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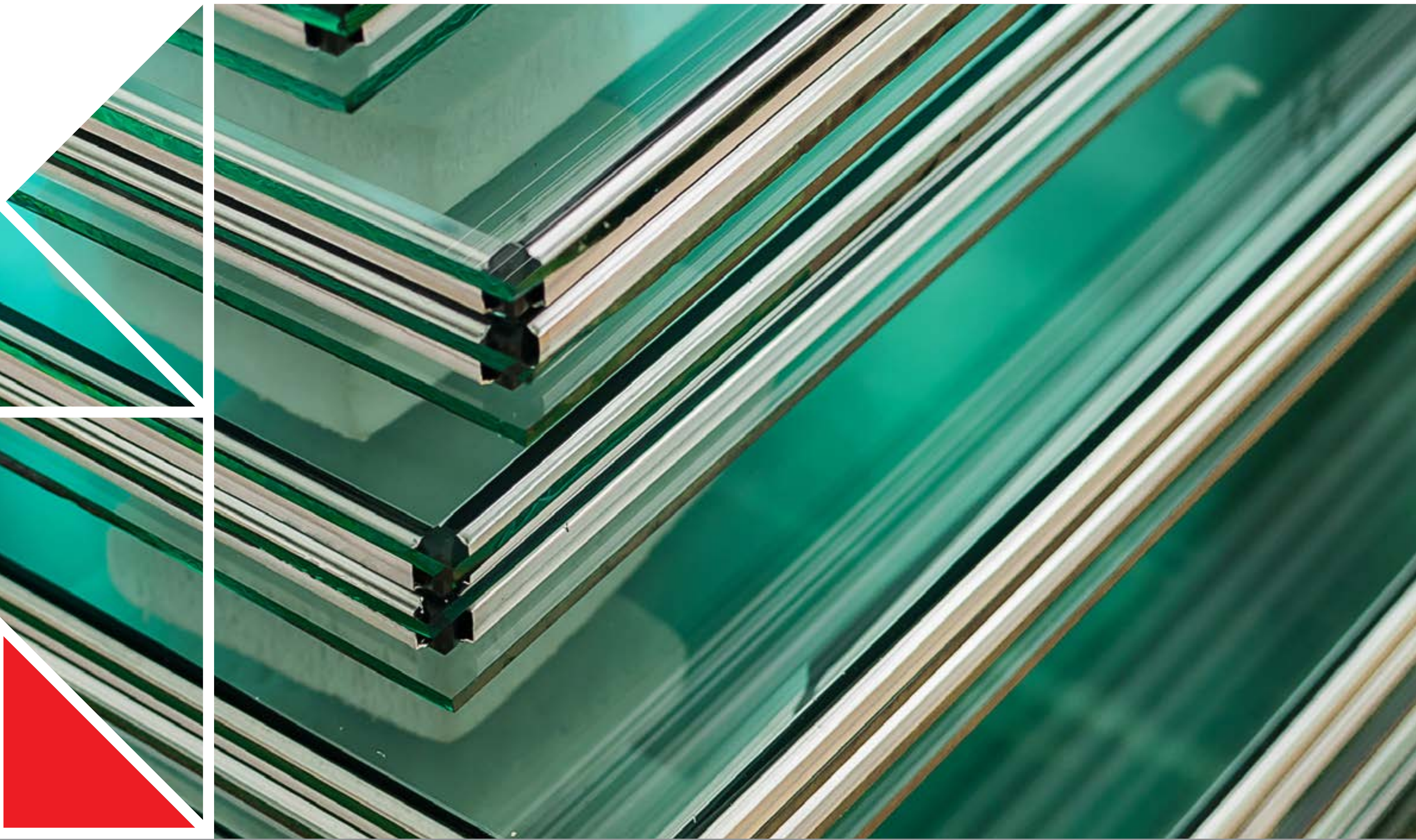
BULLETIN



INSULATING GLASS UNITS (IGU)

December 2022

- H1/AS1 and H1/VM1 5th edition amendment 1 are likely to result in a larger number and greater range of IGUs being installed in housing, and buildings up to 300 m².
- This bulletin gives an overview of the types of IGUs available and what should be considered in specifying them, with a particular focus on housing.
- The bulletin updates and replaces Bulletin 598 of the same name.

