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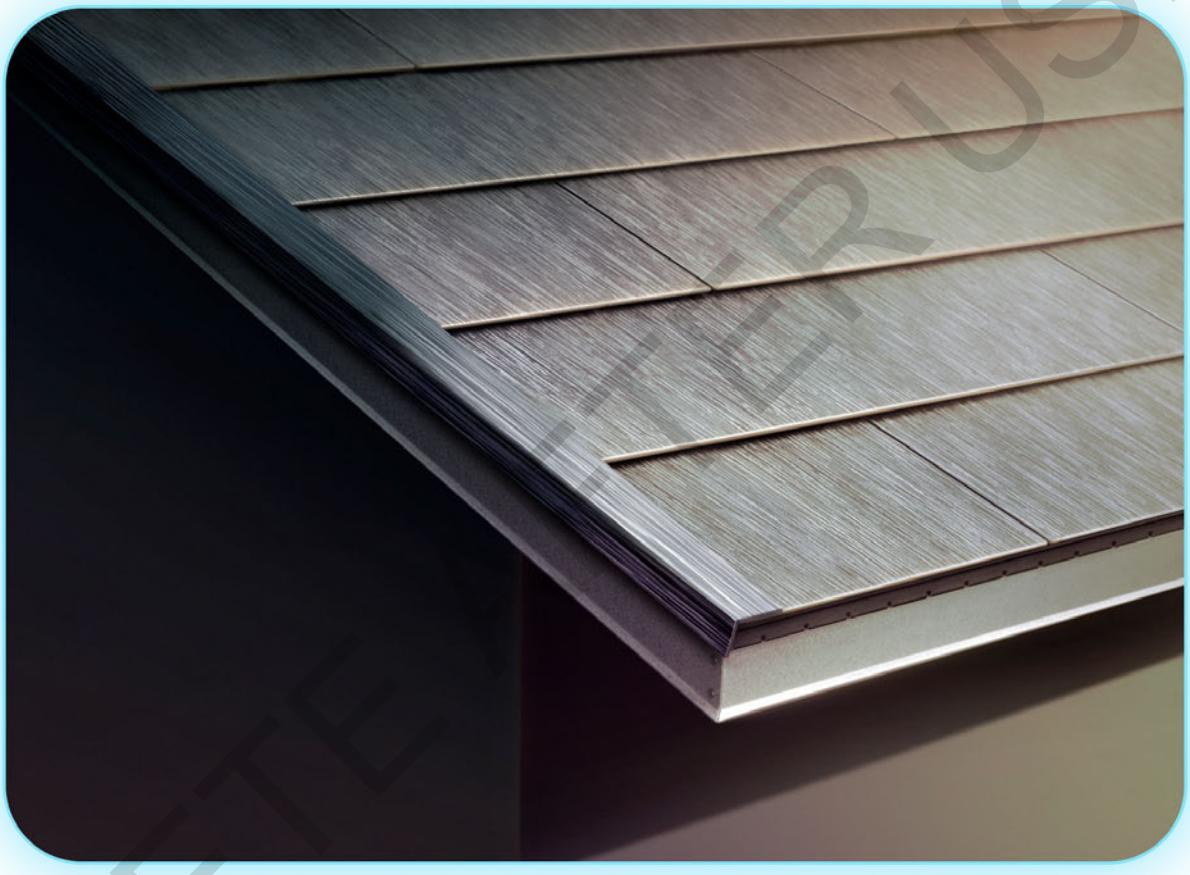
SOLAR ROOF INSTALLATION MANUAL



WHAT'S NEW

DISCLAIMER

This document is updated as often as possible, but some sections may become outdated as a result of rapid, unforeseen changes in the service development process.

Latest Changes to This Manual

NOTE: For full document change log, see *Document Revision History on page 738*.

Date	Changes
11/03/2025	Updated *Working at Heights on page 8* procedures.
10/01/2025	Updated *Part Catalog on page 74* and *Tile Trimmer Maintenance Guide on page 612*.
09/03/2025	Updated *Part Catalog on page 74*.
08/25/2025	Updated *Part Catalog on page 74*.
08/11/2025	Updated *Part Catalog on page 74*.
07/30/2025	Updated *Part Catalog on page 74*.
07/24/2025	Added *Working at Heights on page 8* procedures.
07/22/2025	Added *Tile Trimmer Maintenance Guide on page 612*.
06/19/2025	Updated instructions in *Assisted Access Point on page 573*.
06/02/2025	Updated *Part Catalog on page 74*.
05/28/2025	Updated part number in *Part Catalog on page 74*.
03/31/2025	Added *Assessing and Determining Roof Loading Locations on page 155* to *Preparing the Home for Solar Roof Install on page 83*.
3/25/2025	Updated the part number for Detail Roll in the *Part Catalog on page 74*.
2/6/2025	Updated the *Part Catalog on page 74* by adding a new Tooling section and additional components.
2/5/2025	Updated the *Part Catalog on page 74* by removing the MC4 End Cap (1870689-10-X and 1870688-10-X) from the Rooftop Electrical Section.

DISCLAIMER OF LIABILITY, NOTICES, CONTACT INFORMATION

Disclaimer of Liability

Tesla Incorporated ("Tesla") and its subsidiaries are not liable for any damages caused by failure to follow the instructions and guidelines found in this manual, or from inappropriate use or maintenance of the Solar Roof system. This includes, without limitation, any damages, losses, and expenses caused by non-observance of the instructions of this manual, as well as damages, losses, and expenses caused by, or in connection with, products of other manufacturers.

Notices

The information in this manual is believed to be reliable, but does not constitute an express or implied warranty. Tesla reserves the right to make changes to its Solar Roof Tiles and other products, their specifications, or this manual without prior notice.

The documentation shall state that artificially concentrated sunlight producing a PV module's current above the value reported on the nameplate shall not be directed onto the front side or the back side of the PV module.

This manual applies to Solar Roof PV Tiles, Metal Tiles, the flashing system, and electrical wiring elements manufactured by Tesla. It is explicitly written for qualified professionals ("Installer" or "Installers").

Contact Information

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ISSUE DATE: TBD

HOW TO USE THIS MANUAL

The Solar Roof Training Manual is presented during training sessions (trainers may zoom into the page as needed to assist with visibility). Upon conclusion of the training session, trainees may access this manual at any time to review training content and access step-by-step *work instructions* for Solar Roof installation practices.

Navigating Solar Roof Documentation

Solar Roof Training Manual	*Solar Roof Install Manual*

• All content used during Solar Roof training sessions.
  ◦ Ideal for trainees to refer back to content presented during trainings.
	• Detailed work instructions presented in a step-by-step format including optional tips for best installation practices.
	  ◦ Ideal for trainees and installers looking to learn about every step / detail in any individual procedure.
	• *Tool Catalog*
	• *Part Catalog*
	• *Fastener Schedule*
	• *Introduction to Solar Roof*
	• Specialized for AHJs and other regulatory bodies for compliance, permitting, etc.
	• Summaries of core installation and wiring procedures.

IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE IMPORTANT SAFETY INSTRUCTIONS

All instructions must be read and understood before attempting to install, wire, operate, or maintain a PV system. Failure to read and comply with any of the limitations noted herein can result in property damage, serious bodily injury, or death.

Abide by local, regional, and national statutory regulations when installing the system, and obtain a building permit if necessary. Consult your local authority for guidelines and requirements for building or structural fire safety.

DANGER: NOTE TO TRAINED PROFESSIONALS

Tesla Solar Roof requires specialized skills and knowledge. Use qualified personnel for installation. The installer assumes the risk of all injury that might occur during installation, including, without limitation, the risk of electric shock.

Tesla Solar Roof is slippery when wet and is a fall hazard. Only access a Solar Roof with appropriate safety equipment and while wearing personal fall protection equipment. Use fall protection when working from heights of 6 feet (183 cm) or above. Follow Occupational Safety and Health Act (OSHA) or local governing safety regulations regarding Fall Protection.

An approved and safe walking platform should be used when accessing the roof to prevent falls, and damage to the roof. In addition, skylights, roof openings and light transfer panels must be covered with approved covering to prevent falls.

Tesla Solar Roof is engineered to safely withstand applicable live loads required by building code for steep slope applications. However, to ensure safety and maintain maximum roof life, walking on a Solar Roof should be avoided except by trained Tesla Solar Roof installation professionals and first responders. This is a common recommendation for other high-end roof types, including slate, clay, concrete, and composite tile products.

In the event of a fire at the premises, rapid shutdown equipment in the array will reduce voltages and control the hazard for firefighter operations. Nevertheless the array wiring should be treated as potentially dangerous, especially if it is damaged by heat or flames. Inform the fire crew about the particular hazards from the PV system, and stay away from all elements of the PV system during and after a fire until the necessary steps have been taken to make the PV system safe.

When replacing lightweight roofing materials such as architectural shingles, metal, synthetic, or other roof coverings, it may be necessary to evaluate the existing structural framing and lateral system. In these instances, the installer shall consult with a registered design professional prior to installation of Solar Roof.

IMPORTANT SAFETY INSTRUCTIONS

DANGER: ELECTRICAL SAFETY PRECAUTIONS

- **Use equipment, connectors, and wiring suitable for solar electric systems.** Use insulated tools that are approved for working on electrical installations. Do not open electrical connections or unplug connectors while the circuit is under load.
- Do not use PV Tiles near equipment or in places where flammable liquid, gases, or other hazardous materials are located.
- **Work under dry conditions and use dry tools.** Do not handle Solar Roof PV Tiles under wet conditions unless wearing appropriate protective equipment or attempt to make an electrical connection with wet, soiled, or otherwise faulty connectors.
- **Prevent damage to Solar Roof Tiles.** Wear non-slip gloves when carrying Tiles and exercise caution when transporting and installing Tiles. Do not lift any PV Tiles by the Tile's junction box or electrical leads. Do not drop Tiles or allow objects to fall on Tiles. Do not leave a Tile unsupported or unsecured. A damaged Tile cannot be repaired and must not be used. Do not use a PV Tile with broken glass.
- **Do not disassemble or modify PV Tiles in any way.** Do not apply paint or adhesive to any PV Tile top surface or backsheet. Doing so may degrade performance or cause irreparable damage and will void any applicable warranties.

DANGER: OPERATION CONDITIONS

- The operating temperature of PV Tiles must be within -40°C (-40 °F) to 85°C (185 °F).
- Do not install PV Tiles above 13,120 ft (4,000 m) altitude above sea level.

A PV Tile may experience conditions that produce more current and/or voltage than reported at standard test conditions. Follow the requirements of the National Electrical Code (NEC) in Article 690 to address these increased outputs. In installations not under the requirements of the NEC, multiply the values of Isc and Voc marked on the Solar Roof PV Tiles by a factor of 1.25 when determining component voltage ratings, conductor capacities, overcurrent device ratings, and size of controls connected to the PV output.

WORKING AT HEIGHTS

First Person Up (FPU), Last Person Down (LPD)

First Person Up (FPU) Process

Scope and Applicability

Only employees that have completed fall competent training are allowed to perform First Person Up/Last Person Down duties. The Fall Competent Person is responsible for the proper and safe installation of all fall protection equipment on the roof.

First Person UP (FPU) Duties

- Fall Competent Person ascends closest to ladder access anchor location identified on Site Safety Plan.
- Fall Competent Person installs the first anchor and lifeline and ties off to that anchor before installing additional anchors and lifelines.
- Fall Competent Person then proceeds to install additional anchors as designated in the Site Safety Plan; the Fall Competent Person attaches lifelines to each anchor as each anchor is installed and sets each limiting knot, secured with a zip tie. The ladder access lifeline is brought back to the ladder access point for other workers to tie-off before they access the roof at the ladder stepping off point.

Determine Anchor Layout

Identify quantity of bullring anchors needed:

- Dedicated ladder access rope (for each ladder used to access roof)
- Working ropes for each mounting plane
- Additional ropes for transitioning:
    - There must always be at least two more ropes than people on the roof. One for ladder access/egress rope and one for transitioning.
    - Additional ladders require additional dedicated ladder access rope.

Determine anchor spacing and placement:

- Anchor spacing must accommodate for length of lifeline with limiting knot.
- Workers must be able to reach the next lifeline without removing the limiting knot and without disconnecting from their current lifeline.
- Additional transition ropes may be needed to move from one working area or mounting plane to another working area or mounting plane.
- Additional anchors will be needed for conduit runs.

Prepare for Roof Access

Tools and Equipment

Required PPE

- Cut-resistant gloves
- Safety glasses
- Closed-toed non-slip shoes
- Hard hat

Tools and materials

- Ladder
- Ladder straps
- Bolt hanger anchor
- Pitch meter (to verify 75° angle)

Determine best placement for ladder (consider the following):

- Flat even surface for ladder base
- Avoid slippery areas (mud, debris on cement)
- Avoid setting on loose or broken tiles, bricks, or pavers.
- Along an eave (avoid setting up on gable end unless absolutely necessary)
- Clear walking path on the ground around the ladder.
- In line with a walking path on the roof (consider where panels will go)
- No less than 4 ft from the rake end.

Set up ladder according to safe ladder setup requirements:

- Install stand offs when needed.
- Lean ladder against the eave at a 75° angle.
- Use a meter to measure angle to verify.
- Extend ladder at least 36 in above walking surface (3rd rung must be above, not even with, the walking surface.
- Using three points of contact, carefully ascend ladder and begin installing ladder anchor (bolt hanger anchor) and straps.
- Wrap ladder straps securely around each side of the ladder.

Accessing Roof and Install Fall Protection System

Hazards

- Fall hazards (from ladder or roof) due to pitch, uneven surfaces, debris, etc.

Tools and Equipment

Required PPE:

- Full body harness
- Shock pack
- Cut-resistant gloves
- Safety glasses
- Closed-toed non-slip shoes

- Hard hat

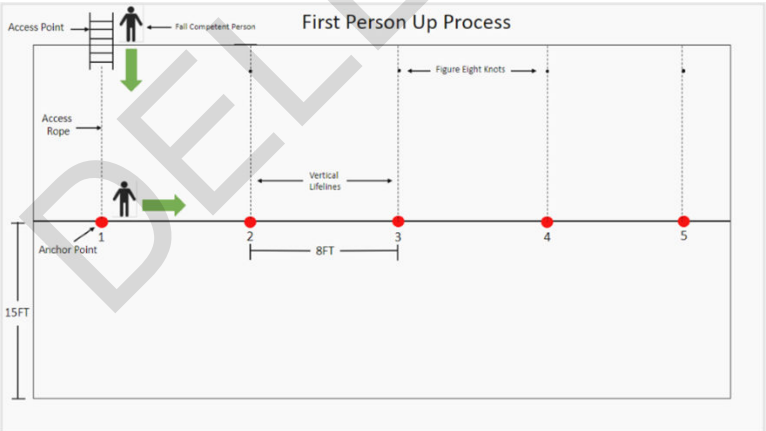
Tools and Materials

- Fall protection anchors, lags, and lifelines
- Bolt hanger anchor and ladder straps
- Ladder
- Rope grab (Kong)
- Impact drill
- AMA equipment when applicable

Follow these steps to access the roof:

Determine if an AMA method is needed (greater than 33.7° pitch, refer to *Assistive Method for Access - Roof Access on page 19*). If no AMA is needed, proceed with following steps:

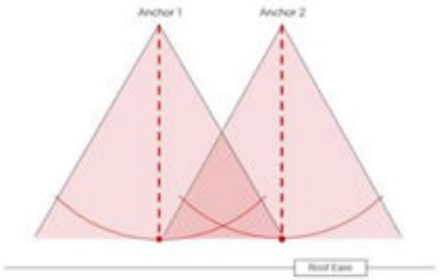
- While carrying only the necessary materials for ladder access lifeline (rope), ascend ladder and access roof.
- Stay directly above the ladder proceed to ridge.
- Install access anchor and lifeline (rope) directly above the ladder below the ridge.
- Attach snap hook end of lifeline to anchor.
- Attach rope grab (Kong) to lifeline with arrow on the rope grab pointed up roof towards the anchor.
- Attach carabiner to the rope grab (Kong).
- Using the carabiner, connect the lifeline to shock pack located on the back of the employee's body harness and ensure rope grab is set close to the anchor.
- Carefully walk down towards the eave adjusting the rope grab as needed.
- Tie limiting knot at appropriate length, considering the following:
  - Must allow employees to easily attach and detach from the rope grab while standing on the ladder.
  - Minimize slack to ensure employees will not be exposed to a significant fall when transferring to and from the ladder/roof.
- Retrieve additional materials for setting working and transitioning anchors/lifelines.
- Continue installing anchors and lifelines following the Fall Protection Plan.



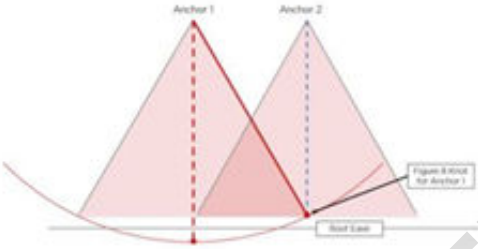
- Tie limiting knots to each lifeline to ensure workers remain in fall restraint while performing work.

- The purpose of the limiting knot is to prevent a worker from either reaching the fall hazard altogether (fall restraint) or to prevent them from hitting the next lower level (fall arrest). **Tesla Policy is to work in fall restraint at all times (whenever possible).**
- The Competent Person must set the limiting knot based on fall restraint and secure with a zip tie.

Fall Restraint Method

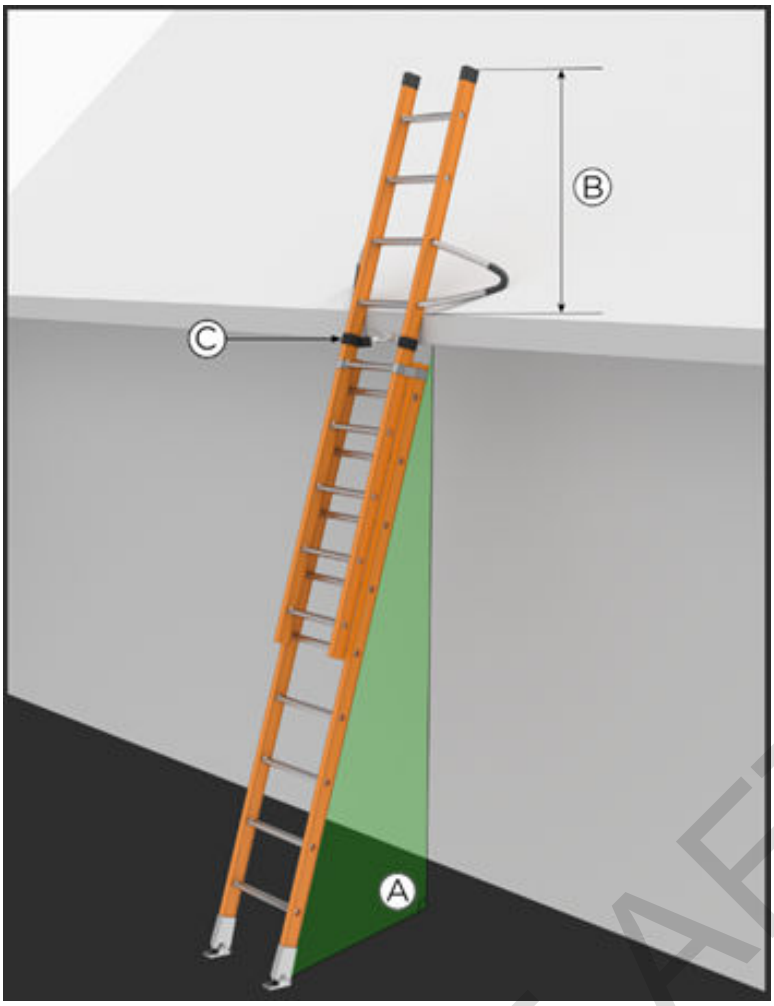


Fall Arrest Method



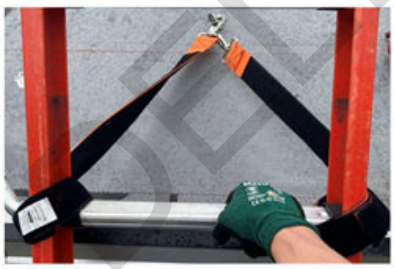
- Anchors located near the rake edge must be no less than 4 ft from the rake edge.
- Once all anchors and ropes have been properly installed by the Fall Competent Person, the rest of the employees can now begin ascending the ladder and accessing the roof.
- **Ladder access lifeline (rope) must always remain free and never be used to perform work!**

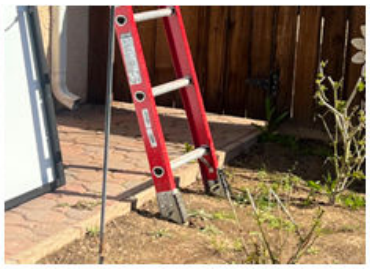
Proper Ladder Setup



What to check for:

- (A) - Ladder angle is 75° (use Pitch Meter inside Tesla One app)
- (B) - Ladder extends at least 36 inches above the walking surface. (Measured along ladder sides- from where the ladder touches the top of the walking surface to the top of the ladder).
- (C) - Ladder straps are wrapped around the side rails of the ladder and secured with a bolt hanger anchor.
- Ladder feet are angled and dug into ground when on dirt, grass, gravel, bark, etc.





First Person Up (FPU) Supplemental Equipment

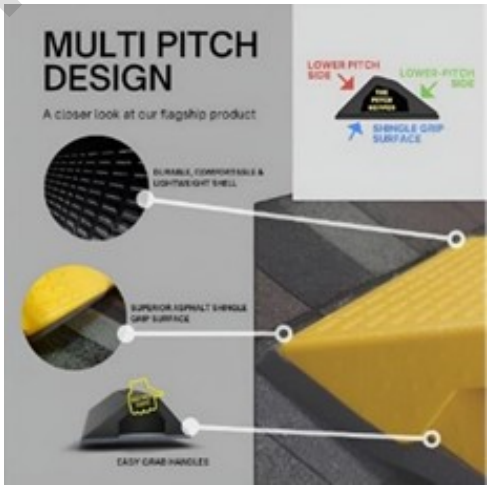
Pitch Hopper

- Scope and Applicability:

  - The Pitch Hopper is a roofing tool that helps roofers work safely and efficiently on steep roofs. It is designed to stick to asphalt shingles using friction force foam on its underside. The soft foam texture prevents dents or scratches in the shingles, and the friction between the foam and the shingles keeps the wedge in place. The Pitch Hopper can support a roofer's weight, as well as the force of jumping up on it or dropping shingles on top. It's also lightweight enough to move around the roof easily.
  - Intended Usage and Benefits

- Improve traction on steep surfaces
- Takes pressure off calves
- Pitch Hoppers can be used to place tool bags, drills, and other items down while working on the roof to prevent them from sliding off the roof.
- Steep Pitch Side allows for level surface on a 12/12 pitch. Can also be used on pitched roofs as low as 9/12.

- Lower Pitch Side allows for a level surface on a 9/12 pitch. Can also be used on any pitch below 9/12.



Traction Mats

Scope and Applicability

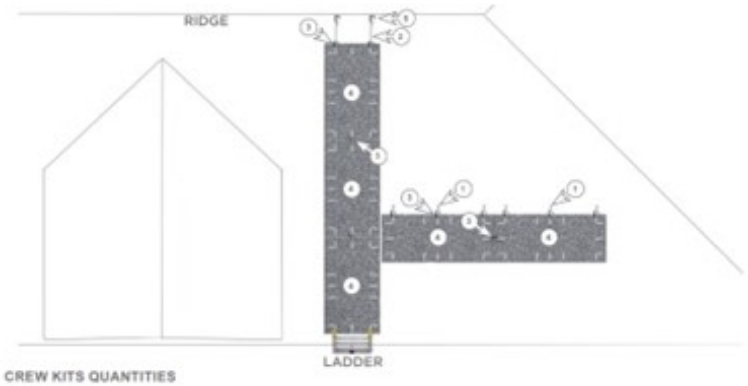
The Traction Mat is strictly designed as a supplemental safety tool that improves traction on slippery surfaces and does not replace conventional fall protection Methods. The use of this mat is supplemental to Tesla required fall protection equipment. Although effective this must not be trusted to protect your life. **Only one person on a single mat at any given time.**

Intended Usage and Benefits

- Improve traction on wet, damp, or dry glass surface
- Improve traction on wet or damp underlayment
- Create an easy ingress/egress path

Tools and Materials for Task

- Traction Mat
- Glass hooks
- Carabiners
- Branched webbing
- Climbing anchor
- Anchor fasteners



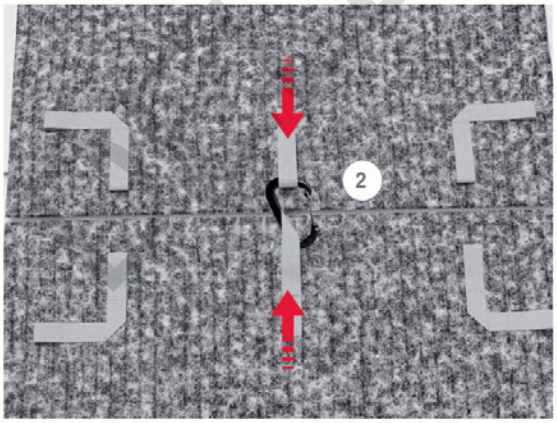
CREW KITS QUANTITIES

1. Glass Hooks + Webbing X 50
2. Branched Webbing X 8
3. Carabiner X 60
4. Traction Mat X 20
5. Climbing Anchor X 10
6. Anchor Fasteners 2.25" X 10

Step by Step Process - Ingress and Egress Path Setup

- The ingress/egress pathway is created by 1 to 3 connected traction mats. Connect the top mat with a Climbing anchor and fasten to the ridge (1). Note: All Tesla employees are required to use Traction Mat at ingress and egress areas where the ladder is located. Non-Tesla employees are recommended to use Traction Mats in these cases.

- Next, connect the following mats with carabiners (2). If the conditions of the roof are dry and the slope is low it is OK to use 1 carabiner per chain. For wetter and steeper slope conditions use 2 to 3 carabiners.



- The last mat chain must be placed near the eave to eave or ladder without interfering with the ladder connection to the roof (3).

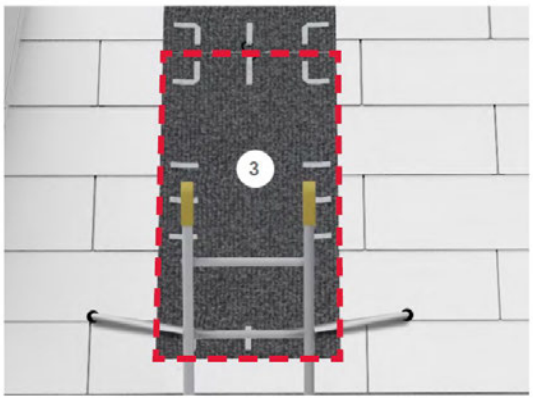
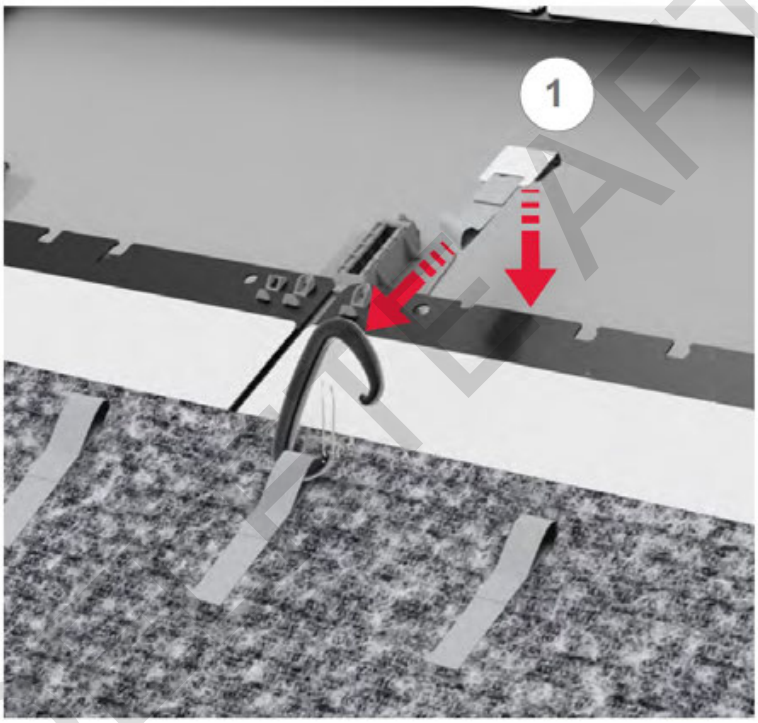


Table 1. Maximum Number of Mat Chains per Pitch

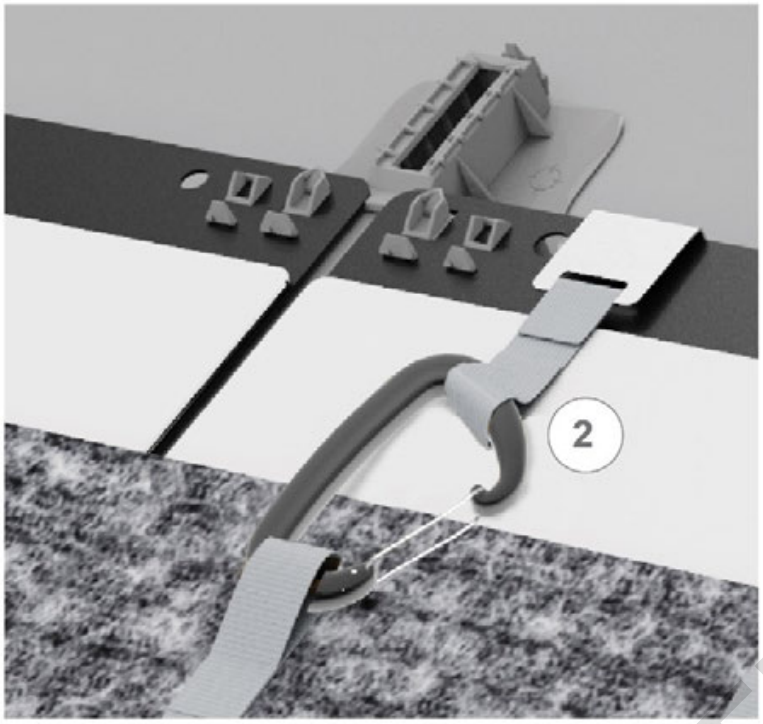
Pitch	Max Chain Length
9 - 12:12	4 Mats
6 - 8:12	6 Mats
0 - 5:12	8 Mats

Step by Step Process - Ingress and Egress Path Setup

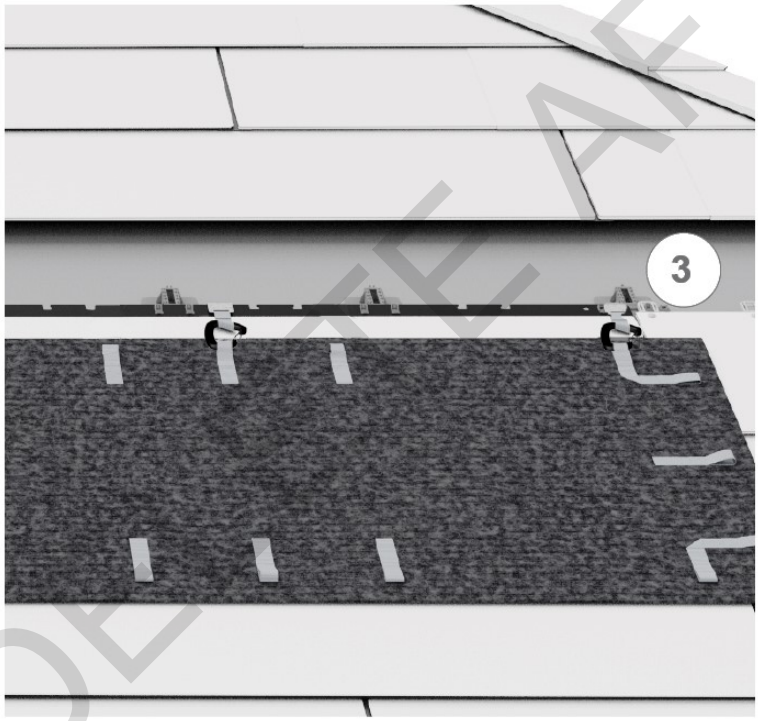
- Before the second tile course is laid up the roof, attach a tile clip with webbing to the top (1).



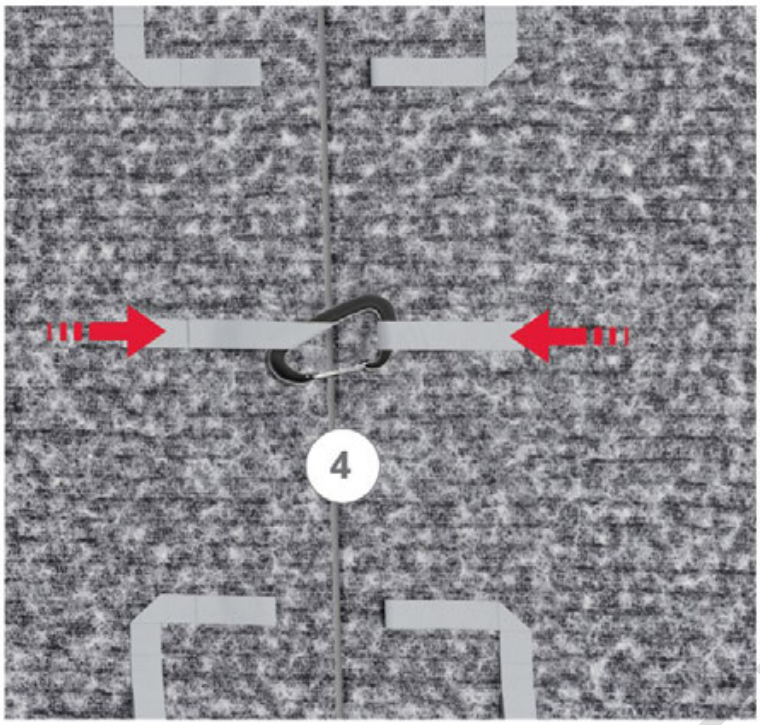
- Attach a carabiner to the loops facing the horizontal side of the mat. Once the traction mat is in place, you can fully install the tile.



- It is recommended that you install 3 glass clips per tile to ensure stability (3).



- Chain each traction mat together in the middle with carabiners (4). Keep in mind that glass clips cannot be used as anchors and are only rated for single static person weight. Be sure to inspect all traction mats, glass clips, branched webbing, and carabiners for damage before installing.



- *Tools Usage and Setup for Traction Mat Procedure*
- *Link to Tesla Traction Mat Powerpoint*

Last Person Down (LPD) Process

Step by Step Process

- When all work at heights is complete, including any equipment and materials removed and system tested, the Last Person Down process may begin.
- Remove anchors and lifelines in reverse order from FPU, e.g. the last anchor that was installed must be the first removed.
- Transition to next lifeline prior to removing the current lifeline.

- Work your way through each mounting plane, removing anchors while still tied in until only the ladder access anchor and lifeline remain.
- Before removing the last anchor, remove all other anchors and lifelines off the roof.
- Once all other anchors have been removed, the Fall Competent Person will remove the final anchor and lifeline (Ladder access).
- The Fall Competent Person will carefully make their way toward the ladder (carrying only the last anchor and rope in a carryall bag).
- Employee will step off the roof and onto the ladder.
- Remove bolt hanger anchor and straps and descend the ladder (if possible, have another employee hold the base).

Assistive Method for Access - Roof Access

Scope and Applicability

- Assistive Method for Access (AMA) must be used while performing first person up duties on any roof with a pitch greater than 33.7°, regardless of roof material.
- Only the Fall Competent Person that signed as such on the Site Safety Plan and Job Hazard Analysis shall perform AMA.
- Review jobs in advance to determine when AMA will be needed and which AMA method is best suited for individual jobs.
- Other site and environmental conditions posing additional slip risk hazards will require AMA: including adverse weather (rain, snow, etc.) and moss, dust, or other slippery surfaces.

Pitch Ratio	Pitch Degree	Risk	Assistive Method Required
0:12 - 4:12	0° - 18.43°	Low	No
5:12 - 7:12	22.62° - 30.26°	Med	No
8:12 - 12:12	33.7° - 45°	High	Yes
> 12:12	> 45°	High	Yes
Adverse Weather - All pitches		**High**	**Yes**
Environmental Hazards - All pitches		**High**	**Yes**

Low Side Anchor

- Low side anchor is the preferred method and can be used in a majority of cases as long as there is access to the opposing mounting plane.
- Ridgeless roofs do exist and may not work with low side anchor method. Refer to *Low Side Anchor Training* .

Tools and Equipment

Required PPE:

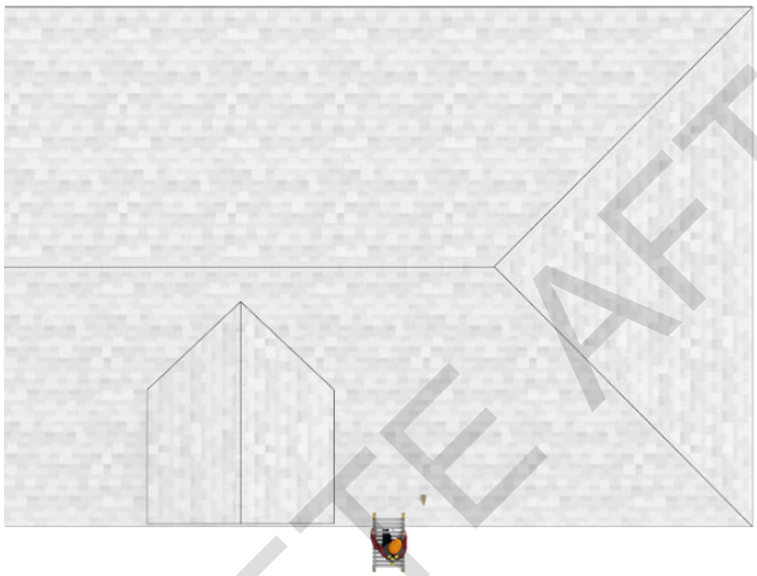
- Full body harness
- Shock pack
- Cut-resistant gloves
- Safety glasses
- Closed-toed non-slip shoes
- Hard hat

Tools and Materials

- Fall protection anchors, lags, and lifelines
- Bolt hanger anchor and ladder straps
- Ladder
- Impact drill
- Low side anchor kit (throw bag and throw line)

Follow these steps to install the low side anchor:

1. Set up and secure ladder on opposite side of house from where the access/egress ladder will be set up according to safe ladder set up requirements.
2. Fall Competent Person will ascend the ladder.
3. The first fall pro/bullring anchor will be installed on the roof and into a rafter roughly a foot above the gutter/ eave by the Fall Competent Person



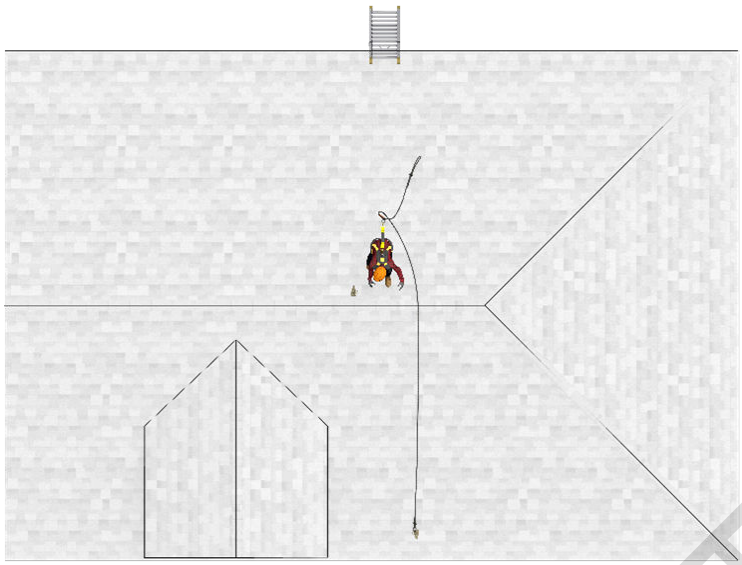
   - *Install low side anchor at the eave*

4. Employees will attach a lifeline to the anchor (preferably 50′ foot lifeline.)

> ⚠ **CAUTION:** Do not attach Kong and carabiner yet! This could break tile or a window.

5. Firmly tie one end of the thin rope to the lifeline and the other end to the throw bag.
6. Descend ladder.
7. While standing on the ground, Fall Competent Person will then toss the throw bag directly over the ridge, so the rope and throw bag are hanging off the eave on the opposite side.
8. Use the throw line to pull the lifeline from the low side anchor over the ridge and to the access ladder.
9. Workers will then remove the ladder and place it where the lifeline, throw line and throw bag are located on the opposite side.
10. Set up and secure ladder following Ladder SOP.
11. Remove thin rope and throw bag then attach their fall arrest device (Kong) and carabiner to the lifeline.

12. Fall Competent Person will don their full body harness and ascend the access ladder.
13. From top of ladder, set the limiting knot, attach the lifeline to their shock pack, and proceed to step on the roof.
14. Once on the roof, the employee will ascend towards the ridge while tied in with tension on rope.
15. When the employee reaches the ridge, they can begin installing the ladder access anchor and lifeline.



    - *Access roof on opposite mounting plane as low side anchor, ascend to ridge to install fall protection anchor (using low side anchor lifeline.)*

16. Employee will transition to the ladder access rope then proceed with installing the rest of the required anchors according to the Fall Protection Plan drawn on the SSP by the Fall Competent Person on site.
17. Remove the lifeline from the low side anchor or tie in a bundle to prevent accidental use as a working rope. (Reattach before performing LPD.)

WARNING: When installing the access anchor and lifeline, make sure not to cross over the ridge onto the mounting plane that the low-side anchor is secured to. A fall down the low-side anchor mounting plane would likely result in contact with the ground!

Low Side Anchor Removal

Required PPE:

- Full body harness
- Shock pack
- Cut-resistant gloves
- Safety glasses
- Closed-toed non-slip shoes
- Hard hat

Tools and Materials

- Drill
- Sealant

Follow these steps to remove the low side anchor:

1. When all work at heights is complete, including any equipment and materials removed and system tested, the Last Person Down process may begin.
2. Before removing the ladder access rope and anchor, the fall competent person will attach themselves to the low-side anchor lifeline and proceed to remove the ladder access rope and anchor.
3. Once the last anchor is removed, the fall competent person will make their way toward the ladder while properly managing their slack and maintaining tension on the low-side anchor lifeline.
4. Employee will step off the roof, onto the ladder, remove Fixe anchor and straps, remove carabiner and fall arrest device (Kong) from the low-side anchor lifeline, and descend the ladder while another employee holds the base.
5. Ladder will be placed where the low-side anchor was originally installed, FPU/LPD will ascend the ladder while another employee holds the base, and FPU/LPD will begin to uninstall the low-side anchor.
6. Once low-side anchor and lifeline is removed, employee can descend the ladder.

Ridge Pro

Required PPE:

- Full body harness
- Shock pack
- Cut-resistant gloves
- Safety glasses
- Closed-toed non-slip shoes
- Hard hat

Tools and Materials

- Ridge Pro

- Fall protection anchors, lags, and lifelines
- Bolt hanger anchor and ladder straps
- Ladder
- Impact drill

Scope

The Ridge Pro is a safety device that helps installers mount and dismount ladders on sloped roofs. Only for use on shingled roofs with pitches from 6/12 to 12/12 (26.57° - 45° pitch.) When using the Ridge Pro, be careful not to stand on or snag the lifeline.

Ridge Pro is only to be used for primary access/ascent for installation and removal of the first fall protection anchor and not for any other working conditions on the roof.

Follow these steps to set up the Ridge Pro:

1. Remove the clevis pin from the pole.
2. Insert the pole onto the Ridge Pro and secure with clevis pin.
3. Set the Ridge Pro angle based on the pitch of the roof. Secure the red and yellow sections with the clevis pin. Use the markings on the side to set correct pitch.

4. Attach lifeline to the pre-installed shackle ring on the Ridge Pro.
5. Attach fall arrest device (Kong) and carabiner to the lifeline.
6. Extend pole to desired length.

Prepare for roof access:

- Set up and secure ladder according to safe ladder setup requirements.
- Position the Ridge Pro by hanging the Ridge Pro temporarily from a ladder or gutter at roof level.
- Ascend the ladder.

Follow these steps to install the Ridge Pro:

1. From the top of ladder, use the extension pole to roll the Ridge Pro to the roof peak.
2. Rotate the pole so the Ridge Pro straddles the ridge and makes contact with both roof slopes.

3. Pull firmly on the lifeline to set the Ridge Pro into place.

4. Set limiting knot.

Accessing the roof:

- Attach the lifeline to shock pack and proceed to step on roof.
- Once on the roof, the employee will ascend towards the ridge while tied in with tension on rope.

- When the employee reaches the ridge, they can begin installing the ladder access anchor and lifeline.
- Employee will transition to the ladder access rope then proceed with installing the rest of the required anchors according to the Fall Protection Plan drawn on the Site Safety Plan by the Fall Competent Person on site.
- Remove lifeline from the Ridge Pro or tie in a bundle to prevent accidental use as a working rope.

Removal of Ridge Pro by Fall Competent Person

Follow these steps to remove the Ridge Pro:

1. When all work at heights is complete, including any equipment and materials removed and system tested, the Last Person Down process may begin.
2. Reattach Ridge Pro lifeline.
3. Before removing the ladder access rope and anchor, the Fall Competent Person will attach themselves to the Ridge Pro lifeline and proceed to remove the ladder access rope and anchor.
4. Once the last anchor is removed, the Fall Competent Person will make their way toward the ladder while properly managing their slack and maintaining tension on the Ridge Pro lifeline.
5. Employee will step off the roof, onto the ladder.
6. Using the Ridge Pro pole, rotate the Ridge Pro 180 degrees until it rests on the wheels.
7. Roll the Ridge Pro down the mounting plane and rest on the ladder or pass down to crew member.
8. Remove bolt hanger anchor and straps and descend the ladder while another employee holds the base.

Fall Protection Planning

Scope and Applicability

A Fall Protection Plan is to be created and put in place by the Fall Competent Person. The Fall Protection Plan outlines the set up of fall protection on the roof, the set up of Restricted Access Zone (RAZ) on site, and the location of emergency shut off valves and is documented on the Site Safety Plans.

Term	Definition
Fall Protection Planning	The planning process for setting up fall protection to ensure safe access to the roof, roof work zones, and transitions while remaining in fall restraint at all times; or allowing for safe swing fall when work must be completed in fall arrest.
Site Safety Plan	The documentation that must be completed and updated accordingly.
Fall Competent Person	The Fall Competent Person identified on the Site Safety Plan is responsible for the planning and set-up of fall protection equipment.

