Technical Information

Section Directory

Sustainable Energy Information

Windows Placement and Sizing

This fact sheet contains information and recommendations on the sizing and placement of windows to maximise winter sun penetration, while minimising excessive summer heat gain and winter heat loss.

Benefits of good window design:

Windows are a vital part of any home - they allow natural light into the home providing views and fresh air.
Well-planed and protected windows improve comfort year-round and reduce the need for heating in winter and cooling in summer.

Window size, orientation, glazing treatment, shading and internal coverings can have a significant impact on energy efficiency and comfort. Designing north windows for maximum solar access can reduce winter heating bills by up to 25%. External shading can block up to 80% of summer heat gain through windows. Internal window coverings and double glazing can reduce winter heat losses by around 40%.

Window design and shading principles:

The three main principles of energy smart window design are listed below:

1. Maximise winter heat gain by orientating the amount of thermal mass in the dwelling.
2. Minimise winter heat loss through appropriate window sizing, together with double glazing and/or close-fitting internal coverings such as drapes with pelmets.
3. Minimise summer heat gain by protecting windows with external shading devices, and through appropriate sizing and positioning of windows.

The same principles apply to other types of glazing, such as glass doors, roof windows and skylights.
Wherever the term 'window' is used in this fact sheet, it encompasses all forms of glazing.

Heat flow through glass:

The main heat gain through windows is due to solar radiation. Windows receive this as both diffuse radiation reflected from the sky and ground, and direct radiation when the sun shines on the window. On average, between 30-40% of total radiation to north windows is diffuse, depending on weather conditions.

A greenhouse effect occurs when radiation from the sun enters the home through the glass. As this term is now commonly used to refer to the global warming caused by the increase of certain gases in the atmosphere, the term "glasshouse effect" will be used here to avoid confusion.

Figure 5.1 shows how the glasshouse effect occurs. Radiation from the sun (shortwave radiation) passes through glass to the interior virtually unimpeded. This radiant heat is absorbed by furniture and building elements, which then heat up and re-radiates heat to the room air. This re-radiated heat (long wave radiation) does not pass through glass as readily, resulting in convective heat build-up within the room.

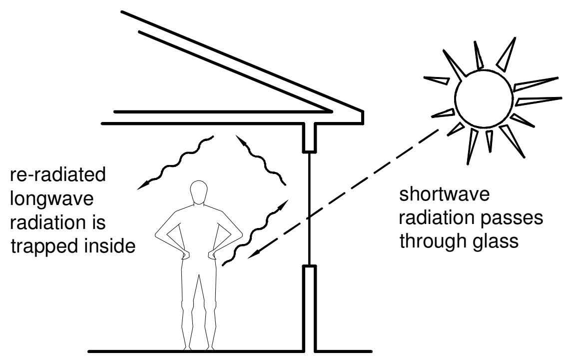

Figure 5.1:

The glasshouse effect can be used to advantage in winter to keep a home warm. In summer, however, it should be avoided by shading glass from the direct rays of the sun.

Heat also passes through glass by conduction, caused by heat flowing through glass from areas of higher to lower air temperatures. A bare window with a sheet of three-millimetre glass can gain (or lose) up to ten times more heat than through an insulated wall of the same size. On a winter night, large amounts of heat can be lost through unprotected glazing in a home. Glass is therefore the potential weak link in building design.

The amount of heat transmitted through the glass depends on a number of factors including window orientation size, amount of external shading, and glass treatments such as tinting or reflective films. Net heat gains depend on the balance between the amount of direct and diffuse radiation received and the amount of heat lost. It is vital to have a net heat gain through windows in winter and net heat loss in summer.

Window orientation:

The amount of radiation received by a window varies according to orientation and time of year. During summer all windows receive net heat gains, but especially those facing east and west. Figure 5.2 compares the summer radiation received by windows of different orientations with the heat given out by a two-bar radiator operating three hours per day. As can be seen, most unshaded windows receive substantial heat gains.

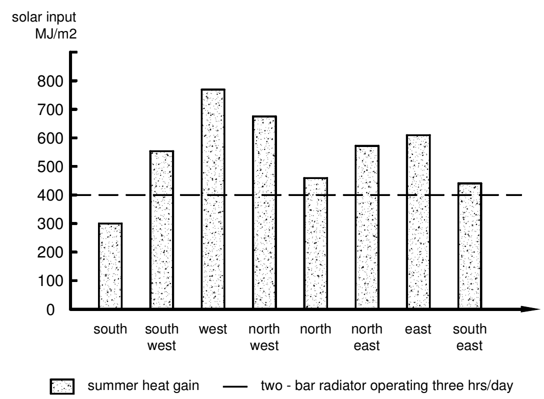

Figure 5.2: Window orientation and summer radiation (unshaded glass)

In winter, the situation is different. Only windows facing north, north-west and north-east have a net heat gain over winter, with heat gains outweighing heat losses (see figure 5.4). Although east and west windows receive substantial solar radiation in the morning and afternoon, respectively, the overall heat losses outweigh the gains over a 24 hour period. Windows orientated to the south also have net heat loss.

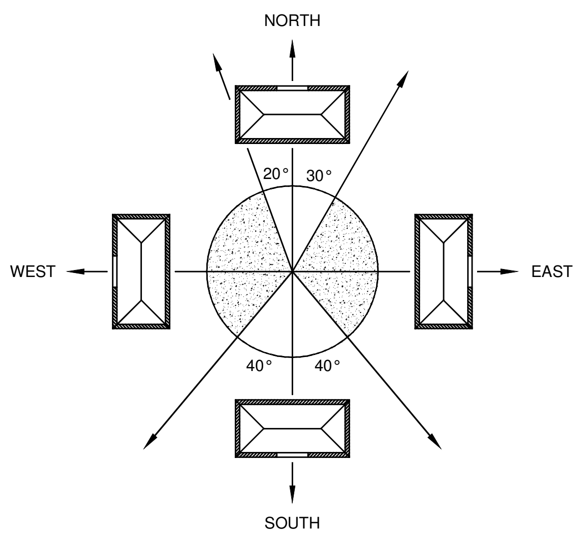

Figure 5.3: Window orientations considered to be north, east, west and south.

