installed on the interior of, exterior of or integral with any opaque surface of the building envelope.

Convection heat

As air warms it becomes lighter, due to expansion, therefore it rises and it is replaced by cold air which is heavier. Liquids and gasses react in a similar fashion, as the liquid or gas warms it expands (become less dense - lighter) and rise, the warm liquid is displaced by denser colder product at a lower temperature level.

Deemed-to-satisfy

A level of performance for a given criteria which will satisfy the requirements.

Deemed-to-satisfy requirement

Non-mandatory requirement, the compliance which will ensure compliance with a functional regulation

Density

The mass of a substance per unit of volume. SI unit of measure is kg/m³.

Design climate

Climatic data modified so as to exclude the effects of readings which are outside of a selected probability range.

Dew point

The temperature at which water vapour in air is saturated. As the temperature falls the dew point is the point at which the vapour begins to condense as drops of water.

Direction of heat flow

Most significant heat flow at a given time.

Note: Heat flows from hot to cold environments and this is considered to be the direction of natural heat flow. Thus “upwards” implies heat flow from a conditioned space through the ceiling or roof and “downwards” implies the opposite. Likewise, horizontal flows can be described as inwards and outwards.

Electrolytic corrosion

Corrosion that occurs through an electrochemical reaction, such as between copper and aluminium.

Embodied energy

Total energy used to create, use and dispose of a product including all the processes involved in harvesting, production, transportation, construction, use and disposal or re-use.

Note: This can represent a significant portion of the total energy used during the lifecycle of a building.

Emissivity – symbol “e”

The ratio of the power per unit area radiated by a surface to that radiated by a black body (surface) at the same temperature.

Emittance - see Exitance

Energy labelling

A system of rating the energy performance of new and existing buildings. This may include a star rating system.

Energy Performance of a Building

Calculated or measured amount of energy actually used or estimated to meet the different needs associated with a standard use of the building, which may include, *inter alia*, energy use for heating, cooling, ventilation, domestic hot water and lighting

Exitance - symbol “m” (formally emittance)

The radiant of luminous flux emitted per unit area of a surface measured in watts per square metre.

Fenestration

Any light-transmitting section in a building wall or roof, including glazing material (which may be glass or plastic), framing (mullions, muntins and dividers), external shading devices, internal shading devices and integral (between glasses) shading devices

Heat transfer

The temperature of energy (heat) induced by a temperature difference by conduction, convection, radiation or any combination

Insulation

Material or combination of materials that resist heat flow.

Note: Insulation of the building envelope helps keep heat in during the winter and out during summer to improve comfort and save energy. A well insulated and well designed home or building will provide year-round comfort, cutting cooling and heating costs and reducing greenhouse emissions. Resistance to heat flow is achieved by the use of either bulk insulation or reflective insulation, which work in different ways.

Insulation R-Value

All insulation materials are rated for their performance in restricting heat transfer. This is expressed as the “R-Value”, which is the measure of the material’s resistance to heat transfer, alternatively known as thermal resistance. The higher the R-Value the greater the insulation effect. It is the reciprocal of thermal conductance/transmittance.

Life-Cycle Cost Analysis (LCCA)

Life-cycle cost analysis (LCCA) is a method for assessing the total cost of facility ownership. It takes into account all costs of acquiring, owning, and disposing of a building or building system.

Note: The LCCA should be performed early in the design process while there is still a chance to refine the design to ensure a reduction in life-cycle costs (LCC).

Naturally ventilated

A structure ventilated by natural means and do not have centrally controlled heating, cooling and ventilation systems.

Net floor area

The floor area excluding the area occupied by vertical elements

Occupancy

Particular use or the type of use to which a building or portion thereof is normally put or intended to be put
 Note: Regulation **A20** classifies and designates occupancies (see Page 16 Chapter 3.3 Occupancy or Building Classifications in accordance with SANS 10400 Part A).

Orientation

The direction a building envelope element faces i.e. the direction of a vector perpendicular to and pointing away from the surface outside of the element

Passive design

A design that does not require mechanical heating or cooling, for example, buildings that are designed to take advantage of natural energy flows to maintain thermal comfort.

Radiant energy

The rate of energy emitted from a surface depends on its absolute temperature and surface characteristics

Rational design

Any design by a competent person involving a process of reasoning and calculation, and may include a design based on a standard or other suitable document.

Reference building

A hypothetical building that is used to determine the maximum energy usage for the proposed building

Reflective insulation

Any material with a reflective surface such as a reflective foil laminate, reflective barrier or foil batt capable of reducing radiant heat flow, in combination with air spaces and low emissive surfaces

R-Value

The thermal resistance ($m^2.K/W$) of a component (see Thermal Resistance)

The measurement of the thermal resistance of a material which is the effectiveness of the material to resist the flow of heat, i.e. the thermal resistance ($m^2.K/W$) of a component calculated by dividing its thickness by its thermal conductivity.

Thermal break

An element of low thermal conductivity placed in an assembly to reduce or prevent the flow of thermal energy (transfer of heat) from one component to another.

Thermal calculation method (by mathematical analyses)

A means of calculating the cooling and heating loads of the cooling and heating systems.

Thermal conduction “C”

Is the transfer of heat through a solid (material).

Note: When one end of a metal rod (poker) is left in a fire the opposite end will also become warm although not in direct contact with the flame.

The flow of heat along the length of the rod is by conduction. The rate of heat (energy) flow is influenced by the temperature difference between one side and the opposite side e.g. indoor to outdoor, the area of the material mass, the distance (thickness) through the material from warm side to cool side, and the thermal conductivity of the material. Most insulating materials (mass type) have low thermal conductivity, which combined with their thickness, density and the operating temperature provides a barrier that reduces conductive heat transfer.

Thermal conductance – Symbol (“C”)

A measure of the ability of a substance or material to conduct heat.

Thermal conductivity – Symbol “k”

The thermal transmission through a unit area of a material. It is measured per unit temperature difference between the hot and cold faces, and the unit is $W/(m.K)$.

Notes: 1) It is the rate of heat flow through a unit area ($1m^2$) of 1 metre thick homogenous material in a direction perpendicular to isothermal planes; induced by a unit temperature gradient viz 1 metre cube of material will transmit heat at a rate of 1 watt for every degree of temperature difference between opposite faces.

2) A “k” value cannot be given for Reflective Sheet Insulation as these are highly dependable upon orientation and position of surrounding air spaces. The heat flow across an air space is not directly proportional to its thickness. Variations in direction of heat flow, the position of the air space (viz horizontal, vertical, etc) and variance in mean temperature etc, affects the thermal resistance of the system.

Thermal mass

The ability of building materials to store heat. The basic characteristic of materials with thermal mass is their ability to absorb heat, store it, and at a later time release it.

Note: By adding thermal mass within the insulated building envelope it helps to reduce the extremes in temperature experienced inside the home/building, making the average internal temperature more moderate year-round and the home/building more comfortable. Building materials that are heavyweight store a lot of heat and have high thermal mass. Materials that are lightweight do not store much heat and have low thermal mass

The use of heavyweight construction materials with high thermal mass (concrete slab on ground and insulated brick cavity walls) can reduce total heating and cooling energy requirements compared to a home built of lightweight construction materials with a low thermal mass (brick veneer with timber floor).

Thermal resistance - symbol “R-Value”

The resistance to heat transfer across a material. It is the mean temperature difference between two defined surfaces of a material or construction system under steady state conditions

Note: Thermal resistance is measured as an R-Value. The higher the R-Value the better the ability of the material to resist heat flow it is measured in $m^2.K/W$

Total R-Value

The sum of the R-Values of all the individual component layers in a composite element including the air space and associated surface resistances measured in $m^2.K/W$

Total U-Value

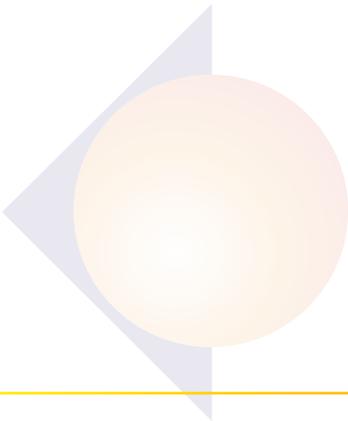
The thermal transmittance ($W/m^2.K$) of the composite element including the air space and associated surface transmittance.

Notes: 1) The U-Value addresses the ability of a material to conduct heat, while the R-Value measures the ability to resist heat flow. The higher the U-Value number, the greater the amount of heat that can pass through that material. A lower value would mean a better insulator.

2) U-Value is measured under NFRC 101 test conditions but varies with environmental conditions to which the insulator is exposed (such as temperature and wind velocity).

Solar energy

Electromagnetic energy radiated from the sun



CHAPTER 3

COMPLIANCE WITH SANS 10400-XA: ENERGY USAGE IN BUILDINGS

3.1 BUILDING ENVELOPE REQUIREMENTS FOR BUILDING

(REFER SANS 10400:XA)

3.1.1 Floors

If an in-slab heating system is installed, the requirements of SANS 204 for in-slab heating shall apply.

3.1.2 Walls

- a) Constructions with a surface density less than 180 kg/m², shall achieve a minimum total R-Value of:
 1. for climatic zones 1 and 6, a total R-Value of 2.2; and
 2. for climatic zones 2, 3, 4 and 5, a total R-Value of 1.9.
- b) Constructions with a surface density greater than 180 kg/m², shall achieve a minimum total R-Value of 0.4.

Notes:

- 1) External walls are defined as the complete walling system, as measured from the outer skin exposed to the environment, to the inside of the inner skin exposed to the interior of the building, and does not include glazing. The requirements for glazing are included in SANS 204.
- 2) Designers should consider that interstitial condensation occurs in walling systems which are not able to accommodate moisture migration. The selection of vapour barriers and appropriate construction materials, including insulation, is important for the thermal efficiency of walling in climate zones where damp and high relative humidity is experienced.
- 3) Thermal resistance that is added to external walling with high thermal capacity, should be placed in between layers e.g. in the cavity of a masonry wall. Thermal resistance should not be added to the internal face of a wall with high thermal capacity.

3.1.3 Fenestration

The energy performance requirements for fenestration shall be in accordance with the provisions of SANS 204 as relevant.

3.1.4 Roofs and Ceilings

The energy performance requirements of roofs and ceilings shall be in accordance with the provisions of SANS 204 as relevant.

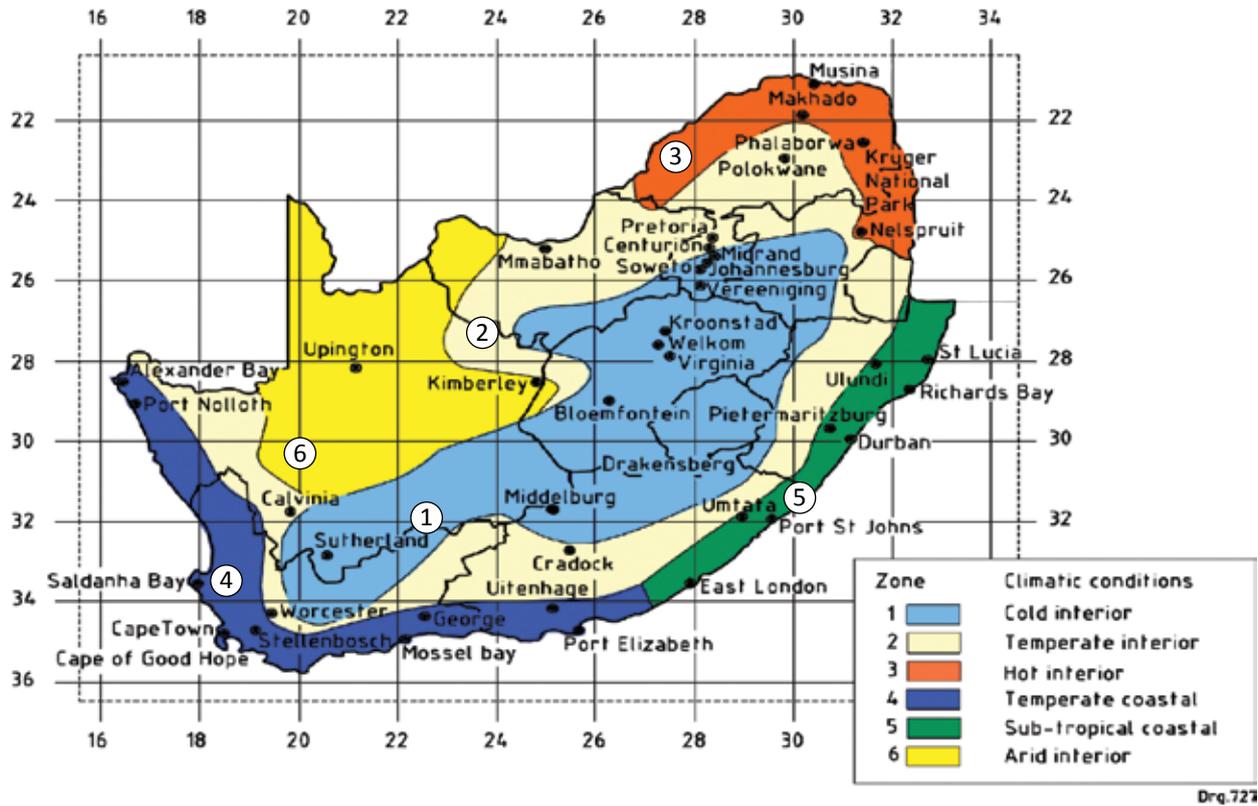
This Guide is in compliance with SANS 204 deemed-to-satisfy provisions – see Chapter 7 page 31.

3.2 OCCUPANCY OR BUILDING CLASSIFICATION IN ACCORDANCE WITH SANS 10400 PART A

Class of Occupancy	Occupancy
A1	Entertainment & Public Assembly - Occupancy where persons gather to eat, drink, dance or participate in other recreation
A2	Theatrical & indoor sport - Occupancy where persons gather for the viewing of theatrical, operatic orchestral, choral, cinematographical or sport performances.
A3	Places of instruction - Occupancy where school children, students or other persons assemble for the purpose of tuition or learning.
A4	Worship - Occupancy where persons assemble for the purpose of worshipping.
A5	Outdoor sport - Occupancy where persons view outdoor sports events.
B1	High risk commercial service - Occupancy where a non-industrial process is carried out and where either the material handled or the process carried out is liable, in the event of fire, to cause combustion with extreme rapidity or give rise to poisonous fumes, or cause explosions.
B2	Moderate risk commercial service - Occupancy where a non-industrial process is carried out and where either the material handled or the process carried out is liable, in the event of fire, to cause combustion with moderate rapidity but is not likely to give rise to poisonous fumes, or cause explosions
B3	Low risk commercial service - Occupancy where a non-industrial process is carried out and where neither the material handled nor the process carried out falls into the high or moderate risk category.
C1	Exhibition hall - Occupancy where goods are displayed primarily for viewing by the public.
C2	Museum - Occupancy comprising a museum, art gallery or library.
D1	High risk industrial - Occupancy where an industrial process is carried out and where either the material handled or the process carried out is liable, in the event of fire, to cause combustion with extreme rapidity or give rise to poisonous fumes, or cause explosions.
D2	Moderate risk industrial - Occupancy where an industrial process is carried out and where either the material handled or the process carried out is liable, in the event of fire, to cause combustion with moderate rapidity but is not likely to give rise to poisonous fumes, or cause explosions.
D3	Low risk industrial - Occupancy where an industrial process is carried out and where neither the material handled nor the process carried out falls into the high or moderate risk category
D4	Plant room - Occupancy comprising usually unattended mechanical or electrical services necessary for the running of a building.
E1	Place of detention - Occupancy where people are detained for punitive or corrective reasons or because of their mental condition
E2	Hospital - Occupancy where people are cared for or treated because of physical or mental disabilities and where they are generally bed-ridden
E3	Other institutional (residential) - Occupancy where groups of people who either are not fully fit, or who are restricted in their movements or their ability to make decisions, reside and are cared for.
E4	Health care - Occupancy which is a common place of long term or transient living for a number of unrelated persons consisting of a single unit on its own site who, due to varying degrees of incapacity, are provided with personal care services or are undergoing medical treatment.
F1	Large shop - Occupancy where merchandise is displayed and offered for sale to the public and the floor area exceeds 250 m ²
F2	Small shop - Occupancy where merchandise is displayed and offered for sale to the public and the floor area does not exceed 250 m ²
F3	Wholesalers' store - Occupancy where goods are displayed and stored and where only a limited selected group of persons is present at any one time.
G1	Offices - Occupancy comprising offices, banks, consulting rooms and other similar usage.
H1	Hotel - Occupancy where persons rent furnished rooms, not being dwelling units.
H2	Dormitory - Occupancy where groups of people are accommodated in one room.
H3	Domestic residence - Occupancy consisting of two or more dwelling units on a single site.
H4	Dwelling house - Occupancy consisting of a dwelling unit on its own site, including a garage and other domestic outbuildings, if any.
H5	Hospitality - Occupancy where unrelated persons rent furnished rooms on a transient basis within a dwelling house or domestic residence with sleeping accommodation for not more than 16 persons within a dwelling unit.
J1	High risk storage - Occupancy where material is stored and where the stored material is liable, in the event of fire, to cause combustion with extreme rapidity or give rise to poisonous fumes, or cause explosions.
J2	Moderate risk storage - Occupancy where material is stored and where the stored material is liable, in the event of fire, to cause combustion with moderate rapidity but is not likely to give rise to poisonous fumes, or cause explosions.
J3	Low risk storage - Occupancy where the material stored does not fall into the high or moderate risk category.
J4	Parking garage - Occupancy used for storing or parking of more than 10 motor vehicles.

