THERMAL SAFETY 2C
FRAMING SYSTEM INFLUENCE

The temperatures of the edges of the glass are directly influenced by the thermal properties of the framing system into which they are glazed. The design of the frame, and the materials from which it is constructed, will influence the level of heat transfer from the glass, to the framing system, the surrounding structure and the external environment. These factors will also influence the rate at which the frame can heat up with increases in ambient environmental temperatures.

The frame into which a unit is glazed will also shade the glass edges (as illustrated below) from incident solar radiation, and so prevent direct solar heating. Due to the shading, the only heating of the glass edge will come from the rebate temperature and conduction through the glass and contact with the frame.

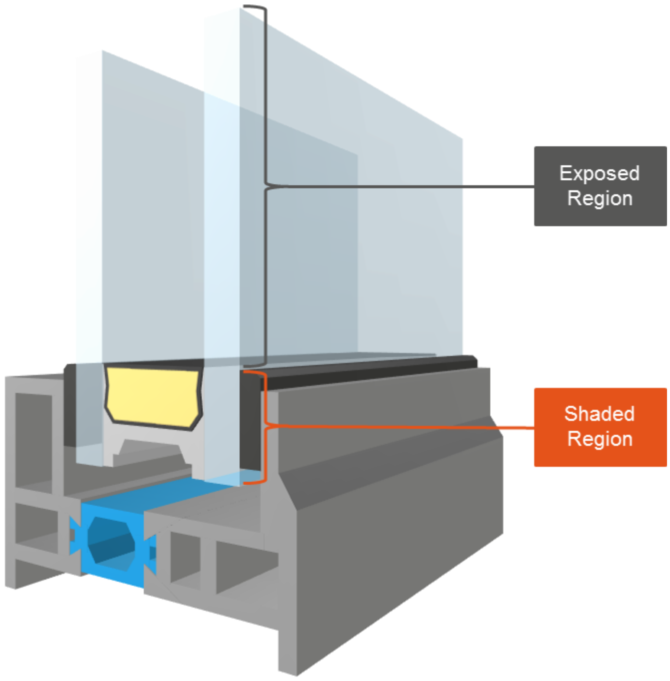

Figure 1 - Frame Areas

SOLAR HEATING OF THE FRAME

Heating of the frame will occur when it is exposed to sunlight and with changes in ambient temperatures.

Although when frames are under shading, from building elements or other external obstacles, there is no direct incident solar radiation, some diffuse solar energy will still reach the surface. This diffuse solar energy results from sunlight reflected from nearby objects and the ground. The colour of frame will influence the mount of thermal energy gained from this diffuse light, and as such, the temperature of the rebate. Lighter colours (white, silver) will reflect more solar energy than dark coloured frames (black, dark grey), which will absorb a higher portion, and so heat up to a greater degree.

HEATING AND COOLING WITH AMBIENT TEMPERATURE

The thermal mass of a frame, structure or building, relates to the amount of thermal energy that it can store, and in doing so, provide thermal resistance, or inertia, against variations in ambient temperature. Thermally diffusivity (α) should also be considered, and relates the thermal mass of a material to its thermal conductance, It is dependent on thermal conductivity (k), density (ρ) and heat capacity (c), related by the equation;

$$\alpha = \frac{k}{\rho c}$$

Effectively a material with a low thermal diffusivity will react less quickly with external temperature changes, compared to a material with a high thermal diffusivity. The below table shows some common building and frame materials for comparison;

Table 1 - Material Thermal Diffusivities

Material	Thermal Diffusivity (m^2/s)
Concrete	8.52E-07
Aluminium	8.44E-05
Steel	1.42E-05
Wood	9.88E-08
uPVC	1.73E-07
Glass	5.00E-07

This delayed reaction, known as building lag, or decrement delay, allows buildings to be designed to maintain a more consistent temperature against diurnal temperature ranges. For framing materials, the lag will directly influence the glazing edge temperatures.

