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BULLETIN

UPGRADING THE THERMAL PERFORMANCE OF TIMBER WINDOWS

February 2021

- Around a million houses in New Zealand have timber-framed windows, most with single glazing. These windows can have problems with draughts, poor thermal performance and poor solar control.
- This bulletin describes approaches for upgrading thermal performance including reducing air infiltration, replacing ordinary single glazing and retrofitting insulating glass units (IGUs).
- This bulletin updates and replaces Bulletin 507 *Timber windows – retrofit glazing options for thermal improvement*.

1 INTRODUCTION

1.0.1 An estimated 1 million New Zealand houses have timber windows. Most of these windows are single glazed, and many will be draughty and/or experience excessive condensation.

1.0.2 Aluminium windows became popular in the 1970s as they were considered to be maintenance free and cheaper than timber. Today, most new building work includes aluminium windows, and many homeowners considering upgrading the thermal performance of their homes see replacing timber windows with double-glazed aluminium windows as an option.

1.0.3 However, timber has a number of advantages over aluminium including its thermal performance. The R-value (a measure of resistance to heat flow through a material) of a small single-glazed timber window is almost the same as the R-value of a double-glazed aluminium window where the aluminium frame does not have a thermal break. The reason is that timber is a good insulator while aluminium is a good conductor of heat. Unless thermally broken, there is a significant heat loss through the frames of aluminium windows.

1.0.4 As heat loss from a timber window is primarily through the single glazing, upgrading the glazing will result in significantly improved thermal performance. Upgrading can be done by:

- replacing single glazing with insulating glass units (IGUs) retrofitted into existing timber sashes
- retrofitting new uPVC or aluminium double-glazed windows into existing timber frames
- installing secondary glazing over the existing glass.

1.0.5 Note that replacing ordinary single glazing with single low-emissivity (low-E) glass has been used in the past. Recent work commissioned by EECA has shown that the low e coating can 'overcool' the glazing, resulting in significant amounts of condensation. This is because the low-E surface works so well at rejecting heat that it cools down the single glazing layer to such an extent that condensation covers the low-E surface, reducing its performance to worse than clear single glazing. It is better to avoid the use of low-E panes in single glazing and use them instead within IGUs.

1.0.6 Full replacement of existing windows is not discussed in this bulletin as it is a far more costly option that may require building consent.

1.0.7 Options described in this bulletin involve specialised work and should be carried out by specialist tradespeople, and proprietary options should be discussed with the manufacturer or supplier.

1.0.8 This bulletin updates and replaces Bulletin 507 *Timber windows – retrofit glazing options for thermal improvement*.

2 CONSIDERATIONS FOR UPGRADING THERMAL PERFORMANCE

2.0.1 Selecting the best option for upgrading timber windows depends on a number of factors such as:

- the size and type of window – although most types of timber windows can be adapted to improve the thermal performance, windows with very large frames may not be able to carry the weight of an IGU
- the location of the window – for example, whether it is in a habitable room such as living room or bedroom or a service room such as a bathroom or laundry
- the climate zone – in a warmer climate, the payback period on the cost of the upgrade is likely to be longer
- the level of insulation of the house – if the house is uninsulated or poorly insulated, retrofitting ceiling and underfloor insulation as a minimum should be a priority
- how much thermal improvement of the window is required
- the cost of the upgrade versus the long-term cost benefit of lower heating costs.

2.0.2 Depending on the option selected, the benefits of upgrading the thermal performance of timber windows may include:

- reduced heat loss
- lowered heating costs (winter) and cooling costs (summer)
- elimination of condensation on glass
- fewer draughts
- reduced level of noise coming in from outside
- increased indoor comfort.

2.1 TOTAL THERMAL PERFORMANCE

2.1.1 The thermal performance of a window is influenced by both the glazing and the frame. To accurately determine the total thermal performance of a window, both components must be taken into account.