3.3 MAP OF CLIMATIC ZONES OF SOUTH AFRICA

Figure 1 - Climatic Zone Map



Zone Number	Description	Major Centres
1	Cold interior	Johannesburg, Bloemfontein
2	Temperate interior	Pretoria, Polokwane
3	Hot interior	Makhado (Louis Trichardt), Nelspruit
4	Temperature Coastal	Cape Town, Port Elizabeth
5	Sub-tropical Coastal	East London, Durban, Richards Bay
6	Arid interior	Upington, Kimberley

CLIMATIC ZONES OF SOUTH AFRICA

1	2	1	2	1	2
Location	Zone	Location	Zone	Location	Zone
Alexander Bay	4	Jacobsdal	6	Pretoria	2
Aliwal North	1	Jan Kempdorp	1	Prieska	6
Amsterdam	2	Johannesburg	1	Pudimoe	1
Baberton	2	Kammieskroon	4	Queenstown	2
Badplaas	2	Kainoplaagte	6	Reivilo	2
Barrydale	4	Kimberley	6	Richards Bay	5
Beaufort West	2	King Williamstown	5	Richmond	2
Bloemfontein	1	Kirkwood	4	Riversdale	4
Boshoff	2	Klerksdorp	1	Rooibokkraal	3
Brakpan	1	Kokstad	2	Sabie	3
Brandfort	2	Komatipoort	3	Sakrivier	6
Butterworth	5	Kroonstad	1	Saldanha Bay	4
Calvinia	2	Kruger National Park	3	Sibasa	3
Cape Agulhas	4	Krugersdorp	1	Soweto	1
Cape of Good Hope	4	Kubus	4	Springs	1
Cape Town	4	Kuruman	2	St Lucia	5
Cederberg	4	Ladysmith	2	Standerton	1
Centurion	2	Laingsburg	1	Stellenbosch	4
Ceres	2	Makhado	3	Steytlerville	2
Colesburg	1	Marken	3	Stoffberg	2
Conway	1	Melmoth	5	Stutterheim	2
Cradock	2	Mica	3	Swartberg	1
Dealsville	1	Middelburg	1	Swellendam	4
Delmas	1	Midrand	1	Thabazimbi	3
Dendron	2	Mkuze	5	Toska	6
Derdepoort	2	Mmabatho	2	Touwsrivier	2
Dordrecht	1	Mosselbay	4	Uitenhage	4
Drakensberg	1	Mussina	3	Ulundi	5
Dullstroom	1	Nelspruit	3	Umtata	5
Dundee	2	Newcastle	1	Upington	6
Durban	5	Niewoudtville	4	Utrecht	2
East London	5	Northam	2	Ventersdorp	2
Elliot	1	Olifantshoek	6	Vereeniging	1
Ermelo	1	Ottosdal	2	Victoria West	1
Estcourt	2	Oudshoorn	2	Vioolsdrif	2
George	4	Petrusburg	1	Virginia	1
Gouda	4	Phalaborwa	3	Volksrust	1
Grahamstown	4	Piet Plessis	2	Vryburg	2
Graskop	3	Piet Retief	2	Warrinton	2
Gravelot	2	Pietermaritzburg	5	Watervalboven	1
Guyani	2	Pilgrims Rest	2	Welkom	1
Harrismith	1	Pofadder	6	Wellington	4
Hartbeesfontein	1	Polokwane	2	Williston	1
Heidelberg	4	Pongola	2	Witbank	1
Hopetown	1	Port Elizabeth	4	Worcester	2
Hotazel	2	Port Nolloth	4	Zeerust	2
Hutchinson	1	Port St Johns	5		

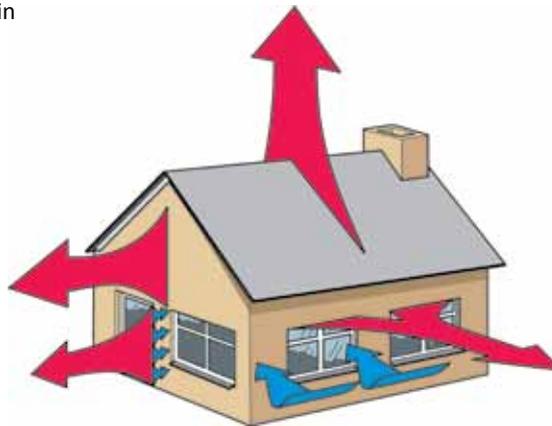
CHAPTER 4

ENERGY EFFICIENCY PERFORMANCE PRINCIPLES

4.1 THE BUILDING ENVELOPE

Building envelope is a term used to describe the roof, walls, fenestration and floors of a building. The envelope controls heat gain in summer and heat loss in winter. Well-designed envelopes maximize cooling air movement and limits exposure to direct sunlight in summer. In winter, they trap and store heat from the sun and minimise heat loss to the external environment. The fundamental principles of passive design, as previously defined, are relatively simple but should be applied to building types and construction systems in South Africa within the varying climatic zones.

Heat loss/gain



4.2 ENERGY SMART DESIGN

The Building Industry, in particular the Residential Sector has great potential for energy savings since building design is the major factor determining the energy use of a household.

Energy smart homes can be up to 5°C warmer in winter and up to 10°C cooler in summer, making the home brighter and more comfortable to live in throughout the year. Energy smart design enables substantial savings to be made on the running costs of heating, cooling and lighting, and will minimize greenhouse gas emissions and pollution from the use of fossil fuels.

The energy usage reduction challenge is possible with the implementation of an energy smart design and regulation.

The principles of energy smart house design are simple and cost effective and can be put into practice to improve comfort and energy efficiency. While doing this, they add value to any home or building.

4.3 DESIGN FOR ENERGY EFFICIENCY

Any style of home or building can be designed to be energy efficient and any existing home or building can improve its energy efficiency.

The design of an energy efficient home or building begins with the decisions made in the early stages of planning the design procedure.

For best results the floor plan and the dwelling/site relationship need to be planned at the same time. The orientation of the building to gain northern winter sun will affect the zoning and relationship of internal spaces, the placement of windows, the location and the layout of major outdoor features, and the planting for sun-shading and wind-screening.

Getting the first steps right means that overall energy efficiency will be easier to achieve. The northerly sun can be harnessed to warm the most frequently occupied areas of a home in the winter and can be easily controlled in summer with the appropriate shading.

4.4 PASSIVE DESIGN

Passive design is a design that does not require mechanical heating or cooling. Buildings that are passively designed take advantage of natural energy flows to maintain conditions required for human thermal comfort.

Incorporating the principles of passive design:

- Incorporate the use of day lighting opportunities
- Significantly improves comfort
- Reduces or eliminates heating and cooling bills.
- Reduces greenhouse gas emissions from heating, cooling, mechanical ventilation and lighting levels

4.5 PRINCIPLES OF ENERGY SMART DESIGN

There are many factors that contribute to energy smart design. Some must be dealt with in the planning and design process if they are to be incorporated (e.g. orientation of living areas), while others may be added after construction if necessary (e.g. draught-stripping to doors and windows).

Getting the 'hard to fix later' factors included at the outset is crucial to maximizing energy benefits and lifecycle savings.

While some components of energy smart design have the potential for greater energy savings than others, overall energy savings depend on their combination and interaction.

The key principles of energy smart design include:

- design for climate
- appropriate siting
- orientation - daytime living areas with large north-facing windows to receive unobstructed winter sun;
- internal planning to create zones which reduce the amount of energy required for heating and cooling;
- windows which are appropriately orientated and sized with protection from winter heat loss and summer heat gain;
- adequate thermal mass (building materials) to stabilize indoor temperatures;
- adequate thermal insulation in roofs, ceilings, walls and floors;
- good draught proofing;
- cross ventilation for summer cooling;
- an efficient hot water system and fittings, located close to user station;
- efficient lighting and appliances; and
- landscape design that assists in modifying the microclimate for more comfortable conditions.

4.6 DESIGN FOR CLIMATE: CLIMATIC ZONES

Design for comfort and energy efficiency is influenced by climatic considerations.

The Deemed-to-Satisfy Provisions in this document are based on six climatic zones. Energy intervention measures will vary from region to region as well as areas within a zone.

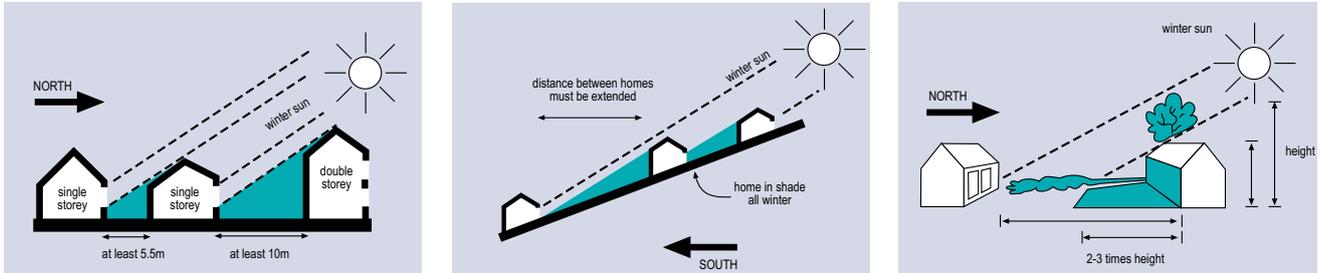
To achieve the best results, building design and construction materials should be appropriate to the climate of a region. While each of the six climate zones have different heating and cooling needs, the same principles of energy efficient design apply, with their application varying slightly, e.g. different levels of insulation or thermal mass or variations in window sizes.

4.7 TOWN PLANNING

A building that is well positioned on its site delivers significant lifestyle and environmental benefits. Optimum orientation of buildings must be a major consideration when planning a new development. Poor design of services (lighting, water, sewerage and roads) on sites can restrict orientation options. Thus, building orientation must be considered at town/site planning stage. Optimum orientation increases the energy efficiency of a building, making it more comfortable to live and work in. Consult the Town Planning section of the Built Environment. Further information is obtainable from the CSIR Red Book (Guidelines of Human Settlement Planning and Design).

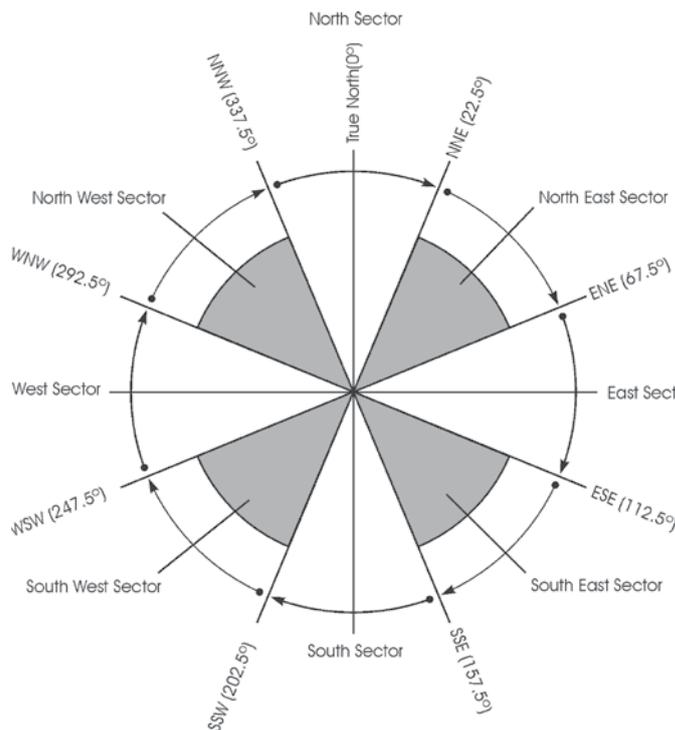
4.8 BUILDING ORIENTATION

Choose a site with good orientation for your climatic and regional conditions. Build or renovate to maximize the potential and to achieve the best possible orientation for living and working areas.



Poor orientation can exclude winter sun, and cause overheating in summer by allowing low angle east or west sun to strike glass surfaces.

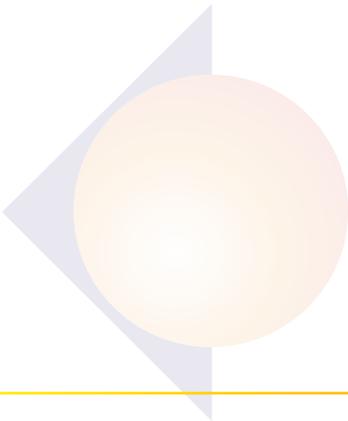
4.9 ORIENTATION SECTORS



Correct orientation and siting to achieve a high level of unobstructed winter sunshine is essential.

A house or building should be designed to respond to site conditions to maximize free solar access and energy. Solar access refers to the amount of the sun's energy available to a building. Good solar access means reduced energy requirements, improved comfort levels and environmental benefits.

All forms of housing, including medium and high density housing, can save significantly on energy use for heating and cooling if solar access is good. Where possible, choose a site that can accommodate north-facing daytime living, working areas and outdoor spaces.



CHAPTER 5

THERMAL INSULATION

Insulation is the most effective way to improve the energy efficiency of a home or a building. Insulation of the building envelope helps keep heat in during the winter and out in summer to improve comfort and save energy. Insulation could add additional benefits such as acoustics and waterproofing. Effective draught proofing, moisture control and ventilation are important at design stage.

The appropriate level of insulation intervention will depend on climate, building construction type, and whether auxiliary heating and/or cooling is used.

5.1 INSULATION - OVERVIEW

Insulation reduces heat flow and is essential to keep a building warm in winter and cool in summer. A well insulated and well designed building will provide year-round comfort, decreasing energy costs. This, in turn, will reduce greenhouse gas emissions.

Climatic conditions will influence the appropriate level and type of insulation. Establish the climatic zone from the Map of Climatic Zones of South Africa (Pages 17-18).

Passive design techniques must be used in conjunction with insulation. For example, if insulation is installed but the building is not correctly shaded, built up heat can be trapped in by the insulation creating an 'oven' effect. Air tightness of a building is important, as draughts can account for up to 25 percent of heat loss in winter.

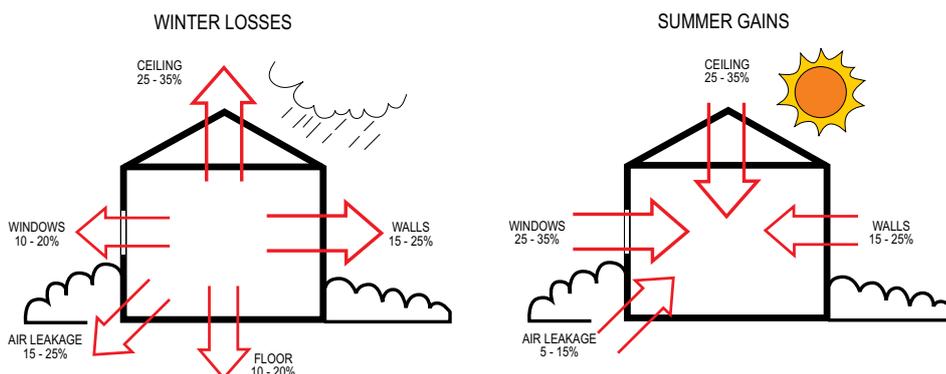
Ensure proper ventilation in buildings where fossil fuels are burned as an energy source.

Certain types of insulation can assist with weatherproofing and control moisture problems such as condensation. Some types of insulation also have soundproofing qualities. Some products are environmentally friendly and contain recycled material.

The most economical time to install insulation is during construction.

5.2 HOW DOES INSULATION WORK?

An un-insulated home is subject to considerable winter heat losses and summer heat gains.



The term 'insulation' refers to materials or a combination thereof which provide resistance to heat flow.

When these materials are installed in the roofs, ceilings, walls, and floors of a building, heat flow into and out of the building is reduced, and the need for heating and cooling is minimized. Although ceilings and walls may be insulated, heat loss will still occur in winter if there are large areas of unprotected glass or through fixed wall vents, gaps electric light entry points and cracks around external doors and windows.

Appropriate internal window coverings (e.g. lined drapes with pelmets) and draught proofing are vital to complement insulation. Insulation should always be coupled with appropriate shading of windows and adequate ventilation in summer. Without shading, radiant heat entering the home through the windows will be trapped inside by the insulation and cause discomfort.