To illustrate this, if consider a unit glazing directly into concrete (low diffusivity), against a unit glazed within an aluminium frame (high diffusivity), the rebate temperature for the concrete will lag significantly behind the ambient external temperature in comparison to the aluminium frame. This will mean that the edge of the glass, when within concrete will vary more greatly relative to the ambient temperature, and the temperature of the glass.

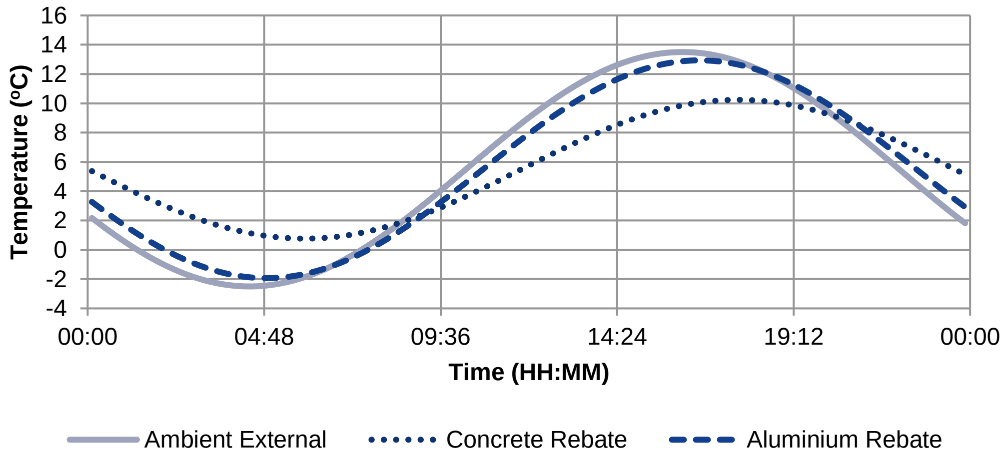

Figure 2 - Indicative Rebate Responses

THERMAL CONDUCTANCE THROUGH GLAZING SYSTEMS

When assessing the temperatures at the edge of the glass, the conductance of the framing system must also be considered with respect to heat being conducted directly away from the glass.

An efficient path for thermal conductance between a frame elements and support structures will result in an increased heat loss from the frame, and as a result, the glass edge. The below image shows simplified models of two systems; a standard aluminium frame and a thermally broken frame. With sunlight at 750 W/m^2 incident on the glazing but not the frame, an external temperature of 0ºC and an internal temperature of 21ºC, heat is conducted from the edges of the glass, and the warmer interior, and lost through the frame.