Fall Competent Person Requirements and Responsibilities

Fall Competent Person: One who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees- and has the authorization to take prompt corrective measures to eliminate them.

Training and Requirements:

- Completed EHS.EN.20.426 Fall Protection Authorized Person and EHS.EN.20.427 Fall Competent Person
- Crew Lead/Installer Lead
- Must be at least Installer/Roofer Level 3 or above

Responsibilities

- Assigned as the Fall Competent Person on site and documented on the Site Safety Plan.
- Properly filling out safety documentation and communicating any associated hazards to Fall Protection Authorized Users.
- Fall Competent Persons, unless performing the duties of FPU/LPD where assisted methods of access are not required, MUST maintain 100% tie off to fall protection systems while working at heights.
- Ensuring proper ladder placement and set-up, including ample access/egress points in an emergency. (Ladder may be set up by Fall Authorized; however, Fall Competent Person is accountable for verifying proper setup.)
- Verify proper placement and securement of ladders and maintain ladder access to the correct specifications.
- Fall Competent Persons have the overall site accountability for safe work at heights.
- Performs duties of the First Person Up and Last Person Down.
- Complete Fall Pro Plan and document on the SSP.
    - Anchor spacings correct and matches what is on the roof.
    - Access points identified.
    - Identify location where materials will be passed.
    - Emergency gas and water shutoffs identified.
    - All on site have signed.
    - All hazards identified.

Fall Authorized User Requirements and Responsibilities

Authorized User

Training and Requirements

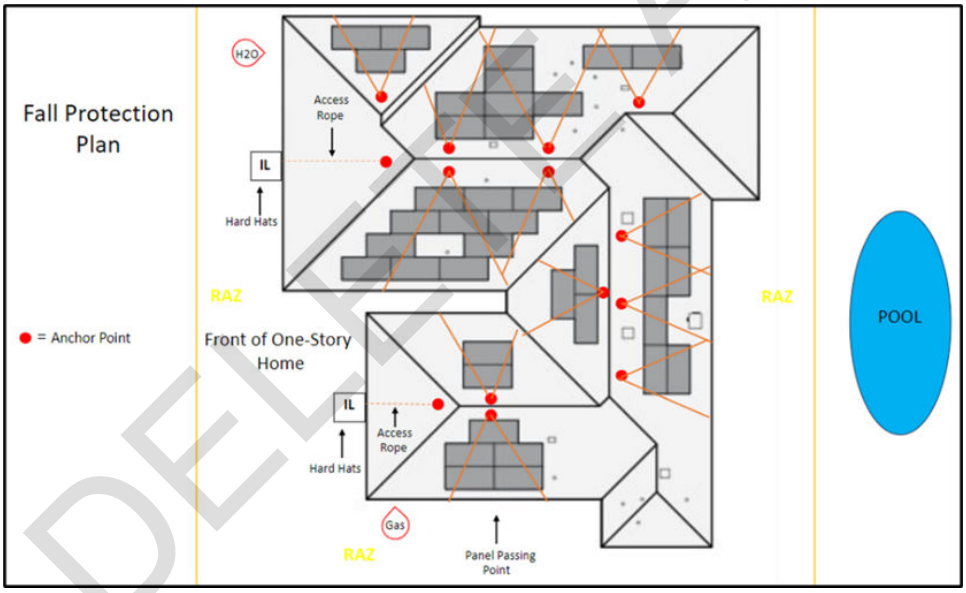
- Completed EHS.EN.20.426 Fall Protection Authorized Person or EHS6025 Fall Competent Authorized User

Responsibilities

- Access the roof using fall protection equipment installed by the Fall Competent Person.
- Initial issue and daily inspections of personal protective equipment (harness, shock pack, gloves, glasses, hard hat, closed-toed non-slip shoes.)
- Proper storage of fall protection PPE.
- Use of personal fall restraint or arrest systems deemed and installed by the Fall Competent Persons.
- Utilize subsequent safeguards to protect from working at heights hazards. (Limiting knots, zip tie securement, etc.)
- Required to read and understand the jobs' associated hazards during the pre-job brief and pre-task planning, ask any questions they might have to the Fall Competent Person, and acknowledge any required documentation with their name and signature if deemed applicable.
- Fall Authorized Users MUST always be on rope (tied off to fall protection system) while working at heights.
- Authorized users, even under the supervision of a Fall Competent Person, are **NOT allowed to perform First Person Up/Last Person Down responsibilities**.

Fall Protection Plan Elements

- Ladder Placement
- Anchor Spacing and Layout
- Limiting Knot Placement
- Restrictive Access Zone (RAZ)
- Emergency Electrical, Gas, and Water Shutoff Valves
- Site Safety Plan - Documents the Fall Protection Plan elements



Ladder Placement

Identify best placement for ladder considering:

- Flat, or near flat, surface - avoid angled driveways and walkways when possible.
- Clear path for access at the bottom of the ladder - area around base of ladder must be free of debris, holes in the ground, bushes, steps, and other trip hazards.

- Clear path for roof access - consider where solar panels will be placed.
- Avoid slick surfaces (ice, wet decking, wet tiles, etc.)

Anchor Spacing and Layout

Identify quantity of bullring anchors needed:

- Dedicated ladder access rope (for each ladder used to access roof.)
- Working ropes for each mounting plane.
- Additional ropes for transitioning.
    - There must always be at least two more ropes than people on the roof: one for ladder access/egress rope and one for transitioning.
    - Additional ladders require additional dedicated ladder access rope.

Determine anchor spacing and placement:

- Anchor spacing must accommodate for length of lifeline with limiting knot.
- Workers must be able to reach the next lifeline without removing the limiting knot and without disconnecting from their current lifeline.
- Additional transition ropes may be needed to move from one working area or mounting plane to another working area or mounting plane.
- Additional anchors will be needed for conduit runs.

Array Design:

- Evaluate the array design to ensure workers can get from the ladder to each array while safely transitioning ropes.
- Ensure ladder and ladder access rope are set up where there will be a path around the arrays. Avoid setting up ladder directly below an array.

Setting and Securing Limiting Knots

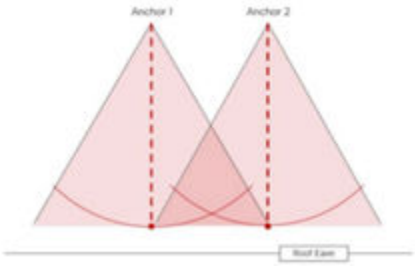
Personal Fall Restraint Systems

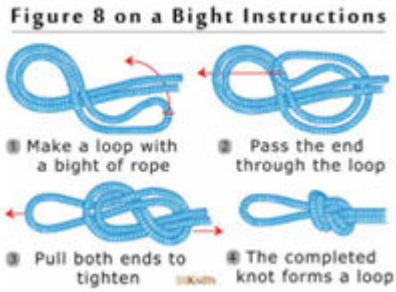
Fall restraint is designed to prevent a worker from ever reaching a leading edge while working at heights. Fall Competent Person is trained and authorized to set the limiting knot in a position on the lifeline to avoid free fall from the eave.

Effective Safeguards: Limiting Knot

- Notify the Fall Competent Person if the limiting knot is not at the proper length. Proper length is long enough to reach the working area yet short enough to remain in fall restraint.

WARNING: ONLY Fall Competent Person can adjust limiting knot.





- Fall Competent Person applies tamper-resistant zip ties to secure limiting knot to prevent unauthorized removal.

NOTE: Use side cutters to remove zip ties at the end of the day.

- Additional limiting knots can be added further up rope.

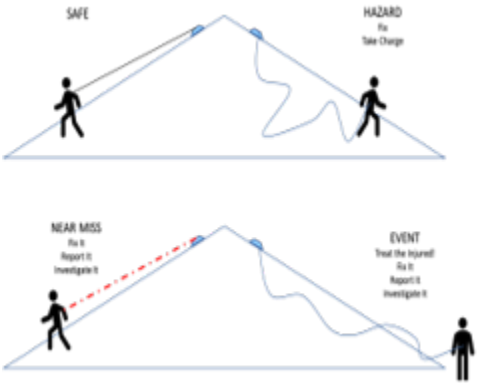
Rope Management

- No slack shall be present in the lifeline.
- Limited slack minimizes the potential for a slip, trip, or fall on the roof and ensures a slip or trip does not result in a swing fall.

Do not remove or modify limiting knots set by the Fall Competent Person.

Verify fall restraining is effective by doing the King of the World pose (KOTW.)

Communicate any issues with Fall Competent Person if corrections are needed.



Restrictive Access Zone (RAZ) for Drop Zone

There are two components of RAZ to ensure that customers and pedestrians are safe from drop hazards:

- Inner RAZ: Placed around all doorways that lead from the house to outdoors. (Front door, back door, side door, garage door, etc.)
- Outer RAZ: Placed around the outside of the drop zone.
    - RAZ must extend 10 ft per story. (1 story house = 10 ft RAZ boundary, 2 story house = 20 ft RAZ boundary, 3 story house = 30 ft RAZ boundary, etc.)

Barricades:

- Yellow Barricade = CAUTION *(Hazards that are non-life threatening) (Personnel can enter an area but must be aware of the hazards and have on the appropriate PPE)*
- Red Barricade = DANGER *(Hazard can create catastrophic event or fatality) (DO NOT ENTER without permission)*
- A barricade is not complete unless it has **NO** points of entry.

Site Safety Plan Documentation

Site Safety Plan must be completed before work begins. Accuracy and legibility will ensure everyone knows the specific challenges and hazards on the job site.

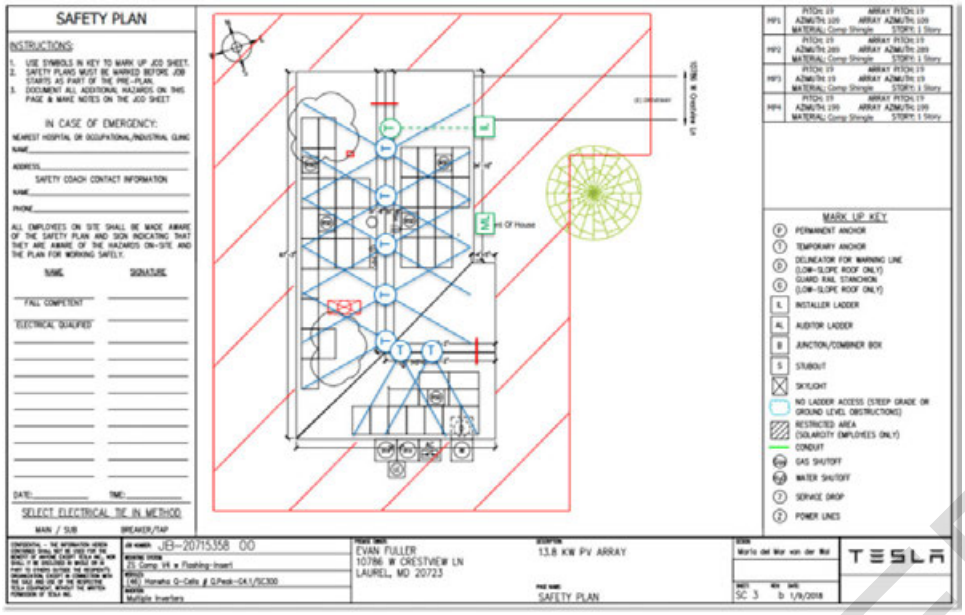
Completed by the Fall Competent Person performing FPU/LPD duties.

Reviewed and signed by all persons on site.

Site Safety Plan Documentation Elements:

- Ladder Location
- Anchor Locations
- Restricted Access Zone (RAZ) Boundaries
- Electrical Shutoff
- Water Shutoff
- Gas Shutoff
- Powerlines
- Service Drop Location
- Fall Competent Person On-site (performing FPU/LPD duties)
- Electrical Qualified Person

- EHS Representative



Equipment

Daily and pre-use inspection:

- All fall protection equipment must be inspected daily (look for wear and tear, breakage, or build up of dirt or sealants that prevent proper function.)
- New equipment must be inspected prior to first use (look for manufacturer defects.)

Semi-Annual Inspections (Every 6 months)

- All fall protection components must be inspected by a Fall Competent Person every 6 months and marked with a colored paint pen (color determined by EHS for each semi-annual inspection period.)

Equipment inspections: What to look for:

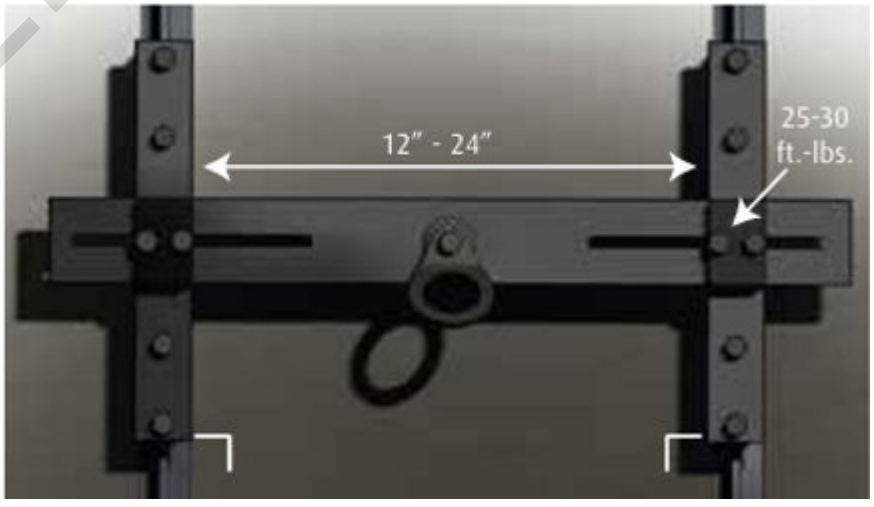
- Full Body Harness - Check for tears, rips, excessive wear, corrosion, rust, missing components, loose stitching, d-ring cracks and/or warping, and possible manufacturer defects.
- Shock Pack - Check for signs of impact deployment, tears, rips, rust, corrosion, cracks, and excessive wear.
- Lifeline (Rope) - Check for tears, rips, excessive wear, chemical exposure, and signs the lifeline has been exposed to a fall.
- Rope Grab (Kong) - Check for cracks, dents, rust, corrosion, excessive wear, and manufacturer defects.
- Bullring Anchor (Guardian/SafeWaze) - Check for dents, warping, cracks, rust, corrosion, and manufacturer defects (missing/broken welds.)
- Lags - Check for rust, corrosion, cracks, bends, and manufacturer defects.
- Horizontal Lifeline (HLL) - Check for any cracks, tears, rips, rust, corrosion, warping, missing components, and manufacturer defects.
- Ladders - Inspect ladders for bends, cracks, rust, missing components, loose/broken rungs, legible labels, and excessive wear and sun exposure.
- Carabiners - Check for cracks, dents, warping, rust, corrosion, defective parts, and integrity of three-part locking system.

- Trauma Straps - Check that both are fully intact in the zippered pouch.

Roof types

Select the correct anchor for the type of roof:

- Comp Shingle and Tile (with rafters 2x4 or greater)
  - Guardian Bull Ring Anchor - Installed pointed downward. Requires (5x) ¼ in x 3 in steel hex head lag screws.
  - SafeWaze Bull Ring Anchor - Installed pointed upwards. Requires (3x) 5/16 in x 3 in steel hex head lag screws.
- Flat Roof (with rafters 2x4 or greater)
  - Guardian Bull Ring Anchor - Installed pointed downward. Requires (5) ¼ in x 3 in steel hex head lag screws.
  - SafeWaze Bull Ring Anchor - Installed pointed upwards. Requires (3) 5/16 in x 3 in steel hex head lag screws.
- Flat Roofs (Not able to make penetration into roof)
  - Eco Anchor - Requires engineering review and approval due to weight of the anchor.
  - Guardian Angel Anchor - Requires engineering review and approval due to weight of the anchor.
- Structural Insulated Panel (SIP) Roof
  - Escalate to Engineering team to determine blocking methods and proper anchor type.
- Standing Seam Metal Roof (SSMR)
  - Guardian Adjustable Standing Seam Roof Anchor - maximum user weight (including all clothing, tools, and equipment) is 130 - 420 lbs.
    - Ensure make, model, and material of selected SSMR are compatible with the Adjustable Standing Seam Roof Anchor (Refer to compatible SSMR list in the installation guide provided by manufacturer.)
    - Installation
      - Adjust Standing Seam Anchor to match roof seam spacing. Compatible with roof seams from 12 - 24 in apart. Tighten all (4) bolts on Tie-Off Bar to 25 - 30 lb/ft.
      - Place all S-5 Clamps over selected roof seams. Both sets of S-5 Clamps (4 on each side) must be the same distance from roof edge.



- Insert Set Screws in bottom two holes of all S-5 Clamps. All set Screws must face same direction. Ensure all Set Screws will compress against roof seam when fully installed.
- Use 3/16 in hex key attachment with compatible ¼ in drive screw gun to install Set Screws.
- As installation of Set Screws progresses, torque values of already installed Set Screws may change as tension on roof seam increases. As necessary, re-torque Set Screws until all Set Screws are within torque range specified.

- If roof is 22 gauge or thicker, torque all S-5 Clamp Set Screws to between 13.33 - 15 lb/ft.
- If roof is thinner than 22 gauge, torque all S-5 Clamp Set Screws to between 10.83 - 12.5 lb/ft.

> ⚠ **CAUTION:** Never over-torque set screws; doing so could strip hardware or damage roof panels.

- TJI and Metal Rafters
  - Guardian Temper Anchor - Designed for wood, metals, or concrete substrates. Maximum user weight (including all clothing, tools, and equipment) is 100 – 420 lbs.
    - Compatible Roof Pitch
      - Installed over roof peak: 0:12 - 12:12
      - Installed on flat surface: 0:12 - vertical/sheer.
    - Fastener Requirements:
      - Wood: 16d nails, or #12 – 2 in wood deck screws.
      - Metal: #12 - 2 in metal deck screws.
      - Concrete: ¼ in x 2 ¾ in concrete screws.
    - Minimum Thickness:
      - Wood: ¾ in
      - Metal: 20 g
      - Concrete: 4 in @ 4,000 PSI

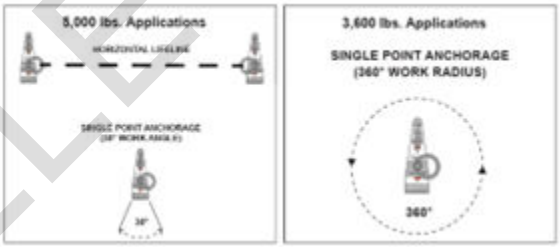
Specifications	Guardian	SafeWaze
Lags Required	(5x) ¼ in x 3 in	(3x) 5/16 in x 3 in
Lag Bolts (Tesla P/N)	1576690-00-X	1576692-00-X
Directional Load	360°	360°
Horizontal Lifeline (HLL) Compatible	**Yes**, only approved anchor for HLL	**No**, not approved for HLL

Specifications	Guardian	SafeWaze
Weight Min/Max (including equipment and tools)	130 - 310 lbs	130 - 310 lbs
Lag bolts must be replaced every job and properly disposed of in metal recycling.		

Guardian

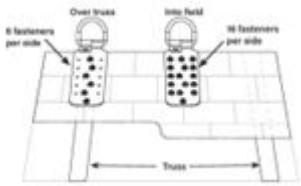
SafeWaze

	Anchor Components	Materials
A	5/16 in. x 3 in. Hex Lag Screws (3)	Stainless Steel
B	O-ring	Zinc Plated Steel
C	Anchor Plate	Zinc Plated Steel



Guardian Adjustable Standing Seam Roof Anchor

Guardian Temper Anchor



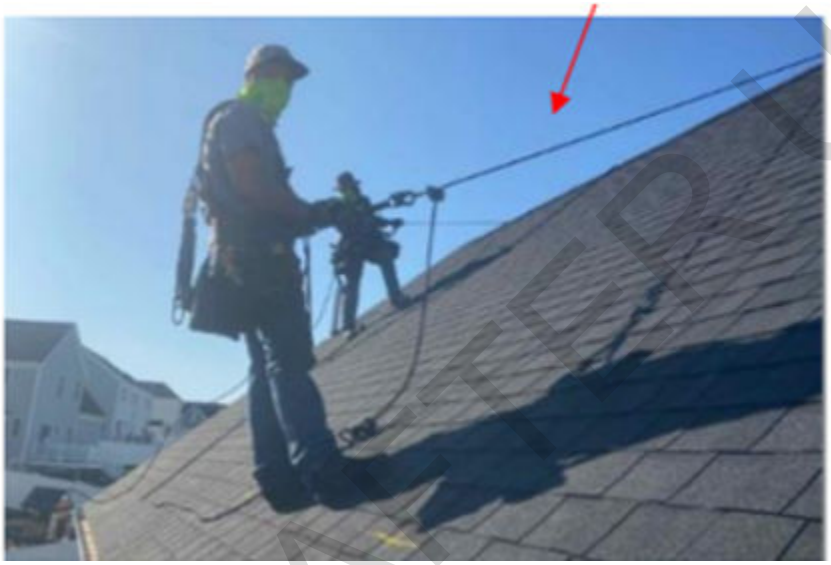
Pitch

- Steep pitch roofs require additional equipment.
  - Y-Lanyards - Designed to allow an employee to be supported and work while leaning into their harness on high-slope roofs.

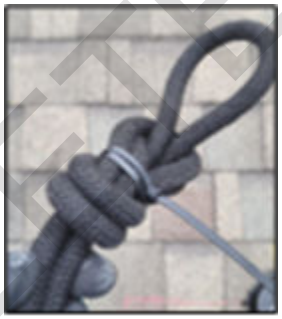
    - Effective use of Y-Lanyards for working positioning:
      - Work positioning is the recommended best practice for roofs greater than 37° (9:12 pitch).
      - Lifeline is connected to side (hip) D-rings via a Y-Lanyard.

    - Rope grab must be set on "1-way movement" (work positioning mode.)

- Rope must remain under constant tension.



- Workers must remain in fall restraint by using limiting knots to prevent access to a fall hazard.
- To remain in restraint, position limiting knot before the eave of the roof.



- Assistive Method for Access (AMA) must be used while performing first person up duties on any roof with a pitch greater than 33.7°, regardless of roof material.
  - Low Side Anchor
  - Ridge Pro

Pitch Ratio	Pitch Degree	Risk	Assistive Method Required
0:12 - 4:12	0° - 18.43°	Low	No
5:12 - 7:12	22.62° - 30.26°	Med	No
8:12 - 12:12	33.7° - 45°	High	Yes

Pitch Ratio	Pitch Degree	Risk	Assistive Method Required
> 12:12	> 45°	High	Yes
Adverse Weather - **All pitches**		**High**	**Yes**
Environmental Hazards - **All pitches**		**High**	**Yes**

Weather Restrictions - When to Call Off a Job

- Lightning - within 5 miles.
- Excessive Rain or Snow – Crew Lead will work with Manager and Local EHS to make the call.
- Wind Speed – Measured with an anemometer before start of work and throughout the day during windy conditions and documented on the JHA.

Wind Speed	Roof Pitch	
	≤ 7:12 (30.26°)	≥ 8:12 (33.69°)
	Recommended Action	
> 10 MPH	Normal Work	Normal Work
10 - 20 MPH	Normal Work	No carrying large material or equipment on the roof*
20 - 30 MPH	No carrying large material or equipment on the roof*	No work at heights
> 30 MPH	No work at heights	No work at heights
*No carrying large materials or equipment refers to items which could catch a gust of wind such as PV panels, boxes of skirts, rolls of underlayment, roof sheet decking, etc.		

Receiving and Passing Panels

When receiving or passing down PV panels from a roof, always ensure the following is in order:

- Stand at least 1 ft away from the leading edge.
- Keep tension on the lifeline.
- Ensure the limiting knot is set within fall restraint distance and secured with a zip tie.
- Take shock pack length into consideration when tying a limiting knot.
- Limiting knot must not allow workers to walk beyond the leading edge/eave.

The same rules apply when hoisting materials and tools up to the roof and down to the ground.

Staging Materials and Tools/Housekeeping

- Materials and tools must be stored in a manner that would restrict the items from falling off the roof, securing them to the roof using a single lag anchor.

- Refrain from bringing materials and equipment to the roof until they are needed.
- Keep tools, materials, and equipment away from the leading edge.

Skylights and Holes

- Identify skylights or large openings in roof
- Materials
    - Plywood board
- All covers must be capable of supporting without failure, at least twice the weight of employees, equipment, and materials that may be set on the cover.
- Covers must be secured when installed to prevent accidental displacement by the wind, equipment, or employees.
- Covers must be marked with the word "HOLE-Do Not Remove."

Transitioning Lifelines on the Roof

Employees must transition lifelines to safely access other sections of a roof.

Employees must never stretch a single lifeline across an entire roof. To properly transition a lifeline while on a roof, follow these steps:

- While remaining tied into the current lifeline, grab the next adjacent lifeline, open the carabiner, and attach the shock pack to the carabiner on the new lifeline.
- Once attached to the new lifeline, the worker can now remove the previous lifeline from their shock pack and proceed to a different roof section.
- Workers must remain between the space of the anchors located to the right and left of them when near the leading edge.
- When coming down for a break or lunch, workers must transition lifelines one by one until they reach the access rope closest to the ladder.
- Workers must constantly adjust their rope slack to ensure continuous tension is present between the lifeline and fall arrest device (Kong.)
- **Workers must never come down from the roof at the same time. The only lifeline near the ladder must be the access rope.**

Role	Required Competency	Skill Level	Training
Fall Competent or Roof Lead	Recognize and mitigate Fall Pro hazards on site.	Advanced	Fall Competent
	Fall Pro planning and design for appropriate anchor selection/installation and layout/spacing.		
	Ensure safe access/egress and rescue plan available for emergencies.		
Electricians	Recognize and mitigate Fall Pro hazards on site.	Advanced	Fall Competent
	Fall Pro planning and design for appropriate anchor selection and layout/spacing.		
	Ensure safe access/egress and rescue plan available during emergencies.		

Role	Required Competency	Skill Level	Training
Installers	Knowledge of fall protection equipment (lanyard, harness, anchors) use. Can inspect for good condition and properly maintain.	Intermediate	Fall Pro Authorized User

Skill Levels

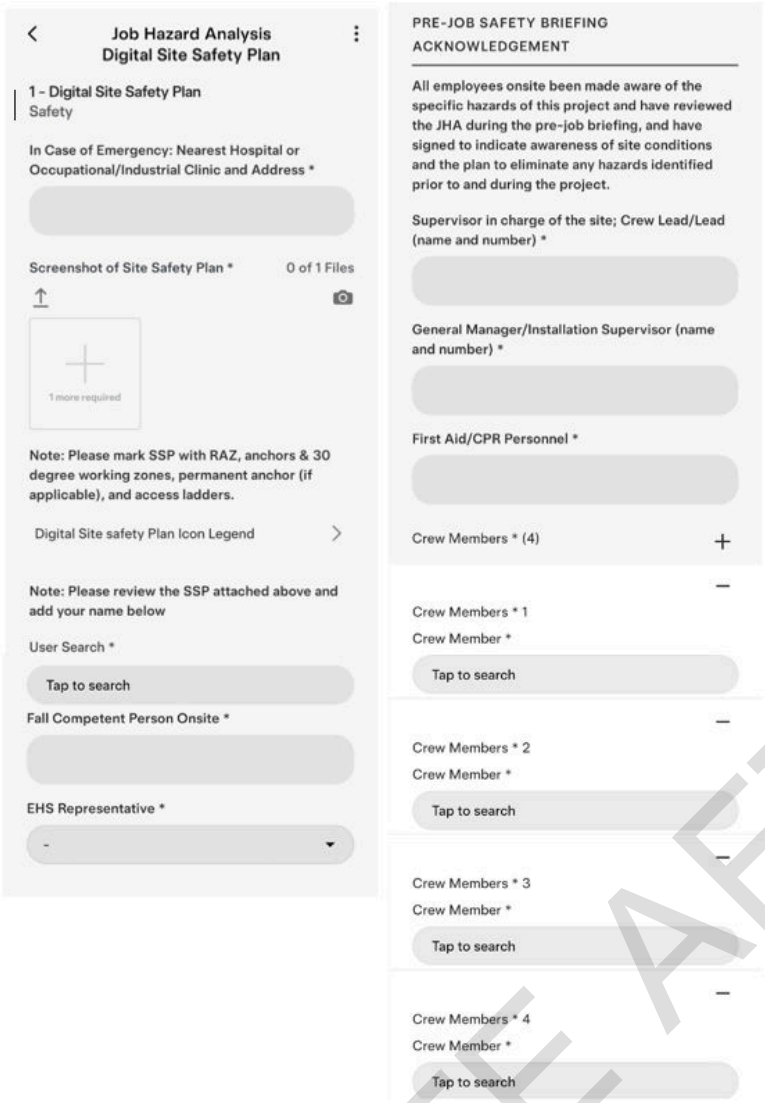
- Basic: Awareness of fall protection principles and practices.
    - Applies to trained workers who execute tasks under supervision.
- Intermediate: Practical experience with fall protection equipment inspections, system design, and hazard identification.
    - Applies to installers following the FPP implementation.
- Advanced: Expertise in regulatory compliance, risk assessment, and program development.
    - Applies to Crew Leads and Roof Leads responsible for creating and auditing FPPs.

Job Hazard Analysis (JHA) with Site Safety Plan (SSP)

Scope and Applicability

Job Hazard Analysis (JHA) is a crucial safety management process designed to prevent workplace injuries and illnesses by proactively identifying and controlling potential hazards associated with specific job tasks. This method involves a series of steps to examine individual job roles, identify risks, and implement effective measures to mitigate these risks, thereby ensuring the safety and health of employees.

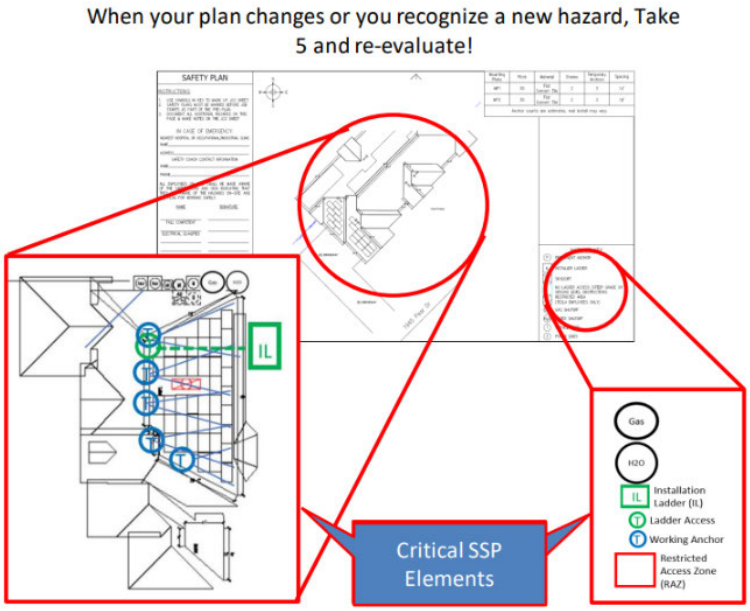
Job Hazard Analysis and Site Safety Plan must be completed before work begins. Accuracy and legibility will ensure everyone knows the specific challenges and hazards on the job site.



JHA and SSP are **required** for:

- Jobs with the potential to cause severe or disabling injuries or illness, even if there is no history of previous accidents.
- Jobs in which one simple human error could lead to a severe accident or injury.
- Jobs that are new to your operation or have undergone changes in processes and procedures.
- Jobs complex enough to require written instructions.

When your plan changes or you recognize a new hazard, TAKE FIVE and re-evaluate.



- If something changes on the jobsite, ensure that it is reflected on the JHA & SSP.

The JHA alone is not a safeguard against a potential hazard, however, the JHA is used to identify and validate the safeguards used to mitigate the associated hazards of a job.

If a hazard is not addressed during the completion of a JHA, stop and TAKE FIVE. Call your manager and local EHS representative before proceeding.

Responsibilities

Fall Competent Person:

- Completes the Site Safety Plan ensuring all required components are documented.
- Uploads picture to JHA & SSP Bolt Form.
- Fill out all questions on the JHA & SSP Form and upload required pictures for each question.

Electrically Qualified Person:

- For jobs with work at heights and electrical work, the Electrically Qualified Person must ensure that electrical work is accounted for on the JHA+SSP completed by Fall Competent Person (or separate JHA+SSPs may be filled out for roof work and electrical work)
- For electrical-only jobs. the Electrically Qualified Person is responsible for the completion of the JHA+SSP.
    - Completes the Site Safety Plan ensuring all required components are documented.
    - Uploads picture to JHA+SSP Bolt Form
    - Fills out all questions on the JHA+SSP Form and uploads required pictures for each question.

All persons on site:

- Review Site Safety Plan and verify proper documentation of site set up and safety contact information.
- Sign the Site Safety Plan to acknowledge you have reviewed its contents and agree the SSP is correct.

JHA and SSP Elements

- Scope of work being performed
- Fall protection

- Ladder safety
- Electrical safety
- Attic safety
- Jobsite security
- Weather and environment
- Heat-related illness prevention
- Airborne contaminates
- Restroom facilities
- Mobile equipment
- Additional hazards present
- Pre-job safety briefing acknowledgment:
    - Supervisor in charge of site (Crew Lead name and number)
    - General Manager/Installation Supervisor (Name and number)
    - First Aid/CPR personnel
    - Crew Members - list all crew members on site
- Digital Site Safety Plan:
    - In case of emergency: nearest hospital or clinic
    - Picture of completed Site Safety Plan
        - Ladder location
        - Anchor locations
        - Restricted Access Zone (RAZ) boundaries
        - Water shutoff
        - Gas shutoff
        - Powerlines
        - Service drop location
    - Fall Competent Person on-site (performing FPU/LPD duties)
    - Electrical Qualified Person
    - EHS representative

Procedure for Completing Jobsite-Wide Job Hazard Analysis

Define the scope of the Jobsite Analysis:

- Identify the specific worksite area to be analyzed (customer's home, backyard, front yard, etc.)
- Determine the range of work activities, operations, and personnel involved across the site, without focusing on individual tasks.

Conduct a walkthrough of the jobsite;

- Physically inspect the entire jobsite to observe the environment, equipment, materials, and general work practices.
- Note areas of activity, such material staging areas, drop zone, access points, and shade/rest area for workers.
- Document conditions like weather exposure, terrain, or proximity to hazards (powerlines, traffic, impalement hazards, pools, etc.)

Identify broad categories of hazards across the site.

- Assess potential hazards that could affect multiple tasks or areas. Categories might include:
  - Physical Hazards: Falling objects, slips/trips/falls, noise, vibration, or electrical risk.
  - Environmental Hazards: Extreme temperatures, poor lighting, dust, or wind.
  - Chemical Hazards: Exposure to fuels, solvents, or hazardous materials stored or used on-site.
  - Biological Hazards: Mold, insects, asbestos, or other health risks in the environment.
  - Ergonomic Hazards: Repetitive work or poor workstation setups affecting many workers.
  - Human Factors: Fatigue, inadequate training, or communication issues across teams.
- Consider hazards that could arise from interactions between different work groups or activities (e.g. roof crew carrying metal materials past electrician working in panel).

Assess the severity and likelihood of identified hazards:

- Evaluate the potential impact of each hazard on workers, equipment, or the project. Could it cause minor disruptions, injuries, or catastrophic events?
- Estimate the likelihood of occurrence based on site conditions, past incidents, or frequency of exposure.
- Prioritize hazards that pose the greater risk to address first.

Develop site-wide control measures to mitigate hazards.

- Apply the hierarchy of controls to reduce or eliminate risks across the site:
  - Elimination: Remove hazards where feasible.
  - Substitution: Use safer alternatives.
  - Engineering Controls: Install site-wide protections.
  - Administrative Controls: Establish policies or procedures.
  - Personal Protective Equipment (PPE): Mandate PPE for all workers as needed.
- Focus on controls that protect the largest number of workers or address the most critical hazards.

Document the jobsite-wide JHA.

- Create a comprehensive JHA form that includes:
  - Jobsite location and project description.
  - Date of analysis and names of individuals involved in the assessment.
  - List of identified hazards, their potential impacts, and corresponding control measures.
- Use maps or diagrams of the site to highlight hazard zones and control implementations.

Communicate and train all personnel:

- Share the JHA findings with all workers and visitors to the site through pre-work briefing.
- Provide training on site-wide safety protocols, emergency procedures, and proper use of PPE or equipment as outlined in the JHA.
- Ensure barriers (RAZ tape) are visible to reinforce hazard awareness.

Implement and monitor site-wide controls:

- Put the identified control measures into action across the site. Verify their effectiveness through regular inspections and worker feedback.

Review and update the jobsite JHA:

- Reassess the JHA periodically, especially when site conditions change (new phase of work, weather changes, etc.).
- Update the analysis to reflect new hazard or controls and communicate updates to all personnel.

- Review after incidents or near-misses to incorporate lessons learned.

Additional Considerations:

- Cross-Activity Coordination: Since multiple tasks occur on-site, consider how activities interact and address overlapping hazards.
- Regulatory Compliance: Ensure the JHA aligns with applicable safety standards, such as OSHA regulations in the U.S. or other local agencies.
- Emergency Preparedness: Include site-wide emergency plans (evacuation routes, first aid kits, cool down areas) as part of the mitigation strategy.

Potential Pitfalls to Avoid:

- Overgeneralizing hazards and missing specific risks that might be critical in certain areas or for certain roles.
- Failing to update the JHA as the site changes, leading to outdated or ineffective controls.
- Not engaging all stakeholders, which can result in overlooked hazard or lack of buy-in for safety measures.

Filling out Proper JHA

Arrival on Site: Preparation and Initial Assessment

- Conduct a thorough visual inspection of the area to spot any immediate risks such as debris, slippery surfaces, or overhead dangers.
- Document with photos.

Site Assessment: Hazard Identification

- Review the work area for potential hazards.
    - Uneven ground
    - Exposed wires
    - Overhead obstacles
    - Anything else that might pose a risk to workers
- Pay attention to environmental factors like weather conditions, lighting, and noise levels that might affect safety.
- Document with photos.

Work at Heights: Fall Protection and Safety

- Before starting work at heights, inspect all fall protection gear (harnesses, anchors, lifelines, Kongs and carabiners.) Document their condition and setup with photos.
- Ensure that all equipment used for working at heights is properly set up and secured (ladders, ladder straps, Fixe anchors.) Document with photos.

Electrical Work: Ensuring Electrical Safety

- Inspect arc-rated protective clothing, rubber insulating gloves, and mats prior to each use. Document with photos.
- Document the implementation of lockout/tagout procedures to ensure all electrical systems are safely shut down before work begins.

Establishing Restricted Access Zones (RAZ): Managing High-Risk Areas

- Set up Restricted Access Zone according to SOP.
- Document all areas designated as Restricted Access Zones with photos.

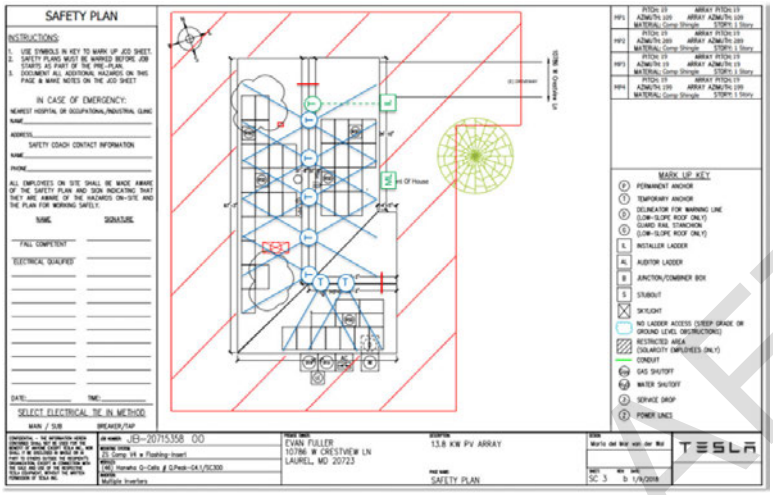
Quality Control of JHA Documentation: Ensuring Accuracy and Clarity

- Review all photos and notes documented in the JHA & SSP to ensure they are clear and accurate.

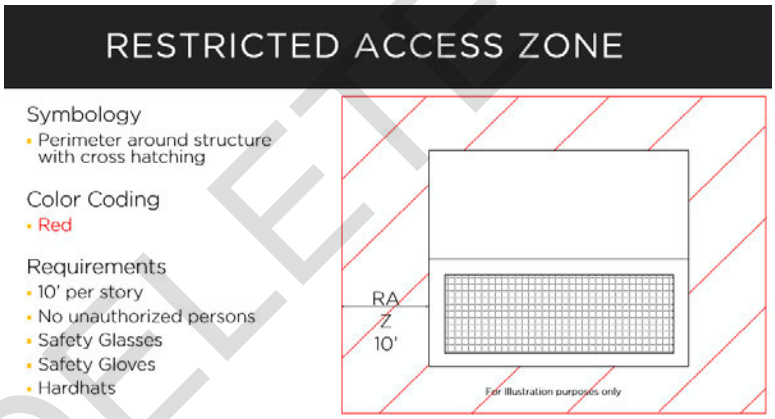
Continual Improvement: Review and Update

- Continuously update the JHA documentation to reflect any changes in work conditions, procedures, or equipment that could impact safety.

Filling out Proper SSP



- Draw where the Restricted Access Zone is established. (Include boundary lines.)



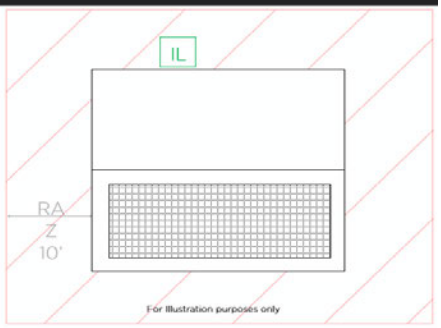
- Mark IL for where the installation ladder is established for roof access.

ACCESS LADDER

Symbology
- "IL" inside of a square box

Color Coding
- Green

Requirements
- Outside edge of roof structure
- Located away from windows and doors
- Safe access point to roof



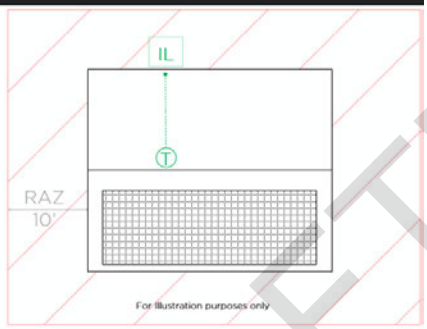
- Appropriate number of anchors with working angles for vertical lifelines.

ACCESS ANCHOR

Symbology
- "T" inside of a circle
- Dashed line

Color Coding
- Green

Requirements
- Clear walking path from ladder
- Only used for access or egress



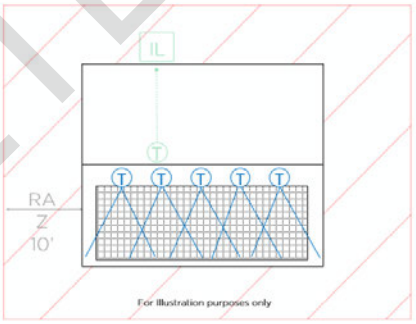
- Mark any areas where utility shut-off valves are located (electrical, water, or gas lines.) Ensure the crew knows how to operate them.
- Identify hazards and calculate the required number of anchors to complete the work.

WORKING ANCHORS

Symbology
- "T" inside of a circle
- Working zone (30° left and right)

Color Coding
- Blue

Requirements
- Cover entire work area
- Maximum anchor distance
- Hierarchy of controls



- Ensure the plan matches the ACTUAL layout at the site. There must be an equal number of anchors on the plan as there is on the roof.
- Record any other hazards that you feel warrant documentation and communication to the crew and visitors.
- Once the SSP is completed, Fall Competent Person shall communicate the plan's contents to all crew members, highlighting the hazards identified, locations of ladders, anchors, and 30° working zones.
- All crew members and visitors must review and sign off on the plan, acknowledging they have reviewed and understand the plan.
- **If you deviate from the plan, such as adding and removing anchors, the plan must be updated to reflect the changes. The plan is a living document and must be constantly evaluated for accuracy.**

Rescue Plan (What to do if things go wrong)

Pre-planning is required for any fall risk where a worker may need to be rescued.

Consider the following:

- How to get off the roof if someone has fallen using the ladder access rope?
- What is needed to assist someone in suspense?

If a fall occurs, all fall equipment involved (harness, shock pack, Kong, lifeline, anchor) must be immediately removed from service and not used until inspected and determined by a competent person to be undamaged and suitable for service.

Ladder Usage

Scope and Applicability

Ladders are used to access/egress roofs, attics, elevated work areas (conduit runs, etc.), and for hoisting materials. Fall Competent Persons are responsible for properly setting up and securing all ladders. While authorized users may assist, they are not responsible for the initial setup or safety of the ladder.

Equipment Selection

Only use non-conductive ladders with 1A minimum rating.

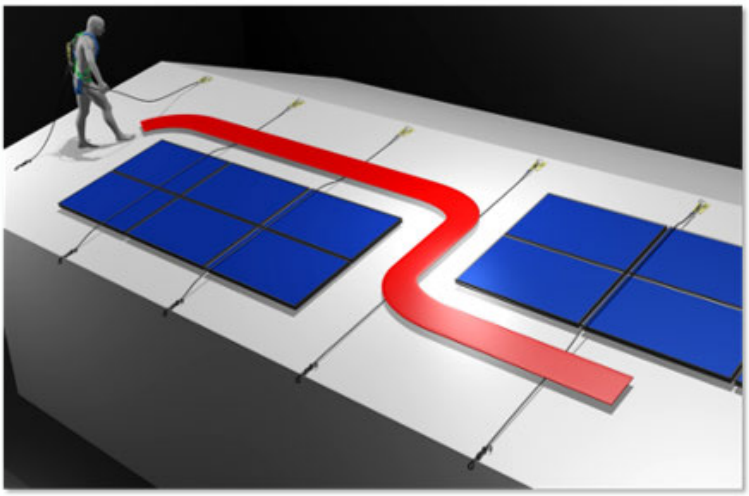
Ladder Type	Recommended Use/ Application	Setup	Don'ts
A-Frame	• Primarily used to reach areas to conduct elevated work from the ladder. • Typically has wider steps for better stability while standing on it. • Folds up for easy storage.	• Must have support arms locked when opened. • Set on stable ground.	• Never use to access an elevated surface such as a roof or attic. • Never stand on the two uppermost steps/rungs nor top cap. • Do not climb while folded and leaning against a structure.

