



## **WHAT YOU NEED TO KNOW ABOUT THERMAL INSULATION**

### **Why energy efficiency measures?**

In South Africa we take energy for granted, with the consequence that our energy consumption is higher than it should be. Whilst our historically low electricity price has contributed towards a competitive position, it has also meant that there has been little or no incentive to save electricity.

Perhaps the most neglected area for implementation is the promotion of public awareness about the costs and benefits of energy efficiency. Major energy savings can only be achieved through changes in people's behaviour, and that depends on informing them about what options exist.

### **Environmental effects**

Coal is the main source of energy in South Africa. When coal is used as energy source, its combustion generates carbon di-oxide which causes air pollution and emission of greenhouse gases. This is an environmental concern as it leads to climatic changes.

South Africa has already seen changes in temperature and rainfall patterns due to global warming. Cheap electrical energy has given rise to excessive use thereof, diminishing the long-term resources and contributing to environmental pollution.

### **Economical effects**

Despite ongoing calls for greater fuel diversification, several coal-linked projects are already under way or in the pipeline and, given its cost advantages, it is widely-anticipated that more mega-watts will inevitably mean more coal.

South Africa would require between one and three new coal-mines over the next ten years to ensure supply to its expanding coal-fired power stations. As predicted, the country's existing power generation capacity is insufficient to meet the rising national maximum demand.

The problem is set to worsen and there might also not be enough energy to supply certain areas during off-peak periods. This could result in mass blackouts and 'brownouts' (reduced energy supply) across the country.

South Africa need to build more power stations - which would take eight to 12 years – and teach people to learn how to manage energy output.

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

The installation of thermal insulation will reduce the need to use mechanical heating or cooling, supporting Eskom's Demand Side Management.

### **Effect on the Building Industry**

The vast majority of buildings and affordable homes currently being built are not energy efficient, further escalating the problem of energy wastage into the future.

The Building Sector has great potential for energy savings since building design is the major factor determining the energy efficiency.

The implementation and sustainability of energy efficiency measures will result in the creation of new job opportunities.

### **Legislation**

The Department of Minerals and Energy, with relevant collaboration from the Department of Housing and Trade & Industry, has spearheaded the development of energy efficient standards for buildings at the SABS namely SANS 10400 Part XA - The application of the National Building Regulations Part X: Environmental sustainability Part XA: Energy usage in buildings and SANS 204 – Energy Efficiency in Buildings. SANS 204 specifies the design requirements for energy efficiency in buildings and of services in buildings with natural environmental control and artificial ventilation or air conditioning systems.

The National Building Regulations and Buildings Act (Act 103 of 1977) has been amended to include the abovementioned.

## General guidelines to energy efficient building design

- Design for climate as per climatic zones
- Building orientation – main living areas to the north to receive unobstructed winter sun;
- Internal planning to create zones which reduce the amount of energy required for heating and cooling;
- Fenestration (windows & frames) which are appropriately orientated and sized with protection from winter heat loss and summer heat gain, allowing for cross ventilation in summer for cooling;
- Thermal mass (building materials) to stabilize indoor temperatures;
- Thermal insulation in roofs, ceilings, walls and floors – installation of recommended insulation levels to minimise heat loss or gain
- Good draught proofing;
- Efficient hot water system and fittings, located close to user station - insulate geysers and pipes;
- Efficient lighting and appliances;
- Landscape design that assists in modifying the microclimate for more comfortable conditions.

### Why is the building process so important?

The Building Sector has great potential for energy savings since building design is the major factor determining the energy efficiency.

The best thermal design can be ruined if badly built. The builder, and even the owner builder, should understand the intention of the designer. The builder takes co-responsibility for the final product since he is the last authority in the whole process of building procurement that can discover and correct mistakes made in the previous work.

### What makes a comfortable home or building?

A thermally comfortable home or building is neither too hot nor too cold. This can be achieved by a clever combination in the design of the building, north orientation, north facing windows, thermal insulation in the roof, indoor mass and draught proofing.

### How does insulation work?

Understanding the role of insulation in improving thermal comfort ensures that requirements are met in the most appropriate and cost-effective way, while ensuring optimal energy efficiency.

The primary purpose of insulation is to reduce heat transfer. Heat losses and gains will happen when two different temperature zones are next to each other. During winter, when the outside temperature is lower than the desired

internal temperature, heat transfer takes place from inside the building to the outside, resulting in the inside of the house losing warmth. In summer, heat is transferred from outside, warming up the inside of the house. Similarly, the temperature difference between the water in a geyser and water pipes causes energy flow towards the outside in the form of heat losses.

### What is draught proofing?

It means reducing the uncontrolled and unwanted leakage of outside air into or out of the building. The outside air should not leak into the building because it is too warm in summer and too cold in winter (cold draught). This would defeat the objective of insulation, thermal mass and heating.

