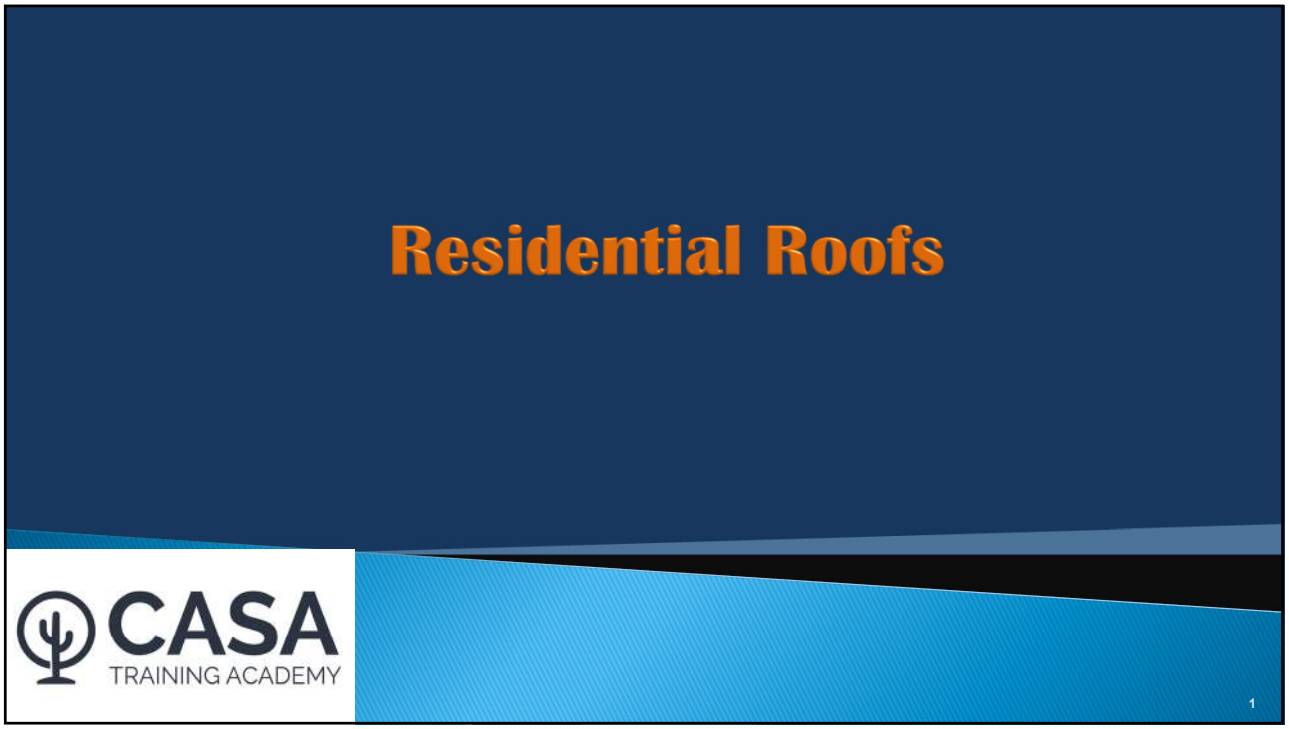
Residential Roofs
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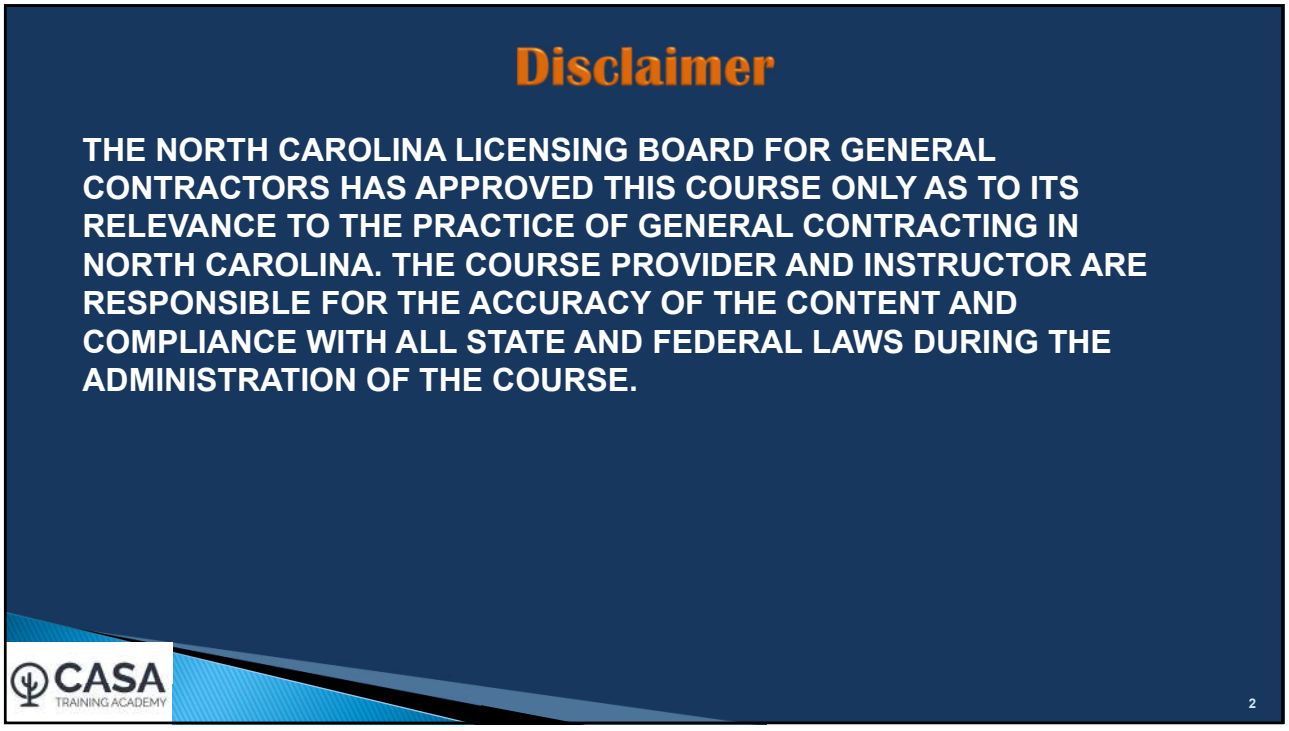
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Purpose of Course

To offer a course of study that will provide the basic understanding of the roof covering systems on a residential structure, including current and historical materials.

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Purpose of Course

- Overview of Roof systems
- What does the NC Residential Building Code say about:
  - Roof structures
  - Roof decks
  - Roof coverings
  - Flashings
  - Roof Design considerations
- Re-Roofing
- Most Common Roof Leaks
  - Moisture intrusion, water paths, Water penetration

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NC Residential Building Code

- Roof Ventilation (R806)
  - Minimum Vent Area (R806.2)
    - Total net free area shall not be less than 1/150 of the space ventilated
    - Can reduce to 1/300 provided at least 50% and not more than 80% is provided by a ventilator located in upper portion of space at least 3 feet above the eave or cornice vents with the balance of the required ventilation provided by the eave or cornice vents.
    - Or, the net free cross-ventilation area may be reduced to 1/300 when a Class I or II vapor retarder is installed on the warn-in-winter side of the ceiling.

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NC Residential Building Code

- Roof Ventilation (R806)
- VAPOR RETARDER CLASS. A measure of the ability of a material or assembly to limit the amount of moisture that passes through that material or assembly. Vapor retarder class shall be defined using the desiccant method with Procedure A of ASTM E96 as follows:
  - Class I: 0.1 perm or less
  - Class II: 0.1 < perm ≤ 1.0 perm
  - Class III: 1.0 < perm ≤ 10 perm

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NC Residential Building Code

- Roof Ventilation (R806)
- VAPOR RETARDER CLASS
  - Class I examples – glass, rubber membrane, polyethylene sheeting, sheet metal, aluminum foil.
  - Class II examples – unfaced expanded polystyrene, fiber-faced polyisocyanurate, asphalt-backed kraft paper on fiberglass batt insulation, kraft paper coated with bitumen, 30lb asphalt-coated paper, plywood

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NC Residential Building Code

- Roof Ventilation (R806)
  - Exceptions:
    - Enclosed attic/rafter space less than 1 square foot of ventilation may be vented with continuous soffit vents only.
    - Enclosed attic/rafter spaces over unconditioned spaces may be vented with continuous soffit vents only.

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NC Residential Building Code

- Roof Ventilation (R806)
  - Vent and insulation clearance (R806.3)
    - Insulation shall not block the free flow of air.
    - Not less than a 1-inch space shall be provided between the insulation and the roof sheathing and at the location of the vent.
  - We install Styrofoam or cardboard baffles.

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NC Residential Building Code

- Unvented attics and unvented enclosed rafter assemblies (R806.5)
  - Unvented attics and unvented enclosed roof framing assemblies created by ceilings that are applied directly to the underside of the roof framing members and structural roof sheathing applied directly to the top of the roof framing members/rafters shall be permitted where all the following conditions are met:
    1. The unvented attic space is completely within the building thermal envelope.
    2. No interior Class I vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly or the ceiling side of the unvented enclosed roof framing assembly.
    3. Where wood shingles or shakes are used, a minimum ¼ inch vented airspace separates the shingles or shakes and the roofing underlayment above the structure sheathing.
    4. Deleted.