1 INTRODUCTION

1.0.1 Insulating glass units (IGUs) are glazing units made up of two or more panes of glass, composites or plastics spaced apart and factory sealed hermetically with dry air or argon or other inert gas in the cavity between the panes. They are commonly referred to as double or triple glazing.

1.0.2 When using the schedule method in H1/AS1 5th edition amendment 1, IGUs are the required glazing type in all housing, and buildings up to 300 m². The 5th edition documents require significantly improved thermal performance from windows and doors over the 4th edition. There is a staged implementation of these requirements (see section 3).

1.0.3 IGUs may not be required for some designs using the calculation method in H1/AS1 or the modelling method in H1/VM1. These methods still enable the use of single glazing or low thermal performance IGUs where thermal performance elsewhere in the building envelope is improved to compensate.

1.0.4 The primary benefit of IGUs is enhanced thermal performance – reduced winter heat loss and reduced summer heat gain compared to windows with a single pane – but they have other potential benefits. Depending on design and glazing options specified, they can:

- reduce the amount of condensation on glazing
- reduce sound transmission through glazing
- modify solar and optical properties of glazing – for example, giving more privacy
- reduce fading of interior furnishings
- provide increased security – the extra glass makes the window harder to break and/or penetrate, and security laminates can enhance this function.

1.0.5 IGUs are expected to have a durability of not less than 15 years under the New Zealand Building Code. Many have manufacturer warranties of 10 years, but a good-quality IGU that is well installed can potentially provide service for much longer. Specification that is appropriate for the location/circumstances, quality of installation and regular and appropriate maintenance are all important factors in durability.

1.0.6 This bulletin primarily covers IGUs in housing and small buildings. It refers to thermal performance requirements in the Building Code only briefly. For more information on that topic, see Bulletin 670 *Specifying windows and doors under H1* (October 2022 updated version).

2 CONSTRUCTION OF AN IGU

2.0.1 The most common form of IGU consists of two panes of glass separated by a spacer around the edge (Figure 1). The spacer will have a desiccant to absorb small amounts of moisture. The cavity between the glass panes is usually filled with dry air or argon gas. An edge seal is used to connect the spacer to the glass panes and prevent moisture entry between the panes.

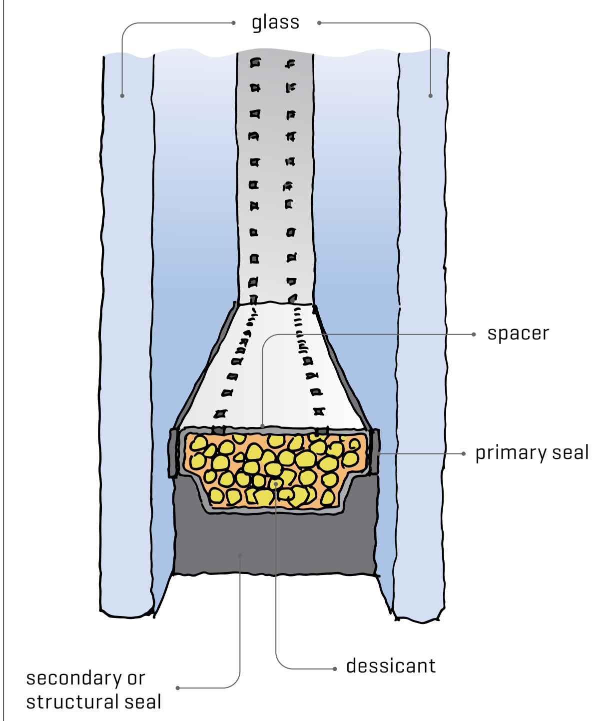


Figure 1. Schematic drawing of a typical IGU.