2.1.2 The thermal performance (R-value) of a glazing system without the frame is typically referred to as the centre of glazing R-value (R_{cog}), the frame as R_f and the thermal performance of a total window is referred to as R_w.

2.1.3 A large window will have an R_w that is impacted more by the glass R-value, while a small window will have an R_w that is impacted more by the frame R-value. Figures 1 and 2 show how the total R-value changes when the ratio of glass to frame changes. (Note that uPVC and fibreglass frame windows give a very similar result to the timber frame result.)

2.1.4 Figures 1 and 2 also demonstrate that a smaller timber window has a higher window R-value (R_w) than an aluminium window of the same size. As the percentage of glazing increases and the glass has a larger impact on the total R-value, the R_w values of timber and aluminium frame windows become more aligned.

2.1.5 A window energy efficiency rating system (WEERS) has been developed jointly by BRANZ, the Ministry of Business, Innovation and Employment and the Window Association of New Zealand (now the Window and Glass Association NZ) to provide a means of comparing the thermal performance of different size windows with different frames and glazing. Based on the calculated R-value of the window system, a rating with values ranging between 1 and 6 stars is allocated to the

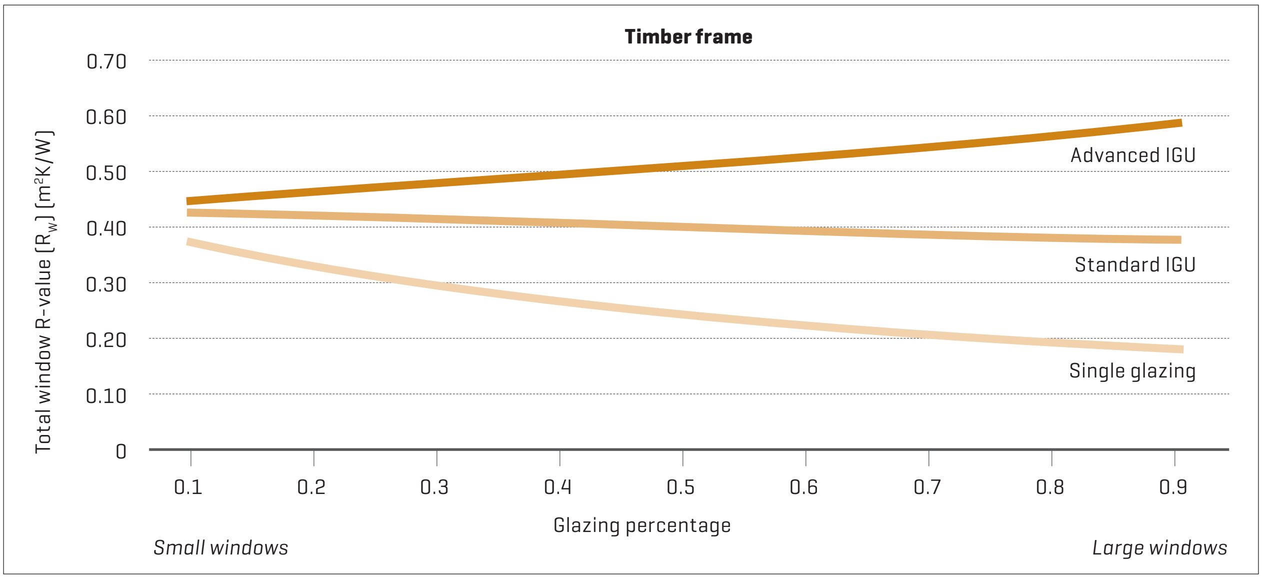

Figure 1. Timber frame – approximate variation in R_w with window size.

