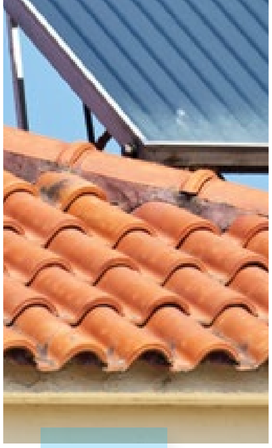
NATIONAL HOME BUILDERS
NHBRC
REGISTRATION COUNCIL

GUIDELINES FOR BUILDING AN ENERGY EFFICIENT HOME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INTRODUCTION

One of the key mandates of the National Home Builders Registration Council (NHBRC), as stipulated in the Housing Consumers Protection Measures Act (Act 95 of 1998) as amended, is to establish and promote ethical and technical standards in the home building industry. In view of the mandate the NHBRC has developed a strategy, through its Centre for Research and Housing Innovation, to position the organisation as a leader in knowledge creation, technical and technological building solutions through strategic partnerships.

It has become compulsory to provide Energy Efficiency measures for all buildings, including all homes, since the coming into operation of the SANS 10400 XA in terms of the National Building Regulations in November 2011. All role players in the building industry must understand and be able to implement the correct minimum deemed-to-satisfy rules of the SANS 10400 XA. To assist with this endeavour, this document provides a rationale (reasons) on why energy efficiency interventions are crucial, the objectives of this document and the guidelines of how to apply the minimum energy efficiency measures. It is important to note that the guidelines must be read in conjunction with SANS 10400 XA and SANS 204, which provide the minimum benchmarks according to which energy efficiency measures must be designed.

RATIONALE

An energy efficient home can be described as a home that uses less energy and in turn emits less carbon to benefit people socially, economically and environmentally. These homes can be achieved through relevant energy efficiency interventions that will improve living standards for all and take into consideration the environment to sustain our planet for future generations.

> **“Living standards can be enhanced by reducing the electricity usage and hence the shortfall of energy for all homes in South Africa.”**

The urgency of the electricity shortage was realised in 2007 when South Africa started experiencing the power shock of widespread rolling blackouts as the supply fell behind the demand. This has led to energy poverty and continuous rising energy costs. Adequate energy efficiency interventions will moreover improve the indoor temperature and air quality to increase productivity indoors and health.

As a developing nation South Africa has significant heavy industry, which is, by its nature, energy intensive. The energy intensity economy largely relies on indigenous coal reserves for its driving force and, as a result, South Africa remains one of the highest emitters of the greenhouse gas (CO_2 gas) per capita in the world. At a local level, the problems of SO_4 (sulphur tetroxide) and smoke emissions have been the focus of concern for many communities living adjacent to heavily industrialised areas. By introducing energy efficiency regulations for all buildings and mitigating (reducing) energy consumption in the form of fossil fuels, we are contributing to combating climate change and ensuring a sustainable environment.

OBJECTIVE

This simple guideline provides the interpretation of how to apply energy efficiency measures when designing or inspecting a new home to comply with the National Building Regulations XA and the deemed-to-satisfy rules in SANS 10400 XA. It is mandatory to adhere to these regulations when submitting plans to the municipality for approval, or knowing what to look out for when inspecting a home. The areas covered in this guideline are in accordance with the SANS10400 XA as follows:

1 Climate zones 2 Orientation 3 Shading 4 External walls 5 Fenestration Frames and glazing

6 Roof assembly 7 Under Floor heating 8 Services Lighting and Power 9 Hot water

This guideline specifically illustrates how a benchmark can be achieved in line with the SANS 10400 XA by providing examples of calculations based on a 60m² north orientated home in one climate zone. It also needs to be noted that the materials used in the examples are not the only suitable materials and that a variety of other materials will also comply.

GUIDELINES

National Building Regulations XA

The functional National Building Regulations XA (Government Gazette 34586, Notice No. R. 711, 9 September 2011) and deemed-to-satisfy rules SANS 10400 XA provide the minimum requirements for energy efficiency interventions in buildings, which is designed according to the competent person.

The intentions of the National Building Regulations are listed below:

To use energy efficiently while fulfilling user needs in relation to thermal comfort, lighting and hot water.

To have a building envelope and services which facilitate the efficient use of energy, appropriate to their function and use, internal environment and geographical location.

To ensure that at least 50% (volume fraction) of the annual average hot water heating requirement shall be provided by means other than electrical resistance heating, including, but not limited to, solar heating, heat pumps, heat recovery from other systems or processes and renewable combustible fuel.

To satisfy the requirements of sub-regulation XA1 by designing and constructing a building in accordance with the following requirements:

the orientation, shading, services and building envelope is in accordance with SANS10400 Part XA

OR

is the subject of a rational design by a competent person, which demonstrates that the energy usage of such building is equivalent to or better than that which would have been achieved by compliance with the requirements of SANS 10400 XA (excl.houses)

OR

has a theoretical energy usage performance, determined using certified thermal calculation software (Agremént South Africa), less than or equal to that of a reference building in accordance with SANS 10400 Part XA.

In general, a competent person may demonstrate compliance with these guidelines in accordance with the minimum requirements of SANS 10400 XA and SANS 204, or complete a rational design (e.g. east/west orientation). A competent person is a professional that 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 the functional regulation e.g. an architectural professional who, in accordance with the South African Council for the Architectural Profession’s policy on the identification of work, is certified to complete energy efficiency calculations.

How do we apply the minimum energy efficiency requirements for all homes?

1 Climate Zones

There are six climate zones in South Africa with different thermal requirements for buildings – measured in the R-values (thermal resistance in m².K/W) or heating and cooling loads (energy consumption in KWh). The first step is to establish in which climate zone the relevant house falls in order to comply with its related benchmarks. The climate zones are illustrated in Figure 1.