Ladder Type	Recommended Use/ Application	Setup	Don'ts
Extension	• Used to access elevated working surfaces. • Vary in length from 16 feet to 40 feet.	• Must be set up on firm, level ground, or leveled and secured when not possible. • Must be secured to the structure by First Person Up and prior to any other worker climbing using ladder straps and a Fixe anchor. • Must be set up at the proper angle (75°). • Must extend 36 in above the stepping off point. ◦ *If walkthroughs are not being used, the ladder rails must extend 36 in (or 4 rungs) above the leading edge.*	• Don't use a damaged ladder. (Check for cracks, bent rungs, broken feet, etc.) • Never step on top three rungs of any extension ladder. • Don't overreach or lean too far. (Keep belt buckle between the rails). • Don't exceed the ladder's rated load capacity (consider employee weight plus weight of tools/ materials).
Multipurpose	Offers a great amount of versatility for work, interior or exterior.	• Must be set up on firm, level ground, or leveled and secured when not possible. • Must be secured to the structure by First Person Up and prior to any other worker climbing using ladder straps and a Fixe anchor (when using for roof access). • Must be setup at the proper angle (75°). • Must extend 36 in above the stepping off point. ◦ *If walkthroughs are not being used, the ladder rails must extend 36 in (or 4 rungs) above the leading edge.* • *Never step on top three rungs of any extension ladder.*	• Don't use a damaged ladder. (Check for cracks, bent rungs, broken feet, etc.) • Never step on top three rungs. • Don't overreach or lean too far. (Keep belt buckle between the rails). • Don't exceed the ladder's rated load capacity (consider employee weight plus weight of tools/ materials).

Planning Access and Egress

When reviewing your site for ladder placement take into consideration the following:
Clear Path:

- Free of obstructions (panels, vents, overhead lines/drops) that can hinder or delay evacuation.
- Ensure you will be able to safely egress the roof.
- During maintenance work on PV installs, ensure access and egress to the roof without walking over PV panels.



Base of the Ladder:

- Area surrounding base and top of ladder must be free of debris, equipment, tripping hazards, etc.
- Ensure that the area that you're placing the ladder allows for the ladder to be set up level to prevent it from slipping out.

Electrical Drops/Overhead Service Lines:

- Not within the 10 ft limited approach boundary of an overhead service drop or lines.

Emergency Access/Egress

Ladder Setup

To prevent the ladder from becoming displaced or failing while someone is ascending or descending, ensure to establish the following:

Proper ladder angle is 75°.

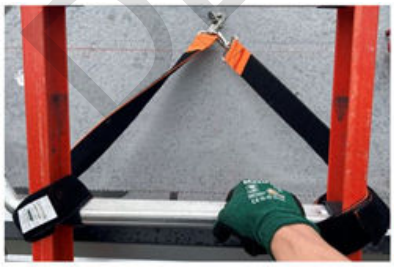
- Measurable with Pitch Meter in Tesla One app or a 4:1 rise to run.
- Ladder angles less than 75° (shallow) may slip out at base.
- Ladder angles greater than 75° (steep) may fall backwards or cause employees to fall from the ladder.

Firm level ground:

- Portable ladders must be established on firm, level, and dry ground.
- If the jobsites terrain does not offer ground that is level, ladders can be equipped with ladder levelers.
- Avoid setting up on mud, sand, and other soft surfaces.
- Foot the ladder to ensure stability during First Person Up.
- Ladders set up on soft ground may slowly sink into soil and cause ladder to tilt.

Slip-Resistant Surface

- Avoid setting up on wet grass.
- If walking on wet grass to get to ladder, provide material for workers to dry off feet prior to ascending ladder.
- Foot the ladder to ensure stability during First Person Up.
- Ladder set up on slippery surface may slip out at base.




Secured at the top (Fixe anchor) and the bottom (when used on the roof to access the next level.)

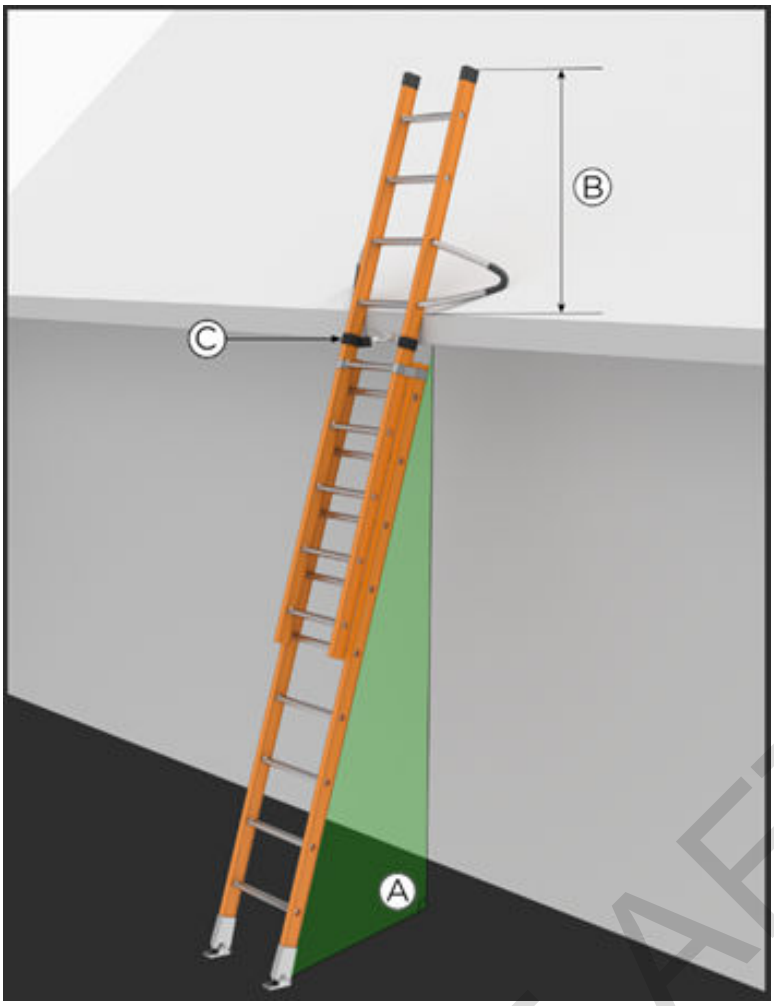
- Ladder straps must be secured to the top of the side rails and must be parallel to the ground.

- Ladder straps must be fixed to the structure using Fixe anchors. DO NOT use under eave clamps.
- The ground that the ladders are established on must be a slip-resistant surface. **The ladder legs must be tilted back to bite into soft ground when set up on dirt, grass, or gravel.**

Walkthrough/standoff installed when necessary.

- Walkthroughs are designed to allow safe passage from the ladder onto the roof and provide a handhold when transitioning. If walkthroughs are not being used, the ladder must extend 36 in above the stepping off point.
- Ladder standoffs are an additional protection that stabilize the ladder for the worker and protect the structure.

- During setup/takedown, a second person MUST foot the ladder to prevent it from slipping out.
- Use two people to carry ladders or to load on and off ladder racks.



What to check for:

- Ladder angle is 75° (use Pitch Meter inside Tesla One app)
- Ladder extends at least 36 in above the walking surface to the top of the ladder.
- Ladder straps are wrapped around the side rails of the ladder and secured with a bolt hanger anchor.
- Ladder feet are angled and dug into ground when on dirt, grass, gravel, bark, etc.

Ladder Handling

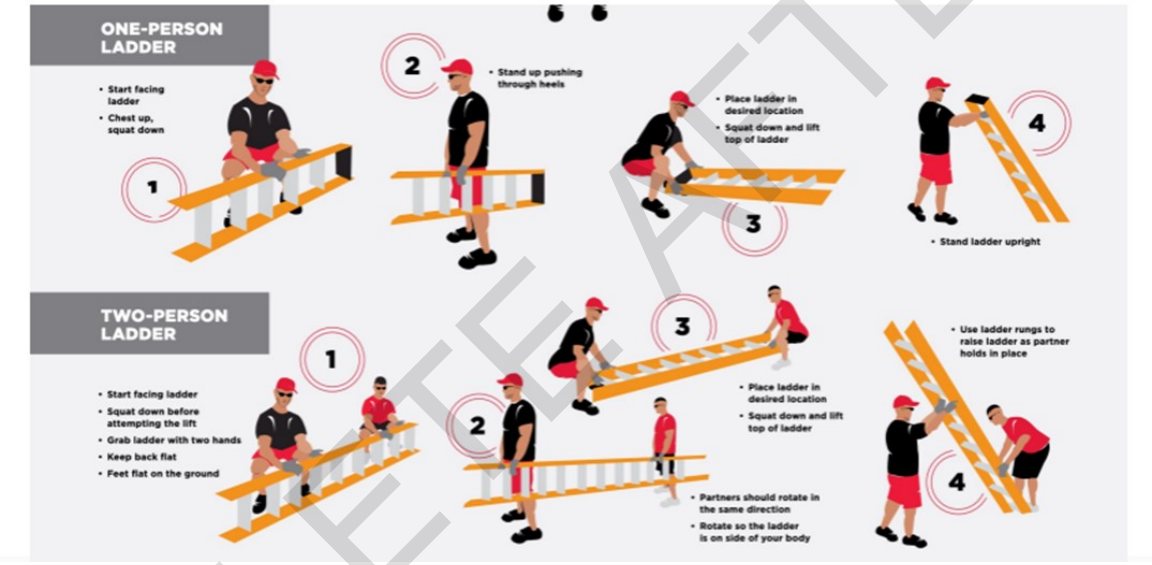
To prevent injuries when carrying, loading, transporting, or staging ladders:

- Use optimal body mechanics:
  - Ensure a secure, 2-handed grip.
  - Ensure stable footing and an open stance.
  - Use legs to bend and lift.
  - Avoid twisting the body to reduce injury risk.
  - The optimal lifting zone is above the knees and below the shoulder.
  - Ask for help when needed and ensure to communicate during team lifts.
  - Follow the procedures and work instructions.
  - Ensure clear walking path.
- Lift with assistance when possible (when two or more are on site).

- Wear hard hat and gloves.

Ladder Lifting Mechanics:

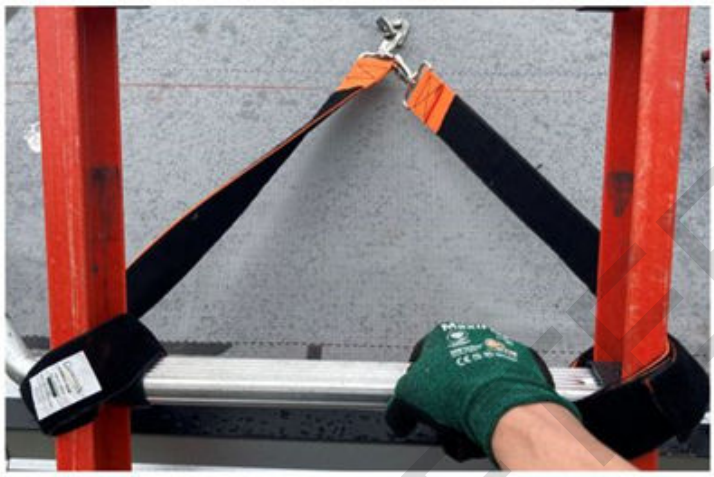
-
    - One-Person Ladder:
        - Start off facing the ladder. Ensure stable footing and open stance. Chest up, squat down.
        - Stand up pushing through heels.
        - Place ladder in desired location. Squat down and lift top of ladder.
        - Stand ladder upright.
    - Two-Person Ladder:
        - Ensure to communicate during team lifts.
        - Start off facing the ladder. Squat down before attempting to lift. Grab the ladder with two hands. Keep back straight and feet flat on the ground.
        - Partners must rotate the ladder in the same direction. Rotate so the ladder is on side of your body.
        - Place ladder in desired location. Squat down and lift top of ladder.
        - Use ladder rungs to raise ladder as partner holds in place.



Proper Use - Ascending/Descending for Roof Access

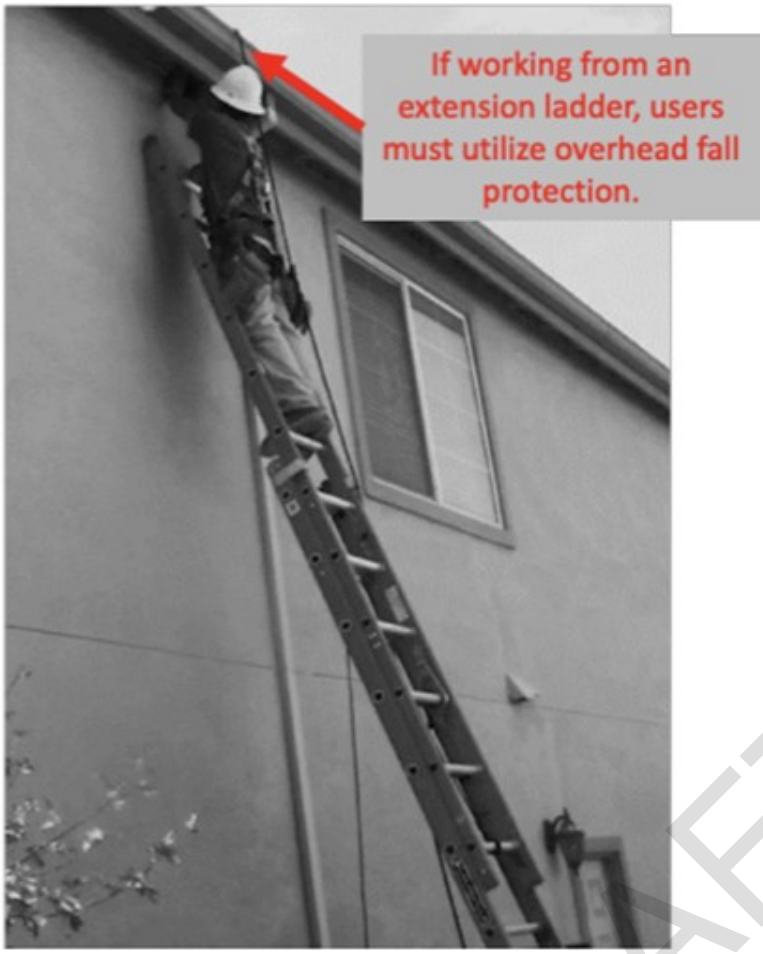
- 3 points of contact:
    - 3 points of contact means 2 feet 1 hand or 2 hands 1 foot (while stepping up).
    - Do not rush when climbing a ladder, take each step consciously.
    - NEVER carry materials or bags up a ladder with your hands. Secure materials in a backpack, use a canvas haul bag, or use a rope to hoist materials to the roof.
    - Do not exceed the weight limit of the ladder. You must account for your body weight plus the weight of your tools and equipment in the haul bag.
- Always face the ladder when climbing.
- Stay centered (Keep your body between the rails.)
- Only one person on the ladder at a time

- Do not step on top 3 rungs of extension ladder or top two steps and top cap of A-frame ladder.
- Tie in before stepping from ladder to roof.
- Do not remove lifeline until both feet are fully back on the ladder.
- Wet Conditions:
    - Inclement weather (rain).
    - Environment (sprinklers, morning dew on grass, etc.)
        - Dry feet with a towel before stepping onto ladder.



Proper Use - Working from Ladder

- If working from a ladder at heights of 6 ft or greater, or any time 3 points of contact cannot be maintained, users must utilize a personal fall arrest system (anchor, lifeline, harness).



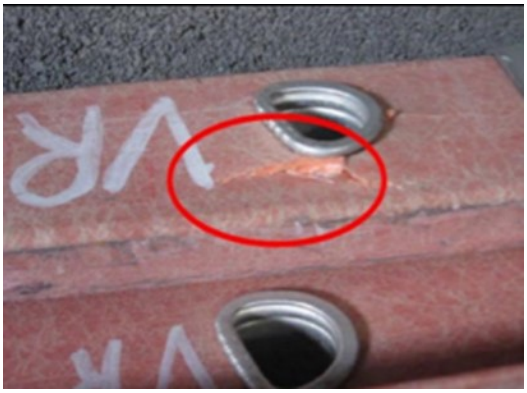
- Always face the ladder when climbing.
- Stay centered (Keep your body between the rails).
    - Do not overreach! If unable to reach something, climb down and move the ladder over.
- 3 points of contact:
    - Do not rush when climbing a ladder, take each step consciously.
    - NEVER carry materials or bags up a ladder with your hands. Secure materials in a backpack or use a canvas haul bag.
- Only one person on the ladder at a time.
- Do not step on top 3 rungs of extension ladder or top two steps and top cap of A-frame ladder.
- Wet Conditions:
    - Inclement weather (rain).
    - Environment (sprinklers, morning dew on grass, etc.)
        - Dry feet with a towel before stepping onto ladder.

Ladder Inspections

- Inspect all ladders BEFORE USE and after any occurrence, such as a fall, which could damage the ladder.
    - Labels must be legible and intact.
    - Check the side rails – not cracked, split, or frayed.

- Check the rungs – not cracked, bent, or missing.
- Check the feet – not missing pads, no signs of damage, move freely.
- Make sure the ladder top is not cracked or loose.
- Make sure the spreaders are not bent or too loose.
- Make sure all components are in place and working correctly.
- Ladder is free of oil, grease, or slippery material.

- If ladder fails inspection:
  - Replace with new ladder.
  - Failed ladder must be cut up and disposed in waste bin.

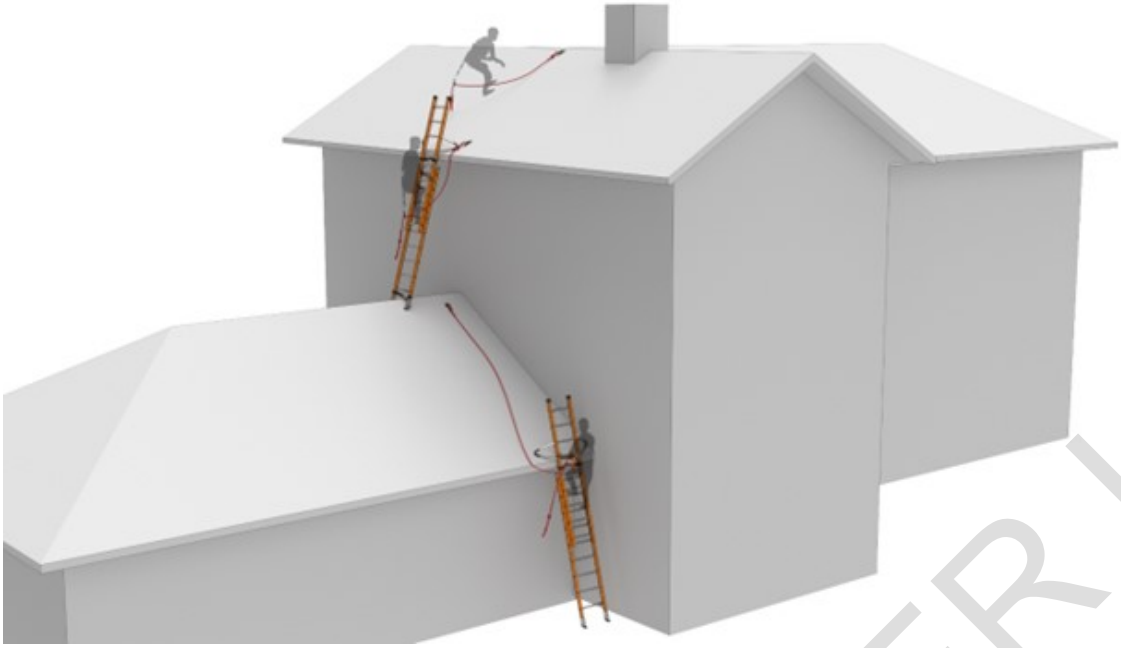


Double Staged Ladders

Step by Step:

- Set up 1st story ladder. FPU ascends ladder to secure the top. 2nd crew member foots the bottom of the ladder.
- Once ladder is secured, FPU ascends the roof to put in the first anchor. Once anchor is secured, FPU ties in.
- FPU will retrieve 2nd story ladder from the employee on the ground. Set up 2nd story ladder and secure at the bottom.
- FPU ascends 2nd story ladder, secures the top, then lags in anchor for ladder transition rope.
- FPU transitions to ladder transition rope, ascends roof to set up the ladder access rope/anchor.
- FPU transitions to 2nd story ladder access rope and continues to put in working/temporary anchors.

NOTE: All ladders will be at 75°. Always secure at the top and bottom of 2nd story ladders. All limiting knots will be set to keep employees in fall restraint and secured with a zip tie.



Restricted Access Zone (RAZ)

Scope and Applicability

The restricted access zone (RAZ) is a visual indication to deter unauthorized persons from entering a work zone. The RAZ clearly defines the work area for the jobsite. It protects the site, employees, and public from dropped objects or other potential hazards; created by setting up delineator cones around the home and stringing caution tape between them.

When to set up a Restricted Access Zone

- RAZ must be set up before work begins.
- Must remain set up during work activities, including work at heights, electrical work, or any other hazardous work performance.
- RAZ must not be removed until all work is complete and materials/equipment are stowed away.

Restricted Access Zone types

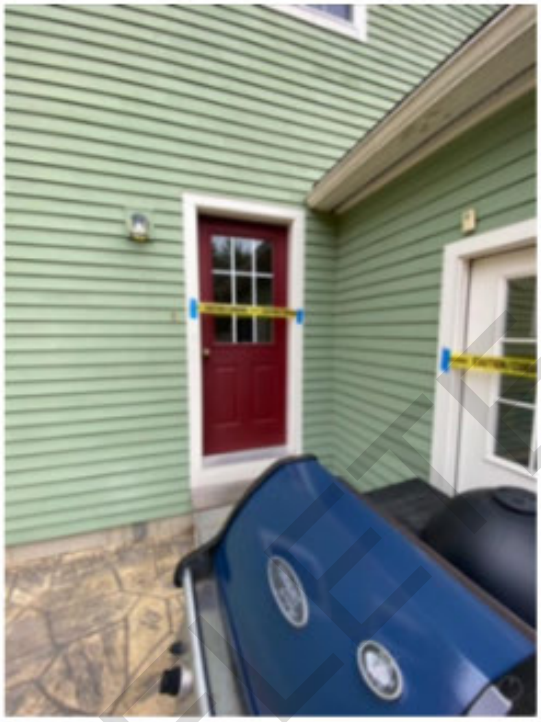
- Outer RAZ – Set up around the perimeter of the property to alert neighbors, delivery people, and other pedestrians of the hazardous zone.
- Inner RAZ – Set up at each doorway of the home (front door, back door, garage door, and any other entry point to the house) to alert the homeowner of the hazardous zone.

How to set up a Restricted Access Zone

- Use caution tape and delineators to mark off the work area, between 3 - 4 ft above ground, based off construction area and drop zones drawn on the Site Safety Plan.
- Mark off entry and exit ways of the home using caution tape (at height of 3 - 4 ft above ground) or cones (painters' tape can be used to secure caution tape across doorways).

WARNING: Marking off entry/exit ways helps remind customer if they are leaving the residence to alert the crew to stop work until they are outside of the RAZ.

Homeowners must not be in the RAZ. Stop work if the homeowner needs to enter or exit their home.



Required Restricted Access Zone Distance

10 ft per story around the structure:

- One story house – 10 ft out from house
- Two story house - 20 ft out from house

Minimum Personal Protective Equipment (PPE)

To be worn when there are overhead hazards or potential for dropped objects within the RAZ:

- Hard hat

- Safety glasses
- Closed-toed non-slip shoes

Types of Boundaries

Barricades:
- Yellow Barricade = CAUTION *(Hazards that are non-life threatening) (Personnel can enter an area but must be aware of the hazards and have on the appropriate PPE)*
- Red Barricade = DANGER *(Hazard can create catastrophic event or fatality) (DO NOT ENTER without permission)*
- A barricade is not complete unless it has **NO** points of entry.

- Barricade tape to restrict access of non-Tesla personnel.
  - Tesla personnel can enter the area but must be aware of the hazards and don the appropriate PPE.
- Signage, in combination with barricade tape.
  - Signage stating "hard hat area" may be used in addition to barricade tape but is not to be used alone. (Barricade tape is required).

NOTE: A barricade is not complete unless it has NO points of entry.

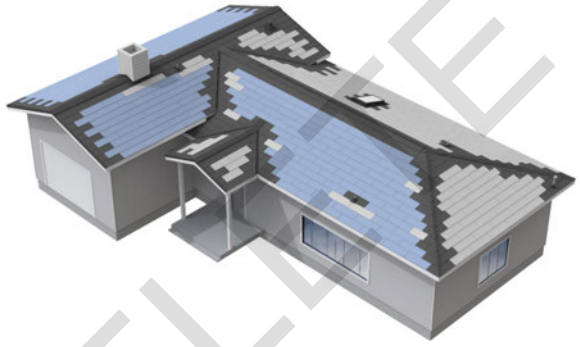
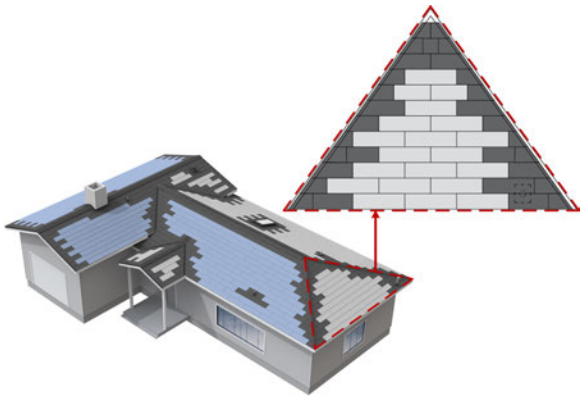
INTRODUCTION TO SOLAR ROOF

Solar Roof is a building-integrated photovoltaic (PV) system that is an aesthetically unparalleled solar energy solution. The seamless combination of power-producing and non-power-producing tiles allows a Solar Roof to be fully integrated and customizable to various roof shapes and sizes.

A Solar Roof functions in fundamentally the same way as traditional roof-mounted PV systems. Sunlight is converted to DC electricity at each individual module. Individual modules are connected in series to form a complete PV "string." One or more strings connect in parallel at a typical string inverter to convert power to AC.

Solar Roof features include:

- DC Tiles
- Tempered glass
- Silicon cells
- Glass-reinforced composite & encapsulant
- J-boxes, PV wire and Listed connectors
- Series strings below 600 V
- DC - AC inverters
- Rapid shutdown

Base / Fortified System **Key Components Overview**		**High Velocity Hurricane Zone (HVHZ) System** **Key Components Overview**	
			
Legend		**Legend**	
PV Tiles		PV Tiles	
Metal Tiles		Glass Tiles	
Metal Flashings		Metal Flashings	

System Specifications

Mechanical Loading and Operation Parameters	
Tile Reveal and Coverage	14 in x 45 in (4.4 sqft)
Roof Pitch Limit	Minimum: 2:12 slope (9.46°)
Wind Rating	Up to 86.72 m/s | 194 mph V_{ult}
Impact Resistance Rating	UL 2218 Class 4
Fire Rating	UL 7103/UL 790 Class A
Safety Class	Class II
Roof Snow Load	Up to 7.18 kPa | 150 psf surface-normal Up to 4.93 kPa | 103 psf shear
PV Tile Power Output Tolerance	-0 /+5 %
Operational Temperature	-40 °C / -40 °F up to 85 °C / 185 °F

System Certifications and Compliance		
UL 7103/UL 790 Class A (UL Listed)	TAS100 (PRI Listed)	California Cool Roof Compliant
UL 61730 (UL Listed)	UL 7103 (UL Listed)	IBHS Fortified Roof Compliant
UL 1741 (UL/ETL Listed)	UL 9703 (UL Listed)	WUI Compliant Roof Assembly
UL 3741 (ETL Listed)	ASTM D1970 / ICC AC188 (ETL, PRI Listed)	Florida Building Code Approved
UL 790 Class A (UL Listed)	ASTM D3161 Class F (UL Listed)	High Velocity Hurricane Zone Approved

Warranty Information

Please find the latest warranty information on *this Partner Portal page*.

Decking Requirements

Substrate and Sheathing Requirements

Decking for Solar Roof shall be a code-compliant wood structural panel conforming to DOC PS-1 or DOC PS-2, rated Exposure 1 or Exterior Grade; or code-compliant closely-fitted solid sheathing boards. Refer to **Thickness Requirements** below to determine the governing thickness based on fire classification and required wind resistance.

Sheathing and supporting framing shall be free of damage, defects, or decay which could impact strength, serviceability, or fastener performance.

Thickness Requirements	
Material	**Minimum Deck Thickness for Fire Classification** Class A, Class B
Plywood	15/32 in
OSB	7/16 in
Boards	¾ in

The roof deck surface needs to be free from loose or protruding nails or staples, dust, dirt, debris or any other protrusions. Lifted fasteners may compromise the new underlayment. Hammer down or remove nails and staples so they are flush to the deck. Ensure that the work surface is clean, smooth, and dry for your team's safety and convenience. Do not install over the following conditions:

- Widely spaced sheathing boards (sometimes referred to as “skip sheathing”) or sheathing that is less than the required minimum thickness
- Areas where the sheathing is not installed correctly, for example leaving gaps greater than ¼ in
- Areas with water damage, dry rot and/or mold
- Pest damage such as termites

Where the existing sheathing does not meet these requirements, use one of the following remediation routes:

- Sheathing overlays, where permissible by the Authority Having Jurisdiction, shall be provided such that the net embedment of all roofing fasteners is not less than ¾ in.
- Sheathing replacement, with a performance class in compliance with all applicable code requirements, shall be performed, with a minimum thickness greater than or equal to those specified above.

Do not install Tesla Solar Roof over widely-spaced sheathing boards (sometimes referred to as “skip sheathing”). Retrofitting the existing structure with solid sheathing would be necessary. Verify the capacity of the existing structure to carry this additional load. As this procedure is beyond the scope of this manual, contact Tesla for engineering support prior to such modification.

Underlayment Overview

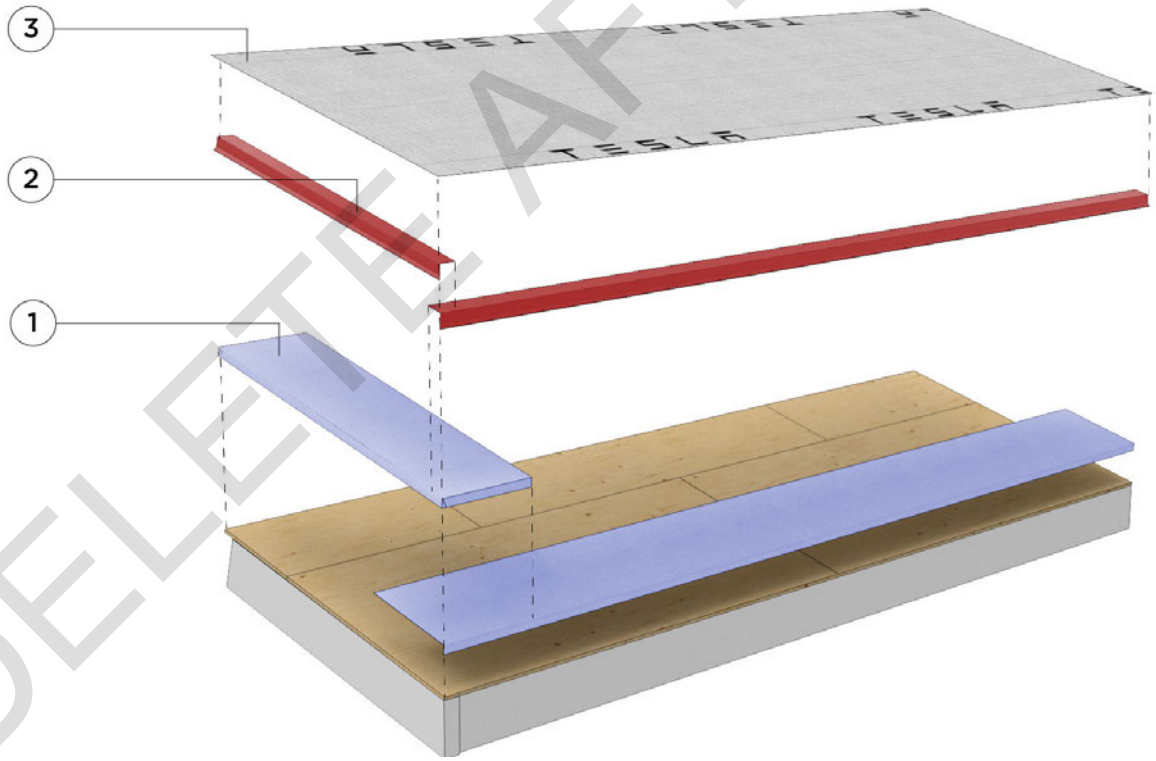
Model Number	SR-SAUL-1 SR-SAUL-4

SR-SAUL-1 and SR-SAUL-4 is a self-adhering peel and stick roofing underlayment designed for sloped roof applications to help protect against water infiltration from ice dams and wind-driven rain. It is installed with Solar Roof as a single layer application.

Certifications
ASTM D1970/ICC AC48
ICC AC188
ASTM E108 Class A when installed with the Solar Roof system

Underlayment Installation and Layering Order

1. Detail Roll
2. Drip Edge
3. Underlayment



Tile Overview

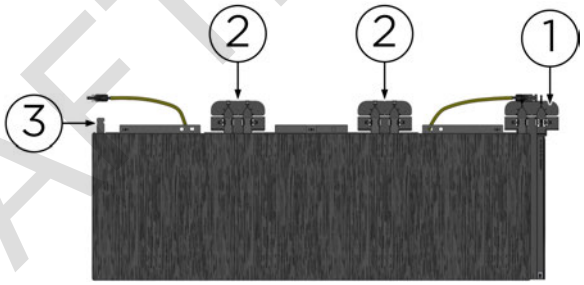
PV Tile Overview

Model Number	SR72T3R, SR73T3R
Principal Materials	Glass, Polymers, Fiberglass and Silicon
Dimension	381 mm x 1140 mm x 6.2 mm 15 in x 44.875 in x 0.25 in
Tile Reveal	Fixed: 14 in
Height from Deck	35.3 mm | 1.375 in
Roof Covering Weight	16.31 kg/m^2 | 3.31 psf
Validated to	UL 61730, UL 9703, UL 1741, UL 3741, UL 790 Class A, UL 7103

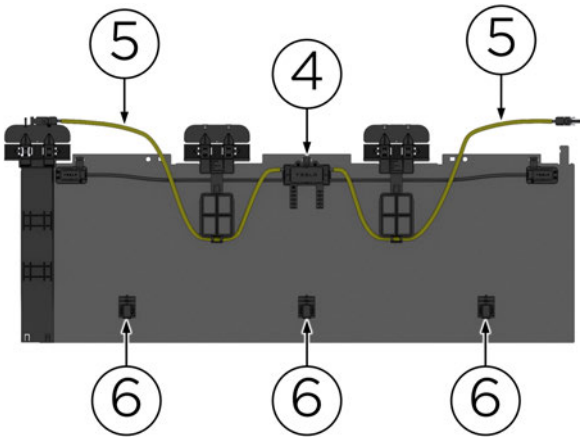
PV Tile Overview

1. Footlap
2. Foot
3. Backer
4. Junction Box
5. PV Wires
6. PV Tile Hooks

Top View



Bottom View



Electrical Characteristics		
	SR72T3R Model	**SR73T3R Model**
Test Method	STC	
Max Power, P_{MAX}	72 W	73 W
Open Circuit Voltage, V_{OC} per diode	14.20 V	
Short Circuit Current, I_{SC}	6.80 A	6.60 A
Max Power Voltage, V_{MP}	11.30 V	11.60 V
Max Power Current, I_{MP}	6.30 A	
STC	1000 W/m^2, 25°C, AM 1.5 spectrum	

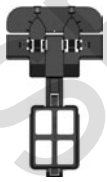
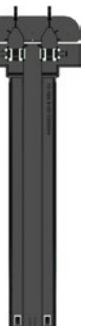
Temperature Rating (STC)	
Temperature Coefficient of Isc	0.038 % / °C
Temperature Coefficient of V_{OC}	-0.266 % / °C
Temperature Coefficient of P_{MAX} (W)	-0.372 % / °C

Operation Parameters	
Operational Temperature	-40 °C / -40 °F up to 85 °C / 185° F
Power Output Tolerance	-0 /+5 %
Max System Voltage	DC 1000 V (IEC/UL) for installations above 2000 m but below 3000 m the system voltage is 877 V
Max Series Fuse Rating	10 A
Safety Class	Class II

Mechanical Parameters	
Cells	14
Junction Box	IP68, 1 diode
Cable	12 AWG PV Wire 850 mm | 33 in length
Connector	Staubli MC4 type PV-KST4/6II-UR or type PV-KST4-EVO2 (male) and Staubli MC4 type PV-KBT4/6II-UR or type PV-KBT4-EVO2 (female)

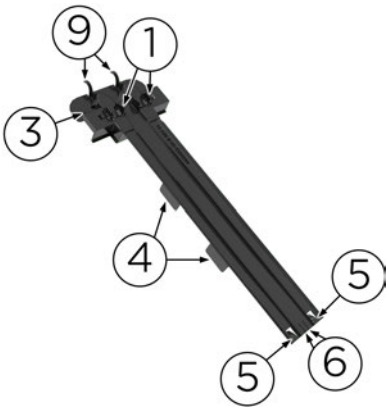
Mounting Hardware

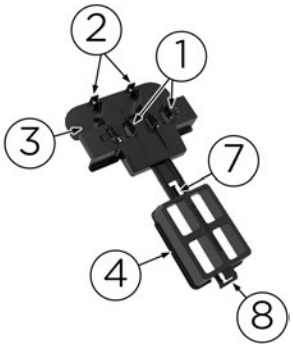
The PV tile comes pre-assembled with mounting hardware: the foot and footlap. These components also have features that aid in fastening, tile alignment and wire management.

Name	Model Number	Image
Foot	SR-FOOT-3R	
Footlap	SR-FOOTLAP-3R	

Foot / Footlap Hardware Overview

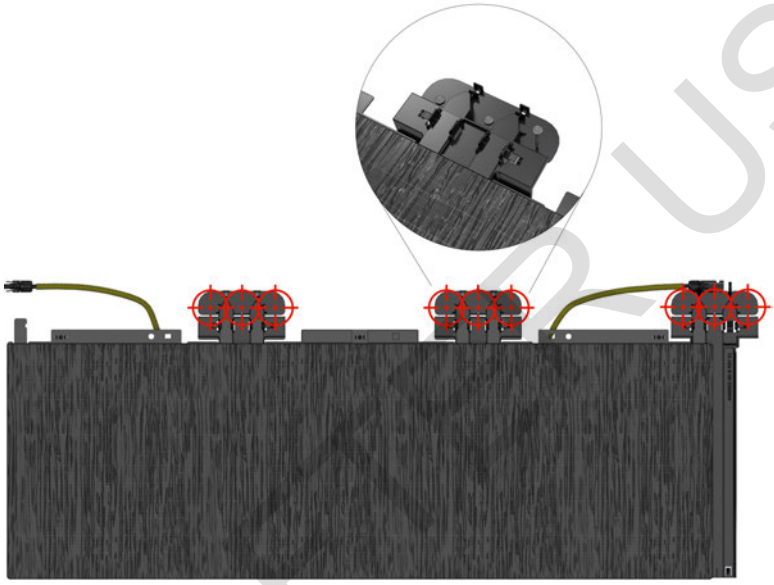
1. Engagement Clips
2. Home Run / Jumper Cable Management Slots
3. Target Holes
4. Supports
5. Footlap Interference Prevention Tabs
6. Alignment Marks
7. Junction Box Wire Slots
8. Wire Management Slot
9. Connector Management Slot



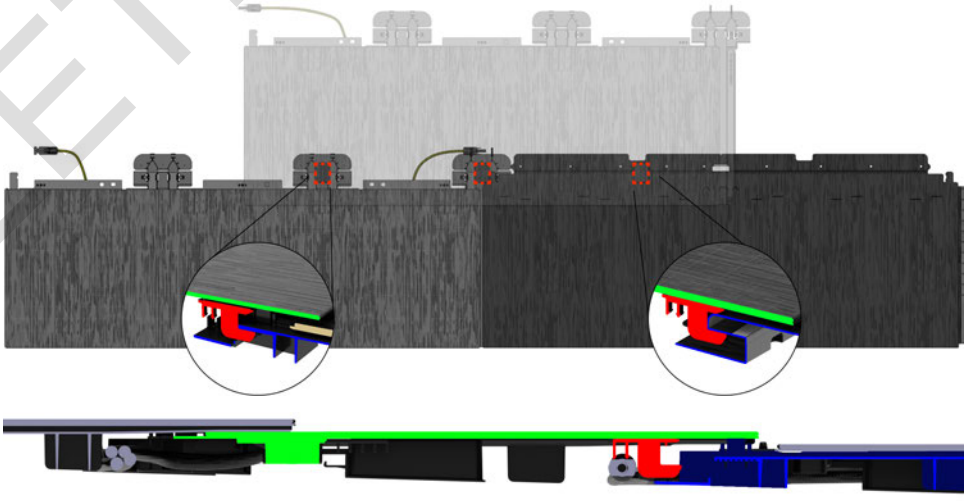


Fastening Hardware

NOTE: Refer to the *Fastener Schedule on page 703* for fastener specifications.

Foot / Footlap Target Holes	
Description	Target holes that define PV tile fastening locations.
Image	

Interlocking / Alignment Hardware

PV Tile Hook	
Description	Built-in hooks that engage with the foot and footlap dedicated slots and metal tile nailing flange to secure the PV tile into place.
Image	

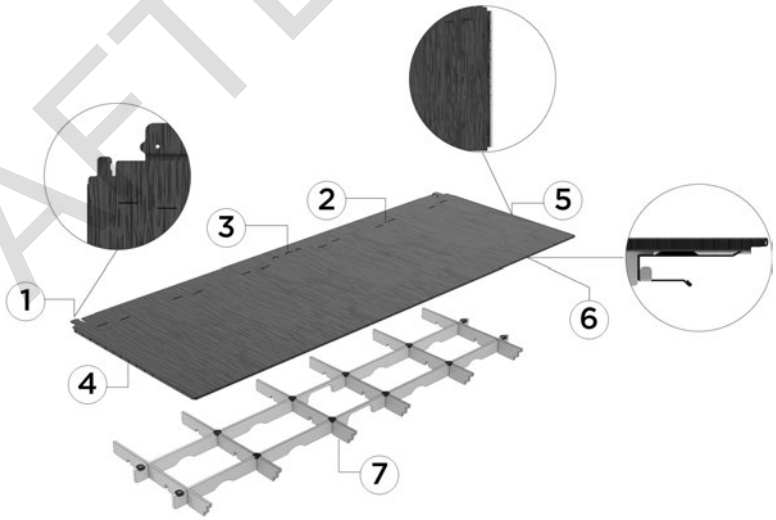
Metal Tile Overview

Metal tiles can be installed in place of PV tiles as well as below, adjacent to, or over PV tiles. Metal tiles can also be installed anywhere on the roof that requires tile cutting or modification.

Model Number	SRMTT-3R
Principal Materials	PVDF Coated 24 Gauge Galvalume
Dimension	424 mm x 1140 mm x 5 mm 18.75 in x 45.25 in x 0.25 in
Tile Reveal	Adjustable: 13.75 in to 14.25 in
Height from Deck	35.3 mm | 1.375 in
Roof Covering Weight	8.82 kg/m2 | 2.15 psf
Validated to	UL 1897, UL 7103, UL 790 Class A, ASTM D3161 Class F, TAS100

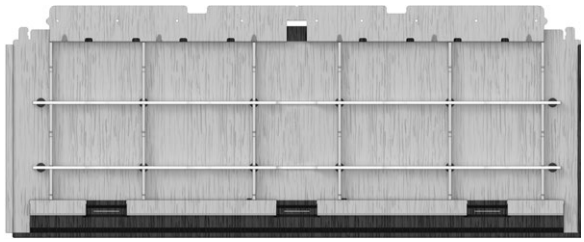
Metal Tile Overview

1. Engagement Tab, Metal Tile Nose
2. Nominal / Max Reveal Marks
3. Tile Timing Marks
4. Left Side Open Hem
5. Right Side Open Hem
6. Lower Engagement Hook
7. Lattice for Structural Support



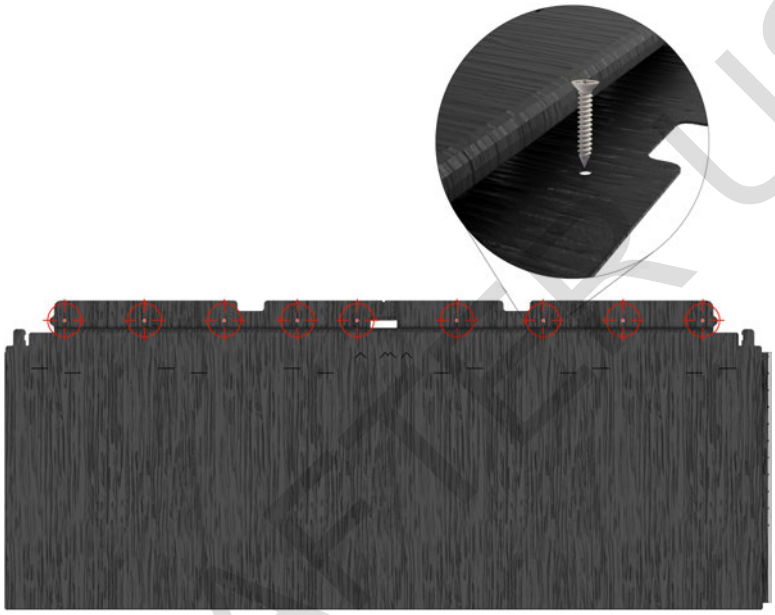
Top View

Bottom View

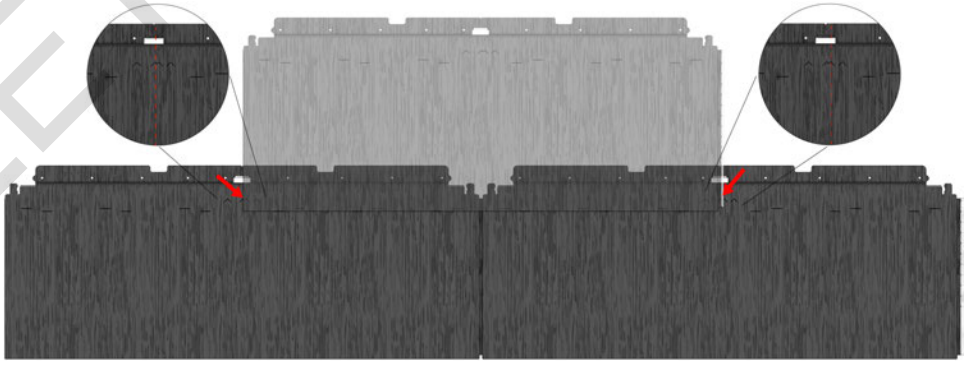


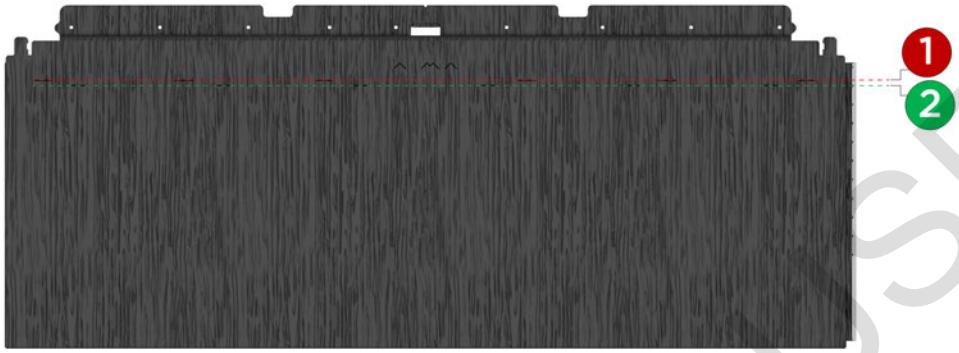
Fastening Hardware

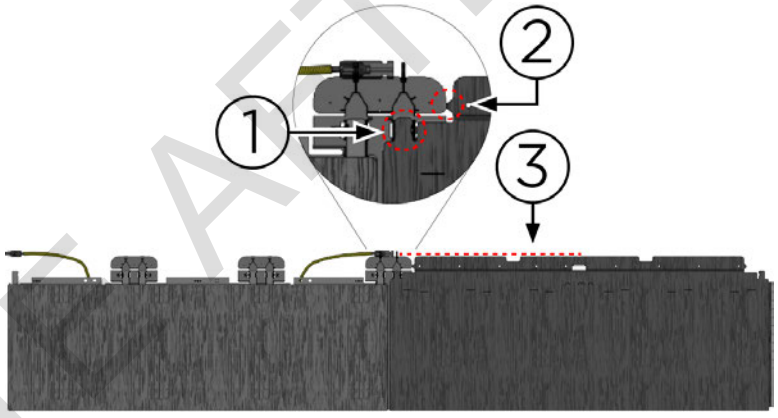
NOTE: Refer to the *Fastener Schedule on page 703* for fastener specifications.

