White Paper

Passivhaus

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Australian Glass Group®

Passivhaus

Passivhaus is a German originated design standard that focuses on healthy, comfortable, energy efficient buildings. It is performance based and focuses on building fabric and materials to offer an effective thermal envelope in both Residential and Commercial buildings. It considers key factors such as:

- Thermal Insulation
- Water recycling
- Air tight envelope
- Eliminating Thermal Bridges
- Effective Ventilation
- A set minimum number of air changes per hour
- Onsite renewable energy generation and storage
- Orientation to maximise passive heat in winter and natural shading in summer
- Energy Efficient Glazing

An effective Passivhaus building could have no need for artificial heating and cooling. It can require up to 90% less energy to heat during colder periods and the remaining 10% it does require can come from your own body heat, from passive heat via the sun, appliances and even your light bulbs.

Here in Australia, we have the Australian Passivhaus Association which helps educate and promote the Passivhaus standard and Certification process locally.

Passivhaus: Certification Process

The Passivhaus Certification process requires a Passivhaus Certifier to pass your building based on key factors like the design and construction elements, conducting both an initial basic and then detailed analysis before testing the built construction. These are strict global requirements and include exact specifics such as:

- Minimum 20 degrees Celsius inside temperature during winter and summer, with no more than 10% of a year's hours to be over 25 degrees Celsius
- Heating demand to be no more than 15kWh/m^2 per year
- Cooling demand to be no more than 15kWh/m^2 per year
- Humidity must not exceed 12g/kg for more than 20% of the year
- Airtightness to be a minimum 0.6ACH50 (verified on site)
- Overall Energy use to not exceed 60kwh/m^2 per year

There are 3 levels of Passivhaus Certification:

1. Classic - does not require onsite renewable energy generation
2. Plus - self generating the energy required
3. Premium - self generating more energy than required

Passivhaus: Glazing

Glazing plays a critical role in a Passivhaus building, specifically Energy Efficient glazing. As well as the air tight role windows and glass doors need to play, the Insulation (U-value) of its glazing must be high performing while the Solar Control factor (g-value) must be specific to the environment that the building is in (ie. cold, mixed or hot climates).

Generally, glass units used in Australian Passivhaus buildings will be a Double Glazed Unit (DGU) with 1x softcoat LowE coating, or a Triple Glazed Unit (TGU) with 2x softcoat LowE coatings. Argon gas used in the air gaps as well as a thermally broken 'warm edge' spacer bar. Note that a DGU with 1x softcoat LowE has better Insulation performance (lower U-value) than a standard TGU with no coating and the difference is only marginal when comparing against a TGU with 1x softcoat LowE coating. Using 2x softcoat LowE's in a TGU is when we see phenomenal improvements over a DGU with 1x softcoat LowE.

Generally, frame types used in Australian Passivhaus buildings are Thermally Broken Aluminium, uPVC, Timber or a composite (eg. Timber & uPVC). The partnership of such glass and framing will offer excellent overall thermal performance and also allow the potential to avoid smaller windows and glass doors without compromising the required performance.

It is important to note that the Passivhaus rating does not directly compare to our Residential ratings tools (NatHERS and BASIX). Coming from Germany they utilise European Standard (EN) glass values and a key calculation of Installed Whole of Window performance (glass + edge of glass + frame).

AGG recommended Softcoat LowE products with suitable low U-value:

Insulglass LowE Plus®

Insulglass LowE Advance®

Insulglass LowE Max®

Note that Insulglass LowE Plus® is available in 4mm, 5mm, 6mm, 8mm and 10mm thick while Insulglass LowE Advance® and Insulglass LowE Max® are both available in 6mm, 8mm and 10mm.

Passivhaus: Installed Whole-of-Window Calculation

In Australia we follow the Australian Fenestration Rating Council (AFRC) protocols of calculating both Glass Only performance values and Total System performance values (Glass + Frame + Sealants). AFRC protocols stem from the North American protocols; National Fenestration Rating Council (NFRC).

