Condensing Surfaces
Dewpoint (50% RH, 70°F)

Location of condensation and frost

Exterior sheathing

Outside

Inside

70°F

0°F
Simple linearized energy-temperature relation for water
From Straube & Burnett, 2005
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

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.
Perfect Wall
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer
Cladding
Control layers
Structure
Ice Rinks
Rigid insulation
thermal break

Unfaced cavity insulation installed
over blanket insulation between
thermal breaks

Metal roofing

Purlins

Blanket insulation draped
over purlins

Blanket Insulation Purlin Roof System
Exterior face (water control layer, air control layer, vapor control layer)

Thermal control layer

Interior face (air control layer and vapor control layer)

Insulated metal panel

Vapor Profile
Figure 7: Typical ice pad construction (IIHF, 2010)
Refrigerated Buildings
Aspen Recreation Center
Swimming Pools
Vented roof

All structure inside; okay, not the trusses but you know what I mean

Ventilated cladding

Thermal control layer outside of air and vapor control layers

Continuous air control and vapor control layer outside of structure

Ventilated cladding

All services inside; all, not some, all and I really mean it
Minimum R-50 rigid insulation in two or more layers with horizontal and vertical joints staggered

Plywood roof sheathing

Roofing membrane (vapor permeable liquid applied or roofing felt)

Vented space

Roof sheathing

Shingles

Roofing paper

Air control layer/vapor control layer

Wood decking

Timber rafter or exposed joist
- Fully-adhered roofing membrane
- Coverboard and hygric buffer
- Rigid insulation (min. two layers; joints offset)
- Screw attachment
- Gypsum sheathing (paperless)
- Fully-adhered air control layer/vapor control layer
- Metal deck
Fully-adhered roofing membrane

Coverboard and hygric buffer

Venting layer

Intermediate plywood layer; joints sealed

Screw attachment to structural deck

Rigid insulation

Gypsum sheathing (paperless)

Fully-adhered air control layer/vapor control layer

Screw attachment

Metal deck
Denver Art Museum
Steel angle with flat extension inserted under lap in membrane and fastened to plywood sheathing

Titanium cladding

Slip sheet

Paperless gypsum sheathing

Fully-adhered, single-ply EPDM membrane 36” (914 mm) wide with 6” (152 mm) lap

Metal purlins for cladding attachment at 24” (610 mm) o.c.

3/4” (19 mm) plywood fastened to purlins

2x4 purlins in two layers; lower purlins fastened to metal deck; upper purlins fastened to lower purlins

1 1/8” (38 mm) rigid insulation

Membrane air barrier

1 1/2” (38 mm) rigid insulation

Membrane

Gypsum sheathing

Metal deck
Grow Rooms – Grow Opps
Uninsulated wood frame/wood floor above (must not be steel studs)

Two layers of 1\textquoteleft-thick untaped extruded polystyrene (XPS) with joints offset horizontally and vertically; each layer taped with exterior sheathing tape

Untreated 1\times 4 wood furring with stainless steel screws

Acrylic latex sealant (applied as each layer of foam is installed)

Interior lining (wood/non-paper faced gypsum board skim coated with plaster)

Uninsulated wood frame

See Figure 2b for alternative wood floor detail

Building Science Corporation
SIP’s
Insulated Metal Panels
Water control layer, air control layer, vapor control layer and thermal control layer: insulated metal panel

Uninsulated steel stud cavity

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Exterior face (water control layer, air control layer, vapor control layer)

Thermal control layer

Interior face (air control layer and vapor control layer)

Insulated metal panel
Exterior seal providing continuity of the exterior air control layer and vapor control layer

Flashed and drained joint

Interior seal providing continuity of the interior air control layer and vapor control layer

Direct contact between thermal control layers of adjacent panels provides continuity of the thermal control layer
Exterior seal providing continuity of the exterior air control layer and vapor control layer.

Drained vertical joint.

Interior seal providing continuity of the interior air control layer and vapor control layer.

Direct contact between thermal control layers of adjacent panels provides continuity of the thermal control layer.
Standing seam provides continuity of the water control layer.

Exterior seal providing continuity of the exterior air control layer and vapor control layer.

Direct contact between thermal control layers of adjacent panels provides continuity of the thermal control layer.