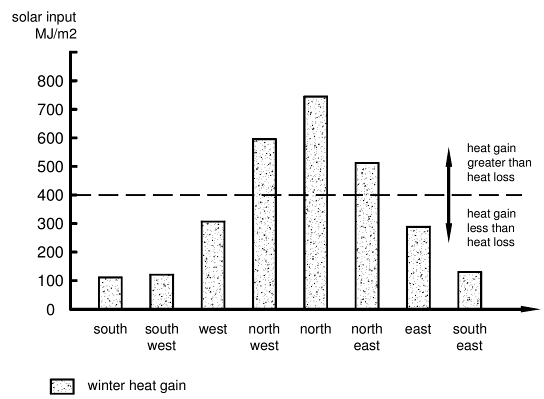

Figure 5.4: Window orientation and winter radiation (unshaded glass)

Figure 5.3 shows the range of orientation for Victoria within which a window is regarded as facing north, east, west or south. These orientations are used for all tables and calculations in this fact sheet.
North-facing windows receive winter sun, allowing light and warmth into the home. They can be easily shaded in summer to help keep the home cool. If north-facing windows are too large, they will suffer excessive heat loss in winter and heat gain in summer. The optimum size of north-facing windows will depend on solar access and the building materials used.

East and west-facing windows receive little winter, autumn and spring sunlight, but excessive summer sunlight. They should therefore be kept small, especially those facing west, and be well shaded.

South-facing windows receive no direct sunlight in winter and only receive early morning and late afternoon sunlight in summer. They should be kept small; however, with cooling breezes in summer usually coming in from the south, they are useful for cross-ventilation.

Optimum window size:

The most appropriate size of windows for energy smart design depends on building orientation and the amount of thermal mass in the internal building materials. The total glass area is best kept between 20 -25% of the total floor area for brick veneer houses and 22 - 30% for double-brick houses.

Three factors to consider in sizing windows are listed below:

1 Window area must be kept within acceptable limits.

2 Balancing different orientations of north, south, east and west glass should be used.

3 Glass in individual rooms should be correctly sized.

In addition, Victorian building regulations require a minimum glass area of 10% of the room's floor area for each habitable room.

The **FirstRate** House Energy Rating can be used to assess the effect of variations to glass areas, window orientations, shading, internal coverings or double glazing on energy efficiency.
Thermal mass can be used to moderate temperature and balance the area of glass.

Total window area:

Table 5.1 gives recommended total window areas expressed as a percentage of total floor area. Larger areas of glass are better suited to homes with higher levels of thermal mass and larger north-facing windows.

Construction Type	Total Area % when North Glass is less than 5% of total floor area	Total Area % when North Glass is more than 5% or total floor area
Timber Floor		
Brick veneer and weatherboard walls	20%	22.50%
Brick cavity walls	22.50%	27.50%
Concrete slab floor		
Brick veneer and weatherboard walls	22.50%	25%
Brick cavity walls	25%	30%

Table 5.1: Maximum total glass area as percentage of total floor area

Balancing different orientations:

It is recommended that the majority of glass be orientated towards the north. This provides maximum winter benefits, and can be easily shaded in summer. Smaller amounts should face east and south, with smaller amounts facing west.

North-facing windows:

Between 30degrees east of true north and 20degrees west of true north (see figure 5.5)

Ideal sizes of north-facing windows depend on solar access and the building materials used. Additional thermal mass such as internal brick walls can improve energy efficiency and allow the use of more north-facing glass.

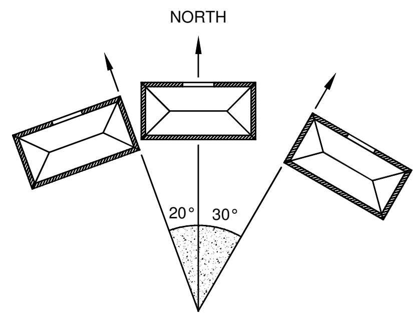

Figure 5.5: Range of acceptable orientations for north-facing windows.

If solar access is good and the floors are concrete slab:

> the area of north-facing windows should be large: between 10-15% of the homes total floor area;

and

> the area of north-facing windows in individual rooms can be up to 25% of the room's floor area.

If solar access is good and the floors are timber:

> the area of north-facing windows should be large: around 10% of the home's total floor area; and

> the area of north-facing windows in individual rooms can be up to 20% of the room's floor area.

If solar access is poor:

> the area of north-facing windows should be kept reasonably small: less than 8% of the home's total floor area: and

> keep the window area in individual rooms less than 15% of the room's floor area.

South-facing windows:

Between 40degrees east of south and 40degrees west of south (see figure 5.6)

> Keep south-facing windows reasonably small: total window area should be less than 5% of the home's total floor area.

> Keep the window area in individual rooms less than 15% of the room's floor area.

> Place south-facing rooms and windows so that cooling summer breezes can pass through the rooms easily.

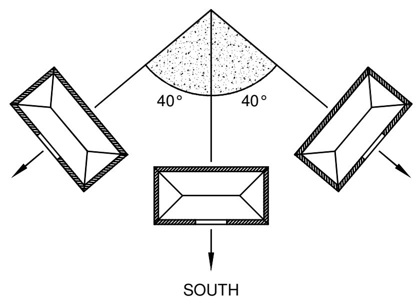

Figure 5.6: Orientation of windows considered to be south-facing

East-facing windows:

Between 30degrees east of true north and 40degrees east of south (see figure 5.7)

> Keep east-facing windows reasonably small: total window area should be less than 5% of the home's total floor area.

