Building Science

Adventures In Building Science

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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
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

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

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

Figure 2a

Vapor Profile
Figure 2b

Vapor Profile

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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
Air Leakage
Cant
Engineered wood blocking
Fully adhered roof membrane
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Two (2) layers insulation; joints staggered horizontally and vertically
Peel and stick transition membrane; air and water control
Fiberglass batt insulation
Backer rod fills gap
Peel and stick transition membrane; air and water control
Fully-adhered water, air and vapor control membrane
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
Leaky air handling unit and supply ducts

Air handling unit

Supply

Return

Supply

Depressurized conditioned space inducing infiltration
Houses With Vented Attics Suck
Houses With Vented Attics Suck
Not all the Time.....but......
Outside

Inside

70°F

Dewpoint
(50% RH, 70°F)

Location of condensation and frost

0°F

Exterior sheathing
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 shows monthly temperature fluctuations with:
- 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
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 the following:
- 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

Month: April, May, June, July, August, September, October, November, December, January, February, March, April, 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

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" 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 backdamp

Soffit

Roof underlayment sealed to drip edge

Gypsum board with latex paint (acts as thermal barrier separating occupiable space from non-occupiable space)
Conditioned Attics Not Unvented Attics
Step 1
- Remove strip of OSB from each side of ridge

Remove 12" 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

Metal strap nailed over top of vapor open membrane sheet (acting as pressure bar)

Step 3
- Construct wood ridge vent with 2x2 furring

\[ \frac{1}{4}'' \text{ OSB} \]

2x2 furring @ 16'' o.c.
Shingles
Dense glass
gold at ridge
Plywood
Roofing
membrane
Plywood
2x2 framing
Two layers
2” stone wool
Cavity insulation
Zip (OSB)
sheathing
Two 2x14
microlams
2x10’s
Plywood
Continuous exterior insulation

Cladding

Rodent protection for continuous rigid insulation

Cavity insulation

Gypsum board

Sealant, adhesive or gasket

Sill gasket

Masticated 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
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

Concrete foundation wall

Geotextile (filter fabric)

Granular capillary break and drainage pad (no fines)

Rigid insulation as bond break material

Concrete footing below frost depth

Capillary break
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

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
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
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.
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