High Performance Glazing
Technologies, Applications & Resulting Performance

Presented by Mike Florence, DUXTON Windows & Doors
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Presentation Overview

- Window vs. Overall Wall Performance
- Performance Specifications
  - Insulating low conductivity frames
  - Insulating glass coatings and spacers
  - Operable window types
  - Durability
  - Installation details
- Selective Glazing by Orientation
- Occupant Considerations
- Emerging Technologies
Food for Thought
Responsibility towards our environment

RESPONSIBILITY
No single drop of water thinks it is responsible for the flood.
~ Author Unknown
How do Windows Contribute to Overall Building Performance?

- Windows in the U.S. consume 30% building heating and cooling energy
- Focus on the building envelope 1\textsuperscript{st} – heating & cooling 2\textsuperscript{nd}
- Windows can be “net energy gainers”
  Windows with high solar heat gain coefficients (SHGC) can admit more useful solar gain than the conductive energy lost

\textit{SOURCE:} Dariush Arasteh, Steve Selkowitz, Josh Apte Lawrence Berkeley National Laboratory (Zero Energy Windows), Marc LaFrance U.S. Department of Energy
"One of the reasons this house has such a simple mechanical system is because it is getting over 50 per cent of its energy just from the sun coming through those south-facing windows," says Amerongen. "So once you reduce your total heating load it's small enough we can get all of the energy we need from those solar panels."
# Impact of Window R-Value on Overall Wall R-Value

<table>
<thead>
<tr>
<th>Window 15% of Wall Area</th>
<th>Wall R-Value with Windows w/Varied Wall Insulation Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-Value</td>
<td>R-0</td>
</tr>
<tr>
<td>0.30</td>
<td>R-5</td>
</tr>
<tr>
<td>0.20</td>
<td>R-5</td>
</tr>
<tr>
<td>0.15</td>
<td>R-5</td>
</tr>
<tr>
<td>0.10</td>
<td>R-5.5</td>
</tr>
</tbody>
</table>

**Sources:**

“Holes in the Wall: To Improve the Energy Performance of Walls, Look at the Total R-Value,” Journal of Light Construction, February 2014;
Multi-Assembly R-Value / U-Value Calculator – Cascadia Windows and Doors;
Michael Blasnik Presentation, 2014 ACI Conference
The more glazing, the bigger the impact of window performance.
Keeping Heat In (or Out)

**U. Value (U-Factor)**
The measure of a window’s rate of non-solar heat loss or gain (Btu/hr.-sq.ft.-°F in imperial).
- Consider overall u-value

**R. Value:**
The measure of a window’s resistance to heat flow.
- The inverse of U-value, or \( R = \frac{1}{U} \).

Windows lose and gain heat by:
- Conduction
- Convection
- Radiation
- Air Leakage
Conduction

**Definition:** Movement of heat through a solid material – like touching a hot skillet

*Aim for a less conductive frame material*

**Conductivity Comparison**

- **Material:** Soft Wood, PVC, Fiberglass, Float Glass, Steel, Aluminum
- **U-Values:**
  - FIBERGLASS FRAME AND STOP
  - ALUMINUM FRAME AND STOP

Both simulated with a Tripane 2 Low-E Silver Coatings (2&5), Argon, Warm Edge Spac
Conduction

**Definition:** Movement of heat through a solid material – like touching a hot skillet

*Aim for a less conductive spacer*

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| Double Glazed Aluminum Spacer | Double Glazed SuperSpacer™ (Silicone Foam) | Triple Glazed Aluminum Spacer | Triple Glazed SuperSpacer™ (Silicone Foam) |
---|---|---|---|

**The difference between spacers is less meaningful in triples.**

- Typical warm edge triple is at least 8°F warmer than dual equivalents
- Lowest performing spacers in a triple will be equal or better than the best performing double pane.
Convection

Definition: Heated indoor air contacts the interior window surface, the air cools, drops, warm air takes its place, and creates a loop recognized like a draft.

