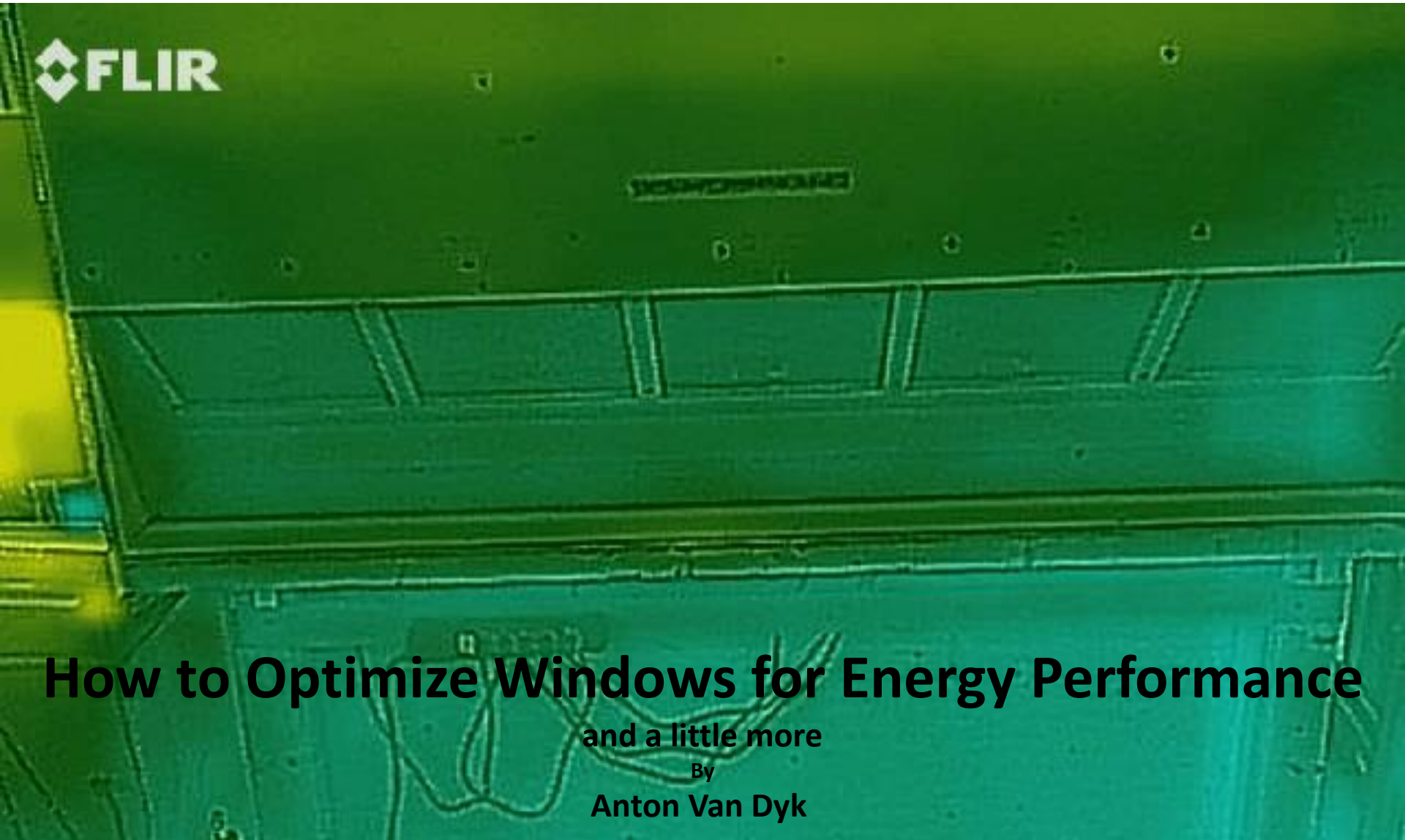
Centra® WINDOWS EXTERIORS RESTORATIONS
TRUST EXPERIENCE



How to Optimize Windows for Energy Performance

and a little more

By

Anton Van Dyk

Understanding Window Thermal Performance Units of Measure

- U_{metric} , $U_{imperial}$ & R Value
- The relationship between U_{metric} and $U_{imperial}$ is a simple division by 5.678. Similar function as centimeters to inches.
- The U value is the inverse of the R value – 1/U or 1/R

How to Convert U_{metric} value to R value example:

- U_{metric} must first be converted to $U_{imperial}$ then divided 1 by the $U_{imperial}$ value
- Example 1.4 U_{metric} / 5.678 = 0.25 $U_{imperial}$ then 1/0.25 = 4 or R4

Or, just Google it.

U Value / R Value Reference Ranges

- The BC Building Code uses U values and starts at U1.8
- The simplified relationship between U and R is as follows:
  - R2.9 is 2.0 BC Energy Efficiency Act
  - R3 is 1.8 BC Building Code minimum
  - R4 is 1.4 Vancouver SF/DP minimum – MF, Permit after March 2018
  - R5 is 1.1
  - R6 is 0.95
  - R7 is 0.81
  - R8 is 0.71 Somewhere around a Passive House Window

- As the R value gets bigger the U value gets smaller

U Value / R Value Reference Ranges

- The BC Building Code uses U val
- The simplified relationship betw ollows:
  - R2.9 is 2.0 BC Energy Efficie
  - R3 is 1.8 code minimum
  - R4 is 1.4 Vancouver single family minimum
  - R5 is 1.1
  - R6 is 0.95
  - R7 is 0.81
  - R8 is 0.71 Somewhere arou Window

Glass

Frame

Most double glazed PVC product sits in this range

Most triple glazed product sits in this range

Getting to R8 takes significant frame design - PH

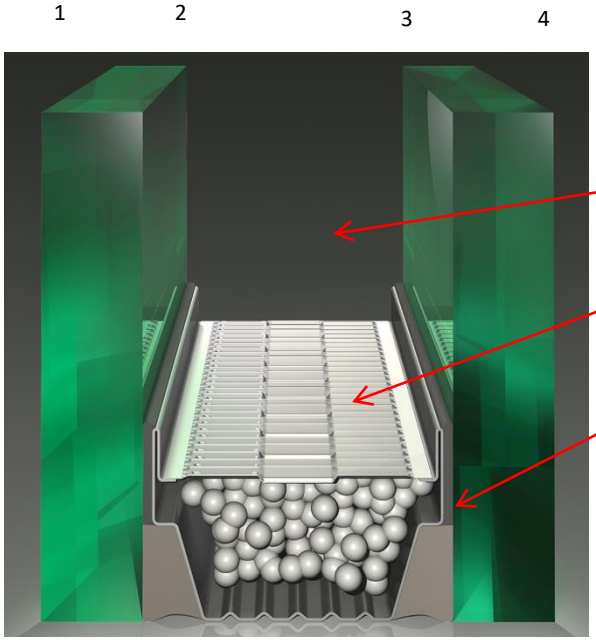
Very Important Note:

- A window's U value should always be listed as the whole window U value and not just the Center of Glass U value.
- Whole window U values are the sum of the following individual values
  - Center of glass U value
  - Edge of glass U value
  - Frame U value

- Don't be mislead by Center of Glass (COG) values only.