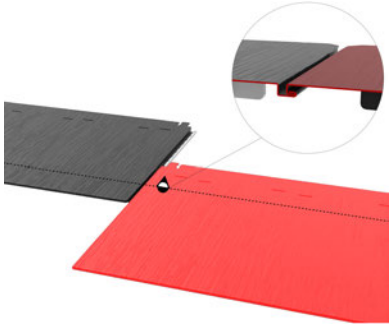
Metal Tile Target Holes	
Description	Optional target holes located on the metal tile nailing flange that can guide fastening (fastening directly through these target holes is not required).
Image	

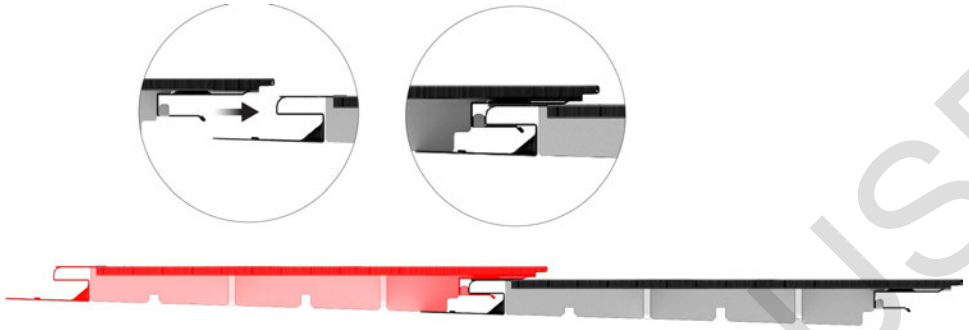
Interlocking / Alignment Hardware

Metal Tile Timing Marks	
Description	Vertical marks that set proper tile stagger during installation.
Image	

Metal Tile Nominal / Max Reveal Marks	
Description	Horizontal marks that determine the tile max **(1)** and nominal **(2)** reveal.
Image	

Metal Tile Horizontal Alignment Features	
Titles / Description	• Engagement Tabs **(1)**: Installed into the footlap engagement clips to ensure alignment • Bump Out **(2)**: Aligns with the footlap edge • Tile Top Edge **(3)**: Coincides with the top edge of the footlap
Image	

Metal Tile Open Hem	
Description	Adjacent metal tiles lock into each other through the open hem along the water channel. The tile slides down from the top until it reaches the nominal reveal line.
Image	

Metal Tile Lower Engagement Hook	
Description	When installing metal tiles over each other, the upper metal tile's lower engagement hook engages with the lower metal tile's nailing flange.
Image	

Metal Tile Cutting Marks	
Description	The metal tile sides feature marks at 1 in increments to guide cutting.
Image	

Glass Tile Overview

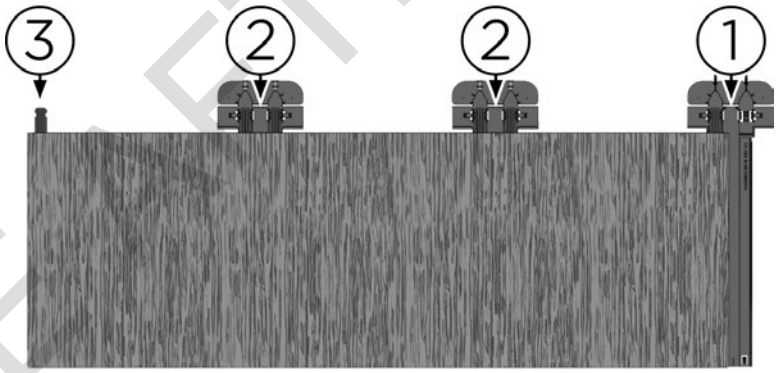
Non-electrical tempered glass tiles buffer the solar array at all edge conditions and are installed in High Velocity Hurricane Zones (HVHZ). Glass tiles can be installed in place of, below, adjacent to or over PV tiles. Glass tiles can also be installed against metal trim and flashings.

Model Number	SR72T3R
Principal Materials	Glass, Polymers and Fiberglass
Dimension	381 mm x 1140 mm x 6.2 mm 15 in x 44.875 in x 0.25 in
Tile Reveal	Fixed: 14 in
Height from Deck	35.3 mm | 1.375 in
Roof Covering Weight	16.31 kg/m^2 | 3.15 psf

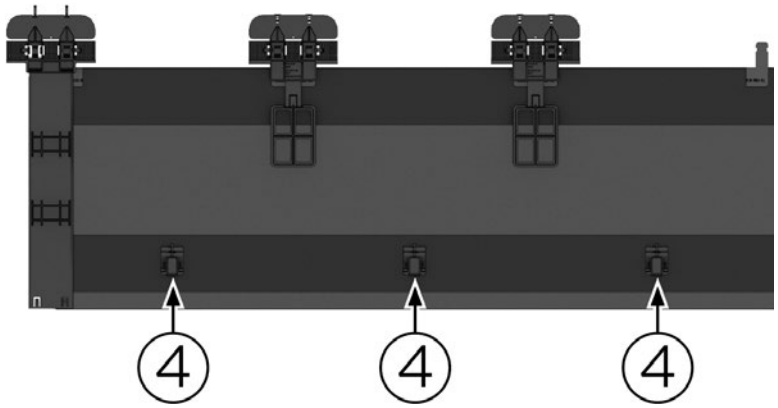
Glass Tile Overview

1. Footlap
2. Foot
3. Backer
4. Glass Tile Hooks

Top View

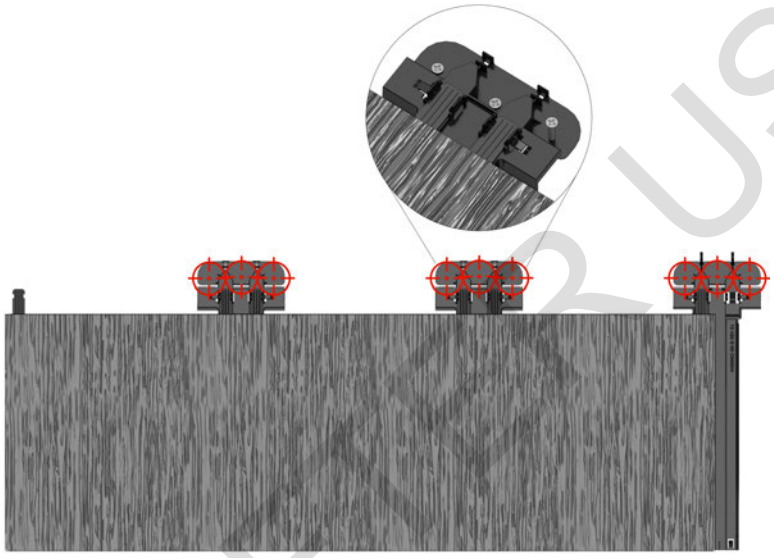


Bottom View



Fastening Hardware

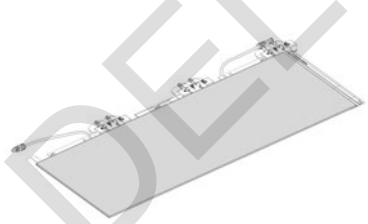
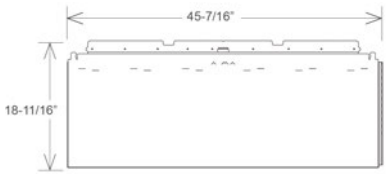
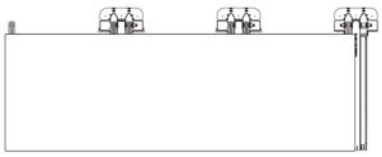
NOTE: Refer to the *Fastener Schedule on page 703* for fastener specifications.

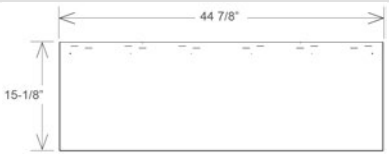
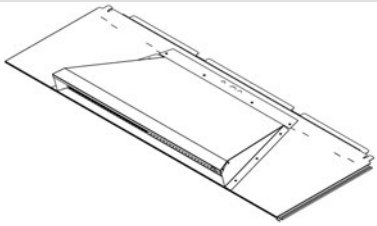
Foot / Footlap Target Holes	
Description	Target holes that define glass tile fastening locations.
Images	

Part Catalog

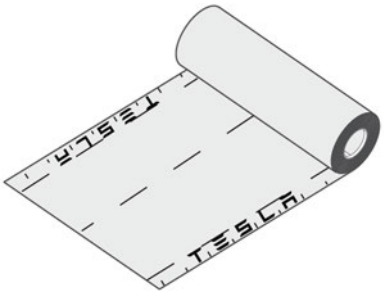
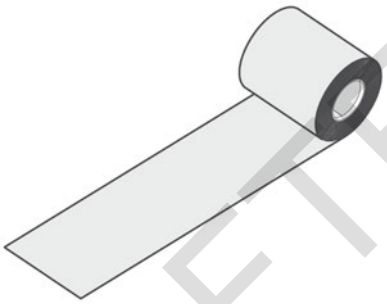
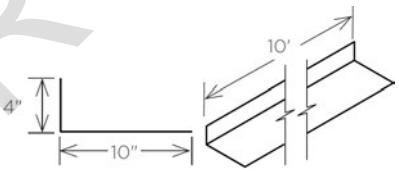
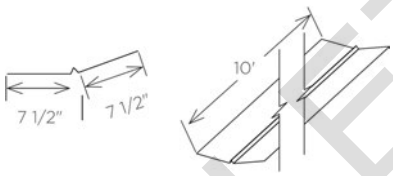
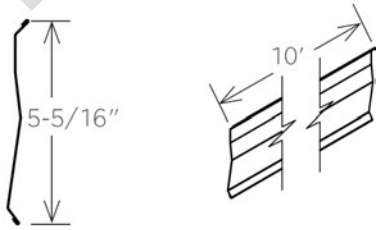
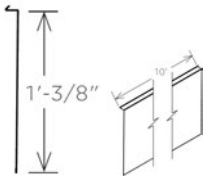
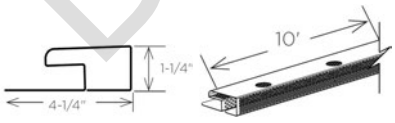
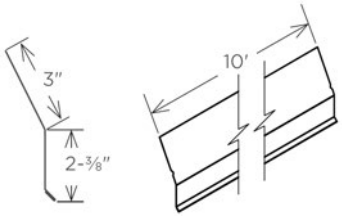
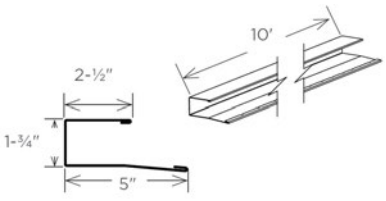
NOTE: Please note that the letter "X" at the end of all part numbers signifies a generalized letter that replaces the most up to date letter. When ordering, ensure that the numerical part number is accurate in Partner Portal.

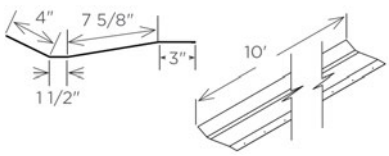
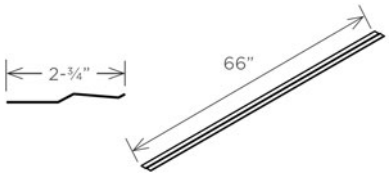
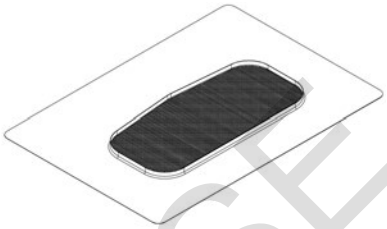
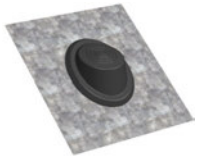
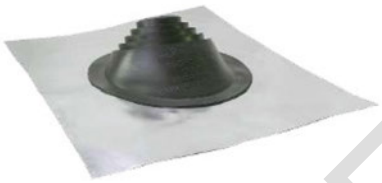
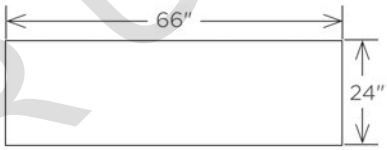
Tiles

Tiles		
Title: PV Tile **Part number:** 1350002-00-X 	**Title:** Metal Tile **Part number:** 1833222-01-X 	**Title:** Glass Tile **Part number:** 1840710-00-X 
Title: Tile Skin **Part number:** 1847636-01-X	**Title:** Tile Vent **Part number:** 1840821-01-X	

Tiles		
		

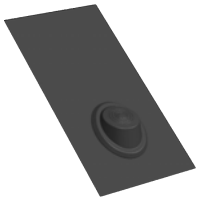
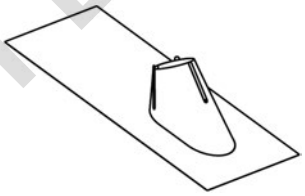
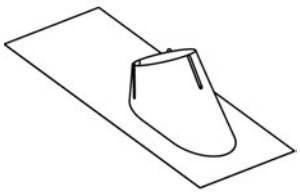
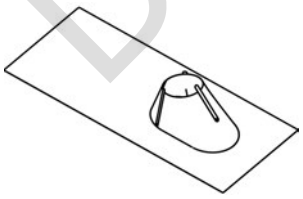
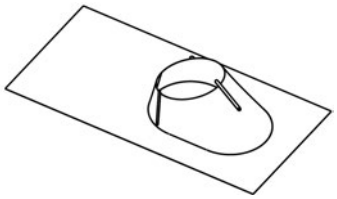
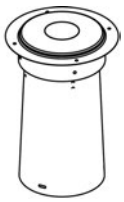
Dry In and Perimeter

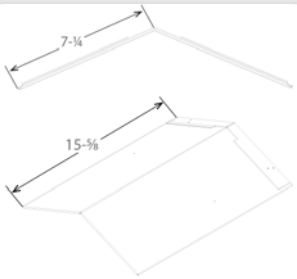
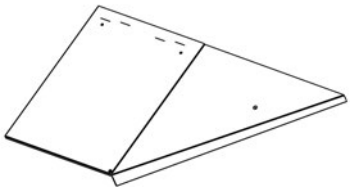
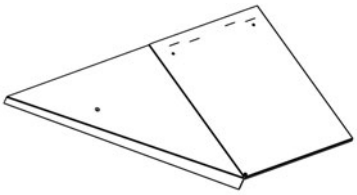
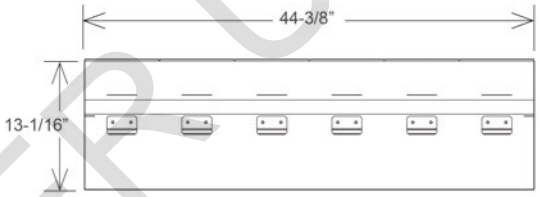
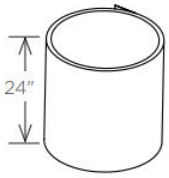
Dry In and Perimeter		
Title: Underlayment **Part numbers:** Class A 1613738-03-X 1947922-00-X Class C 1751844-00-X 	**Title:** Detail Roll **Part number:** 1636403-10-X 	**Title:** Wall Flashing **Part number:** 1813367-00-X 
Title: Valley Pan **Part number:** 1809953-01-X 	**Title:** Surface Mount Counter Flashing **Part number:** 1145837-02-X 	**Title:** Reglet **Part number:** 1145809-04-X 
Title: Vented Riser **Part number:** 1854532-00-X 	**Title:** Drip Edge **Part number:** 1849932-01-X 	**Title:** Channel Flashing **Part number:** 1818864-01-X 
Title: Transition Flashing	**Title:** Cleat	**Title:** Deck Vent

Dry In and Perimeter		
Part number: 1810487-01-X 	**Part number:** 1849921-00-X 	**Part number:** 1606873-00-X 
Title: DWV - Deck Boot, 1-1/4 to 4 in **Part number:** 1856360-00-X 	**Title:** Heat Vent - Deck Boot, 3 to 8 IN **Part number:** 1719372-00-X 	**Title:** Flat Stock 2 ft x 5.5 ft **Part number:** 1843746-02-X 

Dry In and Perimeter		
Title: Black Sealant **Part number:** 1784898-00-X 	**Title:** Flex Flashing Roll **Part number:** 1776371-01-X 	**Title:** Wire Mesh **Part number:** 1460521-00-X 
Title: Ridge Roll **Part number:** 1893856-00-X 		

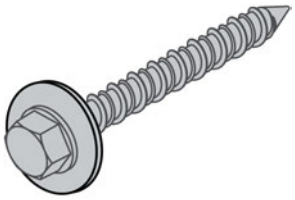
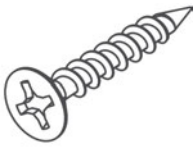
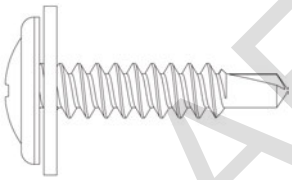
Tile Level Flashings

Tile Level Flashings		
Title: DWV - TILE BOOT-1/4 to 4 in **Part number:** 1856360-11-X 	**Title:** Heat Vent - Flashing, 4 in, High Pitch **Part number:** 1820727-01-X 	**Title:** Heat Vent - Flashing, 8 in, High Pitch **Part number:** 1820727-11-X 
Title: Heat Vent - Flashing, 4 in, Low Pitch **Part number:** 1820726-01-X 	**Title:** Heat Vent - Flashing, 8 IN, Low Pitch **Part number:** 1820726-11-X 	**Title:** Heat Vent Cap, 4 in **Part number:** 1666803-02-X 
Title: Heat Vent Cap, 8 IN	**Title:** Cap **Part numbers:** 1812163-01-X	**Title:** Right Adjustable Trim Cover **Part number:** 1879857-01-X

Tile Level Flashings		
Part number: 1666807-02-X 		
Title: Left Adjustable Trim Cover **Part number:** 1880185-01-X 	**Title:** Footlap **Part number:** 4400002-00-X  	**Title:** Shingle Flashing **Part number:** 1877905-00-X 
Title: Black Coil Flashing **Part number:** 1472512-05-X 		

Fasteners

WARNING: Only use approved fasteners. Do not substitute without Engineering approval.

Fasteners		
Title: Ring Shank Nail, 1.25-IN, SS **Part number:** 1549330-00-X 	**Title:** Hi-Lo Screw+WSHR, 3/16x2-IN, SS +EPDM, BLK **Part number:** 1877425-00-X 	**Title:** Wood Screw, 10-13x2.375-IN, SS, BLK **Part number:** 1917819-00-X 
Title: Deck Screw, 1-in **Part number:** 1470351-00-X 	**Title:** Self-Tap Screw+WSHR, 8-18x0.75-IN, SS, BLK **Part number:** 1916307-00-X 	

Rooftop Electrical

<table>
<tr><th colspan="3">Rooftop Electrical</th></tr>
<tr>
<td>Title: ASY, MCI-2, 600V, 12A

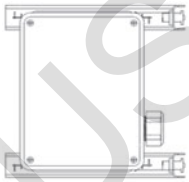
Part number: 1879359-15-X

  </td>
<td>Title: MC4 Y Connector

Part numbers:1578537-00-X MC4-EVO2 Y Connector (socket), 11578538-00-X MC4-EVO2 Y Connector (plug)

  </td>
<td>Title: Junction Box, 4 String

Part number: 1571739-00-X

  </td>
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<tr>
<td>Title: Pass-Through Box

Part number: 1713348-00-X

  </td>
<td></td>
<td></td>
</tr>
<tr>
<td>Title: 1x Jumper, pre-sleeved, length: 59.8 inches

Part number: 1705337-41-X</td>
<td>Title: 3x Jumper, pre-sleeved, length: 150 inches

Part number:1705337-43-X</td>
<td>Title: 5x Jumper, pre-sleeved, length: 240.1 inches

Part number: 1705337-45-X</td>
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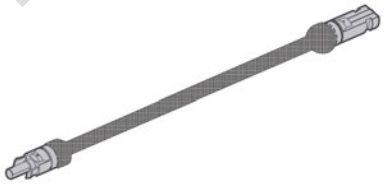
<td colspan="3">  </td>
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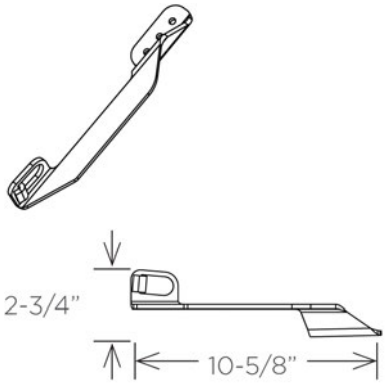
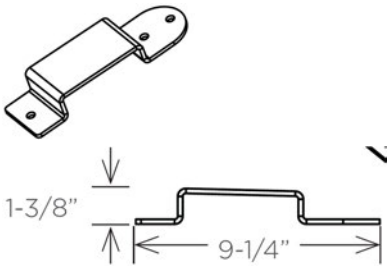
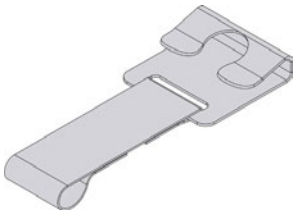
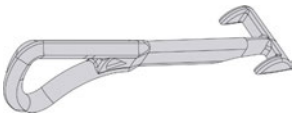
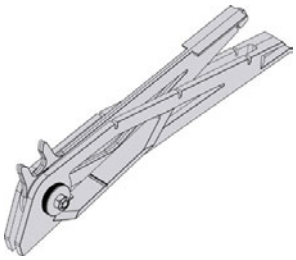
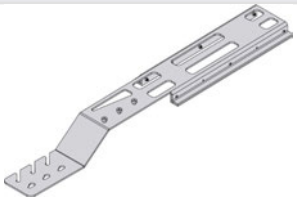
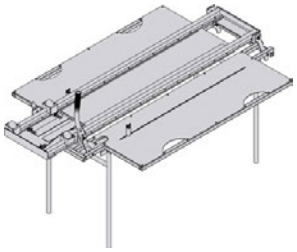
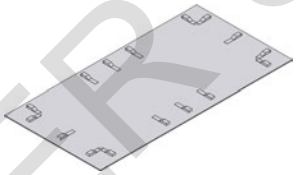
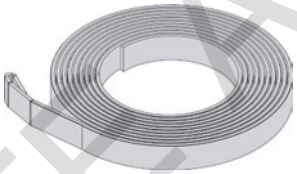
Accessories

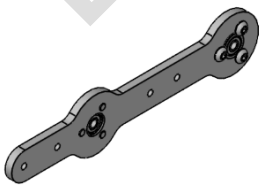
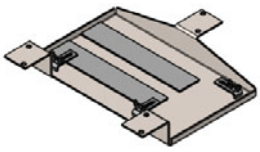
Accessories		
Title: Assisted Access Point **Part number:** 1683151-00-X 	**Title:** Accessory Bracket Kit, Box of 5 **Part number:** 1877133-00-X 	**Title:** Solar Roof Yard Sign **Part number:** 1650144-00-X 
Title: Paint Pen **Part number:** 2192490-00--X 	**Title:** Hose Clamp **Part number:** 1853696-00-X 	

Tooling

Tooling		
Title: Carabiner **Part number:** 1606894-00-X 	**Title:** Glass Hook, Traction Mat **Part number:** 1606892-00-X 	**Title:** Hammerhead Hook **Part number:** 1874380-00-X 
Title: Robin Jig	**Title:** Roof Bracket Adapter **Part number:** 1738051-00-X	**Title:** Roof Rack Straps **Part number:** 1874559-01-X

Tooling		
Part number: 1900190-00-X 		
Title: Roof Staging Rack 2.0 **Part number:** 1555870-00-X 	**Title:** Tile Trimmer 2.0 **Part number:** 1947389-00-X 	**Title:** Traction Mat, Solar Roof **Part number:** 1606891-00-X 
Title: Up & Over Jig **Part number:** 2021540-00-X 	**Title:** Webbing, Traction Mat **Part number:** 1607148-00-X 	**Title:** Anchor, Traction Mat, Solar Roof **Part number:** 1607147-00-X 

Replacement Parts

Replacement Parts		
Title: Sub Assembly, Link, Tile Trimmer 2.0 **Part number:** 2221492-00-X 	**Title:** Sub Assembly, Saw Plate, Tile Trimmer 2.0 **Part number:** 2220454-00-X 	**Title:** Rubber Strip, Right, 4.0", Tile Trimmer 2.0 **Part number:** 1948342-02-X 

PREPARING THE HOME FOR SOLAR ROOF INSTALL

Site Survey

In addition to general rooftop assessment requirements, Solar Roof sites must take extra considerations for:

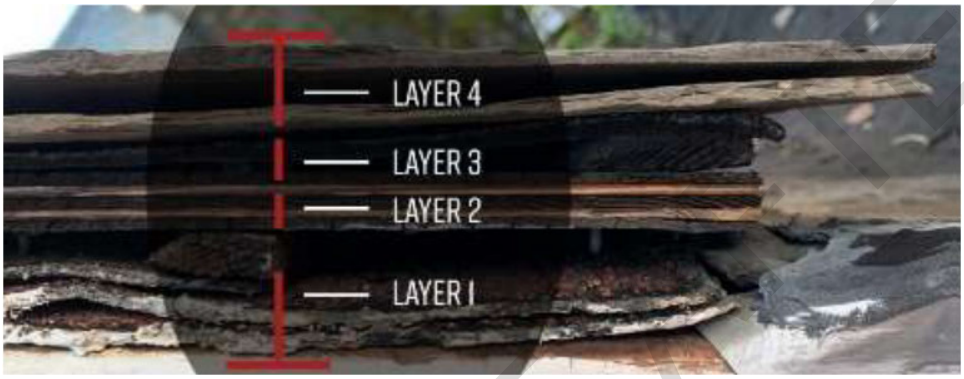
Gutters Present

Gutters located on the eave of Solar Roof MPs must be documented.

Gutters must be removed to properly install the drip edge flashing at the eave. Removing gutters adds additional time/cost to the install.

More than One Roofing Layer

Removing an additional layer of roofing adds additional cost/time to the tear off.



Decking Replacement

Solar Roof is required to be installed over plywood decking and that decking must meet certain thickness/gap requirements.

Document affected square footage when the existing decking does not comply with Solar Roof installation standards.

Examples of non-compliance:

- Decking is damaged
- Decking does not exist on the home
- Existing decking is not > ½ in nominal thickness plywood or OSB
- Existing decking/sheathing is not tightly fitted together (no large gaps)

½ in Nominal Plywood or OSB Sheathing

Look for the stamped information label with thickness, or measure between gaps with a ruler/tape.

No 3/8 in Nominal Thickness Plywood or OSB Overlaying Solid or Wood (< 1/8 in Gaps)

Skylight Replacement

Document the quantity of skylights with images of each unique edge length with tape measure included.

Look for broken gaskets, cracks on the glass, and any indication of leaking.

Skylight Deletion

Skylights too close to a valley need to be deleted. All Obstructions should be a minimum of 12 in away from a valley.

If a customer requests to delete a skylight, you will also select this section.

Existing Rooftop System Removal

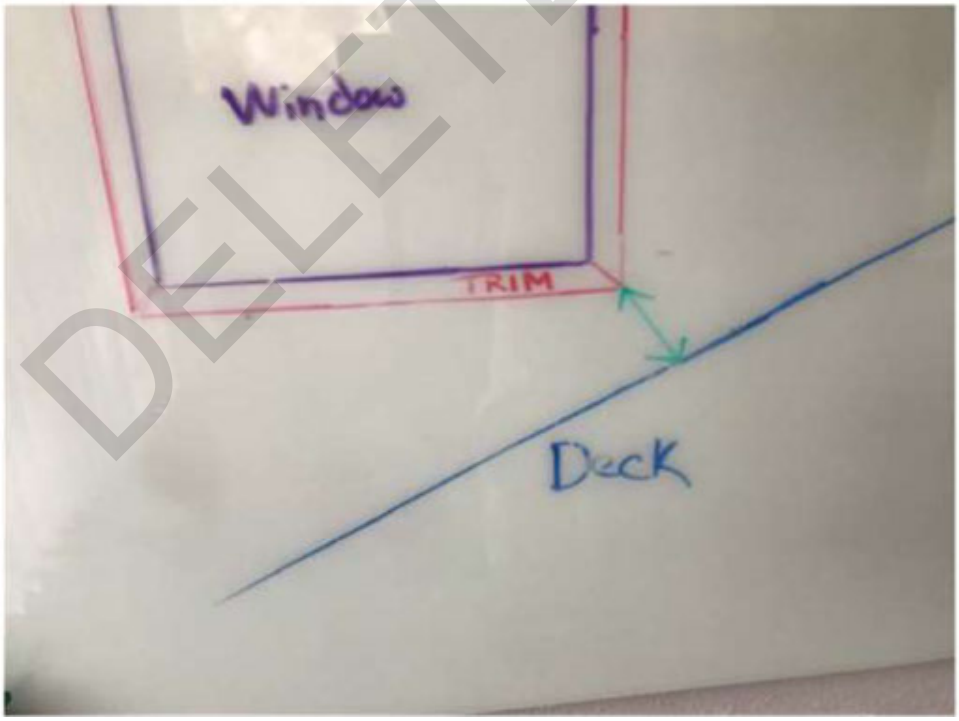
Document existing rooftop PV and solar thermal systems.

These will need to be removed prior to Solar Roof installation.

Low Window FAE Solution Required

When a window exists on an adjacent sidewall, headwall, or endwall, verify a 4 in minimum clearance from the lowest point of window apron/trim to the roof deck.

Document window openings requiring a solution with photos with your tape measure.



NOTE: The deck to wall flashing must be able to go up the wall a certain amount to properly waterproof, if the glass is too close to the deck and cannot allow the flashing to be installed.

The work around for 2 - 8 in windows requires additional work/time/cost

There is no work around for < 2 in, therefore the job must be DQ'd unless the home owner moves the window up on the wall.

Solid Wood Sheathing Repair

Document when the existing decking is solid wood sheathing and sheathing is cracked, warped, modified, or damaged so as to compromise the safety of the installation.

Fascia/Soffit/Eave Repair

Existing soffit/eave dry rot needs to be taken care of to ensure warranty on Solar Roof product and improve aesthetics of customer's homes.

Check all “extended roof” past the exterior walls for damage.

- Discoloration, cracks, peeling are all visual signs of damage.

- Feel for soft or hollow spots to confirm wood rot or termite damage.

Rafter Repair

Damaged rafters can cause the roof to sag/bend which can result in broken tiles over time and an unsafe installation.

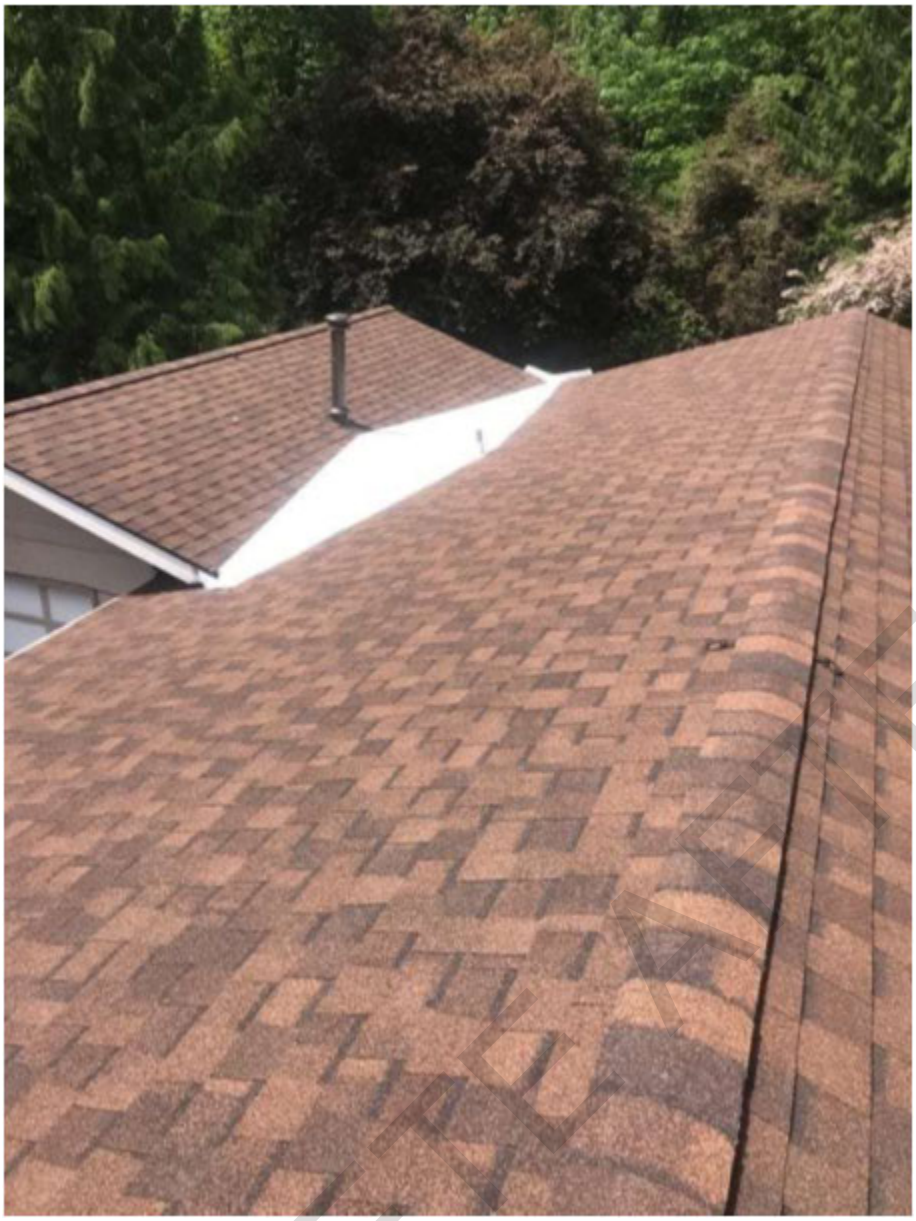
Look for sags on the mounting planes, high spots where a rafter is pushing up on the deck, and any points where the roof is not a flat plane (usually easily visible from the ground when lining the eave up with the ridge.)

Count the number of rafters affected by the sag. Make sure to count at least one rafter past the sag on either side.

Flat Roof Interacting with Solar Roof

Identify any flat roof sections.

Important: Identify any sections where a valley does not have an egress angle for water to leave. These will need to be cricketed and flat-roofed as well (hog-valleys.)



Rooftop-Mounted HVAC Present

When rooftop-mounted HVAC units are identified, take clear images of sheathing and attic under the unit.

More than Two Stories

Document when the scope of work requires access to a third story or higher rooftop.

Mechanically Attached Underlayment

Document when the underlayment is attached to the roof using fasteners.

Ventilation

Ventilation Requirements

Solar Roof complies with the International Residential Code (IRC) (Section R806) (2021 edition) and International Building Code (IBC) (Section 1202.2) (2021 edition), including the following:

- Minimum ventilation ratio of 1:150 or 1 ft^2 of Net Free Vent Area (NFVA) for every 150 ft^2 of attic floor space / roof area
    - Amount of ventilation may be reduced to 1:300 if **both** of the following conditions are met:
        1. Class I or II vapor retarder is installed on the warm-in-winter side of the ceiling for buildings located in Climate Zones 6 through 8
        2. A balanced ventilation system is being used

NOTE: State and local jurisdictions may amend roof ventilation requirements outlined in the International Building Code (IBC) or the International Residential Code (IRC). Always consult, verify and follow local building codes and requirements.

Solar Roof complies with **Wildlife Urban Interface (WUI) requirements**.

Solar Roof complies with **California Building Code (CBC) 706A.2 requirements**.

Solar Roof is designed to meet the WUI and CBC requirements above. To do so, the Solar Roof's ventilation openings for enclosed attics, enclosed eave soffit spaces, enclosed rafter spaces formed where ceilings are applied directly to the underside of roof rafters, and underfloor ventilation openings should be fully covered with wire mesh, vents, other materials that meet one of the following requirements:

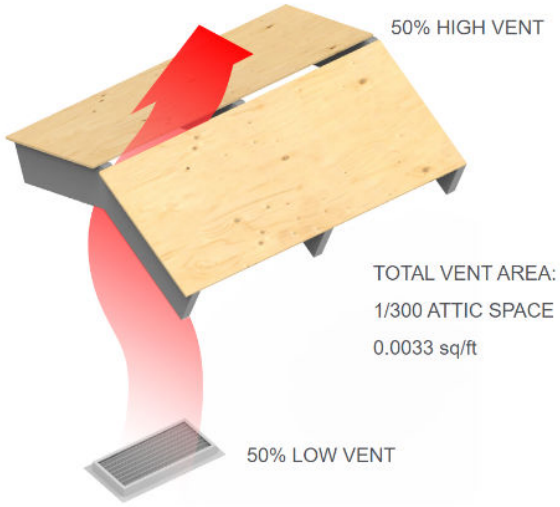
- **2.** Vents complying with all of the following:
    - **2.1** The dimensions of the openings therein shall be a minimum of 1/16 in (1.6 mm) and shall not exceed 1/8 in (3.2 mm.)
    - **2.2** The materials used shall be noncombustible.
    - **2.3** The materials used shall be corrosion resistant.

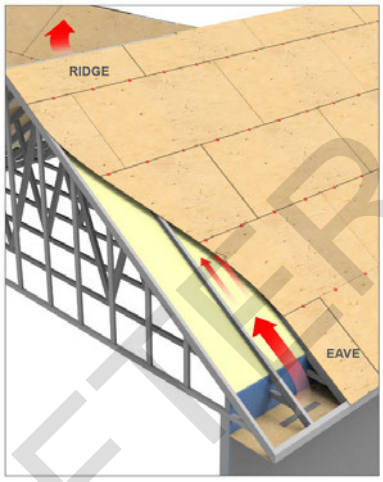
Vent Types

The types of vents used on Solar Roof are continuous vents at the soffit and ridge which have ratings based upon square inches per linear foot. A balance between exhaust and intake ventilation is necessary for a ventilation system to work properly. Thus, vents must be sized correctly such that 50% of the total ventilation is provided by exhaust ventilation and the remaining 50% is provided by intake ventilation.

Solar Roof uses two types of vents: **ridge vents** and **tile vents**.

- Ridge vents are used exclusively as exhaust vents





- Tile vents are used in areas where hip-to-hip features cover a large amount of surface area and can be used as either intake or exhaust vents depending on the ventilation system design
  - Tile vents are used near the ridge to provide exhaust ventilation for roofs with minimal or no ridgeline (such as hip roofs.)

  - Tile Vents are used near the eave to provide intake ventilation for roofs with limited or no soffit areas.

Flashing Assemblies

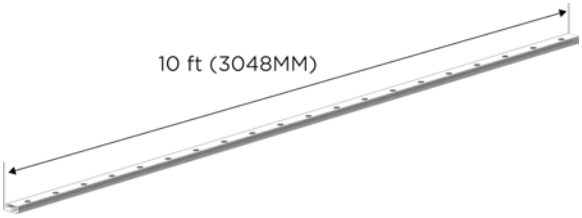
Ridge and eave flashing systems are designed to ensure that embers cannot enter into the building in the event of a wildland fire.

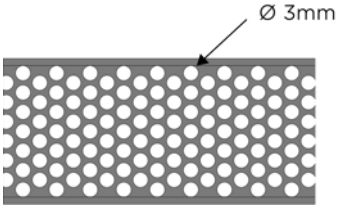
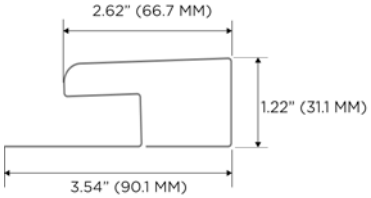
Attic Space Venting - Ridge Flashing Assembly

Ridge vents are enclosed with a flashing assembly consisting of a ridge cap and vented riser flashing. The vented riser flashing has 3 mm round holes and is installed along the entire length of the ridge. The Net Free Area of Solar Roof ridge vent is 12.5 in^2/ft.

1. Ripped Metal Tile
2. Vented Riser
3. Ridge Cap
4. Ridge Cap Roll

Vented Riser

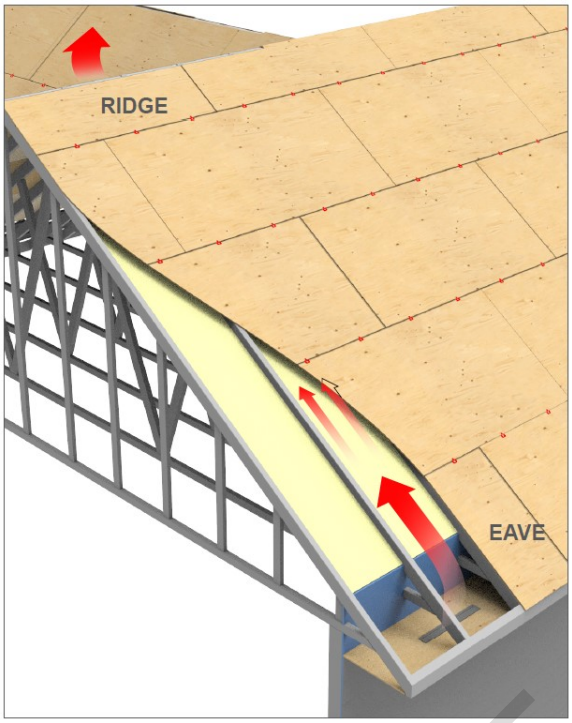


Front View	Side View
	

Assessing Attic Ventilation

Overview

This section provides guidance for assessing attic ventilation. Adequate attic ventilation is important for moisture reduction and mold inhibition. The size and location of vents should be completed at the design phase based on audit information and is all planned out upon arrival to the site. The site audit takes the following into consideration: Type, quantity, size and location of existing venting; design of attic space; footprint of attic space and house; ridge beam size if applicable; and customer preference.