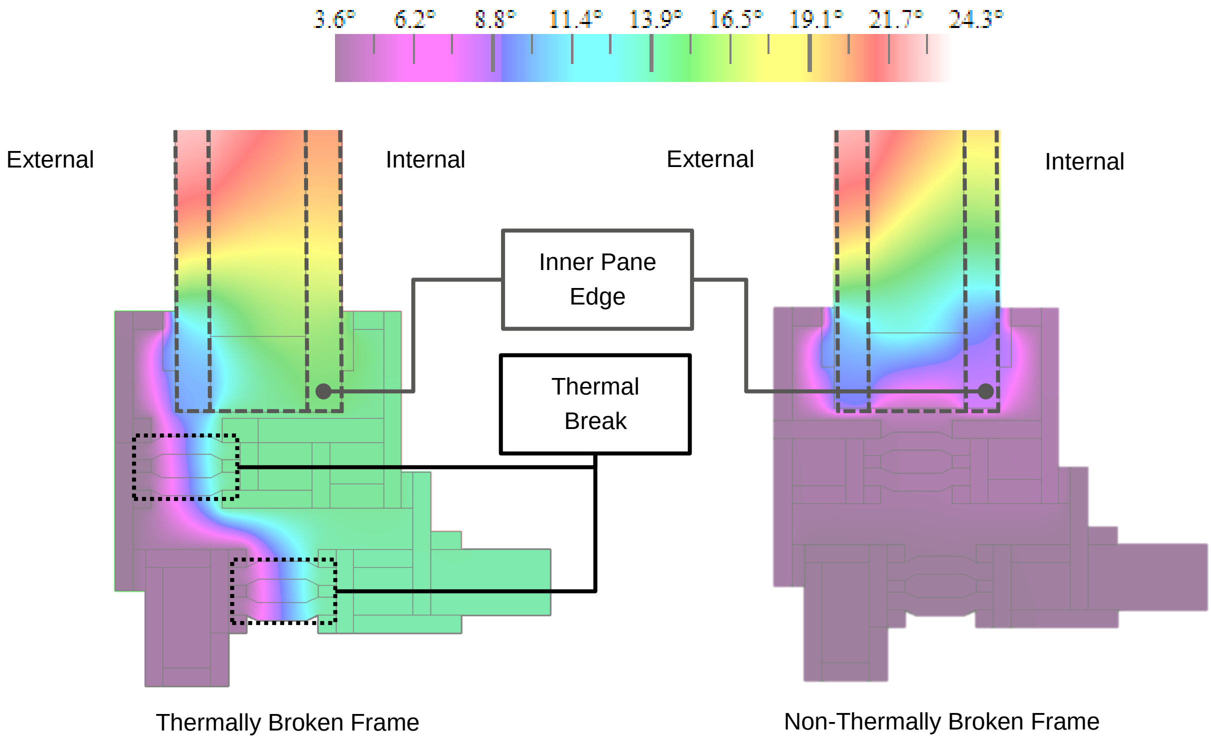

Figure 3 - Thermal Conductivity Through a Framing System

As can be seen from the steady-state temperatures, the thermally broken frame allows the inner pane of the IGU, and the outer pane, to a lesser extent, to remain warmer as a reduced amount of heat is conducted from the glazing and through the framing system to the outside.

INFLUENCE ON CALCULATED TEMPERATURE DIFFERENCES

Due to the multitude of available framing systems available, standard factors are used in place of thermal modelling when carrying out thermal safety calculations. The factors used consider the influence of the framing system on the temperature difference between the regions of the pane in sunlight and in the rebate. Two factors are used;

A frame factor (F_F) relating the influence of the frame on the basic temperature difference between the body of the glass in sunlight and the edge.

A frame coefficient (C_F), which modifies the temperature difference to consider heat transfer through the frame when the external temperature is cooler than the internal.

Table 2 - Frame Factors and Coefficients for Calculation

Frame Material	Colour	Frame Factor, K_F	Frame Coefficient, C_F
Concrete	Light	1.00	0.5
	Dark	0.95	0.5
Steel	Light	0.85	0.5
	Dark	0.80	0.5
Steel (Thermally Broken)	Light	0.70	0.2
	Dark	0.65	0.2
Aluminium	Light	0.75	0.5
	Dark	0.70	0.5
Aluminium (Thermally Broken)	Light	0.70	0.2
	Dark	0.65	0.2
Wood	Light	0.90	0
	Dark	0.80	0
uPVC	Light	0.75	0
	Dark	0.65	0
Structural Sealant Glazing Systems		0.50	0.5

Both a higher frame factor and coefficient indicate a worse case, and influence the calculated temperature differences (ΔT_c), as below;

Outer Pane: $$\Delta T_{c;1} = \left[\Delta T_{b;1} + T_{bl;1} + T_{bu;1}\right] \cdot \boxed{F_S} \cdot F_F$$

Inner Pane: $$\Delta T_{c;2} = \left[\Delta T_{c;1} + T_{bl;1} + T_{bu;1} + \boxed{C_F} \cdot (T_i - T_e)\right] \cdot \boxed{F_S} \cdot F_F$$