Good Windows

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Windows

- Need to control
  - heat loss,
  - air leaks,
  - solar radiation
  - rain, etc

Objectives

- Learn
  - appreciate impact of performance on bldg
  - differentiate between window features
  - understand variables in selection
  - to avoid big mistakes

Windows

- Functions: Same as wall - *plus*
  - transparent and allow ventilation
  - not easy, hence expensive and compromise
- Structure - transfer loads
- Rain control
- Heat control
- Airflow control
- Solar gain control

Why Good Windows?

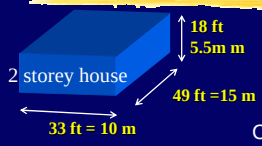
- Major impact on
  - energy performance, e.g. HVAC equip
  - condensation resistance
  - comfort (warm, no drafts
  - view and light
  - rain penetration resistance
  - sound control (airtight)

Controlling Heat Flow

- Windows usually have the lowest thermal performance of all parts of the enclosure
- Must control heat for
  - Comfort
  - Energy
  - Health
  - Durability

} *Prevent Condensation*

Heat Fow: Important

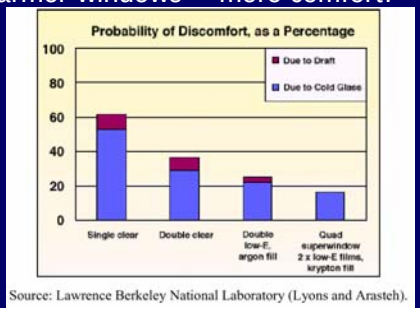


Conduction Losses only
Window area 18% floor area

2950 sf wall area of which:		
80% (2360) opaque @ R20	**= 132**	**28%**
20% (590) window @ R2	**= 295**	**63%**
1600 sf roof area @R40	**= 40**	**9%**
	= 467	**100**
Air Leakage at 0.35 ACH	**=164**	

Comfort

- Warmer windows = more comfort!



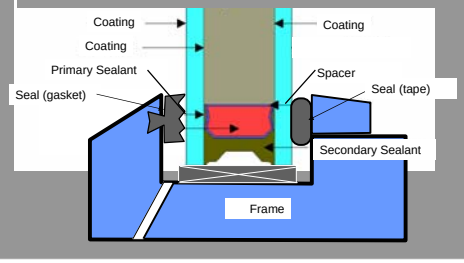
Source: Lawrence Berkeley National Laboratory (Lyons and Arasteh).

Window Performance Metrics

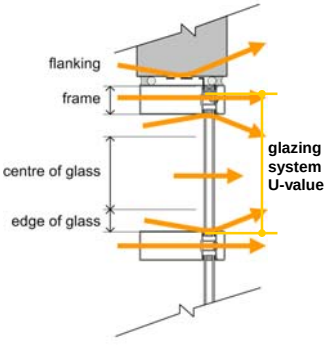
- Heat flow (R,U)
- Solar Heat Gain Coefficient (SHGC)
- Visual Transmittance (VT)
- Air leakage
- Condensation resistance
- Water penetration

Parts of a Window

1. Frames
2. Glazing (IGU)
3. Gaskets and hardware

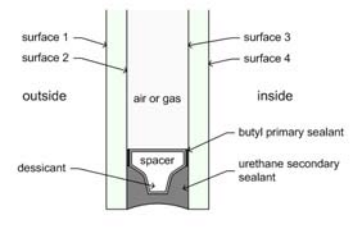


Total Heat Flow



Anatomy of an IGU

- IGU = Insulated Glazing Unit
  =Coating+ Glazing + Spacer + Seal + Fill
- Must be sealed to control condensation
- Desiccant absorbs moisture for 25+ years



Gas Fills

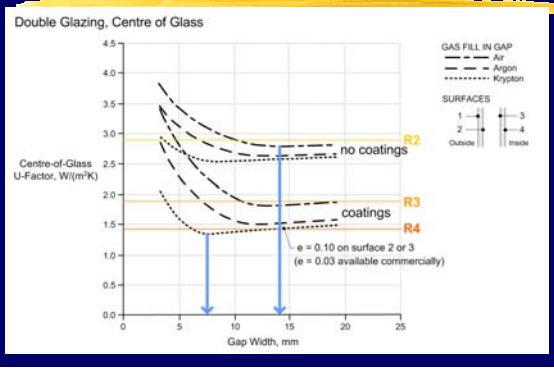
- Gas fills reduce the amount of heat transferred by conduction and convection through the space in the glazing unit
- No impact on solar gain

Fill	Conductivity (W/mK)	Reduction in Conductive Transfer
Air	0.0241	-
Argon	0.0162	33%
Krypton	0.0086	64%
Xenon	0.0051	79%