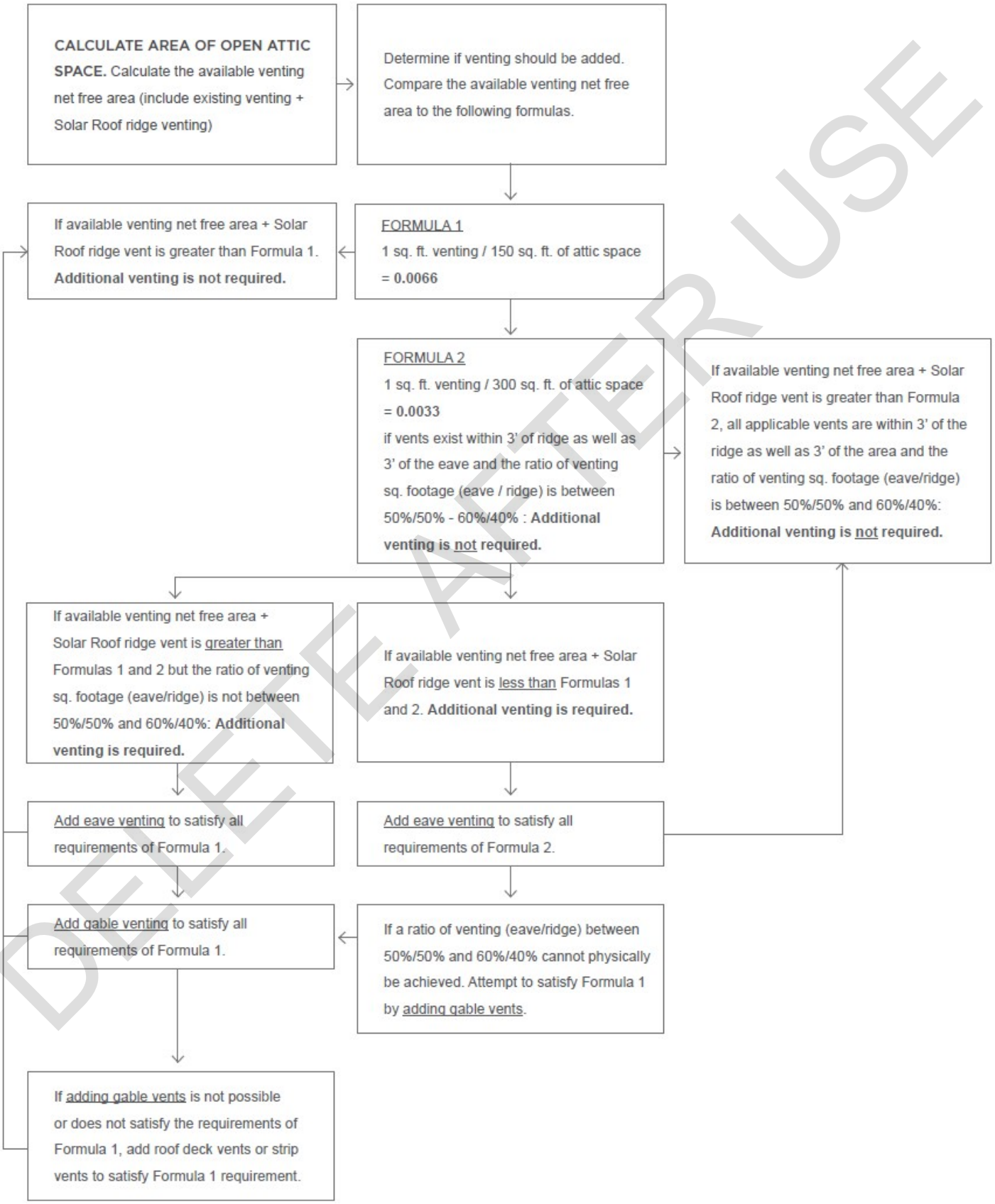
Ventilation Calculations

Table 2. California Building Code

FORMULA 1 1/150′ 0.0066 ft^2 minimum	The minimum net free venting area shall be 1/150 of the area of the venting space.
	In other words, 1 ft^2 of venting per 150 ft^2 of building. This is used when there are vents at one height, one type of venting, either gable vents, soffit vents, eave vents, ridge vents, at one height. To determine if the ridge vent provides enough vent area to satisfy this formula, determine the amount of net free venting.
FORMULA 2 1/300′ 0.0033 ft^2 minimum	The minimum net free ventilation area shall be 1/300 of the vented space provided one or more of the following conditions are met: 1. In Climate Zones 14 and 16, a Class I or II vapor retarder is installed on the warm-in-winter side of the ceiling. 2. Not less than 40% and not more than 50% of the required ventilation area is provided by ventilators located in the upper portion of the attic or rafter space. Upper ventilators shall be located not more than 3 ft (914 mm) below the ridge or highest point of the space, measure vertically, with the balance of the required ventilation provided by eave or cornice vents. Where the location of wall or roof framing members conflicts with the installation of upper ventilators, installation more than 3 ft (914 mm) below the ridge or highest point of the space shall be permitted.
	In other words, 1 ft^2 of venting per 300 ft^2 of building in plan view. This formula is used when there are vents at two heights. For example, both eave and ridge, eave and gable, etc. Vents need to be split by 50% high vent and 50% low vent, at minimum a 60% to 40% split. This pulls air in from cooler, lower locations and the hot air exits at a higher location.

PREPARING THE HOME FOR SOLAR ROOF INSTALL

Venting is important for moisture reduction and mold inhibition. The size and location of vents should be completed at the design phase based on audit information and is all planned out upon arrival to the site. The site audit takes the following into consideration: Type, quantity, size and location of existing venting, design of attic space, footprint of attic space and house, ridge beam size if applicable, customer preference.



Example 1:

Total square ft (top down perspective):

(9 ft x 2 ft) x 150 ft = 2700 ft^2

Net free venting area from ridge vent:

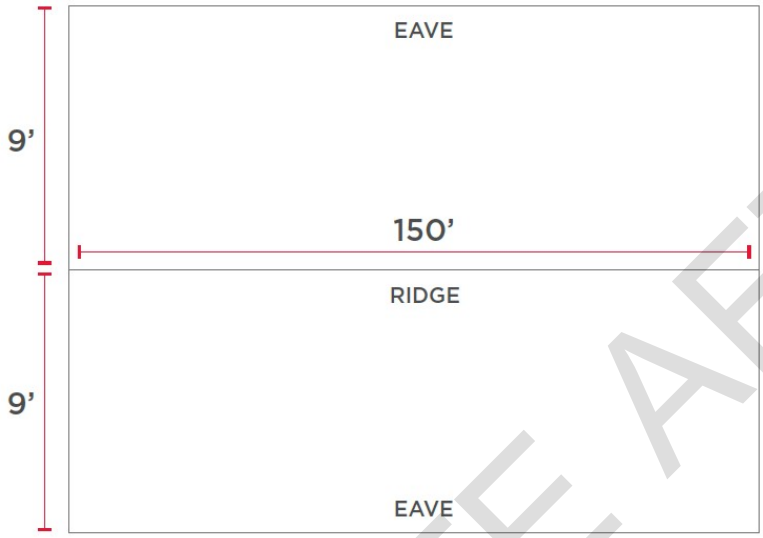
1.5 in x 150 ft = 18.75 ft^2

Venting Value:

18.75 ft^2 / 2700 ft^2 = 0.006944 ft^2

0.006944 ft^2 > 0.00666 ft^2

Result: Therefore, this house satisfies Formula 1. No additional venting is needed.



Example 2

Total square foot (top down perspective):

(10 ft x 2 ft) x 150 ft = 3000 ft^2

Net free venting area from ridge vent:

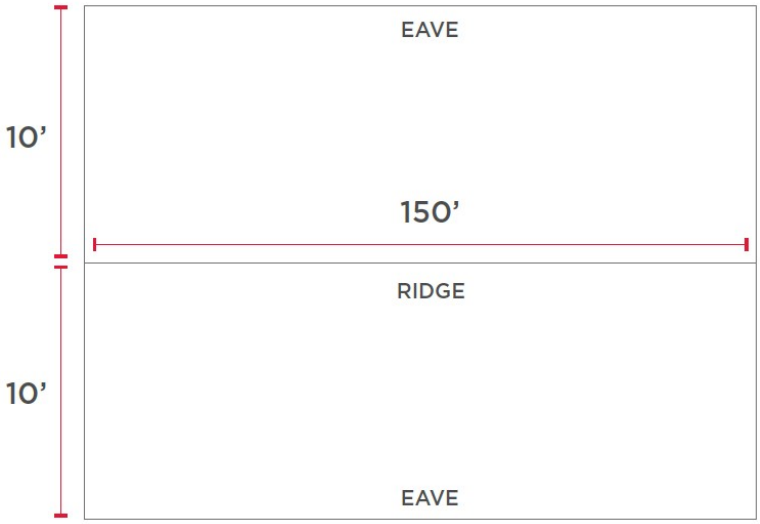
1.5 in x 150 ft = 18.75 ft^2

Venting Value:

18.75 ft^2 / 3000 ft^2 = 0.00625 ft^2

0.00333 ft^2 > 0.00625 ft^2 > 0.00666 ft^2

Result: Therefore, this house doesn't satisfy Formula 1. It does satisfy Formula 2, unless the venting is not split a minimum 60% to 40%. If it is not split 60/40, additional vents are needed.



Example 3

Total square foot (top down perspective):

(19 ft x 2 ft) x 150 ft = 5700 ft^2

Net free venting area from ridge vent:

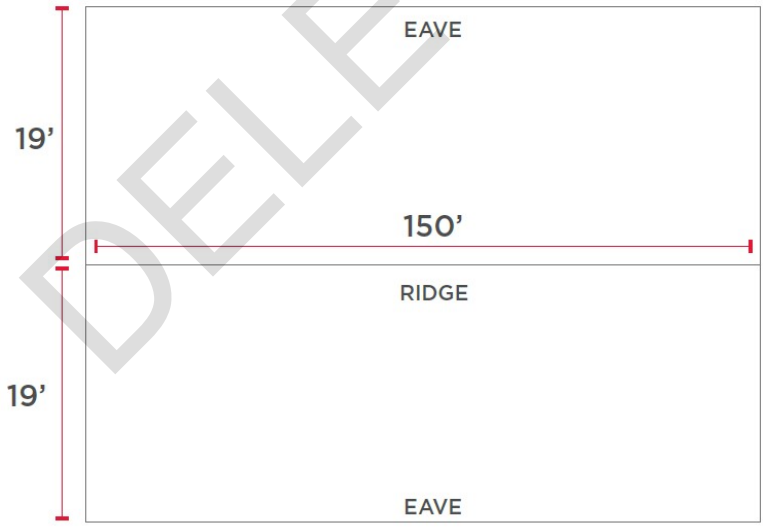
1.5 in x 150 ft = 18.75 ft^2

Venting Value:

18.75 ft^2 / 5700 ft^2 = 0.0003289 ft^2

0.0003289 ft^2 < 0.00333 ft^2

Result: Therefore, this house doesn’t satisfy Formula 1 or Formula Additional venting is needed. Since ridge vents can’t be expanded, venting at another level needs to be added. Venting will need a minimum of 60% to 40% split between high and low vents to satisfy Formula 2. For example, 40% eave and 60% ridge.



Cutting Vents

Ridge vents are cut prior to underlayment installation. This will keep the circular saw blade clean.

Cutting Vents

Tools and Equipment

- Circular Saw
- Measuring Tape

CAUTION: The dust and debris created from cutting the ridge back can cause a slip hazard when underlayment and/or glass is already installed.

NOTE: The ridge vent is only cut into attic spaces only. It should not extend into valley areas or rakes.

1. Angle the circular saw plate so that it matches the pitch of the roof with the blade still positioned plumb. Cutting a plumb line will maximize the amount of available space to mount feet and brackets at the ridge.
2. Set the depth of the blade so the cut penetrates only through sheathing material and not into framing members.

Cutting Vents with a Ridge Beam

1. When a ridge beam is present, measure ¾ in from either side of the beam.
2. Cut the ridge vent openings. Offset the vent cut a minimum of 18 in away from valleys, rake edges, sidewalls, or ridge interactions.
3. Temporarily seal the vent with underlayment to protect the home from moisture.

Cutting Vents without a Ridge Beam

1. When there is no ridge beam, measure an opening that is a total of 1 ½ in width.
2. Cut the ridge vent openings. Offset the vent cut a minimum of 18 in away from valleys, rake edges, sidewalls, or ridge interactions.
3. Temporarily seal the vent with underlayment to protect the home from moisture.

Cutting Vents for Larger Beam Sizes (Duplicate to Tile)

Larger beam sizes include 4x or 6x beams.

Ridge beams that are wider than 2 in are vented using holes rather than a slotted vent. This is because a slot offset from a wider beam will remove too much material. Using holes ensures sufficient surface area for mounting brackets and feet to be fastened.

Glass Tiles:

CAUTION: If the tile installation is glass, do not cut ridge vent slots during the dry in phase.

Metal Tiles:

If the terminating tile is a metal tile, venting holes can be drilled during the dry in phase. This is because glass tiles do not use mounting feet.

1. Drill maximum of 3 holes between each rafter on standard spaced rafters.

> **NOTE:** Avoid drilling through rafters.

2. For glass tiles, cut vent holes between feet after tile installation is complete.

Cutting Non-Ridge Vents (Move to Dry In)

This procedure can take place after dry-in is complete and installation is underway.

Tools and Equipment

- Cordless Circular Saw
- Pencil
- Hammer
- Speed Square

1. Start by determining the approximate location of the vent on the roof.
2. Install tiles to just below this location. This will ensure that there is no conflict with module feet landing on the sub vent location.
3. Locate and mark rafters by using a hammer to check for the areas which resonate as hollow.
4. Mark the outer vent periphery, then use a speed square to mark the vent hole.
5. Set the blade depth to match the thickness of the decking on a cordless circular saw to avoid cutting the framing members.

> **DANGER:** Do not cut into rafters.

6. Make plunge cuts around the marks.
7. Continue to flashing installation.

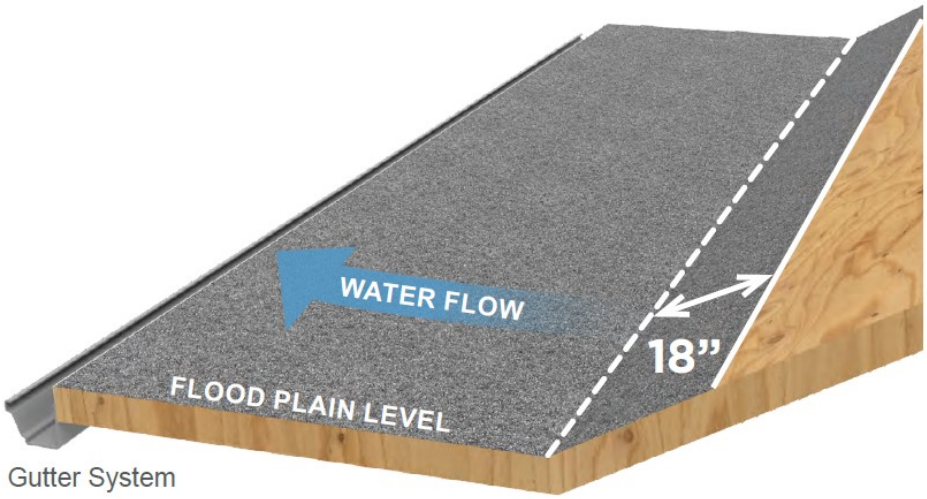
Evaluating Low Slope Roofs

Overview

This section provides guidance for evaluating whether the existing flat roof meets our integration specification. The minimum required coverage of the current flat roof material is 18 in up from flood plain level. If the amount of existing flat roof material extending up the pitched roof does meet the requirements outlined in the Flood Plain Table or the conditions are outside the scope of the Flood Plain Table, please contact your Tesla PM for further instruction.

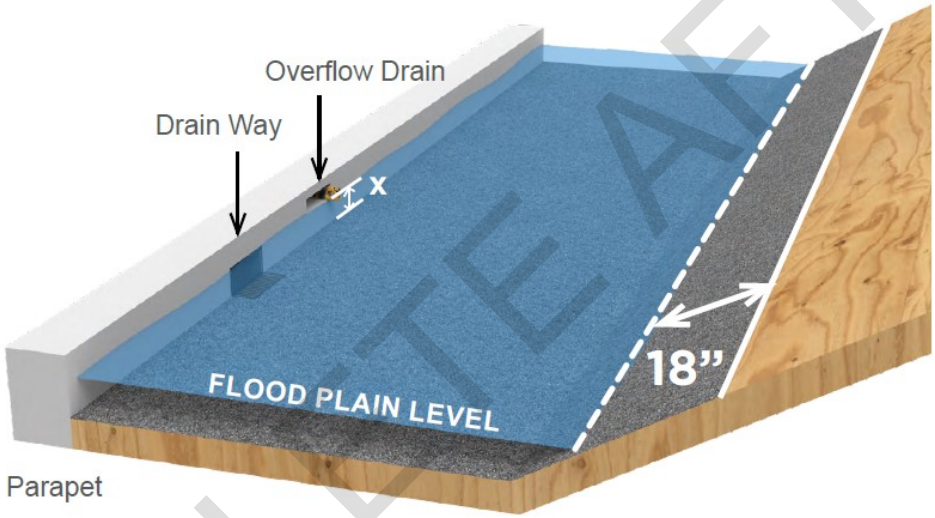
Flood Plane at Gutter

In a gutter system the flood plane is in line with the deck, therefore the required coverage is 18 in as measured from the roof deck.



Flood Plane at Parapet

If the structure allows water to collect, for example if a parapet wall is present with an overflow drain, measure the 18 in up from the overflow drain or maximum flood plane level.



Required Clearance for Wall Integration

Overview

Solar Roof modules and mounting components stack up approximately 1.6 in from the roof deck. Flashings require a fastening clearance of 1 ¾ in into the roof surface. Preparing the wall surfaces prior to dry-in will prevent punctures and damage to underlayment. Completing any needed cuts during this initial phase will also make it easier to clear the roof surface free of debris, sawdust or sealant. All cuts should be executed in a clean straight line without damage or chipping to the aesthetics of the home. Deck level flashings are always installed behind the building wrap.

NOTE: Do not damage or destroy the waterproofing barrier behind the siding.

Required Clearance for Wall Integration

Tile level flashings that are integrated into the building envelope require additional clearance, depending on the substrate type.

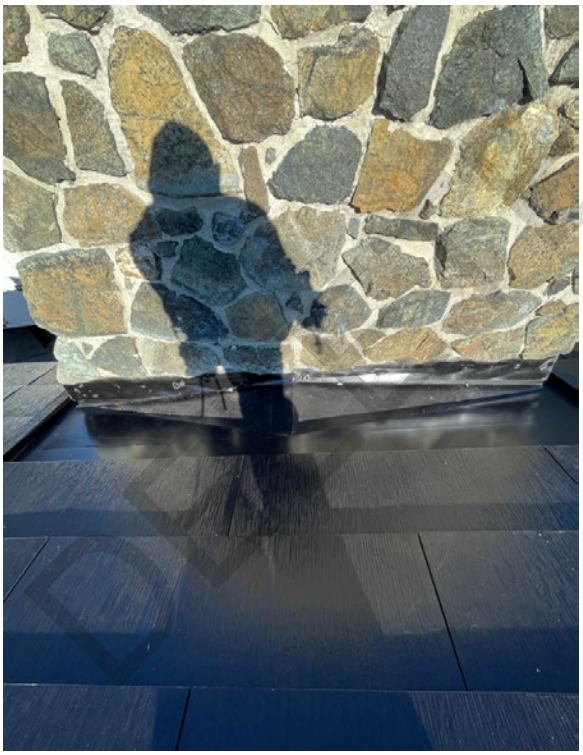
Substrate Type	Flashing Integration	Flashing	Height of Cut
Vinyl Siding	Tucked under	Sidewall Step Flashing, Headwall Flashing, Endwall Flashing	3 in (+/- ¼ in)
Wood Siding			
Natural Stone	Kerf mounted	Reglet Counterflashing	8 in
Brick			7 in - 16 in
Stucco	Surface Mounted	Surface mount Counterflashing	4 in + 2 in chipped away

Prepping the Siding for Solar Roof

Wood Siding:

Vinyl Siding:

Stone Siding:



Composite/Hardie Board Siding:

Brick Siding:

Stucco Siding:

Overview

As Solar Roof covers the entire roof, it needs to be integrated into the walls of a home for the system to be watertight at the deck level.

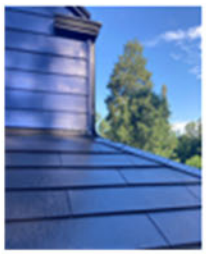
To ensure that the system does not leak, it is sometimes necessary to remove the siding and expose the building paper to make sure that the flashings are properly lapped.

When possible, and if the condition of the existing flashing is still good, reusing the existing flashing would be more efficient and there is no need to remove the siding. (See *Adapting and Reusing Existing Flashing on page 130*)

Existing Flashing	Use	Remove
Flashing is undamaged	✓	
Flashing is damaged, but it is possible to properly repair it.	✓	
Flashing needs to be painted, but reusing it will save time/work.	✓	
Flashing is unique and undamaged.	✓	
Flashing is damaged beyond repair.		✗
Flashing is undamaged, but is causing delays.		✗
Flashing is improperly installed.		✗
Flashing is elevated more than ½ in off the deck.		✗
Any of the following are present: Rust, corrosion, excessive sealant or mastic, broken welds.		✗

Graph Procedures for Different Siding Types

Here are the proper steps to take for each siding type when replacing the existing flashings.



Wood Siding

Composite/Hardie Board Siding

Vinyl Siding

Remove the trim.

Measure and mark a 3 inch cut line up from where the roof deck meets the wall.

Cut at the 3 inch line with an appropriate blade to remove the siding and expose the building paper.

Remove the existing "Z" bar or J Channel.

Remove the sidewall, headwall and/or the endwall.

Replace the "Z" bar or J Channel.

Replace the flashings with Tesla's black flashings.

Brick Siding

Stone Siding

Use a grinder and wire brush to clean out the existing mortar and remove the reglet flashing.

Does the siding go through the roof? If not, some siding material may need to be removed to expose the building paper.

Remove the sidewall, headwall and/or the endwall.

Replace the reglets.

Replace the flashings with Tesla's black flashings.

Stucco Siding

Measure and mark a 3 inch cut line up from where the roof deck meets the wall.

Cut at the 3 inch line with an appropriate blade to remove the siding and expose the building paper and remove the weep screed.

Decide if a "Z" bar is going to be added and the stucco repaired. If so, chip away an additional 2 inches of the stucco to expose the chicken wire.

Remove the sidewall, headwall and/or the endwall.

Replace the weep screed and/or "Z" bar.

Replace the flashings with Tesla's black flashings.

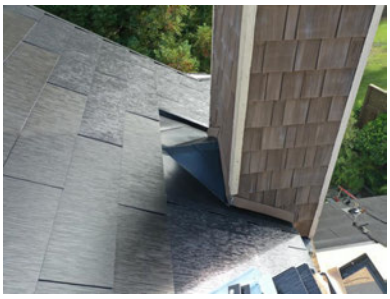
If an additional 2 inches of stucco was not removed, Tesla's counterflashing can be used for the finished look.

PREPARING THE HOME FOR SOLAR ROOF INSTALL

Preparing Wood, Composite, Hardie Board, Vinyl Sidings

This work instruction provides an overview of how to prepare wood, composite, Hardie board and vinyl sidings for Solar Roof installation.

Wood Siding:



Composite/Hardie Board Siding:

Vinyl Siding:

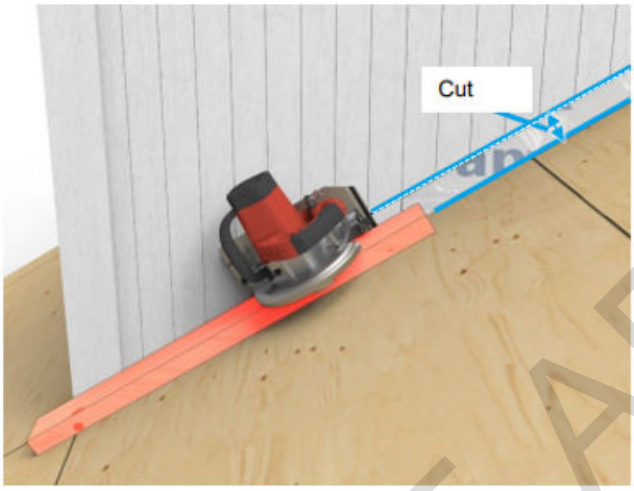
Tools and Equipment:

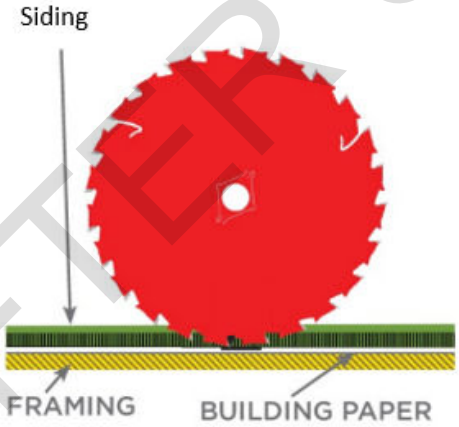
- Carpenter's Pencil
- Speed Square
- Measuring Tape
- Framers Circular Saw (Worm Drive saw)
- 18T Circular Saw Blade
- Impact Driver/ Nail Gun
- Chalk Line
- Hammer
- Pry bar

- Metal Snips
- 10 ft Brake/ Seamers
- Caulking Gun/ Sealant
- Flat Stock

Work Instructions: Cutting Wood, Composite, Hardie Board and Vinyl Walls: (Sidewall)

1. First, use a pry bar or a hammer to remove the trim. Make sure to try and keep the trim in good condition, so it can be reused.
2. Next, measure and mark a line (minimum 3 in and maximum 6 in) up from where the roof deck meets the deck.
3. Cut at the line and remove the bottom section.
4. Ensure that the saw blade is set only to cut the thickness of the siding and not the building paper. Remove any bottom fasteners so that the siding has enough clearance to wedge flashings behind it and the building paper.

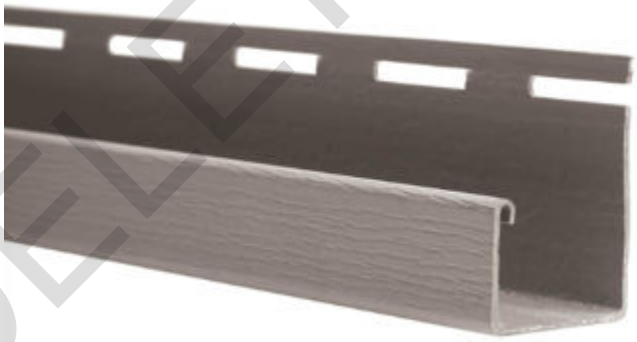




Example of Correct Blade Depth

a. If present, remove any J channels or “Z” bars at this time.

J Channel:



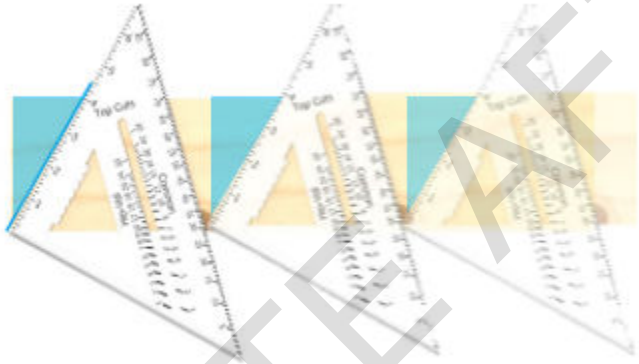
"Z" Bar:

NOTE: Protip: Using a 2X4 stud as a guide will provide adequate clearance when cutting.

Vinyl blades can be purchased to cut vinyl siding to avoid cracking.

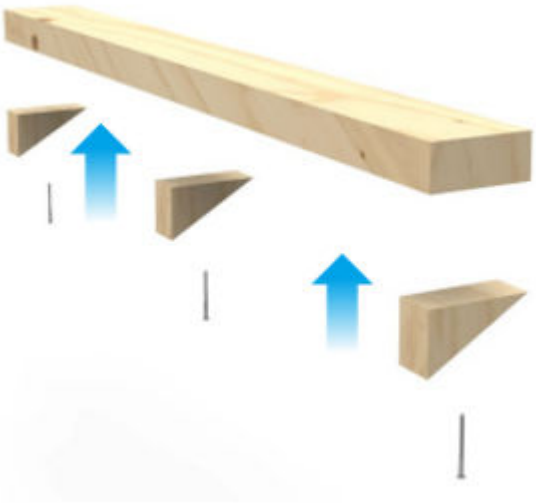
Work Instructions: Cutting Wood, Composite, Hardie Board and Vinyl Walls: (Headwall/Endwall)

1. Start by creating a guide to cut the headwall.
   a. Use a speed square to mark out three wedges to the pitch of the roof on a piece of 2X4 lumber.

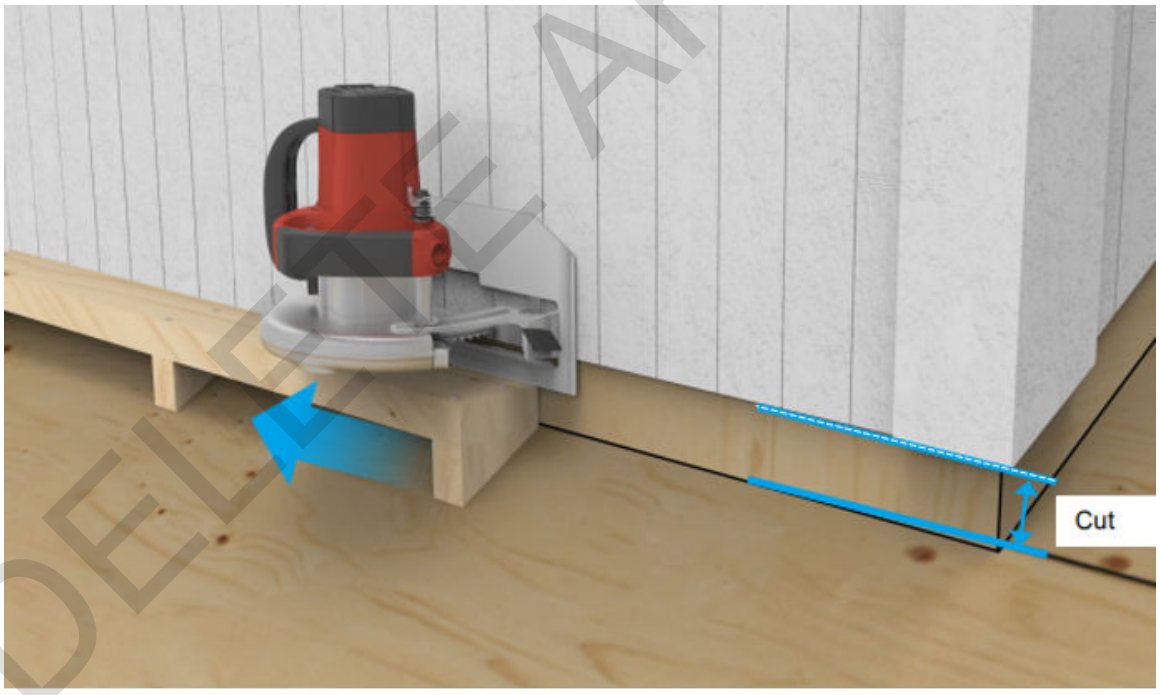


   b. Cut out with a circular saw and drill pilot holes at the bottom of the wedge.

   c. Fasten the three wedges underneath another 2X4 piece of lumber approximately 4 ft long.



2. Use a pry bar or a hammer to remove the trim. Make sure to try and keep the trim in good condition, so it can be reused.
3. Next, measure and mark a line (minimum 3 in and maximum 6 in) up from where the roof deck meets the deck.
4. Adjust the saw blade for the correct depth, set the circular saw's blade guide on top of the jig and cut the bottom section off. Remove any bottom fasteners so that the siding has enough clearance to wedge flashings underneath.
    a. If present, remove any J channels or "Z" bars at this time.



Work Instructions: Preparing Wood, Composite, Hardie Board and Vinyl Walls: (Headwall/Endwall/Sidewall)

1. Once the siding is cut, evaluate the condition of the wall:
    - Does it need new building paper?
    - Can the J channel/ "Z" bar be reused or is it necessary to make/ source new ones?

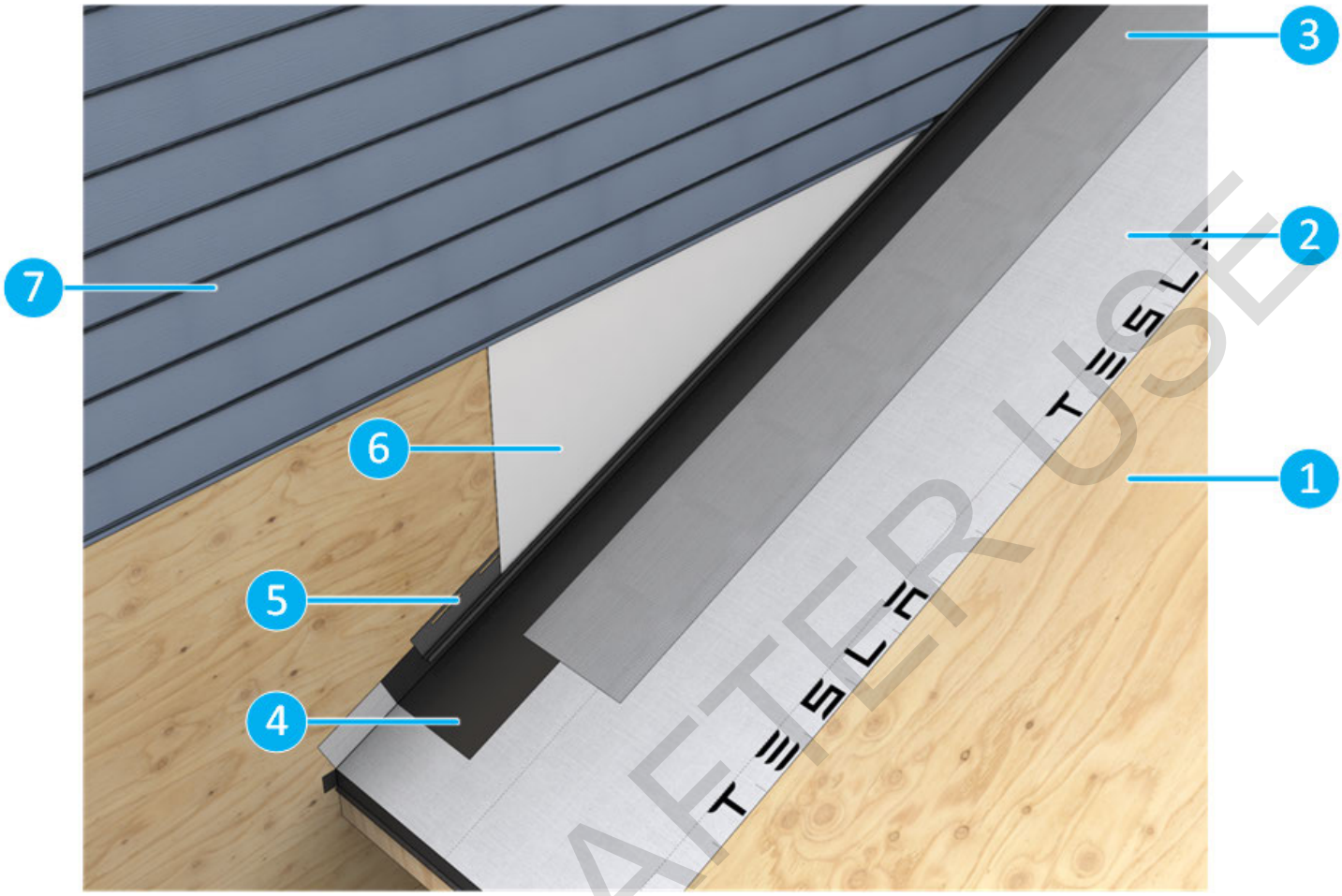
- Is there any damage to the siding that wasn't cut off that needs repair?
- Does any paint needs touch up?

2. The "Z" bar and J Channel can now be replaced and repainted.
    a. Use appropriate sealant when needed.

3. If any siding needs to be repaired or replaced, that needs to be done after the "Z" bar/ J channel.

> **NOTE:** Both "Z" and J flashings need to be fastened through the top flange. Extra siding may need to be removed and then replaced to fasten. Also, when replacing the trim, it will need to be cut down to match where the siding was cut back.

Vinyl Siding:



1 - Roof Deck

2 - Underlayment

3 - Detail Strip

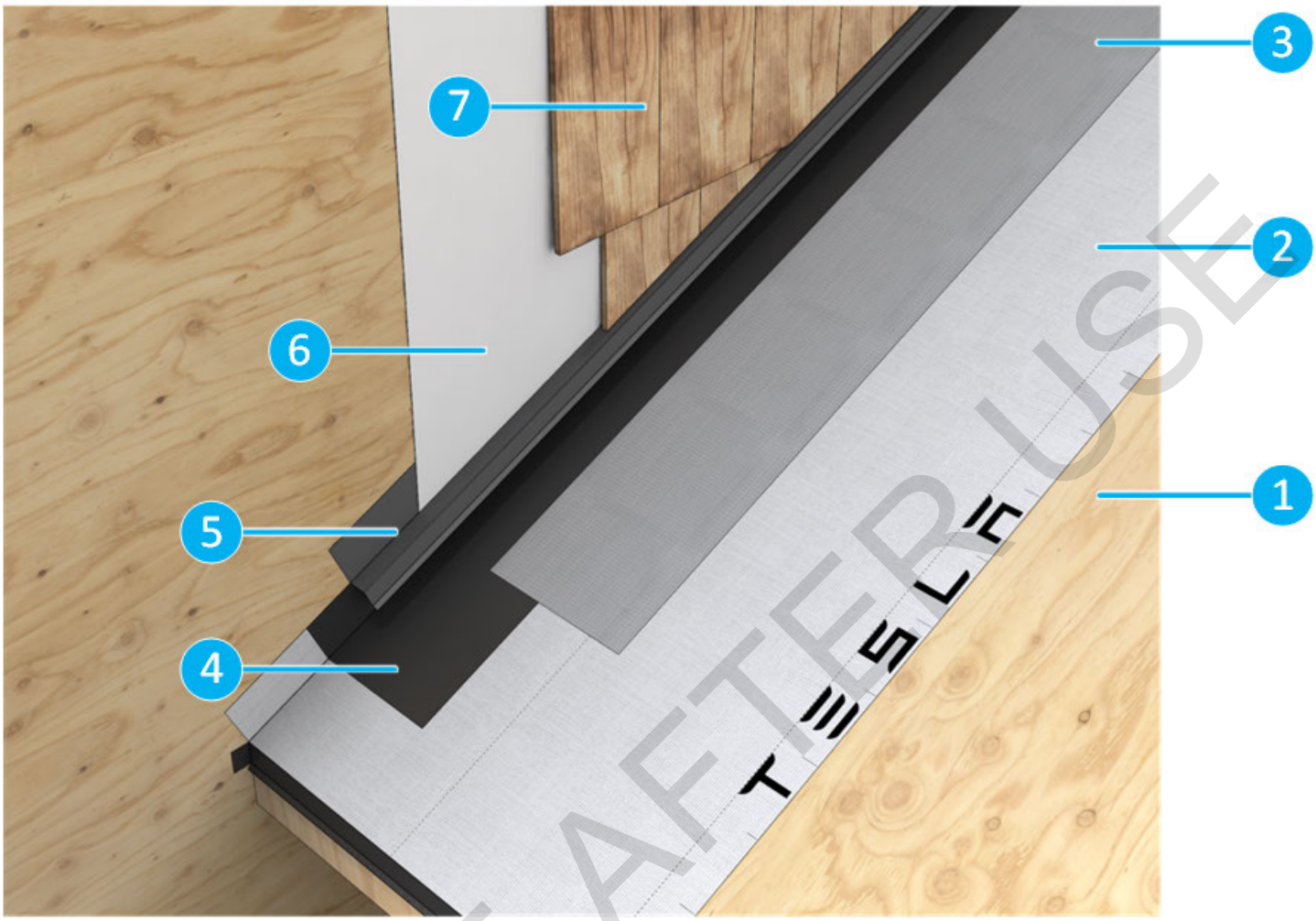
4 - Tesla's Black Flashing

5 - "J" Channel

6 - Grade D Building Paper

7 - Vinyl Siding

Wood Siding:



1 - Roof Deck

2 - Underlayment

3 - Detail Strip

4 - Tesla's Black Flashing

5 - "Z" Bar

6 - Grade D Building Paper

7 - Wood Siding

Preparation Process in Pictures:

1 - Start

2 - Tear off the old roofing material

3 - Cut/Remove siding.

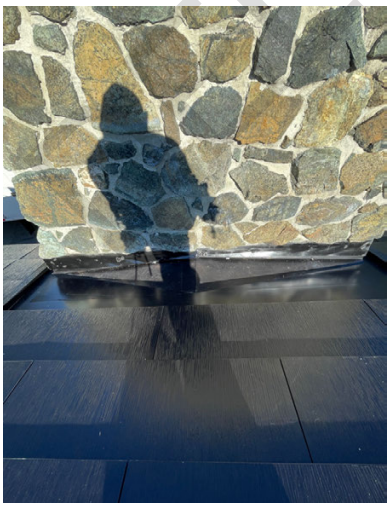
4 - Install the flashing behind the building paper.

5 - Replace the siding. Begin dry in.

Preparing Brick and Stone Sidings

This work instruction provides an overview of how to prepare brick and stone sidings for Solar Roof installation.

Stone Siding:



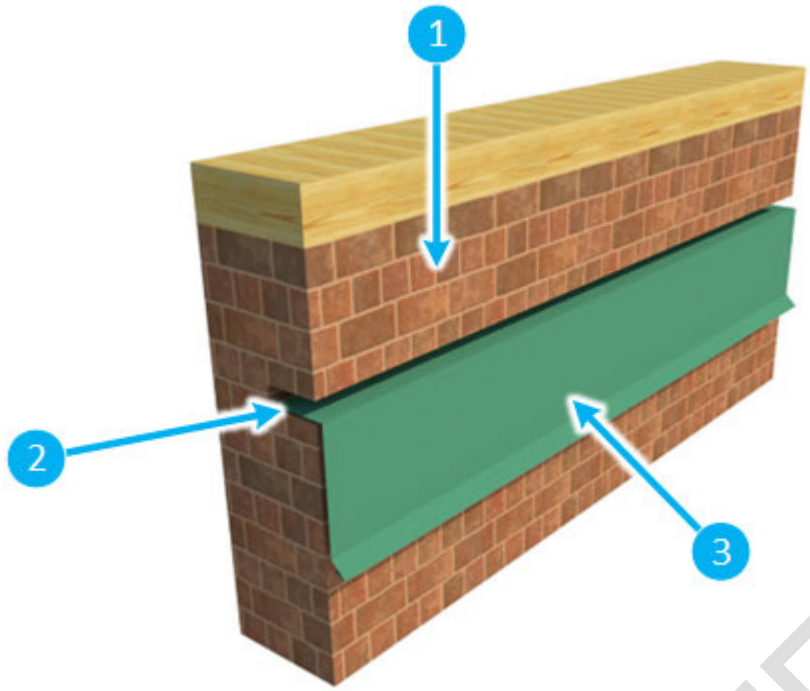
Brick Siding:

Tools and Equipment:

- Measuring Tape
- Grinder
- Wire Brush
- Impact Driver/ Nail Gun
- Drill with Concrete Bit
- Chalk Line
- Hammer
- Pry bar
- Metal Snips
- 10′ Brake/ Seamers
- Caulk Gun/ Sealant
- Battery Powered Blower
- Flat Stock

Work Instructions: Preparing Brick and Stone Sidings

1. Remove the existing reglet flashing by cleaning out the existing mortar in the grout with a grinder.



1 - Wall

2 - Grout Line

3 - Reglet

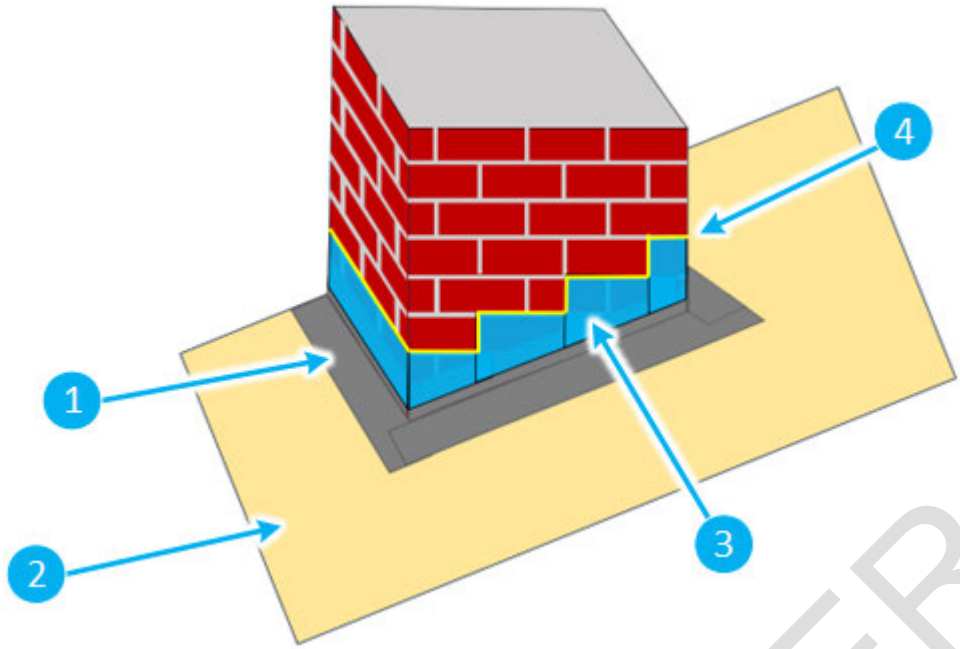
2. After removing the reglet flashing, use a wire brush and blower to remove debris from the grout.

> **NOTE:** It is very important to do this step as it will ensure a proper seal during the installation of the new reglet.

> **NOTE:** Sidewalls will step up the mounting plane, creating a staircase look. Each step will be about 2-3 brick/ stone courses high and overlap each other by at least 3 in.

3. Remove the wall flashings.
4. At this time, begin the dry in process and replace the reglet flashings.

   Use appropriate sealant in grout lines and vertical lines/laps. Reglets may need to be fastened; use appropriate drill bit/fasteners.



1 - Existing Flashing

2 - Roof Deck

3 - Reglets: will be placed 2 - 3 rows high and overlap by a minimum of 3 in

4 - Grout line: will need to be cleaned out to remove the existing flashings

Preparation Process in Pictures:

1 - Remove the existing flashings with a grinder.

2 - Replace deck level flashings.

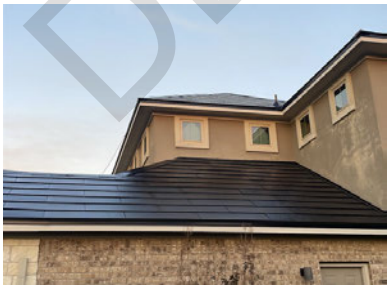
3 - Replace the reglets.

4 - Seal the reglets.

Preparing Stucco Sidings

This work instruction provides an overview of how to prepare stucco siding for Solar Roof installation.

Stucco Siding:



Tools and Equipment:

- Measuring Tape
- Grinder
- Impact Driver/ Nail Gun
- Drill with Concrete Bit
- Chalk Line
- Hammer
- Pry bar
- Metal Snips
- 10 ft Brake/ Seamers
- Caulk Gun/ Sealant
- Flat Stock
- Surface Mounting Counterflashing

Work Instructions: Preparing Stucco Siding

There are 2 ways to finish prepraing a stucco wall for Solar Roof.

