Overview

This technical bulletin addresses the phenomenon of distortion in architectural glass.

The Glass Industry continues to raise the level of insulation in windows to meet the customer demand for energy efficiencies through the use of glass coatings that reflect radiant energy back to it’s source.

At the same time new safety features in glass have been developed such as lamination and heat treatment to make glass less fragile to the point that it can stop bullets.

In the quest for higher performing construction material both in terms of low emissivity and high strength we have a cost to pay at this time. Distortion in reflected images has been increasingly noticeable by end customers in high performance reflective and heat strengthened glass. Distortion has always been present in glass, however as the industry continues to push the performance of the material, distortion becomes pronounced. This is particularly true when we begin combining the different elements of strength and reflection together into complex high performance insulated units.

What is Distortion?

We see reflected images in glass because light rays moving in wave fronts bounce off of the surface and return to the eye. When glass is flat, the reflected image is seen as normal with the light rays reflecting at equal but opposite angles.

When light wave fronts bounce off of curved glass, the angles are no longer equal and this causes the reflected image to be modified.

On a concave surface the reflected image appears to be short and thin while on a convex surface the images appears to be stretched.

Combining the two effects as seen in heat treated glass with roll wave distortion can create a reflection that can stretch and compress based on the observer’s movement in relation to the glass surface.

Distortion Examples
“Note the irregularly shaped flags and trees have less noticeable distortion to their reflective image than the linear lines of the building below.”
Contributing Factors

Reflected distortion is an inherent characteristic of glass and many variables contribute to the overall distortion of the image.

Heat Treatment

During the process of heat treatment the glass is heated to a point where it begins to move towards a liquid state. The surface undergoes physical changes which can include bends at the trailing edge of the glass (end kink), small (.008") rises and falls of the surface (roll wave), or even overall bowing of the glass. These shape changes of course contribute to creating convex and concave conditions on the glass surface that will distort reflected images. They are intrinsic of the heat treatment process and cannot be eliminated.

Reflective Coating

“If it is normal, how come I have never seen it before?”

When it comes to clear glass there is relatively low reflection and so while distortion has always been there it was not the first thing that a person would notice when looking at glass.

As the industry has looked to low emissivity coatings to increase insulation we have also added to the reflective properties of the glass. This movement to more reflection allows all these distortion variables that once would be an issue much more noticeable.

Industry Standards

As distortion is an inherent characteristic of glass there are currently no Industry Standards to address how much distortion is too much. Both standards concede that reflective distortion is a characteristic of heat-treated glass.

ASTM C 1048 - 04

7.4.1 “The original flatness of the glass is slightly modified by the heat treatment, causing reflected images to be distorted.”

7.4.2 “Fully tempered and heat-strengthened glass that has been made in a horizontal furnace may contain surface distortion (for example, picture framing, heat distortion or roller wave distortion.) Distortion will be detected when viewing images reflected from the glass surface.”

7.4.5 “Regardless of glass flatness, the degree of reflected distortion perceived is largely due to characteristics or symmetry of the object being reflected. Linear objects (such as building curtain wall and telephone poles) and moving objects (such as cars) may appear distorted. Irregular and free-form objects such as trees and clouds will appear to have little perceived distoration.”

7.4.6 “Specified bow and warp limits may not adequately define, or control, the distortion that may become apparent after glazing.”

CAN/CGSB-12.1-M90

8.2 “Tempered glass by the nature of the process, is not as flat as annealed glass particularly along the edges. The deviation from flatness depends on thickness, width, length and other factors. Usually greater thicknesses yield flatter products.”