5.3 PRINCIPLES OF INSULATION

Resistance to heat flow is achieved by the use of either bulk insulation, reflective insulation or a combination of both, which work in different ways.

5.4 WHAT YOU NEED TO KNOW-

There are various factors to consider before making an insulation decision:

5.4.1 Thermal Performance - Installed R-Value

When insulating a home or building, it is important to ascertain the R-Value specified by the National Building Regulations. It's also important that the product provide long-lasting thermal performance. It is the overall R-Value installed that is important.

5.4.2 Life Time Performance

In order to ensure the expected energy savings, it is important that the insulation does not deteriorate, or settle, over time.

5.4.3 Fire Safety

Thermal insulation material shall be either non-combustible, when tested in accordance with SANS 10177-5 and may be installed in all occupancy classes, or materials classified as combustible in accordance with SANS 10177-5, shall be tested and classified in accordance with SANS 428 protocol for the appropriate use and application. Some facings attached to bulk insulation are combustible. Ensure all insulation products and composites are tested in accordance with the relevant standards and classified in accordance with SANS 428 Fire performance classification of thermal insulated building envelope systems, before purchasing

5.4.4 Moisture

Insulation will lose its insulating efficiency or R-Value when exposed to moisture. Some insulation products are not absorbent and, if exposed to moisture, will not wick up or hold water. If allowed to dry out insulation may retain its original R-Value. In wall applications certain insulation material may be applied as vapour retarders, or moisture barriers.

5.4.5 Air Infiltration

Air infiltration generally occurs in the areas of a home that are not correctly sealed or insulated, such as around windows, doors, fireplaces, HVAC ductwork and perimeter joints. It can, and should, be controlled with proper caulking, and sealing of band joists, sill plates, header plates, and around doors, windows, electrical outlets and other openings.

5.4.6 Environmental Benefits

As environmental consciousness has been heightened, the building industry has responded by using increasing amounts of recycled material in their products. This kind of rethinking has led to a strong push to use building materials with lower environmental impact.

5.4.7 Life-cycle analysis

A life-cycle analysis is an appraisal of the environmental impacts connected with a product through an examination of the product's environmental traits during many stages including pre-manufacturing; manufacturing; distribution/packaging; use, reuse, maintenance; and waste management. In reviewing each of these stages, a life-cycle evaluation clearly shows its environmentally beneficial attributes.

This is just the first step..."

5.5 HOW INSULATION PERFORMANCE IS MEASURED

The thermal performance of all components and systems except windows and doors is expressed in terms of R-Value; for windows and doors, performance is expressed in terms of U-Value.

5.5.1 What is an R-Value?

Insulation materials are rated for their performance in restricting heat transfer. This is expressed as the R-Value, also known as thermal resistance. The R-Value is a guide to its performance as an insulator-the higher the R-Value, the better the insulation (i.e., resistance to heat flow) it provides.

R-Values are expressed using the metric unit's $m^2.K/W$, where:

- m^2 refers to one metre squared of the material of a specified thickness;
- K refers to a one degree temperature difference (Kelvin or Celsius) across the material;
- W refers to the amount of heat flow across the material in watts.

Use the nominal R-Values as listed by the manufacturer on the packaging of the insulation to determine the performance.

Products which have the same R-Value will provide exactly the same insulating effect as each other, provided they are correctly installed. The higher the R-Value the more effective the insulation. Products must be installed in accordance with the manufacturer's specifications.

The information available on the product data sheet and/or label must include the R-Value and whether it must be installed professionally or DIY. Ensure that it suits your particular application. Ask if performance guarantees and/or test certificates are available.

Material R-Values – the thermal resistance values of bulk/mass type insulation are measured on the product alone according to international standards.

System R-Values – the thermal resistance value of reflective insulation is calculated based on international standards and depend on the product being installed as specified in accordance to manufacturer's specifications. This is known as a system R-Value which incorporates air spaces.

Composite R-Values - the thermal resistance values of composite insulation products are measured by testing the composite product as a unit according to international standards.

Direction of heat flow effect

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).

5.5.2 What is a U-Value?

Sometimes insulation or systems are rated in terms of its thermal transmittance (U-Value), rather than its R-Value. The U-Value measures the transfer of heat through a material or a building element (thermal transmittance), whereas the R-Value measures the resistance to heat transfer. U-Values are often used in technical literature, especially to indicate the thermal properties of glass and to calculate heat losses and gains.

The U-Value is the reciprocal of the R-Value, $R=1/U$ or $U=1/R$. For example, with an R-Value of 2.0, the U-Value is 1/2 or 0.5.

The U-value is expressed using the metric units $(W/m^2.K)$ where:

- W refers to the amount of heat transmitted across the face or through the material in watts;
- m^2 refers to one metre squared of the material of a specified thickness; and
- K or 'degree Kelvin' refers to each $^{\circ}C$ temperature difference across the face of the materials or through the material.

A smaller U-Value results in lower heat flow, and therefore less heat loss. Higher U-Values mean greater heat loss.

5.5.3 What is an Overall R-Value?

The overall R-Value is the total resistance of a building element or system combination. It takes into account resistance provided by construction materials used in a wall or ceiling, internal air spaces, thermal bridging, insulation materials and air films adjacent to solid materials. Each of these components has its own inherent R-Value, the sum of which provides the overall R-Value.

5.5.4 What is Intervention or Added R-Value?

The intervention added R-Value or added thermal resistance is the value of the insulating material alone. This is the term most used when buying thermal insulation.

The manufacturer should provide the R-Value of the insulation on the packaging. Some products will have a higher R-Value for a specified thickness. For example, a 70mm thick extruded polystyrene board and 100mm thick glass wool blanket may have the same apparent R-Value.

Reflective insulation requires that air spaces are positioned correctly within the building system to be effective, reflective membranes cannot have an R-Value without the air space or air spaces.

To compare the relative performance of bulk and reflective insulation membranes, the resistance of such membrane in combination with air space(s) must be calculated. Reputable manufacturers can supply this information. Note: The effectiveness of reflective insulation installed on horizontal or sloping surfaces may eventually be reduced due to dust build-up, which reduces reflectivity, thereby increasing absorption.

5.5.5 What is the difference between R-Value and Total R-Value?

The **R-Value** is the material thermal resistance, i.e. product only whereas the **Total R-Value** describes the total thermal resistance of the system to heat flow provided by a roof and ceiling assembly (inclusive of all materials and air films), a wall or a floor. These values are calculated from the resistance of each component, including the insulation. Total R-Values are the best indicator of performance, as they show how insulation performs within the building envelope. See example in section 7.5.

5.5.6 What is Thermal Bridging?

Thermal bridging is the transfer of heat across building elements, which have less thermal resistance than the added insulation. This decreases the overall R-Value. Wall frames and ceiling beams are examples of thermal bridges, having a lower R-Value than the insulating material placed between them. Because of this, the overall R-Value of a typical ceiling and/or wall is reduced.



CHAPTER 6

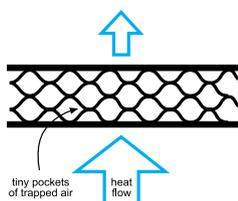
THERMAL INSULATION TYPES & APPLICATIONS

INSULATION TYPES AND THEIR APPLICATIONS

The level of insulation will depend on the climatic zone, building construction type, and whether auxiliary heating and/or cooling is used.

6.1 BULK INSULATION

Bulk insulation mainly resists or slows down the transfer of heat by conduction and convection, relying on pockets of trapped air or low conductive gasses within its structure. Its thermal resistance is essentially the same regardless of the direction of heat flow through it. For bulk insulation, R-Values are provided for a specific thickness and density of material at a given temperature. The thicker the insulation, the higher the R-Value for that product.



Bulk insulation traps air in still layers. The air does the insulating - the material simply traps it, slowing down or lowering the flow of heat or heat transfer.

Bulk insulation includes materials such as glass fiber, slag wool, rock fiber, cellulose fiber, polyester fiber, polystyrene, polyurethane and polyisocyanurate. Each product has a material R-Value for a given thickness, density and temperature.

TYPES OF BULK INSULATION

6.1.1 Batt Blanket & Matt Insulation



Glass Fiber (Glasswool) manufactured from molten glass spun and formed into mats, rolls and blankets of fine fibers coated with a binding resin. Batts and blankets are light weight, fit standard tie beams and stud spaces, easy to cut and install. Should not be compressed or moistened. Butt all ends and edges together firmly. If installed carefully it will not slump or settle. During installation glass fiber can cause eye, skin and respiratory irritation, and manufacturer's safety recommendations should be followed. Maximum limited operating temperature 350°C.



Mineral Wool (Slag/Rock Wool/Stonewool) manufactured from molten industrial slag, which is fiberized, treated with oil and binders to suppress dust, and maintain shape. It is similar to glass fiber in texture and appearance but denser than glasswool so R-Value per unit thickness is higher. Rock Wool is manufactured in a similar manner except that natural rock is used instead of slag. These materials have a high fire resistance, limiting maximum operating temperature 850°C. Generally rock wool is more expensive than glasswool. It can cause eye, skin and respiratory irritation during installation.



Polyester Fiber made from polyester fibers (including recycled PET bottles) spun into a flexible mat. Available as blankets. Easy to cut and install, non-irritable, with no known physical or health hazards. When exposed to a direct flame the product would melt and shrink away from the flame. Maximum limited operating temperature 150°C.



Polyester Fiber batts or ceiling panels are produced using a mix of virgin and recycled polyester fiber, or Kenaf, a renewable plant fiber which is thermally bonded. It is a non-toxic and non-harmful, low VOC product. The density can vary between a 24-100kg/m³ batt or a 50-300kg/m³ board-product.

6.1.2 Loose Fill Insulation



Cellulose Fiber insulation is made from finely shredded recycled paper which is milled into a light fibrous matrix, which is chemically treated to resist fire and fungal growth. Due to the small size of the particles, cellulose can 'flow' around obstructions (nails, electrical wires, trusses, etc) to give a uniform fill.

If the insulation is not blown to manufacturer's recommended density and thickness it can settle over time, and the intended R-Value will not be achieved and maintained. Blown cellulose can be installed in vertical wall cavities using a variety of specially designed, reinforced interior sheathing products.

6.1.3 Rigid Board Insulation



Vermiculite is a mineral closely related to mica, which when heated expands to form a light weight exfoliated material with insulating properties. There are two types of vermiculite: untreated and treated. The treated material is coated with asphalt to make it water-repellent, for use in high moisture areas. Untreated vermiculite absorbs water and once wet dries very slowly.

Vermiculite is usually hand-installed, and is suitable for both horizontal and vertical applications. It is non-combustible, odourless and non-irritating, although due to its high density it is not usually the material of choice where a high R-Value is desired.



Expanded Polystyrene (EPS) is a lightweight, plastic foam insulation produced by trapping small amounts of pentane gas into solid beads of polystyrene. The pentane gas expands under the action of heat, applied as steam, to form perfectly closed cells of EPS. These cells occupy approximately 40 times the volume of the original polystyrene bead. The EPS beads are then moulded into blocks or boards in three standard densities. EPS has excellent thermal properties, is moisture resistant, and provides environmentally safe lifetime durability. EPS StyFRene is fire retardant. EPS is easy to install, non-toxic, contains no CFC's or HCFC's and is recyclable. Limited surface operating temperature 100°C



Extruded Polystyrene (XPS) is a closed cell polystyrene foam board, which retains gas but excludes water. It is produced on a continuous, fully automated extrusion process. It is manufactured in two densities. The high density board should be used where the material will be exposed to relatively high pressures, such as be low a concrete slab or in built-up roofing. Most commonly used for slab-edge and cavity brick wall insulation. Polystyrene will 'break-down' if left exposed to sunlight for prolonged periods, and must also be protected from solvents and non compatible adhesives. Limited surface operating temperature 100°C



Polyurethane and Polyisocyanurate insulations are manufactured by chemical reactions between poly-alcohols and isocyanurates creating or forming tiny air cells. The cells contain refrigerant gases (fluorocarbons) instead of air. The boards are usually double-faced with foil, or sometimes come bonded with an interior or exterior finishing material. The boards must be protected from prolonged exposure to water and sunlight, and if used on the interior must be covered with a fire-resistant material, such as drywall. Due to the relatively high cost of these insulations, use is generally limited to areas which require a high R-Value but where space is very limited.



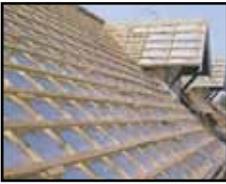
Phenolic Foam is manufactured from phenol formaldehyde resin, and is available as either an open or closed cell product. The boards usually come with a foil facing on one or both sides. It is much less combustible than other rigid insulations. It should be protected from prolonged exposure to sunlight and water. It is suitable for wall sheathing, and for use on the interior, both above and below grade. Use is generally limited to areas which require a high R-Value, but where space is very limited.

6.1.4 Spray Foam Insulations



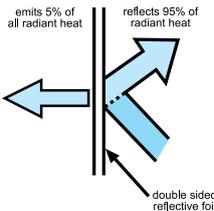
Polyurethane Foam is closed cell foam, which is usually pale yellow in colour, and can be used for a variety of spray applications. The material is mixed on site with special equipment for large applications. For small applications, single component foam is available in spray cans, for sealing around windows, doors, etc. The foam will act as an air barrier, but not a vapour barrier and should be protected from prolonged exposure to sunlight. When the foam is used in the interior of a house, it must be covered with a fire-resistant material, such as drywall.

6.2 REFLECTIVE FOIL LAMINATE (RFL) INSULATION / RADIANT BARRIER



Reflective Foil Insulation as a barrier to heat flow, predominantly Radiant Heat, is effective only when installed/applied in combination with air spaces. These products are commonly referred to as reflective foil laminates "RFL" and are tested in compliance with SABS standard SANS 1381 Part 4.

The principles on which their performances are based differs from and is more complicated to appreciate than mass or bulk type materials however, the common denominator is air. Whereas bulk, mass and fibrous products entraps great numbers of air or small gas pockets, Reflective Foils in turn is the division of and creation of defined air spaces, together with high reflective/low emissive surfaces facing the air spaces. The reflective surfaces should be positioned to face the brighter side downwards.



To simply define this method of insulation as reflective is a misnomer, as the principles which determine their performances are based on Reflection, Absorbption, Conductance and, most importantly, the ability of high reflective surfaces to only emit a small percentage, between 3-5%, of the heat absorbed to an accompanying air space. Therefore highly polished surfaces in combination with air spaces, within the insulation system or below the membrane, is important in reducing the level of emitted radiant heat together with reducing conductive heat transfer.

Reflective insulation is more effective at reducing summer heat gain than reducing winter heat losses and this must be considered at design stage. The thermal resistance of reflective insulation varies with the direction of heat flow through it, i.e. vertical, horizontal or sloped, the number of air spaces and defined thicknesses of the air spaces. Furthermore, that the bright surfaces facing the air space/spaces remains untarnished on at least one surface.

The system "R"-values for reflective foils is stated as being up or down, alternatively as winter or summer. When evaluated in accordance with SABS standard SANS 1381 part 4, they are tested at a given air space thickness and air temperature. Users must ensure that the system values provided by the manufacturers relates to their particular application. An R-Value resistance or k-value conductivity cannot be given for the membrane/laminate by itself; the heat flow values, thermal transmittance or "U"-value is given for the system based on the thicknesses and orientation of the air spaces, in combination with the materials. Values for total "R"-resistance or "U" stated in this guide is based on the upper surface, facing the roof cover, being completely and totally dust covered, as dust build-up reduces the reflectivity and therefore the R-Values.

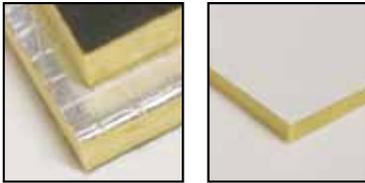


Reflective Foil Insulation materials are often Aluminium Foil laminates with reinforcement strands or low density polyethylene bubble encapsulated with air laminated to foil supplied in rolls. In addition to their thermal performances they are effective dust-proofing, waterproofing and air barriers, as well as affording protection from U.V., providing they comply with SABS standard SANS 1381 part 4, in terms of physical properties such as tear, puncture tensile resistance and U.V stabilising.

Damages to surfaces such as excessive severe creasing, scuffing, puncture holes or openings will reduce the performance and needs to be repaired or made good.

Reflective Foils are valuable when used in combination with bulk insulation for improved performance.

6.3 COMPOSITE BULK / COMPOSITE MASS INSULATION



Composite bulk and reflective materials are available that combine some features of both types.

Examples include Foil bonded to bulk insulation, whether blankets, batts or boards, i.e. foil faced blankets, foil faced batts and foil faced boards.

6.4 ENVIRONMENTAL IMPACT

Insulation contributes to reduce the energy consumption over the life of a building and provides ongoing environmental benefits, reducing the carbon foot print.

In assessing the environmental benefits of insulation materials, consideration must be given to a broad range of issues relating to the resources going into the production, manufacturing processes, pollutants given off during lifecycle, durability, recyclability, and impact on indoor air quality. Recycled content is a recognized environmental feature of building products.