Interior seal providing continuity of the interior air control layer and vapor control layer.
Insulated Metal Panel Roof System

Blanket Insulation Purlin Roof System
Walls
Cladding
Furring
Stone wool/mineral fiber rigid insulation
Building paper
OSB sheathing
Fiberglass batt/cellulose
2x6 wall framing
Polyethylene vapor barrier
Gypsum board
Interior latex paint

Drying to Exterior
Cladding
Furring
Building paper
OSB sheathing
Spray polyurethane foam (SPF) (2 lb/ft$^3$ density) in wall cavity applied to interior side of exterior OSB sheathing
Fiberglass batt/cellulose
2x6 wall framing
Gypsum board
Interior latex paint

Drying to Interior
Brick veneer/stone veneer

Drained and vented cavity

Thermal control layer - exterior rigid insulation - extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass

Membrane or trowel-on or spray applied or liquid applied water control layer, air control layer and vapor control layer

Concrete block

Metal channel or wood furring

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Figure 1a

Vapor Profile
Brick veneer/stone veneer

Drained and vented cavity

Thermal control layer - exterior rigid insulation - extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass

Membrane or trowel-on or spray applied or liquid applied water control layer, air control layer and vapor 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 1b

Vapor Profile
Brick veneer/stone veneer
Drained and vented cavity
Thermal control layer - exterior rigid insulation - extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied or liquid applied water control layer, air control layer and vapor 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 1c

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
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
Brick veneer

Drained cavity

Water control layer, air control layer, vapor control layer and thermal control layer: insulated metal panel

Uninsulated steel stud cavity

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Brick veneer/stone veneer

Drained and vented cavity

Water control layer, air control layer and thermal control layer - exterior rigid insulation - extruded polystyrene, isocyanurate

Insulated wood stud cavity

Vapor control layer and air control layer - polyethylene

Gypsum board

Latex paint

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 vapor barrier (Class I vapor retarder), air barrier and drainage plane (impermeable)

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

Membrane or trowel-on or spray applied vapor barrier (Class I vapor retarder), air barrier and drainage plane (impermeable)

Concrete block

Insulated steel or wood stud cavity

Cavity insulation (unfaced fiberglass batts, spray-applied cellulose or spray-applied low density foam)

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Latex paint

Stucco rendering

Concrete block

Rigid insulation (vapor semi-permeable) — unfaced extruded polystyrene, unfaced expanded polystyrene, fiber-faced isocyanurate

Metal channel or wood furring

Gypsum board

Latex paint or vapor semi-permeable textured wall finish
Latex paint

Stucco rendering

Concrete block

Rigid insulation (vapor semipermeable) — unfaced extruded polystyrene, unfaced expanded polystyrene, fiber-faced isocyanurate

Insulated steel or wood stud cavity

Cavity insulation (unfaced fiberglass batts, spray-applied cellulose or spray-applied low density foam)

Gypsum board

Latex paint or vapor semipermeable textured wall finish

Vapor Profile
Latex paint

Stucco rendering

Building paper bond break

Drainage space between bond break and drainage plane

Building paper or house wrap drainage plane

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

Insulated steel or wood stud cavity

Cavity insulation (unfaced fiberglass batts, spray-applied cellulose or spray-applied low density foam)

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
- Latex paint
- Stucco rendering
- Building paper bond break
- Drainage space between bond break and drainage plane
- Building paper or house wrap drainage plane
- Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
- Insulated steel or wood stud cavity
- Cavity insulation (fiberglass batts, spray-applied cellulose or spray-applied low density foam)
- Kraft facing on a fiberglass batt or a "smart vapor barrier membrane"
- Gypsum board
- Latex paint or vapor semi-permeable textured wall finish
Polymer-based (PB) stucco rendering

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

Drainage space between exterior rigid insulation and drainage plane

Building paper or house wrap drainage plane

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

Insulated steel or wood stud cavity

Cavity insulation (unfaced fiberglass batts, spray-applied cellulose or spray-applied low density foam)

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Latex paint

Precast concrete

Insulated steel or wood stud cavity

Cavity insulation (unfaced fiberglass batts, spray-applied cellulose or spray-applied low density foam)

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Latex paint

Precast concrete

Rigid insulation (vapor semi-permeable) — unfaced extruded polystyrene, unfaced expanded polystyrene, fiber-faced isocyanurate

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 sheathing, plywood or OSB

Spray foam insulation

Gypsum board

Latex paint or vapor semi-permeable textured wall finish
Brick veneer/stone veneer
Drained cavity
Drainage plane
Non paper-faced exterior sheathing, plywood or OSB
Spray foam insulation
Gypsum board
Latex paint or vapor semi-permeable textured wall finish
Stucco

Expanded polystyrene insulation (EPS)

Concrete masonry unit wall

Metal channel

Gypsum board interior lining

Latex paint
Stucco

Expanded polystyrene insulation (EPS)

Air gap

Water control layer

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

Insulated wood stud cavity

High density spray polyurethane foam (SPF)