### How is air leakage controlled?

Air leakage can occur through gaps around exterior doors and windows, airbricks, ceilings and other small holes in the building shell.

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.

Caulking and weather-stripping are the best means of sealing cracks and holes in and around a house or building.

Common areas that require insulation or draught-proofing include:

- Doors and windows  
Windows and doors should close properly to prevent air leakage into and out of the building. Windows and doors that do not shut tightly should be sealed. Foam tape of different thickness can be used to seal window frames and doorframes. Foam tape has a self-adhesive surface that is attached to the frame. Closing the door or window compresses the foam and serves as an efficient air seal.

Door “snakes” (tubes filled with sand) can also be used as effective seals to stop cold or hot outside air from entering the home under the doors. Aluminium door skirts with rubber seals that are screwed to the outside of the doors are also available and act as an effective air and water seal.

- **Walls**  
The cavities in and between bricks act as thermal bridges and should be caulked or sealed to prevent unwanted heat loss and gain and improve thermal insulation. Gaps between bricks can be filled with polyurethane. It is best to seal walls before the final coat of paint is administered to the building.
- **Chimneys**  
The best way to seal a chimney is to have a damper installed that is closed when the chimney is not in use. If the chimney is not utilised at all, it should be sealed off at the top and bottom.

### What is thermal insulation?

Thermal Insulation is the material that is used to reduce the rate of heat transfer through external surfaces in the home or building. Basically, when you insulate your building you are wrapping it in a “protective blanket” which reduces the transfer of heat into and out of the building.

In winter it reduces the rate at which heat is lost from the building, and in summer it reduces the rate of heat entry into the building. For example, in an un-insulated building on a hot day, heat is conducted easily through your roof, windows and walls from outside, raising the temperature inside.

### Where and what is the recommended level of insulation (‘R-value’) for your location?

Ceiling insulation is by far the most effective way of insulating a home or building in order to reduce heat penetration in summer and prevent heat generated by heating systems from escaping during winter. The level of insulation will depend on the climate zone, building construction type, and whether mechanical heating and/or cooling is used.

In accordance with SANS 10400-XA Energy usage in buildings a roof system shall achieve the minimum total *R-value* specified in Table 1 for the direction of heat flow.

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.

	1	2	3	4	5	6
<b>Climate zones</b>	Zone	Zone	Zone	Zone	Zone	Zone
<b>Minimum required Total R-Value</b>	3.7	3.2	2.7	3.7	2.7	3.5
<b>Dominant direction of heat flow</b>	Up	Up	Down & Up	Up	Down	Up

Zone	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

### 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.

### What is insulation ‘R-value’?

The level or performance of an insulation product is measured by its Thermal Resistance or ‘R-value’.

This is a measurement of the insulation's resistance to heat transfer and is expressed as a number normally between 1 and 3. The greater the 'R-value', the more effective is the insulation at resisting conducted heat flow into the building in summer, and out of it in winter.

Therefore the 'R-value' is actually a measure of performance.

One brand of insulation may be thicker or thinner than another, but if they both show the same 'R-value', they will perform equally.

### What types of insulation are there?

There are various types and brands of thermal insulation available on the local market.

Generally insulation is divided into three categories:

1. Bulk insulation
2. Reflective Foil insulation
3. Composite bulk insulation

#### 1. Bulk insulation

This is the type of insulation that most people are familiar with. The insulation material itself is usually fiberglass, mineral wool (also called rock wool) or synthetic fiber (polyester). Each product has a material R-value for a given thickness, density and temperature.

These products come in two forms, either in rolls, called blankets, which must be cut to fit the length of space or in pre-cut lengths, called batts. In a horizontal space like a roof space, blankets or batts are simply laid between the timber joists.

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 material, the higher the "R-value" i.e. the performance 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 transfer of heat or heat transfer.

#### Types of bulk insulation (Batt, Blanket & Mat 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 temperatures are at 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 glass-wool 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 glass wool. 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. The product is available as batts or blankets. It is 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.

#### Cellulose 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 sheeting products.

#### Rigid Board Insulation

- **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.

- **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 below 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.
- **Polyurethane & 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.
- **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.

## 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.

## 2. Reflective Foil Laminates (RFL's)

Reflective Foil Insulation (Radiant Barrier products) mainly resists radiant heat flow due to their reflectivity, low radiant heat absorption, and low emissivity (ability to re-radiate heat). Reflective insulation is usually shiny aluminum foil laminated with reinforcements or low density polyethylene bubble encapsulated with air and laminated to foil and are supplied in rolls.

Reflective insulation is more effective at reducing summer heat gain than reducing heat losses in winter and this should be taken into account at design stage. RFL's relies on the presence of a defined air space next to the shiny surface.