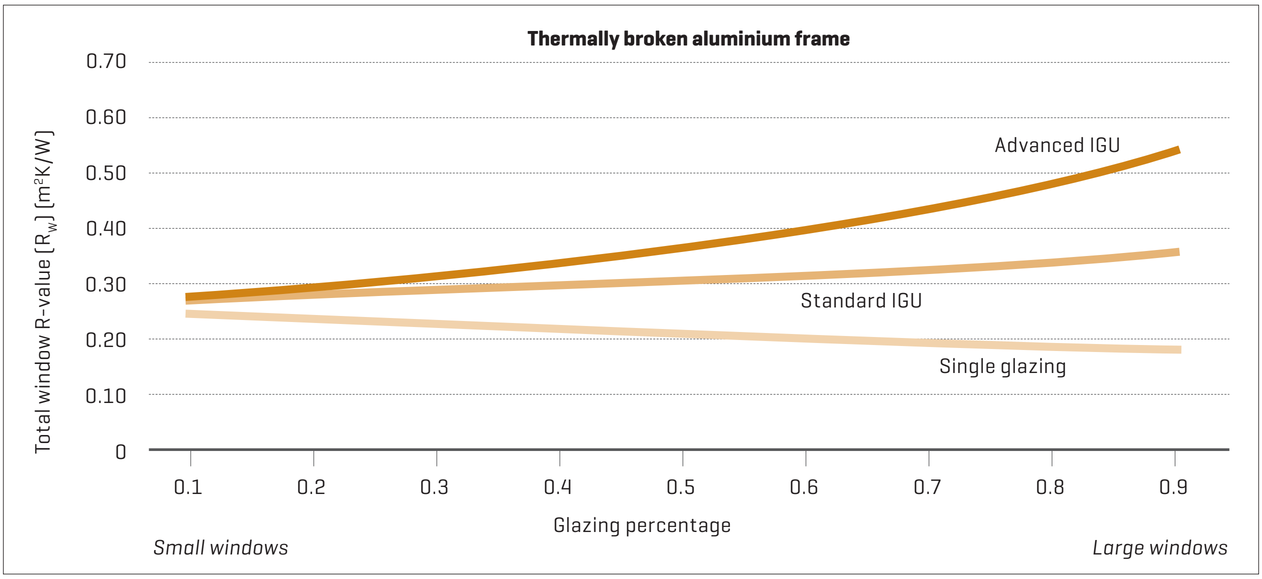

Figure 2. Thermally broken aluminium frame – approximate variation in R_w with window size.

system. A 1-star rating applies to single-glazed systems, while a 6-star rating applies to advanced double-glazed systems.

3 GLASS OPTIONS

3.0.1 Windows in older houses were typically fitted with clear or opaque glass with very few alternative options available. Glass technology has improved in recent years with a range of coating treatments now available that provide significant improvement to the thermal performance and solar transmission of glass. Tinting reduces the visible light transmission through the glass so there is less solar gain (heat) into the building interior, but it does not improve the thermal performance in preventing heat loss to the exterior.

3.0.2 The types of glass and design criteria for single glazing and IGUs are described in:

- NZS 4223.1:2008 *Code of practice for glazing in buildings – Glass selection and glazing*
- NZS 4223.2:2016 *Glazing in buildings – Part 2: Insulating glass units*
- NZS 4223.3:2016 *Glazing in buildings – Part 3: Human impact safety requirements*.

3.1 LOW-EMISSIVITY (LOW-E) GLASS

3.1.1 Low-E glass reflects long-wave infrared radiation (heat) while letting short-wave radiation (light) pass through the glass and can reduce heat loss by 30–50% compared to ordinary glass.

3.1.2 Low-E glass has a thin metallic oxide coating applied to the surface. The application of the coating may be either:

- pyrolytic – the oxide is applied at very high temperature during manufacture of the glass and produces a durable, hard finish
- sputtered – the oxide is applied in a vacuum or by magnetron after the manufacture of the glass and is deposited on the hardened glass resulting in a soft coating that is more susceptible to damage.

3.1.3 Only a pyrolytic low-E coating should be used for single pane glazing as the sputtered low-E coating is easily damaged.