Figure 1: South Africa climate zones (SANS 10400XA, 2011: 12)

2 Orientation

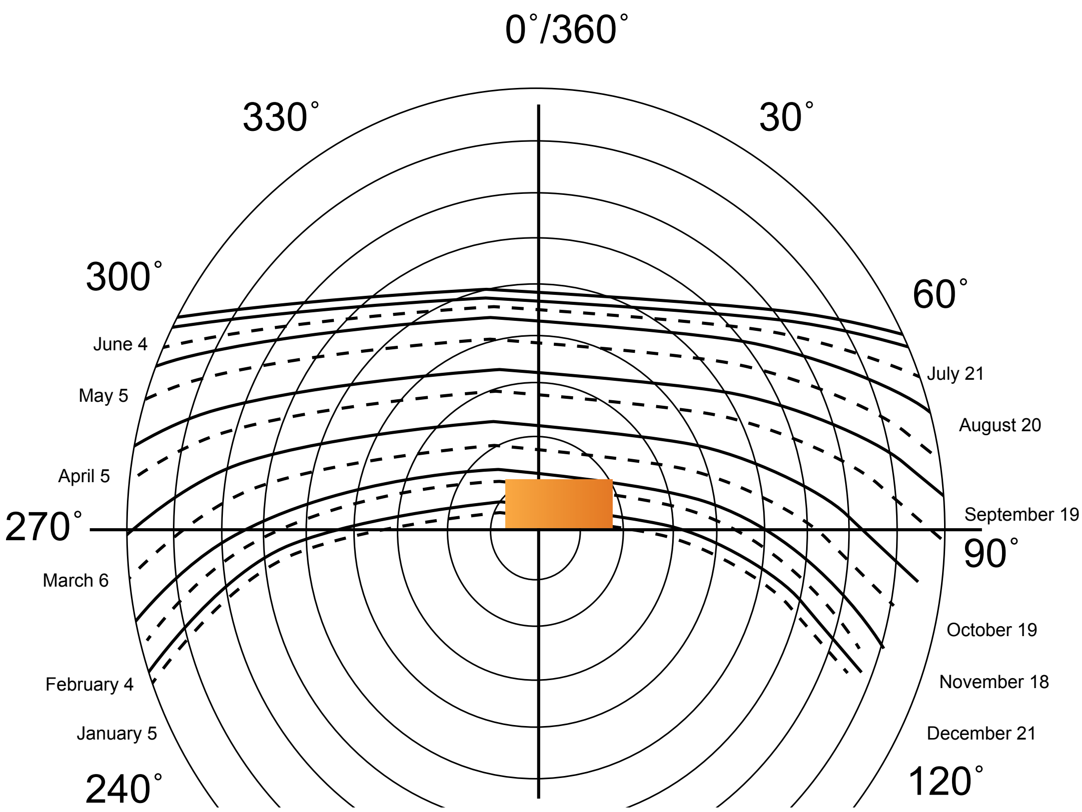
2.1 Best Orientation

The best orientation for houses must be true north or approximately e.g. the best orientation for Johannesburg is true north and can be within +/-15˚ of true north (SANS 10400XA 4.4 refers to SANS 204 B1-B6). If a building is not orientated to the best orientation and is east or west orientated then the design is subject to a rational design, using thermal software certified by Agrèment South Africa.

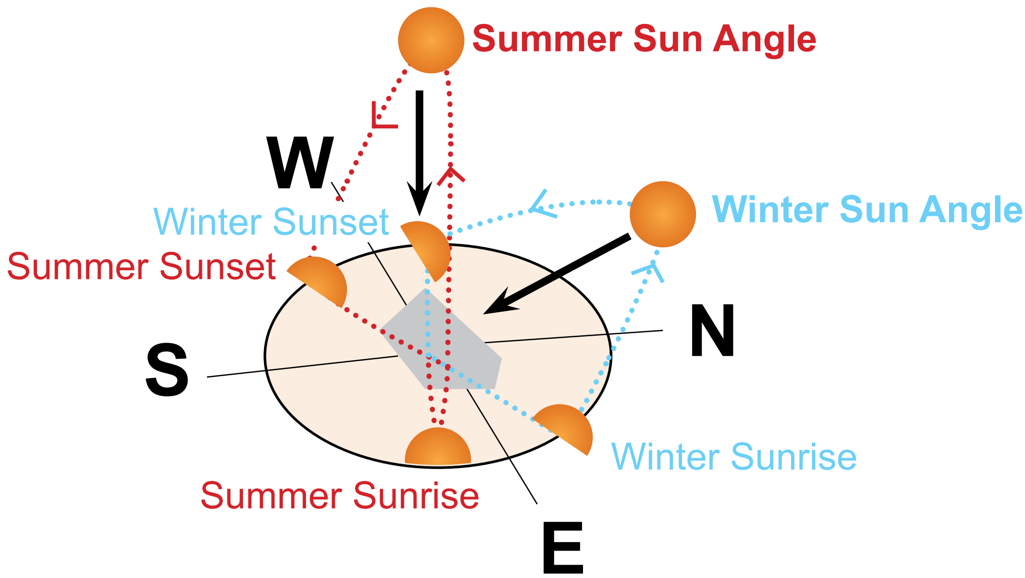
2.2 Orientation of Living Spaces

In a north orientated home, living spaces should be arranged such that rooms where people spend most of their hours are located on the northern side of the unit. This implies that the longer axis of the house must be north/south orientated and the shorter sides of the house east/west orientated. Most windows should preferably be on the north side, then south and the least windows on the east and west side. In winter when the angle of the sun is low then the surfaces get more direct sunlight and warm the building's surface. Then again in summer when the suns angle is higher, the sun does not shine directly on the northern surfaces and keeps the building cooler. The rooms such as bathrooms and storerooms can be used to screen unwanted western sun or to prevent heat loss on the south facing facades. Figure 2 indicates the path of the sun in relation to a building.