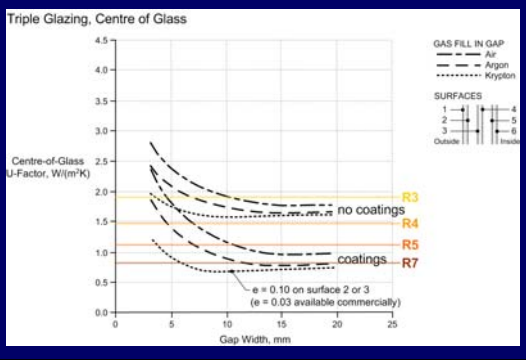
Low-E, Gas Fills, Gap Size

- Double and Triple Glazing can have very good R-values and control solar gain
- Major factors for glazing
  - Radiation control coatings (low E)
  - Gas fills
  - Size of Gap

Double IGU

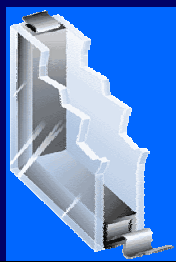


Triple IGU



Warm-edge / super spacers

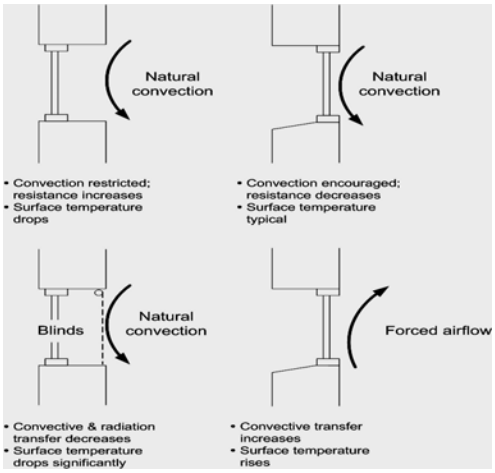
- Heat flow through spacers is important
- Critical for condensation control
- Super spaces
  - Plastic/foam edges seals
  - stainless steel, very thin
  - Dramatically reduce cool glazing edges



Left to right: vinylm butyl-rubber and silicone-foam insulating edge spacers.

Condensation

- Requires cold surface AND high indoor relative humidity
- Solutions
  - energy efficient glazing
  - reduced thermal bridging (frame/spacers)
  - reduce RH via ventilation/source control
- Priorities
  - control interior RH (cheap repair or retrofit)
  - Thermal break (alu) or insulated frames
  - Warm edge spacers, then Low-E argon



Frame Materials

A wide selection

Frames

- Different modes of operation
  - fixed, awning, casement
- Different materials
  - aluminum
  - wood
  - vinyl
  - fibreglass
  - wood-plastic composites

Wood

- Insulates well
- Pretty Strong and Stiff
- Aesthetic

- Rots
- Requires maintenance
- Combustible??

Aluminum /Metal

- Durable
- Stiff
- Strong

- Very Conductive (1600 times wood)
- Must have a thermal break
- bigger break is better

Wood Clad w/Alu or Vinyl

- Insulates well
- Pretty Strong and Stiff
- Requires little maintenance
- Interior Aesthetic

- Still Rots
- Combustible ??

Vinyl

- Inexpensive
- Insulates well (design influences this)
- Low maintenance
- Can have added insulation

- Expands, contracts, warps
- Corners leak
- Flexible - may need stiffeners

Fibreglass

- Strong and Stiff
- Durable
- Excellent insulation

- Expensive (?)

Composites

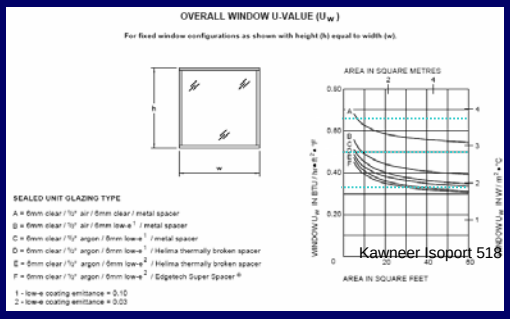
- Wood and plastic resin
- Strong and stiff
- Insulates like wood
- Less maintenance
- No rot

- New

Functions

Performance Metrics

Frames = Heat Loss



Kawneer Isoport 518

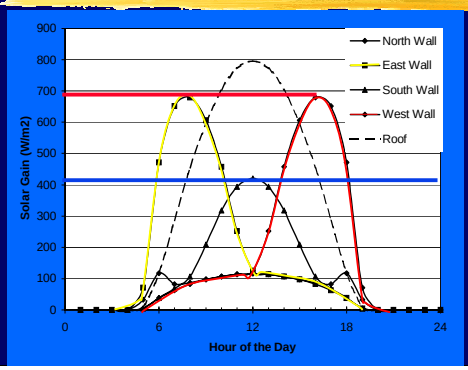
Solar Heat Gain Coefficient

- SHGC = Solar Heat Gain Coefficient
  = Fraction of solar radiation that passes
- Typical clear, dbl-glazed window SGHC = 0.72
  - Typical Double glazing 0.72 – 0.76
  - Reflective or dark time 0.10 - 0.30
  - Spectrally Selective clear 0.30 - 0.40
- Higher SHGC?
  - Maybe small residential buildings in heating climate
- Low SHGC? (<0.5)
  - Commercial buildings
  - Buildings with large glazing ratios (large window/wall area)
  - Buildings in cooling or mixed climate

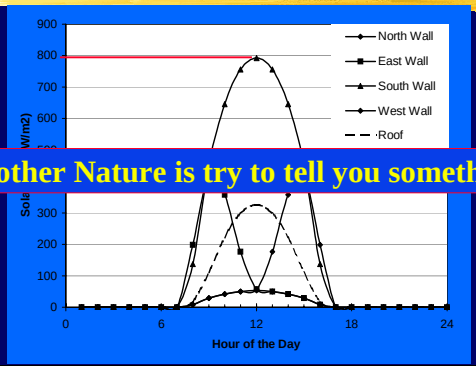
How much difference does SHGC make?

