WHAT IS DOUBLE GLAZING?

Increasing use of double glazing is creating some challenges for the building industry, but knowing its special characteristics helps understand some of its limitations.

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Ordinary glass accounts for less than 5% of a window's insulation value. The rest is supplied by the much greater heat flow resistance of still air layers on either side of the glass. Hence, a double glazing unit made of two glass panes enclosing an airspace will have two sets of still air layers, giving about twice the insulation value of a single pane window (that is, half the heat loss). This is why double glazing units are called insulating glass units (IGUs), as they provide insulation to the windows of a building.

Increasing the glass thickness or using laminated glass makes little difference to the insulation, but low-E coatings applied to the glass during manufacture will reflect long wave radiation and improve the insulation, both in single glazing and IGUs.

Pressure and temperature effects

An IGU is made by sealing dry air or gas between panes of glass. When the unit is sealed, the pressure and temperature of the trapped air is the same as outside the unit.

As long as the unit remains sealed, the mass of the air between the panes is constant. However, the thin glass panes of an IGU are flexible, meaning that they will deflect if there is a difference in pressure from one side to the other. Hence, an IGU can be considered a sealed flexible chamber.

If the pressure outside the unit increases while the temperature remains the same, the difference in pressure will cause the glass panes to deflect inward, thus decreasing the volume of trapped air. If the pressure outside the unit decreases, the glass will deflect outward, increasing the volume of trapped air. This is why, for special applications such as windows installed at high altitudes, it is important to consider any differences in air pressure between where and when it was sealed and the building location.

The common causes of air pressure changes that affect units are:

- barometric changes in weather conditions
- differences in altitude between the manufacturing and installation sites
- wind effects
- outdoor and indoor air density differences at different temperatures
- operation of an HVAC system in the building.

Temperature changes also result in pressure and volume changes. An increase in temperature causes outward deflection of the panes, and a decrease in temperature causes inward deflection. The change in pressure induced by a temperature rise of 2.7°C is about the same as that caused by a barometric drop of 1 kPa.

Barometric pressure averages 101.3 kPa at sea level and drops by about 1 kPa per 100 m in elevation or altitude. This is why special care must be taken for units glazed at high altitude. Often, pressure equalisation is required once the unit is installed, using pressure valves or capillary tubes.

Panes of installed IGUs constantly deflect in and out with changes in climate. This puts stress on the edge seals and, if excessive, can shorten their life. It can also create changes in the appearance of transmission and reflection images, especially if the units are made from tinted or reflective glass.

If the unit is large and/or square, the airspace may not be wide enough to stop the two panes deflecting in and touching, leading to an effect called 'Newton's rings'. The glass is no longer insulating if the panes are touching, and in some cases, the glass surfaces can rub and cause permanent surface damage inside the unit.

Wind pressure effects

Windows must be strong enough to withstand the effects of wind without breaking. The wind pressure may be positive or negative on a window, depending on its location, height and the orientation of the building surface to the wind, known as the pressure coefficient. The wind action also affects the air pressure inside the building.

When the outer pane of an IGU is subjected to external wind pressure, it deflects inward, and the air space acts like a spring, forcing the inner pane to do the same. Some spring resistance is lost by the airspace, so the inner pane may not deflect as much as the outer. The amount of loss is a complex issue, but for an IGU made of monolithic annealed glass of the same thickness, the new NZS 4223.4:2008 *Code of practice for glazing in buildings – Wind, dead, snow, and live actions* gives a load-sharing factor of 0.625. A load-sharing formula is given to calculate the individual strength of panes of different type and thickness.

Keeping deflections small

When calculating wind load deflection, the load is shared and each pane calculated according to its thickness. In reality, the airspace provides some cushioning under wind load so the inner pane will deflect a little less if ➝

Key points to remember about IGUs

- Designers should keep window and door sizes realistic.
- Joinery used must be able to cope with the unit thickness and weight.
- Wind loads, glass spans and deflections are key design criteria.
- Large airspaces are required for large units.
- Glass type and/or thickness may be limited in large units.
- Builders and window companies must allow for more on-site glazing.
- Site access is critical for on-site glazing.
- Cranes and mechanical lifting equipment are often required for large units.

the same thickness. Hence, it is often better to have the stiffer glass on the outer pane, depending on the glass types.

Heat-treated glass, such as toughened or heat-strengthened glass, may also have an inherent bow or roller wave that can add to the apparent deflection in the unit. If possible, two large, square, thin panes of toughened glass should not be used in an IGU, even if they meet the design load requirements. Roller wave direction can also be important to reduce a distortion and should be horizontal if possible.

Deflection due to wind load should be limited to approximately 1.5 times the airspace thickness, or 20 mm maximum, otherwise it can become visually disturbing. Thus, for large units, it is important to have large airspaces (12–16 mm), but this is often not possible with the thickness of frame rebate available. The short side length (span) is the crucial governing factor for deflection, and units wider than 2,000 mm tend to create the most problems, so tall narrow units are better than wide square ones.

The Insulating Glass Unit Manufacturers Association has prepared a guide for recommended maximum unit sizes (see Table 1).

