Transitioning from Traditional Insulation Contractor to Building Enclosure Expert

Joseph Lstiburek, Ph.D., P.Eng., ASHRAE Fellow
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer
Cladding

Control layers

Structure
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
Building Science Corporation

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
Outside

70°F

Dewpoint
(50% RH, 70°F)

Exterior sheathing

0°F

Location of condensation and frost

Inside
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 showing temperature (°F) over the months of the year:
- Mean monthly outdoor temperature
- Potential for condensation
- Dew point temp. at 50% R.H., 70°F
- 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

Temperature (°F)

- 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.
<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Rigid Board or Air Impermeable Insulation</th>
<th>Total Cavity Insulation</th>
<th>Total Wall Assembly Insulation</th>
<th>Ratio of Rigid Board Insulation or Air Impermeable R-Value to Total Insulation R-Value</th>
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<tr>
<td>4C</td>
<td>R-2.5</td>
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<td>R-3.75</td>
<td>R-20</td>
<td>R-23.75</td>
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<td>5</td>
<td>R-5</td>
<td>R-13</td>
<td>R-18</td>
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<td>R-7.5</td>
<td>R-20</td>
<td>R-27.5</td>
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<td>R-7.5</td>
<td>R-13</td>
<td>R-20.5</td>
<td>35%</td>
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<td>R-11.25</td>
<td>R-20</td>
<td>R-31.25</td>
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<td>7</td>
<td>R-10</td>
<td>R-13</td>
<td>R-28</td>
<td>45%</td>
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<tr>
<td></td>
<td>R-15</td>
<td>R-20</td>
<td>R-35</td>
<td>45%</td>
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<td>8</td>
<td>R-15</td>
<td>R-13</td>
<td>R-28</td>
<td>50%</td>
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<td>R-20</td>
<td>R-20</td>
<td>R-40</td>
<td>50%</td>
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*Adapted from Table R 702.1 2015 International Residential Code*
Air permeable insulation (fiberglass batts, netted blown cellulose, netted blown fiberglass, spray applied fiberglass)

Gypsum board

Sheathing

Air Control Layer (air barrier)

Rigid Insulation

Furring

Cladding
Air permeable insulation
(fiberglass batts, netted blown cellulose, netted blown fiberglass, spray applied fiberglass, stone wool / mineral wool batts)

Cladding

Furring

Water Control Layer

Sheathing

Air impermeable insulation
("closed cell" spray polyurethane foam)

Air permeable insulation
(fiberglass batts, netted blown cellulose, netted blown fiberglass, spray applied fiberglass, stone wool / mineral wool batts)

Gypsum board
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Gypsum board
Air permeable cavity insulation
Plywood/OSB sheathing
Air barrier membrane
Rigid insulation
Cladding
Shingles

Roofing paper

Roof Sheathing

Air impermeable insulation
(aka spray polyurethane foam)
Roof Sheathing
Air permeable insulation (fiberglass batts, netted blown cellulose, netted blown fiberglass, spray applied fiberglass)
Roofer paper
Roof Sheathing
Rigid Insulation
Air control layer (air barrier)
Shingles

Roofing paper

Roof Sheathing

Air impermeable insulation (aka spray polyurethane foam)

Air permeable insulation (fiberglass batts, netted blown cellulose, netted blown fiberglass, spray applied fiberglass)
Shingles
Roofing paper
Roof Sheathing
Air impermeable insulation ("closed cell" spray polyurethane foam)
Air permeable insulation ("open cell" spray polyurethane foam)
<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Rigid Board Insulation</th>
<th>Code Required R-Value</th>
<th>Ratio of Rigid Board Insulation or Air Impermeable R-Value to Total Insulation R-Value</th>
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<tr>
<td>4A, 4B</td>
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<tr>
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<tr>
<td>6</td>
<td>R-25</td>
<td>R-49</td>
<td>50%</td>
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<tr>
<td>7</td>
<td>R-30</td>
<td>R-49</td>
<td>60%</td>
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<tr>
<td>8</td>
<td>R-35</td>
<td>R-49</td>
<td>70%</td>
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</tbody>
</table>

*Adapted from Table R 806.5 2015 International Residential Code

Table 1
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
Plywood/OSB sheathing

Water control layer

3/8” spacer strip
Rain Screen
Beer Screen?
2\textsuperscript{nd} Law of Thermodynamics
In an isolated system, a process can occur only if it increases the total entropy of the system

Rudolf Clausius
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
Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less
Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less

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
PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
Barometric Pressure: 101.325 kPa
SEA LEVEL

Below 0°C Properties and Enthalpy Deviation Lines Are For Ice
Vapor

Liquid
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
Interior at 70°F and 40% RH

1/3 quart of water

4x8 sheet of gypsum board with a 1 in² hole
Interior at 70°F and 40% RH

30 quarts of water

Diffusion
Air leakage
Exterior at 74°F dewpoint
4x8 sheet of gypsum board
Interior at 75°F and 50% RH
1 1/2 pints of water

Exterior at 74°F dewpoint
4x8 sheet of gypsum board with a 1 in² hole
Interior at 75°F and 50% RH
14 pints of water
Commercial Enclosure: Simple Layers

- Structure
- Rain/Air/Vapor
- Insulation
- Finish