TechDirect™ White Paper

Quality Expectations

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1. INTRODUCTION

Architectural float glass is manufactured and then processed into a wide variety of finished products, ranging from simple single glazed panes to sophisticated multi-component systems. Once manufactured, the base glass can be assembled into insulated glass units (IGUs), laminated for enhanced safety or acoustic control, or shaped into complex forms with precision cut-outs for fixings and hardware.

While there is often an expectation that glass surfaces will appear flawless under every lighting and atmospheric condition, the reality is more nuanced. Each stage of production - whether handling, cutting, edge finishing, heat treatment, or lamination - can influence the final outcome. In addition, the inherent properties of glass itself can result in natural variations in appearance and performance.

To ensure consistent quality and management of these expectations, the industry relies on established standards that define acceptable tolerances:

- **AS/NZS 4667 – Quality requirements for cut-to-size and processed glass**
- **AS 4666 – Insulating glass units**

These standards outline requirements for characteristics such as inclusions from float glass manufacture, permissible surface marks, optical distortions, subtle colour variations, and allowable size or thickness tolerances. Taken together, they provide a framework for balancing manufacturing realities with the high aesthetic and performance expectations placed on architectural glass.

2. BACKGROUND

This document addresses a range of glass characteristics that are sometimes perceived as quality faults. Its purpose is to clarify which features are recognised within industry standards as acceptable manufacturing or processing tolerances, and to distinguish between genuine defects and natural variations that do not affect performance or require replacement.

It is important to note that Viridian operates as a glass processor, not a glass manufacturer. We source pre-manufactured float glass (stock sheets) from trusted suppliers, rather than producing glass from raw materials. Our role is to transform this base glass through processes such as cutting, toughening, laminating, double glazing, and shaping to meet both customer specifications and relevant industry Standards.

While Viridian applies rigorous quality assurance throughout processing, certain characteristics and tolerances are inherent to the original manufacturing of the glass itself. These aspects remain outside the processor’s control but are accounted for within the established Standards that govern glass quality in Australia.

Finally, the scope of this paper is limited to glass products. Other building materials may also influence overall quality expectations, but they are not considered within this document.

Manufacturing phase

Architectural glass is produced using the **float glass process**, in which raw materials - such as sand, soda ash, and recycled glass cullet - are melted at high temperatures and floated on a bath of molten tin to create a perfectly flat sheet. During this process, small inclusions or air pockets, known as *“seeds”*, can naturally occur.

To minimise these imperfections, manufacturers employ advanced fault-detection scanners to identify and remove most seeds and inclusions before the glass is cut into stock sheets. However, because glass is derived from natural raw materials, a limited presence of such features is unavoidable. The **AS/NZS 4667** standard specifies the acceptable number of seeds and inclusions per square metre for cut-to-size and processed glass, providing a clear framework for quality assessment.

Additionally, the float process inherently produces a **"tin side" -** the surface that was in contact with molten tin during manufacture. This side may retain slight residues or traces of tin, which can influence subsequent processing stages such as coating, laminating or painting.

Figure 1. Example of a "seed" (Viridian Glass, 2025)

Coated glass types

To enhance the naturally poor insulating performance of standard float glass, specialised coatings are often applied during or shortly after the manufacturing process. These **low emissivity (Low E) coatings** reduce heat transfer through the glass, improving insulation performance. In addition, more advanced coatings with multiple stocks of silver are specifically designed to also reflect infrared (IR) radiation, making them particularly effective where reducing solar heat gain (SHGC) is a priority.

There are two primary types of Low E coatings used in architectural glass:

Hard coat (pyrolytic coating – CVD process)

- Applied during the float glass manufacturing process, typically as the glass ribbon exits the molten tin bath.
- Created through a **chemical vapour deposition (CVD)** process that fuses the coating to the hot glass surface.
- The coating is relatively **thick and durable**, allowing the glass to be handled, transported, and even installed as single glazing.
- However, the slightly rougher surface interacts with angled light, creating a visible **haze effect** under certain conditions - most noticeable when the sun is low on the horizon, similar to the glare experienced when driving into the sun through a car windscreen.

Soft coat (magnetron/sputter coating)

- Applied after the float process in a controlled vacuum chamber, where metal particles (such as silver) are deposited onto the glass surface by electron bombardment.
- Produces **extremely thin and smooth coatings**, which deliver superior thermal performance and significantly reduced haze compared to hard coats.
- Because of their delicate nature, these coatings are **sensitive to handling and environmental exposure**. They require protection and must be incorporated into **insulated glass units (IGUs)** within tightly controlled timeframes to preserve their performance.

