Code Change
R806.5 Unvented attic and unvented attic enclosed rafter assemblies.

• vapor diffusion port
• port area 1:600 of the ceiling area
• vapor permeance greater than 20 perms
• roof slope greater than 3:12
• air supply 50 cfm/1000 ft² ceiling area
• insulation installed directly under the roof deck
• Climate Zones 1, 2 and 3
Vapor Diffusion Port: A passageway for conveying water vapor from an unvented attic to the atmosphere.
Arrhenius Equation
For Every 10 Degree K Rise
Activation Energy Doubles

\[ k = A e^{-E_a/(RT)} \]
Damage Functions
Water
Heat
Ultra-violet Radiation
Vapor Pressure and Relative Humidity
Sorption Isotherms
Change in the storage of moisture in a porous building material as the partial pressure of water vapor in the ambient air increases from zero to full saturation value at a given temperature.

**Sorption Curve**

The graph illustrates the moisture content (MC) in materials as a function of relative humidity (RH). Different materials, such as Spruce, Plywood, Cellulose Insulation, Fiberboard, Stucco, Mortar, Concrete, and Red Brick, are represented by distinct lines. The x-axis denotes RH (%), ranging from 0 to 100, while the y-axis represents MC (%), ranging from 0 to 25. Each material shows a unique pattern of moisture absorption and release with changes in RH.
Average sorption isotherm for wood as a function of temperature

From Straube & Burnett, 2005
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
Vented Attics Are Climate Dependant
Roof insulation

Insulation wind baffle
2" minimum space

Continuous ridge ventilation

Attic ventilation

Water protection membrane

Gypsum board with vapor semi-permeable (latex) paint
Consider increasing depth of insulation by using deeper trusses or oversized (longer) trusses
Caulking or sealant
Gypsum board with permeable (latex) paint

Continuous soffit vent

Vinyl or aluminum siding

Rigid insulation
(taped or sealed joints)

Unfaced cavity insulation,
cellulose or low-density spray-applied foam
40% to 50% of vented area

50% to 60% of vented area
Houses With Vented Attics Suck
Houses With Vented Attics Suck
Not all the Time.....but......
Infiltration/Exfiltration Controlled Ventilation
Shingles

Roofing paper

Minimum R-50 rigid insulation in two or more layers with horizontal and vertical joints staggered

Nail base for shingles (plywood or OSB) screwed through rigid insulation to wood decking or timber rafters

Air barrier membrane

Wood decking

Timber rafter or exposed joist
Minimum R-50 rigid insulation in two or more layers with horizontal and vertical joints staggered.

- Roof sheathing
- Roofing membrane
- Vented space
- Air barrier membrane
- Wood decking
- Timber rafter or exposed joist

Roof sheathing
Roofing paper
Shingles
Dewpoint (50% RH, 70°F)

Location of condensation and frost

Exterior sheathing

0°F

70°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
Potential for condensation
Dew point temp. at 35% R.H., 70°F
Dew point temp. at 20% R.H., 70°F

Month
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

Temperature (°F) vs. Month: April to May
Figure 8-7. Outside vapour pressure, saturated vapour pressure and inside vapour pressure for Winnipeg.
Outside

Roof sheathing

Condensation and frost accumulating on underside of roof sheathing

Attic

Attic insulation

Dewpoint

Inside
Radiation to
night sky

Outside

Roof sheathing

Condensation and frost
accumulating on underside
of roof sheathing

Roof sheathing
and top of attic
insulation are
radiation-coupled

Attic

Condensation and frost
accumulating on top of attic
insulation

Inside

Attic insulation
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

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

Vinyl or aluminum siding

Caulking or sealant

Gypsum board with semi-vapor permeable (latex) paint

Unfaced batt insulation
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

Underside of roof sheathing is typically the “first” condensing surface
Unfaced batt insulation
Gypsum board with vapor semi-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
Truss Uplift
Truss bows upward

Top chord lengthens

Bottom chord shrinks
Bead of adhesive

18"

Bead of adhesive

Continuous bead of drywall adhesive required here

Clips may also be used

Continuous bead of drywall adhesive required here
Float drywall at wall corners

Slotted anchor at non-bearing walls

Drywall clips
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
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

Non-occupiable space

Gypsum board with latex paint (acts as thermal barrier separating occupiable space from non-occupiable space)
Conditioned Attics Not Unvented Attics
Conditioned Attics Not Unvented Attics Need Supply Air
Conditioned Attics Not Unvented Attics
Need Supply Air
50 cfm/1000 ft² of Attic
Hygric Buoyancy
<table>
<thead>
<tr>
<th>Components in Dry Air</th>
<th>Volume Ratio compared to Dry Air</th>
<th>Molecular Mass - $M$ (kg/kmol)</th>
<th>Molecular Mass in Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>0.2095</td>
<td>32.00</td>
<td>6.704</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.7809</td>
<td>28.02</td>
<td>21.88</td>
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<tr>
<td>Carbon Dioxide</td>
<td>0.0003</td>
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<tr>
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<td>83.8</td>
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</tr>
<tr>
<td>Xenon</td>
<td>$0.09 \times 10^{-6}$</td>
<td>131.29</td>
<td>0</td>
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Total Molecular Mass of Air: 28.97
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Total Molecular Mass of Air: 28.97

Note Water Vapor (H2O) is 18
Dry Air is 29
Shingles

Roofing paper

Wood based roof sheathing

Open cell low density spray foam

Each “Ping” and “Pong” bounces the water molecules up the slope
FRF Data: June 1 - September 30, 1989

15-minute averages

Temperature (F)

Standard Time (h)

White Shingles
Black Shingles
Vented vs. unvented shingle temperatures

South-facing shingle temperatures
Jacksonville, FL  16-Sep to 18-Nov 2000

Number of hourly observations

Temperature (F)

unvented S shingle  vented S shingle
Average Temperatures
Vented and Unvented Attics, Aug-97

Hour of Day (Aug-97)

Temperature (F)

- Vented attic air
- Unvented attic air
- Vented roof ply
- Unvented roof ply
- Outside
Hourly Maximum Roof Deck Temperature
LV24 and LV22

Temperature (F)

Hour of Day for August 1997

- LV24, BAI
- LV22, ref
- Outside
Roof Shingle Temperature

FSEC 3.0: Orlando, 1-Aug

Hour of Day

Temperature (C)

All black shingle simulations

All white tile simulations

Temperature (F)
Bottom of Roof Plywood Temperature

FSEC 3.0: Orlando, 1-Aug

Hour of Day

Sealed R-28 flat
Sealed R-19 flat
Reference house (1:300)
1:150 attic vent
1:37 attic vent
White tile
Ambient
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

Rigid insulation

Building paper drainage plane

Unfaced batt insulation

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

**Step 3**
- Construct wood ridge vent with 2x2 furring
Sweating Ducts
Sweating Ducts
Light Colored Roofs
Cool Roofs
Radiant Barriers
ACCA Manual J, S and D
Ductwork Attic Dehumidification System
Burying Ducts
Cold Climates