> Keep the window area in individual rooms less than 15% of the room's floor area.

> Shade east-facing windows in summer.

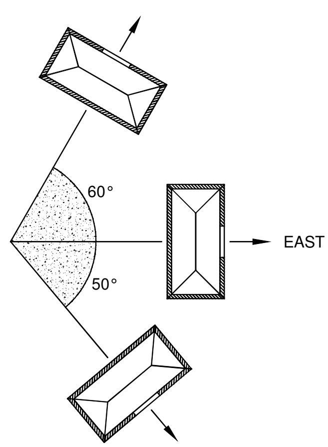

Figure 5.7: Orientation of windows considered to be east-facing

West-facing windows:

Between 20degrees west of true north and 40degrees west of south (see figure 5.8)

> Keep west-facing windows small: total window area should be less than 3% of the home's total floor area.

> Keep the window area in individual rooms less than 10% of the room's floor area.

> Shade west-facing windows in summer.

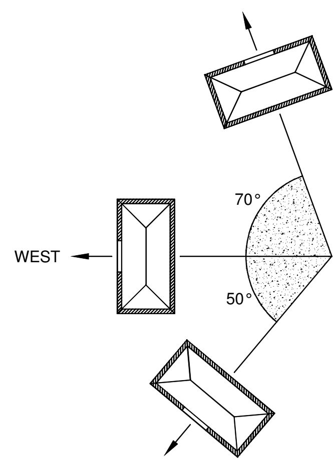

Figure 5.8: Orientation of windows considered to be west-facing.

Roof windows and skylights:

Roof windows and skylights should:

> be kept as small as possible;
> be avoided in living and bedroom areas;
> provide summer shading and protection from winter heat loss; and
> be double-glazed or have a ceiling diffuser fitted.

Windows facing more than one direction:

The maximum window sizes apply to rooms that have windows facing only one direction. If rooms with east or west windows have windows facing other directions as well, maximum sizes should be adjusted as follows:

> reduce east glass by 1% for every 1.5% of north window area and 2.8% of south window area: and

> reduce west glass by 1% for every 2% of north window area and 3.5% of south window area.

Sites with poor solar access:

Innovative design can overcome problems of poor solar access and overshadowing. This is often a problem for renovations, infill development, higher density and small lot developments. In situations with little or no direct solar access (e.g. homes with mainly south-facing windows or heavily shaded sites), appropriate levels of insulation, window protection and draught proofing are vital. Conversely, thermal mass is of less importance. To compensate for poor solar access, the total window area of the home should be kept below 20% of the floor area. Also, the following window design strategies should be considered.

Raise sill heights

Raising sill heights can avoid 'wasted' areas of glass which are permanently in shadow (see figure 5.9). They allow high solar gains to be achieved for north windows with as little as four metres separation between single-storey buildings.

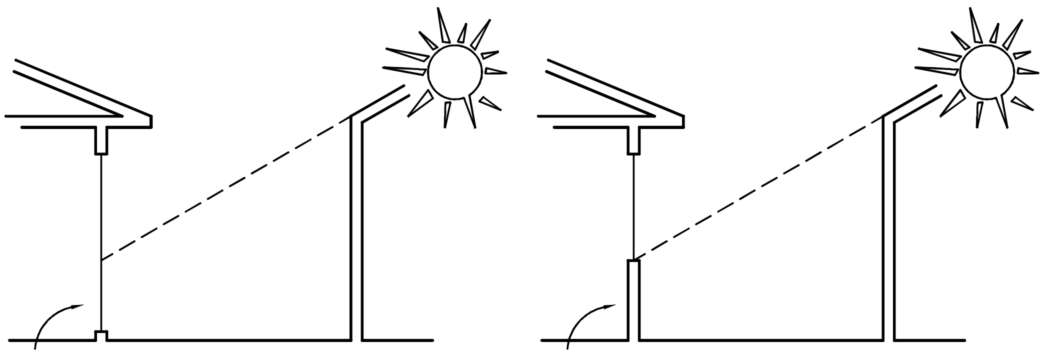

Figure 5.9: Raise sill height to maximise winter heat gain

Table 5.2 shows the recommended sill heights and distance required from a northern obstruction to maintain 90% of winter solar access.

Sill Height	Distance (Meters) needed to maintain 90% solar access		
	One Storey	Two Storey	Three Storey
Eave width (600mm)			
Floor level	5.8	11	16.5
0.3mm	5.3	10	15.2
0.6mm	5	9.4	14.4
Eave width (300mm)			
0.9mm	4.3	8	13.5

Table 5.2: Distance between buildings needed to maintain 90% solar access

Clerestory windows:

North-facing clerestory windows should be considered as they can be particularly useful where there is a building obstructing solar access to the north (see figure 5.10). A simple eave overhang for a northern orientation can shade clerestory windows. For east and west-facing clerestory windows, internally- operated adjustable louvres or blinds installed internally or externally, or sandwiched between two panes of glazing, can be used. Tinted glass could also be considered, although this will reduce winter light and affect heat gain.