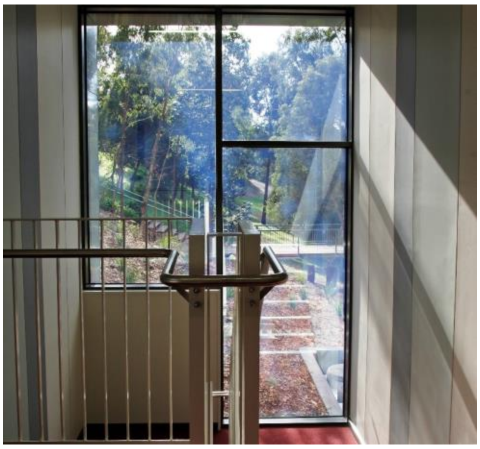

Figure 2. Example of haze (Viridian Glass, 2025)

Some coatings can exhibit variations in off-angle colour, creating subtle differences in hue between adjacent panels. These effects are inherent to the coating process and can be more noticeable in large glazed facades. To maintain visual consistency, tolerances should be confirmed with the coated glass manufacturer, and, where possible, glass from the same production batch should be specified for use across expansive installations such as curtain walls.

Processed glass

Once stock sheets, including coated glass products, are sourced from the manufacturer, they undergo a series of processing steps to produce the final product. These processes may involve **cutting, edge finishing, drilling holes, or creating precision cut-outs for hardware and fittings**. Each stage requires careful handling and the physical transfer of panels between workstations. Naturally, this movement increases the likelihood of minor surface marks or scratches from manual handling.

At more advanced facilities, higher levels of **automation in glass handling and transfer systems** can significantly reduce manual contact, improving consistency and lowering the risk of incidental damage.

During processing, transportation, and installation, the use of handling equipment such as **vacuum lifters, pinch grabs, quench rollers, and separation pads** may leave behind temporary **surface residues**. These may cause *preferential wetting patterns* that become visible when moisture or condensation is present. Such markings are **cosmetic only**: they do not affect the performance, durability, or safety of the glass and typically diminish over time. Consequently, they are **not considered defects** and do not constitute grounds for rejection.

Figure 3. Example of suction marks (u/sunggis, 2023)

Tempered glass (Toughening and Heat Strengthening)

One of the most common requirements in architectural glass specifications is to improve strength and safety through **tempering**. The process involves heating glass to a temperature of around **650 °C**, at which point it softens and loses rigidity, before rapidly cooling it in a high-pressure air quench. This sudden temperature change “locks in” compressive stresses on the glass surfaces, significantly increasing its resistance to mechanical loads and thermal stresses that could otherwise cause annealed glass to fail.

In architectural applications, tempering is typically performed in a **horizontal roller furnace**, where the glass oscillates across ceramic rollers during heating. As the softened glass expands and then rapidly cools, slight distortions can occur. These manifest as:

- **Roller wave** – subtle rippling across the glass surface caused by contact with rollers.
- **Edge kink** – small deviations along the glass edges.

Figure 4. Example of roller wave (Nuline Windows, 2025)

Such distortions are most visible in reflected light, particularly at oblique viewing angles. While **AS/NZS 4667** provides general guidance on acceptable levels of localised distortion, most toughening facilities adopt stricter internal tolerances - typically **0.10 to 0.14 mm** for roller wave and **0.15 to 0.20 mm** for edge kink. In addition, the furnacing process can lead to **overall bowing** of the panel, for which further tolerance limits also apply.

Distortion tends to be more pronounced when **coated glass** is processed. Because coated surfaces absorb and reflect radiant heat differently than clear glass, uneven heating can occur if furnace conditions are not precisely controlled. Modern furnaces often use **convection systems** to minimise these temperature differentials and reduce distortion.

Another by-product of the furnacing process is the presence of **tiny glass dust particles** that accumulate on furnace rollers and adhere to the underside of panels. These particles can sometimes be felt on the glass surface and, under strong angled light, may cause a **sparkling or hazy effect**. Importantly, blades should never be used to clean tempered glass, as they can drag adhered particles across the surface and create permanent scratches.