3.2 REFLECTIVE GLASS

3.2.1 Reflective glass has a surface coating that reflects radiation. Depending on the type of coating and the orientation of the glazing, the reflective coating can either reflect short-wave or long-wave radiation.

3.3 SPECTRALLY SELECTIVE GLASS

3.3.1 Spectrally selective glass has a coating that maximises the amount of visible light transmission through the glass but minimises the heat transmission. This means that, while natural light transmission is maximised, heat loss to the exterior is limited in the winter and heat gain to the interior is limited in the summer.

3.3.2 Spectrally selective glass is defined by a ratio of light to heat transmission. In order to be classified as spectrally selective, glass must have a solar gain ratio of at least 1.25 – at least 25% more light than heat must pass through the glass.

3.4 LAMINATED GLASS

3.4.1 Laminated glass consists of at least two sheets of glass with plastic or resin interlayers permanently bonded between the sheets. The primary aim of laminated glass is to prevent the glass from shattering on impact, but the thermal performance of the glass can be improved by using low-E or other coated glass. Typically, the coating is on surface 2 (Figure 3). The plastic will also provide some thermal and acoustic improvement to the performance of the glass.

4 INSULATING GLASS UNITS (IGUS)

4.0.1 IGUs consist of two or more panes of glass that are separated by a spacer to create a gap, typically between 6 mm and 22 mm. The glass surfaces of IGUs are numbered from outside to inside to identify each face (Figure 4).

4.0.2 The glass used in IGUs may be clear float glass, but coated or treated glass is more generally used to improve the thermal performance. The coating may be either pyrolytic (hard coat) or sputtered (soft coat). While a pyrolytic low-E coating may be located on any face of the glass, a sputtered low-E coating should only be located on an internal face of the IGU in order to protect the soft coating from damage.

4.0.3 Spacers are typically aluminium or stainless steel but for better thermal performance, engineered and thermosetting plastic, PVC or composite silicone-based spacers may be used.

4.0.4 The spaces between panes may be filled with dry air or a gas, typically argon, which has a lower thermal conductivity than air and can result in an improvement to the thermal performance of an IGU by between 5% and 20% (Table 1). A 12 mm gap between panes gives optimal thermal performance for air-filled IGUs, while a 10 mm gap between panes gives optimal thermal performance for argon-filled IGUs. A disadvantage of argon is that, over time, it may slowly leak out of the gap, resulting in a gradual decrease in thermal performance of the IGU.

4.0.5 Two sealants that must be compatible are applied to the perimeter of the IGU. The primary sealant, typically a polyisobutylene (PIB), seals both edges of the spacer and the glass on each side to prevent external moisture from getting into the space between the

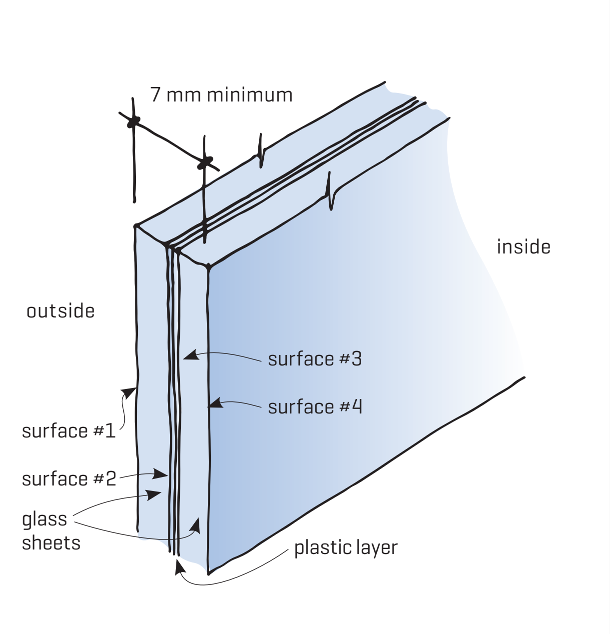

Figure 3. Laminated glass construction.