2.1 FRAMES

2.1.1 Common frame materials for IGUs in housing in Aotearoa New Zealand are:

- Aluminium – although it is strong and durable, it is a good conductor of heat and therefore has poor thermal performance.
- Thermally broken aluminium – with the strength of aluminium, this has increased thermal performance because there is a polyamide or similar insert that separates the inside and outside sections of the aluminium frame, reducing the heat loss/gain through the frame.
- uPVC (vinyl) – usually with galvanised steel or aluminium reinforcement to achieve the required strength. It has better thermal performance than aluminium and thermally broken aluminium frames. uPVC is typically available in white or with a range of finishes/colours that can even have the appearance of timber. This is achieved by fusing a UV-stabilised foil to the uPVC profile.
- Timber – this has very good thermal performance and low embodied carbon but needs regular maintenance.
- Composites – these can include timber, aluminium and uPVC in an assembly designed to optimise the performance of the various materials.

2.1.2 With non-solid frames, breaking up the air cavities in the frame with webs can reduce the movement of air inside the framing and provide better thermal performance than a single cavity (Figure 2).

2.1.3 There are two types of glazing methods. In most systems, the glazing rebate is drained and ventilated, where drainage holes are designed and positioned to ensure the edge seal of the IGU does not sit in water.

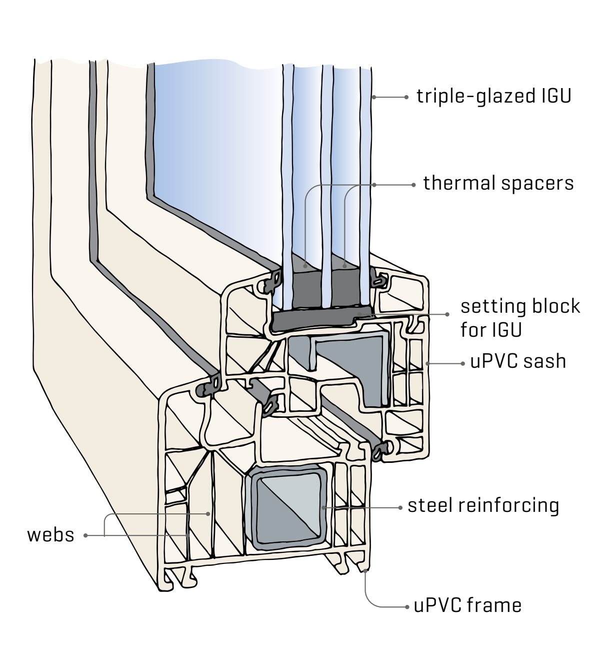


Figure 2. Thermal spacers in a triple-glazed uPVC window.

Alternatively, a dry/sealed method may be used to glaze the IGU into the frame, most commonly with timber frames. Discuss the proposed method of glazing and warranties with your glazier.

2.2 GLAZING

2.2.1 The glazing parameters discussed in Table E.1.1.1 in H1/AS1 are those relevant to a measure of thermal performance – clear glass or glass with one of four levels of low-E coating. There are more glazing options available with IGUs than appear in the table, including the following:

- Tinted or textured glass – a grey tint is the most common. This reduces the level of light passing through the glass and provides sun protection as well as a certain amount of privacy. Various types of glass finish can also be used for privacy.
- Toughened safety glass – see NZS 4223.3:2016 *Glazing in buildings – Part 3: Human impact safety requirements* section 2.7.
- Laminated safety glass and acoustic laminated safety glass – used to reduce sound transfer. With laminated glass, a resin layer sandwiched between two panes of glass dampens sound vibrations. Acoustic laminated glass has a plastic layer sandwiched between two glass panes, designed specifically to reduce noise transmission.

2.2.2 The amount of visible light that is able to pass through a glazing system is measured as a percentage of the maximum possible light transfer:

- An IGU with two panes of clear glass transmits approximately 82% of visible light (compared to approximately 90% for an old single-glazed window).
- Tinted glass can reduce light transmission by half or more – among the lowest visible light transmission (at around 15–20%) is a dark grey tint.
- The visible light reflectivity varies from 8% to 23% for the glazing systems selected but can be much higher for glasses that are specifically selected to be reflective.

2.2.3 In addition to the different types of glass available, there are after-market films and coatings that can be applied to glass. These are typically specified for purposes such as enhanced privacy or a reduction in the transmission of UV light or to make the glass surface easier to maintain.

2.2.4 Discuss all the options with your glazing supplier before purchase or specification to ensure there are no unintended consequences of mixing glass types, films or coatings.