Figure 5. Example of glass dust (Glaston, 2015)

During the furnace heating stage, glass may experience a degree of **central bowing**. As the softened glass passes over rollers, microscopic glass particles can accumulate along a vertical line perpendicular to the roller direction. This phenomenon, commonly referred to as a **"white stripe,"** can sometimes be visible under standard inspection conditions defined in **AS/NZS 4667** (viewed from a distance of 3m and not under direct or concentrated light). When visible, these stripes may be considered objectionable. In some cases, their appearance can be reduced through careful polishing techniques, using compounds such as **cerium oxide** or specialised stainless-steel polishes, provided the affected surface is accessible and not sealed within an insulated glass unit (IGU).

Another characteristic of tempered glass is the appearance of **colour variations or polarisation effects**, often described as *anisotropy*. These take the form of shadow-like patterns or iridescent spots, most noticeable when viewed through **polarised lenses** or at certain angles. Anisotropy is a natural result of non-uniform surface stresses created during the tempering process. It does not compromise the structural performance or durability of the glass and is **not classified as a defect**.

Figure 6. Example of anisotropy (Pasetto, S., 2014)

Laminated glass

Laminated glass consists of two or more layers of glass bonded together with one or more interlayers. While this construction enhances safety, security, and acoustic performance, it can also result in a greater likelihood of **minor visual blemishes** compared to monolithic glass.

Under certain lighting conditions, particularly strong or direct light, laminated glass may exhibit a slight **haze** or optical effects caused by the interlayer. Variations are most noticeable when grey or tinted interlayers are used. During the lamination process, **dust or foreign particles** may occasionally become trapped between the glass layers, and these are assessed for acceptability in accordance with **AS/NZS 4667** and the standard 3m viewing distance criteria.

It is also common for laminated products to show a small degree of **edge creep**, where the interlayer extends marginally beyond the glass edge. Allowances for this are typically defined within individual product specifications and warranties, and minor occurrences are generally acceptable.

Figure 7. Example of laminated glass (Viridian Glass, 2025)

Insulated glass units (IGUs)

By design, **insulated glass units (IGUs)** incorporate multiple panes of glass separated by an air- or gas-filled cavity, which creates more reflective surfaces than single glazing. Whereas a single pane of float glass produces two reflective surfaces, a standard IGU contains at least four, resulting in **double reflections** that may be noticeable under certain lighting conditions. This is considered a natural characteristic of the product.

The sealed cavity within an IGU is manufactured at the air pressure of the production environment. Variations in external air pressure, elevation, or temperature after installation can cause the glass panes to **bow outward (convex)** or **draw inward (concave)**. These pressure-related deflections may alter the way light reflects off the surface, creating visible distortions.

For installations at higher altitudes, typically above **800 metres,** IGUs may require **breather or capillary tubes** to equalise the internal cavity pressure with the external environment and reduce the risk of premature seal failure.

Figure 8. Example of a spacer bar (Viridian Glass, 2025)

Newton's rings

In larger IGUs, differential pressure across the cavity can cause the two panes of glass to flex inward until they come into contact at the centre. This can create **Newton's rings**: distinctive circular, rainbow-like patterns resembling oil on water. In some cases, if the glass panes touch repeatedly, they may develop **permanent white spots** from surface abrasion.

To mitigate these risks, façade consultants or engineers should verify that the **spacer bar width** specified for each project is sufficient to accommodate expected changes in elevation, barometric pressure, and tempering-induced bow. Following the glass manufacturer's spacer guidelines is essential to ensure long-term performance and to prevent undersized cavities in large-format IGUs.

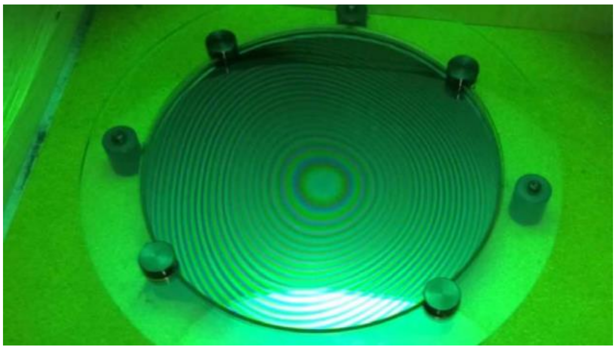

Figure 9. Newton's rings (Viridian Glass NZ, 2025)

Brewster fringes

Brewster fringes, often referred to as the *"rainbow effect,"* can occur when the panes of high-quality float glass within an insulated glass unit (IGU) are exceptionally flat and precisely parallel. Under certain lighting conditions, this optical alignment causes light to **refract and interfere**, producing faint coloured bands or irregular patterns that may appear across the glass surface.

These fringes are a natural optical phenomenon rather than a defect in the glass or its manufacture. While they may be visible under specific viewing angles, they do not compromise the performance, safety, or durability of the IGU.