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NC Residential Building Code

- **Unvented attics and unvented enclosed rafter assemblies (R806.5)**
  5. **Insulation shall be located in accordance with the following:**
     - **5.1. Item 5.1.1, 5.1.2, 5.1.3 or 5.1.4 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.**
       - **5.1.1. Where only air-impermeable insulation is provided, it shall be applied in direct contact with the underside of the structural roof sheathing.**
       - **5.1.2. Where air-permeable insulation is provided inside the building thermal envelope, it shall be installed in accordance with Section 5.1.1. In addition to the air-permeable insulation installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing in accordance with the R-values in Table R806.5 for condensation control.**

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NC Residential Building Code

- **Unvented attic and unvented enclosed rafter assemblies (R806.5)**
  5. **Insulation shall be located in accordance with following:**
     - **5.1. Item 5.1.1, 5.1.2, 5.1.3 or 5.1.4 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.**
       - **5.1.3. Where both air-impermeable and air-permeable insulation are provided, the air-impermeable insulation shall be applied in direct contact with the underside of the structural roof sheathing in accordance with Item 5.1.1 and shall be in accordance with the R-values in Table R806.5 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.**

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NC Residential Building Code

- **Unvented attic and unvented enclosed rafter assemblies (R806.5)**
  5. **Insulation shall be located in accordance with following:**
     - **5.1. Item 5.1.1, 5.1.2, 5.1.3 or 5.1.4 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.**
       - **5.1.4. Alternatively, sufficient rigid board or sheet insulation shall be installed directly above the structural roof sheathing to maintain the monthly average temperature of the underside of the structural roof sheathing above 45°F (7°C). For calculation purposes, an interior air temperature of 68°F (20°C) is assumed and the exterior air temperature is assumed to be the monthly average outside air temperature of the three coldest months.**

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NC Residential Building Code

- **Unvented attic and unvented enclosed rafter assemblies (R806.5)**
  5. **Insulation shall be located in accordance with following:**
     - **5.2. Where preformed insulation board is used as the air-impermeable insulation layer, it shall be sealed at the perimeter of each individual sheet interior surface to form a continuous layer.**

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NC Residential Building Code

- Attic access (R807)
  - An attic access opening shall be provided to attic areas that exceed 400 square feet and have a vertical height of 60 inches or greater.
  - The net clear opening shall not be less than 20 inches by 30 inches and shall be located in a hallway or other readily accessible location.
  - A 30-inch minimum unobstructed headroom in the attic space shall be provided at some point above the access opening.

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NC Residential Building Code

- Attic access (R807)
  - Exceptions
    1. Concealed areas not located over the main structure including porches, areas behind knee walls, dormers, bay windows, etc. are not required to have access.
    2. Pull down stair treads, stringers, handrails, and hardware may protrude into the net clear opening.

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NC Residential Building Code

- Weather Protection (R903)
  - Roof decks shall be covered with approved roof coverings secured to the building or structure in accordance with the provisions of this chapter. Roof assemblies shall be designed and installed in accordance with this code and the approved manufacturer's installation instructions such that the roof assembly shall serve to protect the building or structure.

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NC Residential Building Code

- Flashing (R903.2)
  - Flashings shall be installed in a manner that prevents moisture from entering the wall and roof through joints in copings, through moisture permeable materials and at intersections with parapet walls and other penetrations through the roof plane/
  - Locations (R903.2.1)
    - At wall and roof intersections
    - Wherever there is a change in roof slope or direction
    - Around roof openings
    - To divert the water away from where the eave of a sloped roof intersects a vertical sidewall.
    - If it is metal, the metal shall be corrosion resistant with a thickness not less than 0.019 inch.

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NC Residential Building Code

- Flashing (R903.2)
  - Crickets and saddles (R903.2.2)
    - A cricket or saddle shall be installed on the ridge side of any chimney or penetration more than 30 inches wide.
    - Coverings shall be sheet metal or of the same material as the roof covering
    - Exception - unit skylights installed in accordance with Section R308.6 and flashed in accordance with the manufacturer's instructions shall be permitted to be installed without a cricket or saddle.

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NC Wind Zones

- Next slide includes Table R301.2(4) – Ultimate Design Wind Speeds by County (MPH)
- Any county NOT listed in the table is 115 MPH
- SMR – Special Mountain Regions
- This table is used to determine how many nails are put into shingles.
- Contact your local jurisdiction for verification.

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NC Wind Zones

Allegany – SMR	Chowan – 130	Harnett – 120	Mitchell – SMR	Sampson – 130
Ashe – SMR	Columbus – 140	Haywood – SMR	New Hanover – 140/150	Scotland – 120
Avery – SMR	Craven – 140	Hoke – 120	Onslow – 130/140/150	Swain – SMR
Beaufort – 130	Cumberland – 120/130	Hyde – 130/140	Pamlico – 140	Tyrell – 130
Bertie – 120/130	Currituck – 130	Jackson – SMR	Pasquotank – 130	Washington – 130
Bladen – 130/140	Dare – 130/140	Johnston – 120	Pender – 130/140/150	Watauga – SMR
Brunswick – 140/150	Duplin – 130	Jones – 140	Perquimans – 130	Wayne – 130
Buncombe – SMR	Gates – 120	Lenoir – 130	Pitt – 130	Wilson – 120
Camden – 130	Graham – SMR	Madison – SMR	Richmond – 120	Yancey – SMR
Carteret – 150	Greene – 130	Martin – 120/130	Robeson – 130	

Contact your local jurisdiction for verification

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NC Wind Zones

Ultimate Design Wind Speed for Mountain Regions

First Floor Finish Elevation (feet)	Ultimate Design Wind Speed (mph)
Less than 2,700	115
2,700 to less than 3,000	120
3,000 to less than 3,500	130
3,500 to less than 4,500	140
4,500 or greater	150

Contact your local jurisdiction for verification

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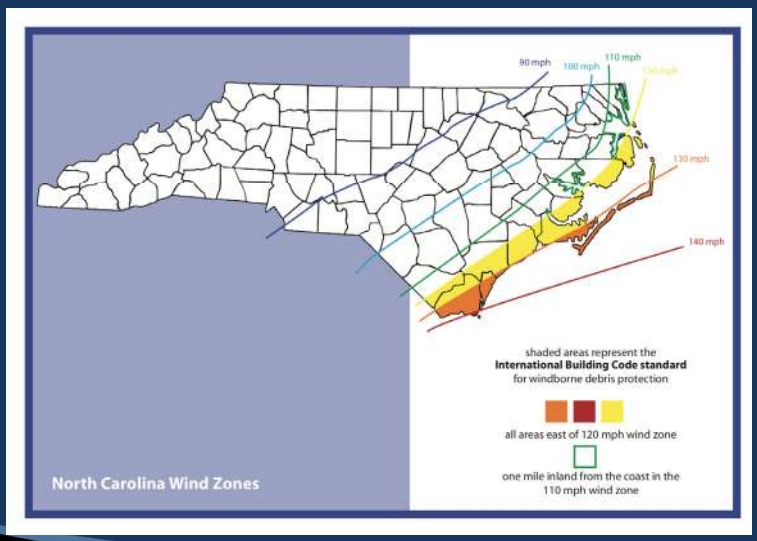
NC Wind Zones



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NC Residential Building Code

- Underlayment (R905.1.1)
  - Has to meet certain American Society of Testing and Materials (ASTM) standards based on the type of roof coverings
  - Asphalt shingles
    - Wind speed < 140 MPH
      - 2:12-4:12 – double layer – 19” starter strip at the eaves, 36” wide sheets overlapped 19”
      - 4:12 and steeper – single layer – Started at the eaves, overlapped 2”, end laps of 4” that are spread 6’ apart
    - Wind speed > 140 MPH
      - Attached with corrosion-resistant fasteners in a grid pattern of 12” between side laps with a 6” spacing at side laps.
      - Attached with metal or plastic cap nails or cap staples with a nominal cap diameter of 1” or more.

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NC Residential Building Code

- Underlayment (R905.1.1)
  - Has to meet certain American Society of Testing and Materials (ASTM) standards based on the type of roof coverings
  - Clay and concrete tile
    - 2.5:12-4:12 – double layer
    - The rest is the same as Asphalt shingles

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NC Residential Building Code

- Underlayment (R905.1.1)
  - Has to meet certain ASTM standards based on the type of roof coverings
  - Metal roof shingles, Mineral-surface roll roofing, Slate and slate-type shingles, Wood shingles, Wood shakes, Metal panels
    - Wind speed < 140 MPH - Apply underlayment in accordance with manufacturer's installation instructions.
    - Wind speed > 140 MPH
      - 2:12-4:12 – double layer – 19" starter strip at the eaves, 36" wide sheets overlapped 19"
      - 4:12 and steeper – single layer – Started at the eaves, overlapped 2", end laps of 4" that are spread 6' apart
      - Attached with corrosion resistant fasteners in a grid pattern of 12" between side laps with a 6" spacing at side laps.
      - Attached with metal or plastic cap nails or cap staples with a nominal cap diameter of 1" or more.

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NC Residential Building Code

- Ice barriers (R905.1.2)
  - In areas where the average daily temperature in January is 25°F or less, an ice barrier shall be installed for all roof coverings
  - Not fewer than two layers of underlayment cemented together or a self-adhering polymer-modified bitumen sheet shall be used in place of normal underlayment and extend from the lowest edges of all roof surfaces to a point not less than 24" inside the exterior wall line of the building.
  - 8:12 or steeper roofs - shall also be applied not less than 36" measured along the roof slope from the eave edge of the building.

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NC Residential Building Code

- Asphalt Shingles (R905.2)
  - Sheathing (R905.2.1) – shall be fastened to solidly sheathed decks
  - Slope (R905.2.2) - can be used on 2:12 or steeper roofs
  - Attachment (R905.2.6) – shall have the minimum number of fasteners required by the manufacturer, but not less than four fasteners per strip shingle or two fasteners per individual shingle.
    - Exception – six fasteners per shingle where the roof is in:
      - Ultimate wind speed is 130 MPH and the eave is 20+ feet high
      - Ultimate wind speed is 140 MPH
      - Special mountain regions

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NC Residential Building Code

- Asphalt Shingles (R905.2)
  - Base and cap flashing (R905.2.8.1)
    - Shall be installed in accordance with manufacturer's installation instructions.
    - Base flashing shall be of either corrosion resistant metal of minimum nominal 0.019" thickness or mineral-surface roll roofing weighing a minimum of 77 lbs/100 sqft.
    - Cap flashing shall be corrosion resistant metal of minimum nominal 0.019" thickness.