Materials with recycled content have four advantages:

1. they require less natural resources;
2. they divert materials from the solid waste stream;
3. creating additional job opportunities for the unemployed by collecting usable waste (recyclable PET plastic bottles); and
4. they use less energy during manufacturing.

The insulation industry is full of good examples of recycled material use:

- **Cellulose Fiber** uses recycled newspaper by weight; the rest is comprised of fire retardant chemicals and-in some products-acrylic binders.
- **Fiberglass** uses a percentage of recycled glass
- **Mineral wool** actually refers to two different materials: slag wool and rock wool. Slag wool is produced primarily from iron ore blast furnace slag, an industrial waste product and Rock wool is produced from natural rocks.
- **Polyester Fiber** uses recycled PET plastic bottles
- **Polystyrene** uses reclaimed polystyrene in many products.

Insulation not only sustains the ecology and economy of the country, it further creates employment opportunities!

6.5 PRODUCT LABEL

Information on the product label either inside the packaging or on the packaging should provide the manufacturer's name, and trade name or trademark, or both; the batch identification or date of manufacture; the nominal length, width and thickness of the material, in mm where appropriate; the nominal and coverage area of the material in square metres; the nominal gross mass; the nominal thermal resistance R-Value of the material, in $m^2.K/W$; the fire performance classification and a warning, referring to precautions for health and safety during handling and installation of the insulation material. Ensure that the product is suitable for the intended application.

6.6 INSULATION SELECTION

When selecting insulation, ensure that the product:

- is in compliance with the relevant South African National Standards applicable to the product;
- conforms to the National Building Regulations;
- is appropriate for the intended occupancy or building classification in accordance with SANS 10400 Part A
- complies with the fire safety requirements given in SANS 10400-T and SANS 428
- complies with the recommended R-Value for the relevant climatic zones in accordance with SANS 204.

CHAPTER 7

INSULATION LEVELS PER CLIMATIC ZONE

The following deemed-to-satisfy rules are to be applied by the building owner at the design stage of the building if he chooses not to consider rational design option. A roof and/or ceiling that are part of the building envelope must achieve the Total R-Value specified in Table 1 for the direction of heat flow.

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

The direction of heat flow in Table 1 is considered to be the predominant direction of heat flow for the hours of occupation of the building. It takes into account the higher rate of occupancy of houses at night time rather than day time.

Where “downwards” is specified in Table 1, this indicates summer heat (a downwards heat flow into the building) is the major concern. A combined downward and upwards requirement means that summer and winter (heating and cooling) have a roughly similar level of energy use on an annual basis, while an upward flow indicates that heat loss from the building during winter is the major concern.

In hot humid climates where buildings are naturally ventilated, high down R-Values and low up R-Values are appropriate for roofs and ceilings.

Climate zones	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Minimum required Total R-Value (for roof solar absorptance of more than 0.55)	3.7	3.2	2.7	3.7	2.7	3.5
Dominant direction of heat flow	Upwards	Upwards	Down and Upwards	Upwards	Downwards	Upwards

Note: Condensation could occur in three areas; the cold interior (Climatic Zone 1), the temperate interior (Climatic Zone 2) and the temperate coastal area (Climatic Zone 4), therefore vapour barriers, adequate ceiling insulation and roof ventilation must be provided.

7.1 ROOFS AND CEILINGS - MINIMUM REQUIRED TOTAL R-VALUE (m².K/W)

A roof shall achieve the minimum total *R-Value* specified in table 1 for the direction of heat flow.

A roof assembly that has metal sheet roofing fixed to metal purlins, metal rafters or metal battens shall have a thermal break consisting of a material with an *R-Value* of not less than 0,2 installed between the metal sheet roofing and its supporting member.

THERMAL INSULATION

Thermal insulation material shall be either:

- non-combustible when tested in accordance with SANS 10177-5 and may be installed in all occupancy classes; or
- material classified as combustible in accordance with SANS 10177-5, shall be tested and classified in accordance with SANS 428 protocol for the appropriate use and application.

The selection and specification of thermal insulation material should always be read in conjunction with the fire safety requirements given in SANS 10400-T.

Note : Roofs and ceilings are defined as the complete roofing/ceiling system, as measured from the outer skin exposed to the environment, to the inside of the inner skin exposed to the interior of the building, and does not include glazing such as roof lights and skylights.

7.2 RECOMMENDED LEVELS OF INSULATION

The deemed-to-satisfy (DTS) recommended levels of insulation can be achieved by the use of reflective foils, bulk insulation or rigid board insulation or in combination with one another. Maximum efficiency may be achieved at reduced thicknesses taking the aforementioned into account. Rational design is always an alternative to DTS Provisions.

Description	Climatic Zones					
	1	2	3	4	5	6
Minimum required Total R-Value (m ² .K/W) (for roof solar absorptance of more than 0.55)	3.7	3.2	2.7	3.7	2.7	3.5
Direction of heat flow	Up	Up	Down and Up	Up	Down	Up
Estimated Total R-Value (m ² .K/W) of roof and ceiling materials(Roof covering & plasterboard only)	0.35 - 0.40			0.41 - 0.53		0.35 – 0.40
Estimated Minimum added R-Value of Insulation (m ² .K/W)	2.30 – 3.35			2.15 – 2.29		3.10 – 3.15

Description			Climatic zones					
			1	2	3	4	5	6
Generic Insulation Products	Density Kg/m ³	Thermal Conductivity W/(m.k.)	Recommended deemed-to-satisfy min thickness (mm) of insulation product					
Cellulose Fiber Loose-Fill	27.5	0.040	135	115	100	135	100	130
Flexible Fiber Glass Blanket	10-18	0.040	135	115	100	135	100	130
Flexible BOQ Polyester Fiber Blanket	24	0.038	130	110	90	130	90	125
Flexible Polyester Blanket	11.5	0.046	160	140	120	160	110	150
Flexible Mineral / Rock Wool	60-120	0.033	115	100	80	115	80	100
Flexible Ceramic Fiber	84	0.033	115	100	80	115	80	100
Rigid Expanded Polystyrene (EPS)SD	15	*0.035	120	100	90	120	80	115
Rigid Extruded Polystyrene (XPS)	32	*0.028	100	80	70	100	65	90
Rigid Fiber Glass Board	47.5	0.033	115	100	80	115	80	100
Rigid BOQ Polyester Fiber Board	61	0.034	115	100	80	115	80	110
Rigid Polyurethane Board	32	*0.025	85	70	60	85	60	80
<p>Note 1: Thermal Conductivity used for calculation of recommended thicknesses of insulation materials as per TIASA Protocol for Routine Testing for naturally ventilated buildings.</p> <p>*Thermal efficiencies are dependant on materials thickness, density, age, operating temperature and moisture. Thicknesses are rounded-up to nearest production standard. This is a guideline for general design purposes. For critical design purposes; i.e. rational design, contact manufacturers for actual R-Values (Thermal Resistance (m²K/W)) and valid test reports or refer to ISO 10456 Building materials and products -- Hygrothermal properties -- Tabulated design values and procedures for determining declared and design thermal values</p> <p>Note 2: The aforementioned deemed-to-satisfy recommended levels of insulation could be achieved by the use of reflective foils, bulk insulation or rigid board insulation or in combination with one another. Maximum efficiency may be achieved at reduced thicknesses taking the aforementioned into account. Rational design is always an alternative to deemed-to-satisfy provisions.</p> <p>Note 3: Actual R-Values for roof construction systems are established through testing in accordance with ASTM C1363 Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus with SAFIERA. Specifiers are encouraged to obtain these test results from manufacturers.</p>								

Insulation shall comply with minimum required R-Values (see table 2), and be installed so that it:

- abuts or overlaps adjoining insulation, or is sealed,
- forms a continuous barrier with ceilings, walls, bulkheads or floors that contribute to the thermal barrier, and
- does not affect the safe or effective operation of any services, installation, equipment or fittings.

Bulk insulation shall be installed so that:

- a) it maintains its position and thickness, other than where it crosses roof battens, water pipes or electrical cabling, and
- b) in ceilings, it overlaps the wall member by not less than 50mm or is tightly fitted against a wall where there is no insulation in the wall.

Note: The R-Value of bulk insulation is reduced if it is compressed. The allocated space for bulk insulation must therefore allow the insulation to be installed so that it maintains its correct thickness.

Reflective insulation shall be installed and supported -

- a) with the necessary airspace, in order to achieve the required R-Value between a reflective side of the reflective insulation and a building lining or cladding; and
- b) with the reflective insulation tightly fitted and taped against any penetration, door or window opening; and
- c) with each adjoining sheet of roll membrane being-
 - 1. overlapped not less than 100mm; or
 - 2. taped together

7.3 R-VALUES CONSIDERED TO BE ACHIEVED BY REFLECTIVE FOIL LAMINATES

The R-Value of reflective insulation is affected by the airspace between a reflective side of the reflective insulation and the building lining or cladding. Dust build-up reduces R-Values. Table 4 gives typical R-Values for reflective insulation in specific circumstances. Table 4 refers to the Building Code of Australia 2007 and does not necessarily comply with South African Building methods.

Emittance of added reflective insulation	Direction of heat flow	R-Value added by reflective foil insulation					
		Pitched roof ($\geq 10^\circ$) with horizontal ceiling		Flat skillion or pitched roof ($\leq 10^\circ$) with horizontal ceiling	Pitched roof with cathedral ceilings		
		Natural ventilated roof space	Non-ventilated roof space		22° pitch	30° pitch	45° pitch
0.2 outer 0.05 inner	Downwards	1.21	1.12	1.28	0.96	0.86	0.66
0.2 outer 0.05 inner	Upwards	0.59	0.75	0.68	0.72	0.74	0.77
0.9 outer 0.05 inner	Downwards	1.01	0.92	1.06	0.74	0.64	0.44
0.9 outer 0.05 inner	Upward	0.40	0.55	0.49	0.51	0.52	0.53

Note:

- a) Reflective foil insulation values inclusive of 15mm air gap. Reflective insulation should work in conjunction with an air gap to be effective.
- b) The R-Value of reflective insulation is affected by the airspace between a reflective side of the reflective insulation and the building lining or cladding. Dust build-up or degradation reduces R-Values.
- c) The reflective surface with the lowest emittance should preferably be facing downwards.

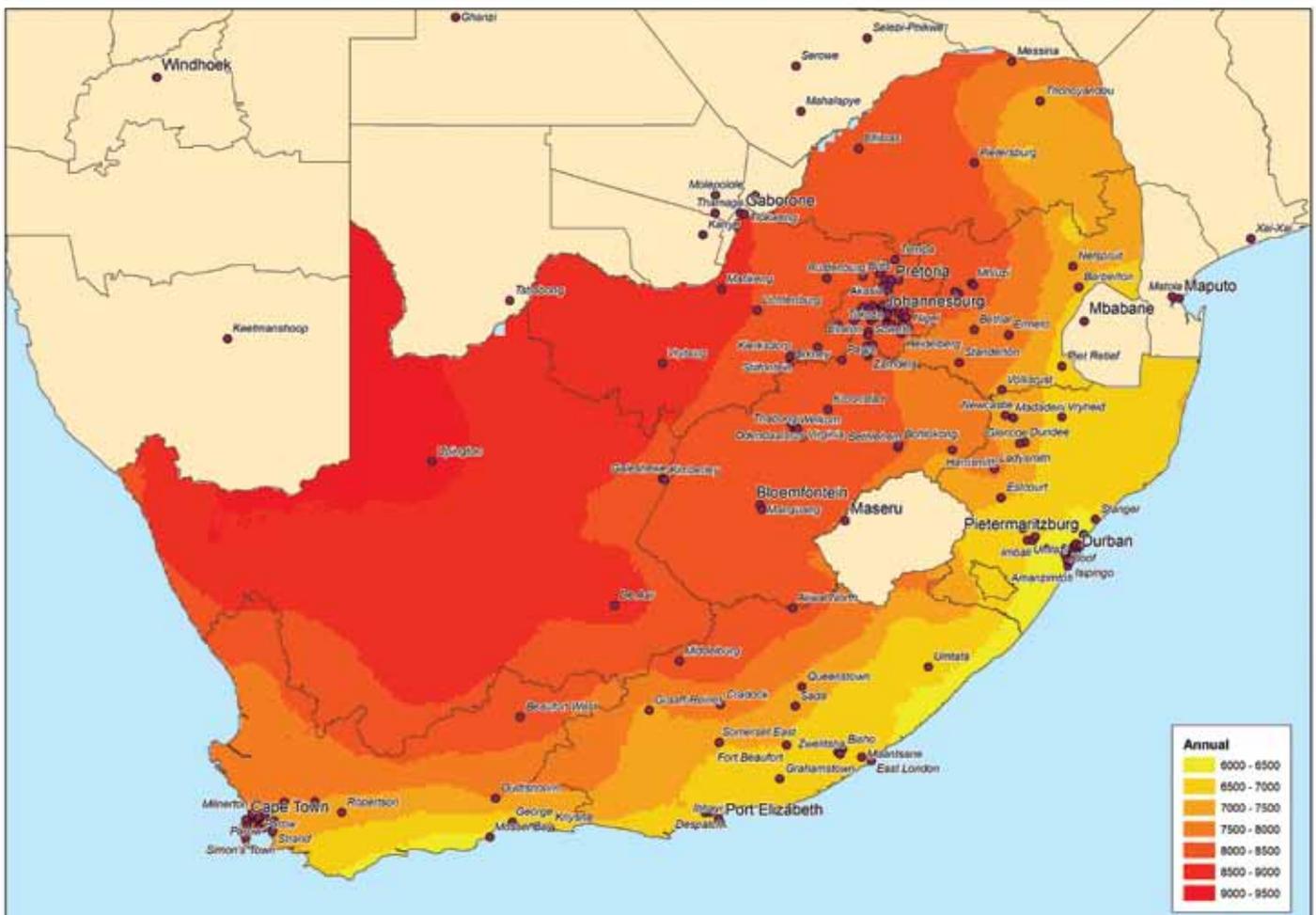
7.4 WHY USE A RADIANT BARRIER / REFLECTIVE FOIL

Reflective insulation materials work on a different concept than conventional bulk insulation like rigid foam boards or fibrous blankets. Reflective Foil Laminates can stop up to 95% of heat transfer through radiation and provide an excellent temperature control method.

A layer of reflective foil insulation is an effective barrier to radiant heat and as a vapour barrier. Reflective insulation gives excellent insulation performance for downward heat flow (summer heat gain), but only moderate performance for upward or horizontal heat flow (slowing heat losses in winter) and requires an air space between the foil and solid surfaces to achieve full insulation qualities.

Reflective Foil insulation products should be installed in conjunction with conventional bulk insulation, to achieve optimum energy savings.

“Annual solar radiation map - measured in MJ/m²” as provided by the CSIR



7.5 TYPICAL R-VALUES FOR AIR SPACES AND AIR FILMS (SANS 204)

Description	Position of air space	Direction of heat flow	R-Value m ² .K/W
Air spaces non-reflective unventilated	Pitched roof space	Up	0,18
	Pitched roof space	Down	0,28
	Horizontal	Up	0,15
	Horizontal	Down	0,22
	45° slope	Up	0,15
	45° slope	Down	0,18
	Vertical	Horizontal	0,16
Air films – Still air	Pitched roof space	Up	Nil
	Pitched roof space	Down	0,46
	Horizontal	Up	0,11
	Horizontal	Down	0,16
	45° slope	Up	0,11
	45° slope	Down	0,13
	Vertical	Horizontal	0,12
Air films – Moving air	7 m/s wind	Any direction	0,03
	3 m/s wind	Any direction	0,04

NOTE R-Values are for a temperature of 10 °C and temperature difference of 15 K.