Example of the path of the sun throughout the year

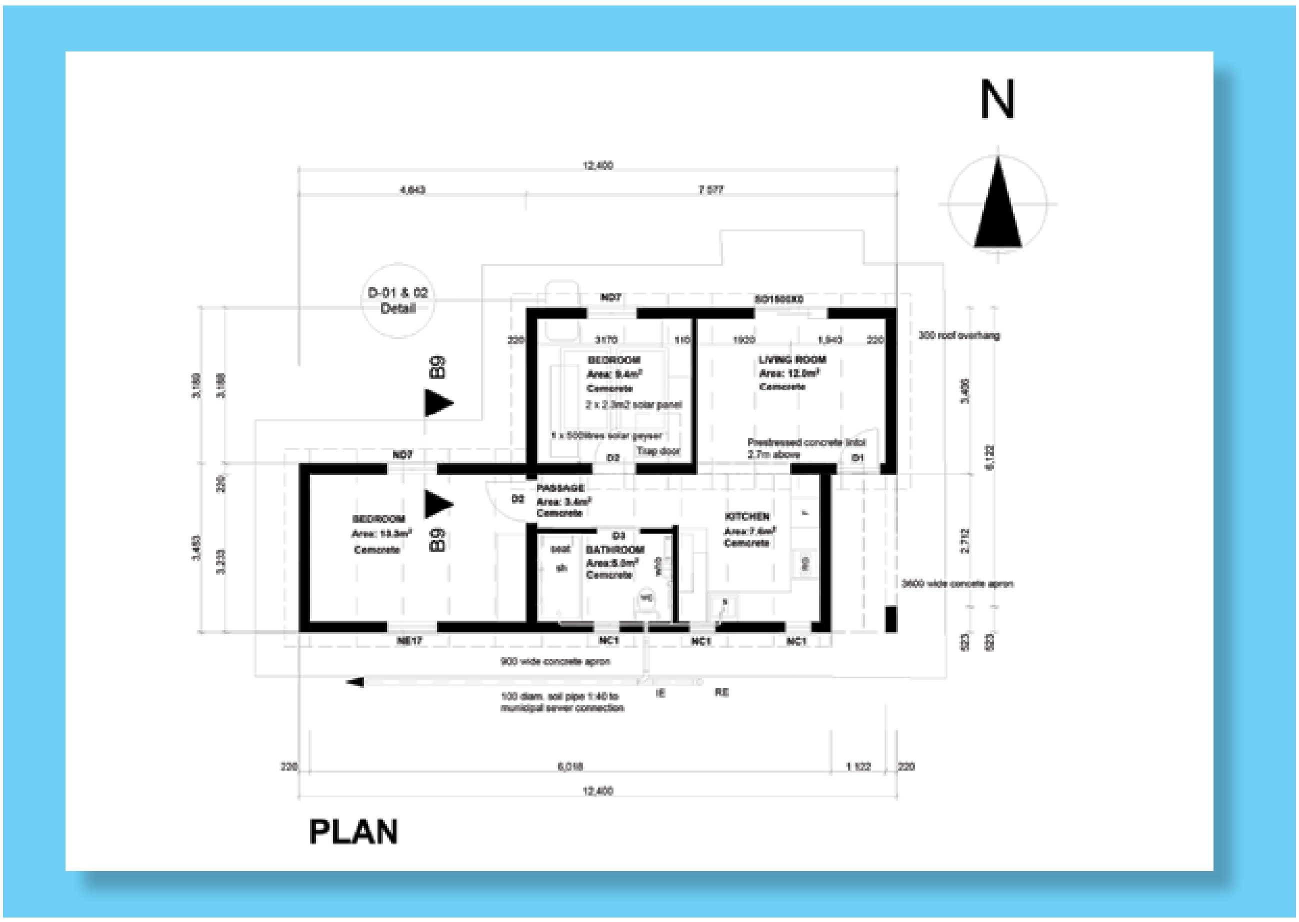


Path of sun and highest position at noon during summer and winter (not to scale)



2.3 Example of a House Design Showing North Orientation

Figure 3: **Example of house on which all calculations are based (not to scale)**



3 External Walls

3.1 Wall Types and Definitions

There are two main categories of walls with different benchmarks for north orientated homes, which can be measured in the R-value i.e. masonry and non-masonry walls. These two categories of walls have different requirements for the relevant climate zones. A masonry wall can be defined as an assemblage of masonry units jointed together with mortar to form a structure and are either made from fired clay or concrete units (every other wall type that does not fall within this description is a non-masonry wall).

Masonry Wall Requirements

A masonry wall that will comply with the minimum requirements of the SANS 10400XA, is a double skin masonry wall with no cavity, plastered internally or rendered (thin premixed plaster of sand, cement and lime e.g. bag wash) externally. A masonry wall that will also comply is a single leaf masonry wall with a nominal wall thickness equal to or greater than 140mm, plastered internally and rendered externally.

Non-Masonry Wall Requirements

A non-masonry wall will have to comply with the minimum thermal resistance (R-value) values for north orientated homes as in Table 1.

Table 1: R-values for non-masonry walls

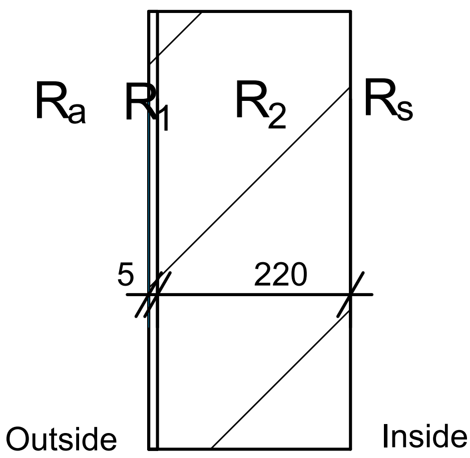
Climate Zone	R-value
For climate zone 1 (Johannesburg, Bloemfontein) and 6 (Upington, Kimberly)	**2.2**
For climate zone 2 (Pretoria, Polokwane), 3 (Makhado, Nelspruit), 4 (Cape Town, Port Elizabeth), 5 (East London, Durban, Richards Bay)	**1.9**

3.2 Measuring Thermal Resistance and Conductivity

The R-value can be defined as the resistance to heat transfer across a material. It is also useful to know the conductance (k-value) of a material to calculate thicknesses. Conductance is a measure of how easily heat passes through a material under specific conditions.

The R-value is calculated by adding up the R-value for each layer of material in series (the horizontal direction – simple method) across a component e.g. wall. Important to note is that R-values can also be calculated by dividing the thickness (m) of material by its conductivity (W/(m.K) (thickness/conductivity= R-value in m².K/W). The R-values and conductivity values can be obtained from recognised technical literature or websites.

Figure 4: Detail-01 of a double skin brick wall indicating position of R-values



3.3 Example of a Masonry Wall R-Value Calculation

Figure 4 shows a typical collar jointed solid wall detail, rendered on the outside, indicating the position of the R-values. An example is provided of how to calculate the total R-value of this wall in Table 2.

Table 2: **Example of R-value calculations for a masonry wall**

No.	Thickness (mm)	Material	Conductivity W/(m.K)	R-value m².K/W
R_a		Moving air film @ 7m/s		0.03
R_1	5	External rendering	0.5	0.01
R_2	220	Brickwork	0.82	0.27
R_s		Still air film hor. up		0.11

Typical R-values for air spaces and air films is according to Table F.2 of SANS 204

R-value = thickness/conductivity (m².K/W) (Example for R1 = 5/1000 ÷ 0.5= 0.01)

R-value = Ra + R1 + R2 + Rs = **0.42 m².K/W**

4 Fenestration

4.1 Fenestration Definitions

The fenestration of a building is defined as any glazed opening including windows, doors and skylights, which comprises glazing and framing elements that are fixed or movable, and opaque, translucent or transparent, which may not exceed a certain percentage of the net floor area (net floor area is defined in SANS 10400-AZ2, which is the total floor area of a building, or a storey thereof, enclosed within the external walls, exclusive of the area occupied by the lift shaft) per storey, to comply with the minimum energy performance requirements.

