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
Activation Energy Doubles

\[ k = Ae^{-E_a/(RT)} \]
Damage Functions
Water
Heat
Ultra-violet Radiation
2\textsuperscript{nd} 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
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer
Cladding

Control layers

Structure
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

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Brick veneer/stone veneer
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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 steel or wood stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Figure 2a
Vapor Profile

- Brick veneer/stone veneer
- Drained and vented cavity
- Thermal control layer - exterior rigid insulation - rock wool or fiberglass
- Membrane or trowel-on or spray applied or liquid applied water control layer and air control layer
- Concrete block
- Metal channel or wood furring
- Gypsum board
- Latex paint or vapor semi-permeable textured wall finish
Brick veneer/stone veneer
Drained and vented cavity
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Commercial Enclosure: Simple Layers

- Structure
- Rain/Air/Vapor
- Insulation
- Finish
Flashings are used to prevent water from entering through cracks or openings in walls. The diagram shows the correct installation of a flashing. The "Down" arrow indicates the water direction, and the "Out" arrow shows the direction of the flashing. Key components include:

- **Upturned leg**: The part of the flashing that is bent up to prevent water from entering.
- **Base sloped to exterior**: The base of the flashing should slope outward to ensure water drains away from the structure.
- **Drip edge**: The outer edge of the flashing that helps to direct water away from the structure.
<table>
<thead>
<tr>
<th>Pascals</th>
<th>mph</th>
</tr>
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<tbody>
<tr>
<td>50 Pa</td>
<td>20 mph</td>
</tr>
<tr>
<td>100 Pa</td>
<td>30 mph</td>
</tr>
<tr>
<td>150 Pa</td>
<td>35 mph</td>
</tr>
<tr>
<td>250 Pa</td>
<td>45 mph</td>
</tr>
<tr>
<td>500 Pa</td>
<td>65 mph</td>
</tr>
<tr>
<td>1,000 Pa</td>
<td>90 mph</td>
</tr>
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</table>

**Wind Speed (mph) vs. Stagnation Pressure (Pa)**

![Graph showing the relationship between wind speed (mph) and stagnation pressure (Pa).]
Plywood/OSB sheathing
Water control layer

⅜” spacer strip
Air Leakage
Supply air into occupied zone returns to AHU by passing through deliberately porous dropped ceiling or through return grilles installed in dropped ceiling.

Air handling unit extracts air from dropped ceiling, conditions it and injects it into the occupied zones via supply ductwork.

Dropped ceiling depressurized by air handling units extracting air from dropped ceiling.
Houses With Vented Attics Suck
Houses With Vented Attics Suck
Not all the Time.....but......
Outside

Exterior sheathing

Inside

70°F

Dewpoint (50% RH, 70°F)

Location of condensation and frost

0°F
Simple linearized energy-temperature relation for water
From Straube & Burnett, 2005
The inside face of the exterior sheathing is the condensing surface of interest.

Wood-based siding
Building paper
Exterior sheathing
R-19 cavity insulation in wood frame wall
Gypsum board with any paint or wall covering

Dew point temp. at 50% R.H., 70°F
Mean monthly outdoor temperature
Dew point temp. at 35% R.H., 70°F
Dew point temp. at 20% R.H., 70°F
Potential for condensation
The inside face of the insulating sheathing is the condensing surface of interest.

- Wood-based siding
- R-7.5 rigid insulation
- R-13 cavity insulation in wood frame wall
- Gypsum board with any paint or wall covering

Graph shows:
- Mean monthly outdoor temperature
- Insulation/sheathing interface temperature (R-7.5 sheathing, R-13 cavity insulation as shown in adjacent drawing)
- Potential for condensation
- Dew point temp. at 35% R.H., 70°F

Month: APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC, JAN, FEB, MAR, APR, MAY
Figure 8-7. Outside vapour pressure, saturated vapour pressure and inside vapour pressure for Winnipeg.
Shingles
Roofing paper
R-19 batt insulation installed with wire stays or twine or netted cellulose
R-5 rigid insulation (vertical and horizontal joints offset from roof sheathing)
\(\frac{3}{8}\)” sheathing over rigid insulation
Roof sheathing
Sealant
Rigid insulation notched around roof trusses and sealed
Vinyl or aluminum siding
Rigid insulation
Building paper drainage plane
Unfaced batt insulation
Gypsum board with vapor semi-permeable (latex) paint
Underside of roof sheathing is typically the “first” condensing surface
The inside face of the roof sheathing forming the cavity is the first condensing surface.