Insulated Glass and LoE Coatings

CARDINAL IG
A CARDINAL GLASS INDUSTRIES COMPANY



What is Gas Fill? Argon

What is a “Warm Edge” Spacer Bar

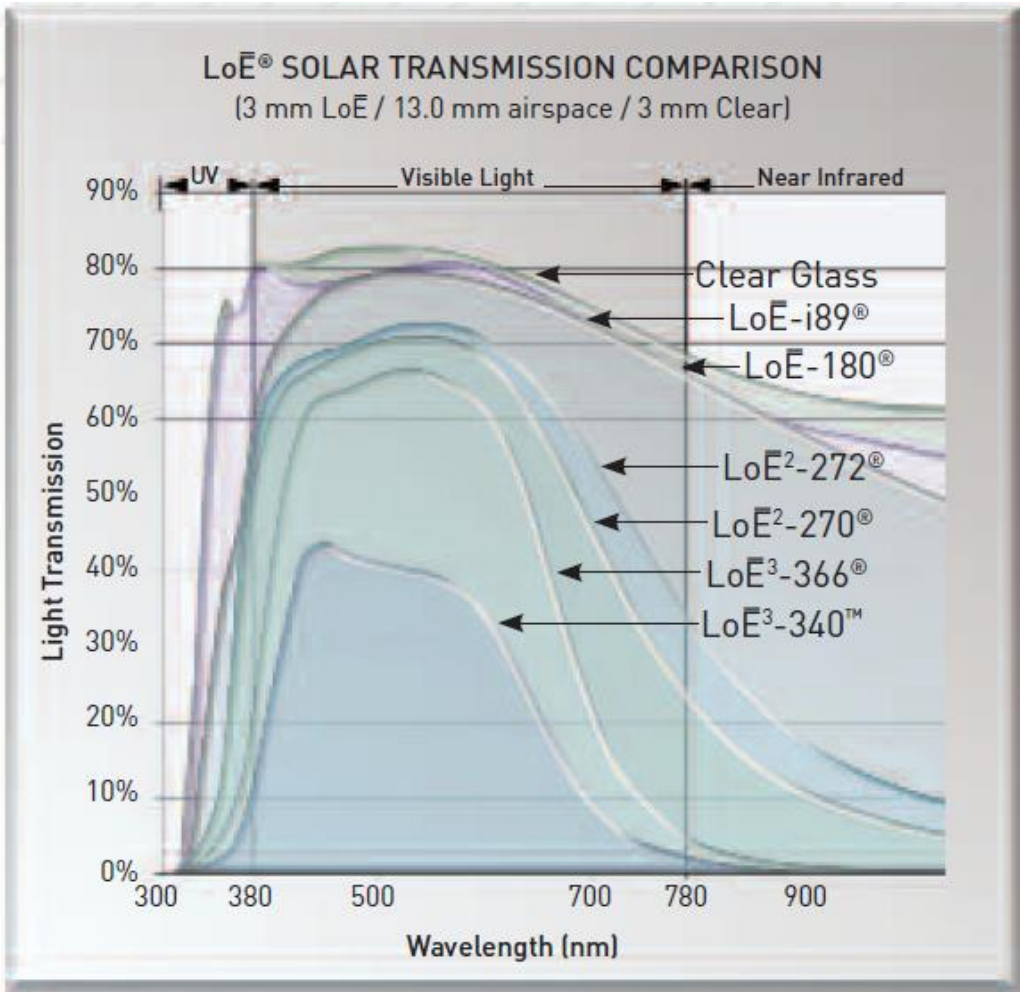
PIB and Silicone

LoE coatings used:

- Soft Coats
  - Silver Based Coating – Less Haze
- Hard Coat
  - Indium Tin Oxide – Durable to Exposure

Purple flame indicates Low E coating is on surface #2

How many LoE coatings are there out there?



How LoE Works - Simplified

Clear Glass

LoE^{1} Glass (180)

LoE^{2} Glass (270)

LoE^{3} Glass (366)

Base Level of Code Compliance (U1.8 to U1.6)

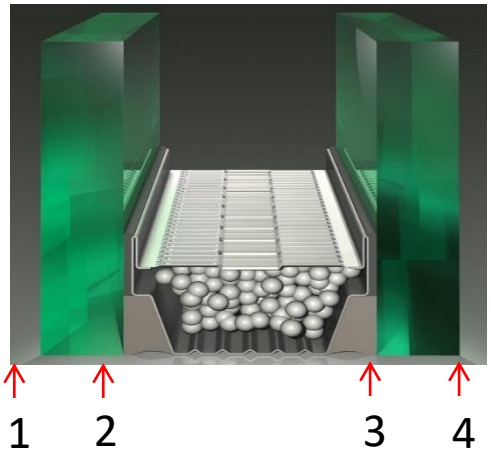
- DG sliding window
  - LoE² on #2 & CL

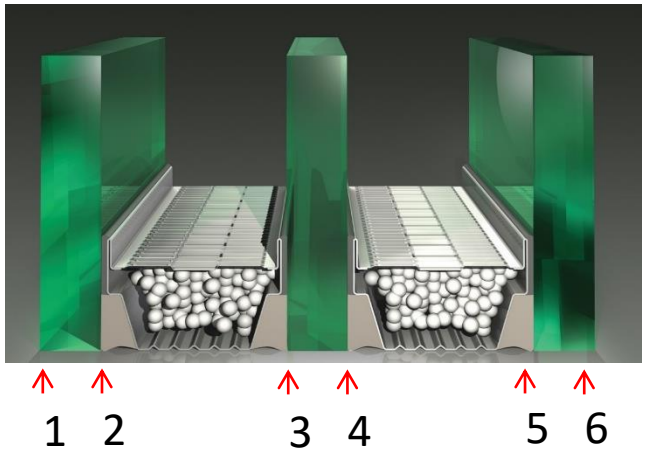
Upgrade #1 (U1.4)

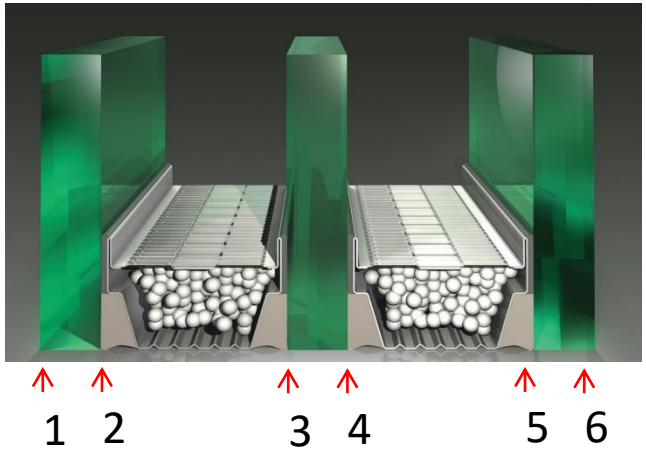
- Option 1 – DG sliding window
  - LoE² on #2 & LoE hard coat #4
- Option 2 – DG casement/awning window
  - LoE² on #2 & CL