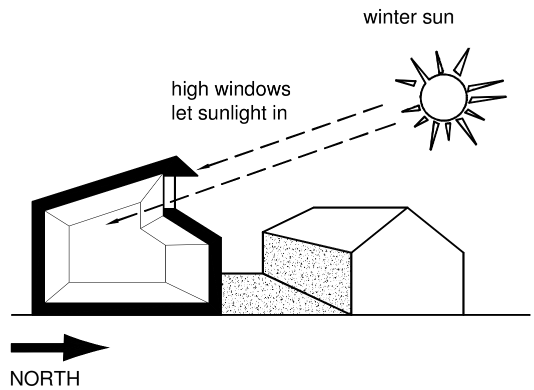

Figure 5.10: North-facing clerestory windows can provide solar access

Courtyards:

A north-facing courtyard can be created with an L-shaped or U-shaped house plan. Courtyard windows need to be small in size, as overshadowing by the side walls of the building itself and adjacent structures will occur, reducing solar access (see figures 5.11 and 5.12).

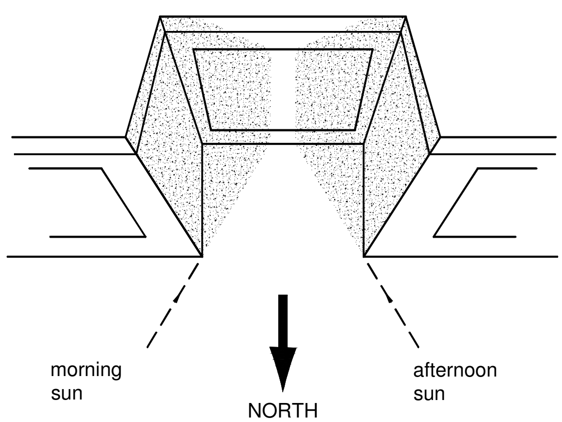

Figure 5.11: Side walls overshadow large windows in deep courtyards in winter

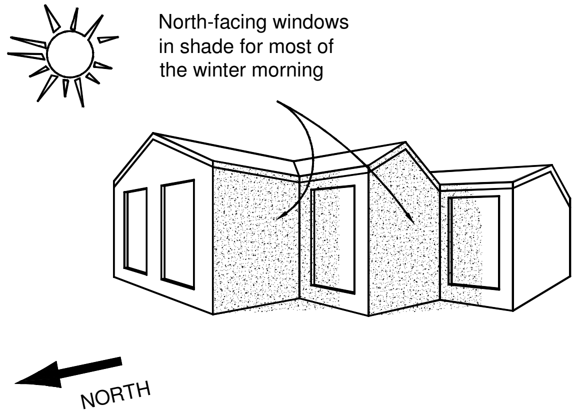

Figure 5.12: East and west-facing walls can shade adjacent north-facing windows in winter.

More overshadowing will occur on the lower part of the wall than the upper, so minimise the use of full-height windows adjacent to side walls. Table 5.3 sets out a formula for identifying the preferred glazing zone. This table allows the optimum area of glazing both above and below 1200mm in height to be gauged.

Depending on the dimensions of the courtyard and the height of adjacent obstructions, courtyard windows may need summer shading (**see table 5.3**).

Window Location and Height	**Distance to inset window from side wall D=Depth of Wall**	**Preferred Glazing Zone**
First Floor		
> Windows with any glazing below 1200mm	D/4 (max 1.5m)	
> Windows with all glazing below 1200mm	D/5 (max 1m)	Insert drawing into fact sheet Page 7
Ground Floor		
> Windows with any glazing below 1200mm	D/2 (max 3m)	
> Windows with glazing below 1200mm	D/3 (max 2.2m)	

Table 5.3: Preferred glazing zone for recessed northern walls

Solar gain from east or west windows

In the absence of northern solar access, windows to the east and west can provide some winter heat gains. As winter heat losses and summer heat gains are greater for east and west windows than for north windows, appropriate shading and protection from heat loss is essential. Keep window areas within the limits suggested.

Thermal Stress and Thermal Fracture in Glass:

The recent introduction of energy efficiency regulations for Class 1 to 4 residential buildings and the forthcoming regulations for classes 5 to 9 has led to a new awareness of the benefits of solar control glass, insulated frames and shading devices for residential and commercial windows.

The use of solar control glass replacing clear glass can in some applications require careful consideration to avoid the possibility of a Thermal Fracture.

The risk of thermal fracture is a consequence of the development of critical thermal stress in glass. There are various factors which independently and combined contribute to the development of thermal stress.

The risk of thermal fracture can be minimised in any type of building but requires an understanding of the characteristics of glass and the factors which influence the development of thermal stress.

Thermal Stress Development

Thermal stress is developed from a differential expansion within a glass panel caused by heating and cooling of areas of the panel.

In a window the edge of the glass is shielded from sunlight by the frame, thus the covered edge will be cooler than the central area, which is exposed to the sun. The expansion of the central area will be resisted by the cool edges. The expansion of the exposed area causes the glass edges to stretch and as a consequence develop tensile stress. If this stretching of the edges becomes sufficiently large then the resulting tensile stress will be sufficient to break the glass. This break is termed a thermal fracture and the tensile stress developed is called thermal stress.

FACTORS WHICH INFLUENCE THE DEVELOPMENT OF THERMAL STRESS:

1. **Solar Absorption and Heat Traps**

   The amount of heat, which is absorbed by the glass, has a direct effect on the temperature of the glass, so is an important factor in the development of thermal stress. A high performing solar control glass will absorb considerably more heat than clear glass so the solar control glass will be at greater risk of thermal fracture than clear glass. In addition to this, blinds reflect heat back into the glass as well as allow the air between the glass and the blind to warm up. This causes the glass to become even hotter than by exposure to the sun passing through the glass alone. The same effect is caused by the presence of drop down ceilings, heat absorbing or reflecting labels or decorations on the glass, etc. Spandrel glazing is an extreme example of a heat trap condition.

