Heat Flow

The Art of Building Science™
Introduction to Heat Flow

- Heat always flows from a region of high temperature to a region of lower temperature
Introduction to Heat Flow

- Three modes of heat flow
  - **Conduction**: Transfer of heat between materials of different temperatures while in direct contact
Introduction to Heat Flow

- Three modes of heat flow
  - **Conduction**: Transfer of heat between materials of different temperatures while in direct contact
  - **Convection**: Transfer of heat due to the motion of gas or liquid over a surface
Introduction to Heat Flow

- **Conduction**: Transfer of heat between materials of different temperatures while in direct contact
- **Convection**: Transfer of heat due to the motion of gas or liquid over a surface
- **Radiation**: Transfer of heat from one object to another due to electromagnetic waves
Benefits of Controlling Heat Flow in a House

- Occupant comfort
- Energy efficiency
Heat Flow
Scientific Principles
Heat Transfer Problems & Solutions

- Roof/ceiling system
- Walls
- Windows
- Basements
- Crawlspace & Slabs
Roof/Ceiling Systems

Heat Flow
Roof/Ceiling System Problems

- Ceiling surface condensation and staining
Roof/Ceiling System Problems

- Underside of roof deck deterioration
Roof/Ceiling System Solutions

- Cathedral ceiling installation
Roof/Ceiling System Solutions

- Properly support & protect knee wall insulation
Roof/Ceiling System Solutions

- Properly insulate recessed lighting

Infrared View
Roof/Ceiling System Solutions

- Insulate attic hatch
Roof/Ceiling System Solutions

- Install attic baffles to maintain insulation effectiveness.
Wood Stud
Walls
Wood Stud Wall Insulation Problems

- Uncomfortable occupant space
- Cold surfaces promote condensation and staining
Wood Stud Wall System Solutions

- Quality installation
Wood Stud Wall System Solutions

- Avoid insulation voids

Infrared View insulation void near top plate
Wood Stud Wall System Solutions

- Blow-In-Blanket System (BIBS)
Wood Stud Wall System Solutions

- Avoid insulation compression

Compressed batt
Wood Stud Wall System Solutions

- Properly insulate around plumbing and electrical penetrations

- Poor fit

- Void

- Compressed
Wood Stud Wall System Solutions

- Use insulating sheathings to increase overall R-value
Window Problems

- Uncomfortable interior space due to radiation heat flow
Window Problems

- Uncomfortable interior space due to radiation heat flow
- Condensation due to cold window surfaces
Window Problems

- Uncomfortable interior space due to radiation heat flow
- Condensation due to cold window surfaces
- Ultra-violet light exposure: Sunlight degrades interior furnishings
Window System Solutions

Install high performance windows
Look for the NFRC label
Install high performance windows
Look for the NFRC label

- Frame type
- Glazing type
- Gas Fill
- Low-E coatings
### Window System Solutions

**U-factor – Like R-value, indicates thermal performance**

**Energy Star recommended maximums**

<table>
<thead>
<tr>
<th>Zone</th>
<th>U-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Zone</td>
<td>0.35</td>
</tr>
<tr>
<td>Central Zone</td>
<td>0.40</td>
</tr>
<tr>
<td>Southern Zone</td>
<td>0.75</td>
</tr>
</tbody>
</table>

*Lower is better*

---

**World’s Best Window Co.**

*Millennium 2000+ Casement*

- Vinyl-Clad Wood Frame
- Double Glaze • Argon Fill • Low E

**ENERGY Performance**

<table>
<thead>
<tr>
<th>Technical Information</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>U</em>-Factor</td>
<td>.31</td>
</tr>
<tr>
<td>Solar Heat Gain Coef.</td>
<td>.45</td>
</tr>
<tr>
<td>Visible Transmittance</td>
<td>.58</td>
</tr>
<tr>
<td>Air Leakage</td>
<td>.3</td>
</tr>
</tbody>
</table>

*Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product energy performance. NFRC ratings are determined for a fixed set of environmental conditions and specific product sizes.*
Window System Solutions

Solar Heat Gain Coefficient – Indicates efficiency in preventing solar radiation from heating house

Energy Star recommended maximums

<table>
<thead>
<tr>
<th>Zone</th>
<th>SHGC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Zone</td>
<td>Any</td>
</tr>
<tr>
<td>Central Zone</td>
<td>0.55</td>
</tr>
<tr>
<td>Southern Zone</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Lower is better
Window System Solutions

Installation is Critical!

*Even the best windows will perform poorly unless they are installed correctly.*
Basements
Below Grade Basement Interior Problems

- Occupant comfort
- Energy efficiency
Below Grade Basement Interior Solutions

- Finished walls – Fill entire space with unfaced insulation between foundation wall and interior sheathing
Below Grade Basement Interior Solutions

- Unfinished walls – Use perforated fire rated facing
Below Grade Basement Interior Solutions

❖ Ceilings

– Conditioned space—
  Insulation improves sound control

– Semi-conditioned space—
  Insulation improves energy efficiency & comfort
Crawlspaces and Slabs
Crawlspace Problems

- Floor surface temperatures above crawlspace
- Energy efficiency above crawlspace
Crawlspace Solutions

- Vented crawlspace – minimum R-19 should be installed in the floor/ceiling cavity for cold climates
Crawlspace Solutions

- Unvented crawlspace—floor/ceiling cavities or walls should be insulated in warm-humid climates
Slab Solutions

- Some climates may require slab edge insulation
  - Check your building codes
Pay Attention to Details
Pay Attention to Details

- Align air and thermal barriers in dropped ceiling
Pay Attention to Details

- Properly insulate bathrooms to keep tub and shower surfaces comfortable

Compression

Voids

Insulate here to finish job

Heat Flow
Pay Attention to Details

- Insulate, sheath and air seal kneewalls over garages
Pay Attention to Details

- Don’t miss insulating around ALL irregular details
  - Bay windows
  - Overhangs
  - Dropped soffits
  - Any irregular walls, etc.
Control heat flow... for comfort and energy efficiency.