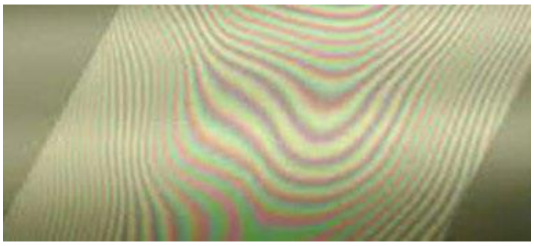

Figure 10. Brewster fringes (Viridian Glass NZ, 2025)

Fogging and unit seal failure

Fogging or **unit break down** can occur when the hermetically sealed cavity of an insulated glass unit (IGU) is compromised. This typically results from a failure of the perimeter seal, which allows external moisture to enter the cavity. Once moisture penetrates, it condenses on the internal glass surfaces, permanently affecting clarity and requiring the unit to be replaced.

As a glass processor, **Viridian complies with the AS 4666 – Insulating Glass Units Standard**, which provides internationally recognised guidance to ensure consistent quality in IGU production. Compliance involves:

- **Daily monitoring** of sealant composition and adhesion.
- **Regular assessment** of desiccant performance.
- **Dimensional and quality checks** on all components.
- Verification of **minimum sealant dimensions**.
- Inspection of **primary seal application**.
- Submission of test units to independent laboratories for **accelerated weather performance testing**.

The primary objective of these requirements is to maintain process consistency across all compliant IGU processors. Adherence provides both processors and customers with confidence in the long-term durability and performance of the final product.

The most common cause of seal failure is **moisture ingress into the glazing cavity**, where it becomes trapped and cannot escape. To minimise this risk, it is essential that the **glazing methodology and framing systems** are compatible with AS 4666 requirements. In drained framing systems, the sill drainage should be checked to ensure it is free from blockages caused by debris such as dirt or leaf litter. **Glazing blocks** must also meet the standard's specifications for composition, dimensions, and placement.

In non-drained systems, the integrity of the IGU perimeter seal is even more critical, as these units rely on the cavity remaining moisture-free throughout the warranty period - and ideally for much longer. The presence of **moisture behind glazing beads or between glass panes** indicates seal failure and requires unit replacement.

For further detail, refer to the glazing requirements outlined in **AS 4666**. An understanding of the fundamental glazing principles in this standard is essential for all tradespeople for correct IGU installation into frames.

3. SOLUTION

To ensure glass products consistently meet industry quality expectations, the following guidelines should be applied throughout **manufacturing, processing, and inspection**.

Relevant standards

Glass products must comply with established Australian and New Zealand standards, including:

- **AS/NZS 4667:2000 – Quality requirements for cut-to-size and processed glass**
- **AS 4666:2012 – Insulating Glass Units (IGUs)**
- **AS 2208 – Safety glazing materials in buildings**

These standards define key requirements such as dimensional tolerances, thickness, flatness, visual quality, and testing methods. Collectively, they provide a framework to ensure **consistency across the industry**, minimise variations in appearance or performance, and set clear expectations for both manufacturers and customers.

Customer acceptance standards

In addition to compliance with national standards, many glass processors establish their own **customer acceptance standards** to address aspects of quality not fully defined in existing codes. These supplementary guidelines often focus on issues such as **distortion, inclusions, and optical effects**, where the perception of quality may vary.

Viridian provides **detailed specification documents** for all processed glass types - including tempered, laminated, and insulated glass units (IGUs) - to ensure consistent interpretation of acceptable quality levels.

Proper inspection methods (How to check for faults)

When assessing glass quality, inspections should follow established industry practice to ensure consistency and fairness:

- Clean the glass thoroughly in line with the manufacturer's recommendations.
- Stand at least **3 metres away** and view the glass **directly at 90°** to the surface.
- Inspect only in **natural daylight**, avoiding direct sunlight or visible surface moisture.
- Where a full 3 metre viewing distance is not possible, stand as far back as the space allows.
- For IGUs, exclude the **defined edge zones** around the perimeter as specified in **AS 4666, Tables 5.5 and 5.6**.

These methods help distinguish between acceptable natural variations and actual defects, ensuring inspection outcomes are consistent with both industry and manufacturer standards.