4.2 Fenestration Requirements

According to 4.4.4.1 of SANS 10400 XA the total area of fenestration, including the frame, is calculated and the total net floor area per floor/storey. If the total fenestration area is equal to, or less than, 15% of the net floor area then the fenestration complies. This usually means that clear glass in accordance with SANS 10400 Part N (glazing dimensions) will comply, but the window frames must comply with the required air leakage benchmark.

Permissible air leakage of external vertical glazing in each storey shall be according to 4.4.3.1.2 of SANS 204. The requirement for permissible air leakage is 0, 31 L/s.m² or less with a pressure difference of 75 Pa when tested in accordance with SANS 613. The fenestration manufacturer must provide proof thereof, which includes the frames and its installation.

4.3 Example of Fenestration Calculation of the Plan

An example is provided on how to calculate the fenestration area of the house in Table 3 to test whether it is within the 15% net floor area. The dimensions of glazed windows and glass doors (not applicable to this project) as indicated on plan (*the timber door on the south is ignored*) are used.

Table 3: Example of window areas and unit areas of the plan

60m² unit:					
North:	ND7$_1$ (W$_1$)	=	2(1.022 x 1.245)	=	2.545m²
	SD$_1$ (W$_2$)	=	1.500 x 2.100	=	3.150m²
South:	NC11 (W3)	=	3(0.949 x0.533)	=	1.517m²
	NE17 (W4)	=	0.654 x 1.022	=	0.668m²
Total fenestration area				=	**7.880m²**
Unit area				=	60m²
Net floor area				=	54m²

The total floor area is checked in the calculation below:

15% of the net floor area of 54m² = 8.1m²

Total fenestration = 7.88m²

7.88m² < 8.1m², which therefore complies with SANS 10400 4.4.4.1 (If the window areas do not comply there is the option to reduce window sizes or 4.3 below applies).

4.4 Fenestration Rational Design

If the fenestration area exceeds the 15% of the net floor area then 4.4.4.2 of SANS 10400XA states that the fenestration shall comply with the requirements in SANS 204. This means a rational design would be required to calculate the conductance (C_u) and solar heat gain (C_{SHGC}) of the glazing. The conductance is important as it is the material's ability to conduct/transmit heat. On the other hand the solar heat gain is also required as it is the measure of the amount of solar radiation (heat) of the glazing.

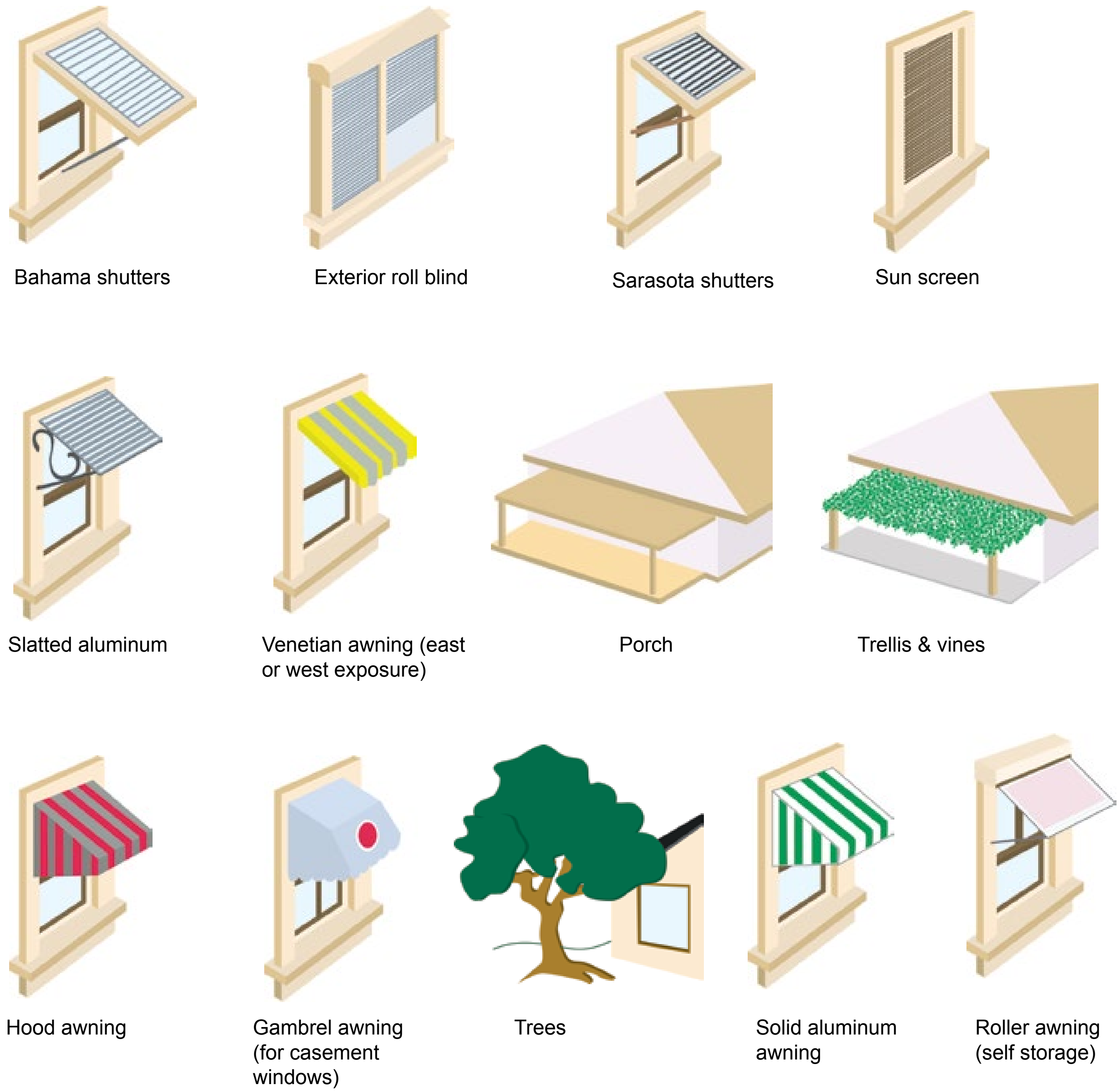
Conductance

The conductance will establish to what extent the clear glazing will have to be insulated and/or whether thermally improved frames would be required. For example, Single-Low E Glazing (e.g. Solar E Smart Glass, a low-emissivity glass) for windows on the west and east could work, or Clear Double Glazing (e.g. Smart Glass InsulVue, a clear double glazing).