Gypsum board

Latex paint or vapor semi-permeable textured wall finish
Stucco

Expanded polystyrene insulation (EPS)

Air gap

Water 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
Brick veneer cladding

Drained and vented cavity

Spray-applied closed-cell high-density foam (2 lb/ft$^3$) water control layer (also air control layer, vapor control layer and thermal control layer)

Concrete masonry unit wall

Metal channel

Gypsum board interior lining

Latex paint
Stone veneer
Drained cavity
Exterior rigid insulation
Membrane air barrier, vapor barrier (Class I vapor retarder) and drainage plane
Concrete block
Metal channel or wood furring
Gypsum board
Latex paint or vapor semi-permeable textured wall finish
Vinyl siding

Drainage plane (vapor permeable building paper, house wrap)

Plywood sheathing

Insulated wood stud cavity

Cavity insulation

Gypsum board air barrier

Latex paint or vapor semi-permeable textured wall finish
Latex paint

Stucco rendering

Concrete block

Rigid insulation (vapor semi-permeable) — unfaced extruded polystyrene, unfaced expanded polystyrene, glass fiber-faced isocyanurate

Uninsulated steel frame wall

Non-paper faced gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Latex paint

Precast concrete

Rigid insulation (vapor semipermeable) — unfaced extruded polystyrene, unfaced expanded polystyrene, fiber-faced isocyanurate

Uninsulated steel frame wall

Non-paper faced gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Latex paint

Precast concrete

Spray-applied low density or high density foam insulation

Uninsulated steel frame wall

Non-paper faced gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Single top plate
2x6 stud wall @ 24” o.c.
Taped and painted 1/2” gypsum wall board as interior finish
Fiberglass or cellulose insulation in stud space
XPS insulating exterior sheathing; 1” to 4” typical
Tape joints in XPS sheathing
Furring strips
Cladding
Spray foam insulation at rim joist
Single top plate
Taped and painted 1/2" gypsum board on inside face of stud
2x6 @ 24" o.c. advanced framing
Remaining cavity filled with 3 1/2" fiberglass or cellulose insulation
2" high density spray foam (SPF) (2.0 pcf) against exterior sheathing
OSB or plywood exterior sheathing
Housewrap
Furring strips
Cladding
Spray foam insulation at rim joist
2x3 interior wall

Plywood cavity closure at top of assembly

Single top plate

2x4 exterior wall @ 16" o.c.

3½" high density spray foam (SPF)(2.0 pcf) against exterior sheathing

Plywood or OSB sheathing

Housewrap

Furring strips

Cladding

6" high density spray foam (SPF)(2.0 pcf) on inside of rim joist

Cellulose insulation in gap between framing

Taped and painted ½" gypsum wall board as interior finish

Cellulose insulation in 2x3 interior wall stud spaces
Taped and painted ½” gypsum wall board as interior finish

OSB exterior panel

Housewrap

OSB interior panel

Furring strips

EPS insulation core

Cladding

Spray foam rim joist insulation
Cast-in-place concrete core

ICF inner and outer faces (typically EPS)

Taped and painted \(\frac{1}{2}\)" gypsum board as interior finish

Furring strips

Cladding
1x4 wood furring attached through rigid insulation to 2x4 wood furring

2x4 wood furring mechanically attached to masonry wall

Fluid-applied water control layer and air control layer

Cladding

Joints offset horizontally and vertically with each layer taped

Masonry wall

Interior plaster and lath
2" semi-rigid mineral fiber insulation; seams offset horizontally and vertically

2x4 wood furring mechanically attached to masonry wall

Fluid-applied water control layer and air control layer

Metal hat channel

Fiber cement panel

"Reveal" in panel joint

Spacer/joint backer

1 1/2" semi-rigid mineral fiber insulation

Masonry wall

Interior plaster and lath
Multi-wythe mass wall

Interior lining (gypsum board)

Spray-applied polyurethane foam (2 lb/ft³ density)

Interior framing
Multi-wythe mass wall

Interior lining (gypsum board)

Interior framing

Rock wool or Roxul rigid mineral wool insulation

Fluid-applied water control layer (vapor semi-permeable)

Cementitious rendering
Multi-wythe mass wall

Interior lining (gypsum board)

Cellulose or fiberglass cavity insulation

Wood frame wall (2x6)

Fluid-applied water control layer (vapor semi-permeable)
Multi-wythe mass wall

Interior lining (gypsum board)

"Strapped wall"; horizontal framing

Membrane "smart vapor barrier"

Cellulose or fiberglass cavity insulation

Wood frame wall (2x6)

Fluid-applied water control layer (vapor semi-permeable)

Cementitous rendering