7.6 TYPICAL R-VALUES FOR ROOF AND CEILING CONSTRUCTION (SANS 204)

Roof construction description	Component	R-Value unventilated		R-Value ventilated	
		Up	Down	Up	Down
Roof 22° to 45° pitch with – horizontal ceiling, and – metal cladding	Outdoor air film (7m/s)	0,03	0,03	0,03	0,03
	Metal cladding	0	0	0	0
	Roof air space (non-reflective)	0,18	0,28	0	0,46
	Plasterboard, gypsum (10mm, 880 kg/m ³)	0,06	0,06	0,06	0,06
	Indoor air film (still air)	0,11	0,16	0,11	0,16
	Total R-Value	0,38	0,53	0,20	0,71
Roof 22° to 45° pitch with – horizontal ceiling, and – clay tiles 19mm	Outdoor air film (7m/s)	0,03	0,03	0,03	0,03
	Roof tile, clay or concrete (1922 kg/m ³)	0,02	0,02	0,02	0,02
	Roof air space (non-reflective)	0,18	0,28	0	0,46
	Plasterboard, gypsum (10mm, 880 kg/m ³)	0,06	0,06	0,06	0,06
	Indoor air film (still air)	0,11	0,16	0,11	0,16
	Total R-Value	0,40	0,55	0,22	0,73
Cathedral ceiling 22° to 45° pitch with – 10mm plaster on top of rafters, and – metal external cladding	Outdoor air film (7 m/s)	0,03	0,03	–	–
	Metal cladding	0	0	–	–
	Roof air space (30mm to 100mm, non reflective)	0,16	0,18	–	–
	Plasterboard, gypsum (10mm, 880 kg/m ³)	0,06	0,06	–	–
	Indoor air film (still air)	0,11	0,16	–	–
	Total R-Value	0,36	0,43	–	–

7.6 TYPICAL R-VALUES FOR ROOF AND CEILING CONSTRUCTION (SANS 204) (CONCLUDED):

Roof construction description	Component	R-Value unventilated		R-Value ventilated	
		Up	Down	Up	Down
Cathedral ceiling 22° to 45° pitch with – 10mm plaster on top of rafters, and – tiles external cladding	Outdoor air film (7 m/s)	0,03	0,03	–	–
	Roof tile, clay or concrete (1922 kg/m ³)	0,02	0,02	–	–
	Roof air space (30mm to 100mm, non-reflective)	0,10	0,18	–	–
	Plasterboard, gypsum (10mm, 880 kg/m ³)	0,06	0,06	–	–
	Indoor air film (still air)	0,11	0,16	–	–
	<i>Total R-Value</i>	0,32	0,45	–	–
Skillion roof 2° to 12° pitch with – 10mm plaster below rafters, and – metal external cladding	Outdoor air film (7 m/s)	0,03	0,03	–	–
	Metal cladding	0	0	–	–
	Roof air space (100mm to 300mm, non-reflective)	0,15	0,22	–	–
	Plasterboard, gypsum (10mm, 880 kg/m ³)	0,06	0,06	–	–
	Indoor air film (still air)	0,11	0,16	–	–
	<i>Total R-Value</i>	0,35	0,47	–	–
100mm solid concrete roof with –10mm plaster, suspended ceiling, and – applied external waterproof membrane	Outdoor air film (7 m/s)	0,03	0,03	–	–
	Metal cladding	0	0	–	–
	Roof air space (30mm to 100mm non-reflective)	0,15	0,22	–	–
	Plasterboard, gypsum (10mm, 880 kg/m ³)	0,07	0,07	–	–
	Indoor air film (still air)	0,11	0,16	–	–
	<i>Total R-Value</i>	0,36	0,48	–	–
100mm solid concrete roof with – 10mm plaster, suspended ceiling, and – applied external waterproof membrane	Outdoor air film (7m/s)	0,03	0,03	–	–
	Waterproof membrane, rubber synthetic (4mm, 961 kg/m ³)	0,03	0,03	–	–
	Solid concrete, (100mm, 2400 kg/m ³)	0,07	0,07	–	–
	Ceiling air space (100mm to 300mm, non-reflective)	0,15	0,22	–	–
	Plasterboard, gypsum (10mm, 880 kg/m ³)	0,06	0,06	–	–
	Indoor air film (still air)	0,11	0,16	–	–
	<i>Total R-Value</i>	0,45	0,57	–	–

NOTE 1 The R-Value of an item, other than an air space, air film or air cavity, may be increased in proportion to the increased thickness of the item.

NOTE 2 The total R-Value of a form of construction may be increased by the amount that the R-Value of an individual item is increased.

NOTE 3 For ventilated spaces, the ventilation rate shall not be less than 0.5 l/s.m²

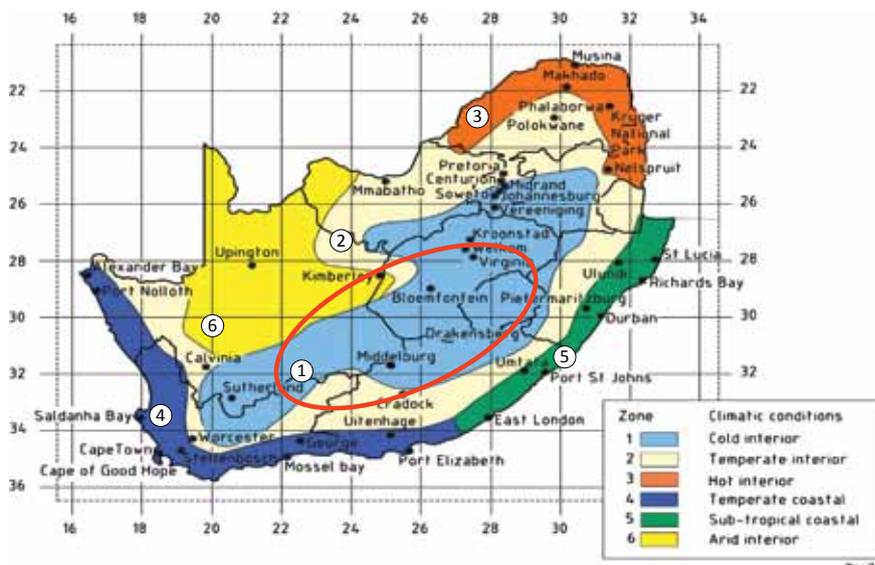
7.7 DEEMED-TO-SATISFY WORKING & CALCULATION EXAMPLES

The first fundamental matter that needs to be determined before applying the deemed-to-satisfy provisions is the climate zone in which the building is to be located.

The map of South Africa shows diagrammatically the extent of each zone and a table detailing the applicable climate zone for common locations.

Example 7.7.1 – Combination of Reflective Foil/Radiant Barrier with Bulk Insulation in Zone 1 – Alternative 1

As an example in this case, the applicable climate zone for Johannesburg is Zone 1.



Roofs in climate zone 1 are required to achieve a minimum Total R-Value of 3.7 in the upwards direction (refer Table 1 page 31).

Table 1 - Minimum required Total R-value (m².K/W) for Roofs

Climate zones	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Minimum required Total R-Value (for roof solar absorptance of more than 0.55)	3.7	3.2	2.7	3.7	2.7	3.5
Dominant direction of heat flow	Upwards	Upwards	Down and Upwards	Upwards	Downwards	Upwards

As an example, a 22° pitch metal roof with a flat ceiling in climate zone 1 achieves a Total R-Value of 0.38 (see 7.6). This means that additional insulation to achieve the minimum R-Value of 3.32 (3.7 - 0.38) in the upward direction is required to be installed in the roof.

1	2	3	4	5	6						
						Roof construction description	Component	R-value unventilated		R-value ventilated	
								Up	Down	Up	Down
Roof 22° to 45° pitch with – horizontal ceiling, and – metal cladding	Outdoor air film (7m/s)	0,03	0,03	0,03	0,03						
	Metal cladding	0	0	0	0						
	Roof air space (non-reflective)	0,18	0,28	0	0,46						
	Plasterboard, gypsum (10 mm, 880 kg/m ³)	0,06	0,06	0,06	0,06						
	Indoor air film (still air)	0,11	0,16	0,11	0,16						
	Total R-value	0,38	0,53	0,20	0,71						
Roof 22° to 45° pitch with – horizontal ceiling, and – clay tiles 19 mm	Outdoor air film (7m/s)	0,03	0,03	0,03	0,03						
	Roof tile, clay or concrete (1922 kg/m ³)	0,02	0,02	0,02	0,02						
	Roof air space (non-reflective)	0,18	0,28	0	0,46						
	Plasterboard, gypsum (10 mm, 880 kg/m ³)	0,06	0,06	0,06	0,06						
	Indoor air film (still air)	0,11	0,16	0,11	0,16						
	Total R-value	0,37	0,55	0,22	0,73						
Cathedral ceiling 22° to 45° pitch with – 10 mm plaster on top of rafters, and – metal external cladding	Outdoor air film (7 m/s)	0,03	0,03	–	–						
	Metal cladding	0	0	–	–						
	Roof air space (30 mm to 100 mm, non-reflective)	0,16	0,18	–	–						
	Plasterboard, gypsum (10 mm, 880 kg/m ³)	0,06	0,06	–	–						
	Indoor air film (still air)	0,11	0,16	–	–						
	Total R-value	0,38	0,53	–	–						



This can be achieved by installing bulk insulation or a combination of bulk and reflective foil insulation/radiant barrier.

In accordance with SANS 204 all tile roofs in climatic zones 1, 2, 4 and 6 shall have a tile underlay or radiant barrier and the joints shall be sealed.

Reflective foil laminate (see Table 4) R-Value = 0.75

Emittance of added reflective insulation	Direction of heat flow	R-value added by reflective foil insulation					
		Pitched roof (≥10°) with horizontal ceiling		Flat skillion or pitched roof (≤10°) with horizontal ceiling	Pitched roof with cathedral ceilings		
		Natural ventilated roof space	Non-ventilated roof space		22° pitch	30° pitch	45° pitch
0.2 outer 0.05 inner	Downwards	1.21	1.12	1.28	0.96	0.86	0.66
0.2 outer 0.05 inner	Upwards	0.59	0.75	0.68	0.72	0.74	0.77
0.9 outer 0.05 inner	Downwards	1.01	0.92	1.06	0.74	0.64	0.44
0.9 outer 0.05 inner	Upward	0.40	0.55	0.49	0.51	0.52	0.53

Note:

- Reflective foil insulation values inclusive of 15mm air gap. Reflective insulation should work in conjunction with an air gap to be effective.
- The R-Value of reflective insulation is affected by the airspace between a reflective side of the reflective insulation and the building lining or cladding. Dust build-up or degradation reduces R-Values.
- The reflective surface with the lowest emittance should preferably be facing downwards.

Zone 1 Total R-Value - **Total R-Value Pitch 22°** - **RFL** = **Additional R-Value**
 3.7 - 0.38 - 0.75 = 2.57 m².K/W

Additional R-Value needed for bulk insulation; as an example: fiber glass blanket = 2.57 m².K/W

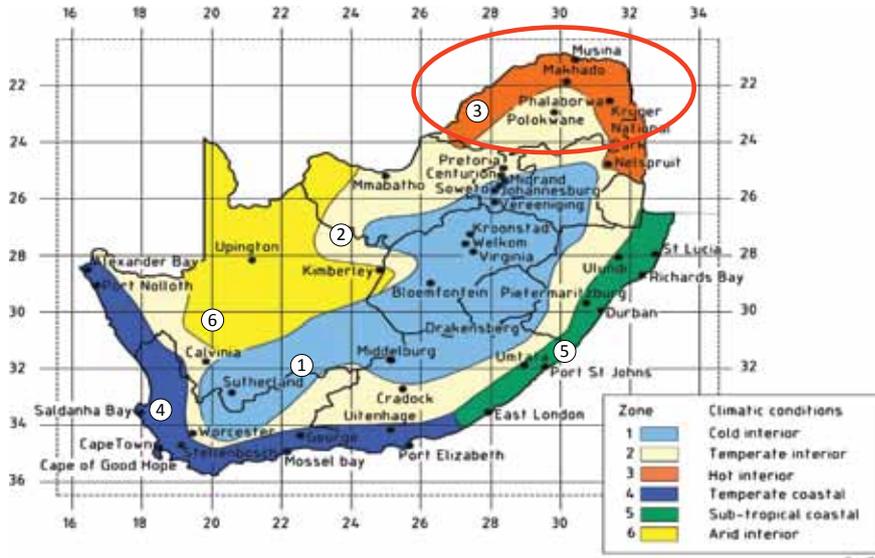
Table 3 Conductivity of Fiber Glass Blanket = 0.040 W/(m.k.)

Table 3 - Typical deemed-to-satisfy thicknesses of generic insulation products			Climatic zones					
Description			1	2	3	4	5	6
Generic Insulation Products	Density Kg/m ³	Thermal Conductivity W/(m.k.)	Recommended deemed-to-satisfy min thickness (mm) of insulation product					
Cellulose Fibre Loose-Fill	27.5	0.040	135	115	100	135	100	130
Flexible Fibre Glass Blanket	10-18	0.040	135	115	100	135	100	130
Flexible BOQ Polyester Fibre Blanket	24	0.038	130	110	90	130	90	125
Flexible Polyester Blanket	11.5	0.046	160	140	120	160	110	150
Flexible Mineral / Rock Wool	60-120	0.033	115	100	80	115	80	100
Flexible Ceramic Fibre	84	0.033	115	100	80	115	80	100
Rigid Expanded Polystyrene (EPS)SD	15	*0.035	120	100	90	120	80	115
Rigid Extruded Polystyrene (XPS)	32	*0.028	100	80	70	100	65	90
Rigid Fibre Glass Board	47.5	0.033	115	100	80	115	80	100
Rigid BOQ Polyester Fibre Board	61	0.034	115	100	80	115	80	110
Rigid Polyurethane Board	32	*0.025	85	70	60	85	60	80

R-Value of Fiber Glass Blanket (1m) = 1/0.040 = 25 m².K/W
 Thickness required = R-Value required / R-Value of material (1m)
 = 2.57 m².K/W / 25 m².K/W
 = 0.102m (approx 100mm)
 = SANS 204

Example 7.7.2 – Combination of Reflective Foil/Radiant Barrier with Bulk Insulation in Zone 3 – Alternative 2

As an example in this case, the applicable climate zone for Limpopo is Zone 3



Direction of heat flow for Climatic Zone 3 is a minimum Total R-Value of 2.7 m².K/W in a downwards direction as well as an upwards direction (refer Table 1 page 31).

Climate zones	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Minimum required Total R-Value (for roof solar absorptance of more than 0.55)	3.7	3.2	2.7	3.7	2.7	3.5
Dominant direction of heat flow	Upwards	Upwards	Down and Upwards	Upwards	Downwards	Upwards

As an example, a 22° pitch metal roof with a flat ceiling, unventilated, in climate zone 3 achieves an R-Value of 0.38 up and /or 0.53 down (see 7.6). This means that additional insulation to achieve the minimum R-Value of 2.32 (2.7 - 0.38) is required to be installed in the roof. Always use worst case scenario which in this case is 0.38

1	2	3	4	5		6	
				R-value unventilated		R-value ventilated	
				Up	Down	Up	Down
Roof 22° to 45° pitch with – horizontal ceiling, and – metal cladding	Outdoor air film (7m/s)	0,03	0,03	0,03	0,03	0,03	0,03
	Metal cladding	0	0	0	0	0	0
	Roof air space (non-reflective)	0,18	0,28	0	0,46	0	0,46
	Plasterboard, gypsum (10 mm, 880 kg/m ³)	0,06	0,06	0,06	0,06	0,06	0,06
	Indoor air film (still air)	0,11	0,16	0,11	0,16	0,11	0,16
	Total R-value	0,38	0,53	0,20	0,71	0,20	0,71
Roof 22° to 45° pitch with – horizontal ceiling, and – clay tiles 19 mm	Outdoor air film (7m/s)	0,03	0,03	0,03	0,03	0,03	0,03
	Roof tile, clay or concrete (1922 kg/m ³)	0,02	0,02	0,02	0,02	0,02	0,02
	Roof air space (non-reflective)	0,18	0,28	0	0,46	0	0,46
	Plasterboard, gypsum (10 mm, 880 kg/m ³)	0,06	0,06	0,06	0,06	0,06	0,06
	Indoor air film (still air)	0,11	0,16	0,11	0,16	0,11	0,16
	Total R-value	0,37	0,55	0,22	0,73	0,22	0,73
Cathedral ceiling 22° to 45° pitch with – 10 mm plaster on top of rafters, and – metal external cladding	Outdoor air film (7 m/s)	0,03	0,03	–	–	–	–
	Metal cladding	0	0	–	–	–	–
	Roof air space (30 mm to 100 mm, non-reflective)	0,16	0,18	–	–	–	–
	Plasterboard, gypsum (10 mm, 880 kg/m ³)	0,06	0,06	–	–	–	–
	Indoor air film (still air)	0,11	0,16	–	–	–	–
	Total R-value	0,38	0,53	–	–	–	–



Use a combination of bulk insulation and reflective foil/radiant barrier

Reflective foil laminate (see Table 4) R-Value = 0.75 m².K/W

Emittance of added reflective insulation	Direction of heat flow	R-value added by reflective foil insulation					
		Pitched roof (≥10°) with horizontal ceiling		Flat skillion or pitched roof (≤10°) with horizontal ceiling	Pitched roof with cathedral ceilings		
		Natural ventilated roof space	Non-ventilated roof space		22° pitch	30° pitch	45° pitch
0.2 outer 0.05 inner	Downwards	1.21	1.12	1.28	0.96	0.86	0.66
0.2 outer 0.05 inner	Upwards	0.59	0.75	0.68	0.72	0.74	0.77
0.9 outer 0.05 inner	Downwards	1.01	0.92	1.06	0.74	0.64	0.44
0.9 outer 0.05 inner	Upward	0.40	0.55	0.49	0.51	0.52	0.53

Note:

- a) Reflective foil insulation values inclusive of 15mm air gap. Reflective insulation should work in conjunction with an air gap to be effective.
- b) The R-Value of reflective insulation is affected by the airspace between a reflective side of the reflective insulation and the building lining or cladding. Dust build-up or degradation reduces R-Values.
- c) The reflective surface with the lowest emittance should preferably be facing downwards.