- **Using a "Z" bar:**

- **Using Tesla's black surface mount counterflashing:**

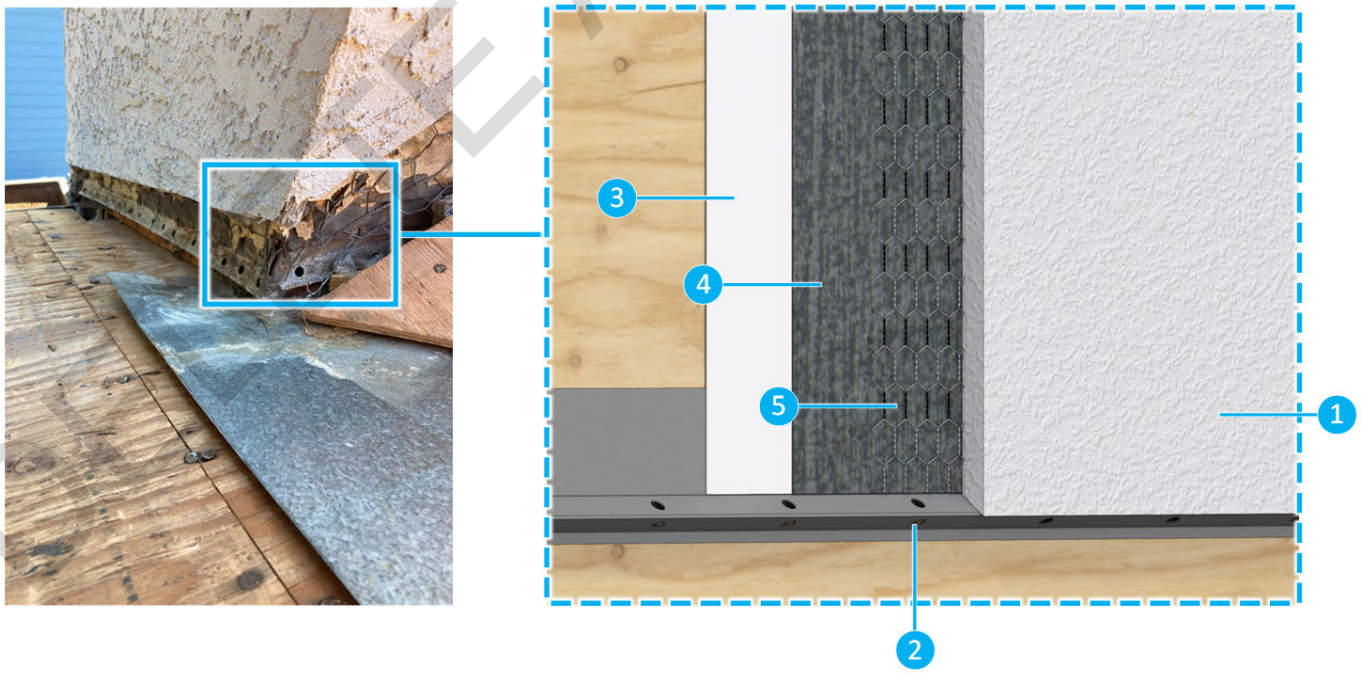
The "Z" Bar Method

1. First, measure and mark a line (minumum of 2 in - maximum of 4 in) up from where the roof deck meets the wall.

NOTE: Tesla's black counterflashing is not an option if more than 4 in of the wall needs to be removed. The "Z" bar method must be used in these situations.

2. Cut into the stucco at the line created in the previous step. Be careful to only remove the layers of stucco.

Trim down the chicken wire and paper as needed. The weep screed can be removed at this time as well.



1 - Stucco Wall

2 - Weep Screed

3 & 4 - Grade D Building Papers

5 - Wire

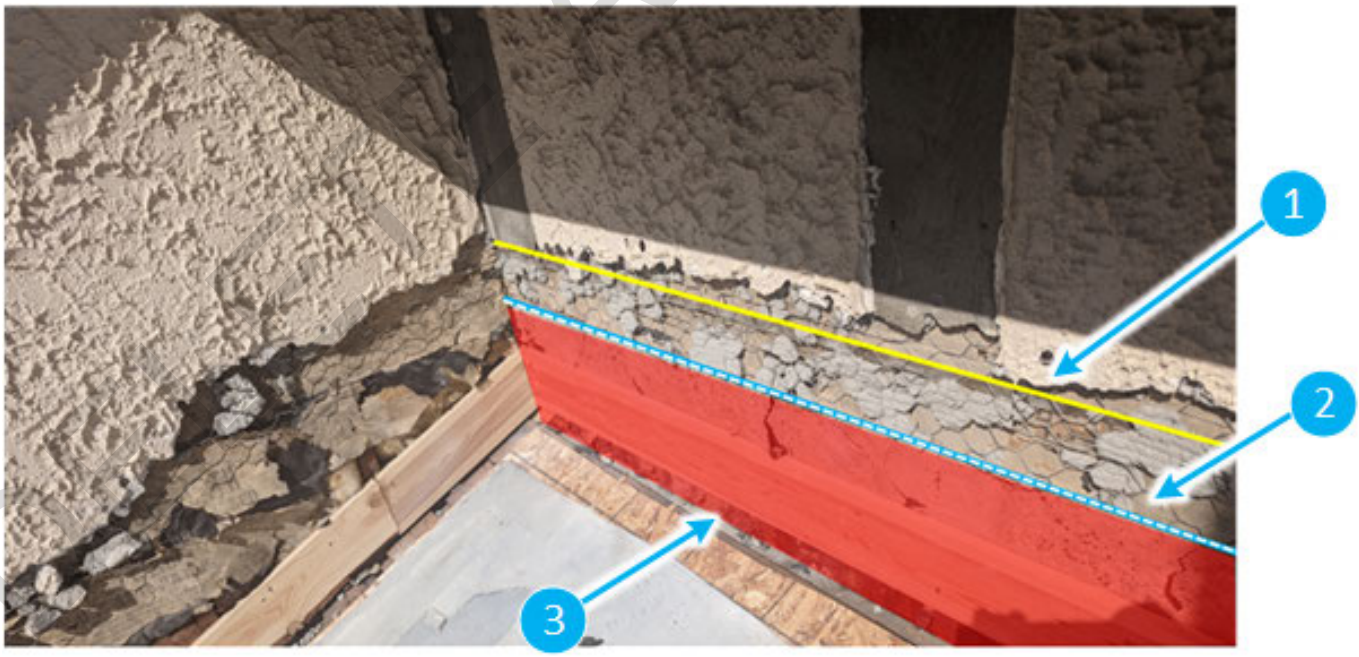
3. Chip away an additional 2 in of the stucco with a hammer.

   This step removes any staples that may block the new flashings and exposes the building paper, so that the new flashings are lapped correctly and chipping the stucco leaves a cleaner look once repaired.

   In some cases, the paper or the wall itself is damaged and the stucco may need to be broken further up to properly repair it.

Damaged Wall

If there is no damage and the paper looks acceptable, the Counterflashing method can be used.

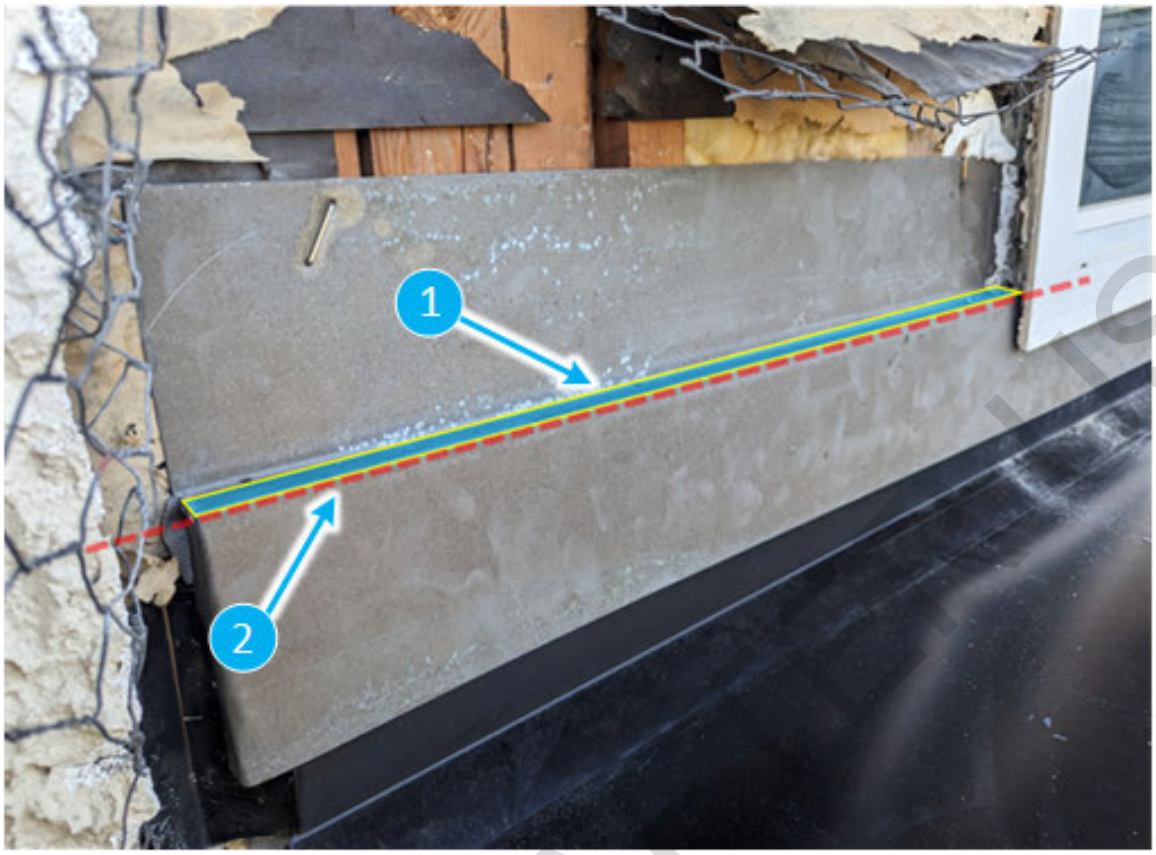


1 - Chipped line ~ 2 in above the cut line

2 - Cut Line

3 - Portion of the wall below the cut line must be cleared of all debris and fasteners

4. Add/replace the “Z” bar. Make sure to use appropriate sealant when needed.



1 - Shelf of "Z" bar

2 - Cut Line

Shelf of “Z” bar lines up with the cut line.

5. Install the weep screed ½ inch - 1 inch above the "Z" bar.

NOTE: If the paper is damaged, Tesla's underlayment can be used as building paper if there is a flat surface. Also, wire mesh may need to be added if chicken wire is damaged or not present.

Damaged Paper

Added Mesh

6. After replacing the weep screed and adding the mesh (if needed), the wall is ready to be repaired.

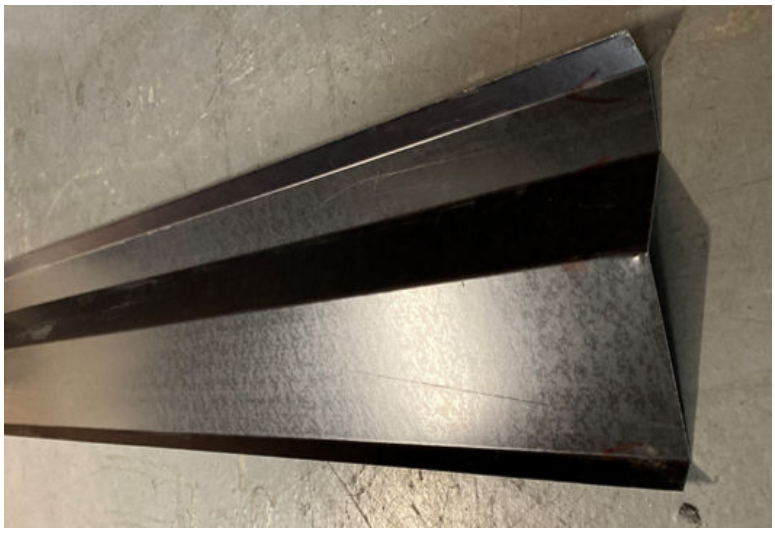
The Surface Mount Counterflashing Method

When using the surface mount counterflashing method, steps 4-6 can be skipped and dry in can begin.

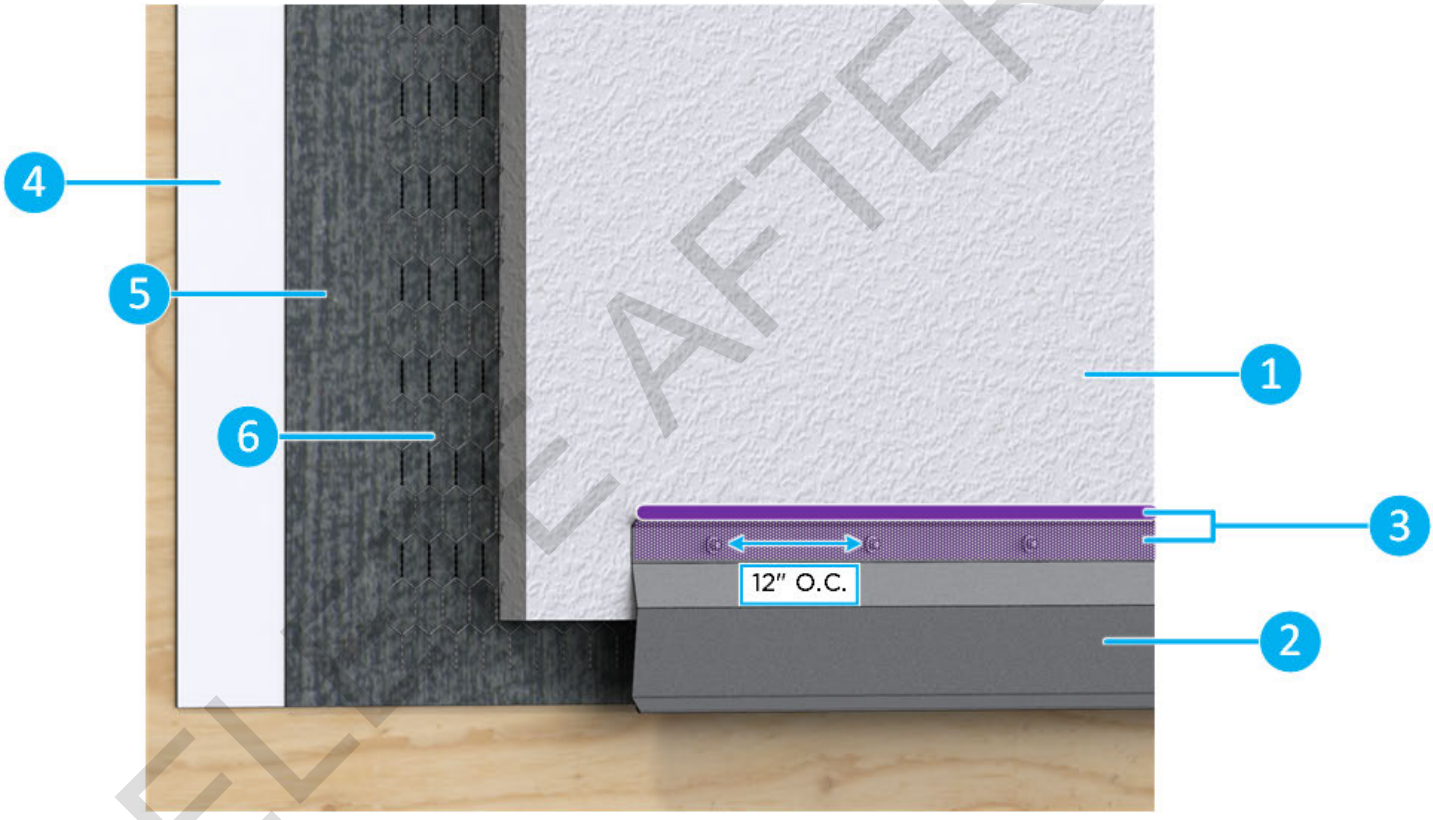
NOTE: This process is possible because the paper and wall are in good condition and the stucco is not broken more than 6″.

Begin the counterflashing method after step 3:

1. Install the underlayment.
2. Replace the old wall flashings. Make sure metals get behind the building paper.
3. Install the counterflashing 1 - 2 in above the chip line. Use appropriate drill bit and fasteners.
4. Apply appropriate sealant.



Example of surface mount counterflashing method



1 - Stucco Wall

2 - Surface Mount Counterflashing

3 - Sealant

4 & 5 - Grade D Building Papers

6 - Wire

Preparing Undershots

Overview

This section provides guidance for preparing the undershot for the dry in phase. This process begins after all existing shingles have been removed.

Tools & Equipment

- Impact driver
- Heavy duty flat bar
- 7 ¼ in Worm drive saw with electric brake
- 2x4 (if fascia board requires cutting)
- Skil Saw (if fascia board requires cutting)
- Safety Glasses
- Gloves

Work Instruction

1. First, locate the plywood covering the undershot.
2. *If the fascia board requires cutting*. Lay a 2x4 on the deck and push it up tight to the fascia board. Using the 2x4 as a guide, to cut through the fascia with the Skil Saw so that it is 3 in off the decking.
3. Visually inspect for any damage or rot, remove the undershot section, and store for reinstallation after dry in is complete.
4. If a soft material is covering the undershot, remove those and store them for reinstallation.

Adapting and Reusing Existing Flashing

Overview

This procedure covers how to reuse and adapt existing flashing. Reusing existing flashing drastically decreases the amount of prep work needed to integrate underlayment and black flashings with the building envelope. This is accomplished by slipping underlayment underneath the existing flashing (but not up the wall), stripping-in the existing flashing with the detail roll, and installing black flashings for the finished Solar Roof aesthetic.

Decision Guide for Reusing Existing Flashing

	Reuse	Remove
Flashing is not bent, ripped or damaged in a way that it no longer sheds water.	X	
Flashing is damaged, but able to be repaired.	X	
Flashing needs to be painted, but reuse saves time/work.	X	
Flashing is unique and undamaged.	X	
Flashing is an incompatible material (i.e. copper)		X
Flashing is damaged and is unable to be repaired.		X
Flashing is not damaged but is causing delays.		X
Flashing is improperly installed.		X
Flashing is continuously elevated more than ½ in off the deck.		X

	Reuse	Remove
Any of the following are present: Rust, corrosion, excessive sealant or mastic, broken welds.*		X

* For larger flashing (specifically non-step flashings), small sections of rust, corrosion, etc. can be removed and replaced with new flashings rather than replacing the entire flashing. If the majority of the flashing is rusted or corroded, do not re-use it.

Examples of Flashings that Can NOT Be Re-Used

- Incompatible material - copper

- Existing flashing is rusted

- Flashing is damaged and unable to be repaired

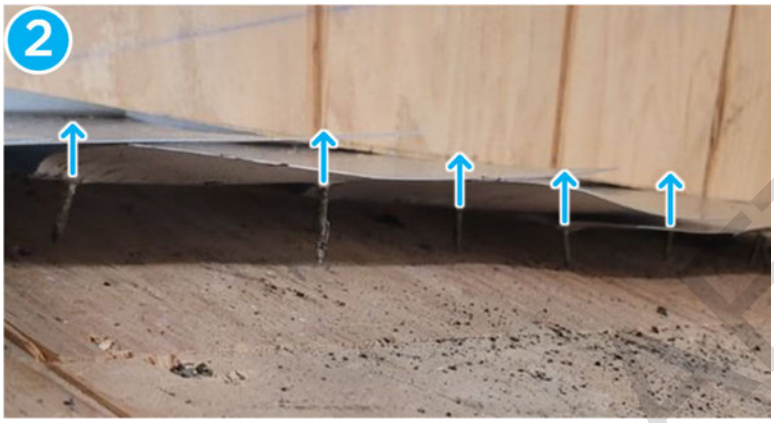
- Flashing is damaged and unable to be repaired

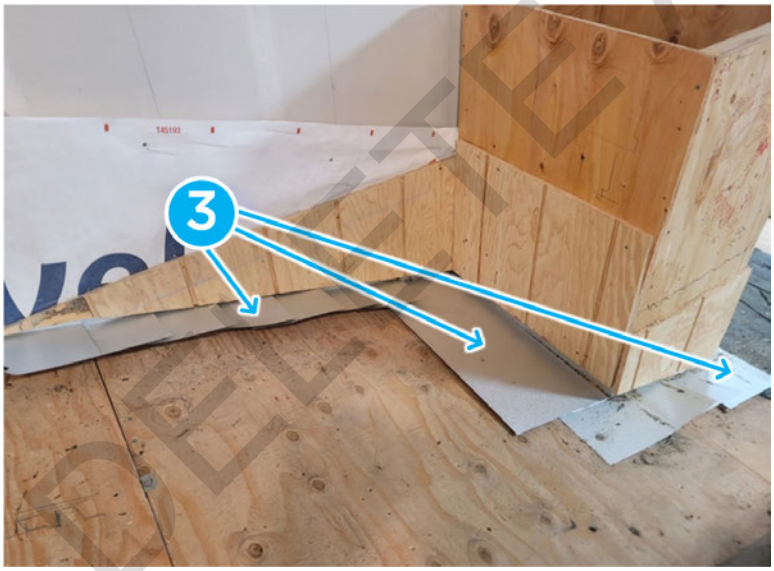
- Flashing is improperly installed

- Flashing is covered by excessive sealant

Preserve the Existing Flashing

Remove all pre-existing shingles **(1)** and nails **(2)**, taking care not to damage the existing flashing **(3)**.

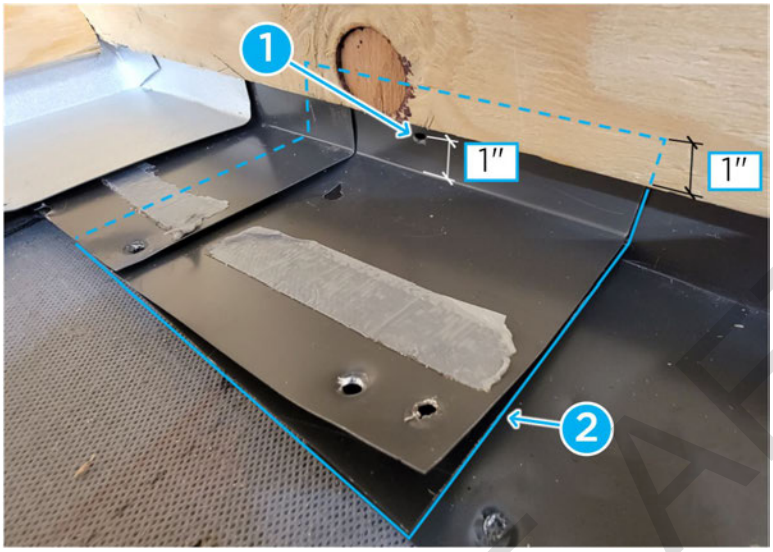




Reshape and Repair Existing Flashing

After removing shingles and pulling nails, the existing flashing may be slightly deformed. Place a scrap piece of metal underneath the flashing to protect the decking and use a scrap piece of wood and a hammer to reshape the deformed flashing.

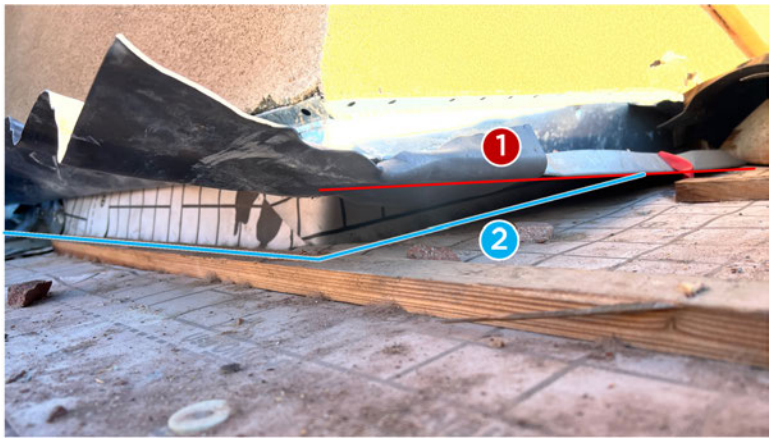
If existing the flashings were ripped or torn during the tear-off process, or if there are holes **(1)** on the vertical portion of the flashing that are within 1 in of the deck flange, new flashing must be added to protect the roof **(2)**. Lap new flashings behind the old flashings to ensure proper material lapping and water drainage. New flashing needs to have a turn-up that tucks at least 1 in behind the siding.



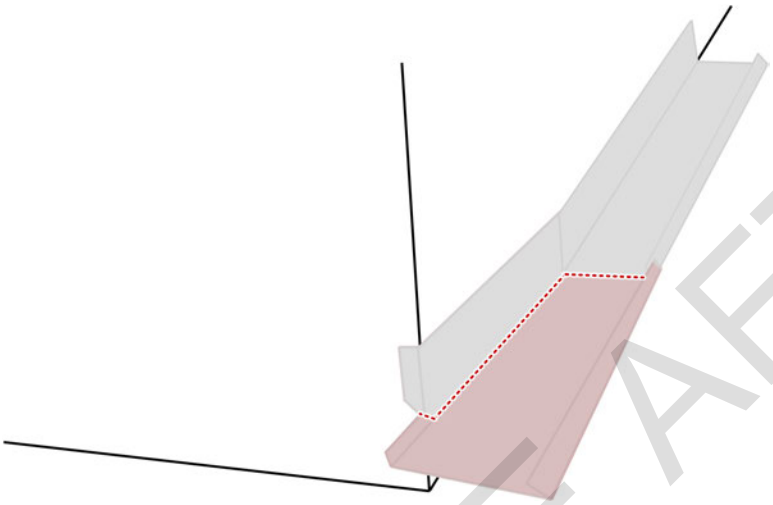
Roofs with Raised Pans

Raised pans need to be altered, so that the raised portions of the pan are brought down to the roof's deck. Raised pans are common where the existing roofing material is installed over a batten system.

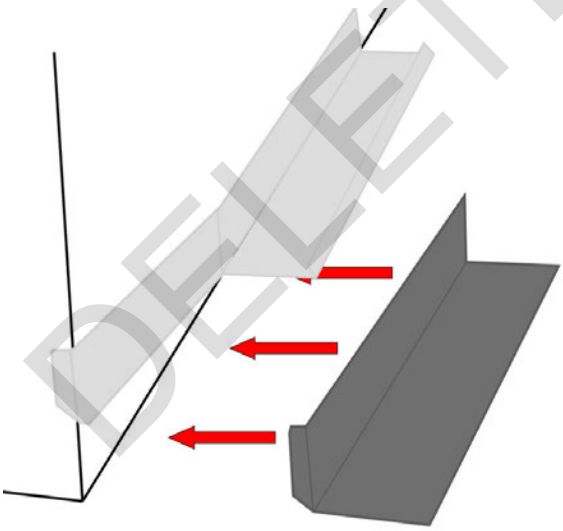
Pictured: Flashing **(1)** and base of the wall **(2)**

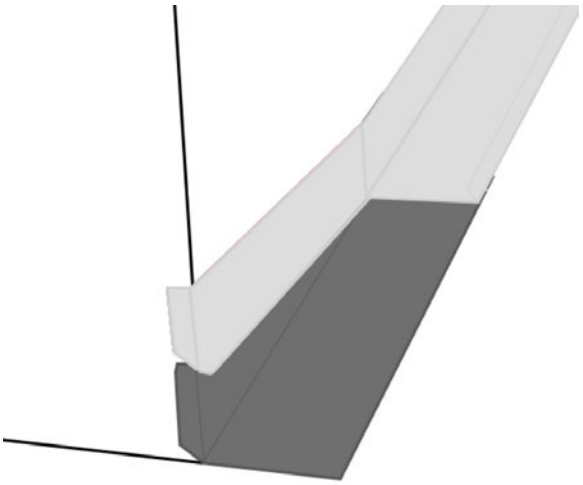


Cut the raised portion of the pan back to the point where the pan contacts the roof's deck.



After the raised portion of the pan is removed, add wall flashing that laps at least 1 in behind the vertical portion of the existing pan and underneath the remaining uproof portion of the pan at least 6 in.





Paint Existing Headwall Flashing

Existing headwall flashing will be visible after installation and must be painted to match Solar Roof's black metal aesthetic.

Prior to painting:

- Repair and/or reshape the existing flashing.
- Cover/mask materials that should not be painted (i.e. siding, trim boards, brick, stone, etc.).

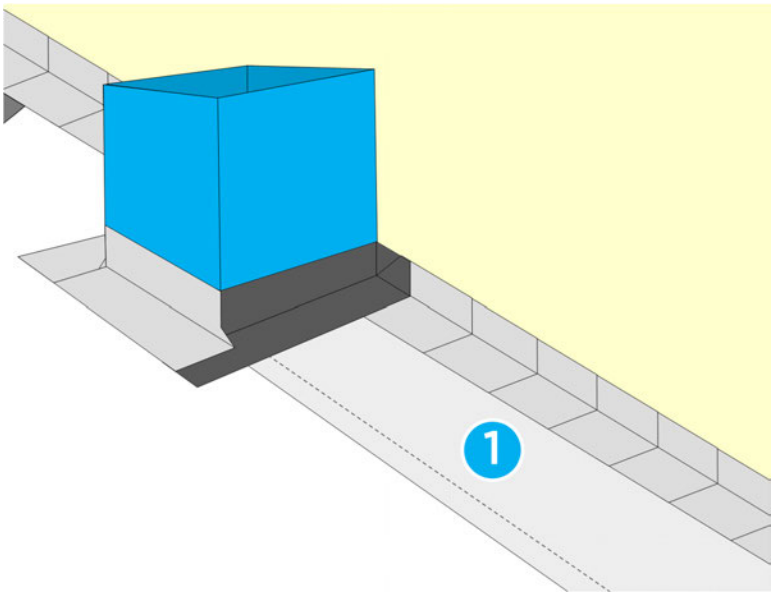
Paint the existing headwall flashing.

Integrating Underlayment and Installing New Flashing

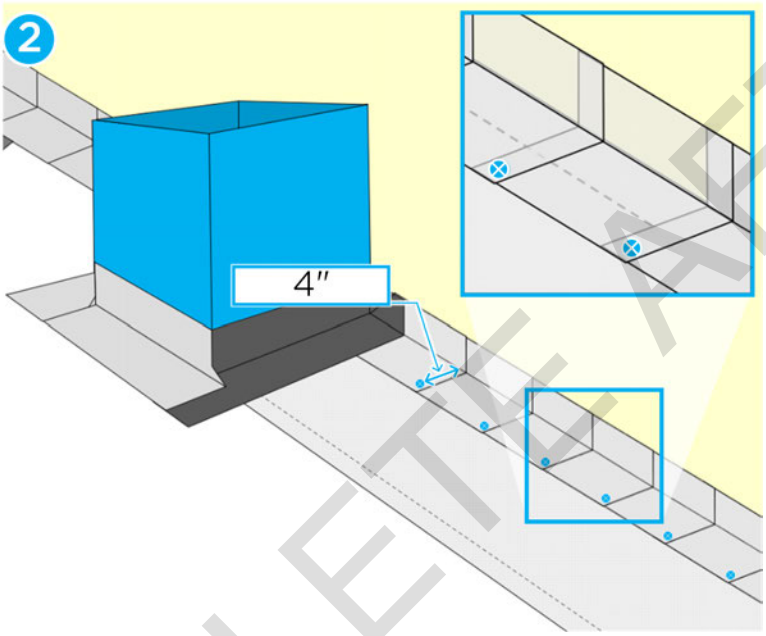
Sidewalls – Integrating Underlayment

Along sidewalls, install a **full-width strip of underlayment (1)** vertically under the existing flashings. The underlayment needs to be installed as tight to the wall as possible. If the sidewall runs into a headwall, lap the vertical strip of underlayment underneath the existing headwall flashing.

NOTE: The vertical strip of underlayment prevents needing to weave individual horizontal courses under the sidewall flashing.

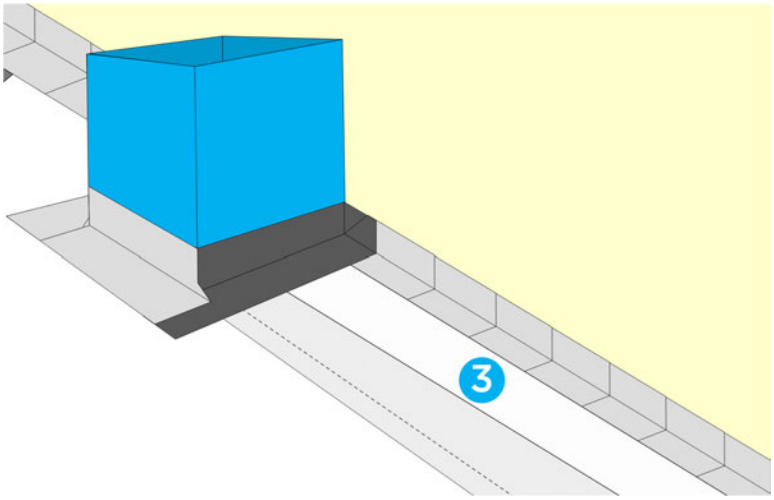


Secure the existing flashing in place with roofing nails. Position nails near the downroof edge of each step flashing so that the nail penetrates through the top of the step flashing below. Do not install fasteners within 4 in of the sidewall.

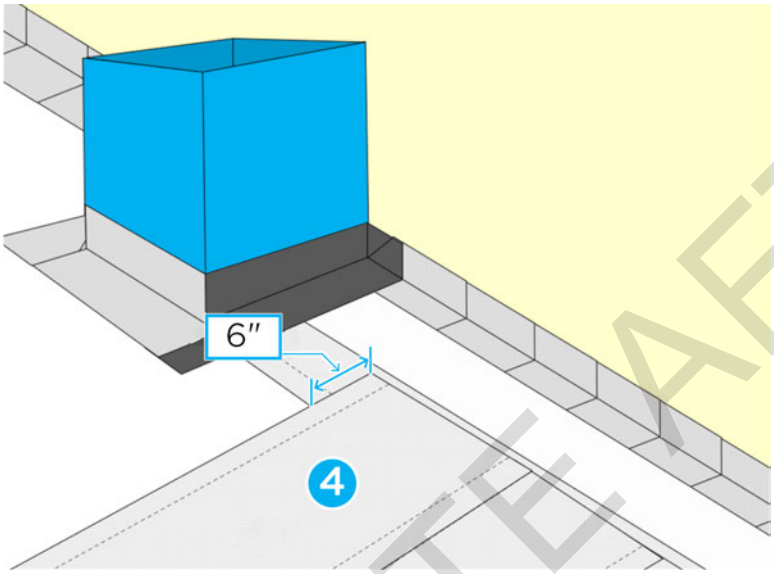


Once the existing flashing is secured, strip it in with the detail roll 1 in away from the wall **(3)**.

NOTE: At this point, the sidewall is ready for new wall flashing to be installed.



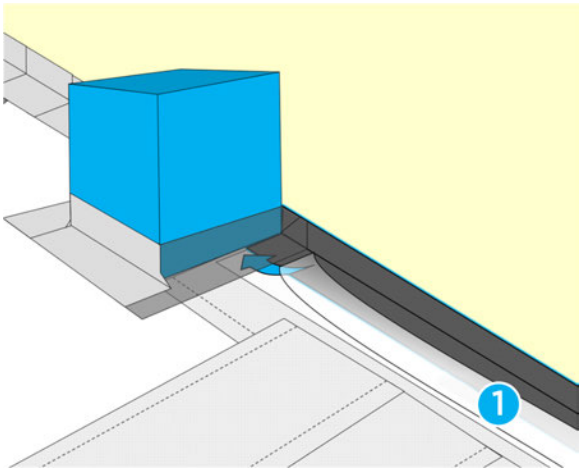
Install horizontal courses of underlayment up roof, ensuring a minimum 6 in lap on to the vertical strip of underlayment along the sidewall **(4)**.



Sidewalls - New Flashing

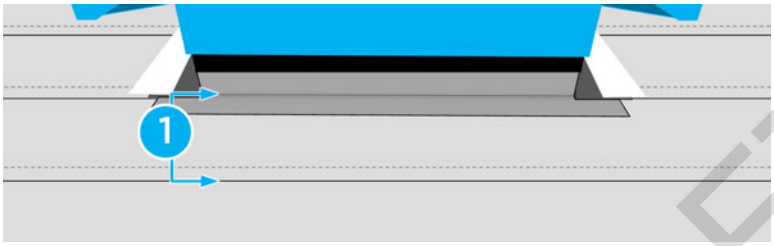
Install wall flashing so that it fully covers the existing flashing. Lap the vertical portion of the wall flashing behind the existing siding and building paper as far possible without altering the siding or removing fasteners. Trim the vertical portion of the wall flashing as needed to tuck behind the siding and building paper. Fasten the wall flashing per the wind tier fastening schedule. Strip-in the wall flashing with the **detail roll (1)**maintaining a 5 in offset from the sidewall.

NOTE: If the sidewall runs into a headwall, ensure that the wall flashing and detail roll strip-in are lapped under the existing headwall flashing.



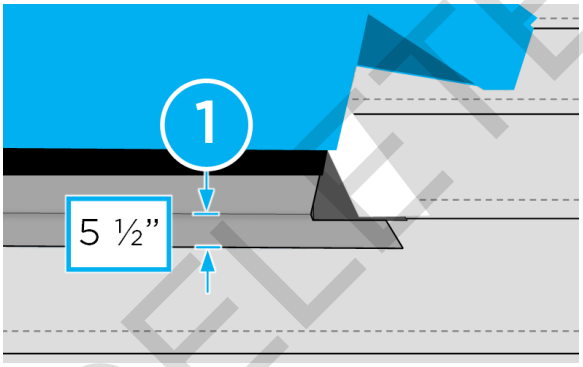
Headwalls - Underlayment

At headwalls, install underlayment underneath the existing headwall flashing up to the point where the deck meets the wall. Do not lap underlayment up the wall itself. **(1)**.



Headwalls - New Flashing

Measure the length of the existing headwall flashing's deck flange **(1)**. If it measures longer than 5½ in, trim the deck flange down to 5 ½ in. This will ensure that transition flashing installed later in this procedure will adequately reach the wall without interference from the existing flashing.



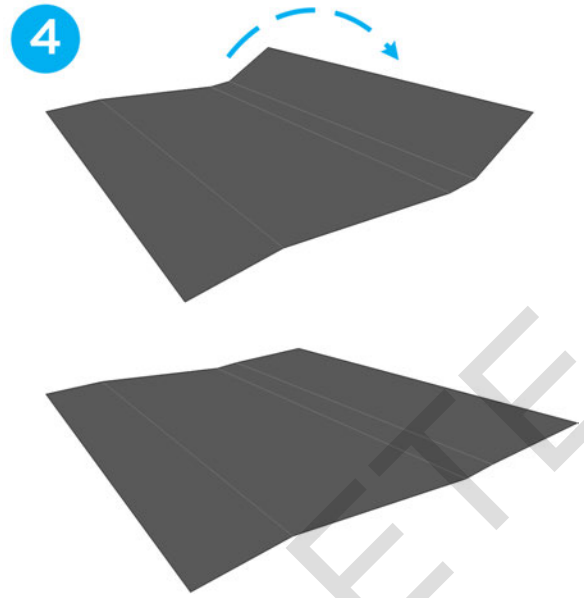
Measure 8 in down roof from the existing headwall flashing's deck flange. Then, measure 10 in past both of the obstruction's sidewalls **(2)**. If tiles land within this zone, trim them until they end at the boundary lines.

PRO TIP: If a small portion of a tile lands within the zone, the tile can be installed without trimming if the following conditions are met: the tile does not interfere with the transition portion of the transition flashing **and** the transition flashing will adequately reach the minimum reveal mark on the metal tiles.

Proceed to install tiles up to the boundary lines **(3)**.

Flatten the vertical flange of the transition flashing in order to allow it to fit underneath the existing headwall flashing **(4)**.

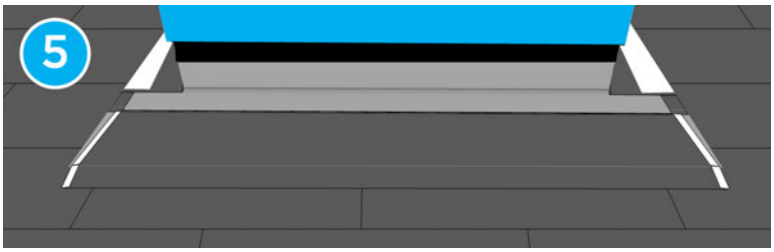
PRO TIP: Place the transition flashing upside down within the brake to flatten it.



Trim the transition flashing as needed to adequately fit underneath the existing flashing. Additionally, *craft a turn down and out on page 307* into the transition flashing.

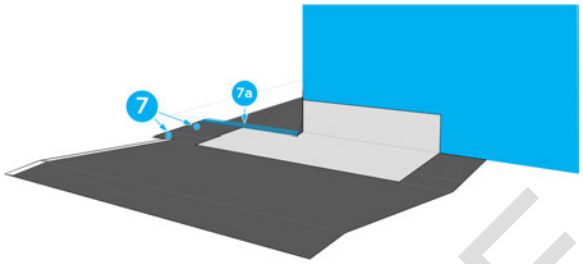
NOTE: At sidewall-headwall inside corners, apply flashing tape to the transition flashing turn down and out **before** tucking it under the existing headwall flashing.

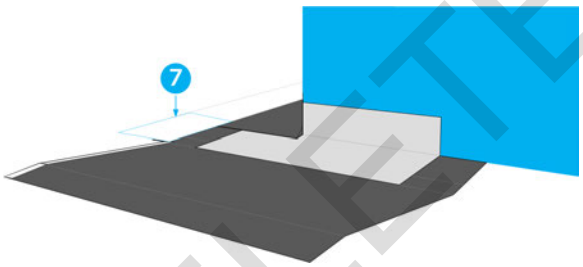
Proceed to tuck the transition flashing under the existing headwall flashing **(5)**. By trimming the existing flashing down to a maximum 5 ½ in in step 1, the transition flashing should reach the corner of the wall without interference from the existing flashing.



Fasten the transition flashing in accordance with the applicable wind tier in the *Fastener Schedule* . Fasten the existing headwall flashing with the same schedule using Hi-Lo screws with washers **(6)**.

At headwall-sidewall outside corners, drive two nails or screws into the flattened flange and apply detail roll **(7)**. Note that the sidewall flashing will overlap the transition flashing by 1 in **(7a)**. Proceed to install channel flashing and continue dry in up roof.



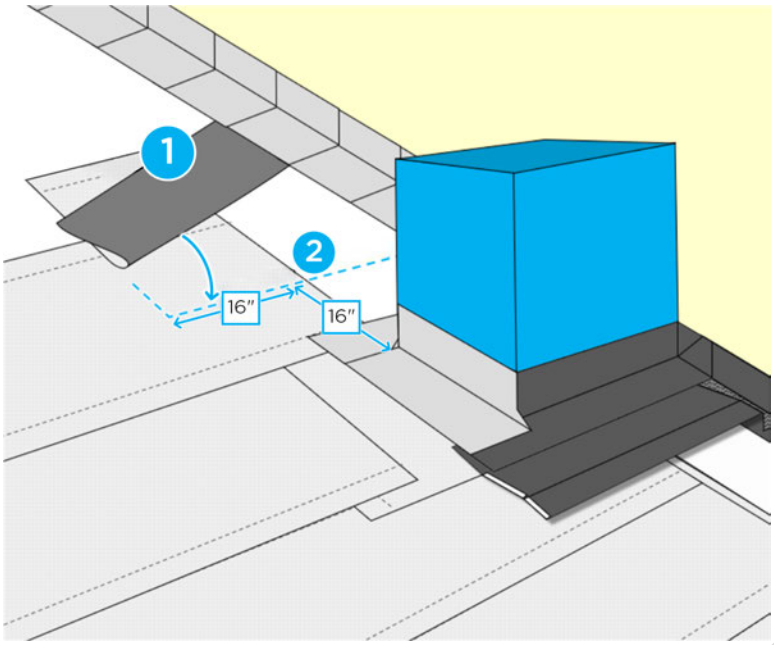


Pictured: *Finished installation*

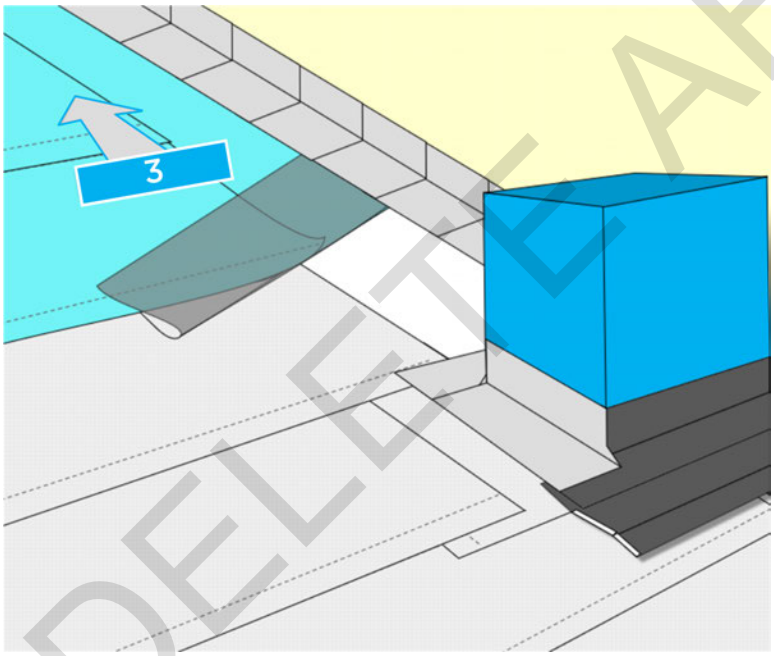
Endwalls - Underlayment

Above endwalls, install a **target patch (1)**, made from a full width sheet of underlayment. **The bottom edge of the target patch (2)** must be placed 16 in up roof from the endwalls. The side edges of the target patch must extend 16 in beyond the endwall's outside corner(s).

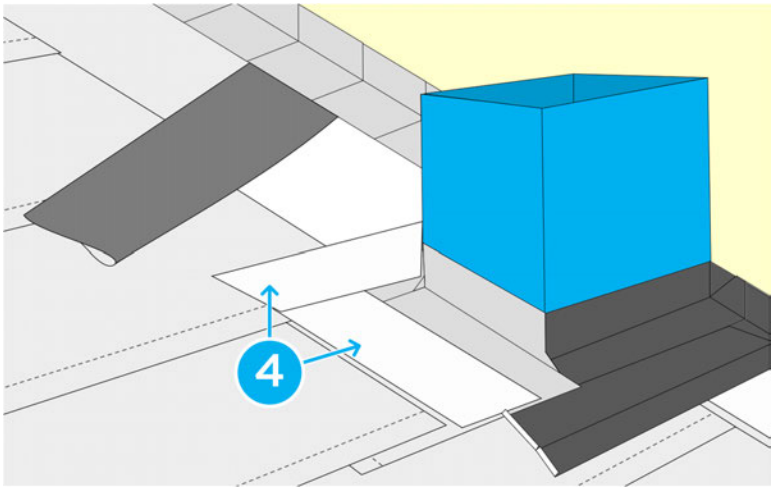
NOTE: The 16 in measurements, from the endwall, will ensure that the target patch provides the minimum required coverage over the endwall pan that will be installed.