The thermal resistance of reflective insulation varies with the direction of heat flow through it, i.e. either vertical, horizontal or at a slope. The system R-values for reflective foil insulation is stated as being either up or down values.

The reported system R-values are tested at a given air space thickness and air temperature. System R-values depend on where and how the reflective insulation is installed. Users should ensure that the system values provided by the manufacturer relate to the particular installation situation.

## 3. Composite bulk insulation

Some insulation products also use a combination of bulk insulation and reflective foil to achieve their insulating effect; this is known as composite bulk insulation.

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

### **How should insulation be installed?**

Flat ceilings with pitched roofs are the easiest to insulate. Use reflective foil laminate over the rafters but below the battens of the roof tiles with a minimum overlap of 150mm.

Bulk insulation should be installed allowing batts and blankets to expand to their natural thickness, cut neatly to fit snugly between ceiling joists, and kept clear of recessed light fittings. Blow in insulation should be sprayed with a solution that prevents disturbance from breezes within the ceiling spaces.

### **Most neglected and very important energy abusing device – the geyser!**

Electric water heaters consume about 42% of the domestic energy usage and contribute 22% to the domestic sector peak demand. One quarter of the energy is wasted in standing losses.

The insulation of hot water pipes and geysers will help to conserve electricity because it limits heat loss to the atmosphere while the water is being stored or in transit through the pipes, lessening the burden on the geyser to keep the water at the desired temperature.

Ideally, all hot water pipes should be insulated within 1 meter of the connection to the heating or cooling system.

### **Hints and tips when buying insulation:**

#### **1. Buy by the ‘R - Value’ only**

The level or performance of an insulation product is measured by its Thermal Resistance or R –Value. The greater the R-value, the more effective is the insulation at resisting conducted heat flow into the building in summer, and out of it in winter.

Insulations with the same R-value have the same insulation performance no matter what materials are used. Batt of an R-value of 2.5, for example, will perform exactly the same as loose fill insulation with an R-value of 2.5.

#### **2. Read the product label!**

The product label should include amongst others the manufacturer's name, and trade name or trademark, the batch identification or date of manufacture; a clearly stated R-value and 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.

### **3. Always get multiple quotes**

Always get multiple quotes and ensure they all stipulate the correct R-value and relevant thermal and fire certification. Ask for copies of these reports. As long as they are installed correctly, insulations with the same R-value have the same insulation performance.

### **4. Fire Safety**

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

The testing protocol in accordance with SANS 428 incorporates all factors required for fire-hazard or fire-risk assessment of the materials, products, or assemblies under actual fire conditions. Ask for copies of the fire reports or contact TIASA for assistance.

### **Frequently asked questions!?**

#### **What is the best type of insulation?**

There are many types of insulation to choose from; however the R-value is a direct, standardized comparison of insulation effectiveness. There may be some other factors that influence your choice of insulation product, for example limited roof space or other installation difficulties. Talk to several insulation suppliers about their products before committing to purchase, and remember that the R-value is a direct comparison of insulation performance.

#### **Is ‘foil’ under the roof an advantage?**

Reflective Foil installed under the roof has advantages in providing waterproofing and also helps to reduce radiant heat transfer into the home or building.

Reflective Foil insulation materials work on a different concept than conventional bulk insulation like fibrous blankets or rigid foam boards. Reflective Foil Laminates can stop up to 95% of heat transfer through radiation and provide an excellent temperature control method. South Africa's solar radiation output is over twice that of Europe - making it one of the highest in the world.

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 prevent heat loss during winter.

### **Does old insulation lose its efficiency?**

Most forms of insulation decrease in efficiency over time. The recommended R-values for various areas in South Africa take this reduction in efficiency into account.

### **I am getting a lot of conflicting information about insulation from different suppliers. Who do I believe?**

The insulation market is very competitive, and there are many claims regarding the relative performances and safety of various products.

### **We suggest:**

1. Treat bold claims from suppliers cautiously.
2. Identify any installation difficulties and discuss with the supplier.
3. Get three quotes from reputable companies, and if you are satisfied with the company and the price and its performance, choose accordingly.
4. When selecting insulation, ensure that the material:
  - is in compliance with the relevant South African National Standards applicable to the product;
  - conform to the South African National Building Regulations;
  - is appropriate for the intended occupancy or building classification in accordance with SANS 10400 Part A General principles and requirements;
  - comply with the fire safety requirements and tested in accordance with the SANS 428 Fire performance classification of thermal insulated building envelope systems requirements.
  - comply with the recommended R-value for the relevant climatic zones in accordance with SANS 10400-XA Energy usage in buildings.

Remember that it is the R-value that determines the performance of the product, not what it is made from.

**For further information please contact TIASA**

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