2. **Shadows**

   The presence of a shadow produces a cool area larger than that from a frame alone which enables the glass to stay even cooler. The consequence is a greater temperature difference between the exposed and shaded areas of the glass, therefore a higher thermal stress and a greater likelihood of thermal fracture. Shadows are commonly cast across glass by vertical mullions, balcony overhangs, eaves and columns etc. The resulting shadows may be static of mobile. A static shadow is more critical because it produces a cooler area of glass than a mobile shadow.

3. **Edge Strength**

   When the tensile stress in the glass exceeds a critical point, a crack will form. The magnitude of this critical point depends on the strength of the glass edge. A clean-cut edge is the strongest as the cutting produces the least amount of damage. A polished edge is close to the strength of a clean-cut edge. The presence of damage to the edge will reduce the edge strength and increase the likelihood of failure due to thermal fracture. The actual edge strength depends on the quality of the glass edge. The strength of a damaged edge is highly variable so it is not possible to determine the risk of thermal fracture. For this reason the process of assessment for the risk of thermal fracture assumes clean cut edges.

   The edges of glass are easily damaged by incorrect handling so it is important that glass is handled carefully during glazing. Do not glaze glass which has damaged edges. If it is likely that the cutting of glass may result in some damage to the edge as with laminated glass then consideration should be given to having the edges polished to remove the damage.

4. **Artificial Heating and Cooling**

   The presence of heating or cooling vents, which blow directly on the glass, can cool or heat the glass excessively. This can cause excessive thermal stress in the glass.

5. **Frame Type and Colour**

   The temperature of the edge of the glass is influenced by the frame in which it is captured. An insulating material such as timber or vinyl will keep the glass edge cool while a conductive material such as aluminium is influenced by the frame colour. A dark colour is more absorptive than white so will enable the frame to absorb more heat so the edge of the glass inside the frame will be warmer than if the frame was white in colour.

   The cooler the edge of the glass the greater the difference in temperature between the warm area of the glass and the edge of the glass so the greater the thermal stress. Therefore an insulating frame will provide a greater contribution to the development of thermal stress than a dark non-insulating frame.

TYPES OF THERMAL FRACTURE

There are two types of thermal fracture and they relate to the magnitude of stress required to cause the fracture.

1 **Low Energy**

   This is by far the most common type of thermal fracture encountered. It is caused by damage to the edge of the glass. This weakens the edge so only a small amount of thermal stress is required to cause a fracture. The likelihood of this type of fracture cannot be determined using a thermal assessment process.

2 **High Energy**

   This is very rare and requires a very high magnitude of thermal stress. The likelihood of this type of thermal fracture can be determined using a thermal assessment process.

PREVENTATIVE ACTIONS

1 **Low Energy**

The vast majority of thermal fractures are of the low energy type so the likelihood cannot be determined using a thermal assessment process. The following can be undertaken to minimise the chances of fracture.

- Where laminated glass is used consideration should be given to having the edges polished.
- Inspect the glass when delivered and check for any edge damage. Reject any damaged glass.
- Inspect the glass before glazing into the frame. Do not glaze glass with damaged edges.

2 **High Energy**

High energy thermal fractures are very rare but their likelihood can be determined by undertaking a thermal assessment. If the thermal assessment determines that the glass is at risk then heat strengthen or toughen the glass as this will increase the thermal resistance and effectively eliminates the potential for thermal fracture in buildings.

Note that Pilkington carries out thermal stress assessments as a service for customers.

Conclusion:

The potential for high energy thermal fracture should be addressed at design time with the completion of a thermal assessment. Decisions can then be taken as to the process best adopted to alleviate the problem.

Low energy thermal fractures can be substantially reduced by examining the glass before it is glazed and not glazing those panels which have damaged edges.

The information contained in this article is offered for assistance in the application of Pilkington Australia flat glass products and like products manufactured and sold under the Pilkington name, but ***it does not constitute a warranty of merchantability or fitness for any particular purpose.*** Actual performance may vary in particular applications.

Source: WINDOWS September, 2005

THE SUITABILITY OF THE USE OF VARIOUS UNTREATED TIMBERS FOR BUILDING CONSTRUCTIONS IN BUSHFIRE PRONE AREAS

Source: WFRA No. 20550

Report Version 20550.2

Executive Summary:

A range of untreated timbers of minimum thickness of 18mm have been tested in a cone calorimeter with an irradiance level of 25 k/W m2 following the procedure specified in AS/NZS 3837:1998. The results obtained from the tests have been assessed against the criteria specified in AS 3959-1999 incorporating Amendments Nos 1 and 2 for fire-retardant-treated timbers which are summarised below:

For the purpose of AS 3959-1999 fire-retardant-treated timber is timber that when tested to AS/NZS 3837 meets the following parameters, after having been subjected to the regime of ASTM D 2898 Method B:

- *Ignition does not occur when the material is exposed to an irradiance of 10 kW/m2.*

- *The maximum heat release rate is not greater than 100 kW/m2 when the material is exposed to an irradiance level of 25 kW/m2.*

The above criteria were derived from the properties of fire-retardant-treated timbers that are available in the US but not in Australia at the time of preparation of this report. It is understood the above criteria are currently under review by the relevant Standards Australia committee due to difficulties experienced in achieving compliance and limited correlation of the performance and test criteria with bushfire data.

It is noted that AS/NZS 3837 allows the cone calorimeter test to be terminated if the specimens did not exhibit evidence of heat evolution during the first 10 minutes of the test. A design fire front duration for bushfires of 10 minutes has also been proposed.

At the time of this report a study is being undertaken by Warrington Fire Research to develop appropriate test methods and performance criteria for the assessment of elements of construction and materials exposed to bushfires.

The following alternative criterion for cone calorimeter testing to determine the suitability of the use of the timber species for building constructions in bushfire-prone areas is currently being considered in lieu of the current criteria in AS 3959-1999:

When subjected to a cone calorimeter test in accordance with AS/NZS 3837:1998:-

- Ignition does not occur in the first 10 minutes when the material is exposed to an irradiance level of 25 kW/m2.