Ø Use a gas fill to reduce the convection within the Insulating Glass (IG) unit.
Ø Same process between layers of glass and in frame cavities

<table>
<thead>
<tr>
<th>Insulating Glass Unit</th>
<th>U-Factor (Btu/hr/ft²/°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Air</td>
</tr>
<tr>
<td>2-Pane Clear</td>
<td>0.48</td>
</tr>
<tr>
<td>2-Pane with 1-Low E272</td>
<td>0.30</td>
</tr>
<tr>
<td>3-Pane Clear</td>
<td>0.31</td>
</tr>
<tr>
<td>3-Pane with 1-Low E272</td>
<td>0.22</td>
</tr>
</tbody>
</table>
Radiation

Definition: Movement of heat – like standing near a woodstove

Ø Consider the most appropriate type of low emissivity (Low E) coating to reduce radiation.

• Types of Soft Coat Low E’s:
  Ø 1 coat of Silver – High solar gain, High visible light
  Ø 2 coats of Silver – Mid-to-low solar gain, Low U-value
  Ø 3 coats of Silver – Low solar gain, Low U-value, Low visible light

Spectrally Selective LoE Coatings
% Transmission per Wavelength

U-Values
Selective Glazing by Orientation
Customizing Low E Coatings by Elevation

Typical Objectives in North America

North:
*Minimize U-value (Maximize R-value) for reduced heat loss.*

South:
*Take advantage of optimal solar heat gain and visible light.*

East:
*Aim for a mid-range product.*

West:
*Control solar heat gain.*
**Air Leakage**

**Definition:** Infiltration of outside air into the building

- Reduced by compression (over sliding) seals and durable multi weatherstripping.

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**Best**

- Fixed
- Casement
- Awning
- Horizontal Slider

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**Worst**

- Single/Double Hung
Performance Advancements on Doors

- Insulated Door Slabs
- Automotive Weatherstripping
- Thermally Broken Adjustable Sills
- Multi-Point Locks
Real-World Application:
Window Upgrade Allows for Smaller HVAC System
Condensation Resistance

Definition: The measure of a window’s **resistance to condensation** on the inside surface.
- Condensation Resistance Factor (CRF) is the AAMA rating, ranging 30 to 80 – measured data
- Condensation Resistance (CR) is the NFRC rating, ranging 1 to 100 – simulated data

- Not directly correlated to U-values which is an area-weighted calculation – more related to thermal bridging
  - Coldest part of most modern windows is the bottom 1/2“ of glazing

- Condensation Variables
  - Buildings with high humidity
  - Thermal bridging in the wall construction
  - Installations near the outside of the wall plane reducing interior air flow
  - Blinds / Draperies reducing interior air flow
  - House plants
  - Hobbies
**Condensation Resistance**

- **Impact of Reducing the Relative Humidity**
  - Increased discomfort
  - Drying of skin – chapping and irritation
  - Increased static electricity

- **Factors to Improve Condensation Resistance**
  - Triple pane glazing
  - Warm edge spacers
  - Low E coatings and Argon gas fill
  - Insulated frames
  - Placement of the window in the wall assembly

*Figure 1a. Window type performance at various humidities and outdoor temperatures. Source: THERM5.2/Windows5.2 NFRC Simulation Manual, Fenestration Heat Transfer Basics, Condensation Resistance*
Solar Heat Gain Coefficient (SHGC)

Definition: The fraction of the solar radiation admitted through a window.

Ø Look for passive solar gain opportunities on south elevations and use large glazing
Real-World Application:
Slim Frames for Maximum Gain and Viewing Area
Real-World Application:
Passive Solar Gain Glazing with Exterior Shading

Design for a few large windows vs. many small windows to give more light and reduce cost.
Real-World Application:
Passive Solar Gain with Patio Access
# Real-World Application:
Selective Glazing by Orientation

<table>
<thead>
<tr>
<th>Glass type</th>
<th>LoE Surface #</th>
<th>Spacer</th>
<th>Gas</th>
<th>R-Value (cog)</th>
<th>Overall U-Value</th>
<th>S.H.G.C.</th>
<th>Visible Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardinal LoE-180</td>
<td>1 and 5</td>
<td>Argon</td>
<td>7.69</td>
<td>0.16</td>
<td>0.56</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>Tripane 2 Coatings</td>
<td>2 and 5</td>
<td>Warm Edge Stainless Steel</td>
<td>Argon</td>
<td>7.69</td>
<td>0.15</td>
<td>0.35</td>
<td>58%</td>
</tr>
<tr>
<td>Cardinal LoE²-272</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Warm Edge Stainless Steel</td>
<td>Argon</td>
<td>7.69</td>
<td>0.15</td>
<td>0.35</td>
<td>58%</td>
</tr>
<tr>
<td>Cardinal LoE³-366</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tripane 2 Coatings</td>
<td>2 and 5</td>
<td>Warm Edge Stainless Steel</td>
<td>Argon</td>
<td>8.33</td>
<td>0.15</td>
<td>0.24</td>
<td>47%</td>
</tr>
</tbody>
</table>
Visible Light Transmittance (VLT)