With Passivhaus being a European standard, it follows European glass standard protocols (EN-673). It is important to note the difference and translate any AFRC values into EN values for the Passivhaus calculation. The formula used by Passivhaus to calculate the thermal performance of the installed whole-of-window is:

$$Uw.inst = \frac{Ug*Ag + Uf*Af + \psi g*Lg + \psi w*Lw}{Aw}$$

Where:

- Uw.inst = the U-value of the complete installed Window (in EN Standards)

- Ug = U-value of the glass only (in EN Standards)
- Ag = the area of the glass (m^2)

- Uf = U-value of the frame only (in EN Standards)
- Af = the area of the frame (m^2)

- ψg = the Psi value of the linear edge of glass
- Lg = the perimeter of the glass (m)

- ψw = the Psi value of the linear installed window coupling against the building material
- Lw = the perimeter of the window (m)

- Aw = total area of the window

Psi Value (ψ)

ψ is the Greek letter Psi (pronounced “sigh”). ψg is talking about heat loss through the glazing, but rather than over a given area (like U-value covers), it is over a given length (linear). This therefore represents the heat loss per metre (m) of glass edge per degree temperature difference (Kelvin) between the inside and outside (W/mK). As opposed to U-value that covers the heat loss per square metre (m^2) of glass per degree temperature difference (Kelvin) between the inside and outside (W/m^2K).

ψw is talking about the heat loss per metre (m) of the coupling between the frame and the building material it is installed in (ie. the wall). With all of these values, the lower the Psi value, the less heat loss, therefore the better the Insulating performance.

With a piece of glass, the edges of that glass conducts more heat loss compared to the rest of the mass body of glass and so by utilising the Psi value (linear heat loss factor), you get a more detailed overall complete installed window heat loss factor – which adds the total heat loss through; the glass, the glass edge, the frame and the installed window coupling to the building material.

The Psi value of the edge of glass (ψg) is essentially determined by the type of spacer bar used in the air gap of the IGU as this is around the whole perimeter edge of the glass. AGG stocks a Passivhaus certified thermally broken warm edge spacer, boasting exceptionally low Psi values as seen below in DGU & TGU options per frame material type:

Ψ PSI Value	Thermally Broken Aluminium	uPVC	Timber	Timber & uPVC Composite
DGU: 4/16/4	0.048	0.039	0.039	0.043
TGU: 4/12/4/12/4	0.043	0.037	0.038	0.041

Table 1 – Psi Values of AGG’s Passivhaus certified thermally broken warm edge spacer

Solar Control vs Climate Zone

While the above focuses on the complete installed U-value of a window or glass door (overall thermal heat loss), Solar Control also needs to be considered based on the location of your Passivhaus building. In Europe it is common to see temperatures fall into the negatives (degrees Celsius) and some cities only have average annual temperatures as high as 6 degrees Celsius. While it can get cold in parts of Australia, it can also get very hot. This is where Solar Control should be considered by the measurement of how much heat from the sun enters inside through the glass (aka g or g-value) and therefore how much is blocked.

In Australia under AFRC standards we use the Solar Heat Gain Coefficient (SHGC) to measure this g-value. SHGC accounts for the direct transmitted heat from the sun into our buildings through the glass/glazing plus the small portion of absorbed heat that eventually enters inside also. The lower the value, the less heat enters inside, therefore the better it is at blocking heat from the Sun entering inside (via a combination of outside reflection and absorption).

Colder climates require a higher SHGC value as it is colder more times of the year than it is warmer and so a high SHGC allows Passive Heat from the Sun to enter inside during those colder periods. Hotter climates require a lower SHGC to block more of the sun heat from entering inside.

In European Standards (EN) they have traditionally used Shading Coefficient (SC) as their primary Solar Control indicator - which is similar to SHGC but is compared against a ‘worst performing’ constant (3mm clear float). SHGC is always a lower value than SC. A rough conversion factor is: SHGC = SC*0.87 or SC = SHGC*1.15.