Upgrade #2 (U1.2)

- Option 1 – DG casement/awning window
  - LoE² on #2 & LoE hard coat #4 (U1.23)
- Option 2 – TG casement/awning
  - LoE² on #2 & CL & CL (U1.19)





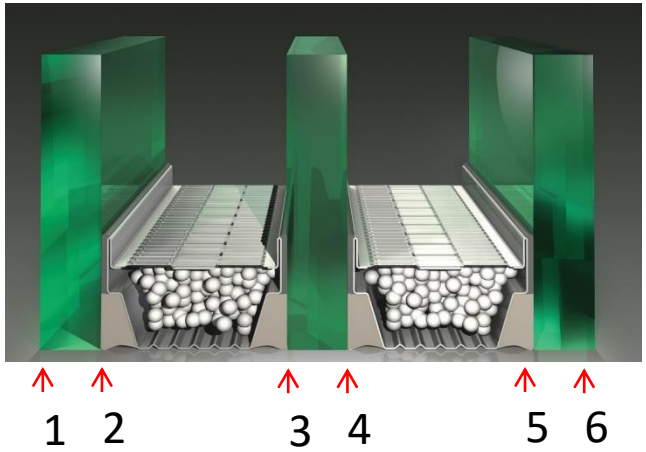


Upgrade #3 (U1.0)

- Option 1 – TG casement/awning
  - LoE^{2} on #2 & CL & LoE^{1} on #5

Upgrade #4 (U0.9 to 0.8)

- Option 1 – TG casement/awning
  - LoE^{2} on #2 & LoE^{1} on #4 & LoE hard coat #6



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- Option 1 – TG casement/awning
  - LoE^{2} on #2 & CL & LoE^{1} on #5

Upgrade #4 (U0.9 to 0.8)

- Option 1 – TG casement/awning
  - LoE^{2} on #2 & LoE^{1} on #4 & LoE hard coat #6

.1 All windows and slider doors to have a maximum U-Value of 1.0 W/M2-K. Alternative prices will require lower U-values. U-value labels shall bear the mark of a recognized certification agency.

.1 Glazing to be Low E with soft coat Low 'E' Coating on #2 surface.

.13 All windows with awning style shall have cam handles that provide opening and locking to operable vents.

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What to look out for when transitioning from double to triple glazed:

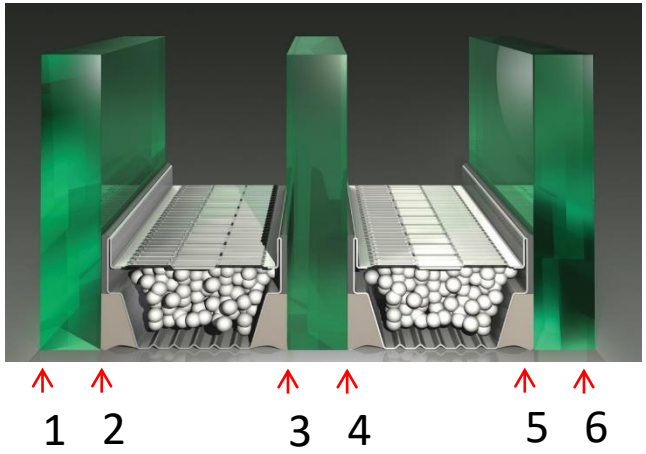
- A poor triple glazed window is similar to a good double glazed window
- Casement sash sizes are limited due to added weight
- Overall added weight of the windows and the willingness for installers
- Product Cost
  - Sliding 2 pane, 1 LoE to a Sliding 2 pane, 2 LoE – 25% increase
  - Sliding 2 pane, 1 LoE to a Casement 3 Pane, 3 LoE – 110% increase
  - Casement 2 pane, 1 LoE to a Casement 3 Pane, 3 LoE – 60% increase
  - Cost increase significantly when you have to change a double pane configuration to a triple pane configuration.


Tin Bath

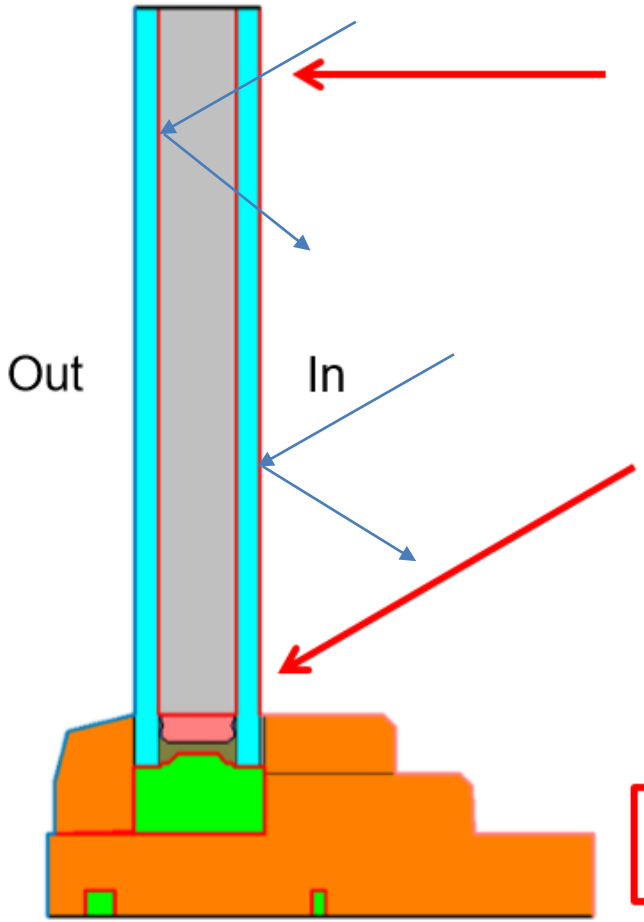
Embodied energy is the **energy** consumed by all of the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery

What is the added embodied energy in a glazing unit with triple glazing?

- 50% more raw material
- 100% more stainless steel
- 50% more natural gas consumption during the float process
- 50% more weight to ship
- Added structural reinforcing in the frame
- Added frame mullions
- Site install – Crane services
- 100% to 150% more site labour



Is there a condensation risk with Surface 4 LoE?