The timber species considered in this report can be classified as follows:

Timbers Satisfying the Definition of Fire-Retardant-Treated Timber Specified in AS 3959-1999 Incorporating Amendments Nos 1 and 2	**Timbers Which Do Not Satisfy the current AS 3959-1999 Definition of Fire-Retardant-Treated Timber but satisfy the Proposed Performance Criteria**	**Timbers Which Do Not Satisfy the Definition of Fire-Retardant-Treated Timber Nor the Proposed Performance Criteria**
Blackbutt Kwila (Merbau) Red Iron Bark River Red Gum Silver Top Ash Spotted Gum Turpentine	Balua (Selangan Batu) Forest Red Gum Jarrah Tallowwood Yellow Stringybark	Hoop Pine Mountain Ash Messmate Radiata Pine Weathered Hoop Pine Weathered Messmate Weathered Radiata Pine

The Suitability of the Use of Various Untreated Timbers for Building Constructions in Bushfire Prone Areas

1.0 *Introduction:*

1.1 This report presents a considered opinion of the suitability of the use of various untreated timbers for building constructions in bushfire-prone areas.

1.2 The opinion is based on heat release rates determined by oxygen consumption calorimetry on a range of timbers of minimum thickness of 18mm, using a cone calorimeter and conducted in accordance with AS/NZS 3837:1998.

1.3 The current Australian Standard AS 3959-1999 requires timbers to be fire-retardant-treated for certain components of a building in a bushfire-prone area, subject to the level of risk of bushfire attack. Therefore, test data for each timber species is assessed against the criteria for fire-retardant-treated timbers specified in AS 3959-1999 incorporating Amendments Nos. 1 and 2.

1.4 For those timber species which do not comply with the definition of fire-retardant-treated timbers specified in AS 3959-1999 incorporating Amendments Nos. 1 and 2, alternate criteria are proposed to assess the suitability of their use for building constructions in bushfire-prone areas.

1.5 The test date considered were obtained from specimens which included Balau (Selangan Batu), Blackbutt, Forest Red Gum, Hoop Pine, Jarrah, Kwila (Merbau), Mountain Ash, Messmate, Red Iron Bark, Radiata Pine, River Red Gum, Silver Top Ash, Spotted Gum, Tallowwood, Turpentine, Yellow Stringybark, weathered Hoop Pine, weathered Messmate and weathered Radiata Pine.

1.6 All tests were carried out at the Victoria University (VU) and the relevant data obtained is summarized in tabular form in Appendix 1.

2.0 *Discussion:*

2.1 Definition of Fire-Retardant-Treated Timber

2.1.1 Fire-retardant-treated timbers are defined by Clause 1.5.6 in AS 3959-1999 incorporating Amendments Nos 1 and 2 as follows:

For the purpose of AS 3959-1999, fire-retardant-treated timber is timber that when tested to AS/NZS 3837 meets the following parameters, after having been subjected to the regime of ASTM D 2898 Method B:

(a) *Ignition does not occur when the material is exposed to an irradiance level of 10 kW/m2.*

(b) *The maximum heat release rate is not greater than 100 kW/m2 and the average heat release rate for 10 min following ignition is not greater than 60 kW/m2 when the material is exposed to an irradiance level of 25 kW/m2.*

2.1.2 At least three samples of each timber species were tested in a cone calorimeter with an irradiance level of 25 kW/m2 in accordance with AS/NZS 3837:1998 and the results are assessed using the above criteria to determine whether they are classified as fire-retardant-treated timbers by AS 3959-1999 incorporating Amendments Nos. 1 and 2.

2.1.3 All samples for each timber species must comply with the criteria listed in Clause 2.1.1 in order to be classified as fire-retardant-treated timber. However AS/NZS 3837:1998 allows the test to be terminated if there is no evidence of heat evolution during the first 10 minutes.

2.1.4 ASTM D 2898 -94 is designed to ascertain the durability of a fire-retardant treatment of wood under exposure to accelerated weathering as fire retardant material could be leached out during the process. However, all timber species considered in this report had not been treated with fire retardant material and therefore it is considered reasonable to waive this weathering process for the purpose of this assessment. Those timbers that had been naturally weathered prior to fire testing exhibited similar or better results to those that had not been subjected to natural weathering.

2.2 *Timber Species Classification*

2.2.1 Spearpoint and Quintiere * reported that the lowest radiant heat flux to cause timber ignition within 90 minutes was approximately 10 kW/m2 and it is dependent on many factors, such as species, moisture content, density and grain orientation.

2.2.2 It has been reported by Drysdale** that piloted ignition of thermally thick wood species may occur after prolonged exposure of a radiant heat flux of approximately 12.5 kW/m2.

2.2.3 The timber species considered in this report are of minimum thickness of 18mm and can be considered thermally thick***.

2.2.4 As the timber species considered in this report are of high density, it is considered that ignition is unlikely for an extended period of time if the timber species are subjected to an irradiance level of 10 kW/m2 and therefore criterion (a) specified in Clause 2.1.1 is deemed to be satisfied to the degree necessary.

2.2.5 Timber Species Which Satisfy Criterion (b) Specified in Clause 2.1.1

2.2.5.1 It is observed from the test results that heat release rates of six timber species, Kwila (Merbau), Red Iron Bark, River Red Gum, Silver Top Ash, Spotted Gum and Turpentine, when ignited did not reach 100 kW/m2 and their average heat release rates for 10 minutes after ignition were below 60 kW/m2. Therefore, these species can be classified as fire-retardant-treated timber in accordance with AS 3959-1999 incorporating Amendments Nos. 1 and 2.