Reflective foil laminate/Radiant Barrier (Table 4- page 33) R-Value = 0.75 up or 1.12 down (non-ventilated)

Use worst case scenario.

$$\begin{aligned} \text{Zone 3 Total R-Value} & - \text{Total R-Value Pitch 22}^\circ & - \text{RFL} & = \text{Additional R-Value} \\ 2.7 & - 0.38 & - 0.75 & = 1.57 \text{ m}^2.\text{K/W} \end{aligned}$$

Additional R-Value needed for bulk insulation; as an example: fiber glass blanket = 1.57 m².K/W

Table 3: Conductivity of Fiber Glass Blanket = 0.040 W/(m.k.)

Table 3 - Typical deemed-to-satisfy thicknesses of generic insulation products			Climatic zones					
Description			1	2	3	4	5	6
Generic Insulation Products	Density Kg/m ³	Thermal Conductivity W/(m.k.)	Recommended deemed-to-satisfy min thickness (mm) of insulation product					
Cellulose Fibre Loose-Fill	27.5	0.040	135	115	100	135	100	130
Flexible Fibre Glass Blanket	10-18	0.040	135	115	100	135	100	130
Flexible BOQ Polyester Fibre Blanket	24	0.038	130	110	90	130	90	125
Flexible Polyester Blanket	11.5	0.046	160	140	120	160	110	150
Flexible Mineral / Rock Wool	60-120	0.033	115	100	80	115	80	100
Flexible Ceramic Fibre	84	0.033	115	100	80	115	80	100
Rigid Expanded Polystyrene (EPS)SD	15	*0.035	120	100	90	120	80	115
Rigid Extruded Polystyrene (XPS)	32	*0.028	100	80	70	100	65	90
Rigid Fibre Glass Board	47.5	0.033	115	100	80	115	80	100
Rigid BOQ Polyester Fibre Board	61	0.034	115	100	80	115	80	110
Rigid Polyurethane Board	32	*0.025	85	70	60	85	60	80

$$\text{R-Value of Fiber Glass Blanket (1m)} = 1/0.040 = 25 \text{ m}^2.\text{K/W}$$

$$\text{Thickness required} = \text{R-Value required} / \text{R-Value of material (1m)}$$

$$= 1.57 \text{ m}^2.\text{K/W} / 25 \text{ m}^2.\text{K/W}$$

$$= 0.062 \text{ m (approx 65mm)}$$

$$= \text{SANS 204}$$

Example 7.7.3 – Alternative 3

As an example: a metal roof pitch 45° < roof with flat gypsum ceiling – Calculation example based on X/BOU 2-8-1971, 2-74-1987- Thermal and Water Vapour Transmission ASHRAE 25-2005 (RSA values used).

Roof Structure Description:

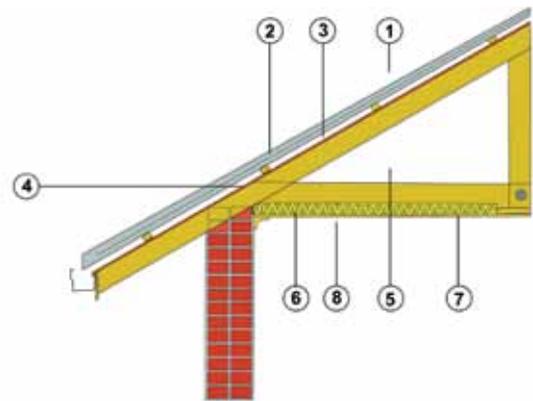
Metal Roof with 45° pitch, colour red or green, timber purlins 50mm thick x 75mm, flat ceiling, 9mm Gypsum Plaster Board fixed to rafter (tie beam), 38mm x 38mm timber battens, Natural ventilated attic space not sealed, Upper surface of Reflective Foil grey (dust covered). Reflective Foil laid as sarking slightly ditched between the trusses fixed under timber purlins.

Installation

Reflective insulation or reflective bulk insulation shall be installed over rafters; under 50mm purlins, thus creating an air space, antiglare side facing outwards and foil side facing inwards. When used reflective foil insulation shall have a 100mm or 150mm overlap in accordance with the manufacturer’s installation specification. Install the bulk insulation between the ceiling joists on the ceiling board in accordance with the manufacturer’s installation specification.

Note: Each air surface and air space contribute to the total resistance of the system in combination with the roof and ceiling material. As shown in the table below, adding a Reflective Foil membrane reduces the downward heat gain into the attic space, stabilizing the mean temperature, resulting in an improved performance of the system.

No	Description
1	Outside Air Surf Co-efficient/film
2	Metal Roof Sheet (e 0.90)
3	Ventilated 50mm air space (purlin)
4	RFL Membrane e upper 0.90 + lower 0.05
5	Air space to ceiling 100mm >+
6	105mm x 12kg Fiber Glass Blanket
7	Ceiling board 9mm Gypsum
8	Inside Air Surface coefficient e 0.90
Note	Items 4, 6 & 7 can be replaced with other insulation materials available on the market. Material properties (R-Values) to be adjusted accordingly.



Example of Bulk Insulation used in conjunction with a Reflective Foil Insulation									
		No Insulation		(4) Reflective Foil Only		Bulk Insulation Only		Reflective Foil & Bulk Insulation	
Direction of Heat Flow		Summer ↓	Winter ↑	Summer ↓	Winter ↑	Summer ↓	Winter ↑	Summer ↓	Winter ↑
1	Outside Air Surf Co-efficient	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
2	Metal Roof Sheet e 0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	50mm Air Gap e 0.90	0.00	0.00	0.192	0.143	0.00	0.00	0.192	0.143
5	Air space to ceiling 100mm >+ e 0.05	0.190	0.140	1.470	0.385	0.190	0.140	1.470	0.385
6	105mm x 12kg Fiber Glass Blanket	0.00	0.00	0.00	0.00	2.630	2.630	2.630	2.630
7	Ceiling board 9mm Gypsum	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
8	Inside Air Surface coefficient e 0.90	0.147	0.091	0.147	0.091	0.147	0.091	0.147	0.091
Direction of Heat Flow		Summer ↓	Winter ↑	Summer ↓	Winter ↑	Summer ↓	Winter ↑	Summer ↓	Winter ↑
Total R-Value (Resistance) m²K/W		0.437	0.331	1.91	0.720	3.070	2.960	4.540	3.349
Total U-Value (Transmittance) W/m²K		2.290	3.020	0.52	1.390	0.326	0.338	0.220	0.300

Note: Calculations are based on X/BOU 2-8-1971, 2-74-1987- Thermal and Water Vapour Transmission ASHRAE 25-2005 (RSA values used).

7.8 EXTERNAL WALLS - MINIMUM REQUIRED TOTAL R-VALUE (m².K/W)

Table 5: Light weight external walls surface density less than 180kg/m ² – Deemed-to-satisfy minimum total R-Value for each climate zone						
Climatic zones	1	6	2	3	4	5
Minimum required Total R-Value for walls (m ² .K/W)	2.2		1,9			

a) Constructions with a surface density less than 180 kg/m², shall achieve a minimum total R-Value of:

1. for climatic zones 1 and 6, a total R-Value of 2.2; and
2. for climatic zones 2, 3, 4 and 5, a total R-Value of 1.9.

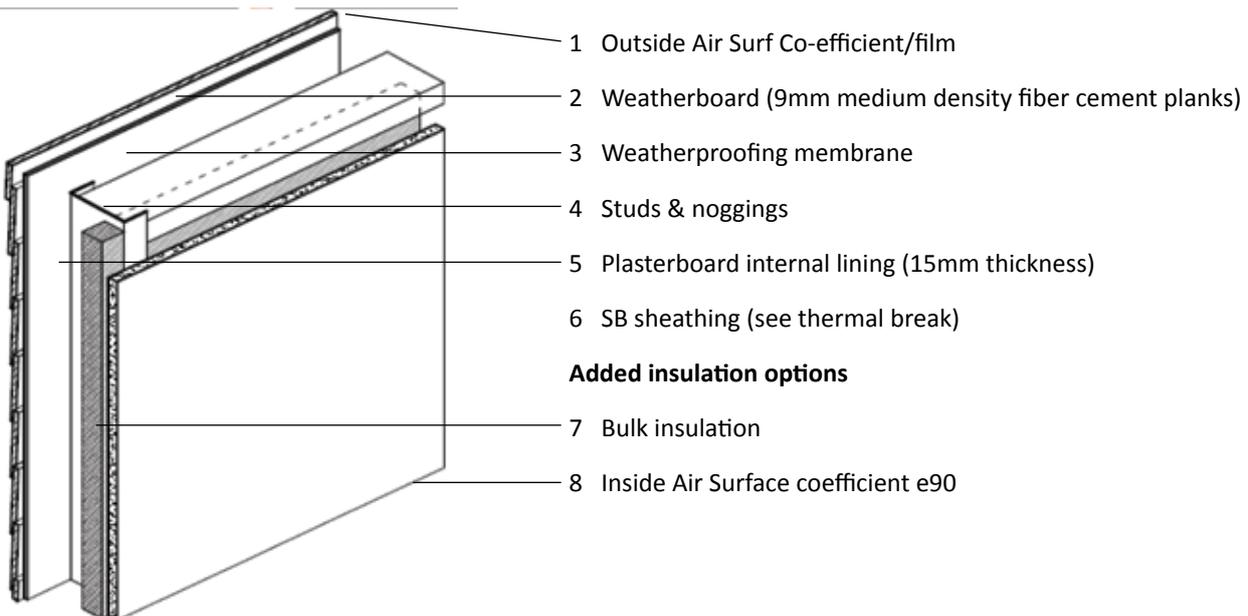
b) Constructions with a surface density greater than 180 kg/m², shall achieve a minimum total R-Value of 0.4.

Notes:

1. External walls are defined as the complete walling system, as measured from the outer skin exposed to the environment, to the inside of the inner skin exposed to the interior of the building, and does not include glazing.
2. Designers should consider that interstitial condensation occurs in walling systems which are not able to accommodate moisture migration. The selection of vapour barriers and appropriate construction materials, including insulation, is important for the thermal efficiency of walling in climate zones where damp and high relative humidity is experienced.
3. Thermal resistance that is added to external walling with high thermal capacity, should be placed in between layers e.g. in the cavity of a masonry wall. Thermal resistance should not be added to the internal face of a wall with high thermal capacity.

Example:

Weatherboard (fiber cement or timber planks) external cladding: Total R-Value of external light weight wall system with a surface density less than 180 kg/m²



7.9 FLOORS - MINIMUM REQUIRED TOTAL R-VALUE (m².K/W):

7.8.1 With the exception of zone 5 (see fig.1 climatic zones), buildings with a floor area of less than 500 m² with, a concrete slab-on-ground shall have insulation installed around the vertical edge of its perimeter which shall

- a) have an *R-Value* of not less than 1,0,
- b) resist water absorption in order to retain its thermal insulation properties, and
- c) be continuous from the adjacent finished ground level
 - 1) to a depth of not less than 300mm, or
 - 2) for the full depth of the vertical edge of the concrete slab-on-ground.

Note: There are no requirements for perimeter insulation in climatic zone 5.

7.8.2 Where an in-slab or in-screed heating system is installed it shall be insulated underneath the slab with insulation having a minimum R-Value of not less than 1,0.

7.8.3 With the exception of climatic zone 5, a suspended floor that is part of a building's envelope shall have insulation that shall retain its thermal properties under moist conditions and be installed:

- a) for climatic zones 1 and 2, with a partially or completely unenclosed exterior perimeter, and shall achieve a total *R-Value* of 1,5,
- b) for climatic zones 3, 4 and 6, with a partially or completely unenclosed exterior perimeter, and shall achieve a total *R-Value* of 1,0, and
- c) with an in-slab heating system, and shall be insulated around the vertical edge of its perimeter and underneath the slab with insulation having a minimum *R-Value* of not less than 1,0.

Note: Care should be taken to ensure that any required termite management system is not compromised by slab edge insulation. In particular the inspection distance should not be reduced or concealed behind the insulation.

7.10 EXPLANATORY INFORMATION

7.10.1 Typical Roof Absorptance

A light coloured roof reduces the flow of heat from solar radiation better than a dark colour roof. A roof with a solar absorptance value of less than 0.55 means the roof is of a light colour such as white, off-white, cream or dull zinc aluminium.

Typical absorptance values are as follows:

Colour	Value
Slate (dark grey)	0.9
Red, green	0.75
Yellow, buff	0.6
Zinc aluminium – dull/aged	0.55
Galvanised steel – dull/aged	0.55
Light grey	0.4
Off white	0.35
Light cream	0.3

Note: A suitable international test for solar absorptance of the roof upper surface is ASTM E903.

7.10.2 Total R-Value of a typical construction

Section 8.2.1 provides examples of various roofs. The Total R-Value required is achieved by adding the Total R-Value of the basic element, i.e. roof and ceiling, walls or floors, and the R-Value of any additional insulation incorporated in that element (described as the “minimum added R-Value of insulation”). The Total R-Value of the basic roof and ceiling has been determined by adding together the R-Values of the outdoor air film, roof cladding, roof air space, ceiling sheet lining and internal film.

7.10.3 Position of insulation in the system

The insulation location options can be used either separately or in combination provided the required thermal performance is achieved and other aspects of the building’s integrity are not compromised. Alternatively, the designer may choose another method to insulate provided the *Total R-Value* is achieved.

It should be noted that insulation installed under the roof, rather than on the ceiling, in a building with a large roof space is less effective for heat retention because of the additional volume of roof air space that would need to be heated or cooled.

7.10.4 Choice of insulation

There are a number of different insulation products that may be used to achieve the minimum added *R-Value*. However, care should be taken to ensure that the choice made is appropriate for the construction and climatic conditions as the location and relationship between the various options may not be suitable in all circumstances for both practical and technical reasons. For instance, in some climate zones, reflective and certain bulk insulation sheets should be installed with due consideration of condensation and associated interaction with adjoining building materials.

7.10.5 Reflective Foil Insulation/Radiant Barrier

Reflective insulation is considered to achieve the *R-Values* as per Table 4 when used in conjunction with the *Total R-Value* of a pitched roof and ceiling construction. To achieve these values, reflective insulation is required to have a minimum air space of 15 mm between a reflective side of the reflective insulation and the adjoining building lining or cladding.

The R-Value of reflective insulation is affected by the airspace between a reflective side of the reflective insulation and the building lining or cladding. The actual *R-Value* added by reflective insulation and its adjoining airspace should be determined for each product or project, taking into consideration factors such as the number of adjacent airspaces, dimensions of the adjacent airspace and whether the space is ventilated or non-ventilated.

When reflective insulation has an anti-glare coating on one side, the emittance value of that side will be greater than the value of the uncoated side. Also, where another emittance value for reflective insulation is used (other than the value used in the table below), care should be taken to ensure that the number of airspaces allowed for is consistent with the form of construction and whether the airspace is reflective, partially reflective or non-reflective. Where bulk insulation fills the airspace, the *Total R-Value* should be reduced to take account of the loss of airspace.

7.10.6 Ventilated and Unventilated airspace

The roof space ventilation option applies to a pitched roof with a flat ceiling to ensure that efficient cross ventilation is achieved in the roof space to remove hot air. Roof space ventilation is generally not suitable for most flat, skillion, cathedral ceiling and similar roof types because of the lack of space between the ceiling and roof. Care should be taken to ensure that the roof ventilation openings do not allow vermin and rain penetration.

The Total R-Value of the roof and ceiling materials may need to be adjusted if other building elements such as “sarking” are also installed. For example, sarking or sheet insulation under tiles may change a roof space from “ventilated” to “unventilated”

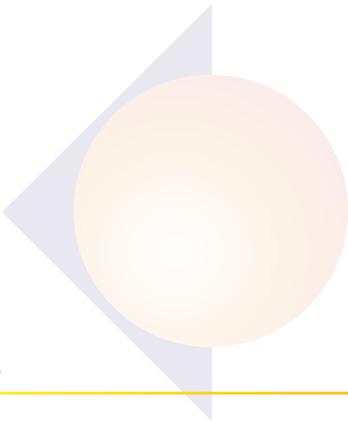
7.10.7 Thermal Bridging

Irrespective of the framing material used, the minimum added *R-Value* specified is deemed to include the effect of thermal bridging created by framing members.

7.10.8 Thermal Break

Because of the high thermal conductance of metal, a thermal break is to be provided where the ceiling lining of a house or building is fixed directly to the underside of the metal purlins or metal battens of a metal deck roof or where there is no ceiling lining. The purpose of the thermal break is to ensure that the thermal performance of this form of roof construction is comparable to that of a similar roof with timber purlins or timber battens.

A thermal break may be provided by materials such as timber, high density polyurethane, polystyrene strips, plywood or high density bulk insulation. The material used as a thermal break must separate the metal purlins or metal battens from the metal deck roofing and achieve the specified R-Value. Reflective insulation alone is not suitable for use as a thermal break because it requires an adjoining airspace to achieve the specified R-Value. Polyurethane or polystyrene strips of not less than 12mm thickness, compressed bulk insulation and timber of not less than 20mm thickness are considered to achieve an R-Value of not less than 0.2.