2.3 LOW-E GLAZING

2.3.1 Low-E (low-emissivity) glass has a microscopically thin transparent metal coating that allows light through but reflects long-wave infrared radiation and associated heat back. Based on its specific properties and the IGU combination, the glazing can assist in keeping a house warmer in winter or cooler in summer.

2.3.2 There is a wide range of low-E coatings available with different attributes and levels of performance. Table E.1.1.1 in Appendix E in H1/AS1 refers to Low-E_1, Low-E_2, Low-E_3 and Low-E_4 (developed for the purpose of the table). The numbers indicate different thermal performance levels of low-E coatings from basic to very high.

2.3.3 The technology of low-E glass has improved considerably in recent years. While some low-E glass reduces light transmission, new low-E glass is available that has virtually the same visible light transmission as clear glass.

2.3.4 The performance of low-E depends not only on the level (Low-E_1 to Low-E_4) but also on the specific face of a glass pane that it is applied to (Figure 3). The impact of low-E glazing in both summer and winter needs to be considered – a compromise in the amount of solar heat entering at one time of year may be necessary to achieve an overall better energy performance outcome. While low-E coatings can significantly reduce heat loss in winter, they generally also reduce the amount of solar heat entering through a window. This is unavoidable. Nevertheless, from a thermal comfort and heating energy efficiency perspective, the reduced heat loss benefit outweighs the reduction in desirable winter solar gains resulting from the low-E.

2.3.5 Low-E coatings are available that are specifically designed to significantly reduce solar heat gain to help avoid overheating in summer. These are generally most suitable for west-facing glazing, which can receive limited sun in winter but may lead to overheating in summer (due to the longer days and higher sun path).

2.3.6 The thermal performance of glazing in New Zealand is measured according to the European standard (EN 673), which differs slightly from American standards. Glazing thermal performance values can be converted unless there are low emissivity panes included in the glazing. The emissivity of glazing in America is calculated according to NFRC 301, which is a very different way from the standard used in NZ (EN 12898), and there is no easy way to convert between the values. Hence it is critical that the emissivity of low-E panes is measured and reported in accordance with EN 12898 in New Zealand.