Europe are now favouring Solar Factor as their most relevant g-value (aka Total Solar Energy Transmittance). Again, it represents how much heat from the sun enters inside a building through the glass and is a more exact SHGC equivalent but using different environmental conditions and slightly different valuation for calculating air mass.

AGG Recommended Softcoat LowE products per climate type:

Cold Climates:	Insulglass LowE Plus®	
Mixed Climates:	Insulglass LowE Plus®	
	or Insulglass LowE Advance®	
Hot Climates:	Insulglass LowE Advance®	
	or Insulglass LowE Max®	

Skylights also benefit from enhanced solar heat protection while maintaining the high levels of natural light transmission required for these applications. Insulglass LowE Max® is therefore the ideal glass choice for skylight installations and should be on the Outer pane of an IGU. Note that Australian Standard AS 1288 applies to skylights and may require the inner pane of an IGU to be laminated.

AFRC vs EN Standards in Glass

As explained, the Passive House calculation of the complete Installed Whole-of-Window U-value utilises European Standard (EN) glass only U-values (Ug), and would follow a Performance Solution (PS) pathway to the NCC. As we use AFRC standards for the common Deemed to Satisfy (DtS) compliance to the NCC, it is important to make sure you are using the correct values for the Passivhaus calculation.

One major difference here is that under AFRC standards, the optimum air gap of a DGU is 12mm thick for the best (lowest) U-value. The U-value will increase in digit value (perform less in its Insulation) if the air gap is either less than, or greater than, 12mm. In EN Standards however, the optimum air gap is 16mm thick for a DGU and 18mm thick for a TGU.

Also, AFRC standards allow a 95% argon filled value for the air spaces while EN uses 90%. Add this to the different environmental conditions and you will notice different results on the same make ups between the two standards (with EN standards always resulting in a lower U-value.

See comparisons below of glass only U-values (Ug) against each standard, also highlighting the 12mm to 16mm (DGU) and 12mm to 18mm (TGU) effect on EN standard values (note that glass only values do not take into consideration any spacer bar types used):

24mm Double Glazed Unit With 1x LowE coating (6/12argon/6)	Glass only Performance Values	
	AFRC Standards (NFRC 2010)	EN Standards (EN 673)
Insulglass LowE Plus®	1.4	1.3
Insulglass LowE Advance®	1.3	1.2
Insulglass LowE Max®	1.3	1.2
Changing the spacer from 12mm to 16mm		
Insulglass LowE Plus®	1.4	1.1
Insulglass LowE Advance®	1.4	1.0
Insulglass LowE Max®	1.4	1.0

Table 2 – DGU glass only U-value (Ug) comparisons between AFRC and EN standards

42mm Triple Glazed Unit With 2x LowE coatings (6/12argon/6/12argon/6)	Glass only Performance Values	
	AFRC Standards (NFRC 2010)	EN Standards (EN 673)
Insulglass LowE Plus® + LowE Plus	0.7	0.7
Insulglass LowE Advance® + LowE Plus	0.7	0.7
Insulglass LowE Max® + LowE Plus	0.7	0.7
Changing the spacer from 12mm to 18mm		
Insulglass LowE Plus® + LowE Plus	0.7	0.5
Insulglass LowE Advance® + LowE Plus	0.7	0.5
Insulglass LowE Max® + LowE Plus	0.7	0.5

Table 3 – TGU glass only U-value (Ug) comparisons between AFRC and EN standards. Note that the secondary LowE is LowE Plus to maintain a higher overall Clarity and Visible Light.

Performance Data

The following pages show AGG's ideal product offerings for Passivhaus application. EN standards, glass only (Ug and Solar Factor g) as per EN 673. For other make ups and glass thickness options, please email specify@agg.com.au for assistance.