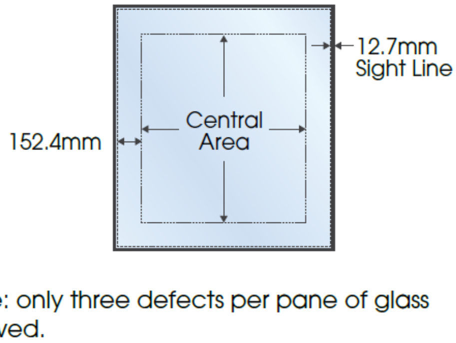

Figure 11. IGU parameter of panel (Viridian Glass, 2025)

Why faults shouldn't be assessed in direct sunlight

Direct or angled sunlight can exaggerate the appearance of even the smallest residues or surface marks on glass. While standard washing processes remove contaminants to the level required by industry standards, they may still leave faint traces that are invisible under normal viewing conditions.

Inspection areas with good, controlled lighting are effective for detecting significant imperfections, but the **intensity of sunlight cannot be replicated indoors** and therefore does not provide a consistent basis for assessment. In addition, the **background colour** behind the glass influences visibility: darker surfaces tend to accentuate imperfections, making them appear more pronounced than they actually are. For this reason, inspections should be carried out under standardised lighting conditions, not in direct sunlight, to ensure alignment with accepted industry limits.

Understanding natural variations

It is important to recognise that certain visual and physical characteristics are **inherent to glass manufacturing and processing**. Minor surface marks, slight distortions (such as roller wave), subtle colour variations, and small inclusions are natural by-products of the production process.

These features should not be regarded as defects **unless they exceed the tolerance limits** specified in the relevant standards or in internal acceptance criteria. In most cases, such variations have no impact on the **performance, durability, or safety** of the glass and therefore do not justify rejection.

Educating Installation Teams

It is essential that installation teams are familiar with the **natural characteristics of glass**, such as the slight bowing that may occur in insulated glass units (IGUs), or the roller wave distortions associated with toughened glass. By understanding these features, installers are better equipped to **manage customer expectations** and to distinguish between acceptable variations and true defects.

Clear communication of these characteristics, combined with adherence to proper installation practices, helps ensure that glass performs as intended once in service. When supported by consistent quality control measures, this approach allows manufacturers and processors to deliver products that **comply with industry standards** while maintaining customer confidence.

4. CONCLUSION

Although glass manufacturing and processing are governed by strict industry standards, it is important to recognise that **natural variations** - including minor surface marks, slight distortions, and subtle colour differences - are an inherent part of production. These features are not considered defects unless they exceed the **tolerance limits** defined in the relevant standards.

When product quality concerns are raised, inspections should be conducted **as soon as reasonably practicable** after supply or installation, ensuring issues are addressed promptly and fairly. By adhering to **AS/NZS 4667:2000**, **AS 4666:2012**, and related standards, and by applying proper inspection techniques, the industry can set clear and consistent expectations for performance and appearance.

Maintaining glass quality also relies on careful **handling**, consideration of **environmental conditions**, and **effective communication with installation teams**. Together, these practices safeguard product integrity, align customer expectations with industry standards, and help ensure that glass performs reliably throughout its service life.

5. APPENDIX

Figure 3. u/sunggis. (2023). *These 4 identical patterns showed up on only one of my windows when they fogged up*. Reddit. https://www.reddit.com/r/mildlyinteresting/comments/10gl3x2/these_4_identical_patterns_showed_up_on_only_one/?rdt=56013

Figure 4. Nuline Windows. (n.d.). *Toughened Glass Roller Wave*. Retrieved [October 2025], from https://nulinewindows.com.au/blog/toughened-glass-roller-wave Nuline Windows

Figure 5. Glaston. (2015, April 23). *White haze in glass: How to eliminate the white haze from tempered glass*. Glastory. Retrieved [October 2025], from https://www.glastory.net/de/killing-the-glass-ghost-how-to-eliminate-the-white-haze-from-tempered-glass/ Glastory

Figure 6. Pasetto, S. (2014). *Anisotropy as a defect in U.K. architectural float heat-treated glass* (MSc Dissertation, University of Bath). Retrieved from https://www.cibse.org/media/fsxoyvrk/pasetto_saverio_anisotropy-as-a-defect-etc.pdf cibse.org

Figure 9. Viridian Glass NZ. “What Are Newton’s Rings?” *Viridian Glass*, [October 2025], https://www.viridianglass.co.nz/rich-snippet-template/what-are-newtons-rings/ Viridian Glass

Figure 10. Viridian Glass. “What Are Brewster Fingers?” *Viridian Glass*. Retrieved [October 2025], from https://www.viridianglass.co.nz/rich-snippet-template/what-are-brewster-fingers/ Viridian Glass