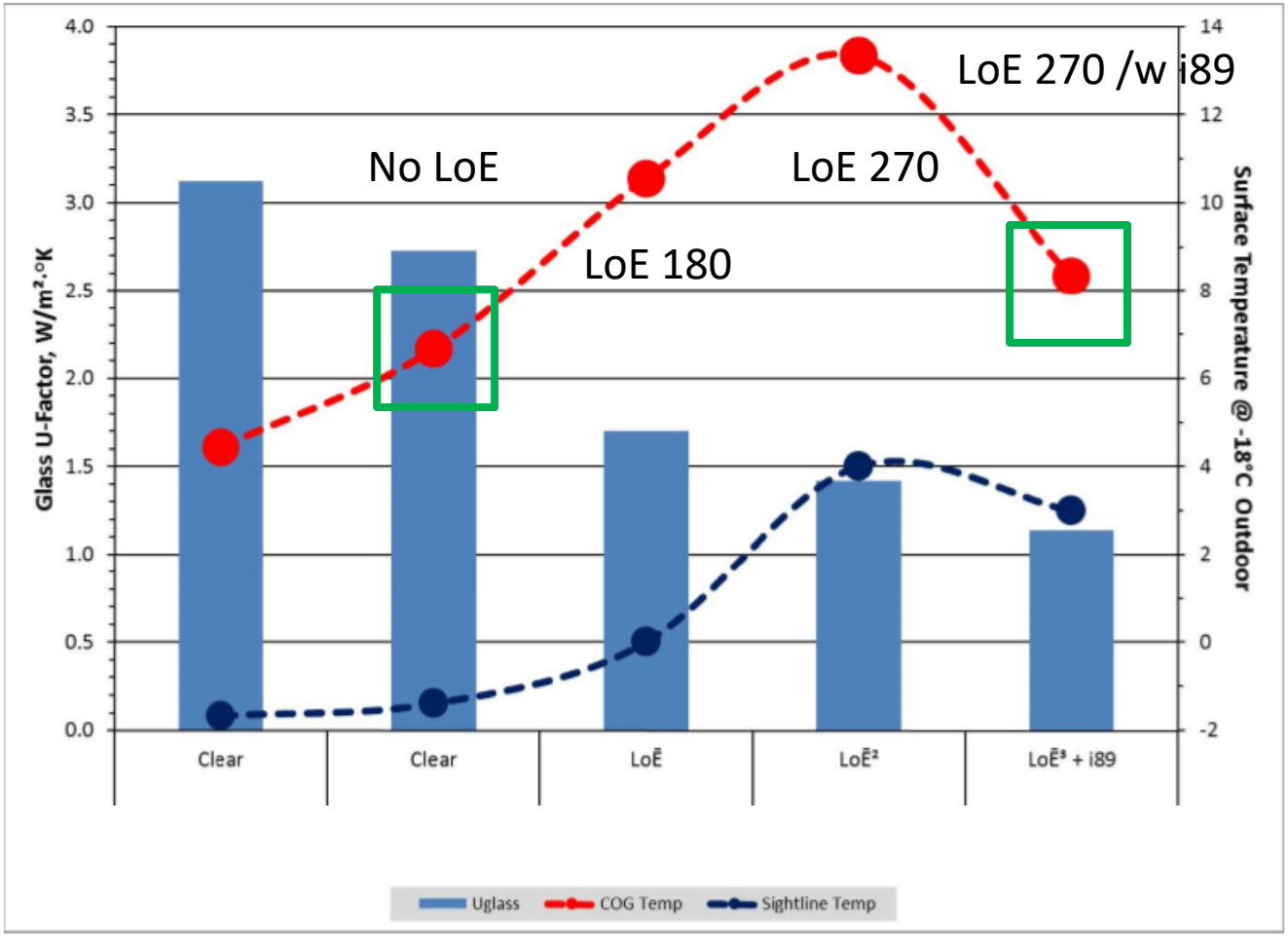
Center of Glass temperature is a function of layer(s)

Sightline temperature is a function of:

1. Edge Seal System
2. Framing/Installation
3. Center of Glass Temp

Both vary with outdoor temp

Is there a condensation risk with Surface 4 LoE?



i89 Durability Test Results

Passed 1 hour soak tests:

i. Sodium Hydroxide (NaOH)
ii. Acid Rain
iii. Vinegar
iv. Windex
v. Ammonia
vi. Bleach
vii. Mineral Spirits
viii. Muriatic Acid 10:1
ix. Muriatic Acid 20:1

Passed wipe tests:

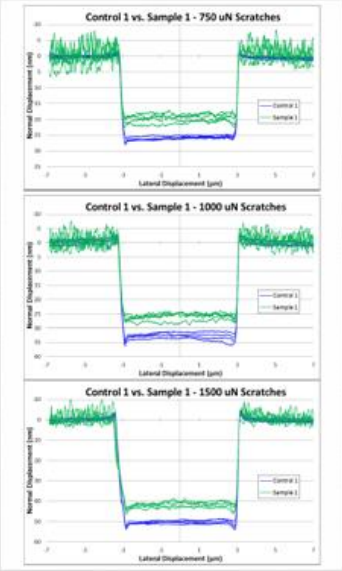
i. Acetone
ii. Isopropyl Alcohol
iii. Cutting Oil

- Standard cleaning solutions can be used following manufacturer's instructions
- Passed humidity testing:
  - 100% relative humidity (504 hours)
  - 90% relative humidity (504 hours)
  - Salt Fog (240 hours)
- Passed Thermo-cycle Tests (168 hours)
  - High Temperature (200°F)
  - Low Temperature (-40°F)
- Passed UV Testing
  - QUV-A (2520 hours)
  - QUV-B (2520 hours)

Note: Fail is if any performance or color number changes by > 1 point

Independent Lab: Scratch Test Results

- TI TribloIndenter™ nanomechanical test instrument was used by an independent lab to compare the scratch resistance of i89 to uncoated glass



- Scratch Depth Results:
  - 750 µN: i89 = 19.5 ± 1.2 and Uncoated = 25.8 ± 0.4
  - 1000 µN: i89 = 25.9 ± 1.1 and Uncoated = 32.7 ± 0.9
  - 750 µN: i89 = 41.6 ± 1.1 and Uncoated = 50.5 ± 0.7

- Report summary: i89 posses a greater scratch resistance relative to uncoated glass

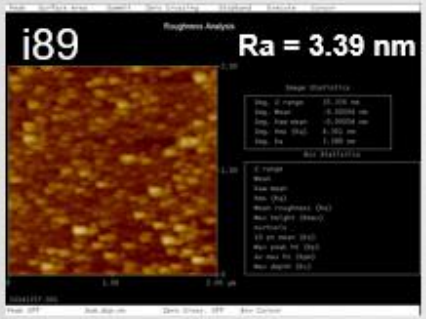
Note: Sharp objects such as razor blades or a squeegee with a metal blade holder should not be used.

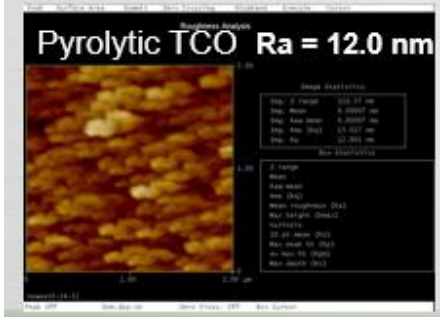
Fig. 1: Results i89 (Green) and uncoated (Blue)

Roughness/Haze Comparison: i89 vs Pyrolytic

Results: i89 is smoother and has 5 times less haze than the Pyrolytic TCO (transparent conductive oxide)

Atomic Force Microscope Images





Sample	AFM Ra(nm)	Haze
Uncoated	0.25	0.08
i89	3.39	0.08
Pyrolytic TCO	12.0	0.4

What is Solar Heat Gain (SHG)

The SHGC is the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward. SHGC is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat it transmits.