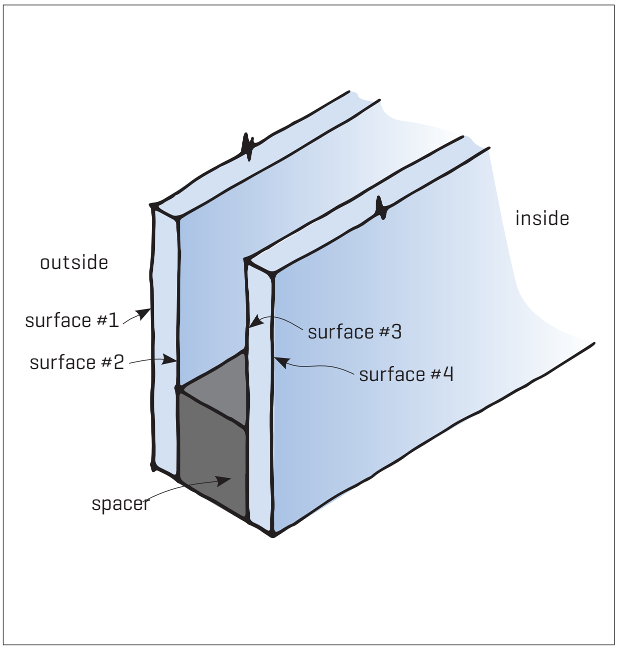

Figure 4. Numbering surfaces of IGUs.

Table 1. Comparison of glazing R-values (obtained from MetroGlass Catalogue 6th edition)

Glazing	R-value
Ordinary, clear float glass (4 mm)	0.17
Laminated with low-E coating on surface 4 (6.38 mm)	0.28
Standard glass IGU (4-12-4)	0.37
Argon gas-filled IGU (4-12-4)	0.39
Low-E glass IGU (4-12-4)	0.53
Low-E glass/argon gas-filled IGU (4-12-4)	0.62

panes. The secondary sealant is installed around the outer perimeter of the IGU. Secondary sealants may be polyurethane, butyl, polysulphide or silicone sealants. In addition to providing protection for the PIB, they provide structural support to the panes.

4.0.6 Most sealants cannot tolerate prolonged wetting so the rebate housing the IGU must have good drainage in order to avoid sealant failure. The spacer usually contains a desiccant to absorb small amounts of moisture from the space between the panes but it cannot remove larger amounts of moisture that may occur if an edge seal fails.

4.0.7 New technologies in filling options for IGUs are available overseas but not yet generally available in New Zealand. These include:

- aerogels – very low-density porous materials that have excellent insulating properties
- vacuum insulation – the space between panes is a vacuum rather than gas-filled and requires only a very small gap (less than 1 mm) between panes so is suitable for situations where only a very narrow IGU can be installed.

5 REDUCING DRAUGHTS AROUND WINDOWS

5.0.1 Air infiltration (the movement of air from outside to inside) and leakage (the loss of indoor air to outside) through poorly fitting timber windows result in a significant heat loss. Timber windows are particularly prone to being draughty as timber constantly expands and contracts in response to changes in temperature and moisture levels, making it difficult to maintain airtight seals in the joinery. Older timber windows and double-hung windows in particular are more likely to be poorly fitting and draughty.

5.0.2 Before considering the options to upgrade the thermal performance of timber windows, draughts should be eliminated or reduced as much as possible. The most effective way to stop draughts is by blocking or sealing the gaps around the window openings.