Double Glazed Units (DGU) – 1 x LowE coatings

GL01. 24mm Insulglass LowE Plus® - 4/16/4

GL02. 26mm Insulglass LowE Advance® - 6/16/4

GL03. 26mm Insulglass LowE Max® - 6/16/4

Triple Glazed Units (TGU) – 2 x LowE coatings

GL04. 48mm Insulglass LowE Plus® - 4/18/4/18/4

GL05. 50mm Insulglass LowE Advance® - 6/18/4/18/4

GL06. 50mm Insulglass LowE Max® - 6/18/4/18/4

Note that for GL05 and GL06 TGO make ups, the secondary LowE is LowE Plus to maintain a higher overall Clarity and Visible Light.

Performance Data – Glass Only (EN-673)

GL-01 DGU Glass Make up

Insulglass LowE Plus®
An Australian Glass Group Product

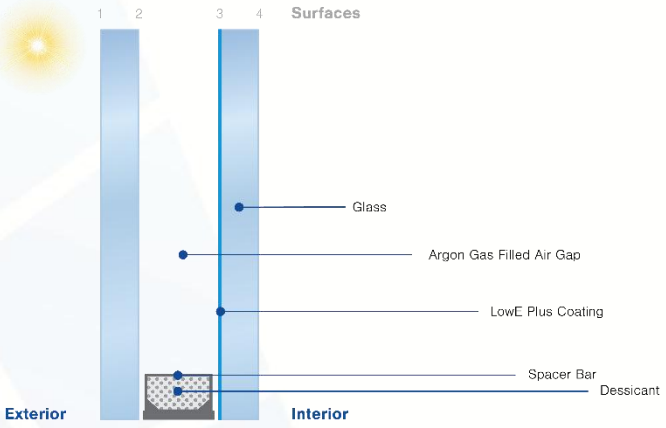
24mm AGG Insulglass LowE Plus® - Clear

4mm Clear (Outer) / 16mm argon / 4mm LowE Plus #3 (Inner)

Aesthetic Colour:	Clear
Visible Light Transmittance (VLT):	81%
Visible Light Reflection – Out (VLR-Out):	13%
Visible Light Reflection – In (VLR-In):	12%
Ug (W/m²k):	1.1
Solar Factor (g):	0.63
Selectivity Light-to-Solar Gain Ratio (LSG):	1.29
Acoustics (Rw):	32
Weight (Kg per m²):	20.0

GL-01 Cross Section

Outer pane:	Clear
Inner pane:	LowE Plus
Coating Surface #:	3



Important Notes:

The performance values shown above represent NOMINAL VALUES for the center of glass values only, with no spacer system or framing. Calculations and terms in this report are based on European EN-673 standards. Different spacer types and the heat treating of glass (Heat Strengthening, Toughening and Heat Soaking) do not impact the performance values shown above.

Performance Data – Glass Only (EN-673)