Solar Heat Gain

For solar heat gain one would have to determine where more shade needs to be provided for the windows. For example, if the roof overhang is not adequate, then windows must be shaded by any other shading feature as illustrated in Figure 5.

Figure 5: **Shading solutions for glazing**



5 Shading

5.1 Shading Requirements

The general requirement for all north orientated houses is that the northern windows be provided with shading in the form of, for example, roof overhangs. The window shading controls the extent of direct sun in winter and summer. The summer period requiring shading is the 23 September to the 21 March with an additional shading period suggested from 21 March to 15 May. It is specifically the summer period where shading must be provided to exclude sun rays and solar radiation. The sun angles of some cities and towns are given in Table 3.

Table 3: Sun Angle Latitudes and Tangents

Zone	Description	Selected Cities/Towns	Latitudes (°S)	Ø (°) 23 Sept - 21 March	Tan Ø
1	Cold Interior	Johannesburg	26.17	26.17	0.49
		Bloemfontein	29.1	29.1	0.56
2	Temperate Interior	Pretoria	25.73	25.73	0.48
		Polokwane	23.9	23.9	0.44
3	Hot Interior	Graskop	24.93	24.93	0.46
		Middleburg	25.82	25.82	0.48
4	Temperate Coastal	Cape Town	33.92	33.92	0.67
		Port Elizabeth	33.97	33.97	0.67
5	Sub-tropical	East London	33	33	0.65
		Durban	29.82	29.82	0.57
		Richards Bay	28.8	28.8	0.55
6	Arid Interior	Upington	28.42	28.42	0.54
		Kimberly	28.72	28.72	0.55

When working out the overhang dimensions, 4.3.5.2 of SANS 204 provides guidance on the following:

- Sun angles to be considered; and
- Definitions for distances for overhangs (P, G and H)

When required, a permanent shading feature for the windows can be provided in a variety of ways and are dependent on calculating the dimensions of overhang projections. The dimensions of the shading feature will have to consider P (horizontal distance from face of glass to shadow casting edge of any shading projection in m), H (vertical distance from the base of the glazing element to the same shadow casting edge used for P) and G (vertical distance from the head of the glazing element to the shadow casting edge of any shading projection) pertinent for calculations and restricting solar heat gain. Shading features P, H and G are illustrated in Figure 6.

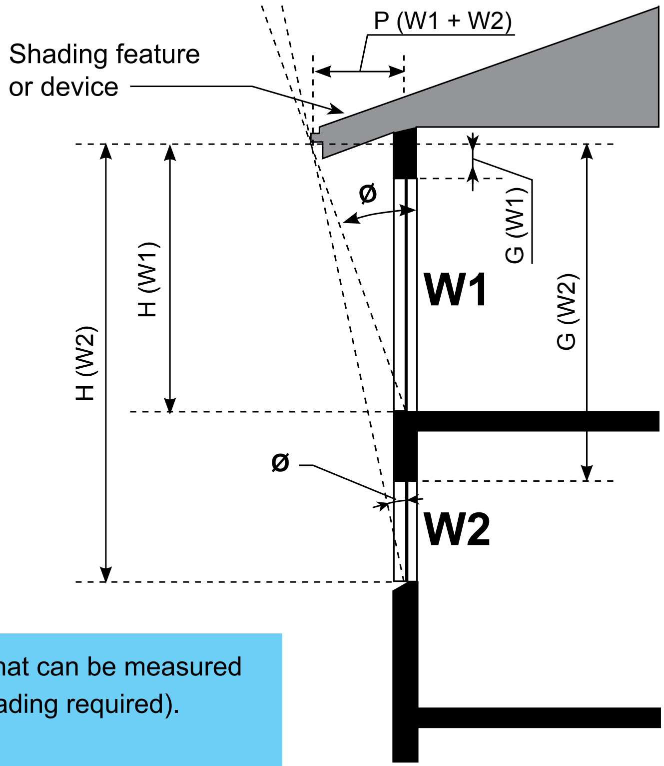
Figure 6: Shading illustrated (SANS 204 4.3.5.2)

P Horizontal distance from the glass face to the shadow casting edge of the shading device

H Horizontal distance from the glass face to the shadow casting edge of the shading device

G Vertical distance from the head of the glazing element to the shadow casting edge of the shading device

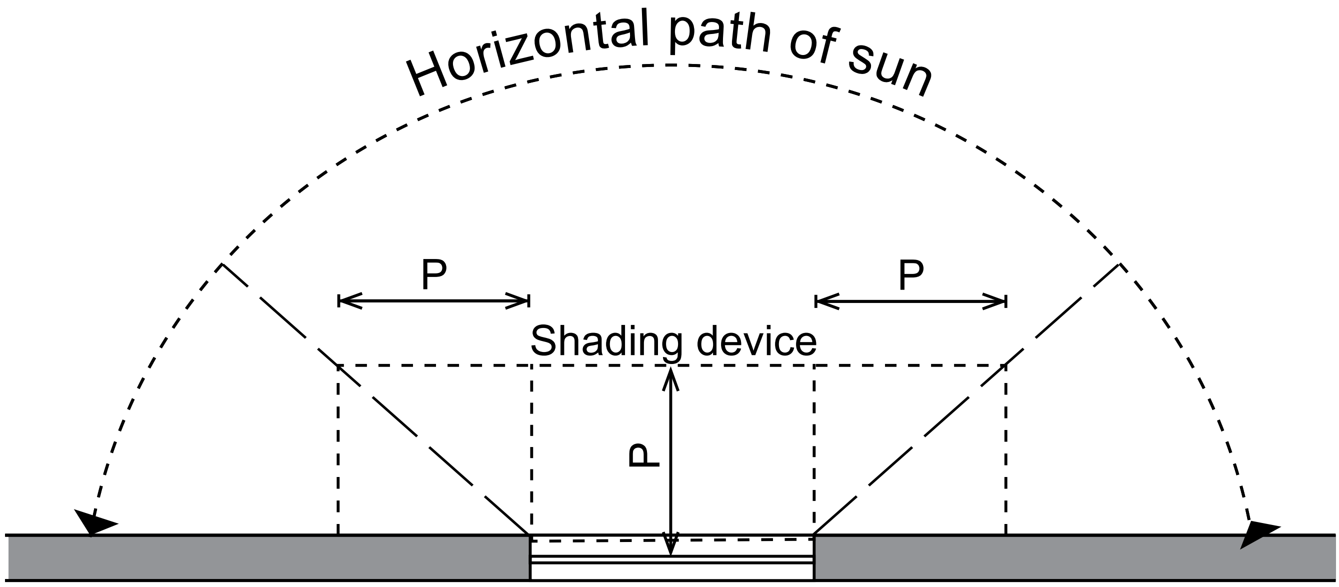
Ø Sun altitude



By knowing the angle of the sun as well as the H-value (that can be measured from drawings) it is possible to determine the P-value (shading required).