CHAPTER 8

WHERE TO INSTALL INSULATION

Where to install Insulation – New Buildings

The most economical time to install insulation is during construction of new buildings and during renovations before walls, floors and ceiling spaces are closed in. However, it's also common (and cost-effective) to install insulation or upgrade insulation in existing homes.

Most heat is lost through the ceiling and roof and that should be the top priority for insulation. The design and construction of a building will affect the specific types of insulation which can be used, and where the insulation can be installed.

With some construction systems - such as aerated concrete blocks and straw bales - little or no additional insulation may be required.

Table 6: Suggested Materials and Typical Applications for Insulation Products

General Material Description	Flat Ceiling	Cathedral Ceilings or Raked Ceilings	Timber Floors	Concrete Slabs	Concrete Slab Edges	Full Masonry Walls	Framed Walls
Batts & Blankets							
Glasswool	•	•	•	•	•	•	•
Rockwool	•	•	•	•	•	•	•
Stonewool	•	•	•	•	•	•	•
Slagwool	•	•	•	•	•	•	•
Polyester	•	•	•			•	•
Loose Fill							
Cellulose Fiber	•	•					
Boards							
Expanded Polystyrene	•	•	•	•	•	•	•
Extruded Polystyrene	•	•	•	•	•	•	•
Polyester Board	•	•	•			•	•
Polyurethane	•	•	•			•	•
Polyisocyanurate	•	•	•	•	•	•	•
Composite Bulk	•	•	•	•	•	•	•
Reflective Foils	•	•	•				•

Fire notice: Products need to be tested and classified in accordance with SANS 428 Fire performance classification of thermal insulated building envelope systems.

8.1 LOCATION OF INSULATION

The thermal performance of the roof may vary depending on the position of the insulation, the climatic conditions, design of the house or building and the way in which it is operated. The insulation location options can be used either separately or in combination provided the required thermal performance is

achieved and other aspects of the building's integrity are not compromised. Alternatively, the designer may choose another method to insulate provided the *Total R-Value* is achieved.

It should be noted that insulation installed under the roof cover, rather than on the ceiling, in a conditioned building with a large roof space is less effective because of the additional volume of roof air space that would need to be heated or cooled. Conversely, for an unconditioned building, the use of reflective insulation is more effective when placed directly under the roof cover.

Care should be taken when installing insulation to ensure that it does not interfere with the safety or performance of domestic services and fittings such as heating flues, recessed light fittings, gas appliances and general plumbing and electrical components. This includes providing appropriate clearance as detailed in relevant legislation and referenced standards such as for electrical, gas and fuel oil installations.

1. Prevent draughts of unused chimneys by sealing.
2. Install loose-fill or blanket insulation in the loft.
3. Insulation can be fitted above a false ceiling.
4. Install insulation around geysers and pipes.
5. Install insulation under floor during building stage.
6. Install reflective foil over the rafters.
7. Install insulation between the rafters.
8. Install insulation in the walls at building stage.
9. Install insulation in partitioning.
10. Use insulation as a ceiling board



8.2 ROOFS AND CEILINGS

Roofs and ceilings work in conjunction when it comes to insulation. About 42% of heat loss from an average un-insulated home occurs through this area and can save on heating and cooling energy with roof and ceiling insulation.

- Install insulation under the roofing material to reduce radiant heat gain.
- Install insulation in the attic to reduce heat gain and loss. In most cases ceiling insulation is installed between the tie beams/trusses directly on the ceiling.

Veranda/Patio/Canopy roofs should be insulated to reduce radiant heat gain in hot climates where outdoor living spaces are used extensively. Heat build up under verandas /patios/canopies not only affects the space below but can affect conditions inside the building; warm air always migrates to a cooler area.

Bulkheads (wall sections between ceilings of different heights) should be insulated to the same level as they are subject to the same temperature extremes.

Adding or "retrofitting" insulation to existing buildings provides a major opportunity to increase comfort and reduce energy costs and greenhouse gas emissions.

Ceiling insulation is simple to fit if the roof space is accessible. If a building 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. A thermal insulated ceiling board could also be retrofitted to the underside of exposed beams or existing ceilings.

Use reflective insulation under the roof cover and bulk insulation in the ceiling. Rolling bulk blanket insulation across ceiling battens between tie beams is the most effective way to insulate the ceiling. Reflective insulation can be difficult to fit to the roof of an existing home unless the roof is replaced.

8.2.1 Typical roof/ceiling insulation applications examples:

Climatic Zones		1	2	3	4	5	6
Minimum required Total R-Value (m ² .K/W) (for roof solar absorptance of more than 0.55)		3.7	3.2	2.7	3.7	2.7	3.5
Direction of heat flow		Up	Up	Down and Up	Up	Down	Up
(a) Flat roof and cathedral ceiling – ceiling lining under rafters (concealed rafters) unventilated roof space							
Tiled roof (clay or concrete)	Total R-Value of Roof & ceiling materials	0.37	0.37	0.37	0.37	0.43	0.37
	Minimum added R-Value of insulation	3.33	2.83	2.33	3.33	2.27	3.13
Metal roof	Total R-Value of Roof & ceiling materials	0.35	0.35	0.35	0.35	0.41	0.35
	Minimum added R-Value of insulation	3.35	2.85	2.35	3.35	2.29	3.15
(b) Flat roof and cathedral ceiling – ceiling lining on top of rafters (exposed rafters) unventilated roof space							
Tiled roof (clay or concrete)	Total R-Value of Roof & ceiling materials	0.37	0.37	0.37	0.37	0.43	0.37
	Minimum added R-Value of insulation	3.33	2.83	2.33	3.33	2.27	3.13
Metal roof	Total R-Value of Roof & ceiling materials	0.35	0.35	0.35	0.35	0.41	0.35
	Minimum added R-Value of insulation	3.35	2.85	2.35	3.35	2.29	3.15
(a)							
(b)							
(c) Pitched roof with flat ceiling – ventilated roof space							
Tiled roof (clay or concrete)	Total R-Value of Roof & ceiling materials	0.22	0.22	0.22	0.22	0.73	0.22
	Minimum added R-Value of insulation	3.48	2.98	2.48	3.48	1.97	3.28
Metal roof	Total R-Value of Roof & ceiling materials	0.20	0.20	0.20	0.20	0.71	0.20
	Minimum added R-Value of insulation	3.50	3.00	2.50	3.50	1.99	3.30
(d) Pitched roof with flat ceiling – unventilated roof space							
Tiled roof (clay or concrete)	Total R-Value of Roof & ceiling materials	0.40	0.40	0.40	0.40	0.55	0.40
	Minimum added R-Value of insulation	3.30	2.80	2.30	3.30	2.15	3.10
Metal roof	Total R-Value of Roof & ceiling materials	0.38	0.38	0.38	0.38	0.53	0.38
	Minimum added R-Value of insulation	3.32	2.82	2.32	3.32	2.17	3.12
(c)							
(d)							

Notes:

1. Required insulation can be installed in the roof, the ceiling or a combination of both.
2. The Total R-Value of the basic roof and ceiling has been determined by adding together the R- values of the outdoor air film, roof cladding, roof air space, ceiling sheet lining and internal film.
3. The Total R-Value of the roof and ceiling materials may need to be adjusted if other building elements such as sarking (Reflective Foil Laminates) are also installed.
4. The Total R-Value in Figure (c) is based on there being natural ventilation of the roof space through the gaps in the roof tiles. However, Figures (a), (b) and (d) assume that there is no ventilation of the roof space through the metal roofing.
5. Where the solar absorptance of the roof upper surface is less than or equal to 0.55, the minimum added R-Value of insulation may be reduced by 0.5 to account for the lower minimum Total R-Values specified for climate zones 3 and 5.
6. The direction of heat flow is considered to be the predominant direction of heat flow for the hours of occupation of the building. It takes into account the higher rate of occupancy of houses at night time rather than day time.
7. Irrespective of the framing material used, the minimum added R-Value specified is deemed to include the effect of thermal bridging created by framing members.

8.3 WALLS

Approximately 24% of heat from an average un-insulated home is lost through the walls. Wall insulation can double as a moisture barrier/retarder.

External walls should be insulated to reduce radiant and conducted heat transfer.

Wall insulation can be installed:

- Within cavities
- On the outside surface of solid 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 (i.e. the internal brick skin) is protected from external temperature changes, and becomes highly effective at regulating temperatures within the building.

Insulate existing cavities by:

- Pumping in loose bulk material to a measured density
- Installing bulk insulation sheets/boards

If using a framed construction system, insulation should be placed in the wall framing. Insulation can also be installed on the outside of the framing (but the insulation must be weatherproof to be effective).

Note that the amount of insulation installed may depend on the thickness and thermal mass of the walls and the size of the framing.

If building a new home or renovation, consider increasing the framing size to fit in more insulation. If using a solid construction system such as concrete, insulation should be placed on the inside of the wall leaf and within the cavity.

8.4 FLOORS

Up to 20% of heat loss occurs through the floor of un-insulated houses. Insulation should be used:

- on the underside of raised timber, mezzanine or floor between upper and lower level, or concrete floors
- on the edge of concrete floor slabs.
- Under slab if under floor heating is installed.
- Mixed into concrete - if tested and designed to use in the specific application.

Total R-Values describe the total resistance to heat flow provided by a roof /ceiling, a wall system or a floor system. These values are calculated from the resistances of each component, including the insulation.

Calculation of R-Values of floor with perimeter insulation, refer to ISO 13370 Thermal performance of buildings - Heat transfer via the ground - Calculation methods.

8.5 INSULATING GEYSERS & PIPES

Hot water pipe cladding or insulation significantly reduces heat losses to the atmosphere while hot water is in transit to outlets and taps. All exposed pipes to and from the hot water cylinders and central heating systems shall be insulated within 1 metre of the connection to the heating or cooling system, with insulation material with an R-Value in accordance with Table 7.



Insulation shall:-

- a) be protected against the effects of weather and sunlight,
- b) be able to withstand the temperatures within the piping, and
- c) achieve the minimum total R-Value given in Table 7.

The whole essence of fitting a geyser with a geyser blanket is to minimize thermal energy (heat) lost and thereby saving energy. Theoretical calculations show that substantial savings can be achieved with the installation of geyser blankets.

Table 7: Recommended Additional Energy Efficiency Interventions

Internal diameter of pipe	Minimum R-Value ^a (m ² .K/W)
≤ 80mm	1,00
> 80mm	1,50
Flat and almost flat surface (for example, surface of water container (geyser))	2,00 ^b

^a Determined with a hot surface temperature of 60 °C and an ambient temperature of 15 °C.
^b Including manufacturer installed insulation

8.6 BUILDING SEALING

While adequate controllable ventilation is essential to provide fresh air, prevent condensation, and help cool a building on summer nights, draughts can create discomfort and lead to energy losses in both summer and winter.

In winter, draughts can account for up to 25% of heat losses. Reducing these draughts can be a cheap and cost effective way of reducing heating and cooling costs.

New buildings should be built to minimize draughts, by avoiding gaps at construction joints between different wall materials, and where walls join or meet the ceiling and the floor, and by ensuring that doors and windows fit snugly in their frames.

Building envelope

Roofs, external walls, and floors that form the building envelope and any opening such as windows and doors in the external fabric shall be constructed to minimize air leakage. The building sealing can be done by methods such as caulking, or adding skirting, architraves or cornices.

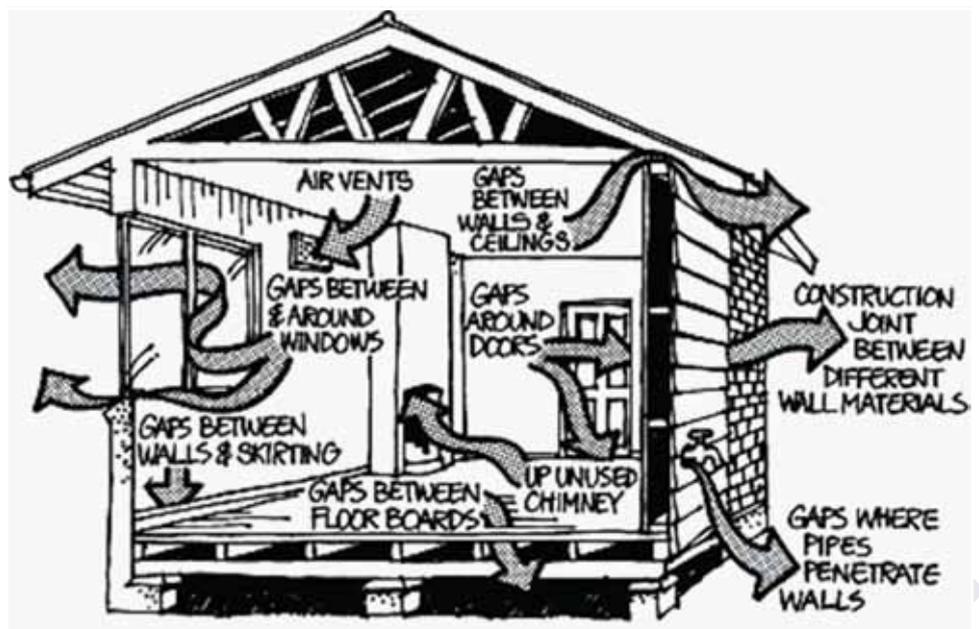
Air infiltration and leakage

In climatic zones 1, 2, 4 and 6 the ceiling voids and attics shall be designed so as to minimize air infiltration. Accordingly, wall plate and roof junctions shall be sealed. All tile roofs in these climatic zones shall have a tile underlay or radiant barrier and the joints shall be sealed. The joints in sheeted roofs shall be sealed.

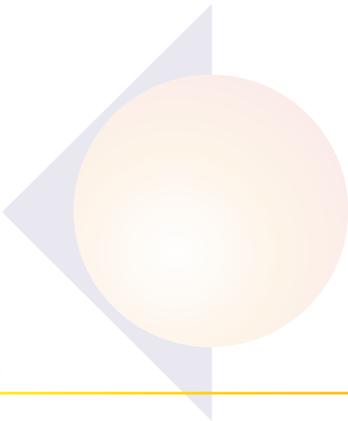
Draughts can be further reduced by:

Draught proofing doors and windows

- Sealing up cracks and gaps
- Sealing unnecessary vents
- Sealing exhaust fans and outlet grills
- Sealing unused fireplaces
- Sealing vented skylights



Major sources of heat leaks and draughts.



CHAPTER 9

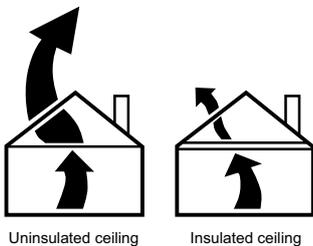
RETROFITS AND RENOVATIONS– EXISTING BUILDINGS

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. The cheapest and simplest way of insulating a loft is to place insulation material on the ceiling between the trusses.

A thermal insulated ceiling board could also be retrofitted to the underside of exposed beams. Various types of natural and man-made materials are available, either in rolled blankets, boards or in granulated form. The choice should be based on the cost and ease of installation and cost benefit.

This section explains how to retrofit insulation to various construction types. Refer to Chapters 6 and 7 to determine the appropriate type and level of insulation for your climate.

9.1 ROOFS AND CEILINGS



Roofs and ceilings work in conjunction with one another to achieve the desired R-Value. Insulating the ceiling will prove cost-effective and simple to achieve in most cases if the roof space is accessible. In the residential market the ceiling is the most important place to insulate because up to 45 percent of the heat loss from an un-insulated house is lost through the ceiling. In the summer, an un-insulated ceiling will provide little protection from the heat. A house will be much more comfortable and energy efficient year-round with an investment in installing insulation.

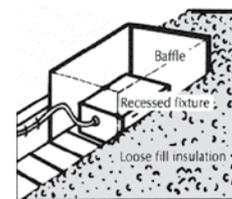
9.1.1 Bulk Insulation or Cellulose Loose-fill

Ceilings can be insulated with blown, poured, or blanket/batt-type insulation materials. Fiberglass or polyester blankets may be used and installed on top of ceilings between beams. Cellulose Loose fill is poured or blown into place. Ensure that the ceiling can support the weight of the insulation required.

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

Whether you're using blown, poured, or batt material, the following preparations are important:

- Heat-producing fixtures should be isolated from the thermal insulation to prevent fire hazards. These include recessed lighting fixtures. Where down lights that penetrate the ceiling are used care must be taken not to have direct contact with insulation or to have the transformers underneath the insulation. Batt-type insulation can be installed around recessed fixtures without having to use baffles, but for safety reasons, clearances should be left around hot objects such as flues from fires, recessed down lights and their transformers, whereas with loose fill it is a requirement.
- Insulation must be kept at least 5cm back from these openings. If using blanket or batt insulation, leave a 5cm spaces on both sides of the fixtures and frame the openings with wood or metal baffles that extend at least 10cm above the depth of the insulation



Note: Wherever possible avoid recessed light fittings as these are a major source of heat loss.