- **150 sq.ft. south-facing glass**
- **Change from 0.57 to 0.27 SHGC**
- **Air conditioning load reduction = ~1 ton!**
- **Avoid air conditioning?**

Solar Gains - July 21 @45 N



Solar Gains - Jan 21 @ 45 N



Mother Nature is try to tell you something

Visible Transmittance

- VT is fraction of visible light that is transmitted
- Clear Double glazing VT = 0.75-0.80
- VT over 0.60 tend to look untinted and helps daylighting
- Tinting changes color
- Low-E coatings do not

Visible Transmittance

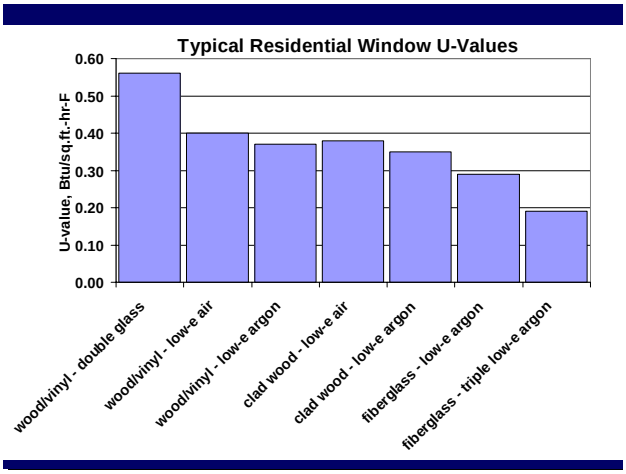
- VT = Visible Transmittance
  = Fraction of visible light that passes
- Typical clear, dbl-glazed window VT = 0.75-0.80
- Windows with VT > 0.50+ are perceived to be clear
- Tinting changes the color of light that passes
- low-e coating does not change color
- **Spectrally selective:** lower SHGC with good VT

Spectrally Selective

- Reduced SHGC with a high VT
- Allows daylighting and view with low solar heat gain
- Tend to have good U-values

Windows - Residential

Including Frame	U	R	SHGC	VT
Double-glaze broken Alu	0.64	1.56	0.62	0.62
Dbl Clr Wood/vinyl	0.49	2.04	0.56	0.58
Dbl Low-E Gain Wood/vinyl	0.36	2.78	0.52	0.53
Dbl Low-E Shade Wood/vinyl	0.32	3.13	0.30	0.50
Triple Low E Fiberglass	0.18	5.56	0.39	0.49

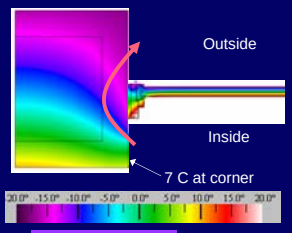


Function: Air Leakage

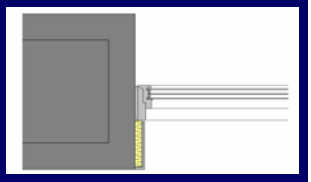
- NFRC AL rates how much leakage based on standard conditions
- Does not include frame to wall!
- Aim for less than 0.20 cfm/ft^2
- Weather stripping & Durability
- Compression fittings are tighter
  - hence casement, awning windows better than sliders

Window Thermal Flanking

- Beware heat flow around window frame



Thermal Flanking



Flanking Reduced

Window Air Leaka

- Joints around window need to be airsealed
- Stuffing with batt does not work

NFRC Label

- Read the label
  - U-value (1/R)(<0.35)
  - SHGC (heating/cooling?, west? South?)
  - VT (>0.50, 0.60)
  - AL (NFRC optional)(low!)
- www.NFRC.org

Support

- Windows are not designed to take loads from the building
  - Design joints to accommodate movement
- Window must support wind loads and transmit these to the secondary structure
  - Larger glazing areas & higher wind loads (e.g. high rise buildings) require thicker glass
  - Beware large flexible PVC
  - Frame transfers load from glazing unit to wall

Rain Control

- Windows are weak spots in enclosures
- They attract water
- They often leak internally
- They often leak around window

www.efficientwindows.org

Residential
Small Buildings
Only

Conclusions

- Understand importance of windows to building performance
- Balance U, SHGC, and VT
- Design and build
  - draining sills, drained windows
  - air barrier continuity with window
- Curtainwalls - use less glass of better quality with better shade

Websites

- University of Waterloo
  Building **E**ngineering **G**roup
  - www.civil.uwaterloo.ca/beg
- Balanced Solutions
  - www.balancedsolutions.com