What Contributes to Visible Distortion?

- Environment
- Glass thickness
- Glass size
- Aspect ratio
- Glass reflectivity
- Heat treatment
- Laminated glass
- Insulating glass
Glass Distortion Examples

- Heat treatment (thicker glass appears flatter)
- IGU expansion/contraction (Ideal Gas Law of Physics)
- Thin glass more flexible (5mm vs 10mm)
- Laminated glass /amplify
- Overheated glass & uneven heating & cooling (hammered appearance, high roller wave distortion, excessive bow and warp, edge kink and picture framing)
Viracon heat-treating specifications are more stringent than industry standards

• **ASTM C 1048 Heat Treated Flat Glass**
  - Heat Treated Flat Glass to be by horizontal (roller hearth) process with inherent rollerwave distortion parallel to the bottom edge of the glass as installed.
  - Maximum bow and warp 1/32” per lineal foot (0.79mm).

• **Viracon Specification**
  - Maximum peak to valley rollerwave 0.08mm in the central area and 0.20mm within 267mm of the leading and trailing edge.
Roller Wave Measurement Methods

- **Mechanical Measurement Method**
  3-point trolley or flat bottom gauge (Regional Fabricator)

- **Optical Measurement Method**
  Online System (Viracon)
Mechanical Measurement Method

- **Roller wave – ASTM C1651**
  Standard measurement method for 3-point trolley or flat bottom gauge

- Usually one measurement down the center of the glass

- One unit per hour
**Optical Measurement Method**

- Viracon System
- Measures *every lite* of glass
- Measures *more area* of each lite
- It sees what *the eye* sees
Viracon Optical Measurement System

- Measures optical distortion in heat treated glass
  - Non-contact
  - On line

- Converts mD (Millidiopter) readings to peak to valley roller wave

- Larger the mD reading the greater peak to valley
Optical Distortion

- Your eye does not see peak to valley, your eye sees change in curvature
- Millidiopter is the universal measure of local curvature of a surface
- Flat Glass
  - Parallel Light Rays Never Converge
- Concave Lens in Reflection
  - Converge and Magnify
- Convex Lens in Reflection
  - Diverge and De-magnify
- Heat Treated Glass Distortion
  - Converging and Diverging (Peaks & Valleys)
How does it work? Diffuser plate (project images) + Glass surface (reflect image) + Camera (record image) + Software = mD (measures change)

- projected image
  - 1" circle
- reflected image
  - top and bottom surface
- amount of change
  - (mD)
3-D View - Good Glass

Key Points

- 3-D image very flat
- PV plot consistent wave, wavelength
3-D View – Overheated Glass

Key Points

Max mD over 125mD

3-D image very wavy, even though its peak-to-valley rollerwave of 0.05mm is way within spec!
Optical Measurement

- Used for measurement and diagnostic capability

- Unlike mechanical measurement, it is able to detect roller wave distortion and also “hammered” appearance, edge kink, picture framing and pillowing
Viracon New Specification

- Viracon has commissioned all optical measurement equipment on all furnaces and has finalized our production specification of:
  - 95% of the glass surface area must be between $-125 \text{ mD (Valley)}$ to $+125 \text{ mD (Peak)}$

- Optical measurement equipment can measure:
  - Glass thicknesses $\geq 5 \text{ mm (3/16")}$
  - Most glass colors

- Optical measurement equipment is not capable of measuring:
  - Silk-screened glass
  - Full coverage frit
  - Dark tints
Viracon vs. Post-Temperable Model

Viracon Coating
Supplied by Viracon

Post-Temperable Coating
Supplied by a Regional Fabricator

Denver Convention Center
Two buildings across the street from each other

Viracon Coating  
Supplied by Viracon

Post-Temperable Coating  
Supplied by a Regional Fabricator

Flat

Distorted
Want Flatter Glass?

- Specify pre-tempered (Viracon) vs. post-temperable (Regional Fabricator) coatings

- Incorporate roller wave distortion tolerances into specifications
  - 95% of the glass surface area must be between – 125 mD (Valley) to +125 mD (Peak)

- Specify thicker glass on the outboard lite
  - 8mm or 10mm glass instead of 6mm
Color Variation

• **Regional Fabricator**
  o Heat-treats the *coated* glass supplied by float glass manufacturer. Overheating the *coated* glass will cause color variation in the coating.

• **Viracon**
  o Heat-treats the *raw* glass first and thereafter coats with our own coating. As such the coating is always in pristine condition.
  o Automated online inspection on every layer of coating to ensure final color uniformity and consistency.
Post-Temperable Coating
Supplied by Regional Fabricator

Iridescent appearance
Post-Temperable Coating
Supplied by Regional Fabricator

Color Variation
Viracon vs. Post-Temperable Model

Viracon Coating
Supplied by Viracon

Post-Temperable Coating
Supplied by a Regional Fabricator

Two identical buildings

Color Uniformity

Color Variation
Value-Added Services & Technical Expertise

• With over 40 years in the glass industry, Viracon stands behind its products and offers expert services
  o Specification consultation review
  o Glass design review
  o Shop drawing reviews
  o Product selection consultation
  o Un-paralleled project execution experience
  o Glass strength analysis
  o Energy cost savings calculations
Glazing Reviews Example

Unsupported Outer Lite

Viracon concerns:

- Larger sightline.
- Secondary seal is placed under long term shear.
- Butyl bead would shear if exterior pane is sagged by 1mm, causing early seal failure.

Structural joints have a movement capability of 10 – 15%.
Exposed Edges

Viracon concerns:

- *Silicone Deterioration* - acid rain, atmospheric pollutants & incompatible materials.
- *Silicone Adhesion* – affected by moisture exposure.
- *Setting Blocks* - durability
Viracon’s Capacity to Deliver

Capable ~4.5 million square meter per Year

- Cutting Machines = 12
- Heat Treating Furnaces = 11
- Insulating Lines = 14
- Laminating Press = 10
- Silk-screen Tables = 7
- Coaters = 5
- Edging Equipment = 5
- Hole-drilling Press = 3
- Heat Soak Ovens = 3
- Digital Printer = 1

Complete and On-Time Deliveries
Commitment to Quality

• Audit Processes
• Inspection Processes
• VPS / MDI Boards
• Dedicated Quality Team
• Lean & Six Sigma Methodology
• Continuous Improvement Resources
• State-of-the-art Inspection Equipment
  o On-line digital roller wave measurements
  o Sophisticated final line inspection process
  o Automated on-line detection

• <1% Quality Escapes
Additional Resources

- Website – www.viracon.com
- Product Guide
- Social Media –  
- Sample Program + Recycle Program
- Contact Us: Mr. K V Krishnan
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