The shading feature should not only be provided in front of the glazing, but should also be provided to the side of the glazing as illustrated in Figure 7.

Figure 7: Horizontal distances to the side of glazing

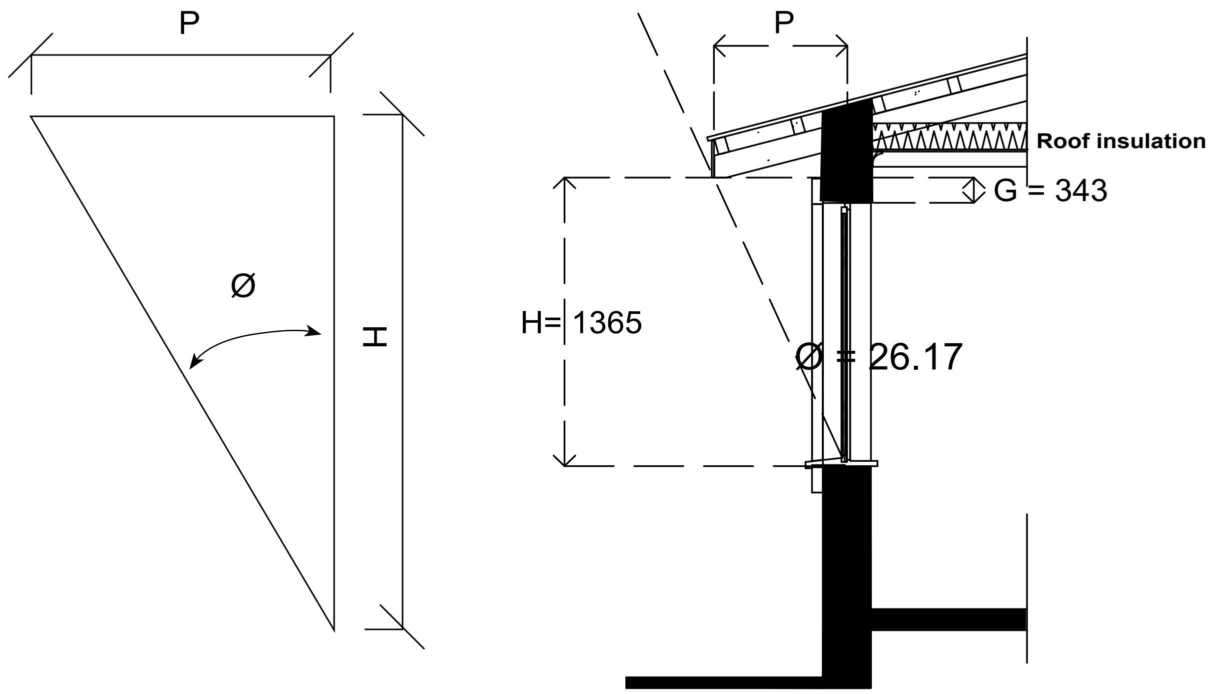


P: Horizontal distance from the glass face to the shadow casting edge of the shading device. (Extends horizontally on both sides of the glazing)

5.2 Example of a Shading Projection Calculation

To calculate the dimension of the overhang feature P of the plan (Window ND7 North) one can refer to Figure 8 for an illustration. The tangent angle (Ø) for major cities is used as given in Table 3.

Figure 8: **Calculating overhangs with tangent Ø**



Ø = 26.17° (Jhb), H = 1 365mm (window height 1022 + (G = 343mm – a figure can be determined from the drawings to test)

TanØ = P/H, therefore

P = TanØ × H

P = Tan26.17 × 1 365

P = 0.49 × 1 365

P = 669mm

This means that the shading to be provided for the northern wall of a Johannesburg house to comply with SANS10400-XA must not be less than 0.669m.

If the calculated overhangs cannot be provided then either the window dimensions must change or SANS 204 applies, whereby the conductance of the glass must be assessed to determine whether another type of glazing such as low emissivity glass would be more suitable.

In terms of 4.3.5.2 of SANS 204 where G exceeds 0.5m, the value of P shall be halved.

6 Roof Assembly

6.1 Roof Assembly Definitions

One can define the roof assembly as the roof or ceiling system (or both), 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 the roof lights and the skylights. The ceiling system requires adding insulation to comply with required R-values of Table 7 of SANS 10400XA.

6.2 Roof Assembly Requirements

The R-value requirements for the different climate zones are in accordance with 4.4.5 of SANS 10400XA as indicated in Table 4 below.

Table 4: **R-value requirements for roof assemblies**

Description	Climate Zones					
	1	**2**	**3**	**4**	**5**	**6**
Min. required total R-value ($m^2.K/W$)	3.7	3.2	2.7	3.7	2.7	3.5
Direction of heat flow	Up	Up	Down & Up	Up	Down	Up

6.3 Example of a Roof Assembly Calculation

Figure 9 shows a typical roof assembly comprising corrugated metal roof, insulation and a horizontal ceiling for a pitched roof between 22° and 45°. An example is provided in Table 5 of how to calculate the R-values and the roof insulation thickness to achieve the required R-value of a house in Johannesburg, which is climate zone 1. A few typical R-values for roof assemblies are provided in Table F3 of SANS 204.