5.0.3 A range of proprietary self-adhesive draught seal and strip products are available:

- Foam draught seals are available in a variety of thicknesses to suit the width of the gap. They can be used for any type of hinged window. However, they can overstress hinges and catches, deteriorate relatively quickly and must be replaced every few years.
- Seals with a V-shaped profile are adhesive-backed vinyl strips that fold into a V shape to fill gaps 1–8 mm wide (Figure 5). They fit a range of gap thicknesses and are particularly effective where the gap size varies. They can be used for casement and awning windows.
- Soft rubber D or O seals compress in the gap to create the draught seal so they suit variable gap sizes. They are available in a variety of shapes and thicknesses and can be used for hinged and awning windows.
- Brush pile seals are used with sliding windows and doors, including double-hung timber windows, and can seal gaps 3–15 mm wide (Figure 6). Double-hung sashes must be removed in order to fit the seals,

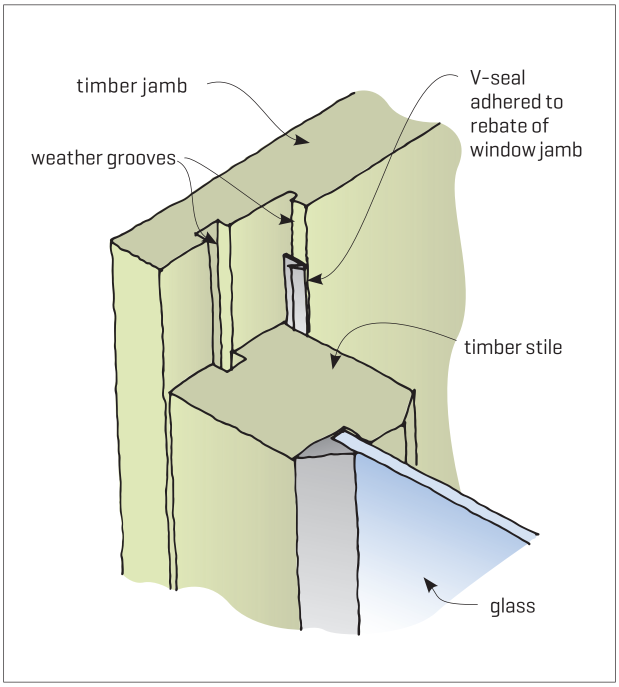

Figure 5. Seal with a V-shaped profile.

Figure 6. Brush pile seal in double-hung window.

which may be adhesive-fixed or housed into sawcuts in the sash and should be removed for maintenance. Larger mouldings are sometimes required to be installed for the seals to be effectively fitted.

5.0.4 Before installing any type of draught seals, check windows for loose hinges, catches and latches and tighten or replace as required as loose hardware will also contribute to air infiltration.

5.0.5 Gaps around older windows are often uneven so check that the thickness of a compressible seal will not make the opening sash difficult to open or close.

6 RETROFITTING IGUS INTO EXISTING TIMBER SASHES

6.0.1 A building consent is not required for retrofitting IGUs into existing window sashes, but all building work must comply with the Building Code.

6.0.2 Retrofitting IGUs into existing timber sashes can significantly improve the thermal performance of the windows. IGUs can be retrofitted into almost any type of timber window. The depth of the existing glazing rebate must be increased to house the IGU so the only limitation is that the sash profile must have sufficient depth, width and strength to carry the extra weight.

6.0.3 Before retrofitting IGUs into timber sashes, the following should be considered:

- The condition of the sashes – if there is evidence of rot in the timber or large gaps at the joints, the sashes should be replaced.
- Double-hung windows often have quite narrow sashes, particularly mid rails with insufficient depth for a rebate to be cut, in which case the sashes should be replaced.
- Weight may be a limiting factor, particularly for hinged windows. Only double-glazed IGUs are generally retrofitted into existing timber frames and sashes as triple-glazed units are likely to be too heavy. Where necessary, replace hardware such as hinges and stays. An alternative option is to make the opening sashes smaller to reduce the weight but this is not always possible.
- The weights that counter-balance double-hung windows should be increased to accommodate the weight of the IGU, and larger mouldings may need to be installed.
- IGUs are generally not able to be retrofitted into split-rail awning windows as the sash rails are too thin so the only option is to replace the sashes.
- For heritage buildings, considerations for preserving architectural features in windows may sometimes require a different approach.