**Definition:**
The measurable amount of solar **visible light** (daylight) that travels through a glazing system.

*Note the changes in Visible Light with changes in Solar Heat Gain*
Real-World Application:
Selecting the Right Glass for the Setting
Durability by Frame Type

**COEFFICIENT OF THERMAL EXPANSION FOR COMMON BUILDING MATERIALS**

<table>
<thead>
<tr>
<th>Material</th>
<th>Coefficient of Thermal Expansion (x 10^-6 per degrees Celcius)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood (1st generation)</td>
<td>0.0 (Wood expands with changes in humidity)</td>
</tr>
<tr>
<td>Aluminium (2nd generation)</td>
<td>23.0</td>
</tr>
<tr>
<td>Vinyl (3rd generation)</td>
<td>62</td>
</tr>
<tr>
<td>Fiberglass (4th generation)</td>
<td>7.4</td>
</tr>
<tr>
<td>Glass</td>
<td>8.7</td>
</tr>
</tbody>
</table>
Real-World Applications:
Window Selections for Longevity and Reduced Maintenance
Characteristics by Frame Type

Aluminum
• Strong, low maintenance, high conductivity, requiring thermal breaks

Wood
• Good thermal performance, expand/contract in response to weather conditions, require regular maintenance

Composite
• Composite wood products / metal clad vinyl / metal clad fiberglass
• Stable, with better resistance to moisture

Vinyl
• Low maintenance, good thermal performance, less dimensionally stable / shorter life span

Fiberglass
• Low maintenance, dimensionally stable, with superior thermal performance to aluminum
Impact of Installation Placement Within the Wall System
Real-World Applications:
Careful Consideration of the Building Envelope as a Whole
Net Zero Projects
The Alberta Sustainable House, Calgary, AB

The total purchased energy requirements per year averages 6% of an ordinary house (0.75 wh/DD/m3).
Net Zero Projects
Riverdale by Habitat Studio, Edmonton, AB

Built back in 2007 the Riverdale net-zero home was a 5,000 square foot duplex. It also had a complex space heating system that depended on an over-built solar thermal set-up with a lot of extra engineering bells and whistles.
“A tough blend of large glazing areas, tight venting windows and innovative triple pane glazing configurations.”
Window Walls with Non-Conductive Frames
Punched Openings with Casements
Triple Low E Glazing
Occupant Considerations
Quality of Living Spaces

Views – Comfort all Year-Round

Privacy
Occupant Considerations
Quality of Living Spaces

Natural Lighting
Occupant Considerations
Quality of Living Spaces

Natural Ventilation

(Dis) Comfort
Emerging Technology
R-20 Centre-of-Glass Sealed Units

LiteZone™ L0679 film layered IGU
1. Exterior glass lite
2. Interior glass lite
3. PET films
4. Proprietary film suspension system
5. Proprietary fiberglass spacer
6. Proprietary pressure equalization conduit with desiccant
7. Back seal
8. Stainless steel foil water vapour barrier
9. VHB tape
10. Front seal
Emerging Technology
Dynamic Glazing
Emerging Technology
Fiberglass Curtain Wall
Summarized: Window Shopping Tips

Low Overall U-Value
• Consider low conductivity insulated frames, triple pane glass & warm-edge spacers

Good Air Tightness
• Triple weatherstripping / Compression seal

Slim Frames
• Typically the glass has a better u-value over the frame

Solar Gain Opportunities
• South elevations

A Few Large Windows vs. Many Small Windows
• Use less energy, give more light, and reduce cost

Durability
• A “cheap” investment today can result in expensive operating & replacement costs in the future.

SOURCES: Peter Amerongen, Net-Zero Energy Home Expert, Habitat Studio, Edmonton, AB.