What is a Building?
A Building is an Environmental Separator
Evolution of Walls
Enclosures
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
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer
Control layer
Control layer
Roof 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
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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 steel or wood stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall finish
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
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
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

Figure 2b
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
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

Figure 2c

Vapor Profile
Commercial Enclosure: Simple Layers

- Structure
- Rain/Air/Vapor
- Insulation
- Finish
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.
Parapet flashing
Fully-adhered water control membrane
Tapered rigid insulation
Cant
Wood blocking
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Fully adhered roof membrane
Two (2) layers insulation; joints staggered horizontally and vertically
Metal deck
Air control membrane
Light gauge steel framing (installed slightly proud of I-beam)
Open web steel joist
Deflection track allows space for sheathing to move
Backer rod fills gap
Peel and stick transition membrane; air and water control
Water, air and vapor control membrane; preferably fully-adhered
Fiberglass batt insulation
Fiberglass batt insulation
Air control layer transition membrane
Water, air and vapor control membrane; preferably fully-adhered
Peel and stick transition membrane; air and water control
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Parapet flashing
Fully-adhered water control membrane
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Water, air and vapor control membrane; preferably fully-adhered
Light gauge steel framing (installed slightly proud of I-beam)
Deflection track allows space for sheathing to move
Metal deck
Air control membrane
Open web steel joist
Houses With Vented Attics Suck
Houses With Vented Attics Suck
Not all the Time.....but......
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

Graph:
- Monthly temperature variation
- Dew point temp. at 50% R.H., 70°F
- Mean monthly outdoor temperature
- Potential for condensation
- Dew point temp. at 35% R.H., 70°F
- Dew point temp. at 20% R.H., 70°F

Month: APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC, JAN, FEB, MAR, APR, MAY
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 showing:
- Insulation/sheathing interface temperature (R-7.5 sheathing, R-13 cavity insulation as shown in adjacent drawing)
- Mean monthly outdoor temperature
- Potential for condensation
- Dew point temp. at 35% R.H., 70°F
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)

3/8" sheathing over rigid insulation

Roof sheathing

Sealant

Rigid insulation notched around roof trusses and sealed

Vinyl or aluminum siding

Unfaced batt insulation

Gypsum board with vapor semi-permeable (latex) paint
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

Rigid insulation

Gypsum board with vapor semi-permeable (latex) paint

Building paper drainage plane
Metal cap
OSB sheathing
Scupper
Sealant
Rigid insulation
OSB
Cavity insulation
Sealant
Polymer modified (PM) or traditional cement stucco
Metal lath
Building paper bond break over drainage plane

18" wide membrane strip under parapet folded down over exterior rigid insulation
Coping wedge
OSB
Rubber roofing membrane
Rigid insulation

Air barrier membrane (membrane roofing in very cold and cold climates; housewraps, building paper in all other climates)

Gypsum board with semi-permeable (latex) paint
Sealant, adhesive or gasket at top plate
Cavity insulation

1/4" cant/ft
1" HD spray foam

2x6 top chord

OSB/plywood sheathing

Drainage plane

Spray fiberglass; 8" nominal

Gypsum board

2x6 frame wall

4 1/2" cellulose or spray fiberglass

1" HD spray foam
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

Non-occupiable space

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

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
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

Continuous bead of sealant between OSB and vapor open membrane sheet

Step 3
- Construct wood ridge vent with 2x2 furring
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

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

Concrete foundation wall

Granular capillary break and drainage pad (no fines)

Polyethylene

Rigid insulation as bond break material

Concrete footing below frost depth

Capillary break
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.)

Concrete footing below frost depth

Capillary break

Concrete foundation wall

Dampproofing

Geotextile (filter fabric)

Granular capillary break and drainage pad (no fines)

Rigid insulation as bond break material
Continuous exterior insulation

Cladding

Rodent protection for continuous rigid insulation

Cellular PVC protection board

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.)

Rigid insulation

Cavity insulation

Gypsum board

Flashing set in mastic sealed to slab

Sealant, adhesive or gasket

Sill gasket

Polyethylene vapor barrier extended under grade beam where it also acts as a capillary break

Concrete grade beam

4" granular capillary break and drainage pad (no fines)

4" concrete slab
Continuous exterior insulation

Cladding

Rodent protection for continuous rigid insulation

Cellular PVC protection board

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

Rigid insulation

Cavity insulation

Gypsum board

Flashing set in mastic sealed to slab

Sealant, adhesive or gasket

Sill gasket

4" concrete slab

4" granular capillary break and drainage pad (no fines)

Concrete grade beam

Polyethylene vapor barrier extended under grade beam where it also acts as a 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
Rodent protection for continuous rigid insulation
For insect protection provide 3'-0" of mulch and then drought-resistant plants

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

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

Polyethylene
Building wrap
Sealant, adhesive or gasket (typ.)
2x4
Capillary break

T&G subfloor
1½” rigid insulation
Plate under load bearing walls only

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.)

Polyethylene
Building wrap
Sealant, adhesive or gasket (typ.)
2x4
Capillary break
T&G subfloor
1 1/2" rigid insulation
Plate under load bearing walls only

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.)

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.
Water, air and vapor control layer

Sheathing

Wood buck (OSB, plywood, etc.)

Sealant “aesthetic” closure

Sealant and backer rod

Thermal control layer