6.0.4 To retrofit an IGU into an existing timber sash (Figure 7):

- Remove the window sash from the frame and take out the existing glass panes.
- Rout out the glazing rebate to fit the thickness of the IGU, creating a 15° slope towards the exterior face of the sash on the bottom rebate to provide drainage. Most sashes have a bevel or ovolo profile on the interior face. The routing should leave at least 1–2 mm depth of the sash bevel or ovolo profile.
- Apply a silicone sealant or butyl glazing tape to the face of the rebate.
- Place silicone setting blocks in the bottom rebate. The setting blocks must have a level top surface to support the glass so they should either be placed on sloped packers or sloped setting blocks should be used.
- Position the IGU on the setting blocks in the rebate and apply additional glazing tape around the exterior face of the glass.
- Fix timber beads around the IGU to hold the glass in position. The bottom rail bead has a deeper profile than the stile and top rail beads and should contain drainage holes or slots. Note that putty must not be used to install IGUs. Linseed oil-based putty is incompatible with the perimeter sealants used with IGUs, and a satisfactory system of drainage cannot be provided by synthetic putty.

6.0.5 A range of proprietary systems for retrofitting IGUs into existing timber sashes are available. These are designed using similar principles of providing drainage at the bottom rebate.

6.0.6 The thermal performance of leadlight windows can be improved by encasing the leadlight glass between two panes of clear glass. While the level of improvement of thermal performance is limited, there is an added benefit of protecting the leadlight glass. To encase in glass, the leadlight window must be removed from the sash, glass placed on either side and the edges sealed. The window can then be reinstalled into the existing sash rebate following the same procedure as installing an IGU.

7 RETROFITTING DOUBLE-GLAZED UPVC OR ALUMINIUM WINDOWS

7.0.1 Although it is a higher cost option to replace timber sashes with double-glazed uPVC or aluminium windows, there are a number of benefits including:

- improved thermal performance is achieved without the associated remedial costs required to reinstate the external and internal claddings and linings with full window replacement
- modern uPVC and aluminium sashes can be more airtight than older style timber sashes
- security can be improved
- trickle ventilation can be incorporated
- both uPVC and aluminium inserts require less maintenance than timber – general maintenance includes:
  - cleaning frames at least one or two times per year using mild detergent and water
  - checking and cleaning out drainage holes or slots as required
  - oiling moving parts annually as recommended by the manufacturer.

7.0.2 The thermal performance of uPVC is similar to that of timber, so retrofitting a uPVC insert fitted with an IGU will achieve a similar thermal performance as when an IGU is retrofitted into an existing timber sash. The uPVC inserts must be custom-made to fit existing windows and can be made to match the style of the original window (Figure 8).

