

Visual Distortion Observed in Low-E Tempered Glass

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The Truth about Tempered Glass

Inherent in glass products is image distortion. Between temperature and barometric pressure changes and wind loads and elevation changes from where products are made and installed, image distortion will occur. Further compounding the image distortion issue is when glass is either tempered or heat-strengthened.

Image distortion is simply fact and one that glass companies fully acknowledge and construction professionals accept.

When Viwinco introduced its impact-resistant product line, OceanView, it featured both tempered and laminated glass. We manufactured both these glasses in-house to control such quality issues and minimize the image distortion as best as possible.

Our tempered glass does and always has met ASTM C1048-04 flatness specification for tempered glass. However in some applications, for example, where homes are built close together – image distortion becomes more noticeable. And though still in spec, it's unacceptable to our high standards.

Observations

A few homes in a coastal Delaware neighborhood that had OceanView windows installed were observed to have more noticeable image distortion, mostly because of the close proximity of the homes. Such distortion is more apparent when viewing horizontal or vertical lines (such as siding) as opposed to distant views of canals, docks, etc.

The area that was affected was the top 3-4" of glass in the upper and lower sashes. This indicated that the leading edge of the tempered glass was the area that was causing the visual distortion.

When we load our tempering oven, the certification label is always the last part of the glass to enter the oven making it the trailing edge and the opposite side of the leading edge. We always put the certification logo on the bottom when installing the IGU into the sash.

Quality & Process Improvements

Viwinco has been working on making improvements to the tempering process to minimize the amount of roller wave and edge curl (another possible side effect of the tempering process) in our tempered glass. To start with, we had to make sure our quality measures could correctly detect quality issues. Part of the quality control measures that we do are a visual inspection of all the glass as it exits the tempering process on the outfeed conveyor with a zebra board (black-and-white diagonal stripes).

It is easy to see where the distortion is located in the tempered glass because the diagonal lines will become distorted. You can see by the severity of distortion if the process is

changing. Because of the cycle time of the machine we cannot leave glass on the outfeed conveyor so we made an area to do offline inspections with a larger zebra board and reflecting wall. The zebra board can give us a visual indication of how the distortion looks on the tempered glass. We also need actual measurements to compare if what is changed in the process is making an improvement.

We run our glass in batches of up to 50 pieces and we measure the glass for flatness, testing the first, last and several pieces in between per batch. All these measurements are recorded and retained per SGCC requirements. We follow the ASTM C1048-04 flatness specification for tempered glass which requires localized warp for rectangular glass shall not exceed 1/16" (0.0625") over any 12" span.

We measure for flatness by using a 12" straight-edge diagonal to the edge and use feeler gauges to determine the thickness of any gap. We found this to be the most reliable method and it is the method suggested in the ASTM C1048-04 spec. Even though less than 1/16" over a 12" span is the industry standard for glass flatness, it is evident to us that the amount of distortion needs to be held to a minimum to reduce the amount of visual distortion.

Two resources Viwinco is using to help us make the best tempered glass possible are John Hidinger, an expert on the tempering process from PPG (our glass supplier), and George Tesnovich, the Glaston service engineer (Glaston makes the tempering ovens).

There are several things that they identified and fixed that have made improvements to the quality of tempered glass:

- We changed the type of abrasive belts used in the seaming processes to improve the quality of the seamed edge. When the edge is not seamed properly, the glass will break in the chiller, one way to overcome the glass breaking is to increase the temperature of the glass exiting the oven which causes roller wave in the glass.
- The manufacturer of the tempering oven installed the convection system incorrectly and had undersized air solenoids used to control the convection creating a 20psi drop in pressure at initial start of convection cycle. The convection system is primarily used for low-e glass to overcome uneven heating created from low-e coating reflecting heat away from one side of glass. If glass is not heated evenly on both sides when the glass is cooled, it will cup toward the cooler side. Viwinco fixed convection piping and installed the correct size air solenoid valves.
- The oven ceramic rollers were inspected and some of them were out of spec, TIR greater than (0.010"). We moved all the ones out of spec to the infeed side of the oven and are working on getting the ones that are out of spec replaced. We found some rollers with loose end caps and are getting them repaired. The ceramic rollers are what the glass rides on in the oven. If they are out of spec or have loose

end caps it will cause roll distortion in the glass and can also require longer cycles causing overheated glass.