2.2.5.2 One sample of Blackbutt tested was found to satisfy criterion (b) specified in Clause 2.1.1. In the other two tests (Tests 1 and 3), although the average heat release rates for 10 minutes after ignition were below 60 kW/m2, the maximum heat release rates obtained were greater than 100 kW/m2. However, the samples did not ignite until after 10 minutes and a heat release rate of 100 kW/m2 was reached more than 15 minutes after ignition.

2.2.5.3 The cone calorimeter test procedure outlined in AS/NZS 3837:1998 states that *if the specimen does not ignite in 10 min, remove and discard, unless the specimen is showing signs of heat evolution.*

2.2.5.4 In tests 1 and 3, the Blackbutt specimens did not ignite in 10 minutes and there were no signs of heat evolution that could be attributed to the onset of ignition. Therefore, the cone calorimeter tests can be considered to have ceased at 10 minutes and could be deemed to satisfy the requirements of AS/NZS 3837:1998. On this basis, Blackbutt may be deemed-to-satisfy criterion (b) specified in Clause 2.1.1 and be regarded as a fire-retardant-treated timber in accordance with AS 3959-1999 incorporating Amendments Nos. 1 and 2.

2.2.5.5 The results and the classification above can also be applied to timber species of thickness greater than 18mm.

2.2.6 Timber Species Which Do Not Satisfy Criterion (b) Specified in Clause 2.1.1

2.2.6.1 Timber species which did not satisfy criterion (b) specified in Clause 2.1.1 include Balau (Selangan) Batu), Forest Red Gum, Hoop Pine, Jarrah, Mountain Ash, Messmate, Radiata Pine, Tallowwood, Yellow Stringybark, weathered Hoop Pine, weathered Messmate, and weathered Radiata Pine.

2.2.6.2 These timber species cannot be classified as fire-retardant-treated timbers in accordance with AS 3959-1999 incorporating Amendments Nos. 1 and 2. However, alternate criteria are proposed to assess the suitability of their use for building constructions in bushfire-prone areas.

2.3 *Proposed Criterion for Suitability of the Use of Timber in Bushfire-Prone Areas*

2.3.1 The following alternative performance criterion is proposed to assess the suitability of a particular timber species to be used for building constructions in bushfire-prone areas.

When subjected to a cone calorimeter test in accordance with AS/NZS 3837:1998:-

(a) Ignition does not occur in the first 10 minutes when the material is exposed to an irradiance level of 25 kW/m2.

2.4 *Appropriateness of the Proposed Criteria*

2.4.1 The existing criteria in AS 3959-1999 were derived from the properties of fire-retardant-treated timbers that are available in the US but not in Australia at the time of preparation of this report. It is understood the above criteria are currently under review by the relevant Standards Australia committee due to difficulties experienced in achieving compliance and limited correlation of the performance and test criteria with bushfire data.

2.4.2 It is noted that AS/NZS 3837 allows the cone calorimeter to be terminated if the specimens did not exhibit evidence of heat evolution during the first 10 minutes of the test.

2.4.3 At the time of preparation of this report a study is being undertaken by Warrington Fire Research to develop appropriate test methods and performance criteria for the assessment of elements of construction and materials exposed to bushfires. The proposed criterion in Section 2.3 of this report is intended to provide an acceptable level of resistance to ignition when exposed to radiant heat while the fire front passes. The effect of direct flame impingement is not considered in the proposed criteria.

2.5 *Assessment of Timber Species Using the Proposed Criteria*

2.5.1 For those timber species which did not comply with the definition of fire-retardant-treated timbers specified in AS 3959-1999 incorporating Amendments Nos.1 and 2, the proposed criteria, specified in Clause 2.3.1, were used to determine the suitability of their use for building constructions in bushfire-prone areas.

2.5.2 The timber species to be assessed using the proposed criteria include Balau (Selangan Batu), Forest Red Gum, Hoop Pine, Jarrah, Mountain Ash, Messmate, Radiata Pine, Tallowwood, Yellow Stringybark, weathered Hoop Pine, weathered Messmate and weathered Radiata Pine.

2.5.3 All samples of each timber species above must comply with the criteria listed in Clause 2.3.1 in order to be considered suitable for building constructions in bushfire-prone areas.

2.5.4 It is observed from the test results that five timber species did not ignite for the first 10 minutes when subjected to an irradiance level of 25 kW/m2 and they are Balau (Selangan Batu), Forest Red Gum, Jarrah, Tallowwood and Yellow Stringybark.

2.5.5 Therefore, Balau (Selangan Batu), Forest Red gum, Jarrah, Tallowwood and Yellow Stringybark of minimum thickness of 18mm satisfy the proposed criteria specified in Clause 2.3.1.

2.5.6 Hoop Pine, Mountain Ash, Messmate, Radiata Pine, weathered Hoop Pine, weathered Messmate and weathered Radiata Pine satisfy neither the criteria for fire-retardant-treated timbers specified in AS 3959-1999 incorporating Amendments Nos. 1 and 2 nor the proposed criteria listed in Clause 2.3.1. Therefore, these timber species are considered unsuitable for building constructions in bushfire-prone areas.

3.0 *Conclusions:*

3.1 On the basis of the above discussion, it is concluded that the following untreated timber species of minimum thickness of 18mm can be classified as fire-retardant-treated timbers in accordance with AS 3959-1999 incorporating Amendments Nos. 1 & 2 and therefore considered suitable for building constructions in bushfire-prone areas:

Fire-retardant-treated timber:

- Blackbutt
- Kwila (Merbau)
- Red Iron Bark
- River Red Gum
- Silver Top Ash
- Spotted Gum

- Turpentine

3.2 For those timber species which do not satisfy the definition of fire-retardant-treated timbers specified in AS 3959-1999 incorporating Amendments Nos. 1 and 2, an alternate criterion has been proposed to assess the suitability of their use for building constructions in bushfire-prone areas. The proposed criterion is as follows:

When subjected to a cone calorimeter test in accordance with AS/NZS 3837:1998:-

(a) ignition does not occur in the first 10 minutes when the material is exposed to an irradiance level of 25 kW/m2.