Figure 9: **Detail-02 of a corrugated pitched roof indicating position of R-values**

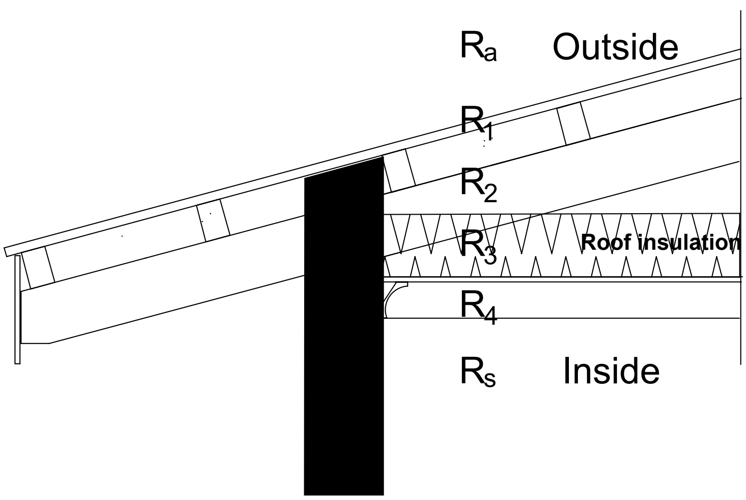


Table 5: Example of material R-values for a roof assembly

No.	Thickness (mm)	Material	Conductivity W/(m.K)	R-value (given) m².K/W
Ra		Outdoor air film @ 7m/s		0.03
R1	0,06	Metal cladding		0
R2	Non-reflective	Roof air space		0.18
R3	d	Insulation		Unknown
R4	10	Gypsum plasterboard		0.06
Rs		Indoor still air film hor. up		0.11

Typical R-values for air spaces and air films are according to Table F.2 of SANS 204

If all the R-values are provided then one must only calculate the R-value for the insulation material and its thickness (Total R-values ≥ 3.7) as follows:

Ra + R1 + R2 + R3 + R4 + Rs ≥ 3.7

0.03 + 0 + 0.18 + R3 + 0.06 + 0.11 ≥ 3.7

R3 = 3.7 – 0.38

R3 = 3.32 m².K/W

Many insulation materials can work and depends on the suitability of a specific product. One can test the thickness (d) of a few insulation materials that are appropriate such as, for example, mineral wool, with a thermal conductivity of 0.033 W/(m.K).

R-value= thickness/conductivity= d/k= (m².K/W)

3.32= d/0.033

d= 3.32 x 0.033

d= 0.10956 x 1000

d= 109.56mm thickness

The closest dimension to 110mm that is available in the market is 135mm from e.g. Isover.

7 Under Floor Heating

7.1 Under Floor Insulation Requirements

Only when under floor heating is provided does 4.4.2 of SANS 10400XA apply. In the case where an underfloor heating system is installed (for this exercise we will assume it will be installed in the screed, although there are many types of systems), the heating system shall be insulated underneath the slab with insulation that has a minimum R-value of 1.0.

7.2 Example of Under Floor Insulation Calculation

If we choose expanded polystyrene board (thermal conductivity of 0.038 W/m.K), for example, then we can calculate the thickness of the board as follows:

R-value= thickness/conductivity= d/k= (m².K/W)

R= d/0.038 (depending on the grade type)

1.0= d/0.038

d=1.0 x 0.038 x1000mm

d=38mm thickness

The closest dimension to 38mm polystyrene board that is available in the market is 40mm from e.g. Styroboard.

8 Services – Lighting and Power

8.1 Energy Demand and Consumption Definitions

Both the energy demand and energy consumption is required to be regulated. The energy demand is the rate at which energy is generated and measured in W/m². On the other hand the energy consumption is how much fuel/energy is used by a utility over a specific period of time and measured in kWh/m².

8.2 Energy Demand and Consumption Requirements

Table 12 of SANS 204 requires that for an H4 class of occupancy (dwelling on its own site) for 4 people, the energy demand shall not exceed 5 W/m² and the energy consumption may not exceed 5kWh/m².

SANS 10400XA 4.2.1 (b) requires that services that use energy, or control the use of energy, must comply with SANS 204.

Therefore, if 5W/m² is the allowed requirement then the total energy consumption in Watts (W) is as follows:

5W/m² x 54.6m² (net floor area example) = **273W max**. (allowed)

8.3 Example of an Energy Demand Calculation

If for example we use 6 x compact fluorescent lamps (CFL) of 18 Watts per lamp and 2 LED lamps of 1,2 Watts per lamp (4 x CFL internal lamps and 2 x CFL external lamps, and 2 LED lamps internally) then the energy demand is calculated as:

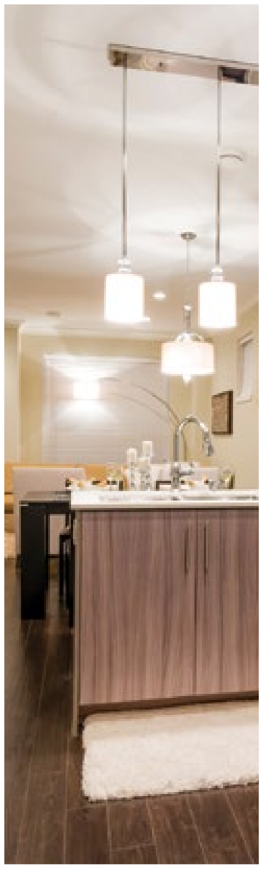
6 CFL @ 18W/lamp: 6 x 18W= 108W

2 LED @ 1.2W/lamp: 2 x 1.2W= 2.4W

Total Energy Demand= 114.4W

114.4W/54.6m²= 2.09W/m²

2.09W/m² < 5W/m² therefore complies



8.4 Example of Energy Consumption Calculation

An example is provided of how to calculate the electricity usage of lighting:

5kWh/m² per annum is allowed = 5kWh/m².a

5kWh/m².a x 54.6m²= 273kWh/m².a max. allowed

Should we assume lights are on from 17h00 to 22h00 each day/annum i.e. 5h/day, then the consumption can be calculated as follows:

Total energy demand = 114.4W =0.114kW

Lights usage per annum= 52 (weeks) x 7 (days) x 5 (hours) = 1820h.a

Energy Consumption per annum= 0.114kW x 1820h.a **= 207.48kWh.a < 273kWh.a therefore complies**

However, should the maximum allowed 235kWh/m².a energy consumption be exceeded, then either the number of compact fluorescent lamps or the watts per amp (for some or all of the lamps) must be reduced such that the energy consumption is lower than the maximum allowed consumption.

9 Hot Water

9.1 Hot Water Requirements

According to 4.2.1b of SANS10400XA, hot water systems need to comply with the requirements of 4.1.

The functional regulations XA2 state that at least 50% (volume fraction) of the annual average hot water heating requirement shall be provided by means other than electrical resistance heating including, but not limited to, solar heating, heat pumps, heat recovery from other systems or processes and renewable combustible fuel.