Energy Star – U values and Solar Heat Gain

A. Windows

Table A1: Energy Rating Qualifying Criteria for Windows

Zone	Minimum Energy Rating Unitless	Maximum Air Leakage L/s/m²
1	25	1.5
2	29	1.5
3	34	1.5

Table A2: Alternate U-factor Qualifying Criteria for Windows

Zone	Maximum U-factor W/m²·K (Btu/h·ft.²·°F)	Minimum Energy Rating Unitless	Maximum Air Leakage L/s/m²
1	1.60 (0.28)	16	1.5
2	1.40 (0.25)	20	1.5
3	1.20 (0.21)	24	1.5

Incorporating this into Energy Star

Energy Rating (ER): a unitless value derived from a formula that balances heat loss (U-factor), air leakage loss and potential passive solar gain of a fenestration product. The ER is applied to fenestration systems intended to be installed in a vertical orientation in low-rise residential buildings. The simplified ER equation is as follows:

$$ER = (57.76 \times SHGC_w) - (21.90 \times U_w) - (1.97 \times L_{75}) + 40$$

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W1 LoE[1]	(0.48)	(1.76)	= ER 27
W2 LoE[3]	(0.22)	(1.6)	= ER 17

Incorporating this into Energy Star

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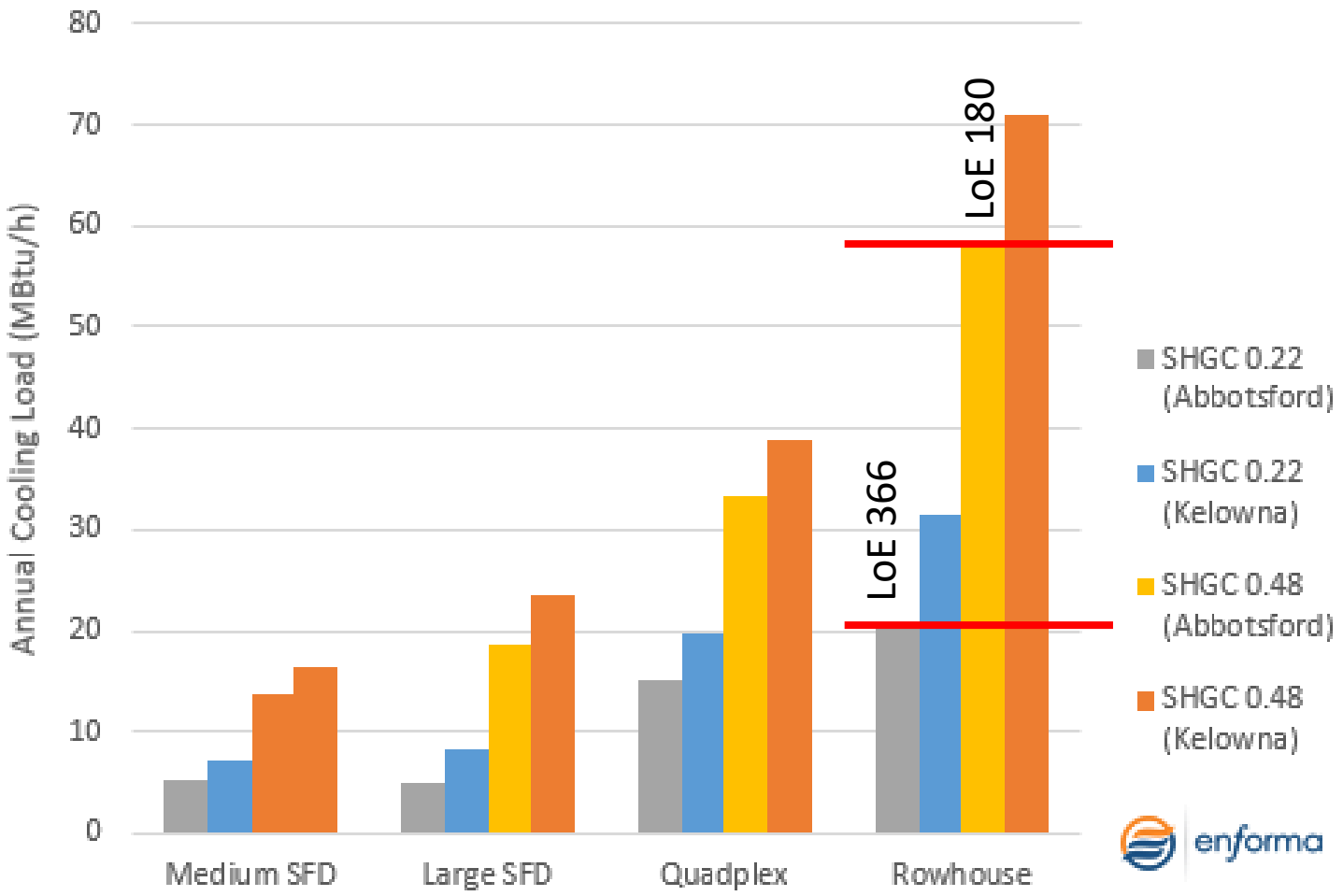
FLIR
No LoE
LoE 180
LoE 270
LoE 366
LoE 366
w/ i89

Annual Cooling and Window SHGC - Kelowna



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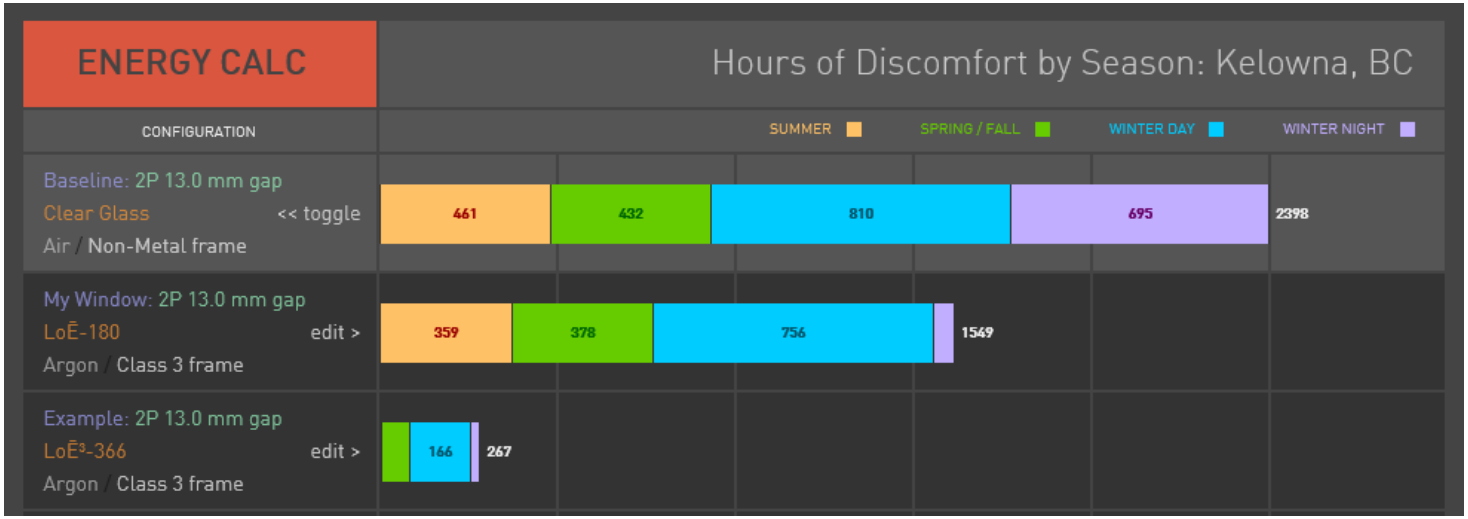