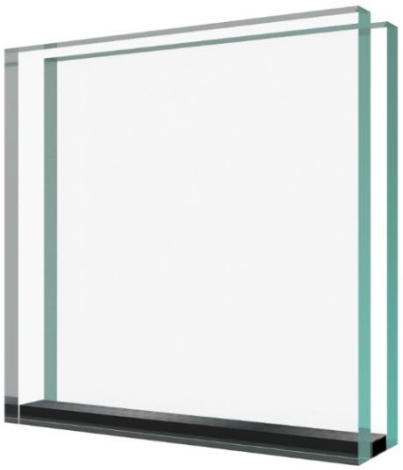
GL-02 DGU Glass Make up

Insulglass LowE Advance®
An Australian Glass Group Product

26mm AGG Insulglass LowE Advance® - Clear

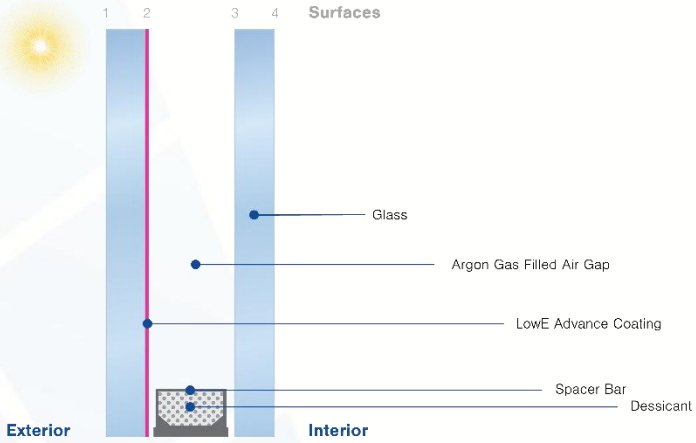
6mm LowE Advance #2 (Outer) / 16mm argon / 4mm Clear (Inner)

Aesthetic Colour:	Clear
Visible Light Transmittance (VLT):	70%
Visible Light Reflection – Out (VLR-Out):	12%
Visible Light Reflection – In (VLR-In):	13%
Ug (W/m²k):	1.0
Solar Factor (g):	0.38
Selectivity Light-to-Solar Gain Ratio (LSG):	1.84
Acoustics (Rw):	34
Weight (Kg per m²):	25.0



GL-02 Cross Section

Outer pane:	LowE Advance
Inner pane:	Clear
Coating Surface #:	2



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Performance Data – Glass Only (EN-673)

GL-03 DGU Glass Make up

Insulglass LowE Max®
An Australian Glass Group Product

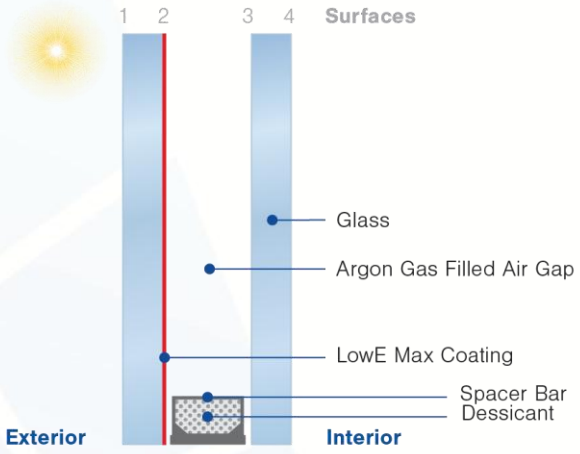
26mm AGG Insulglass LowE Max® - Clear

6mm LowE Max #2 (Outer) / 16mm argon / 4mm Clear (Inner)

Aesthetic Colour:	Neutral
Visible Light Transmittance (VLT):	67%
Visible Light Reflection – Out (VLR-Out):	13%
Visible Light Reflection – In (VLR-In):	14%
Ug (W/m²k):	1.0
Solar Factor (g):	0.31
Selectivity Light-to-Solar Gain Ratio (LSG):	2.16
Acoustics (Rw):	34
Weight (Kg per m²):	25.0

GL-03 Cross Section

Outer pane:	LowE Max
Inner pane:	Clear
Coating Surface #:	2



Important Notes:

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Performance Data – Glass Only (EN-673)

GL-04 TGU Glass Make up

Insulglass LowE Plus®
An Australian Glass Group Product

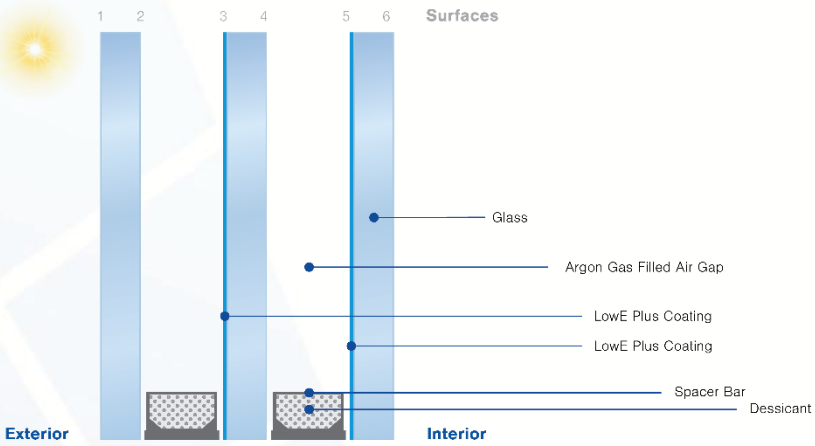
48mm AGG Insulglass LowE Plus® - Clear

4mm Clear (Outer) / 18mm argon / 4mm LowE Plus #3 (Mid) / 18mm argon / 4mm LowE Plus #5 (Inner)