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NC Residential Building Code

- Asphalt Shingles (R905.2)
  - Base and cap flashing (R905.2.8.1)
    - Continuous at horizontal surfaces (apron or head flashing)
    - Step at sloped surfaces
    - 4" in height and 4" in width
    - Counterflashing installed on masonry veneer

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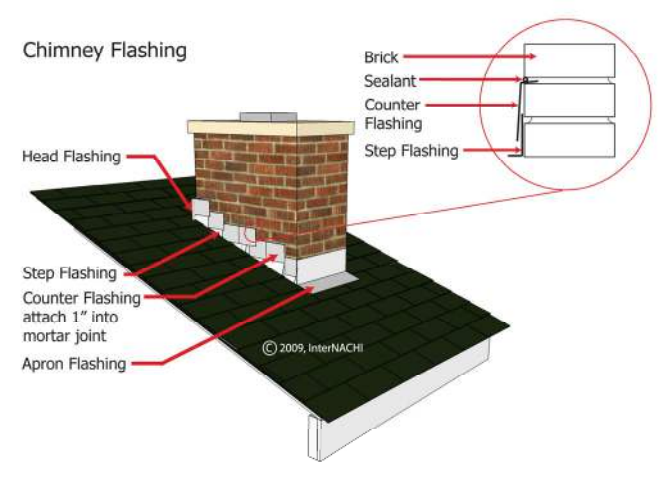
NC Residential Building Code

Masonry chimneys can have four types of flashing
1. Head flashing
2. Step flashing
3. Apron flashing
4. Counter flashing



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NC Residential Building Code

Most of the time, the counter flashing is a solid piece of metal.

Pay attention to the sealant along the top of the flashing.

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NC Residential Building Code

- **Asphalt Shingles (R905.2)**
  - **Valleys (R905.2.8.2) - valley linings shall be installed in accordance with the manufacturer's instructions before applying shingles. Valley linings of the following types shall be permitted:**
    1. **For open valleys (valley lining exposed) lined with metal, the valley lining shall be not less than 24" wide and of any of the corrosion-resistant metals**
    2. **For open valleys, valley lining of two plies of mineral-surfaced roll roofing shall be permitted. The bottom layer shall be 18"and the top layer not less than 36" wide**
    3. **For closed valleys (valley covered with shingles), valley lining of one ply of smooth roll roofing not less than 36" or valley lining as described in Item 1 or 2 shall be permitted. Self-adhering polymer modified bitumen underlayment shall be permitted in lieu of the lining material.**

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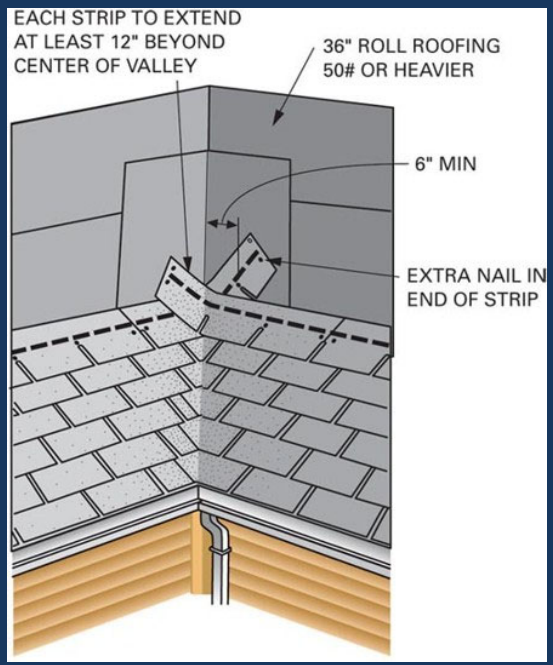
Example of valley underlayment



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Visible part of open valley flashing

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NC Residential Building Code

- Clay (ASTM C1167) and Concrete tile (ASTM C1492) (R905.3)
  - Deck requirements (R905.3.1) –installed only over solid sheathing or spaced structural sheathing boards.
  - Deck slope (R905.3.2) – can be used on 2.5:12 or steeper roofs
  - Fasteners (R905.3.6)
    - Nails shall be corrosion resistant and not less than 5/16" head and penetrate the deck at least ¾" or through the deck
    - Attaching wire for clay or concrete tile shall not be smaller than 0.083".
    - Perimeter fastening areas include three tile courses but not less than 36" from either side of hips or ridges and edges of eaves and gable rakes.

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NC Residential Building Code

- Clay (ASTM C1167) and Concrete tile (ASTM C1492) (R905.3)
  - Application (905.3.7)
    - Tile Shall be applied in accordance with this chapter and the manufacturer's installation instructions based on the following:
      1. Climate Conditions
      2. Roof Slope
      3. Underlayment System
      4. Type of Tile being installed
    - Perimeter tiles – fastened with minimum one fastener / tile
    - Tile with installed weight < 9 lbs. / sqft require minimum of 1 fastener/tile regardless of roof slope.
    - Wind speeds > 130 MPH & Roof > 40' above grade - follow manufacturer's installation instructions
    - Snow areas – minimum of 2 fasteners / tile

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NC Residential Building Code

- Clay (ASTM C1167) and Concrete tile (ASTM C1492) (R905.3)
  - Flashing (905.3.8)
    - At juncture of roof vertical surfaces, flashing and counter flashing shall be provided and metal not less than 0.019" (No 26 galvanized sheet grade) corrosion-resistant metal.
    - Valley flashing shall extend at least 11" from the centerline each way and have a splash diverter rib not less than 1" in height at the flow line formed as part of the flashing.
    - End lap of not less than 4"
    - 3:12 slope and steeper – 36" wide underlayment under valley
    - Average daily temperature in January of 25°F or less, metal valley flashing underlayment shall be solid-cemented to the roofing underlayment for slopes less than 7:12 or be of self-adhering polymer modified bitumen sheet.

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Example of Clay tile installation

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Common Installation Issues:
- Flashing
- Open areas
- Poor plan for water flow

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- Difficult areas to see.
- Gas flue in the center of the roof valley.

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Can any of these flashing boot flanges properly prevent water infiltration?

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NC Residential Building Code

- Metal roof shingles (R905.4)
  - Deck requirements (R905.4.1) – applied to a solid or closely fitted deck, except where the roof covering is specifically designed to be applied to spaced sheathing.
  - Deck slope (R905.3.2) – can be used on 3:12 or steeper roofs
  - Application (R905.4.5) – shall be secured to the roof in accordance with this chapter and the *approved* manufacturer's installation instructions

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NC Residential Building Code

- Metal roof shingles (R905.4)
  - Flashing (R905.4.6)
    - Valley flashing shall:
      - Be corrosion-resistant metal of the same material of the roof coverings
      - Extend 8+" from the centerline
      - Have a splash diverter rib not less than ¾"
      - Have an end lap of 4+"
      - 36" wide underlayment of one layer running the full length of the valley, in addition to underlayment required for metal roof shingles.
      - In area with average daily temperature in January of 25°F or less, underlayment shall be solid cemented to the roofing underlayment for sloped under 7:12 or sell-adhering polymer modified bitumen

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NC Residential Building Code

- Mineral-surfaced roll roofing (R905.5)
  - Deck requirements (R905.5.1) – shall be fastened to a solidly sheathed roofs.
  - Deck slope (R905.3.2) – can be used on 1:12 or steeper roofs
  - Application (R905.4.5) – shall be installed in accordance with this chapter and the manufacturer's installation instructions

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NC Residential Building Code

- Slate & Slate Type Shingles (R905.6)
  - Deck Requirements (R905.6.1) – fastened on solidly sheathed roofs
  - Deck slope (905.6.2) – can be used on 4:12 or steeper roofs
  - Application (R905.6.5)
    - Minimum head lap accordance with table below.
    - Secured with two fasteners per slate

SLOPE	HEADLAP (inches)
4:12 ≤ slope < 4:12	4
8:12 ≤ slope < 20:12	3
Slope ≤ 20:12	2

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NC Residential Building Code

- Slate shingles (R905.6)
  - Flashing (R905.6.6)
    - Flashing and counterflashing shall be made with sheet metal.
    - Valley flashing shall be not less than 16” wide.
    - Valley and flashing metal shall be a minimum uncoated thickness of 0.0179-inch zinc coated G90.
    - Chimneys, stucco or brick walls shall have not less than two plies of felt for a cap flashing consisting of a 4” wide strip of felt set in plastic cement and extending 1” above the first felt and a top coating of plastic cement.
    - The felt shall extend over the base flashing 2 inches.

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Examples of slate shingles

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NC Residential Building Code

- Wood shingles (R905.7)
  - Deck requirements (R905.7.1) – installed to a solid or spaced sheathing. Where spaced sheathing is used, sheathing boards shall be not less than 1”x4” and shall be spaced on centers equal to the weather exposure to coincide with the placement of fasteners.
    - In areas where the average daily temperature in January is 25°F or less, solid sheathing is required on that portion of the roof requiring the application of an ice barrier.
  - Deck slope (R905.7.2) – can be used on 3:12 or steeper roofs

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NC Residential Building Code

- Wood shingles (R905.7)
  - Application (R905.7.5)
    - Laid with a side lap not less than 1 ½" between joints in courses, and two joints shall not be in direct alignment in any three adjacent courses.
    - Spacing between shingles shall be not less than $^{1}/_{4}$ - $^{3}/_{8}$".