Deflection limits on the glass are based on the frame being stiff enough to support the IGU. The torsional rigidity of frames should comply with NZS 4211:2008 *Specification for performance of windows*. Any undue deflection in the frame can also increase stress in the edge seals and reduce unit life.

Table 1: IGUMA recommended maximum sizes of vertically glazed IGUs.

		Wind zones							
		Low (0.65 kPa)		Medium (0.85 kPa)		High (1.2 kPa)		Very high (1.55 kPa)	
IGU makeup	Spacer width	Max. small	Max. large	Max. small	Max. large	Max. small	Max. large	Max. small	Max. large
4 + 4	6	1000	2100	1000	2000	900	1900	800	1800
4 + 4	8	1100	2200	1200	2100	1100	2000	1000	1900
4 + 4	10	1400	2300	1300	2200	1200	2100	1100	2000
4 + 4	12	1500	2400	1400	2300	1300	2200	1200	2100
5 + 4	6	1100	2300	1100	2200	1000	2100	900	2000
5 + 4	8	1200	2400	1200	2300	1200	2200	1100	2100
5 + 4	10	1500	2500	1400	2400	1300	2300	1200	2200
5 + 4	12	1600	2600	1500	2500	1400	2400	1300	2300
5 + 5	6	1200	2400	1200	2300	1200	2200	1100	2100
5 + 5	8	1300	2500	1300	2400	1300	2300	1300	2200
5 + 5	10	1700	2600	1600	2500	1500	2400	1400	2300
5 + 5	12	1800	2700	1700	2600	1600	2500	1500	2400
6 + 5	6	1200	2600	1200	2500	1200	2400	1200	2300
6 + 5	8	1300	2700	1300	2600	1300	2500	1300	2400
6 + 5	10	1800	2800	1700	2700	1600	2600	1500	2500
6 + 5	12	1900	2900	1800	2800	1700	2700	1600	2600
6 + 6	6	1300	2700	1300	2600	1300	2500	1200	2400
6 + 6	8	1400	2800	1400	2700	1400	2600	1400	2500
6 + 6	10	1800	2900	1700	2800	1600	2700	1500	2600
6 + 6	12	1900	3000	1800	2900	1700	2800	1600	2700
8 + 6	10	2000	3100	1900	3000	1800	2900	1700	2800
8 + 6	12	2000	3200	2000	3100	1900	3000	1800	2900
8 + 8	10	1900	3200	1900	3100	1800	3100	1800	2900
8 + 8	12	2000	3150	1950	3200	1900	3200	1900	3000

1. All measurements in are mm.
2. Glass wind load deflections are restricted to 1.5 times the spacer width (i.e. for 12 mm spacer, 1.5 × 12 = 18 mm max.)
3. Unit sizes are restricted to 250 kg in weight. Special manufacturing and handling equipment may be required for heavier units. Unit sizes in white are restricted by manufacturing, handling and transportation limitations.
4. Wider airspaces are always advised for performance, as 12 mm airspace is 15% more efficient than 6 mm airspace.

Designing for human impact

If IGUs are used where there may be human impact from both sides, such as a door, both panes need to comply with NZS 4223.3:1999 *Code of practice for glazing in buildings – Human impact safety requirements*.

If the unit is subjected to human impact from one side only, such as low-level glazing in the first floor of a building façade, only the impact side needs to conform to NZS 4223.3. This standard allows IGUs under human impact to be 1.5 times bigger in area than single glazing (see clause 303.6).

Larger size, bigger handling challenges

The size of large IGUs is often limited by weight, handling and glazing implications. Table 1 gives the normal recommended maximum sizes for vertically glazed IGUs up to 250 kg in weight.

Individual manufacturing plants and processes may also set maximum glass size and/or weight, so check with the supplier. The maximum sizes specified by the plants are typically 4,000 × 2,500 mm, 3,500 × 2,500 mm or 3,000 × 2,000 mm.

Most plants can make up to a maximum of 10 + 10 mm glass, so a very large unit can be in excess of 400 kg. To handle these units requires special equipment or 10+ people, which is impractical. As a guide, units should not be over 250 kg, but even these create handling and glazing problems.

To calculate the approximate weight, use the following: Height (m) × width (m) × 2.6 kg/m^2 × [thickness outer (mm) + thickness inner (mm)]. For example, a 2 × 1 m, 6/12/6 unit = 2 × 1 × 2.6 × (6 + 6) = 62.4 kg.

Handling and glazing large heavy IGUs is best done with strops so both panes are supported, but in some cases, suckers are required. If suckers are used on one side only, they can put shear stress on the IGU seals and damage them.

Joinery must handle the weight

The weight and size of units will mean that a greater percentage of joinery must be site glazed, and this may increase the cost of the project.

The unit thickness and weight of large IGUs can also severely restrict the type of joinery that can be used, especially for sliding and pivot doors, double-hung windows and units with traditional timber joinery sections. In some sash windows, special stays and hardware are required to hold the windows open. Some large sliding doors are hard to slide and to stop once moving.

Also, the weight must be transferred from the frame to the building structure, so special brackets are often required to support the weight.