Building Science

Adventures In Building Science

www.buildingscience.com
What is a Building?
A Building is an Environmental Separator
• Control heat flow
• Control airflow
• Control water vapor flow
• Control rain
• Control ground water
• Control light and solar radiation
• Control noise and vibrations
• Control contaminants, environmental hazards and odors
• Control insects, rodents and vermin
• Control fire
• Provide strength and rigidity
• Be durable
• Be aesthetically pleasing
• Be economical
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer
Cladding
Control layers
Structure
Control layer

Control layer

Roof structure
Configurations of the Perfect Wall
Brick veneer/stone veneer

Drained cavity

Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass

Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder

Concrete block

Metal channel or wood furring

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Brick veneer/stone veneer

Drained cavity

Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass

Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder

Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)

Uninsulated steel stud cavity

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Brick veneer/stone veneer

Drained cavity

Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass

Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder

Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)

Insulated wood stud cavity

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Commercial Enclosure: Simple Layers

- Structure
- Rain/Air/Vapor
- Insulation
- Finish
Rain enters cup due to momentum ("kinetic energy")

Cup drains water to exterior
Rain enters cup due to momentum ("kinetic energy")

Wind enters cup—pressurizing cup; no rain entry due to wind driven rain

Cup can still drain water to exterior

Entire wind pressure taken here
Baffle to deflect raindrops hitting face of cup due to momentum ("kinetic energy")

Pressure in cup is same as pressure outside on face of baffle

Momentum driving force converted to gravity—water drains away

Wind enters cup—pressurizing cup; no rain entry due to wind driven rain

Cup can still drain water to exterior

Entire wind pressure taken here
- Insulating glass unit
- Seal (gasket)
- Seal (tape)
- Setting block (typically two per unit)
- Hole providing drainage and pressurization
- Frame
- Rough opening
Outer seal sees water but not pressure; no pressure difference across this seal, therefore no rain entry.

Key seal is interior seal as it takes maximum wind load but it does not see water.

Pressure in chamber is same as pressure outside on face of assembly.

Air enters and pressurizes chamber.

Entire wind pressure taken here.

Pressure chamber.
Pressure moderated chamber

Interior air seal

Adhesive-backed sill flashing

Housewrap

Sheathing

Beveled wood siding
Intent of sealant is to limit this lateral flow of water between sheathing and building wrap.

- Flashing tape
- Sealant “bedding” joint
- Building wrap “wrapped” into opening
Wind pressurizes chamber between inner and outer seal.
Inner, protected seal

Outer, exposed seal

Drain and vent opening
Life is Tough Enough As it Is…
Life is Tough Enough As it Is…
It’s Harder When You Are Stupid
Don’t Do Stupid Things
“The Ugly”

“The Bad”

“The Good”
WEDGE SHIMS INSERTED BEHIND/FRONT OF ANGLE TO ENSURE DIRECT BEARING ON BRACKET AND PROVIDE LEVEL (IF NECESSARY)

ANCHOR BOLT

FAST™ BRACKET

ANGLE
Zeroth Law – $A=B$ and $B=C$ therefore $A=C$
First Law - Conservation of Energy
Second Law - Entropy
Third Law – Absolute Zero
2nd Law of Thermodynamics
In an isolated system, a process can occur only if it increases the total entropy of the system

Rudolf Clausius
Heat Flow Is From Warm To Cold
Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less
Air Flow Is From A Higher Pressure to a Lower Pressure
Gravity Acts Down
Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less
Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less

Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion
Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less

Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

Vapor Diffusion
Thermodynamic Potential
DIFFUSION

Higher Dewpoint Temperature
Higher Water Vapor Density
or Concentration
(Higher Vapor Pressure)
on Warm Side of Assembly

Low Dewpoint Temperature
Lower Water Vapor Density
or Concentration
(Lower Vapor Pressure)
on Cold Side of Assembly

AIR TRANSPORT

Higher Air Pressure

Lower Air Pressure
4x8 sheet of gypsum board
Interior at 70°F and 40% RH

1/3 quart of water

4x8 sheet of gypsum board with a 1 in² hole
Interior at 70°F and 40% RH

30 quarts of water
Diagram showing the process of cooling and reheating.

- **Cooling** process:
  - 90°F, 90% RH
  - Condensation (55°F, 100% RH)

- **Reheat** process:
  - 75°F, 40% RH
Damage Functions
Damage Functions
Water
Heat
Ultra Violet Radiation
Damage Functions
Water
Heat
Ultra Violet Radiation

Oxidization (Ozone)
Fatigue (Creep)
The Three Biggest Problems In Buildings Are Water, Water and Water…
Heat
Air
Moisture
HAM
Hygrothermal Analysis
### Moisture Transport in Porous Media

<table>
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<tr>
<th>Phase</th>
<th>Transport Process</th>
<th>Driving Potential</th>
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<td>Diffusion</td>
<td>Vapor Concentration</td>
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<tr>
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<td>Suction Pressure</td>
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<td>Osmosis</td>
<td>Solute Concentration</td>
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### Moisture Transport in Assemblies

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<td>Surface Tension</td>
<td>Surface Energy</td>
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<tr>
<td></td>
<td>Momentum</td>
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