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NC Residential Building Code

- Wood shingles (R905.7)
  - Application (R905.7.5)
    - Weather exposure for wood shingles shall not exceed table below:

Length & Grade	Exposure 3:12 < 4:12	Exposure – 4:12+
16 – No. 1	3 ¾	5
16 – No. 2	3 ½	4
16 – No. 3	3	3 ½
18 – No. 1	4 ¼	5 ½
18 – No. 2	4	4 ½
18 – No. 3	3 ½	4
24 – No. 1	5 ¾	7 ½
24 – No. 2	5 ½	6 ½
24 – No. 3	5	5 ½

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NC Residential Building Code

- Wood shingles (R905.7)
  - Application (R905.7.5)
    - Fasteners for untreated (naturally durable) wood shingles shall be box nails in accordance with Table R905.7.5(2).
    - Nails shall be stainless steel Type 304 or 316 or hot-dipped galvanized with a coating weight of ASTM A153 Class D (1.0 oz/ft2).
    - Alternatively, two 16-gage stainless steel Type 304 or 316 staples with crown widths 7/16 inch minimum, ¾ inch maximum, shall be used.
    - Fasteners installed within 15 miles of salt water coastal areas shall be stainless steel Type 316.

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NC Residential Building Code

- Wood shingles (R905.7)
  - Application (R905.7.5)
    - Fasteners for fire retardant-treated shingles in accordance with Section R902 or pressure-impregnated-preservative-treated shingles of naturally durable wood in accordance with AWPA U1 shall be stainless steel Type 316.
    - All fasteners shall have a minimum penetration into the sheathing of 3/4 inch.
    - For sheathing less than 3/4 inch in thickness, each fastener shall penetrate through the sheathing.
    - Wood shingles shall be attached to the roof with two fasteners per shingle, positioned in accordance with the manufacturer's installation instructions.
    - Fastener packaging shall bear a label indicating the appropriate grade material or coating weight.

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NC Residential Building Code

- Wood shingles (R905.7)
  - Valley flashing (R905.7.6)
    - Roof flashing shall:
      - Not less than no. 26 gauge corrosion-resistant sheet metal
      - Extend 10” from the centerline for roofs less than 12:12
      - Extend 7” from the centerline for roofs 12:12 or steeper
      - Have an end lap of 4+”

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Examples of Wood Shingles

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NC Residential Building Code

- Wood shakes (R905.8)
  - Deck requirements (R905.8.1) –
    - Installed to a solid or spaced sheathing.
    - Where spaced sheathing is used, sheathing boards shall be not less than 1”x4” and shall be spaced on centers equal to the weather exposure to coincide with the placement of fasteners.
    - Where 1”x4” spaced sheathing is installed at 10” on center, additional 1”x4” boards shall be installed between the sheathing boards. (different from wood shingles)
    - In areas where the average daily temperature in January is 25°F or less, solid sheathing is required on that portion of the roof requiring the application of an ice barrier.
  - Deck slope (R905.8.2) – can be used on 3:12 or steeper roofs

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NC Residential Building Code

- Wood shakes (R905.8)
  - Interlayment (R9605.8.4) shall comply with ASTM D226 Type I, which is effectively #30 felt paper.
  - Application (R905.8.6)
    - Laid with a side lap not less than 1 ½” between joints in adjacent courses.
    - Spacing between shakes in the same course shall be not less than $^{3}/_{8}$ - $^{5}/_{8}$” including taper sawn shakes.

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NC Residential Building Code

- Wood shakes (R905.8)
  - Application (R905.8.6)
    - Weather exposure for wood shingles shall not exceed table to the right:
    - Notice that R905.8.2 states wood shakes can be installed on roofs of 3:12 but the table only shows 4:12 or steeper.

Roofing Material	Length & Grade	Exposure – 4:12+
Shakes of naturally durable wood	18 – No. 1 24 – No. 2	7 ½ 10
Preservative-treated taper-sawn shakes of Southern Yellow Pine	18 – No. 1 24 – No. 1 18 – No. 1 24 – No. 2	7 ½ 10 5 ½ 7 ½
Taper-sawn shakes of naturally durable wood	18 – No. 1 24 – No. 1 18 – No. 2 24 – No. 2	7 ½ 10 5 ½ 7 ½

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NC Residential Building Code

- Wood shakes (R905.8)
  - Application (R905.8.6)
    - Fasteners for untreated (naturally durable) wood shakes shall be box nails in accordance with Table R905.7.5(2).
    - Nails shall be stainless steel Type 304 or 316 or hot-dipped galvanized with a coating weight of ASTM A153 Class D (1.0 oz/ft2).
    - Alternatively, two 16-gage stainless steel Type 304 or 316 staples with crown widths 7/16 inch minimum, ¾ inch maximum, shall be used.
    - Fasteners installed within 15 miles of salt water coastal areas shall be stainless steel Type 316.

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NC Residential Building Code

- Wood shakes (R905.8)
  - Application (R905.8.6)
    - Wood shakes shall be attached to the roof with two fasteners per shingle, positioned in accordance with the manufacturer's installation instructions.
    - Fasteners for fire retardant-treated shakes in accordance with Section R902 or pressure-impregnated-preservative-treated shakes of naturally durable wood in accordance with AWPA U1 shall be stainless steel Type 316.
    - All fasteners shall have a minimum penetration into the sheathing of 3/4 inch.
    - For sheathing less than ¾" in thickness, each fastener shall penetrate through the sheathing.
    - Fastener packaging shall bear a label indicating the appropriate grade material or coating weight.

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NC Residential Building Code

- Wood shakes (R905.8)
  - Shake placement (R905.8.7)
  - The starter course at the eaves shall be doubled and the bottom layer shall be either 15", 18" or 24" wood shakes or wood shingles.
  - 15" or 18" wood shakes shall be permitted to be used for the final course at the ridge.
  - Shakes shall be interlaid with 18" strips of not less than No. 30 felt shingled between each course in such a manner that no felt is exposed to the weather by positioning the lower edge of each felt strip above the butt end of the shake it covers a distance equal to twice the weather exposure.

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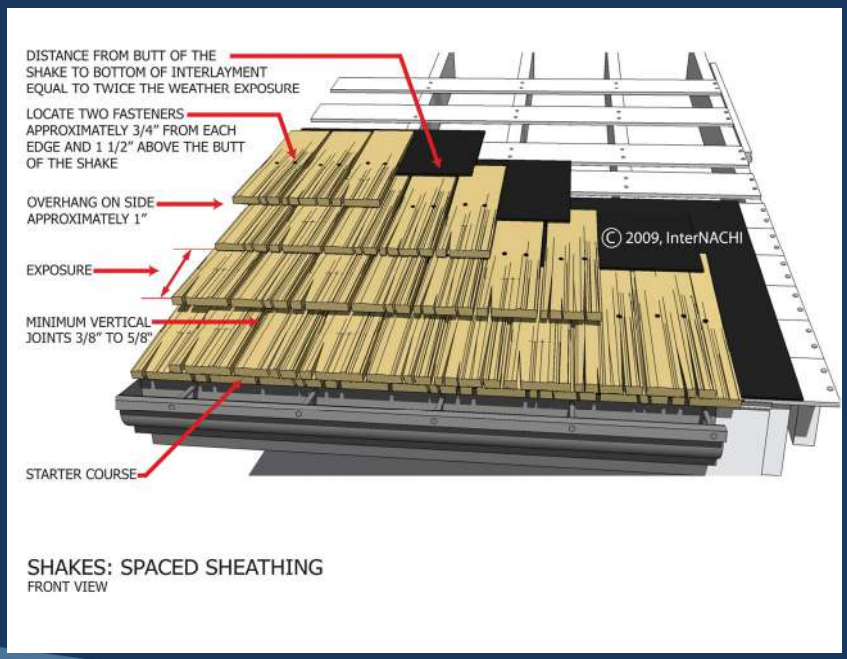
Wood Shake installation



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NC Residential Building Code

- Wood shakes (R905.8)
  - Valley flashing (R905.8.8)
    - Roof flashing shall:
      - Not less than no. 26 gauge corrosion-resistant sheet metal
      - Extend 11+" from the centerline
      - Have an end lap of 4+"

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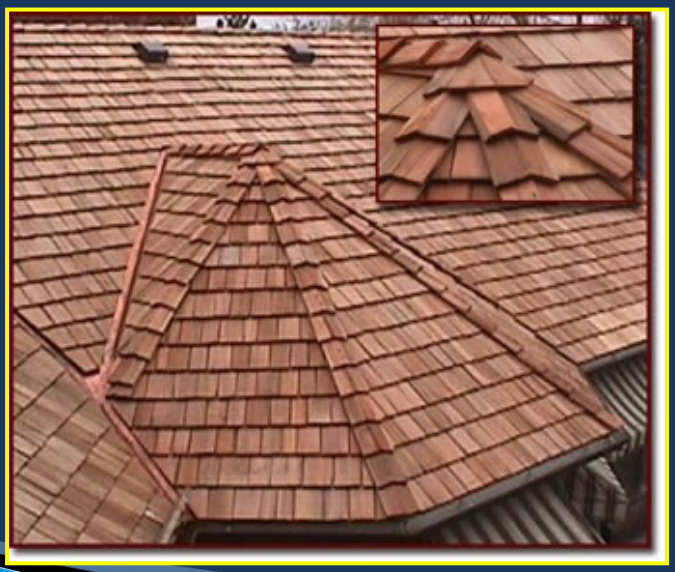
Wood Shake – Proper Installation



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Wood Shakes - Recognizing Roof Defects

- Splitting shakes with alignment issues

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Wood Shakes - Recognizing Roof Defects

- Missing shakes

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Wood Shakes - Recognizing Roof Defects

- Curled/cupped shakes

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Wood Shakes - Recognizing Roof Defects

- Decayed edges
- Heavy moss growth

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NC Residential Building Code

- Built-up roofs (R905.9)
  - Slope (R905.9.1)
    - Minimum ¼:12 (2% slope) for drainage
    - Coal-Tar built up roof – minimum $^{1}/_{8}$:12 (1% slope)
  - Material standards (R905.9.2) – table R905.9.2 list ASTM standards the materials have to follow.
  - Application (R905.9.3) – shall be installed in accordance with this chapter (but the material listed above is the entire chapter!) and the manufacturer's instructions.