3.3 The following untreated timber species of minimum thickness of 18mm, which cannot be classified as fire-retardant-treated timbers in accordance with AS 3959-1999 incorporating Amendments Nos. 1 and 2 satisfied the proposed alternate criterion specified in Clause 3.2.

Balau (Selangan Batu)

- Forest Red Gum
- Jarrah
- Tallowwood
- Yellow Stringybark

3.4 On the basis of the above discussion, it is concluded that the following untreated timber species of thickness of 18mm do not satisfy the criteria for fire-retardant-treated timbers specified in AS 3959-1999 incorporating Amendments Nos. 1 and 2 nor the proposed criteria listed in Clause 3.2 and are therefore considered unsuitable for building constructions in bushfire-prone areas:

- Hoop Pine
- Mountain Ash
- Messmate
- Radiata Pine
- Weathered Hoop Pine
- Weathered Radiata Pine

4.0 *Validity:*

4.1 This appraisal is based on the test method and criteria for fire-retardant-treated timbers specified in AS 3959-1999 incorporating Amendments Nos. 1 and 2 with the modifications stated in this report.

4.2 This appraisal is formulated on the basis of information and experience available at the time of preparation. It should be noted that a research study is currently being undertaken to identify appropriate test methods and criteria for elements of construction and materials exposed to bushfire conditions. The proposed criteria may be subject to change pending the outcome of this research and revision of AS 3939-1999.

4.3 This report only assessed those timber species included as summarised in Appendix 1 and should not be used for other purposes.

Referral Sources:

- Spearpoint M J and Quintiere J.G, *Fire Safety Journal, 36, 2001**
- Drysdale D, *An Introduction to Fire Dynamics, 2nd Edition,* Wile, New York,1999 **
- Mikkola E and Wickham I, Fire and Materials, 14, 1990. ***

- APPENDIX 1

Summary of Support Data

Material*	Thickness (mm)	Time to Ignition (s)	Time for HRR to Reach 100 kW/m2 (s)	Average HRR for 10 Minutes after Ignition (kW/m2)	Test Duration
BA	18	765	1830	59	2444
		764	780	59	2444
		1403	1435	64	2961
BA(s)	18	881	900	60	2330
		1196	1225	58	2816
		813	825	66	2561
BB	19	906	1990	47	2632
		949	n/a	49	2629
		807	1890	41	2359
FR	20	966	n/a	42	1368
		1303	2450	42	3487
		1449	2360	45	3302
HP	20	117	125	60	1470
		140	150	61	1694
		111	120	62	1497
JA	19	742	760	50	1510
		665	675	51	2964
		747	765	46	2905
KW	19	803	n/a	29	1450
		n/a	n/a	n/a	1955
		n/a	n/a	n/a	2055
		n/a	n/a	n/a	2055
MA	19	374	385	58	2165
		390	395	66	2027
		372	385	54	2047
MM	24	615	n/a	35	3600
		344	355	45	3170

		471	485	39	3600
		595	n/a	35	790
		560	590	41	935
MM	18	148	160	50	2110
		123	135	50	1980
		173	175	51	2165
MM	35	615	635	54	3600
		714	735	53	3600
		864	n/a	36	3600
		573	580	53	1420
RI	20	n/a	n/a	n/a	525
		1449	n/a	37	1980
		1165	n/a	33	1875
RP	21	60	75	75	1547
Material*	Thickness (mm)	Time to Ignition (s)	Time for HRR to Reach 100 kW/m2 (s)	Average HRR for 10 Minutes after Ignition (kW/m2)	Test Duration
RP	21	110	120	68	1380
		140	145	61	1486
RR	20	1506	n/a	18	2060
		1008	n/a	33	1855
		933	n/a	26	1410
SG	18	1358	n/a	47	1850
		1041	n/a	36	1690
		1081	n/a	46	1620
ST	18	1303	n/a	48	1850
		888	n/a	39	1615
		869	n/a	37	1440
TA	19	914	935	52	2980
		978	1005	57	2875
		1131	2270	50	2908
TU	19	718	n/a	34	1330
		853	n/a	41	2893
		653	n/a	36	971
WHP	19	67	80	55	1404
		69	80	61	1496
		67	80	49	1615
		72	85	47	1734
WMM	18	167	180	53	2042
		145	160	59	1803
		159	160	61	2039
WRP	21	70	85	52	1190
		99	110	60	1524
		70	75	55	1500
YS	18	996	n/a	<60	3013
		632	660	37	2841
		980	2290	36	2903

Table A1.1

Results obtained from cone calorimeter tests (25 kW/m2) for different timber species.

(n/a signifies that the timber species either did not ignite or did not reach 100 kW/m2)

* Key:		
	BA	Balau (Selangan Batu)
	BA(s)	Balau (Selangan Batu) (with reeded side down, smooth surface)
	BB	Blackbutt
	FR	Forest Red Gum
	HP	Hoop Pine
	JA	Jarrah
	KW	Kwila (Merbau)
	MA	Mountain Ash
	MM	Messmate
	RI	Red Iron Bark
	RP	Radiata Pine
	RR	River Red Gum
	SG	Spotted Gum
	ST	Silver Top Ash
	TA	Tallowwood
	TU	Turpentine
	WHP	Weathered Hoop Pine
	WMM	Weathered Messmate
	WRP	Weathered Radiata Pine