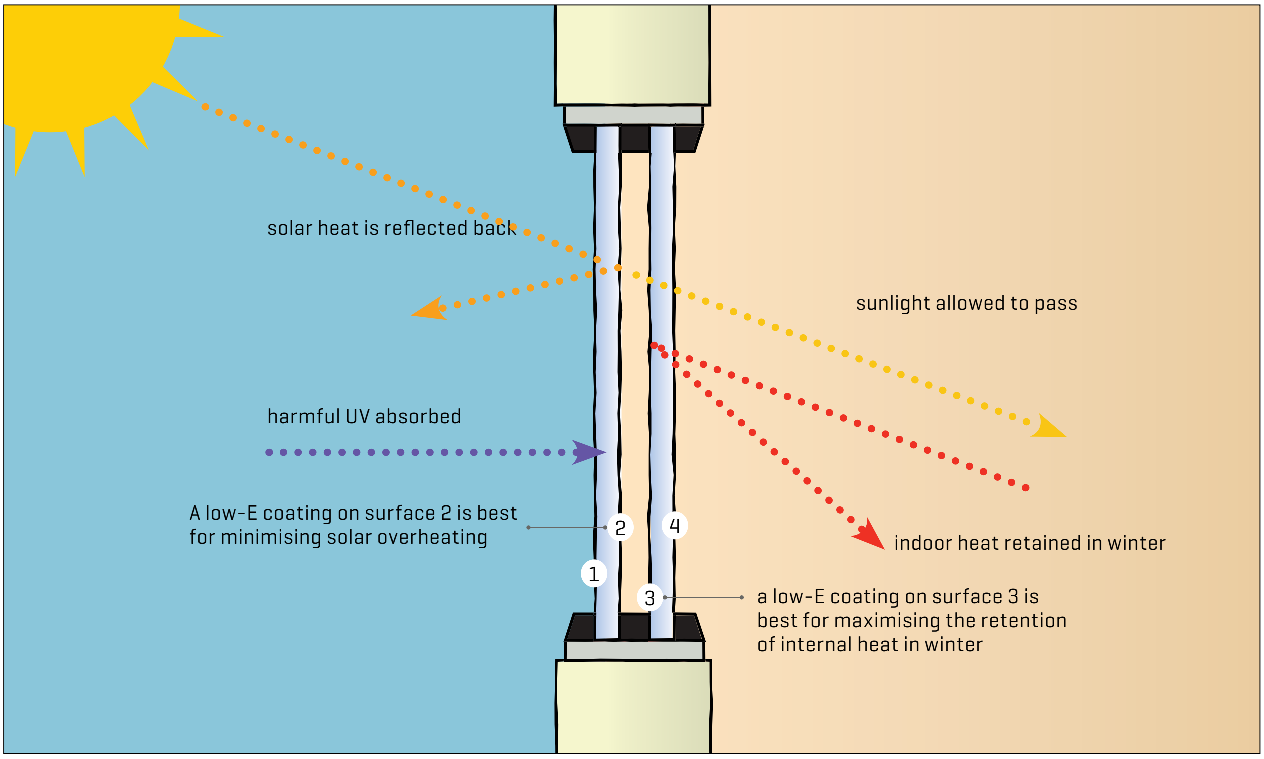


Figure 3. Schematic drawing of the placement of a low-E coating and its effects.

2.4 SPACERS

2.4.1 Spacers separate the glass panes in a double or triple-glazed window (Figure 1). Spacer depth typically ranges from 6–16 mm. Although the thermal performance of air-filled IGUs improves up to a width of about 16 mm, spacers up to 24 mm wide are available. The spacer normally contains a desiccant to absorb small amounts of moisture from the space between the panes. Moisture may be present from manufacture or may slowly leak into the air space. This desiccant will not prevent condensation from occurring between the panes if an edge seal has failed.

2.4.2 The type of spacer – aluminium or thermally improved – is one of the specification criteria for vertical windows in Table E.1.1.1 in H1/AS1. Aluminium is the most commonly used material for spacers but it has high thermal conduction. Ideally, thermally improved or warm-edge spacers should be specified. These are made of materials that transfer much less heat than aluminium spacers.

2.5 SEALS

2.5.1 Edge seals play a crucial role in IGUs. Typically, two sealants are used for greater reliability (Figure 1). Each seal does a particular job. The primary edge seal, installed on the two edges of the spacer, prevents the transfer of water vapour from the outside into the space between the panes. This sealant used is typically polyisobutylene (PIB). The secondary edge seal is applied on the outer edge beneath the spacer, providing structural support for the glass panes. This sealant is typically polysulphide, but silicone or other materials can also be used. The primary and secondary sealants must be compatible with each other and with glazing seals. They are sometimes combined with the spacer and desiccant into a composite edge seal.

2.5.2 Keeping edge seals dry is important for the durability of the IGU. If the edge seal remains in prolonged contact with water, this can degrade the secondary seal and allow moisture to enter the space between the panes. This may lead to condensation between the panes and is the most common cause of IGU failure.

2.5.3 In most situations, the frame must cover the IGU by at least 12 mm to protect the spacer and sealants from direct sunlight, although some spacers and sealants require less coverage.

2.6 CAVITY FILLING

2.6.1 Dry air is most commonly used in the space between panes, although 90% pure argon gas filling is readily available (and the increased thermal requirements of H1/AS1 are expected to make the use of argon gas more common). Table E.1.1.1 in H1/AS1 also includes options with 90% krypton gas.

2.6.2 Argon is easily extracted from the atmosphere (it forms about 1% of Earth's atmosphere), and it reduces window heat loss by around 3–9% compared with an air-filled IGU.

2.6.3 Krypton is an even better thermal insulator than argon but is much more rare and therefore more expensive. Overseas, krypton is often used in retrofitting windows that require a narrower gap between panes. IGUs with krypton filling have rarely been commercially produced in Aotearoa New Zealand to date (late 2022). The specific provision for the gas in H1/AS1 means that this may eventually change, although at the time of publication of this bulletin, krypton has become even more expensive and difficult to obtain.

3 NEW ZEALAND BUILDING CODE AND STANDARDS

3.1 DURABILITY

3.1.1 Under Building Code clause B2 *Durability*, doors and windows in external walls are required to last at least 15 years with normal maintenance.