OSB or plywood nail base for shingles

R-30 unfaced batt ceiling insulation compressed to fit within 2x8 rafters or damp spray cellulose or “netted” dry blown cellulose or fiberglass

R-5 rigid insulation (vertical and horizontal joints offset from roof sheathing)

Sealant

Rigid insulation notched around roof rafters and sealed

Vinyl or aluminum siding

Rigid insulation (taped, shiplapped or sealed joints)

Unfaced batt insulation

OSB or plywood roof sheathing

Gypsum board ceiling with semi-vapor permeable (latex) paint

Caulking or sealant

Gypsum board with semi-vapor permeable (latex) paint
Roofing tile

Roofing paper

Netted cellulose insulation or batt insulation installed with wire stays or twine

Roof sheathing

Underside of roof sheathing is typically the “first” condensing surface

Stucco

Unfaced batt insulation

Gypsum board with vapor semi-permeable (latex) paint

Rigid insulation

Building paper drainage plane
1" HD spray foam

2x6 top chord

OSB/plywood sheathing

Drainage plane

Spray fiberglass; 8" nominal

Gypsum board

2x6 frame wall

4½" cellulose or spray fiberglass

1" HD spray foam
Roof cladding

Roof underlayment

3" HD spray foam (R-19.5)

6 1/4" spray fiberglass (R-21)
Low density spray foam insulation

Asphalt shingles

Roofing paper

Roof sheathing

Raised heel truss

Rigid foam, or comparable, as backdam

Soffit

Roof underlayment sealed to drip edge

Gypsum board with latex paint (acts as thermal barrier separating occupiable space from non-occupiable space)
Map of DOE's Proposed Climate Zones

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

Warm-Humid Below White Line

All of Alaska in Zone 7 except for the following Boroughs in Zone 8:
Bethel  Dillingham  Fairbanks N. Star  Nome  North Slope
Northwest Arctic  Southeast Fairbanks  Wade Hampton  Yukon-Koyukuk

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands

March 24, 2003
Conditioned Attics Not Unvented Attics
RIDGE

EAVE

CENTER OF PANELS

NOT AFFECTED
Step 1
- Remove strip of OSB from each side of ridge

Step 2
- Create air seal with strip of vapor open membrane (tape seams)
- Vapor open membrane sheet sealed to OSB with acrylic caulk sealant
- Hold vapor open membrane sheet in place with metal strapping

Vapor open membrane sheet sealed to OSB with acrylic caulk sealant
Metal strap nailed over top of vapor open membrane sheet (acting as pressure bar)
Continuous bead of sealant between OSB and vapor open membrane sheet

Step 3
- Construct wood ridge vent with 2x2 furring

1/4" OSB
2x2 furring @ 16" o.c.
Building Science Corporation

Joseph Lstiburek  173
Continuous exterior insulation

Cladding

Rodent protection for continuous rigid insulation

For insect protection provide 3'-0" of mulch and then drought-resistant plants

Ground slopes away from wall at 5% (6 in. per 10 ft.)

Dampproofing

Granular capillary break and drainage pad (no fines)

Rigid insulation as bond break material

Concrete foundation wall

Concrete footing below frost depth

Capillary break
Continuous exterior insulation

Cladding

Rodent protection for continuous rigid insulation

Cavity insulation

Gypsum board

Sealant, adhesive or gasket

Sill gasket

Masticed membrane strip

Polyethylene

Concrete slab

For insect protection provide 3'-0" of mulch and then drought-resistant plants

Ground slopes away from wall at 5% (6 in. per 10 ft.)

Dampproofing

Granular capillary break and drainage pad (no fines)

Rigid insulation as bond break material

Concrete foundation wall

Concrete footing below frost depth

Capillary break
Building wrap
Sealant, adhesive or gasket (typ.)
2x4
Capillary break
Rodent protection for continuous rigid insulation

For insect protection provide 3'-0" of mulch and then drought-resistant plants

Ground slopes away from wall at 5% (6 in. per 10 ft.)

T&G subfloor
1 1/2" rigid insulation
Plate under load bearing walls only

Polyethylene
Building wrap
Sealant, adhesive or gasket (typ.)
2x4 Capillary break
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Ground slopes away from wall at 5% (6 in. per 10 ft.)

Polyethylene
Rockwool

1x3 furring @ 24” o.c.
#10 screws @ 16” o.c. vertically
Result: 20 psf cladding weight
with < 2/100” deflection
Second layer of z-bars should be installed perpendicular to the first layer; orientation of the two layers will depend on the requirements of the cladding attachment system.

First layer of z-bars embedded in the insulation layer; should the first layer be installed horizontally, the exterior leg should be turned down to promote drainage to the exterior.
Sealant for air control layer continuity
Stool and apron
Wood buck (OSB, plywood, etc.)
Wood blocking

Window
Sheet metal closure
Precast sill
Thermal control layer
Brick veneer

Water, air and vapor control layer
Water, air and vapor control layer

Sheathing

Wood buck (OSB, plywood, etc.)

Sealant “aesthetic” closure

Thermal control layer

Sealant and backer rod