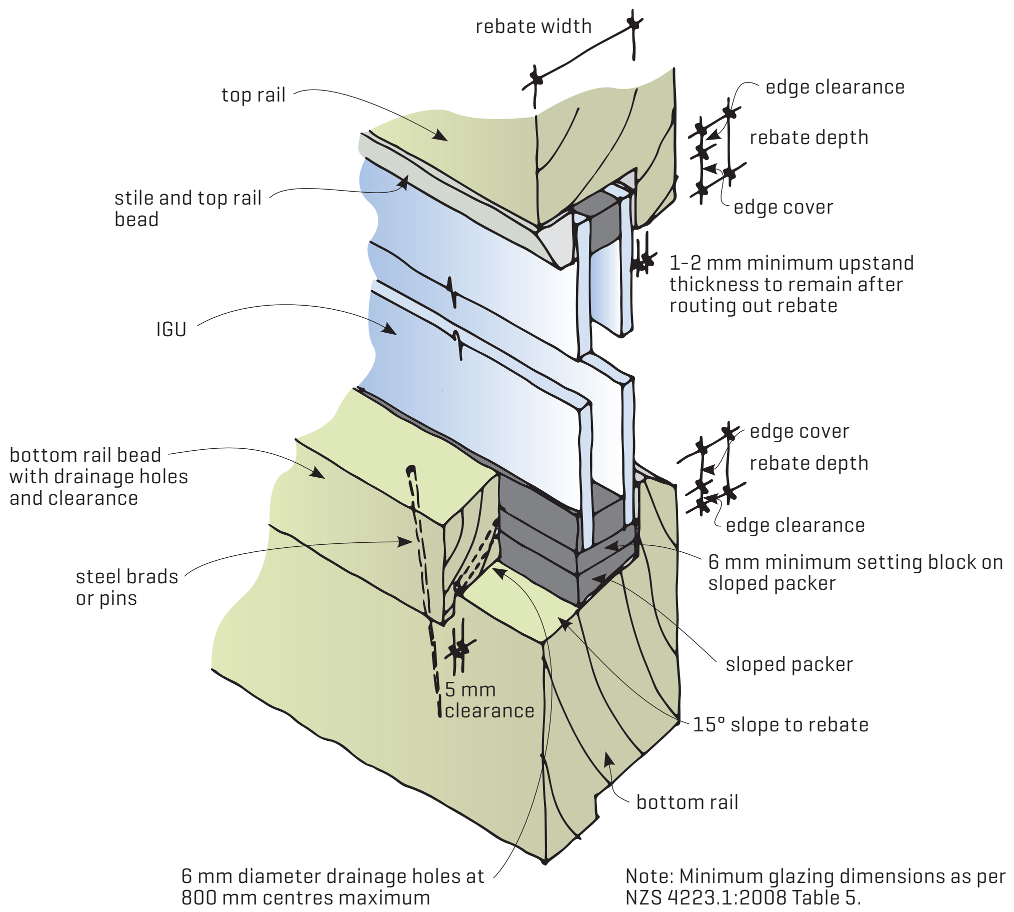

Figure 7. Retrofitting an IGU into a single-glazed sash.

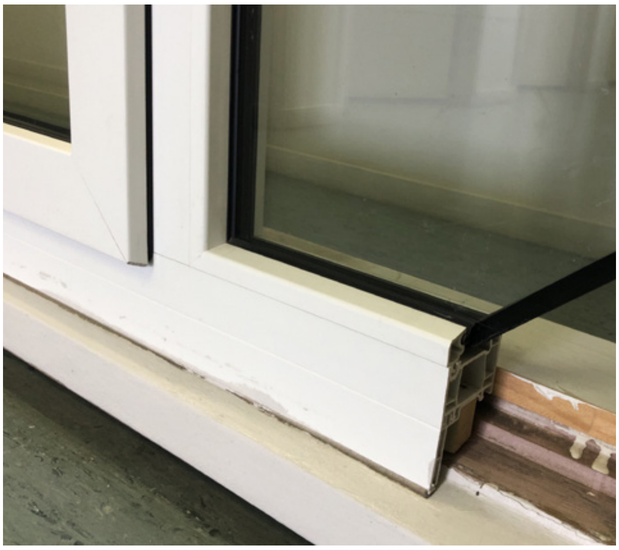

Figure 8. uPVC frames with IGU retrofitted into timber window.

7.0.3 A disadvantage of both uPVC and aluminium windows is that they have a shorter lifespan than timber windows.

7.0.4 Aluminium inserts, even when the frames are thermally broken, do not provide the same R-value increase as uPVC inserts. They must be custom-made to fit existing windows but generally do not match the style of the original window.

8 MORE INFORMATION

BRANZ Bulletin 579 *WEERS – Window Energy Efficiency Rating System*

BRANZ Bulletin 658 *Timber windows*

BRANZ Good Repair Guide *Insulating timber windows*

BRANZ Good Repair Guide *Timber windows*

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