3.1.2 The durability of IGUs can be confirmed with any of these standards:

- EN 1279 Parts 1 to 6: *Glass in building. Insulating glass units.*
- ASTM E2188 *Standard test method for insulating glass unit performance.*
- ASTM E2189 *Standard test method for testing resistance to fogging in insulating glass units.*
- ASTM E2190 *Standard specification for insulating glass unit performance and evaluation.*

3.1.3 The Insulating Glass Unit Manufacturers Association requires members' products to be regularly tested to one of these standards. BRANZ provides testing to these durability standards, which includes accelerated weathering, argon gas retention and exposure to high humidity. It is essential that, to ensure durability, IGUs are purchased from recognised manufacturers that regularly test to these standards and that IGUs are installed according to manufacturers' instructions.

3.1.4 NZS 4223.2:2016 *Glazing in buildings – Part 2: Insulating glass units* contains requirements for the performance of IGUs and provides a means of compliance with the relevant requirements of Building Code clauses B1 *Structure* and B2 *Durability*.

3.1.5 B2/AS1 amendment 12 section 3.5 modifies its reference to NZS 4223.2: 2016 with additional requirements around marking of IGUs. IGUs must be clearly and permanently marked, and the marking must be visible for the life of the unit. Adhesive labels are not acceptable. The marking must include:

- the name or registered trademark of the manufacturer or supplier
- the date of manufacture (the year is the minimum)
- a statement that the IGU complies with NZS 4223.2:2016.

3.2 ENERGY EFFICIENCY

3.2.1 Demonstrating compliance with Building Code clause H1 *Energy efficiency* can be achieved using an Acceptable Solution, Verification Method or Alternative Solution. For housing, and buildings up to 300 m², H1/AS1 and H1/VM1 5th edition amendment 1 replaced the 4th edition documents on 3 November 2022.

3.2.2 For more details about the requirements of H1, see the Building Performance website or BRANZ Bulletin BU670 *Specifying windows and doors under H1*.

3.2.3 Thermal performance of IGUs can be determined by:

- referring to Appendix E in H1/AS1 or H1/VM1 5th edition amendment 1
- BRANZ *House insulation guide* 6th edition (the 5th and earlier editions should not be used for determining the thermal resistances of windows and doors under H1/AS1 or H1/VM1 5th edition because the way the calculations are made has changed)
- manufacturer test data/WEERS data
- thermal modelling with internationally accepted software packages
- using the glazing calculator or other information from the Window and Glass Association NZ.

3.3 IGU HANDLING AND INSTALLATION

3.3.1 IGUs are precision-made units that require great care when handling, loading, transporting, removing protective wrappings and installing into a building. Hard knocks on the corners in particular may lead to leaks in the sealed unit. Damage may not be immediately apparent and may not become apparent until after the IGUs are installed and the building is occupied.

3.3.2 Carefully following the manufacturer's guidance around the handling, transporting and installing of IGUs is crucial.

3.3.3 Poor handling and/or installation of IGUs is one of the main reasons for their failure or for them to have shorter serviceable lives. An IGU has failed if spacers or seals are damaged and/or sufficient moisture enters or develops within the inter-pane space. It may still meet Building Code requirements of clause H1 because the thermal performance of an IGU that relies on dry gas fill and standard glass is not significantly affected by a small amount of moisture between the panes.

4 CARBON CONSIDERATIONS

4.0.1 As with all construction, the carbon footprint of materials should be one of the considerations in their specification. The benefits and drawbacks of particular materials over their whole lives should be assessed.

4.0.2 There are a growing number of tools and resources that can help with this sort of assessment. The BRANZ CO_2NSTRUCT online tool has carbon data for a few window and door constructions, and more are likely to be added in future. Ratings systems such as the New Zealand Green Building Council's Homestar scheme also take the emissions of materials into account, and environmental product declarations (EPDs) are likely to see greater use in Aotearoa New Zealand.

5 SPECIFYING IGU TO AVOID OVERHEATING

5.0.1 Specifying glazing in windows that meet or exceed Building Code requirements will not guarantee that a house will not overheat in summer. There is already evidence of new houses overheating – where inside temperatures exceed 25°C – and the risk of this happening will increase as the climate changes and buildings become more airtight. By the end of the century, Auckland is forecast to have four times the number of days over 25°C each year – 80 days compared to 20 days currently. Most of Canterbury is forecast to have 20–60 more hot days.