No LoE — 2400 Hrs

LoE 180 — 1550 Hrs

LoE 366 — 270 Hrs

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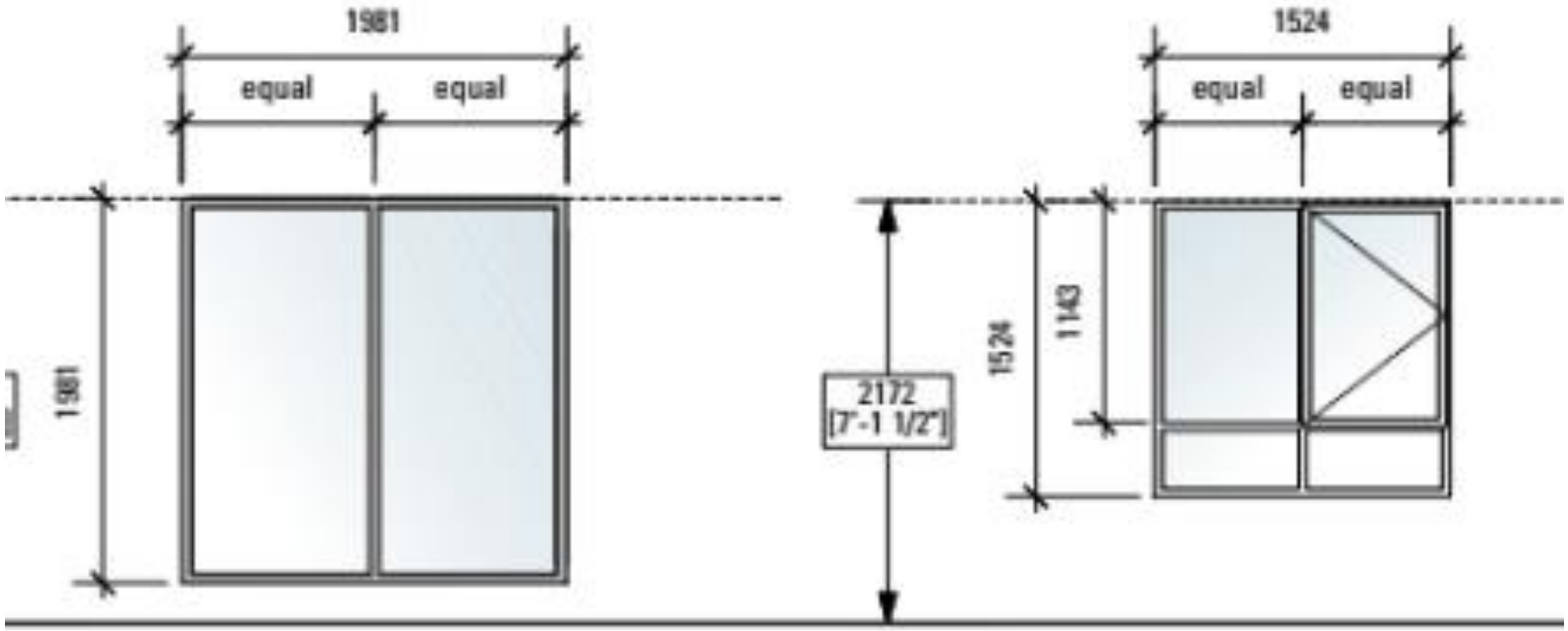
5. Glass shall conform to CAN 2-12M double pane fixed glass.
6. All north facing windows shall have LOW'E' coating on surface #3
7. All other windows shall have LOW'E' coating on surface #2
8. All sealed units shall be filled with Argon gas.
9. Windows to be EnergyStar rated / U. value of 0.28 (1.6) or less / SHGC 0.2 - to meet Step 3 of Energy Step Code for Zone 4
10. "T" on
11. Provi
12. Wind
NAFS
Air In



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$$ER = (57.76 \times SHGC_w) - (21.90 \times U_w) - (1.97 \times L_{75}) + 40$$

(0.2) (1.6) = ER 13

Incorporating this into Energy Star

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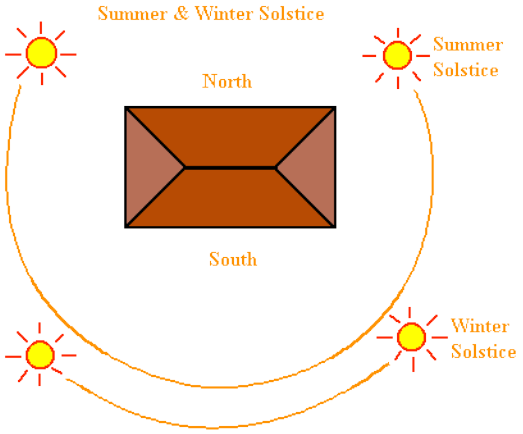
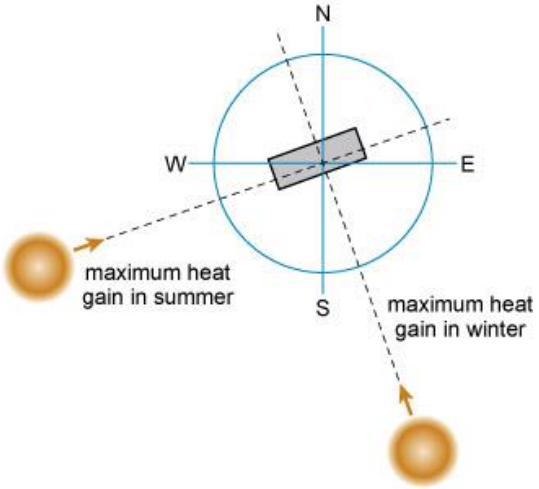
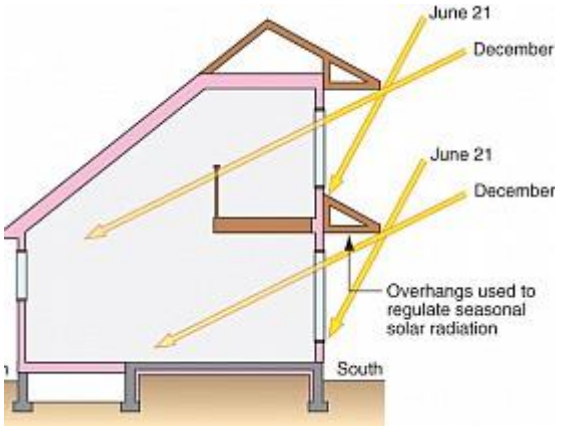
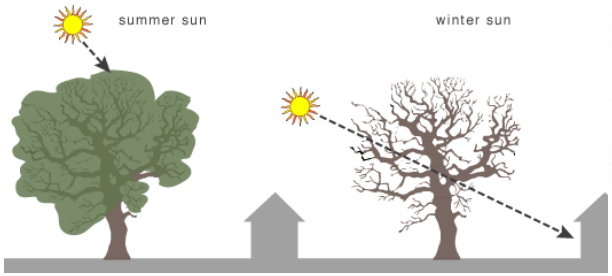
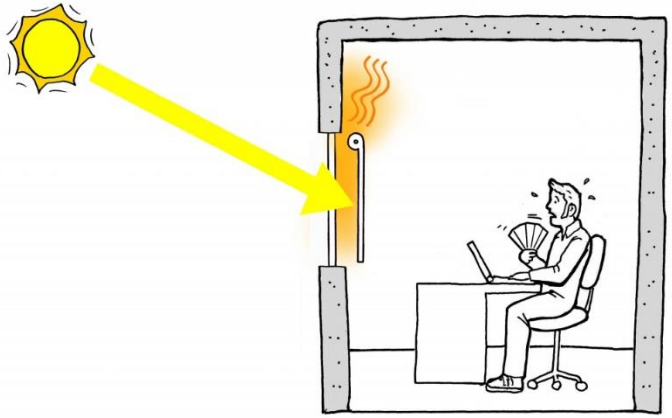
Solar Gain is a Design Component