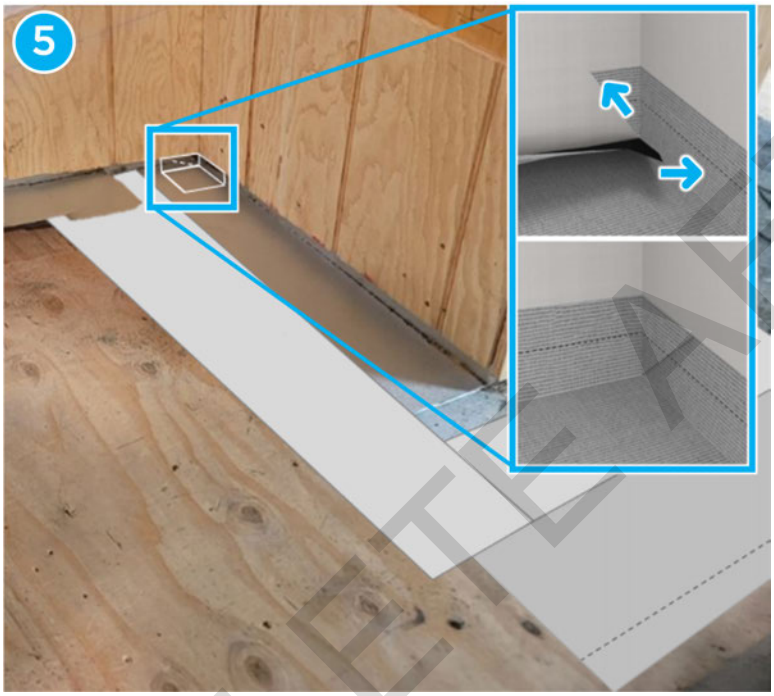
NOTE: The target patch allows the installation of **underlayment (3)** to continue up roof while new flashing is installed around the obstruction. The target patch will lap over the new endwall pan once it is installed.



Secure the existing endwall flashing, then strip it in with the **detail roll (4)**. Ensure that down roof sidewall flashing is also stripped-in.

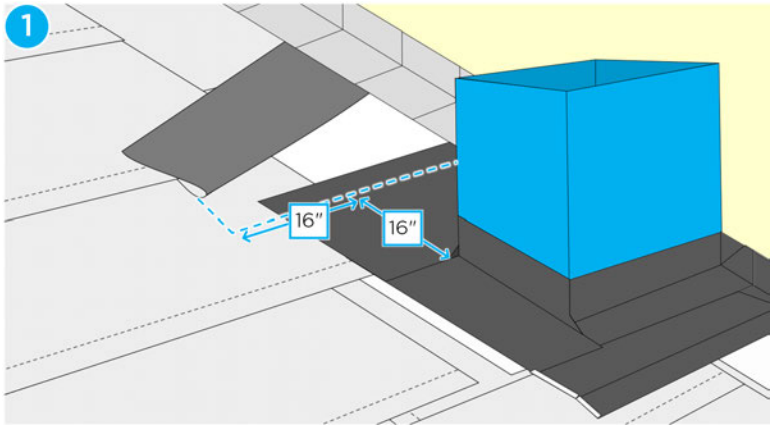


At endwall-sidewall inside corners tuck the detail roll underneath the existing sidewall flashing. Additionally, create an inside corner detail from underlayment and apply it to the inside corner tucking it as far behind siding as possible without altering siding or removing siding fasteners **(5)**.

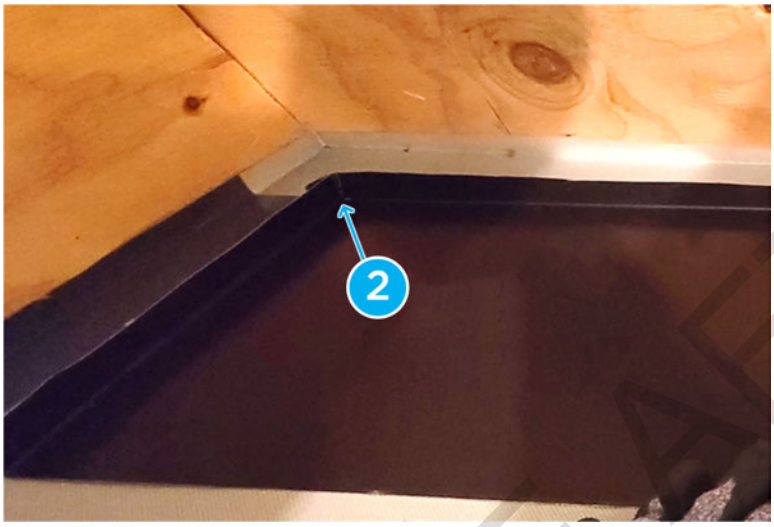


Endwalls - New Flashing

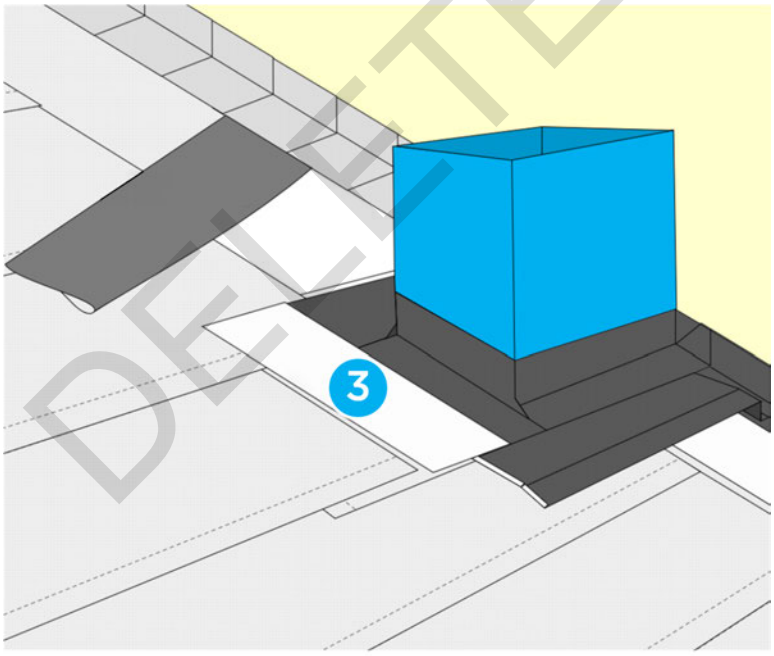
At endwalls, cut and bend flat stock to create an endwall pan that fully covers the existing flashing. Bend the vertical portion of the pan so that it will lap behind the existing siding and building paper as far as possible without altering the siding or removing fasteners. The deck portion of the endwall pan will extend 20 in up roof ensuring that the target patch will provide proper coverage **(1)**.



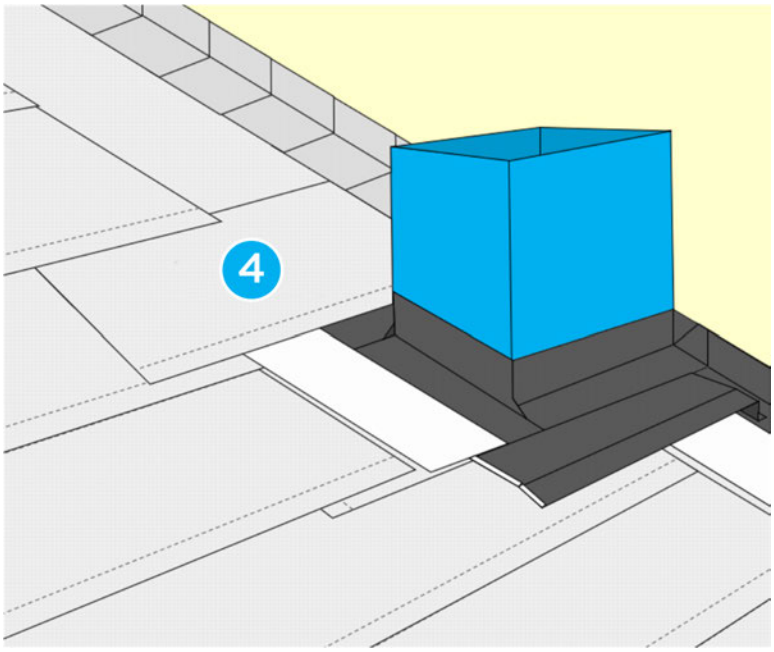
At endwall-sidewall inside corners, craft an inside corner and install the wall flashing under the existing sidewall flashing **(2)**.



Strip-in the wall flashing with the detail roll maintaining a 5 in offset from the lower sidewall **(3)**.



Lastly, cap the wall flashing with the target patch installed in step 1 and continue the up roof installation **(4)**.



Securing Ladders and Material Lifts with Bolt Hangers

Tools and Equipment

- Bolt hangers
- Velcro Straps
- Sealant
- Hammer
- Underlayment
- Drill
- Impact driver
- Anchor lags
- Paint scrapper (for repairing fascia)
- Wood Filler / Wood Putty (for repairing fascia)
- Paint (for repairing fascia)
- Sandpaper (for repairing fascia)

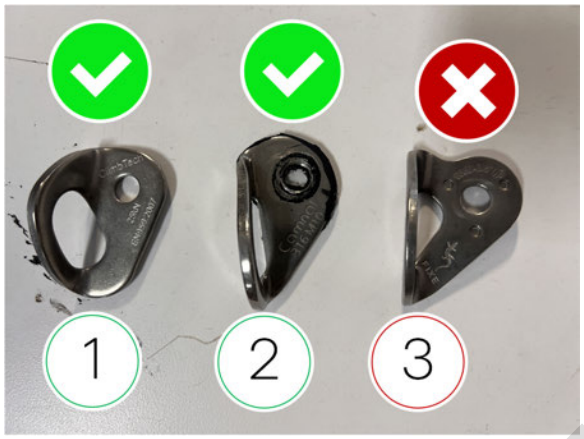
Overview

This section provides guidance for securing ladders and material lifts with bolt hangers. Bolt hangers must be installed for all ladder access and material lifts.

NOTE: IMPORTANT: Bolt hangers are only used to secure ladders, material lifts, or material bags. Do **not** attach ropes and work off of bolt hangers.

Bolt hangers can be ordered via Tesla One part ordering under **part number 1607147-00-A**. Note that inventory under this part number is mixed between the following manufacturers: Werner/ClimbTech M0000304, Camnal 316M10, Fixe/Salamander 038D-3/8 in.

- By default, the **part number 1607147-00-A** will provide the correct bolt hanger. However, transferred inventory may mix in bolt hangers that cannot be installed underneath PV tiles – see distinctions listed below:
  - Werner/ClimbTech M0000304 and Camnal 316M10 bolt hangers **can** be installed underneath PV tiles as they will not break the PV Tile.
  - Fixe/Salamander bolt hangers **cannot** be installed underneath PV tiles as they are too tall and will break the PV Tile.
  - **Always check to ensure the bolt hanger you received is correct.**
  - ***Pictured:*** Acceptable and unacceptable bolt hangers for PV Tile courses: Werner/ClimbTech **(1),** Camnal **(2)**, Fixe/Salamander **(3)**



Velcro straps (Guardian 10815) can be ordered via Fastenal eProcurement punchout or in Fastenal vending machines under **part number 1575599-00-A.**

NOTE: These instructions depict ladders, but all procedures can be applied to material lifts.

Installing Bolt Hangers

Begin by locating a rafter on the roof **(1)**.

NOTE: The ladder supporting the installer locating rafters must be held and secured by a coworker.

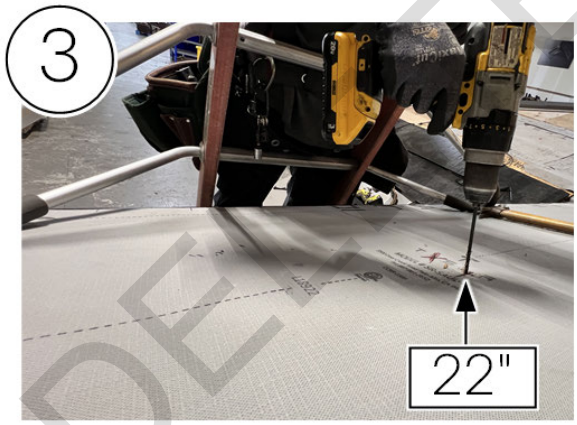
If rafters **are** visible, set up the ladder centered on a rafter.

PRO TIP: If there are no exposed rafters, use the visible rafter nail heads that secure the fascia to identify the exact rafter location **(1a)**.

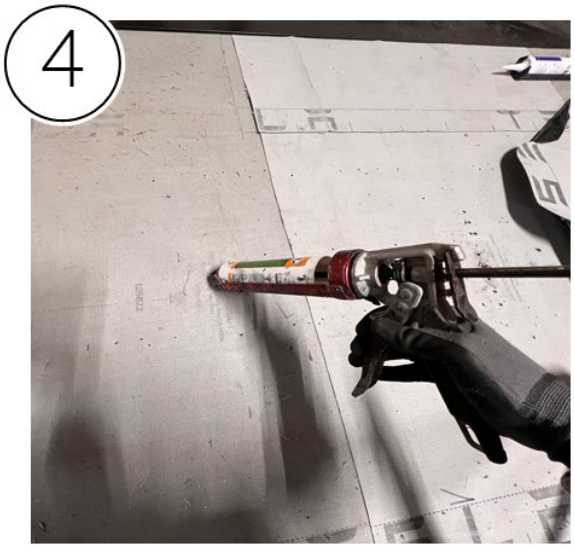
If rafters or rafter nail heads are **not** visible, locate the rafter by tapping a hammer along the deck. Rafters will be determined by a change in sound **(1b)**. Once the rafter is located, set up the ladder centered on the rafter.

Measure and mark 22 in from the eave on the rafter **(2)**. Marking this point will ensure the bolt hanger is installed at the second course of tiles and prevent interference with PV feet, PV footlaps, or Metal Tile supports.

Drill a pilot hole at this 22 in point **(3)**. If there is an exposed soffit and the rafter is missed while drilling the pilot hole, repair the soffit.



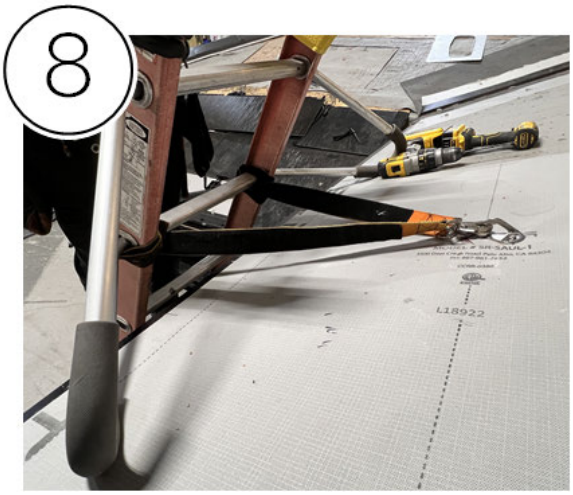
Apply sealant sparingly to all pilot holes. Be mindful of exposed soffits and risk of overflowing sealant **(4)**.



If any holes were drilled outside of the rafter, patch these holes with a piece of underlayment **(5)**.

Apply sealant to the bottom of the bolt hanger **(6)**.

Install the bolt hanger with an anchor lag into pilot hole created in step 3 **(7)**. Secure the ladder to the bolt hanger with Velcro straps **(8)**.



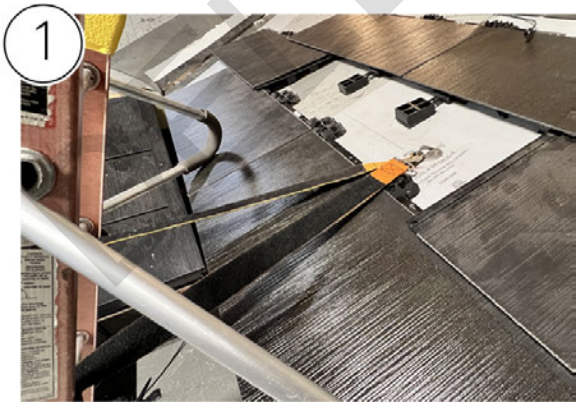
If the bolt hanger is installed at a course of PV tiles, see *Bolt Hanger Interactions with PV Tiles on page 150*.

If the bolt hanger is installed at a course of metal tiles, see *Bolt Hanger Interactions with Metal Tiles on page 151*.

Bolt Hanger Interactions with PV Tiles

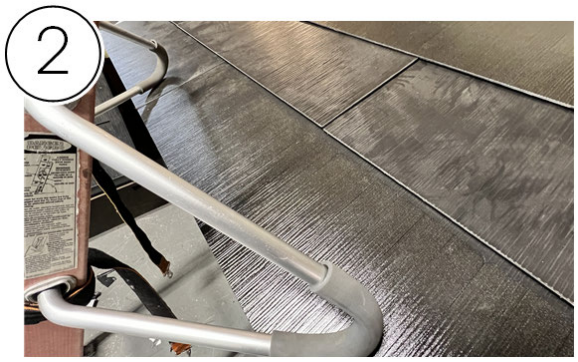
Remove the straps, install the PV Tile, then uninstall the PV glass module and reattach the ladder straps to keep the ladder secure **(1)**.

Pictured: PV glass module removed, and ladder secured to bolt hanger.

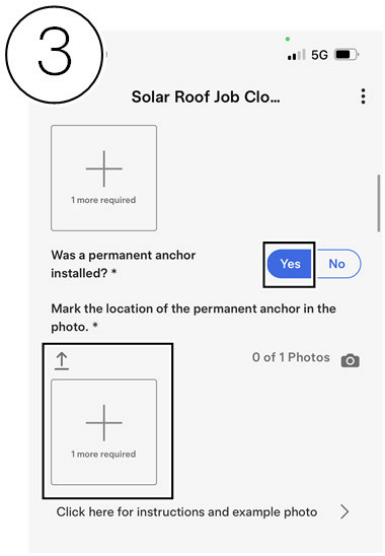


NOTE: If a PV footlap lands on top of the bolt hanger, relocate the bolt hanger to the next rafter over to prevent interference. Follow the same guidance in *Installing Bolt Hangers on page 147*.

When the ladder is no longer needed, remove the Velcro straps from the bolt hanger. Reinstall the PV module over the bolt hanger. Do **not** uninstall the bolt hanger unless a Fixe/Salamander anchor was installed see the *Overview disclaimer on page 147*. **(2)**.

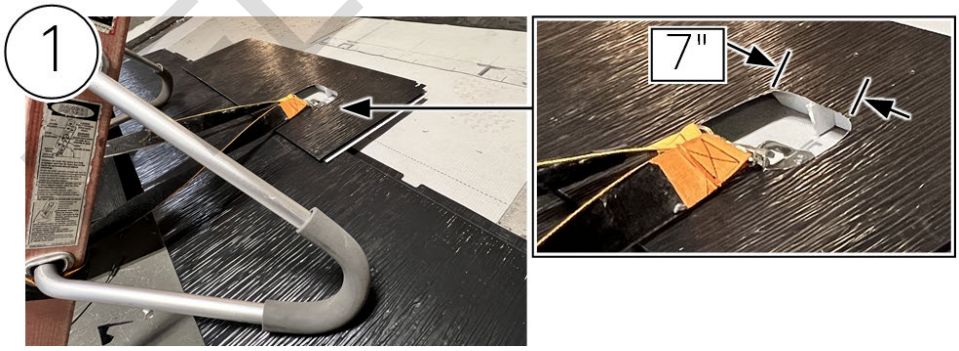


Mark the location of the bolt hanger in the Job Closeout Form in Tesla One **(3)**. This will ensure the bolt hanger locations are noted during future servicing.



Bolt Hanger Interactions with Metal Tiles

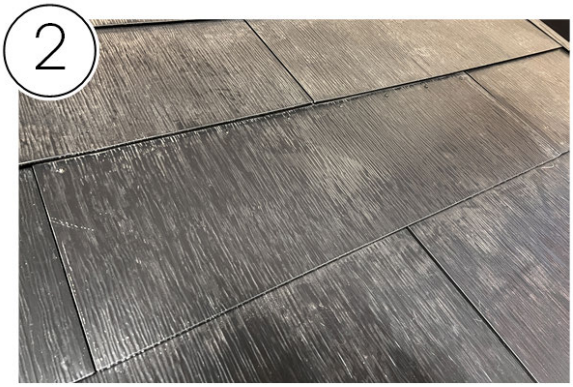
When installing a Metal Tile over the bolt hanger, cut a hole in the Metal Tile at the location of the bolt hanger. Ensure this hole's diameter is less than 7 in to prevent the need for installing a supportive vented riser under the Metal Tile when a tile skin is installed over the hole **(1)**.



NOTE: If a Metal Tile water channel lands on top of a bolt hanger, relocate the bolt hanger to the next rafter over. This will prevent the water channel from being covered with a tile skin. Follow the same guidance outlined in Installing Bolt Hangers.

When the ladder is no longer needed, remove the Velcro straps from the bolt hanger. Install a tile skin over the cut Metal Tile. Do **not** uninstall the bolt hanger **(2)**.

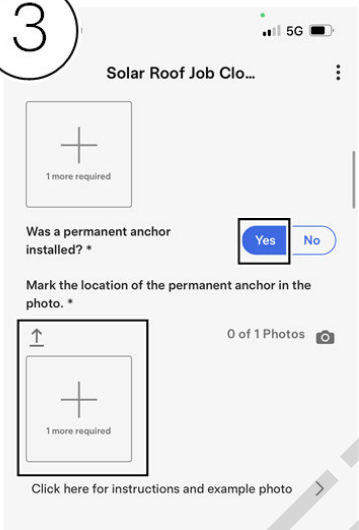
2



NOTE: If an installer is supported by a ladder while installing the tile skin, the ladder must be footed by a coworker during installation.

Mark the location of the bolt hanger in the Job Closeout Form in Tesla One **(3)**. This will ensure the bolt hanger locations are noted during future servicing.

3

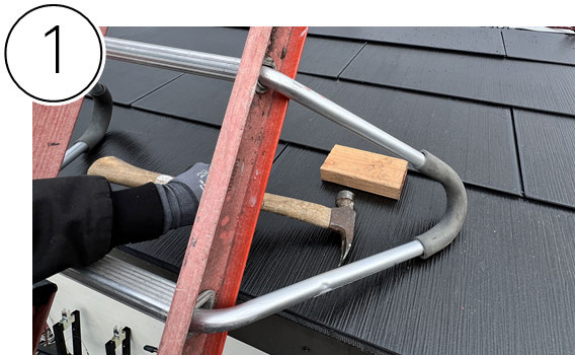


Servicing PV Tile Mounting Planes with Bolt Hangers

Locate the bolt hanger as marked on the Job Closeout Form in Tesla One and remove the PV Tile above it.

PRO TIP: When standing on a ladder, use a wood block and hammer to disengage the PV Tile from the feet **(1)**.

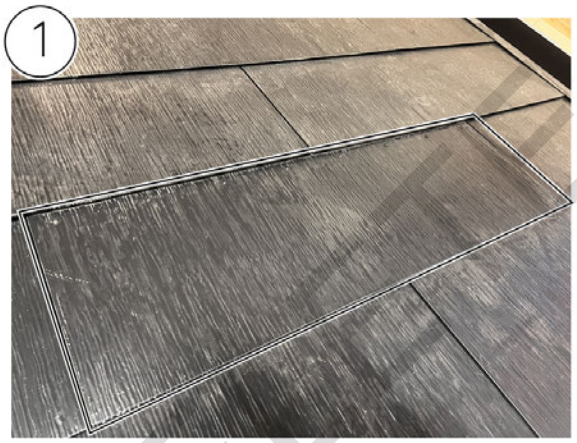
NOTE: The ladder supporting the installer locating the bolt hanger must be footed by a coworker.



Attach Velcro straps to the bolt hanger and secure the ladder **(2)**. Reinstall the PV Tile once the ladder is no longer needed – see *Bolt Hanger Interactions with PV Tiles on page 150*.

Servicing Metal Tile Mounting Planes with Bolt Hangers

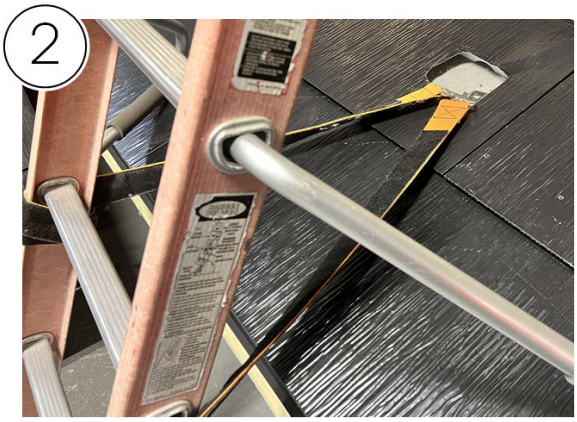
Locate the bolt hanger as marked in the Job Closeout Form in Tesla One **(1)**.



NOTE: The ladder supporting the installer locating the bolt hanger must be footed by a coworker.

Uninstall the tile skin concealing the bolt hanger underneath. Attach Velcro straps to the bolt hanger and secure the ladder **(2)**.

2



Assessing and Determining Roof Loading Locations

This document provides broad guidance for loading a roof with materials. Note that every roof and job site is different and will require special considerations.

Tools

- Utility knife
- Measuring tape
- Cordless impact driver drill

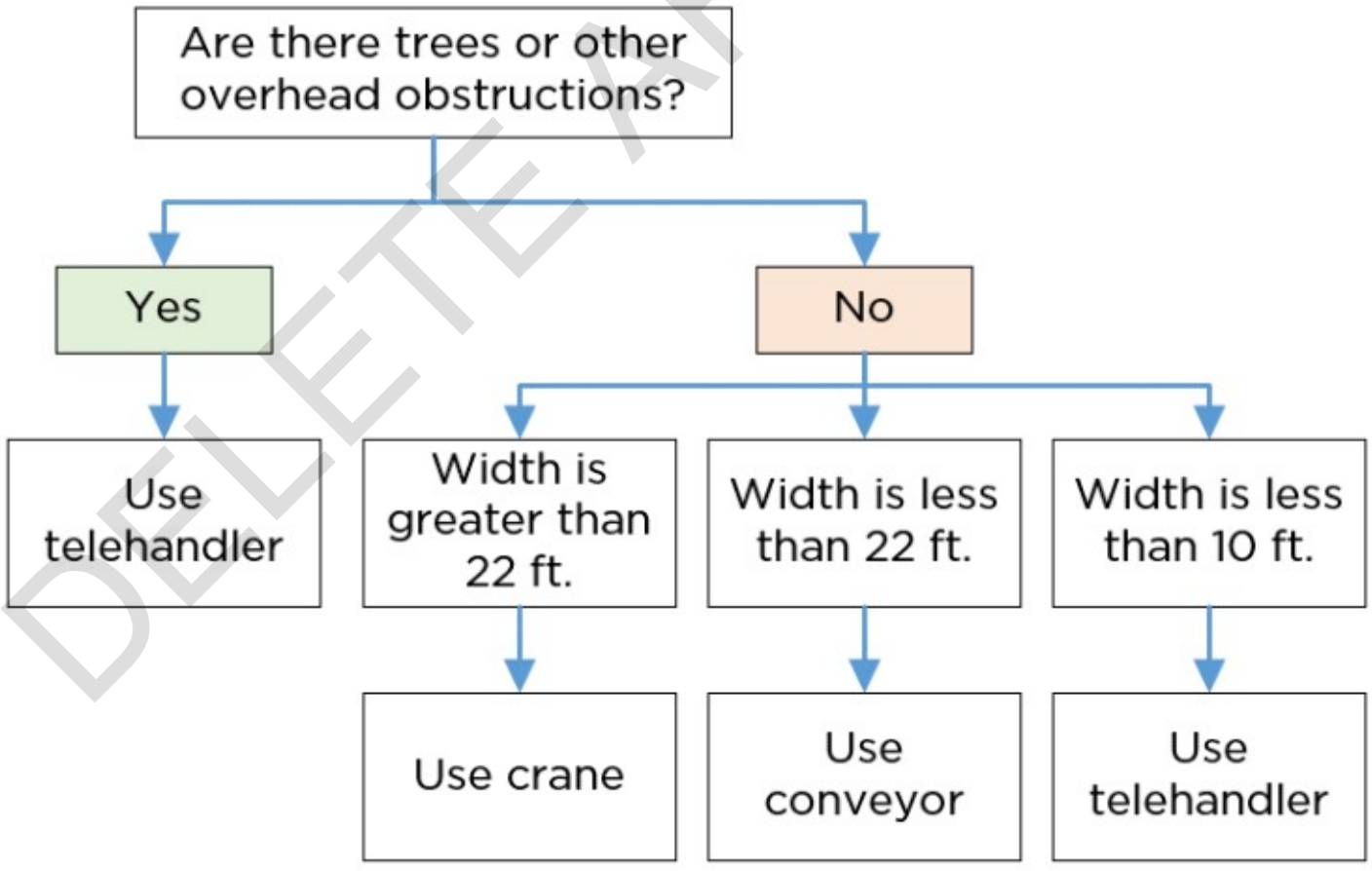
Components

- Knuckle Boom
- Conveyer Truck
- Reach Fork
- Laddervator
- Roof Rack

PPE

- Safety glasses
- Cut-resistant gloves
- Fall protection

Determining Roof Loading Equipment



Typical Loading Equipment

Always try to obtain the equipment at the top of the list, and if unavailable, go to the next row.

Equipment	Notes/Considerations
Knuckle Boom	Requires certain level of site access and overhead clearance (e.g. clear of trees, power lines, etc.)
Conveyer Truck	More flexible when there are overhead barriers; would need enough space on the driveway.
Reach Fork	Requires certified driver, requires hard surface or protection.
Laddervator	~250 - 450 lb. limit, steep roofs may require knuckle piece attachment.

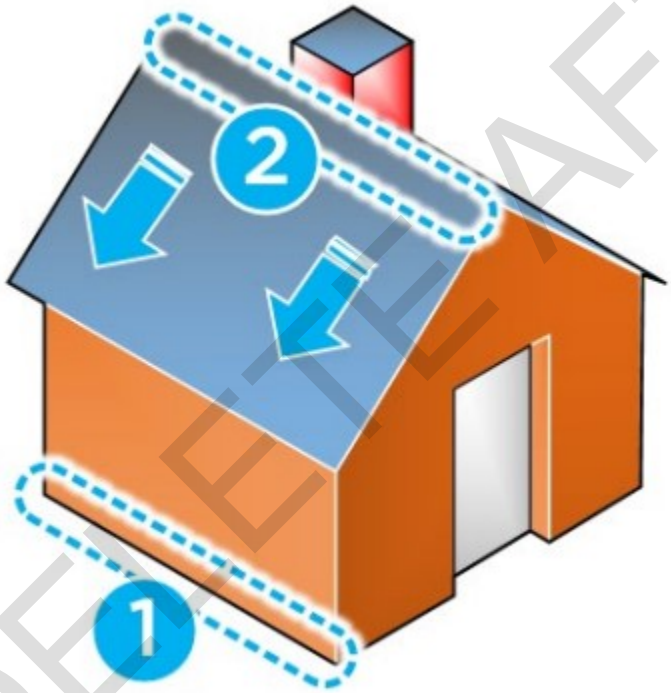
Typical Roof Loading Strategy

As jobsite conditions allow, always plan to load materials at the rear of the roof first, relative to the roof access points. Then, begin loading the roof from rear to front.

Typical Material Specifications
Take note of the following general specifications when strategizing roof load. In general, plan to place racks on the roof as close to the actual area of use as possible.

- One Rack = Half a Square = Six Bundles = 12 Modules

1. Determine the location of trees or other overhead obstructions. If there are trees, use a telehandler. If there are no trees, and the mounting plane width is less than 22 feet, use a conveyer. If the mounting plane width is greater than 22 feet, use a crane.



   - *(1) - Roof access point*
   - *(2) - First area of material load (load here first then move toward roof access point)*

2. Identify roof access points.
3. Identify good locations near the roof access points for initial material placement.

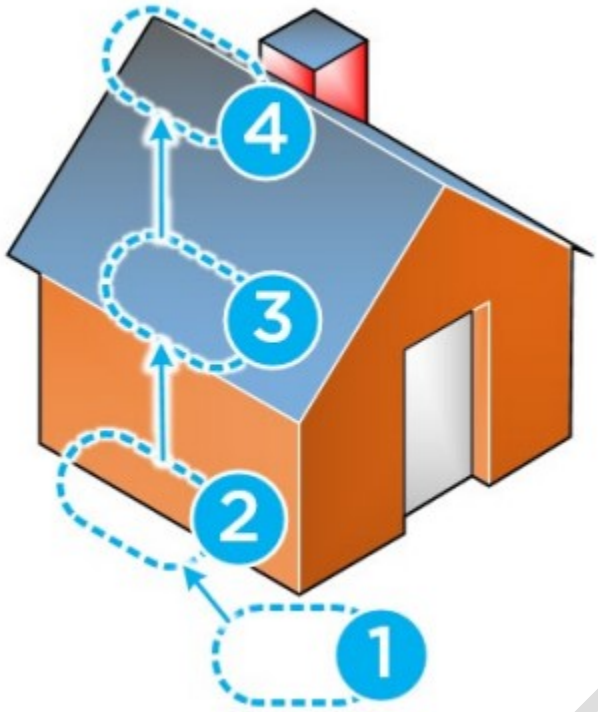
> **NOTE:** Always plan to load the roof from back to front relative to the access point.

- *(1) - Roof access point*
- *(2) - Bad location for initial material placement*
- *(3) - Good location for initial material placement*

4. Assess each mounting plane's size, shape, pitch, etc. to determine the optimal layout of racks.

> **NOTE:** Always plan to load the roof from back to front, relative to the access point.

5. Delegate team members at each station of the roof loading "assembly line" and instruct them on what to do for each rack of material that will begin making its way to the roof.



NOTE: Always prevent team members from having to switch ropes as much as possible.

6. Once the roof loading plan is in place, install loading equipment at the optimal location and begin moving materials to the roof. Begin loading materials as far away from the roof access point as possible, then move toward the roof access point.

NOTE: Always minimize the number of touches and steps required of team members throughout the roof loading process.

SOLAR ROOF INSTALLATION

Solar Roof Installation Basics Video

Installation Basics

Installing PV Tiles

Overview

This section covers the primary use cases and features of PV tiles. For an in-depth overview of wire and cable management practices, see Wire Management.

Tools and Equipment

- Foot
- Footlap
- PV tiles
- MCI (Mid Circuit Interrupter)
- Cordless Roofing Nailer

PV Tile Hardware

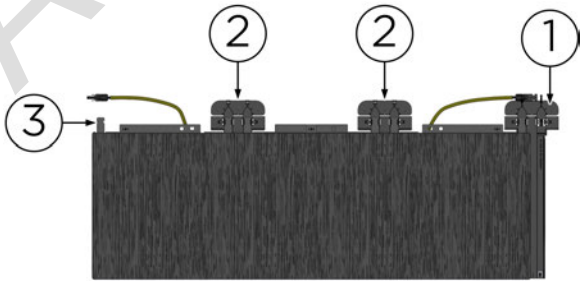
PV tiles consist of solar cells between textured glass and a fiberboard backer. Each PV tile comes pre-assembled with mounting hardware: the foot and footlap. These components also have features that aid in fastening, tile alignment and wire management.

See *Part Inscription Identifier on page 709* for an in-depth list of foot/footlap features.

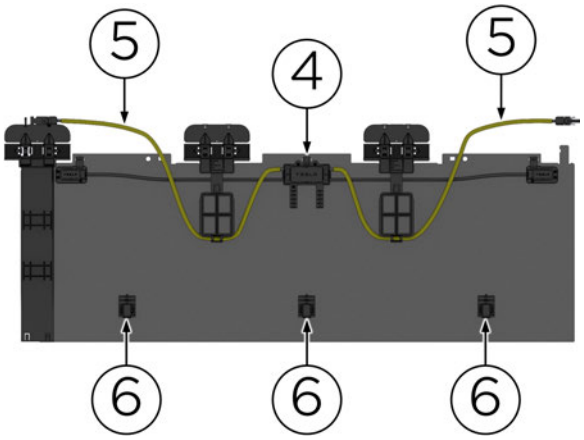
PV Tile Overview

1. Footlap
2. Foot
3. Backer
4. Junction Box
5. PV Wires
6. PV Tile Hooks

Top View

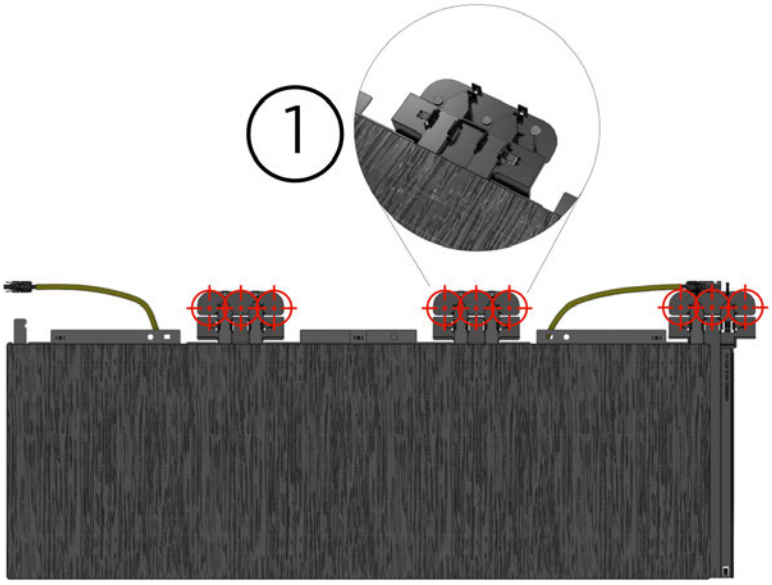


Bottom View

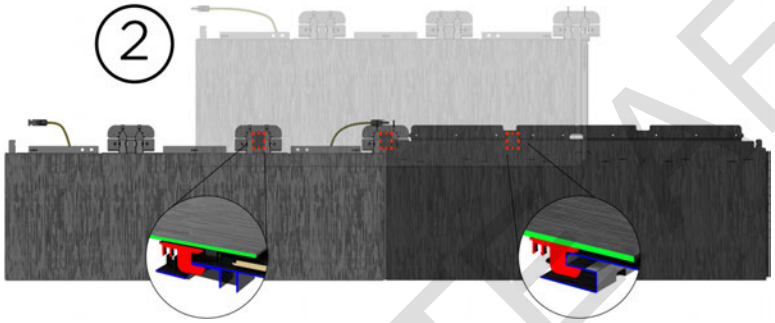


Fastening and Aligning PV Tiles

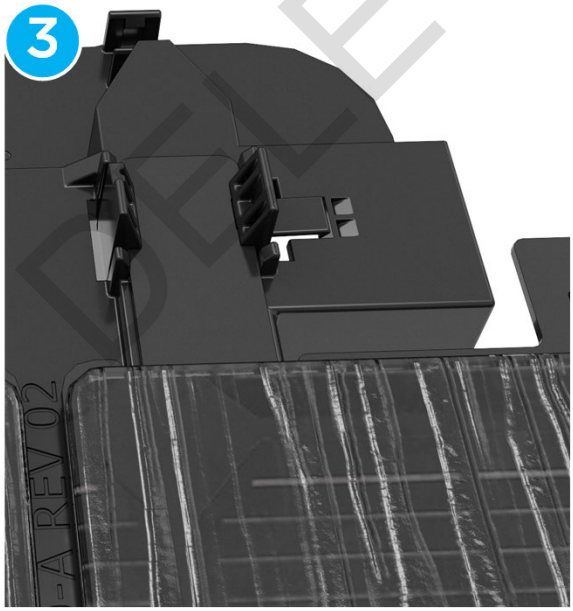
PV tiles are fastened to the deck through the target holes on the feet/footlap **(1)** in accordance with the applicable wind tier in the *Fastener Schedule on page 703*.



The PV tile hooks fit into vented risers, metal tile shoulders and the feet/footlaps of other PV tiles **(2)**. PV tiles installed next to each other will share a footlap.

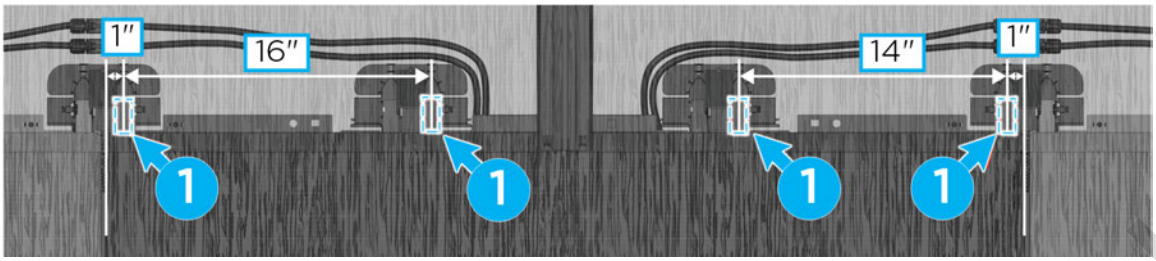


Ensure the tabs on the top of the fiberboard are pushed fully into position in the foot/footlap engagement clips so they are locked into place **(3)**. This ensures tiles will maintain proper alignment.

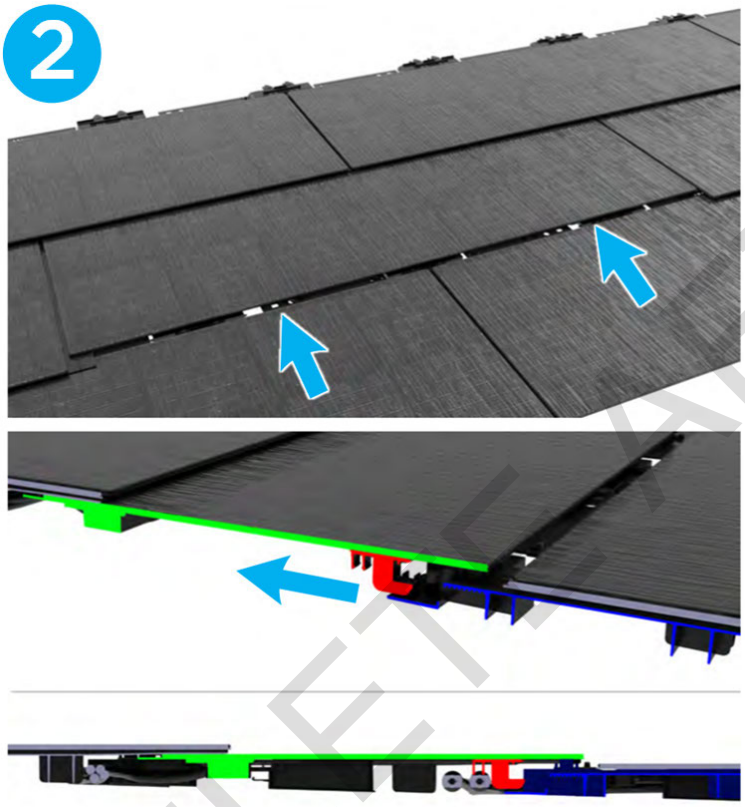


Removing PV Tiles

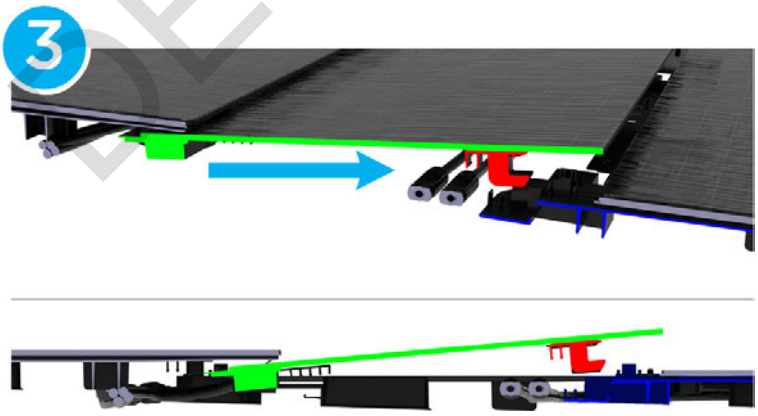
To remove an installed PV tile, the foot/footlap engagement clips holding the tile in place must be shifted into the open position by placing enough even force on the PV tile from the bottom. For reference, the clips are located 1 in away from either edge of the PV tile, 14 in away from the tile's right edge and 16 in away from the tile's left edge **(1)**.



With the engagement clips unlocked, push and slide the PV tile up roof so that the tile's lower hooks disengage from the tile(s) below it **(2)**.



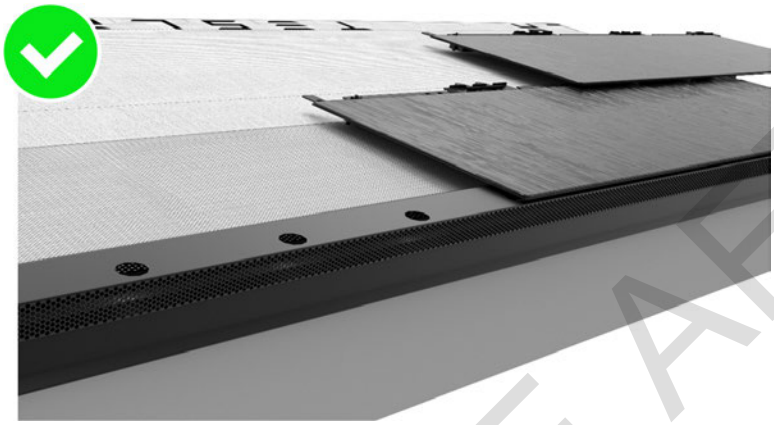
Finally, tilt the tile up and pull it away from the feet/footlaps so that the tabs fully exit the engagement clips **(3)**.



Additional PV Tile Installation Guidelines

It is safe to install metal tiles above, below, and to the sides of PV tiles. However, **never install metal flashings over PV tiles**. This will block the production of solar energy.

PV tiles can also be installed at the first course over the vented riser.



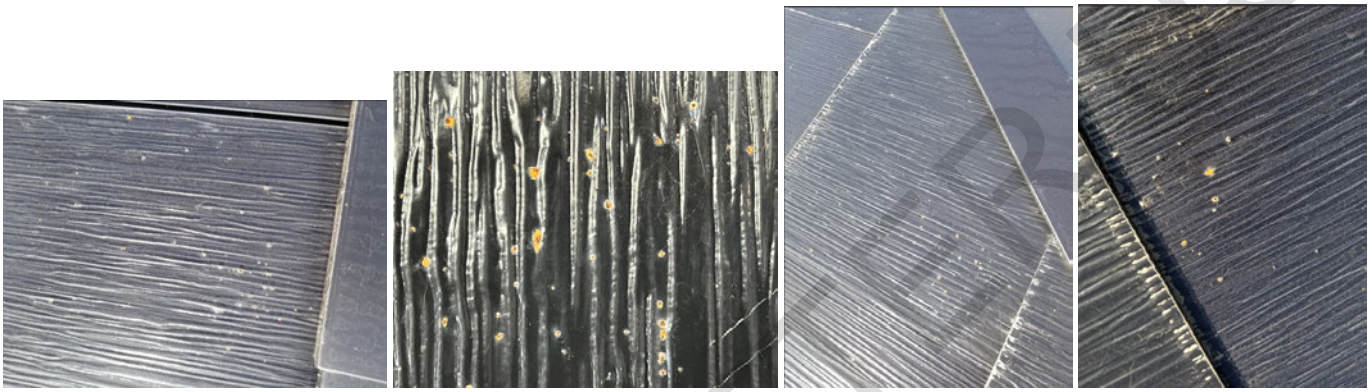
Installing Metal Tiles

Overview

This section covers the primary use cases and features of metal tiles. Metal tiles can be installed in place of PV tiles as well as below, adjacent to, or over PV tiles. metal tiles can also be installed anywhere on the roof that requires tile cutting or modification.