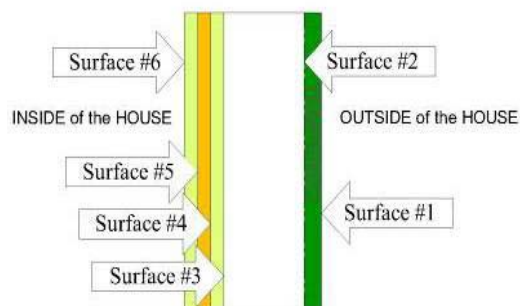
When we began working on the process back in July, the edge curl was on the leading and trailing edge and was measuring between 0.020-0.025" and sometimes had roller wave measuring 0.005". Today the roller wave has been eliminated, the edge curl on the trailing edge is eliminated and the edge curl on the leading edge is under 0.010".

The glass used in the windows in the first house we looked at was from this new process. The windows in the finished house had windows made prior to the changes. These windows had distortion on the top and bottom of each sash. After seeing the distortion in the glass with 0.010" edge curl, it still had a noticeable visible distortion.

Options

We came away from the visit with four options to try to improve the visible distortion:

- Make the tempered glass with a heavier tempered lite. By using a thicker glass (4mm or 5mm) instead of the 3.2mm glass that we currently use, we could minimize the edge curl. We made a sash with the 5mm tempered low-e glass and sent it down with Michael to install and review. Even though the edge curl was minimized the distortion was still slightly visible. We are going to continue to refine the recipe for the 5mm glass. We ordered 4mm glass to test and should be making samples the week of 1/23/12. There is a picture showing the 5mm glass further down (Picture #4).
- Moving the low-e coating from surface 2 to surface 3 in the IGU. The visual distortion is an effect of having the low-e coating which is highly reflective on a tempered glass that is not flat. The light being reflected and refracted at different angles and speed on an uneven surface is what causes the distortion. We evaluated the possibility of moving the low-e coating from the number 2 surface (the inside surface of the exterior lite) to surface 3 (the inside surface of the inside lite). (Example below.) Even though this would eliminate the issue it would have a negative effect on the NFRC and Energy Star thermal numbers. Because of tighter thermal requirements, this is not an option.



- Use annealed low-e glass for the external glass on DH, SH, Casements, Awnings and Sliders. This option would eliminate the effect of visual distortion. In order to do this we would have to retest all products listed above with annealed glass in the outboard lite.
- The final option is to purchase our low-e tempered glass for OceanView products from an outside source. We bought low-e tempered glass from two different suppliers with the hopes of putting them in an IGU and taking them down to one of the houses we looked at doing a comparison. When the glass came in from both vendors it was far worse than ours was back in July. (Pictures #2 and #3).



1. Viwinco Current 3mm Low-E Tempered Glass



2. Vendor #1: 3mm Low-E Tempered Glass 3. Vendor #2: 3mm Low-E Tempered Glass



4. Viwinco 5mm Low-E Tempered Glass 5. Viwinco 5mm Annealed Glass

Conclusion

After reviewing the options above, it was decided that we are going to retest the OceanView DH, Casements, Awnings and Sliders with annealed glass in the exterior lite.

We have already tested and certified our SH window this way at DP65 (both structural and impact) and, effective immediately, will be producing our OceanView SH windows with annealed glass.

If testing goes as expected, we will be offering all DP50 OceanView DH, Casements, Awnings and Sliders with annealed glass starting later this spring.

DP50 OceanView Pictures, Geometrics and Patio Doors will not be affected. This is because our Picture and Geometrics don't have the same issues with image distortion due to our placement of low-e within the IG unit. (The low-e cannot move surfaces in our other products due to Energy Star guidelines.) As for Patio Doors, the areas of image distortion aren't in the sightlines making it a non-issue plus tempered glass in a patio door is required by national building codes.

To ensure due diligence, Viwinco will continue to work on making 4mm and 5mm tempered and heat-strengthened glass to see if we can get it to an acceptable visual standard. We will also still offer OceanView products (DH, SH, Casements, Awnings and Sliders) with tempered glass when specified on orders as long as both our distributors and end-users agree that image distortion within ASTM guidelines will not be treated as a defect and will be non-returnable. Viwinco will develop a disclaimer regarding image distortion for customers to share with their clients.