Building Science

Adventures In Building Science

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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
Arrhenius Equation
For Every 10 Degree K Rise
Reaction Rate Doubles

\[ k = A e^{-E_a/(RT)} \]
Damage Functions
Water
Heat
Ultra-violet Radiation
2nd Law of Thermodynamics
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
Thermodynamic Potential
PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
Barometric Pressure 101.325 kPa
SEA LEVEL
Map of DOE's Proposed Climate Zones

Marine (C)  Dry (B)  Moist (A)

March 24, 2003
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer
Slab
Control layers
Stones
Earth
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.
Intent of sealant is to limit this lateral flow of water between sheathing and building wrap.
Wind pressurizes chamber between inner and outer seal.
- Sealant backer rod
- Inner seal
- Pressure chamber
- Baffle
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)
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
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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
Exterior at 74°F
dewpoint
Interior at 75°F
and 50% RH

1 1/2 pints
of water

4x8 sheet of
gypsum board
with a 1 in² hole
Exterior at 74°F
dewpoint
Interior at 75°F
and 50% RH

14 pints of water
Heating

35°F  
90% RH

70°F  
30% 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
Solar radiation
Rain
Heat exchange with outdoors
Vapor exchange with outdoors
Heat exchange with indoors
Vapor exchange with indoors
# Moisture Transport in Porous Media

<table>
<thead>
<tr>
<th>Phase</th>
<th>Transport Process</th>
<th>Driving Potential</th>
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<tr>
<td>Vapor</td>
<td>Diffusion</td>
<td>Vapor Concentration</td>
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<tr>
<td>Adsorbate</td>
<td>Surface Diffusion</td>
<td>Concentration</td>
</tr>
<tr>
<td>Liquid</td>
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<td>Suction Pressure</td>
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<td>Gravitational Flow</td>
<td>Height</td>
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<tr>
<td></td>
<td>Surface Tension</td>
<td>Surface Energy</td>
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<tr>
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<td>Momentum</td>
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