9.1.2 Reflective Foil Insulation or Radiant Barriers

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 (gap) of at least 25mm next to the shiny surface. In South Africa it is common practice to use a 25mm air gap whereas in Australia a 15mm air gap is used in practice. The insulation is installed across the rafters before the brandering is nailed down, thus providing the air gap. The thermal resistance of reflective insulation varies with the direction of heat flow through it.

Tiled roofs without reflective foil laminates 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 roof space, double sided foil or foil blankets/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 an underlay 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 the addition of heat-reflective roof paints are also an option.

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. Rigid board insulation is a useful material in this situation which will have a dual function i.e. ceiling board and insulation in one.

9.2 CAVITY BRICK WALLS

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 hot conditions. If a wall cavity is insulated, the internal thermal mass (i.e. the internal brick skin) is protected from external temperature changes, and becomes highly effective at regulating temperatures within the building.

9.3 BRICK VENEER AND TIMBER FRAMED WALLS

Brick Veneer 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.

Timber framed walls are low mass construction, and rely entirely upon insulation to maintain thermal comfort. The cavity fill method previously described (see Chapter 8 for types) can be used to insulate these wall types if the lining or cladding is not being removed during the retrofit.

For timber frame walls, the internal plasterboard linings or external cladding should be removed and insulation fitted in the stud frame into the voids between studs and noggings.

Bulk insulation batts or reflective insulation can be retro-fitted to existing wall frames by either cutting up a roll or fitting the pieces between each wall stud and fixing the insulation to the substrate.

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. It is important to choose the correct thickness of insulation to suit the thickness of the cavity.

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.

9.4 FLOORS

Floors do not always require insulation. Raised timber floors should have sub floor 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 sub floor access.

9.5 AIR LEAKAGE

The residential market can improve the energy efficiency of most existing homes by weather sealing.

Overseas standards and research recognizes that the weather proofing or draught sealing of houses is the most effective method of achieving direct energy savings, whilst maintaining healthy indoor air quality. Draughts can account for up to 25 per cent of heat loss from a home.

CHAPTER 10

INSULATIONS TIPS

The following installation principles will ensure the best possible performance from insulation:

10.1 AVOID GAPS AND VOIDS IN INSULATION

Avoid gaps and voids in all types of insulation. Even a small gap can greatly reduce the insulating value. Fit batts snugly and do not leave gaps around ducts and pipes. Tape up holes and joins in reflective insulation. Ensure that corners of walls, ceilings and floors are properly insulated as these are areas where heat leaks most often occur.

For safety reasons, clearances must be left around hot objects such as flues from fires, recessed down lights and their transformers.

Wall insulation must butt into door and window frames. In cold climates, metal frames around glazing should have thermal breaks to reduce heat loss.

Insulate the internal walls between a house and the adjoining un-insulated spaces such as garages and storerooms.

Ensure that all window and door frames are sealed effectively. However ensure that there is sufficient ventilation where fossil fuels are burned directly as an energy source.

10.2 COMPRESSION OF BULK INSULATION

Do not compress bulk insulation as this will reduce its effectiveness. Ensure there is sufficient space for the insulation to regain and retain its prescribed intended thickness.

10.3 THERMAL BRIDGES

Eliminate thermal bridges. The building frame can act as a thermal bridge, particularly in cold climates, conducting heat and allowing it to bypass otherwise effective insulation. Metal framing is a particular issue because of its high conductivity. The presence of the frame reduces the overall insulation value, as the frame can constitute up to 15 percent of the wall, ceiling or floor surface. Conduction via the frame is some 3 -5 times that of the insulated wall.

To help overcome the effect of thermal bridging:

- Use 10mm polystyrene or any other approved non-compressible isolating strips (thermal block) between the frame and the cladding.
- Fix bulk insulation over the external or internal surface of the frame.

10.4 PROTECT INSULATION FROM CONTACT WITH MOISTURE

Keep moisture away from bulk insulation, or its performance will be reduced (water resistant types are an exception). Bulk insulation in cavities should not come into contact with the porous outer skin of the wall. Use a vapour barrier/retarder where there is a risk of condensation.

Cavity fill insulation (loose fill or injected foam) is particularly useful for insulating existing cavity walls.

Potential problems to be aware of include overheating of electrical cables, damp problems (if the insulation is absorbent) and moisture transfer across the cavity by capillary action. Injected foams can cause bowing of the walls in some cases if incorrect application practices are employed.

10.5 PROVIDE VAPOUR AND MOISTURE BARRIERS TO PREVENT CONDENSATION

Provide vapour and moisture barriers to the warm side of the thermal insulation to prevent condensation. Vapour barriers/retarders include polythene sheet, reflective foil, foil backed plasterboard and well maintained water resistant painted surfaces. Water resistant insulation such as polystyrene can also act as a vapour retarder. Tape or glue all joints in vapour barriers to keep out moisture and ensure that there are no tears or pinholes or damage in the membrane.

Use vapour barriers to protect from condensation:

- In hot humid (tropical) climates.
- In cool climates where the difference between indoor and outdoor temperature is significant.
- In roof spaces with a low ventilation rate, for example cathedral or raked ceilings.
- In situations where high amounts of vapour are generated and not exhausted.
- On the underside of metal roofing, to minimize the likelihood of corrosion, surface mould, decay of wood based materials, sheet plastics, etc.

In cold climates place the vapour barrier on the warm inside of the insulation (directly above the ceiling lining and next to the internal wall lining).

In warm climates place the vapour barrier on the outside of the insulation. In hot humid climates it is ideal to have bulk insulation with a double sided vapour barrier. The top vapour barrier can be installed on site or a loose outlay.

Note: The above is a very wide rule of thumb approach and a general design guide, for more critical design each application must be considered on its own merits and may require professional advice.

Use perforated reflective foil in walls and under mezzanine floors when building with porous materials. The perforations prevent water droplets from penetrating but allow vapour through so that the insulation can dry if it does somehow get wet. This prevents rotting behind weatherboards or under timber floors, for example.

10.6 PROVIDE AN AIR SPACE WITH REFLECTIVE INSULATION

Reflective insulation must maintain an air space of at least 15mm next to the shiny surface or both surfaces of reflective insulation (refer Table 4 BCA 2007). If this is not done the insulating properties will be reduced.

Dust settling on the reflective upper surface of insulation will greatly reduce its performance. Face reflective surfaces downwards or keep them vertical.

10.7 ROOF VENTILATION

In hot dry climates (zone 3 & 6), the roof space should be ventilated where possible, to allow the built up heat to dissipate. Even in cooler climates a minimal amount of ventilation is desirable to allow built up moisture to escape. Sufficient ventilation is often achieved through the air gaps along the ridgeline or between tiles. Gable or eaves vents may also be considered.

Ventilated roof spaces in hot humid (tropical) climates (zone 5) can result in excessive condensation under the roof. Minimize roof ventilation in these conditions. Note that roof ventilation only has a marginal effect on cooling compared to good insulation design in these climates. However roof ventilation improves the performance of Reflective Foil insulation for downward heat flow. As a caution to fire risk, cover any openings with fine stainless steel mesh to prevent cinders from entering the roof space. Keep roof spaces weather tight and vermin proof.

Loose-fill insulation should not be used in excessively draughty roof spaces or ceilings with a slope of 25 degrees or more. In other applications, keep the density of the insulation consistent to avoid reducing the R-Value. Note that loose-fill insulation may settle by as much as 25 percent over time. Ask your contractor for a guaranteed 'settled R-Value'. For safety reasons, clearances must be left around hot objects such as recessed down lights and their transformers.

10.8 CONDENSATION

Air always contains a certain amount of water vapour. This vapour can originate from many sources around the home – respiration, cooking, bathrooms and laundries, indoor plants, LPG gas heaters etc. When moist air is cooled below its dew point (i.e. cooled to a temperature at which it can not contain all the water originally present), and if the cooling is caused by contact with a colder surface, the vapour changes to liquid droplets on that surface. This phenomenon is called condensation.

Condensation is more likely to occur:

- where there is a low ventilation rate within the walls or roof space, insufficient to remove water vapour (e.g. cathedral and flat roof ceilings);
- where daytime temperatures do not exceed 5°C (e.g. in alpine areas in winter); and
- where high amounts of water vapour are generated internally but not mechanically exhausted.

Artificial cooling of buildings in some climates can cause condensation to form inside the layers of the building envelope. Such condensation can cause significant structural or cosmetic damage to the envelope before it is detected. Associated mould growth may also create health risks to the occupants. Effective control of condensation is a complex issue. In some locations a fully sealed vapour barrier may need to be installed on the more humid, or generally warmer, side of the insulation.

10.9 BARRIERS TO PREVENT CONDENSATION

Condensation in bulk insulation reduces its insulating properties significantly. Vapour barriers stop the transmission of water vapour generated inside the home, through the building elements and into the building structure.

A vapour barrier installed on the warm side of insulation will prevent moist air from contacting a cold surface. The vapour barrier should be continuous, with no breaks. Vapour barriers include well-maintained painted surfaces, polythene sheeting and aluminium foil laminate.

If aluminium foil is required to act as both thermal insulation and a vapour barrier, ensure that an airspace is provided.

Moisture barriers stop the transmission of water from outside the building entering through the building elements. Sarking may be installed directly under roofing material to act primarily as a moisture barrier. It is usually made of reflective foil laminate (which adds to the insulation effect), or other waterproof material.

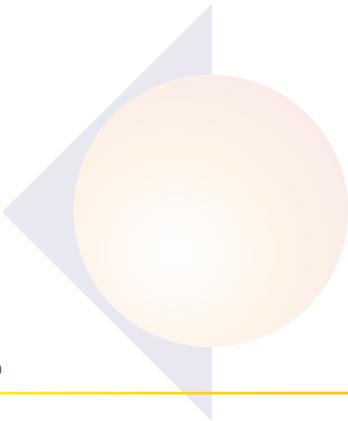
Vapour barriers include polythene sheet, reflective foil, foil backed plasterboard and well maintained water resistant painted surfaces. Water resistant insulation such as polystyrenes can also act as a vapour retarder. Tape or glue all joints in vapour barriers to keep out moisture and ensure that there are no tears or pinholes or damage in the membrane.

Vapour barriers should not have permeability greater than $< 0.005 \text{ g/m}^2$ and vapour retarders should not have permeability greater than $< 0.050 \text{ g/m}^2$.

The moisture vapour transmission rate (MVTR), also known as water vapour transmission rate (WVTR), is a measure of the passage of water vapour through a substance. The most common international unit for the MVTR is $\text{g/m}^2/\text{day}$.

Use vapour barriers to protect from condensation:

- In hot humid (tropical) climates.
- In cool climates where the difference between indoor and outdoor temperature is significant.
- In roof spaces with a low ventilation rate, for example cathedral or raked ceilings.
- In situations where high amounts of vapour are generated and not exhausted.
- On the underside of metal roofing, to minimize the likelihood of corrosion, surface mould, decay of wood based materials, hydration of plastics, etc.



CHAPTER 11

HEALTH & SAFETY TIPS

Important Notice: Clearance around Appliances and Fittings!

Care should be taken when installing insulation to ensure that it does not interfere with the safety or performance of domestic services and fittings such as heating flues, recessed light fittings, gas appliances and general plumbing and electrical components. This includes providing appropriate clearance as detailed in relevant legislation and referenced standards such as for electrical, gas and fuel oil installations.

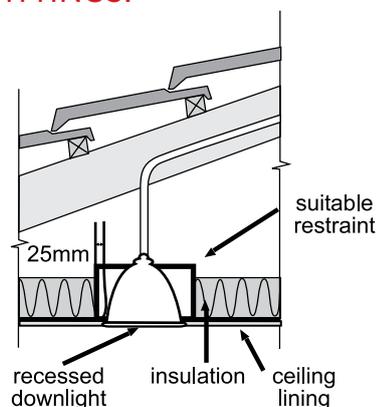
Some appliances and fittings, such as recessed down lights and heater flues, require free space around them for the dissipation of heat, to reduce fire hazards. Insulation should not be placed against these fixtures. Regulations and manufacturers' recommendations should always be checked before installing insulation.

11.1 ALLOW CLEARANCE AROUND APPLIANCES AND FITTINGS.

Electrical wiring must be appropriately installed and should not be covered by insulation or it may overheat.

Unless otherwise specified by manufacturers of insulation;

- Do not install insulation within 90mm of hot flues or exhaust fans, or within 25mm of recessed light fittings.
- Retain a clearance of 90mm for low voltage downlights.
- Restrain loose-fill insulation with non-combustible barriers.



ITEM TO BE CLEARED	TECHNIQUE
Recessed down lights	Minimum clearance of 25mm
Flues and exhaust fans	Minimum clearance of 90mm
Loose fill insulation material	Use barriers to restrain and ensure adequate clearance
Electrical wiring (existing home)	Check by electrician before installing insulation. Keep wiring clear of insulation. Restrain loose fill material by spacers

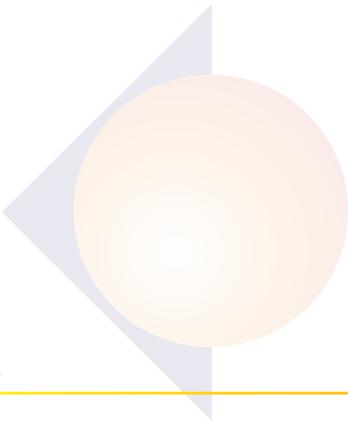
11.2 PROTECTIVE CLOTHING

Wear protective clothing, gloves, goggles and a dust mask when installing fibrous or loose-fill insulation. These materials may cause short term irritation to skin, eyes and upper respiratory tract. It is good practice to always wear protective clothing and/or equipment when working in dusty roof spaces.



11.3 EYE PROTECTION

Wear adequate eye protection when installing reflective insulation, as it can cause dangerous glare. Be aware of the increased risk of sunburn.



CHAPTER 12

FIRE SAFETY

All insulation products should be in compliance with the National Building Regulations SANS 10400 – T Fire Protection and SANS 204 Energy Efficiency in Buildings and should be independently tested in accordance with the relevant standards and classified in accordance with SANS 428 Fire performance classification of thermal insulated building envelope systems, prior to being sold.

This Standard incorporates all factors required for fire-hazard or fire-risk assessment of the materials, products, or assemblies under actual fire conditions.

Standard testing procedures for thermal insulation to measure:

- combustibility;
SANS 10177-5, Fire testing of materials components and elements used in buildings Part 5: Non-combustibility at 750°C of building materials.
- characterization;
SANS 10177-9, Fire testing of materials, components and elements used in building
Part 9: Small-scale burning characteristics of building materials; ignition, flame spread and heat contribution.
- surface fire properties;
SANS 10177-10, Fire testing of materials, components and elements used in buildings
Part 10: Surface burning characteristics of building materials using the inverted channel tunnel test
- designated use and application.
SANS 10177-11, Fire testing of materials, components and elements used in buildings
Part 11: Large-scale fire performance evaluation of building envelope thermal insulation systems (with or without sprinklers)

For more information on insulation products classified in accordance with SANS 428, consult the TIASA Members Fire Performance Classification Register www.tiasa.org.za

National classifications do not automatically equate with the equivalent classifications in the European system, therefore products cannot typically assume a European class, unless they have been tested.

Local products must be tested in accordance with national standards and exporters have to test their products in accordance with the test methods prescribed by the country to which export is envisaged. Similarly imported products shall be tested in accordance with South African National Standards.

Fire resistance is often confused with flame spread and fire retardant abilities.

Fire resistance is tested to determine the fire resistance of specific elements (i.e. occupancy-separating elements) or components on the basis of the length of time within which it will satisfy the criteria in respect of stability, integrity, and insulation (refer SANS 10400 Part T Fire Protection)

- fire resistance
SANS 10177-2, Fire testing of materials, components and elements used in buildings
Part 2: Fire resistance test for building elements.

Thermal insulation association of South Africa



TIASA promotes the benefits of insulation. Although providing a service to all industries, it's initial focus is the development of its products & services for the building and construction industry with specific attention being paid to sustainable energy efficient homes. It is the only organisation that embraces the entire thermal insulation marketplace, including Manufacturers, Distributors, Contractors, Specifiers, Designers, Architects, Energy Service Companies, National and Local government, Utilities as well as End users in the domestic sector.

Thermal insulation

Insulation has proved to be effective and beneficial in the following:

- Reducing energy costs in the home & workplace
- Safety of personnel working in "hot" applications
- Achieving comfort
- Temperature control in processing equipment



energy efficiency

- **SAVE MONEY**
through reducing electricity usage
- **REDUCE**
the possibility of electricity black-outs
- **SECURE**
future peak demands electricity supply



sustainability

- Assisting in the reduction of environmental pollution
- Reducing the consumption of natural resources
- Reducing noise pollution
- Increasing the productivity of workers in factories commercial buildings etc.



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