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NC Residential Building Code

- Metal roof panels (R905.10)
  - Deck requirements (R905.10.1) – shall be applied to solid or spaced sheathing except where the roof covering is specifically designed to be applied to space supports.
  - Slope (R905.10.2)
    - Lapped, nonsoldered-seam without applied lap sealant – 3:12+
    - Lapped, nonsoldered-seam with applied lap sealant – ½:12+
    - Standing seam – ¼:12+

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NC Residential Building Code

- Metal roof panels (R905.10)
  - Material standards (R905.10.3)
  - Metal-sheet roof covering systems that incorporate supporting structural members shall be designed in accordance with the *International Building Code*.
  - Metal-sheet roof coverings installed over structural decking shall comply with Table R905.10.3(1).
  - The materials used for metal-sheet roof coverings shall be naturally corrosion resistant or provided with corrosion resistance in accordance with the standards and minimum thicknesses shown in Table R905.10.3(2).

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NC Residential Building Code

- Metal roof panels (R905.10)
  - Attachment (R905.10.4)
  - Metal roof panels shall be secured to the supports in accordance with this chapter and the manufacturer's installation instructions.
  - In the absence of manufacturer's installation instructions, the following fasteners shall be used:
    1. Galvanized fasteners shall be used for steel roofs.
    2. Copper, brass, bronze, copper alloy and 300-series stainless steel fasteners shall be used for copper roofs.
    3. Stainless steel fasteners are acceptable for metal roofs.

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NC Residential Building Code

- Modified bitumen roofing (R905.11)
  - Slope (R905.11.1) – shall have a design slope of not less than ¼:12 (2% slope) for drainage.
  - Material standards – table R905.11.2 lists the ASTM standards
  - Application (R905.11.3) – shall be installed in accordance with this chapter (this is the entire chapter!) and the manufacturer's instructions.

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NC Residential Building Code

- Thermoset single-ply roofing (R905.12)
  - Slope (R905.12.1) – shall have a design slope of not less than ¼:12 (2% slope) for drainage.
  - Material standards (R905.12.2)– shall comply with ASTM D4637, ASTM D5019 or Canadian General Standards Board (CGSB) 37-GP-52M.
  - Application (R905.12.3) – shall be installed in accordance with this chapter (this is the entire chapter!) and the manufacturer's instructions.
  - Thermosets use a tape or a contact cement to create the lap.
  - Thermosets are from rubber polymers.
  - The most common is EPDM (ethylene propylene diene monomer)

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NC Residential Building Code

- Thermoplastic single-ply roofing (R905.13)
  - Slope (R905.13.1) – shall have a design slope of not less than ¼:12 (2% slope) for drainage.
  - Material standards (R905.13.2) – shall comply with ASTM D4434, ASTM D6754, ASTM D6878 or CGSB CAN/CGSB 37.54.
  - Application (R905.13.3) – shall be installed in accordance with this chapter (this is the entire chapter!) and the manufacturer's instructions.
  - Thermoplastic seams are hot-air welded together to form the lap.
  - Most common are PVC and TPO
  - Most have a reinforcement layer, usually polyester or fiberglass for strength and dimensional stability.
  - Typically lighter in color

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Issues with membrane roofs

- Standing water or wet leaves have no adverse effect on the membrane.
- EPDM has been used as pool liners for years.
- However, ponding should not be allowed on any flat roof
- In other words, water should not remain on a roof longer than 48 hours after precipitation.
- Ponding can exceed structural design weight allowances and freezing over seams can apply stress that may lead to seam failure.
- Ponding can cause temperature differential in sections of the roof, which can allow the material to age/weather differently.
- Ponding can also allow condensation to form in the attic, which is typically not visible.

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Issues with membrane roofs

- **Shrinkage Failure** – prone to shrink (1-2%). On a large area, this can add up to several feet, which can cause bridging and/or failures at flashing and terminations
  - Shrinkage is less likely if roof is fully adhered to the roof deck.
- **Lap Failure**
  - Prior to 1986, lap splice cement was made with neoprene polymer ad laps occasionally failed.
  - Neoprene rubber used as flashing material had a short life and were known to fail after becoming brittle.
  - New technology was introduced often called “Peel and Stick” proved to be reliable.
  - Most recent recommendations is to use uncured EPDM at corners and penetrations and cured EPDM for all other applications.

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Issues with membrane roofs

- If you can't determine if it is PVC, TPO or EPDM, call it single ply membrane.
- Start in the attic if one exists and look for water infiltration – stains/leaks – integrity of roof deck.
- Venting membrane roofs – rare in residential construction, but better to be vented than not.
- Is roof soft to walk on? – can indicate a moisture problem in the decking or insulation.
- Check all laps and perimeter flashing closely – look for separation, wrinkles, openings, splits or tears.

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Issues with membrane roofs

- Check the penetrations – generally will have a pitch pocket or pan, which should be filled with a membrane filler material.
- Wall flashing – usually membrane or a combination of membrane and metal counter flashing. Check for adequate seal, secure anchors or anchor bars.
- Check the entire roof for cuts, punctures, and tears.
- Look for rain drop size moisture spots and check closely for pinholes. If there is a pinhole, heat from the sun will draw moisture out of the pinhole creating a moisture spot.

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Recognizing Flat Roof Defects

- Water ponding on top of EPDM roofing
- Improper slope

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Recognizing Flat Roof Defects

- Evidence of water pooling on top of EPDM roofing with improper slope.

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NC Residential Building Code

- Sprayed polyurethane foam roofing (R905.14)
  - Slope (R905.14.1) – shall have a design slope of not less than ¼:12 (2% slope) for drainage.
  - Material standards (R905.14.2) – shall comply with ASTM C1029, Type III or IV or ASTM D7425.
  - Application (R905.14.3) – Foamed-in-place roof insulation shall be installed in accordance with this chapter (this is the entire chapter!) and the manufacturer's instructions.
    - A liquid-applied protective coating that complies with table R905.14.3 shall be applied not less than 2 hours nor more than 72 house following the application of the foam.

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NC Residential Building Code

- Liquid-applied roofing (R905.15)
  - Slope (R905.15.1) – shall have a design slope of not less than ¼:12 (2% slope) for drainage.
  - Material standards (R905.14.2) – shall comply with ASTM C836, C957, D1227, D3468, D6083, D6694 OR D6947
  - Application (R905.14.3) – Foamed-in-place roof insulation shall be installed in accordance with this chapter (this is the entire chapter!) and the manufacturer's instructions.

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NC Residential Building Code

- Reroofing (R908)
  - Structural and construction loads (R908.2) – structural roof components shall be capable of supporting the roof covering system and the material and equipment loads that will be encountered during installation of the roof covering system.
  - Roof replacement (R908.3) – shall include removal of existing layers or roof coverings down to the roof deck.
    - Exception – ice barrier membrane that is adhered to the deck may remain and must be covered with an additional layer of ice barrier membrane.

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NC Residential Building Code

- Reroofing (R908)
  - Roof re-cover (R908.3.1) – the installation of a new roof covering over an existing roof covering shall be permitted where any of the following conditions occur:
    1. Where the new roof covering is installed in accordance with the roof covering manufacturer's approved instructions
    2. Complete and separate roofing systems, such as standing-seam metal roof systems, that are designed to transmit the roof loads directly to the building's structural system and do not rely on existing roofs and roof coverings for support, shall not require the removal of existing roof coverings.
    3. Metal panel, metal shingle and concrete and clay tile roof coverings shall be permitted to be installed over existing wood shake roofs where applied in accordance with Section R908.4.
    4. The application of a new protective coating over an existing spray polyurethane foam roofing system shall be permitted without tear-off of existing roof coverings.

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NC Residential Building Code

- Reroofing (R908)
  - Roof re-cover not allowed (R908.3.1.1) – a roof recover shall not be permitted where any of the following conditions occur:
    1. Where the existing roof or roof covering is water soaked or has deteriorated to the point that the existing roof or roof covering is not adequate as a base for additional roofing.
    2. Where the existing roof covering is slate, clay, cement or asbestos-cement tile.
    3. Where the existing roof has two or more applications of any type of roof covering.

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NC Residential Building Code

- Reroofing (R908)
  - Roof re-covering (R908.4) - Where the application of a new roof covering over wood shingle or shake roofs creates a combustible concealed space, the entire existing surface shall be covered with gypsum board, mineral fiber, glass fiber or other *approved* materials securely fastened in place.
  - Reinstallation of materials (R908.5)
    - Existing slate, clay or cement tile shall be permitted for reinstallation, except that damaged, cracked or broken slate or tile shall not be reinstalled.
    - Any existing flashings, edgings, outlets, vents or similar devices that are a part of the assembly shall be replaced where rusted, damaged or deteriorated. Aggregate surfacing materials shall not be reinstalled.

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NC Residential Building Code

- Reroofing (R908)
  - Flashings (R908.6)
    - Flashings shall be reconstructed in accordance with *approved* manufacturer's installation instructions.
    - Metal flashing to which bituminous materials are to be adhered shall be primed prior to installation.

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Types of Shingle Failure

- Storm Damage
- Improper Storage and Handling prior to Installation
- Improper Nailing
- Improper Flashing
- Defective Product/Material leading to thermal splitting, cracking, blistering, staining and, in some cases, cupping or curling.