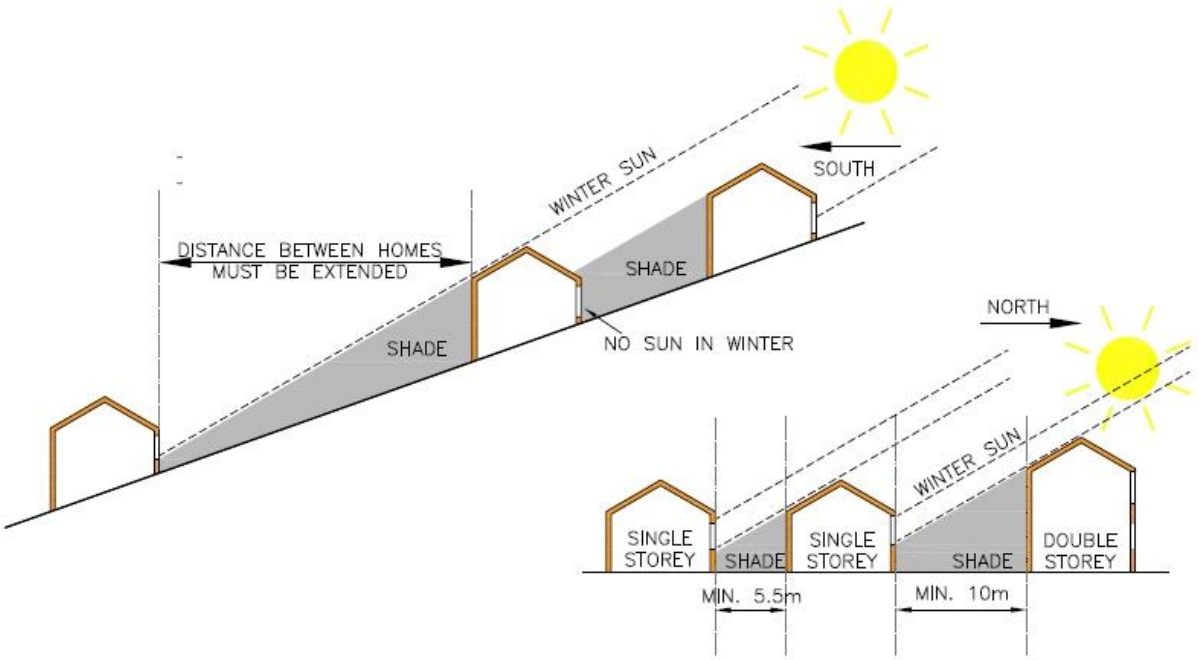


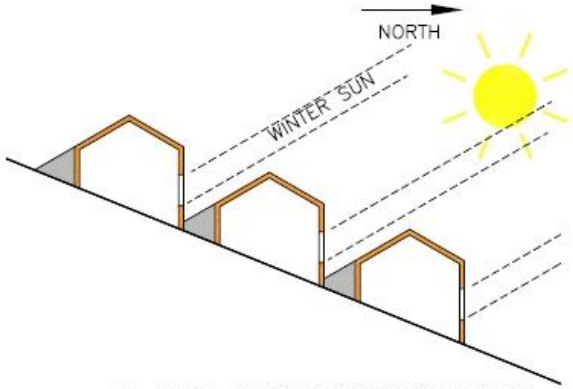












ON NORTH FACING SLOPES THE DISTANCE BETWEEN HOMES CAN BE LESS.

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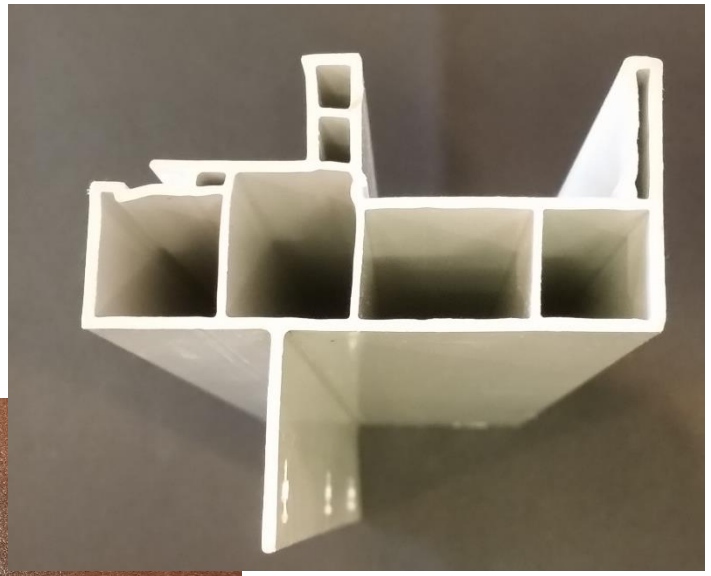
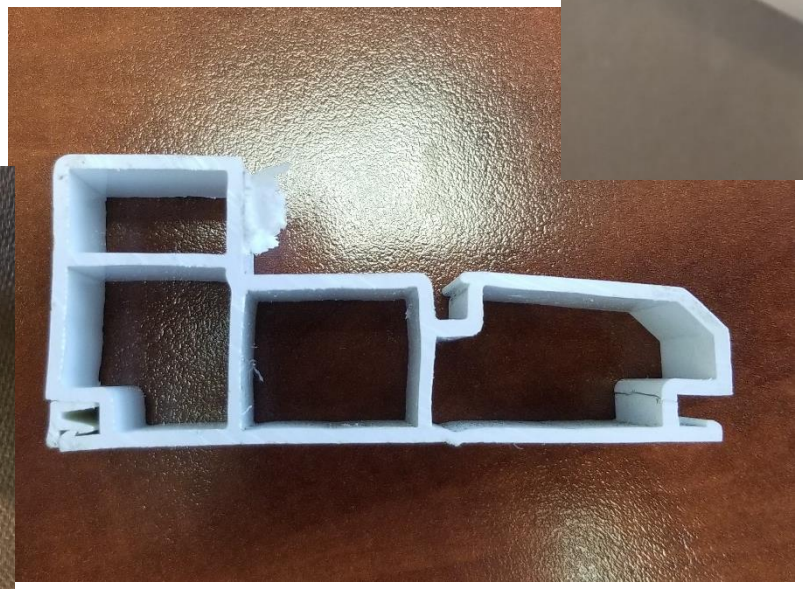
Window Frame Design