Aesthetic Colour:	Clear
Visible Light Transmittance (VLT):	72%
Visible Light Reflection – Out (VLR-Out):	16%
Visible Light Reflection – In (VLR-In):	16%
Ug (W/m²k):	0.5
Solar Factor (g):	0.54
Selectivity Light-to-Solar Gain Ratio (LSG):	1.33
Acoustics (Rw):	36
Weight (Kg per m²):	30.0

GL-04 Cross Section

Outer pane:	Clear
Mid pane:	LowE Plus
Inner pane:	LowE Plus
Coating Surface #:	3, 5



Important Notes:

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Performance Data – Glass Only (EN-673)

GL-05 TGU Glass Make up

Insulglass LowE Advance® AnAustralianGlassGroupProduct

Insulglass LowE Plus® AnAustralianGlassGroupProduct

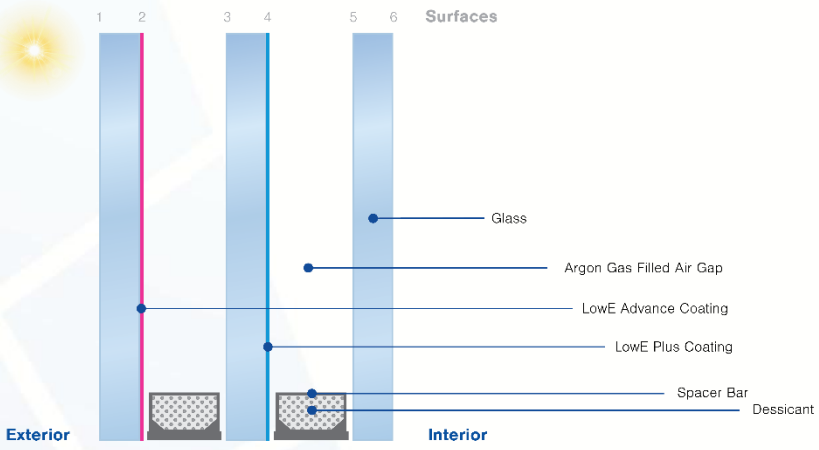
50mm AGG Insulglass LowE Advance with LowE Plus® - Clear

6mm LowE Advance #2 (Outer) / 18mm argon / 4mm LowE Plus #4 (Mid) / 18mm argon / 4mm Clear (Inner)

Aesthetic Colour:	Clear
Visible Light Transmittance (VLT):	63%
Visible Light Reflection – Out (VLR-Out):	15%
Visible Light Reflection – In (VLR-In):	17%
Ug (W/m²k):	0.5
Solar Factor (g):	0.34
Selectivity Light-to-Solar Gain Ratio (LSG):	1.85
Acoustics (Rw):	37
Weight (Kg per m²):	35.0

GL-05 Cross Section

Outer pane:	LowE Advance
Mid pane:	LowE Plus
Inner pane:	Clear
Coating Surface #:	2, 4



Important Notes:

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Performance Data – Glass Only (EN-673)