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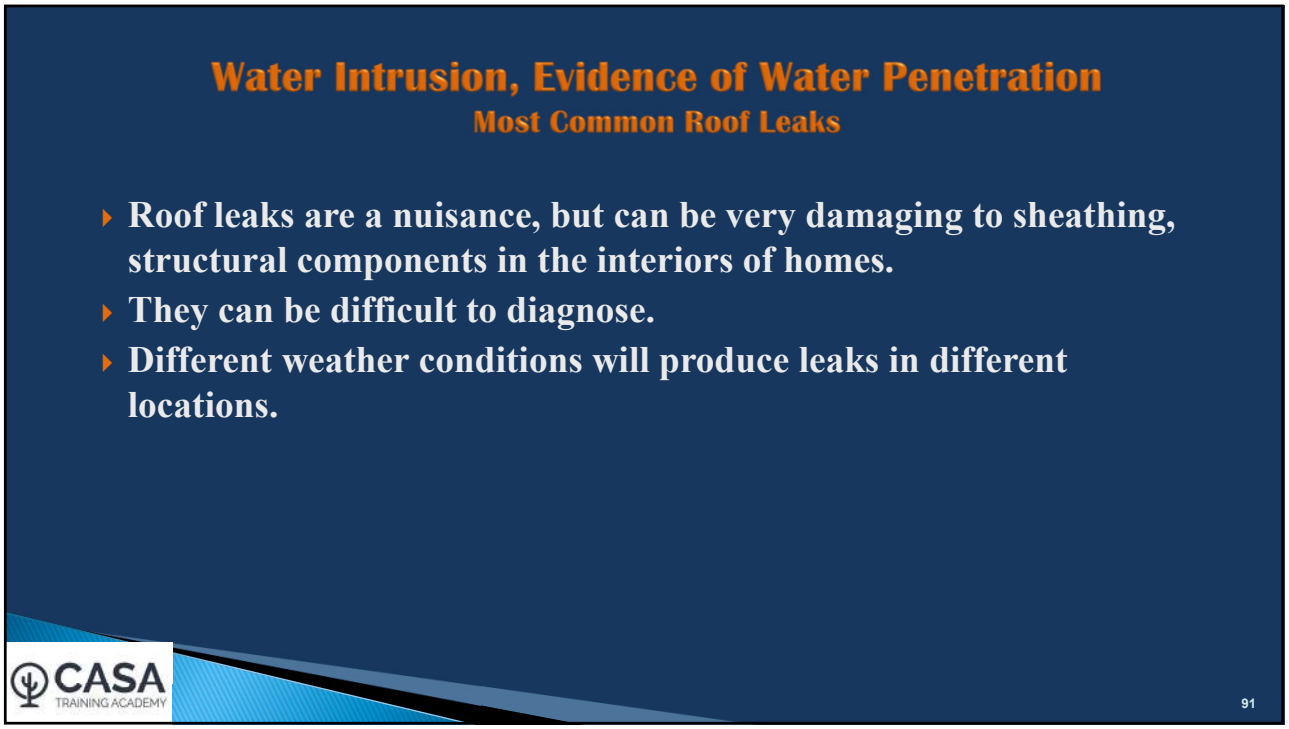
Water Intrusion, Evidence of Water Penetration
Most Common Roof Leaks
Roof leaks are a nuisance, but can be very damaging to sheathing, structural components in the interiors of homes.
They can be difficult to diagnose.
Different weather conditions will produce leaks in different locations.
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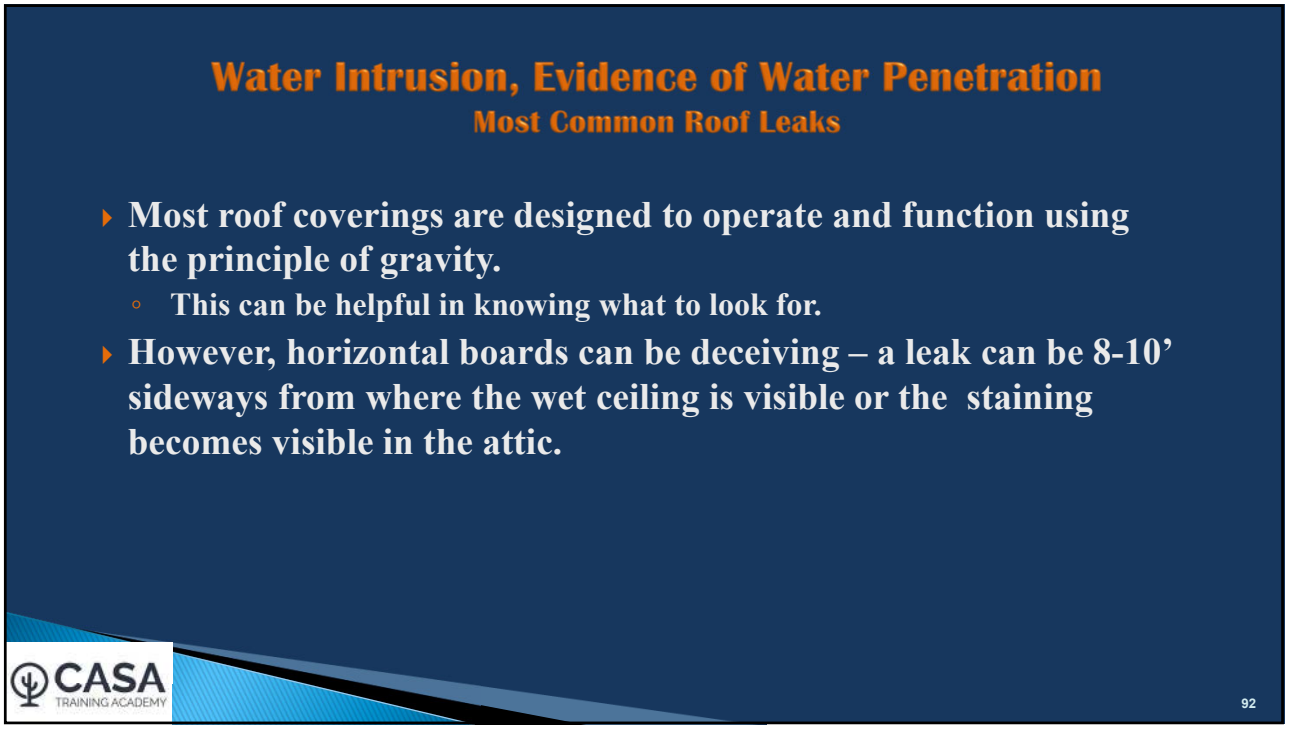
Water Intrusion, Evidence of Water Penetration
Most Common Roof Leaks
Most roof coverings are designed to operate and function using the principle of gravity.
This can be helpful in knowing what to look for.
However, horizontal boards can be deceiving – a leak can be 8-10' sideways from where the wet ceiling is visible or the staining becomes visible in the attic.
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Protocol for Identifying Roof Problems

- Field of Roof Covering
- Valleys
- Head Wall Flashing
- Side Wall Step Flashing
- Chimneys
- Plumbing Vent Pipes
- HVAC Flue Penetrations
- Skylights
- Wind Blown Rain
- Ice Dams
- Non-Roof Leaks

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Protocol for Identifying Roof Problems

- The Field of Shingles
  - With older shingles, it is possible that the leak is within the roof field.
  - This means the expansion of shingles, slate, shakes, whatever.
  - This is inclusive to damaged shingles, cracks, tears, breaking, cupping, curling, loss of granules, pits, bubbles, or blisters.

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Protocol for Identifying Roof Problems

- Valleys
  - Valley is a line where two roof planes intersect.
  - Valley should be re-enforced – additional felt.
  - Valleys should never be walked on – can tear of break shingles or felt under shingles.
  - Several methods for shingles in valleys – open valley, cut/half-woven valley, and fully woven valley.

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Protocol for Identifying Roof Problems

- Headwall flashing
  - Top of roof that stops at a vertical wall/surface.
  - A flashing must be in place to divert water streaming down the wall away from the stopping point of the shingles.
  - Flashing should generally be behind the wall cladding system except for brick.
  - Flashing should be bent and inset 1” in a mortar joint of brick.
  - Tar, caulk, sealant, or roofing cement should never be used in conjunction with these materials except brick.
  - If you see tar, caulk, sealant or roofing cement in these areas, may be a sign of a prior leak and patch work.

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Protocol for Identifying Roof Problems

- Step flashing
  - As each row of shingles is laid, a step flashing is installed over the shingles next to the wall.
  - Part of the flashing turns up the wall and part extends over the shingle tab, then is covered by the next layer of tabs.
  - A hairline crack along the flashing can allow vast amounts of water infiltration
  - Look for rust, holes, extra solder, tar or sealant – can be a clue of a leak.

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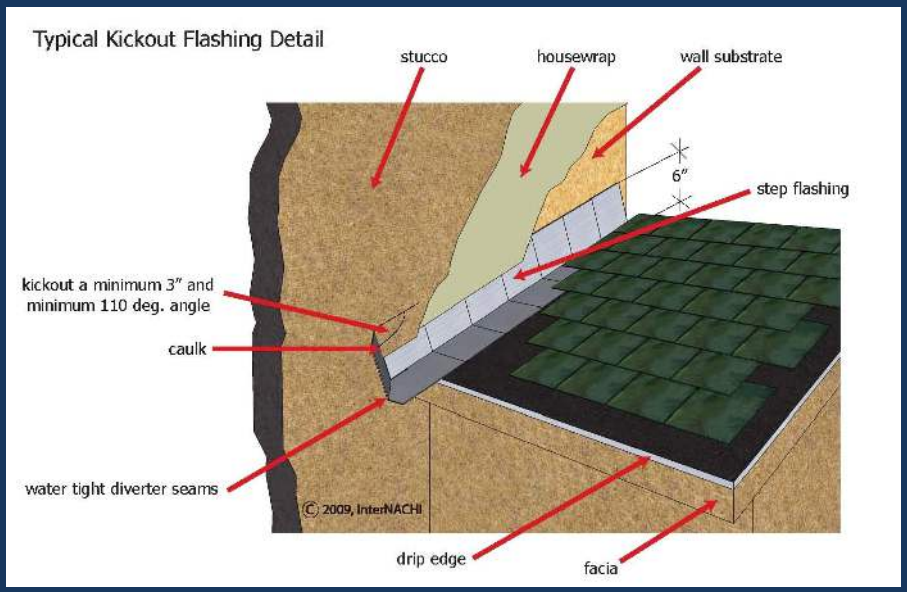
Step & Kickout Flashing



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Protocol for Identifying Roof Problems

- Chimneys
  - Contains 4 different types of flashings.
  - All must be right or leaks will occur.
  - The counter flashing that goes into the brick mortar joints must be right.
  - A hairline crack above the flashing can allow vast amounts of water to run behind the flashing.