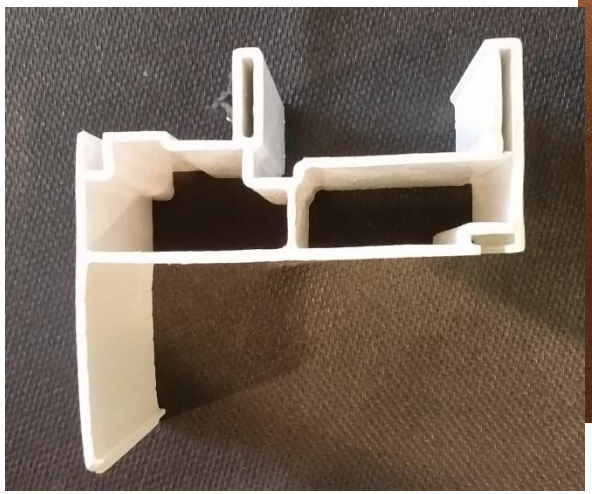
- Number of chambers
- Alignment of chambers
- Insulation fill –Passive House Concept
- Height of profile
  - Balance between energy and water



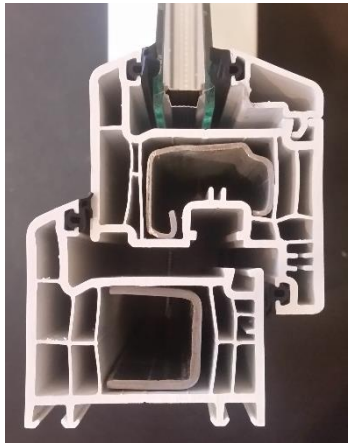
4 Chamber



3 Chamber



2 Chamber



Other Structural Design Considerations

- The only time safety glass (tempered / laminated) is mentioned in the BCBC for **windows** is when a window can be mistaken for a door.

- So when do we use tempered / Laminated glass?
  - Near a shower stall or bathtub – Part 9
  - Base of stairs or stair landing – Part 4
  - Adjacent to an exterior door – Recommended in Appendix
  - Window seats – Recommended

  - When a window acts as a guard rail – Part 4

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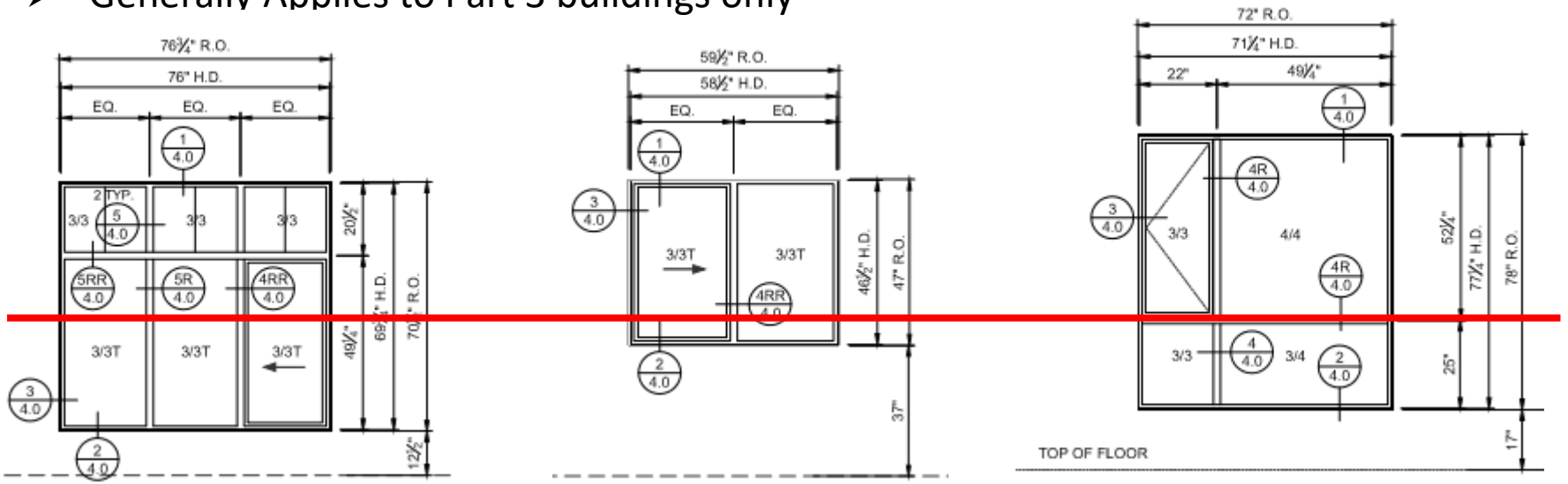
When a window acts as a guard rail

- 2’ or greater separation between floor and grade
- Generally Applies to Part 3 buildings only



.2 Windows shall be designed to conform to current edition of following standards, as applicable:

.1 AAMA/WDMA/CSA 101/I.S.2/A440, “North American Fenestration Standard/Specification for Windows, Doors, and Skylights (NAFS-08)”
.2 CSA-A440S1-09, “Canadian Supplement to NAFS-08”
.3 Glass Association of North America (GANA), "GANA Glazing Manual”
.4 CAN/CGSB-12.8-M, "Insulating Glass Units”
.5 CAN/CGSB 41-GP-19Ma, Rigid Vinyl Extrusions for Windows and Doors
.6 CAN/CGSB 41-GP-20M, Extrusions, Vinyl, non-rigid for Windows and Doors
.7 CAN/CGSB 79.1-M, Insect Screens
.8 BC Building Code
.9 IGMA “Glazing Recommendations for Sealed Insulating Glass Units”
.10 ASTM standard D4726 “Rigid Vinyl Components”

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The End

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