GL-06 TGU Glass Make up

Insulglass LowE Max® AnAustralianGlassGroupProduct

Insulglass LowE Plus® AnAustralianGlassGroupProduct

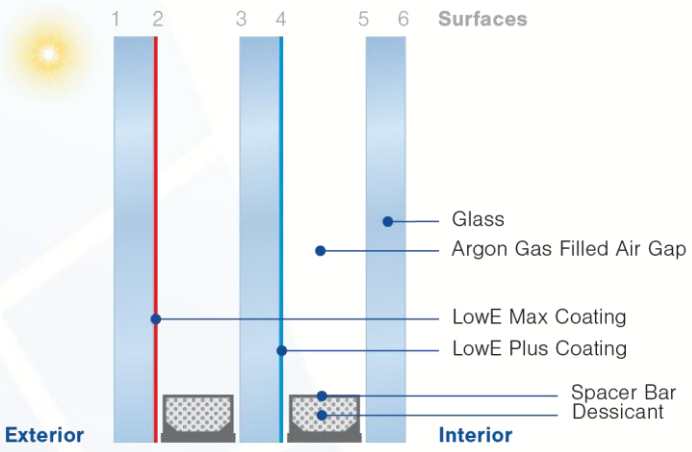
50mm AGG Insulglass LowE Max® with LowE Plus - Clear

6mm LowE Max #2 (Outer) / 18mm argon / 4mm LowE Plus #4 (Mid) / 18mm argon / 4mm Clear (Inner)

Aesthetic Colour:	Neutral
Visible Light Transmittance (VLT):	60%
Visible Light Reflection – Out (VLR-Out):	16%
Visible Light Reflection – In (VLR-In):	17%
Ug (W/m²k):	0.5
Solar Factor (g):	0.28
Selectivity Light-to-Solar Gain Ratio (LSG):	2.14
Acoustics (Rw):	37
Weight (Kg per m²):	35.0

GL-06 Cross Section

Outer pane:	LowE Max
Mid pane:	LowE Plus
Inner pane:	Clear
Coating Surface #:	2, 4



Important Notes:

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Sizes and Weight

The highest performing glass make ups for Passivhaus projects come from Triple Glazed Units (TGU) with 2x Softcoat LowE Coatings. When we also optimise the minimum 18mm air spaces in a TGU we are looking at a minimum of 48mm thick units (4/18/4/18/4). Note that we must adhere to Australian Standards in terms of maximum area (m^2) allowed for windows and glass doors.

AS 1288 Glass in buildings – Selection and installation contains the criteria for human impact safety in its section 5. Here we identify the requirement of Grade A Safety glass in basically; all doors & their direct side panels, all low level glazing up to 500mm, all bathroom glazing, glazing in schools, swimming pools, gymnasiums, aged care facilities & nursing homes. A Grade A Safety glass can be either Toughened glass or Laminated glass. It also dictates the maximum area of Grade A Safety glass per thickness of glass that can be used in an IGU (the same value for either Double Glazed or Triple Glazed) as summarised in the table below:

Type of Glass	Standard nominal thickness (mm)	Maximum Area in an IGU (m^2)
Toughened Safety Glass	4mm	3.3
	5mm	4.5
	6mm	6.0
	8mm	9.0
	10mm	12.0
	12mm	15.0
Laminated Safety Glass	6.38mm	4.5
	8.38mm	7.5
	10.38mm	10.5
	12.38mm	13.5

Table 4 – Maximum Areas (m^2) of Grade A Safety glass as per AS 1288:2021, Section 5.

Depending on how big your Passivhaus windows and glass doors will be, will determine what thickness of glass is needed on each side of the unit. On top of this there may be additional acoustic needs and/or wind load factors that also require thicker glass. All of this must be taken into consideration when choosing your Passivhaus framing system and hardware as they must be able to accept such make ups in terms of total thickness and weight.

Glass panel weight calculation:

2.5 x (thickness of glass in mm) = Kg per m^2

x (total m^2) = panel weight in Kg.

eg. a 54mm Insulglass LowE Plus® Triple Glazed Unit (6/18 argon/6/18 argon/6) that is 1200 x 1800mm:

= 2.5 x 18 (3x 6mm glass in the total make up) = 45 Kg per m^2

x 2.16m^2 (1.2m x 1.8m) = a 97.2 Kg TGU

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