Building Science

New Code Options for Insulating, Sealing and Controlling Moisture in Unvented Attics in Residential Buildings

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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 and unvented attic to the atmosphere.
Technical Background to the Code Change
Arrhenius Equation
For Every 10 Degree K Rise
Activation Energy Doubles

\[ k = Ae^{-Ea/(RT)} \]
Damage Functions
Water
Heat
Ultra-violet Radiation
Vapor Pressure and Relative Humidity
Heating

35°F  
90% RH

70°F  
30% RH
Cooling

90°F
90% RH

Condensation

55°F
100% RH

Reheat

75°F
40% RH
PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
Barometric Pressure 101.325 kPa
SEA LEVEL
Sorption Isotherms
Sorption Curve


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.

Moisture Content in the Porous Body

Partial Pressure of Water Vapor

Relative Humidity (%)

0 20 40 60 80 100

Mono and multilayers of water molecules

Condensation in the pores
Average sorption isotherm for wood as a function of temperature
From Straube & Burnett, 2005
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
Vented Attics Are Climate Dependant
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
Exterior sheathing

Dewpoint (50% RH, 70°F)

Location of condensation and frost

Outside

Inside

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

Temperature (°F)

- Mean monthly outdoor temperature
- Dew point temp. at 50% R.H., 70°F
- 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

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

Temperature (°F)
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

Inside

- Dewpoint
**Outside**

- Radiation to night sky

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**Roof sheathing**

- Condensation and frost accumulating on underside of roof sheathing

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**Attic**

- Condensation and frost accumulating on top of attic insulation

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**Inside**

- Attic insulation

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**Roof sheathing and top of attic insulation are radiation-coupled**
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
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

Gypsum board with vapor semi-permeable (latex) paint

Unfaced batt insulation

Underside of roof sheathing is typically the “first” condensing surface

Building paper drainage plane
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
OSB sheathing
Scupper
Cavity insulation; see Material Compatibility and Substitutions
Polymer modified (PM) or traditional cement stucco
Metal lath
Tyvek® StuccoWrap®
Weep screed flashing tucked behind drainage plane
Parging coat dampproofed with latex paint to reduce water absorption
For termite protection provide 3'-0" of mulch and then drought-resistant plants
Ground slopes away from wall at 5% (6 in. per 10 ft.)

Metal cap
18" wide membrane strip
Coping wedge
OSB
Rubber roofing membrane
Gypsum board with semi-permeable (latex) paint
Sealant, adhesive or gasket at top plate
Caulking or sealant
2X6 24" O.C. advanced framing
Cavity insulation; see Material Compatibility and Substitutions
Sill gasket acts as capillary break
Gypsum board caulked, glued or gasketed to bottom plate; held up from slab
Concrete slab
Sub-slab stone layer (no fines); see Building Science Details
Concrete grade beam
Polyethylene vapor barrier extended under grade beam where it also acts as a capillary break
Perforated drain pipe added to "T" in order to couple sub-slab pressure field to vent stack

Soil gas vent stack
Sealant at all slab penetrations
Sealant at all penetrations
1/4" cantilev
Truss Uplift
Top chord lengthens

Truss bows upward

Bottom chord shrinks

Top chord lengthens
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)

Sealant, adhesive or gasket at top plate

Gypsum board with semi-permeable (latex) paint

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

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
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

Temperature (F)

Number of hourly observations

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

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

Hour of Day for August 1997

Temperature (F)

LV24, BAI
LV22, ref
Outside
Roof Shingle Temperature

FSEC 3.0: Orlando, 1-Aug

All black shingle simulations

All white tile simulations
Bottom of Roof Plywood Temperature

FSEC 3.0: Orlando, 1-Aug

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

![Graph showing temperature variations over the hour of the day for different materials and conditions.](image-url)
Building Science Corporation

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
RIDGE

EAVE

CENTER OF PANELS
NOT AFFECTED
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