5.0.2 The popularity of large windows and doors to enjoy views and support indoor-outdoor flow can contribute to hotter indoor temperatures, particularly if there is too large an area of unshaded glazing to north, west and east-facing walls. Excessive glazing on west-facing walls is especially problematic when the sunlight comes in at a low angle and late in the day after the house has already heated up.

5.0.3 External shading is the most effective option for reducing summer overheating, but the risk of a house overheating can also be reduced through specifying the appropriate IGUs. At the moment, the issue of heatflow into homes through solar gain (solar radiation) is not well addressed in the Building Code. The Building Code focuses on the R-value of building elements, which measures heatflow through building elements by conduction but not by radiation.

5.0.4 The amount of heat that can pass through glazing by radiation has traditionally been measured by the solar heat gain coefficient (SHGC). This figure for glazing will be between 0 and 1, representing the total fraction of available solar radiation that is transmitted through the window (excluding the frame) as heat gain. For example, an SHGC value of 0.6 means that 60% of the solar radiation will pass through the glazed area of the window. It is possible for two IGUs with the same R-value to have very different SHGC values.

5.0.5 Table E.1.1.1 in H1/AS1 5th edition does not include a requirement to separately consider solar heat gain. (This is likely to be addressed in future Building Code changes.) BRANZ has calculated the SHGC for the window systems referenced in H1/AS1 (Table 1). Manufacturers may provide figures for their own systems. Specifying windows with a low SHGC value can help reduce the risk of overheating. These values may vary by region and climate.

5.0.6 Designers who use whole-house thermal simulation models will have a good understanding of the combined impact of R-values and SHGC on the year-round thermal comfort of houses.

6 WINDOW ENERGY EFFICIENCY RATING SYSTEM (WEERS)

6.0.1 The Window Energy Efficiency Rating System (WEERS) is a voluntary 6-star rating programme that assesses the thermal performance of windows in housing and small buildings. It was developed by BRANZ and the Window and Glass Association NZ.

6.0.2 WEERS combines the thermal performance of the frame and glazing together with the size of the window to calculate an individual thermal performance rating (R_W) for each window and, from that, its star rating. The more stars that are shown on the window, the better it will perform at restricting heat loss in winter. The weighted average R_W values for all windows in a houselot are combined to give an $R_{W(av)}$, which is used to give a WEERS star rating (6 is the maximum) for the houselot (Figure 4).

6.0.3 WEERS data can be used by an architect or designer who is carrying out whole-house thermal simulation modelling. The calculation used by WEERS is consistent with the H1/VM1 window calculation methodology.

Table 1. Construction R-values for generic vertical window systems in H1 5th edition and solar heat gain coefficient (SHGC).

The glazing unit R-values are based on IGUs available from large New Zealand suppliers (some may not be readily available currently)						Generic frame types and average frame %			
						Aluminium	Thermally broken	uPVC	Timber – 56 mm
						23%	27%	34%	41%
	Generic IGU description	Gas fill	Spacer	U_g (m²K/W)	Typical SHGC	R_{window} (m²K/W)			
Double glazing	4 Clear / 16 / 4 Clear	Air	Aluminium	2.63	0.77	0.26	0.32	0.40	0.44
	Low-E$_1$ / Clear	Argon	Aluminium	1.90	0.56	0.30	0.39	0.50	0.56
	Low-E$_2$ / Clear	Argon	Improved	1.60	0.55	0.33	0.42	0.56	0.63
	Low-E$_3$ / Clear	Argon	Improved	1.30	0.57	0.35	0.46	0.63	0.71
	Low-E$_4$ / Clear	Argon	Improved	1.10	0.54	0.37	0.50	0.69	0.77
	Low-E$_4$ / Clear	Krypton	Improved	0.90	0.37	0.40	0.54	0.76	0.85
Triple glazing	Clear / Clear / Clear	Air	Improved	1.89	0.69	Not available	0.38	0.50	0.56
	Low-E2 / Clear / Clear	Argon	Improved	1.20	0.50	Not available	0.48	0.66	0.74
	Low-E3 / Clear / Clear	Argon	Improved	1.00	0.52	Not available	0.52	0.73	0.81
	Low-E3 / Low-E3 / Clear	Argon	Improved	0.70	0.47	Not available	0.59	0.86	0.95
	Low-E4 / Low-E4 / Clear	Argon	Improved	0.60	0.43	Not available	0.62	0.91	1.01

Adapted from H1/AS1 Table E.1.1.1 © Ministry of Business, Innovation and Employment 2022.