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Protocol for Identifying Roof Problems

- Plumbing Vent Flashing
  - Many incorporate rubber seals with an aluminum or rubber flashing flange.
  - The rubber can fail, dry rot, deteriorate in 7-15 years.
  - UV radiation is main cause of failure.
  - Look for cracking rubber around the pipe.
  - The flashing should start under the upper shingle and the upper half of tabs, then terminate on top of the lower shingle tab.

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Protocol for Identifying Roof Problems

- Metal Exhaust Vent Flashing
  - Metal boots and metal storm collars/rain caps.
  - The boot is not sealed to the pipe to reduce heat transfer to the roof.
  - Collars/caps must fit tightly around the vertical pipe and be sealed.
  - Collars/caps must be installed at the top of the boot.

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Protocol for Identifying Roof Problems

- Missing metal storm collar/rain cap on center metal exhaust vent

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Protocol for Identifying Roof Problems

- Skylights
  - If not installed absolutely correct – skylights will leak.
  - Leaks develop where the roofing meets the skylight on the ridge side of the roof.
  - Most leaks develop because water pools/puddles on the upper side until it builds up to run down the sides. Pine needles and leaf debris can cause water to pool.
  - A good skylight will have the head of the skylight sloped or bent to divert water to sides of the skylight.

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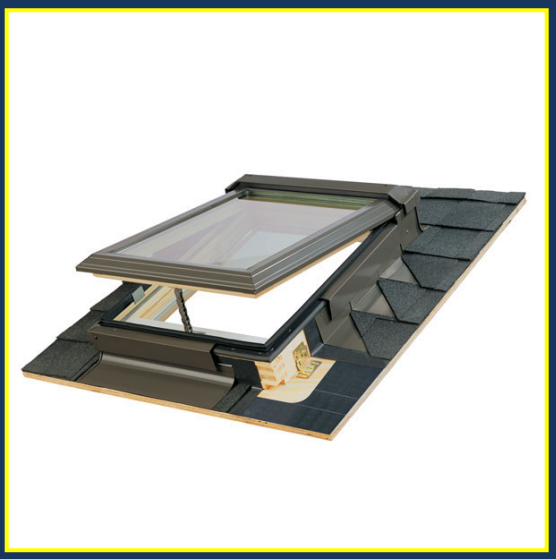
Protocol for Identifying Roof Problems

Example of a skylight and flashing around a skylight



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Protocol for Identifying Roof Problems

Example of a skylight and flashing around a skylight

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Protocol for Identifying Roof Problems

- **Ice Dam Leaks**
  - **Can be very perplexing.**
  - **Leaks can happen even if everything in your roof is just fine.**
  - **Ice dams block the natural flow of water down the shingles.**
  - **Water begins to back up under the flashing, shingles, tar paper, etc.**
  - **The only solution is to install a membrane under the roofing or install a heating strip.**
  - **The membrane will not stop the ice dam, but will stop the leak.**

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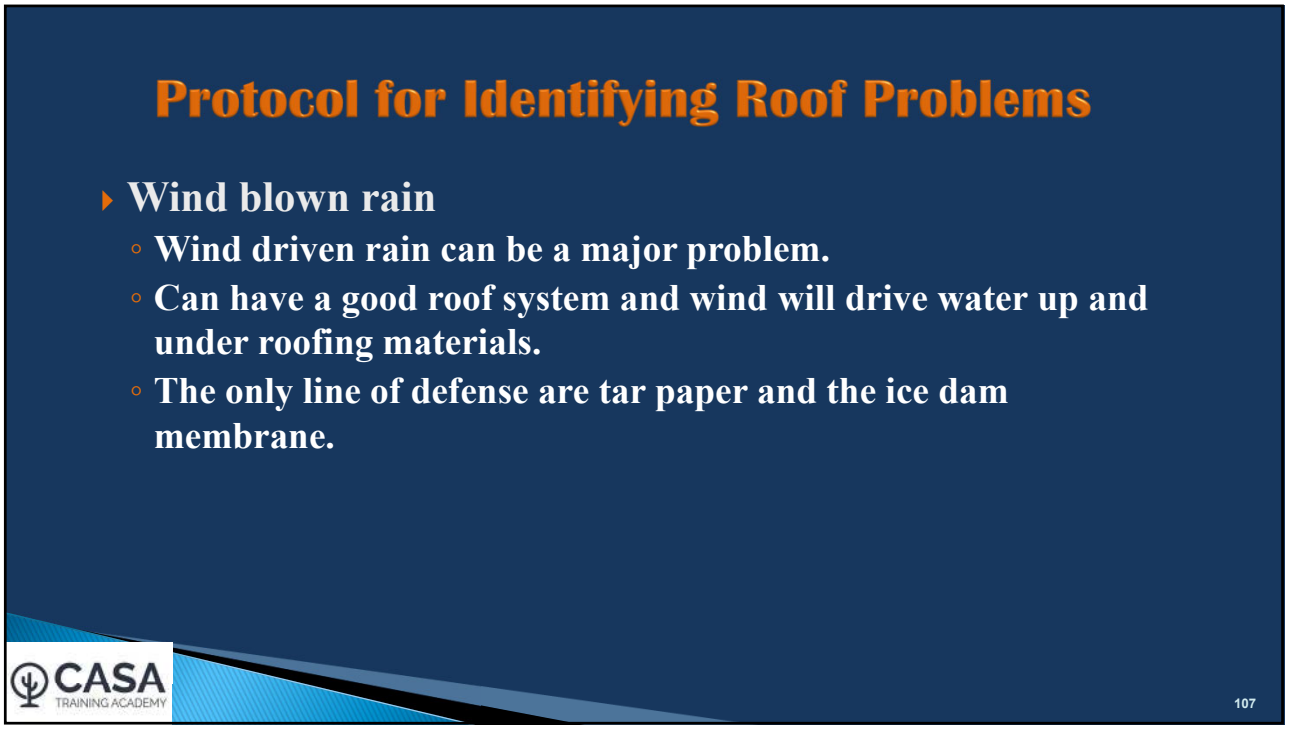
Protocol for Identifying Roof Problems
Wind blown rain
Wind driven rain can be a major problem.
Can have a good roof system and wind will drive water up and under roofing materials.
The only line of defense are tar paper and the ice dam membrane.
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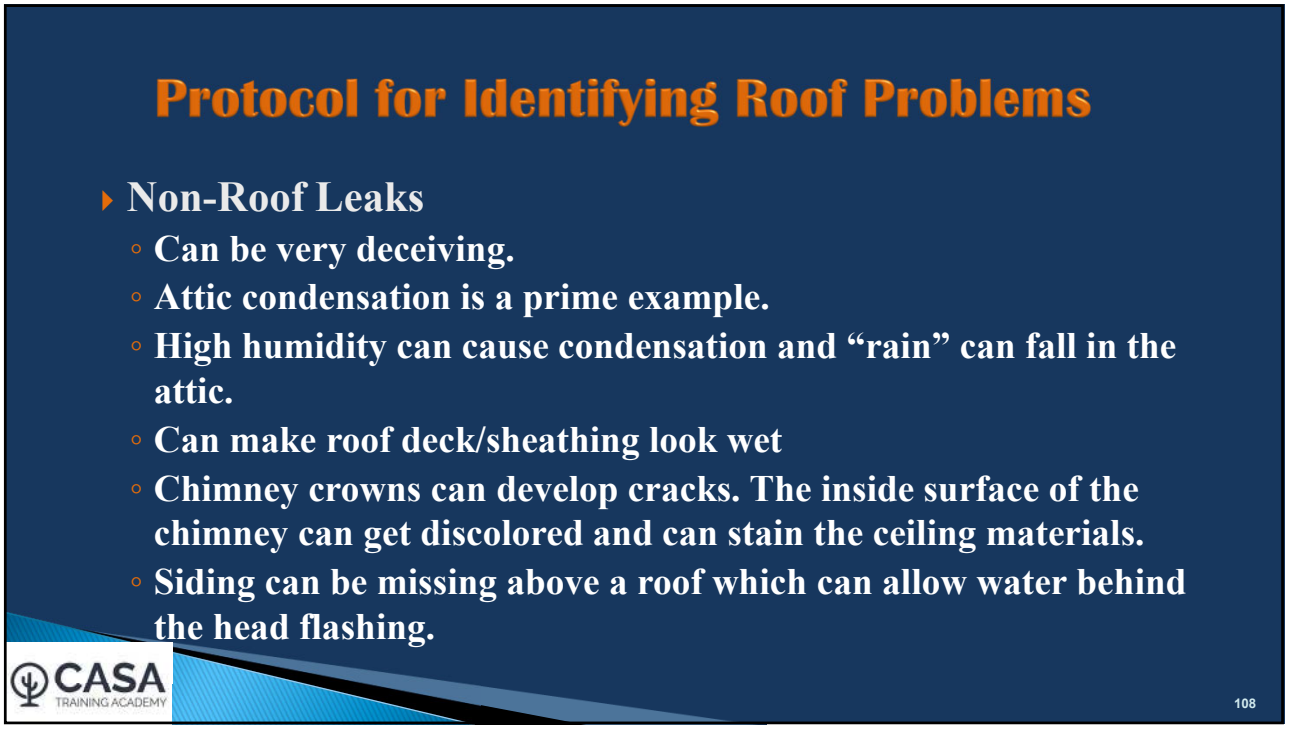
Protocol for Identifying Roof Problems
Non-Roof Leaks
Can be very deceiving.
Attic condensation is a prime example.
High humidity can cause condensation and “rain” can fall in the attic.
Can make roof deck/sheathing look wet
Chimney crowns can develop cracks. The inside surface of the chimney can get discolored and can stain the ceiling materials.
Siding can be missing above a roof which can allow water behind the head flashing.
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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