According to 4.1 of SANS 10400XA in order to comply with the functional regulations XA2 the following standards must be adhered to:

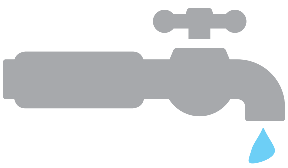
- The volume of the annual average hot water heating requirements shall be calculated in accordance with Tables 2 and 5 of SANS 10252-1:2004.
- If solar water heating systems is used, these shall comply with SANS 1307, SANS 10252-1 and SANS 10254.
- The requirements of water installations in buildings shall be in accordance with SANS 10252-1 and SANS 10254.
- Proof from the manufacturer needs to be obtained for the systems to show compliance with the above standards by producing an SABS test report or mark.

9.2 Hot Water Pipes Requirement

All hot water service pipes shall be clad with insulation with a minimum R-value in accordance with Table 1 of SANS 10400XA. If the pipe diameter is ≤80mm then the min. R-value is 1.0 and if the pipe diameter is >80mm the min. R-value is 1.5. The insulation is to be installed according to the manufacturer's instructions.

9.3 Hot Water Pipes Insulation

Should mineral wool be used as an insulation material with a conductivity of 0.033 then one can calculate the thickness of the insulation material as follows:



R-value for a pipe diam. less than 80mm= thickness/conductivity= d/k= (m²$\cdot$K/W)

1.0= d/0.033

d= 1.0 x 0.033

d= 33mm thickness

The closest available thickness for mineral wool is 40mm.

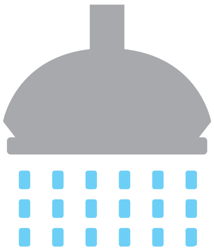
9.4 Example of the Hot Water Usage and Storage Calculations

For this example a solar water heating system will be used, which will be more cost effective in the long term. It is required to calculate how much water is consumed, and how much energy is saved for heating water to decide on which technology to use and its size.

The **first calculations** for renewable solar heating illustrate how 100% of electricity is saved.

According to the design population Table 2 of SANS10400 A21: H4= 2 persons per bedroom= 4 persons for the house in Figure 3.

Daily hot water usage must be in accordance with Table 5 of SANS 10252-1. For low rental (e.g. affordable housing) the requirement is 80 L/capita/d -115 L/capita/d hot water (lowest value is used for this calculation) and the total litres calculated as follows:



Total= 4 persons x 80L/capita/d= 320 litres per day

If storage is 1.1 to 2.5 times (standard factors to calculate storage) the consumption then the total storage is:

320 litres x 1.1 = **352 litres storage (1 x 200ltres + 1 x 150litres)**

352 litres of water uses the following **electricity**:

If 352litres x 365 days = 126 480litres used per annum

Each 100litres uses 4.55 units of electricity (kWh) from 16˚C to 60˚C

Total energy consumption in kWh:

126 480litres/100litres x 4.55 = **5755kWh per annum**

The flat plate collectors can be calculated as follows:

If Solar Water Heating (SWH) of 1m^2 collector saves 1000kWh per year and

1m^2 collector area of SWH area requires 60litres of storage

To save 5755kWh (100% of electricity) one will require 5755/1000 = **5.75m^2 collectors** for 320 litres (1 x 200litres + 1 x 150litres storage)

The **second calculations** take the functional regulation XA2 into consideration, which states that at least **50% (volume fraction)** of the annual average hot water heating requirement shall be provided by means other than electrical resistance heating. This requirement will lead to a 50% electrical saving, resulting in the following storage space and collectors for 4 people:

352litres storage x 50% (50% volume heated by alternative technology) = **176litres of hot water**.
This will require **1 x 200litre solar tank for storage**

50% of 5.75m^2 collectors = **2.87m^2 (1 panel)** of flat plate collector for 176litres of storage (1 x 200litre solar tank)

9.5 Position of Geyser and Collector

An example is provided of where to position a forced circulation indirect split system (built-in pump) and a flat plate collector in Figure 10.

The flat plate collectors come in different sizes and should we require 2.9m² panels then 1 flat plate collector will be required. These collectors should be situated on the north facing roof slope and preferably be placed for winter conditions at an angle of (latitude +10˚= 36˚) or one can add an extra panel to make up for no angle. Figure 11 indicates best panel orientations.

The hot water storage tank should be located as close to the main areas of hot water (bathroom and kitchen) as practically possible. The pipes should be insulated well.

Solar collectors should be positioned as close to the storage tanks as possible. The 1 x 300 litre solar geyser can be placed vertically or horizontally according to standards. If the solar geyser is positioned outside the house it must be of a good quality and insulated well.

Figure 10: Roof position of closed coupled- and split SWHs

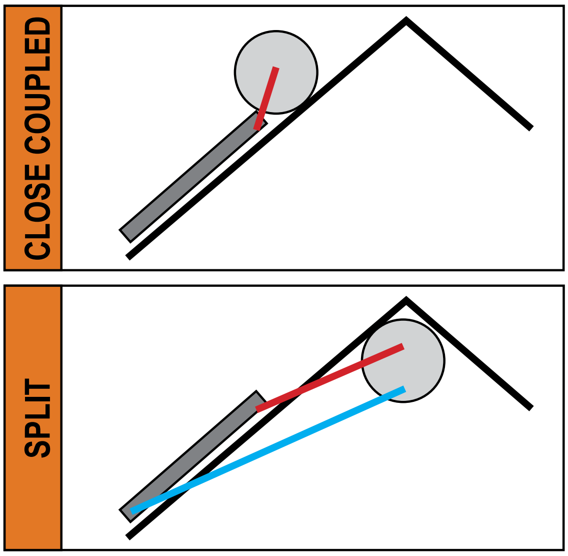
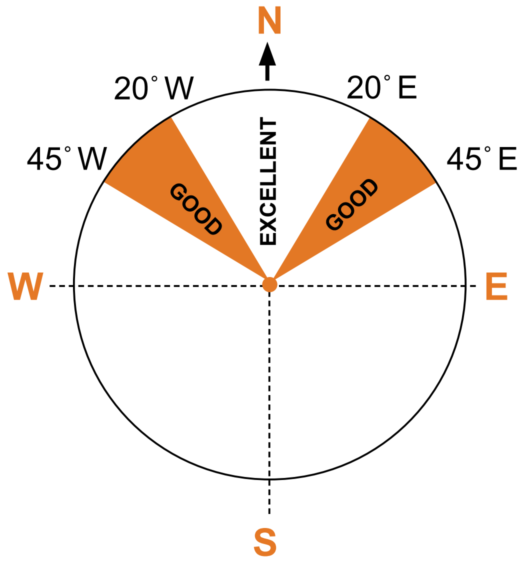


Figure 11: Best SWH panel orientations and panels



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