Figure 4. A WEERS label indicating the window rating of a houselot of windows.

6.0.4 A WEERS rating showing that IGUs as a component of the window element comply with the Building Code could be part of a building consent application.

7 RETROFITTING IGUS

7.0.1 IGUs can sometimes be retrofitted into existing windows. What is possible depends on the construction and dimensions of the existing frames and sashes and the weight they are able to carry. In some cases, an IGU will be too heavy or too wide to be able to be retrofitted into an existing sash or frame. Depending on the existing windows, retrofitting options may be to replace:

- only the glazing
- the glazing and the opening panels/sashes
- the whole window, glazing, panels and frames.

7.0.2 Replacing only the glazing into existing timber frames or replacing only sashes has some advantages over full window replacement. These options retain existing exterior facing boards and internal timber reveals and do not require remedial work on the exterior cladding or work to replaster and refinish internal wall linings. For older timber houses with a particular character, it allows the house to retain its character. Depending on the circumstances, full window replacement may also require building consent.

7.0.3 Retrofitting existing windows and doors with IGUs does not need building consent so long as the existing window has performed well for at least 15 years and the performance of the new IGU (durability, thermal performance) will be comparable to or better than that of the old window. Replacing single-glazed aluminium windows with IGUs will almost always meet this requirement. Where you are adding new windows where they did not exist before or expanding the size of existing windows, the exemption may not apply, so talk to the BCA.

8 MAINTENANCE

8.0.1 Regular washing of IGUs will help ensure long-term durability. Start at the top and work to lower levels. Use warm water to wet the glass and soften any dirt or debris, cleaning with mild detergent or non-abrasive cleaners or a proprietary product. Rinse with clean water and dry with a clean squeegee, cloth or paper towel. Dry the whole unit including gaskets, sealants and frames to avoid the appearance of water spots. Ideally, don't clean IGUs in direct sunlight at the hottest time of day – this is especially the case with tinted or reflective glass.

8.0.2 In urban areas, washing IGUs once every 3–6 months may be sufficient. In areas exposed to seaspray or agricultural or other air pollutants, clean more frequently as necessary. After cleaning and drying the IGUs, check the frame drainage to see that no water is trapped in the rebate.

8.0.3 If concrete or mortar or a similar product splashes onto an IGU, it should be removed with clean warm water and mild detergent immediately.

8.0.4 Avoid using solvents or scrapers with metal blades on IGUs as the surface of the glass may be damaged. If there is a paint splash (or any other substance) on glass, check what the glass supplier recommends to remove it.

9 IGU IN SKYLIGHTS

9.0.1 Skylights are typically used for increasing daylighting in a house. They should be used sparingly. They commonly lead to more heat loss than heat gain over a whole year, and they can also contribute to a house overheating in the hottest summer months.

9.0.2 Guidance for the thermal performance required of IGUs to be used as skylights is given in Appendix E in H1/AS1 and H1/VM1. There is no table showing construction R-values of generic skylights. The values given for vertical windows and doors in Table E.1.1.1 of H1/AS1 are not representative of performance values for skylight frame and glazing combinations fixed horizontally or at an angle, since their thermal performance is reduced as the units are inclined.

10 RESOURCES

BU670 *Specifying windows and doors under H1* (October 2022 updated version)

BU659 Upgrading the thermal performance of timber windows

BU658 *Timber windows*

BU656 *Designing to avoid houses overheating*

BU636 *Protecting glass from damage*

BRANZ House insulation guide 6th edition
(The 5th and earlier editions of the guide should not be used for determining thermal resistances under H1/AS1 or H1/VM1 5th edition amendment 1.)

BRANZ Level website – the authority on sustainable building

WEERS (Window Energy Efficiency Rating System)

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