- Damaged shingles

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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

Missing shingles and/or cladding

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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

Visible wear/damage to shingles

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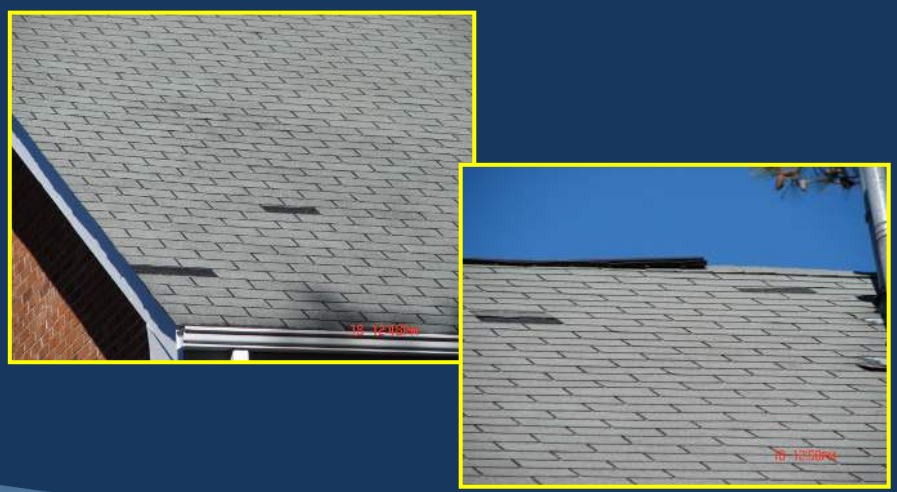
Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

Missing shingles and shingle tabs



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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

Flashing issues

Missing kick-out flashing

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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

Will this work as kickout flashing?

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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

- Moss on roof
- Can damage the shingles
- Not to be confused with algae (dark areas)

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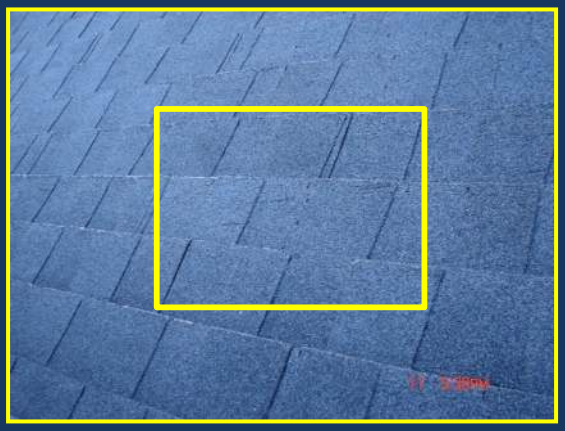
Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

- Scratched shingle surface
- Indentations on a lower low sloped roof from a ladder being placed on the roof



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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces-110 year old house
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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces-110 year old house
Direct light visible into the attic
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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

What can you miss by not using a ladder?

Gaps/holes/missing flashing

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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

Wind Uplift

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Recognizing Roof Defects & Water Paths in Attics, Interiors, and Crawl spaces

- Improper installation of shingles at the step flashing

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Roof Flashing Defects

No visible step flashing and sealant installed along junction of house and roof

No kick-out flashing

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Roof Flashing Defects

Head flashing not installed properly

Visible decay to ceiling material on porch

Could there be hidden damage?

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Roof Flashing Defects

Look for gaps in the attic between the fascia and the bottom of the sheathing

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Roof Flashing Defects

Missing flashing at top of hips

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Roof Flashing Defects

Top edge of step flashing exposed

Can allow water infiltration behind the flashing.

Counterflashing can be installed that flows under the edge of the siding.

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Roof Eaves – Fascia, Soffit, Rakes

Gaps under edge of shingles.

Gap/hole in soffit material

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Recognizing Roof Defects

Nails protruding through shingles

Stains/decay in attic

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Recognizing Roof Defects

Shingles not flat at eave/gutter

Stains/decay in attic at the fascia

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Recognizing Roof Defects

Damaged boots/seals at plumbing vent pipe penetrations

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Recognizing Roof Defects

Damage not visible to boot/seal but light visible in the attic.

Also, no sealant on the nails on the boot.

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Recognizing Roof Defects

Damage not visible to boot/seal but stains visible in the attic under vent pipe.

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Recognizing Roof Defects

Damaged boots/seals at plumbing vent pipe penetrations and stains in attic

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Recognizing Roof Defects

Seal pulled down around pipe

Can retain water at the seal

This boot does have sealant on the nail heads!

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Recognizing Roof Defects

Boot not laced into the shingles.

Also, look for boots installed completely under the shingles.

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Recognizing Roof Defects

The standard plumbing vent pipe boot can be replaced with a PermaBoot, and you will not have the rubber seal

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Recognizing Roof Defects

- Boot with no visible vent pipe.
- Can you get there in the attic?
- Make sure it is properly sealed.

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Recognizing Roof Defects

Trees touching roof can damage shingles

Trees overhanging roof are a future problem.

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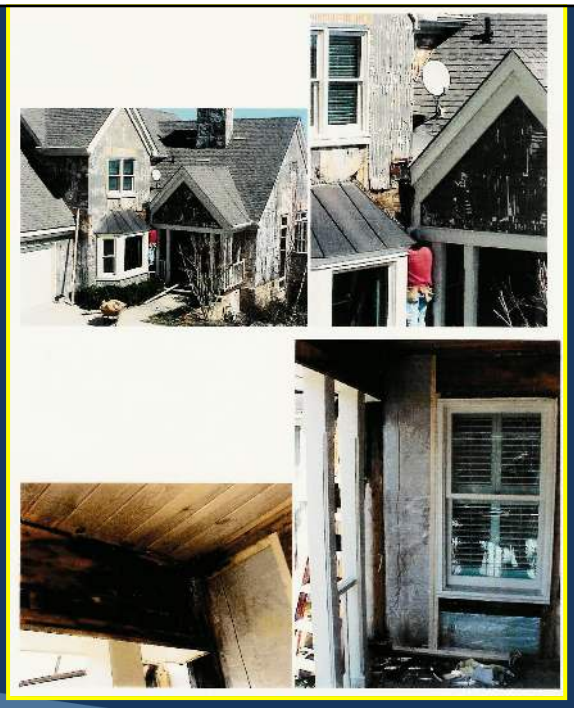
Managing Roof Water Run Off

- Recognize potential problems before they occur.
- Look at water flow on the roof and how does it turn before leaving the roof.



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Managing Roof Water Run Off

- Recognize potential problems before they occur.

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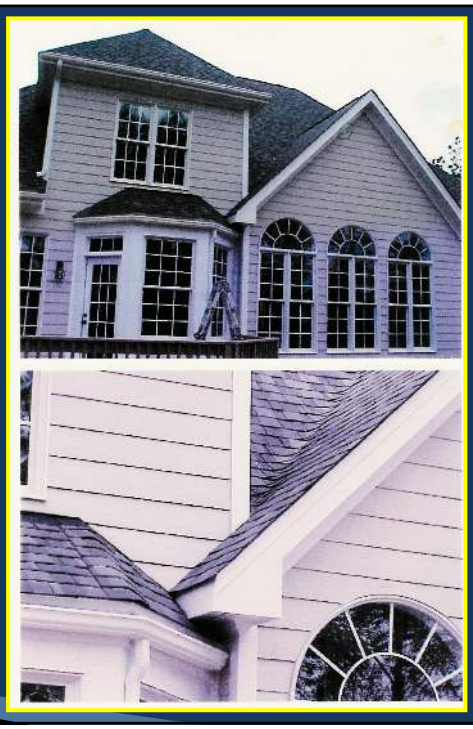
Managing Roof Water Run Off

- Recognize potential problems before they occur.
- Water makes a 90° turn, a 180° turn and ends at a wall.
- Look for flashing and stains!



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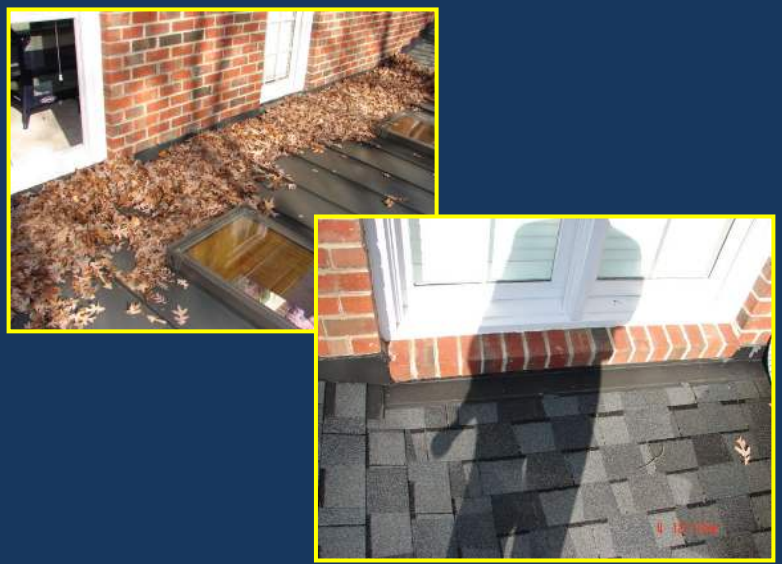
Unsolved Case Study

- Lower metal roof with leaves/debris.
- Adjacent lower shingle roof with good flashing and sealant.



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Unsolved Case Study

- Good flashing and sealant on lower shingle roof

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Unsolved Case Study

- Brick veneer cladding
- Debris on roof

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Unsolved Case Study

- Stains in porch under metal roof
- Stains on interior below shingle roof

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Thank you for Coming

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