NOTE: Metal shavings left on the roof can rust or discolor over time. **Ensure all metal shavings are cleared off the roof once installation is complete.**

Pictured: Tiles with rusted metal shavings on top of them.



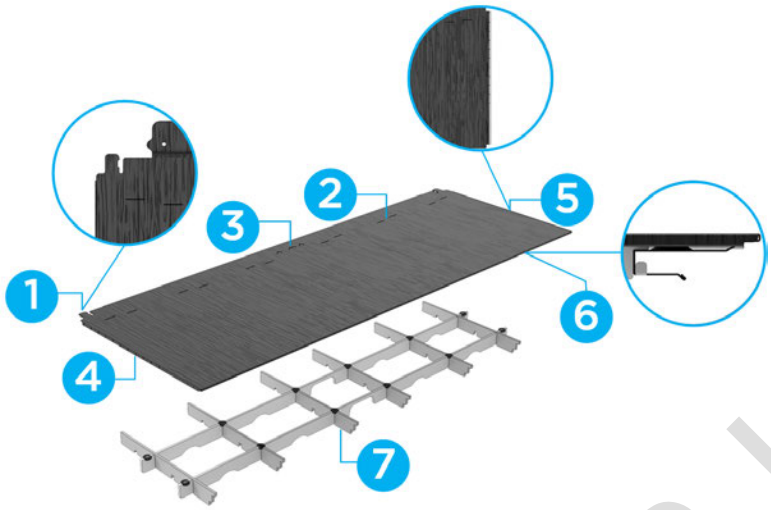
Tools and Equipment

- Metal Tile
- Offset metal snips

Metal Tile Hardware

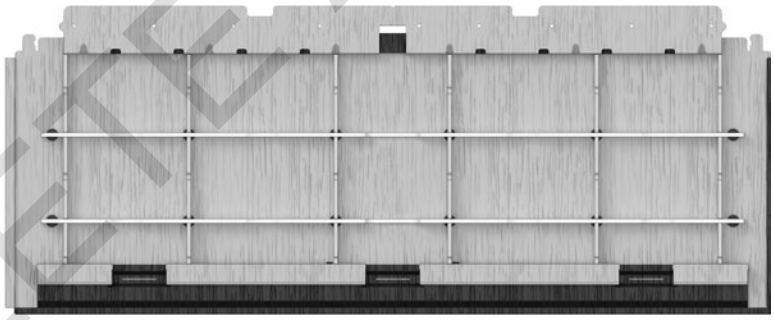
See *Part Inscription Identifier on page 709* for descriptions of metal tile features and their use cases.

(1)	Engagement Tab, Metal Tile Nose
(2)	Nominal / Max Reveal Marks
(3)	Tile Timing Marks
(4)	Left Side Open Hem
(5)	Right Side Open Hem
(6)	Lower Engagement Hook
(7)	Lattice for Structural Support



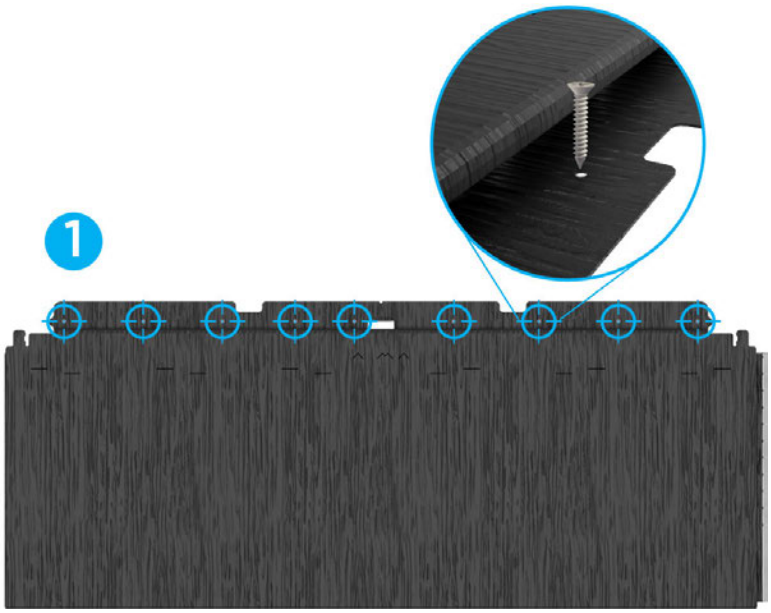
Front of Tile

Back of Tile

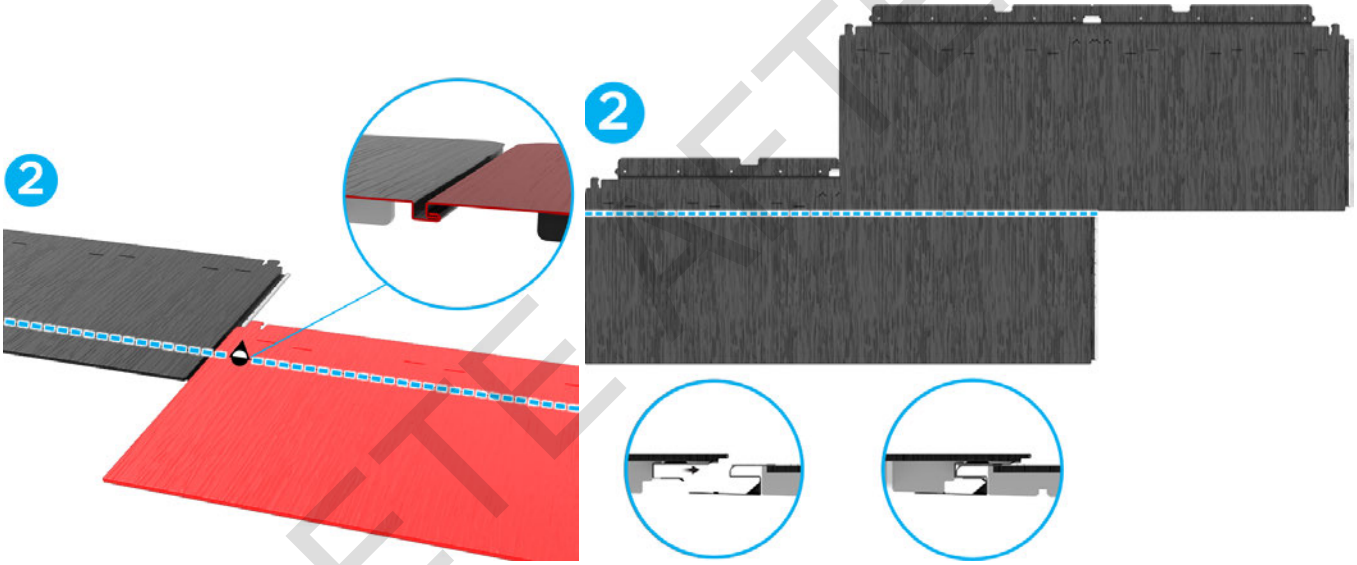


Fastening and Aligning Metal Tiles

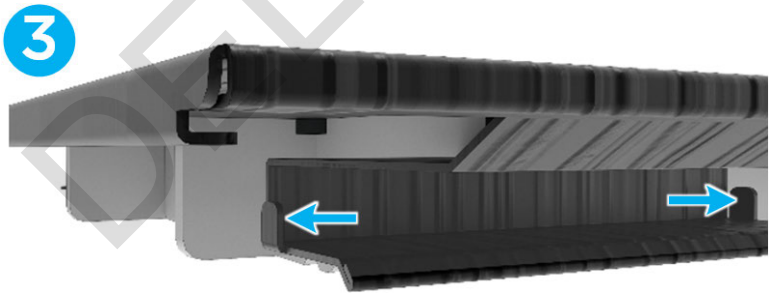
Metal tiles are fastened to the deck through the target holes on the upper flange **(1)**.

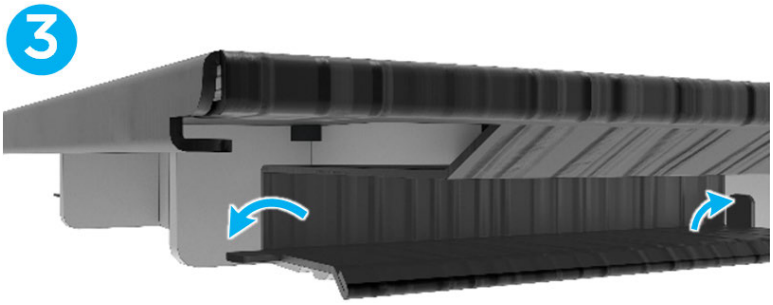


Adjacent Metal Tiles lock into each other through the open hem along the water channel. The tile slides down from the top until it reaches the nominal reveal line **(2)**.

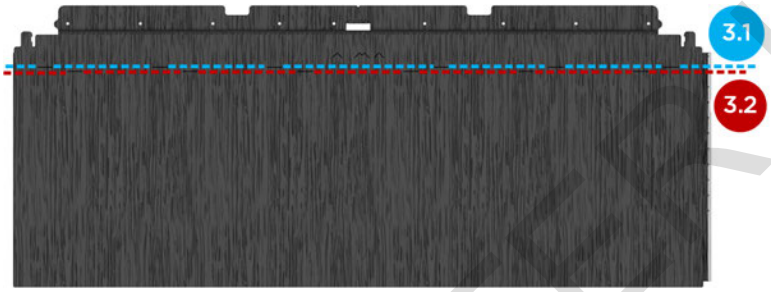


OPTIONAL: If needed, set the minimum reveal by bending the lower engagement hook tabs down flat to increase the overlap **(3)**. There are a total of eight tabs along the hook.





(3.1)	Maximum Reveal
(3.2)	Nominal Reveal

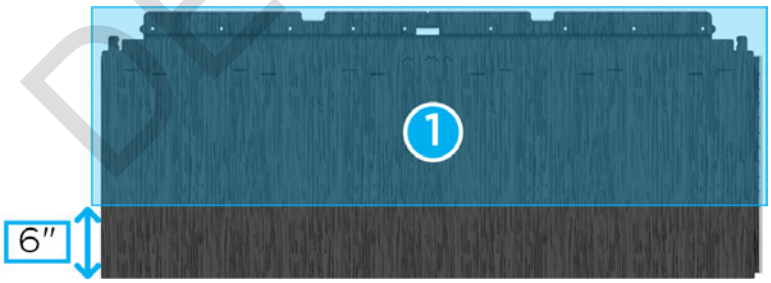


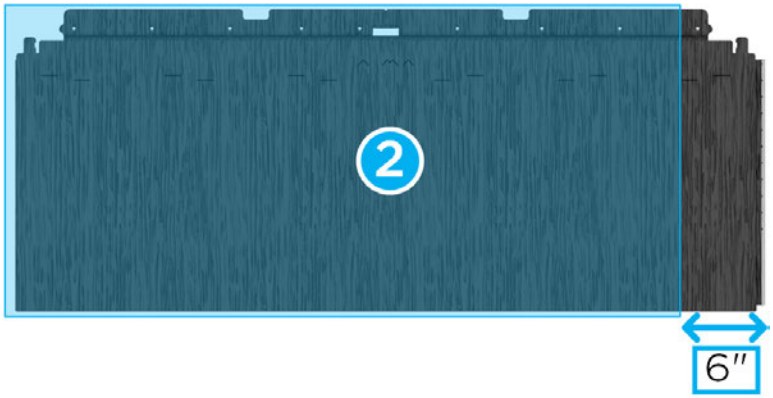
Rows of tile are installed with a half-tile width stagger, so the edges of the upper course are aligned with the middle arrows along the top of the tiles in the course below **(4)**.

Cutting Metal Tiles

Metal tiles can be cut vertically or horizontally to a minimum of 6 in wide or tall.

Pictured: Horizontal cut area **(1)** and vertical cut area **(2)**.

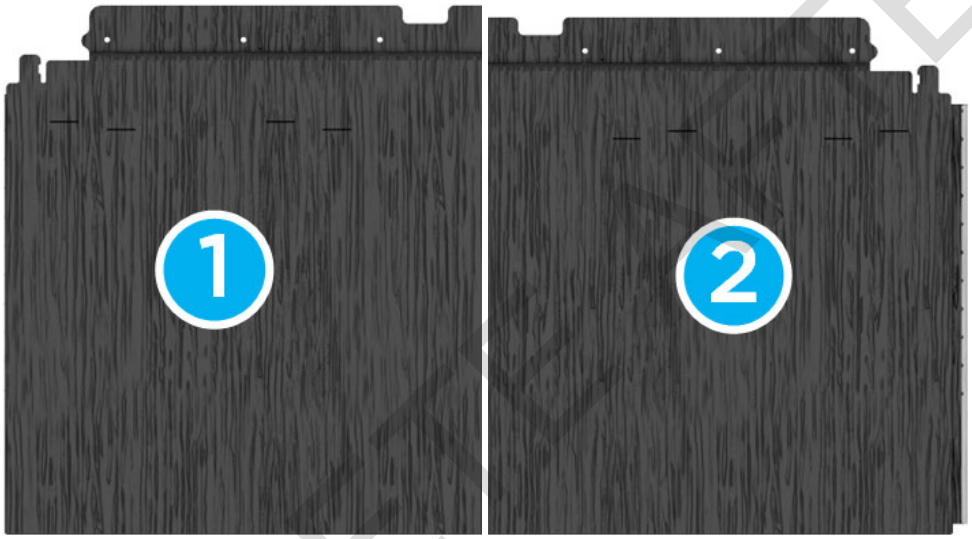




Metal tiles can be cut to the size needed along the end of the mounting planes and at obstructions. Dimensions are typically called down from the roof and cut by personnel at the cutting station. The length plus the callout of factory left or right represents the edge you want to keep.

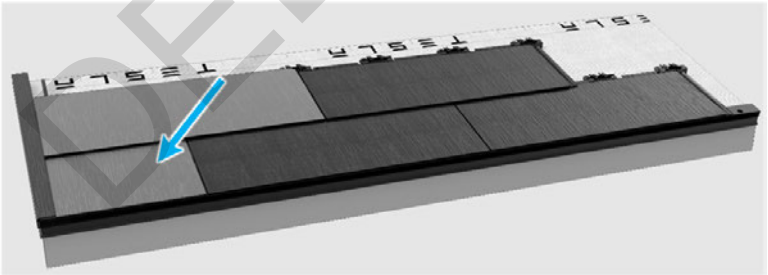
Pictured:

- Example: Factory Left 24 in **(1)**
- Example: Factory right 24 in **(2)**

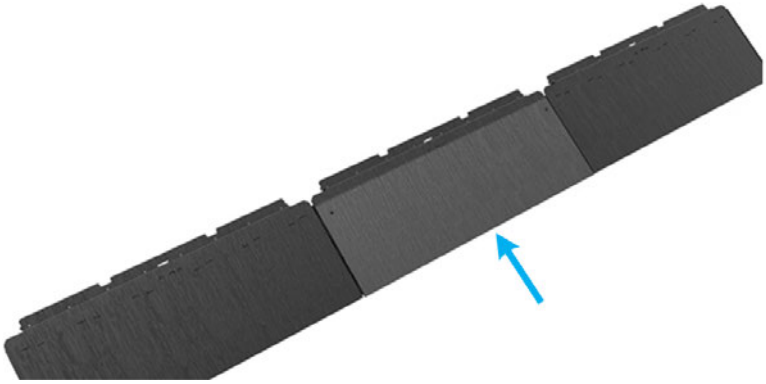


Additional Metal Tile Installation Guidelines

Example of a partial metal tile being used to close out a course on the rake.



If metal tiles become severely dented or damaged, place a tile skin over the tile and secure it with exposed self-tapping screws.



Skinning Metal Tiles

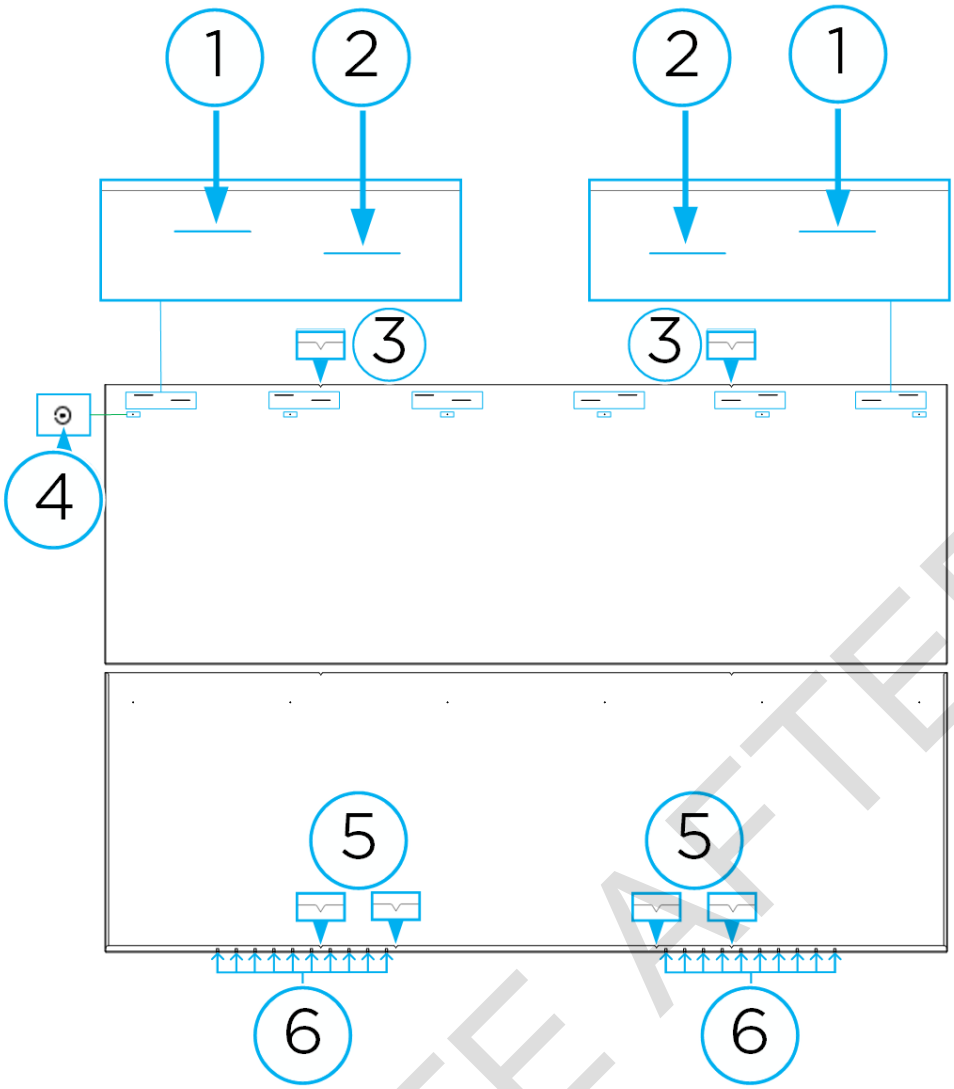
Overview

This section introduces the tile skin (see part number in the *Part Catalog on page 74*), which is used to fill in dead zones, conceal installation accessories, cover damaged tiles and create extreme angle valley trim.

Tile Skin Inscriptions

See tile skin inscriptions defined below. These features are used to aid in correctly installing tile skins in various use cases.

1. Nominal reveal: Next course normally aligns to this mark.
2. Maximum reveal: Next course can be moved up as far as this line if needed.
3. Carets that guide tile skin cuts/modification when installing tiles at guttered obstructions
4. Divots for guiding fastening.
5. Notches used as reference points to create trim covers at extreme valley angles (anything greater than 135°).
6. Weep holes.



NOTE: See all part inscriptions in the *Part Inscription Identifier on page 709*.

Tile Skin Use Cases

Below is a list of tile skin use cases and each applicable work instruction where tile skins are used:

- Covering damaged tiles - See section "Covering Damaged Tiles" below.
- Concealing installation accessories and other parts, such as Pass Through Boxes.
- Guttering Square Obstructions
- Filling in dead zones - See: Rake and Sidewall Dead Zones and Hip Dead Zone in *Cut and Tuck on page 178*
- Create trim for extreme angle valleys (any valleys greater than 135-degrees where adjustable trim will not fit) - See *Valleys Over 135° on page 406*.
- Hips
- Covering Anchors
- Metal Tiles under 6 ft tall and 1 tile wide

Proper Coverage

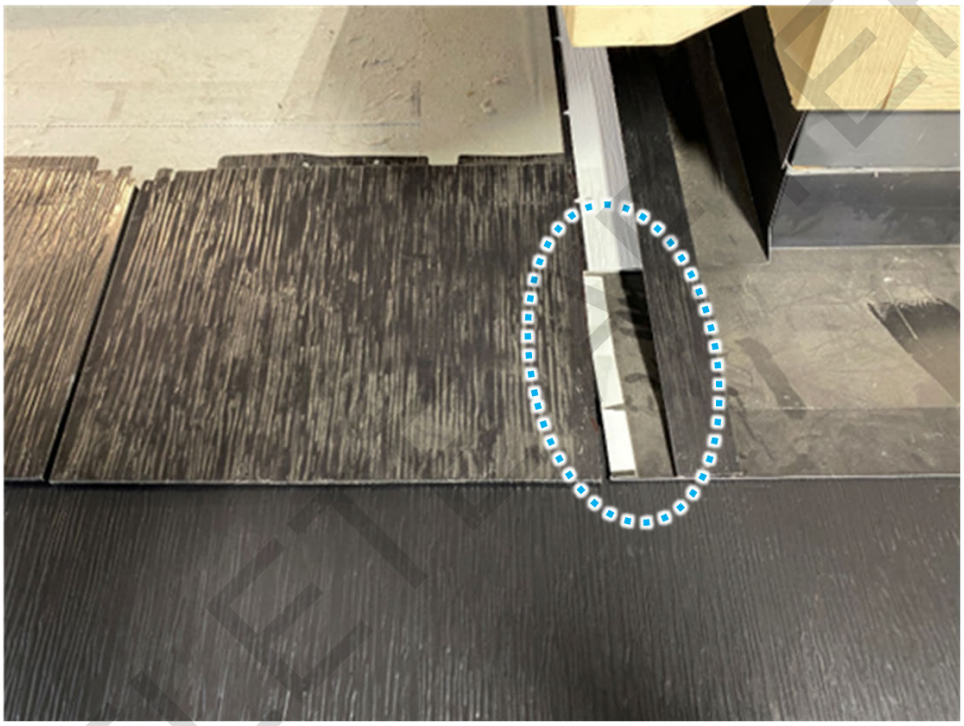
To ensure that the tile skin has proper coverage on the metal tile, always start your scribe for any use case at the 11 in indicator notched into tile skin.

Tools and Materials

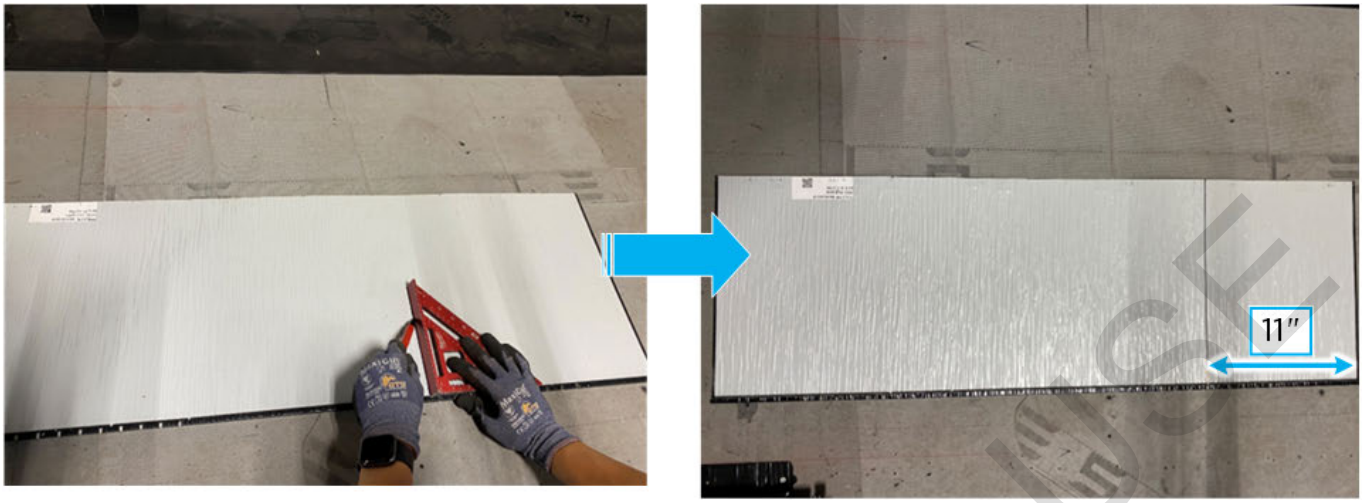
- Tile skins
- Snips
- Square
- Pencil/marker
- Impact
- Self-tapper

Work Instruction

1. Determine the use case of the tile skin. In this example, we are using the skin at a guttered obstruction.



2. Scribe the needed length and angle for cutting the skin. Here, we are using the 11 in indicator already on the skin, which allows one skin to be used on both sides of square obstructions.



3. After the cut, the line has been scribed onto the tile skin. Use snips to cut away unneeded materials.

4. Install the skin over the tile, making sure the leading edge of the skin is flush with the leading edge of the metal tile. Make sure to tuck the cut edge of the skin into the channel flashing, and leave the factory edge exposed.

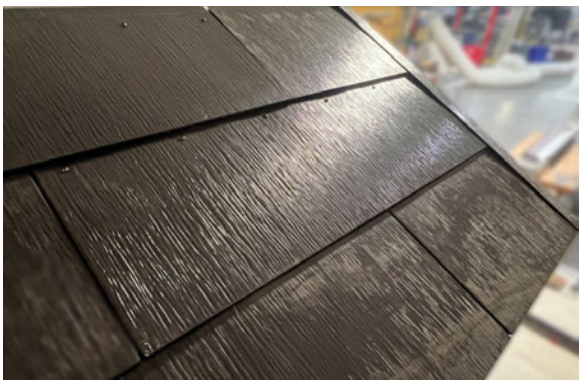
5. Use the square self-tapper to fasten the skin. The locations of the fasteners have been marked in the image below.

Covering Damaged Tiles with Tile Skins

This section provides instructions for installing tile skins over damaged tiles.

Pictured: Damaged metal tile (significant visible scratches).

Pictured: Final Installation.



Tools & Equipment

- Tile skin

Work Instruction

1. Position the tile skin over the damaged tile **(1)**.

Pictured: tile skin **(1a)** placed over a metal tile **(1b)**.

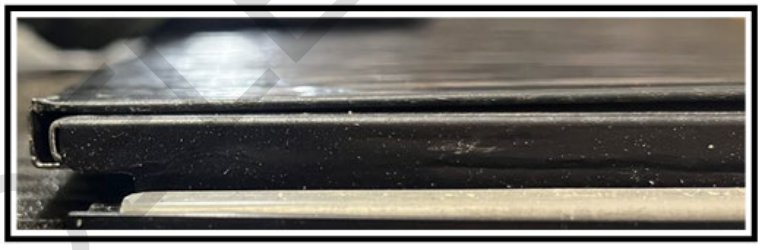
2. Slide the tile skin up roof until the bottom hook fully engages with the bottom edge of the tile **(2).**

Pictured: Tile skin hook NOT engaged with tile, top view, tile skin top edge highlighted.

Pictured: Tile skin hook NOT engaged with metal tile, side view.

Pictured: Tile skin hook engaged with the metal tile, top view, tile skin top edge highlighted.

Pictured: Tile skin hook engaged with the metal tile, side view.



3. Fasten the tile skin through the fastener guide divots in accordance with the applicable *Fastener Schedule wind tier on page 703***(3)**.

Tile Interactions

Overview

This section outlines the basic practices for installing PV tiles next to metal tiles.

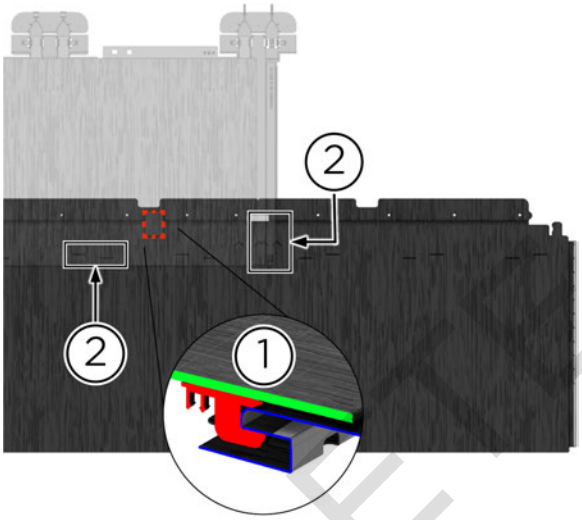
Tools and Equipment

- Metal tile
- PV tile
- Foot
- Footlap

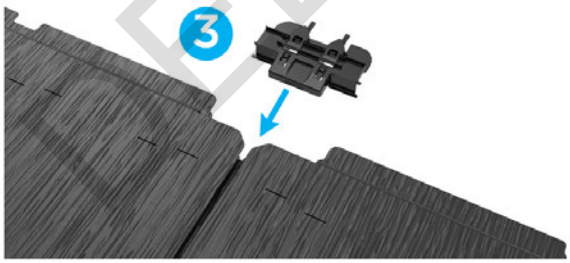
See *PV Tile Overview on page 160*, *Metal Tile Overview on page 164* and *Part Inscription Identifier on page 709* for descriptions of tile features and their use cases.

Work Instruction

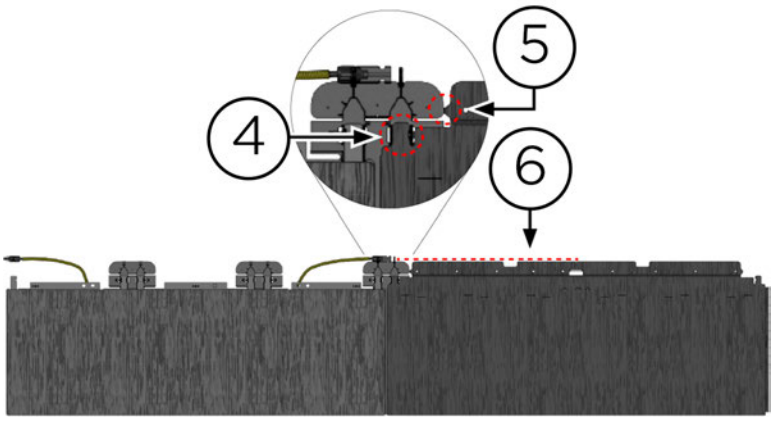
PV tiles are installed over metal tiles by engaging the PV tile hooks with the metal tile shoulder **(1)**. The PV footlaps are also aligned with the center of the outermost metal tile timing marks. Finally, the correct reveal is determined by aligning the PV tile with the metal tile nominal reveal marks **(2)**.



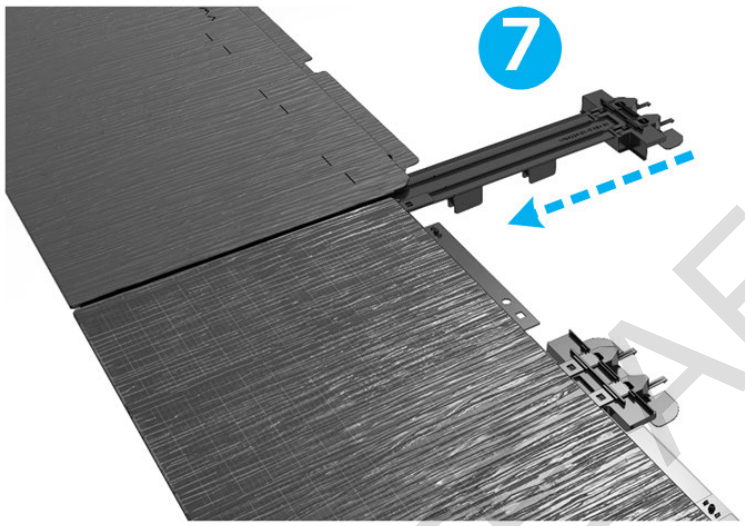
When installing a PV tile above two metal tiles, a cut foot must be placed at the water channel of the metal tiles. This provides more support for the PV tile hook engagement **(3)**.



When PV tiles are installed next to metal tiles, the metal tile engagement tabs are installed into the footlap engagement clips to ensure proper horizontal alignment **(4)**. Proper alignment is also confirmed by the metal tile bump out aligning with the footlap edge **(5)** and the metal tile top edge coinciding with the top edge of the footlap **(6)**.



It is best practice to install the footlap last when installing PV tiles next to metal tiles **(7)**. This will help the metal and PV tiles interlock more easily.



Cut and Tuck

Overview

This section provides guidance for cutting and tucking tiles into channel flashing at square roof features.

Tools & Equipment

- Measuring tape
- Digital angle finder
- Channel flashing
- PV tiles
- Metal tiles

Work Instruction

Rake and Channel Flashing

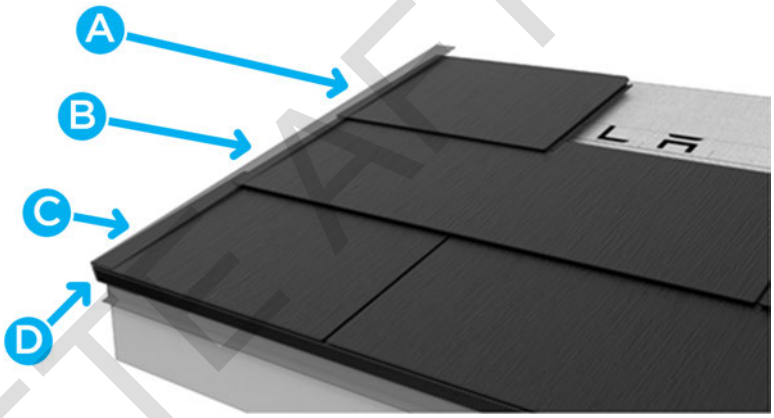
Please take note of the following rules:

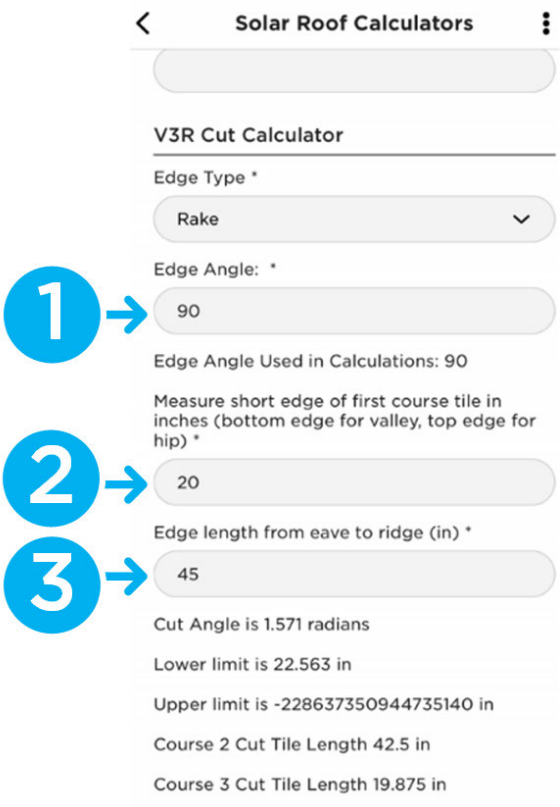
- When cutting tiles for tucking purposes, measure such that tiles are 1 in off the channel flashing wall, except for the first course, which must be 1 in longer than normal so that it is touching channel the wall and blocking off the hole in the channel flashing.
- After the initial closing-out of the gap, ensure that there is still a 1 in gap the rest of the way up in the channel flashing to allow for wiggle room.

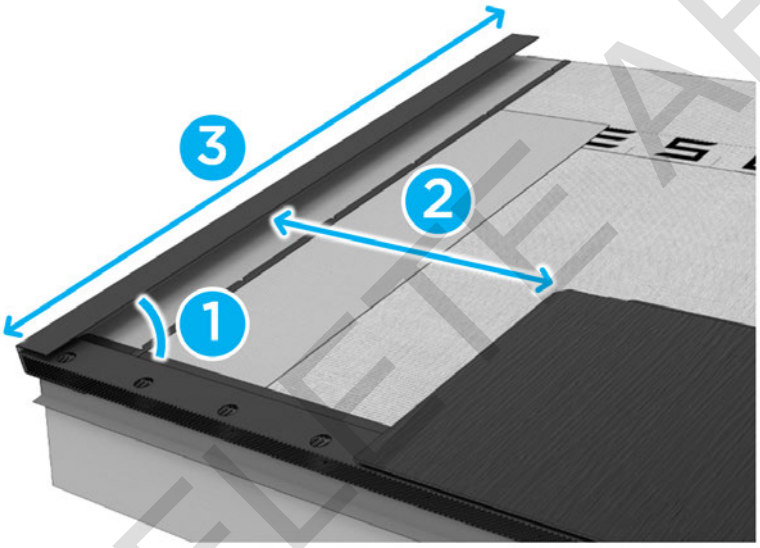
> **NOTE:** The 1 in gap ensures that there is placement buffer for the tiles if the rake is not perfectly square, eliminating the need to trim full tiles to fit.

- **Example:** Starting a plane with a rake:
  - When starting a rake with half-tile stagger, the first cut tile will need to be 23 ½ in, which is one additional inch on the half tile to help fill in the gap between the top of the riser and the channel flashing due to the setback.
  - For the rest of the half tile courses, cut the tiles perfectly in half at 22 ½ in, install ensuring a 1 in setback from the inner edge of the channel flashing.

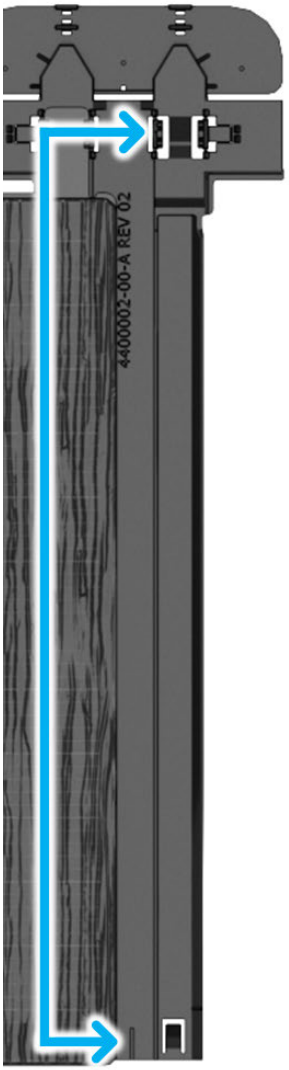
(A)	Cut tile - 1 in
(B)	Full tile
(C)	Cut tile + 1 in
(D)	Closed gap



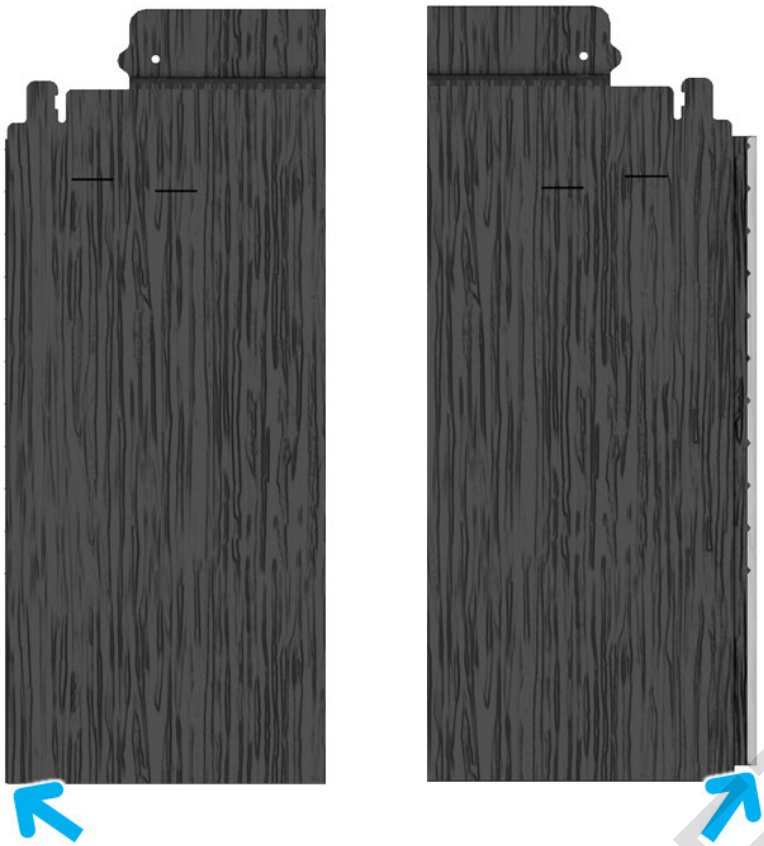




Pictured: Water channel on PV tile / footlap



Pictured: Water channel on metal tile

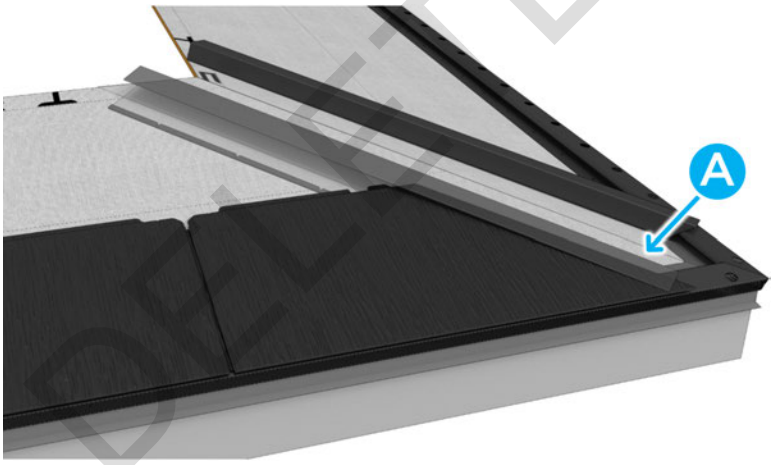


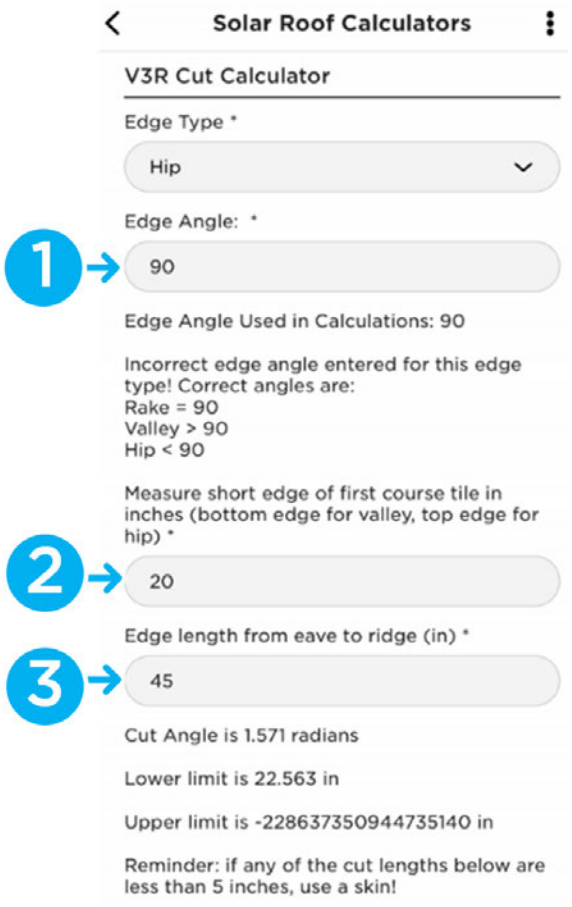
Hip

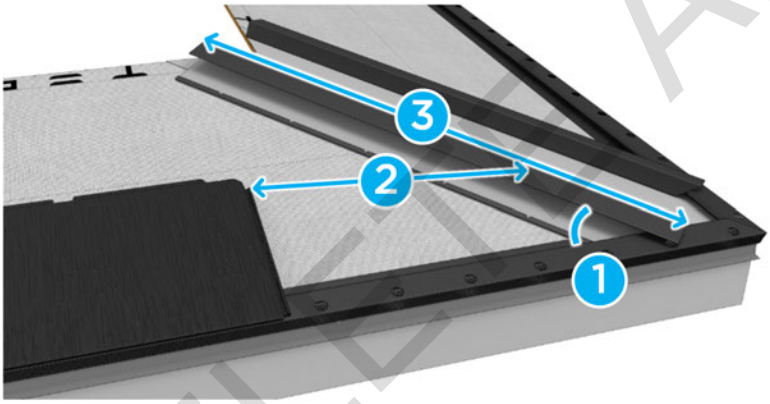
Cut tiles to size by measuring from the water channel to the inside of the channel flashing, minus an inch.

NOTE: For hip-to-hip courses, place a full tile in the middle and build out to the cut metal tiles.

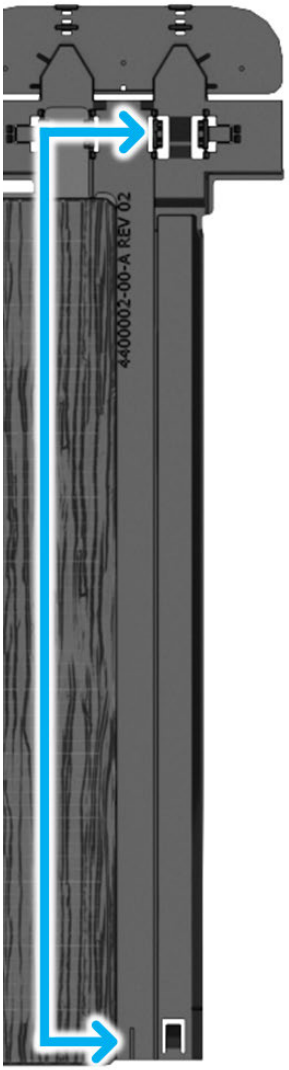
Pictured: Cut tile - 1 in **(A)**



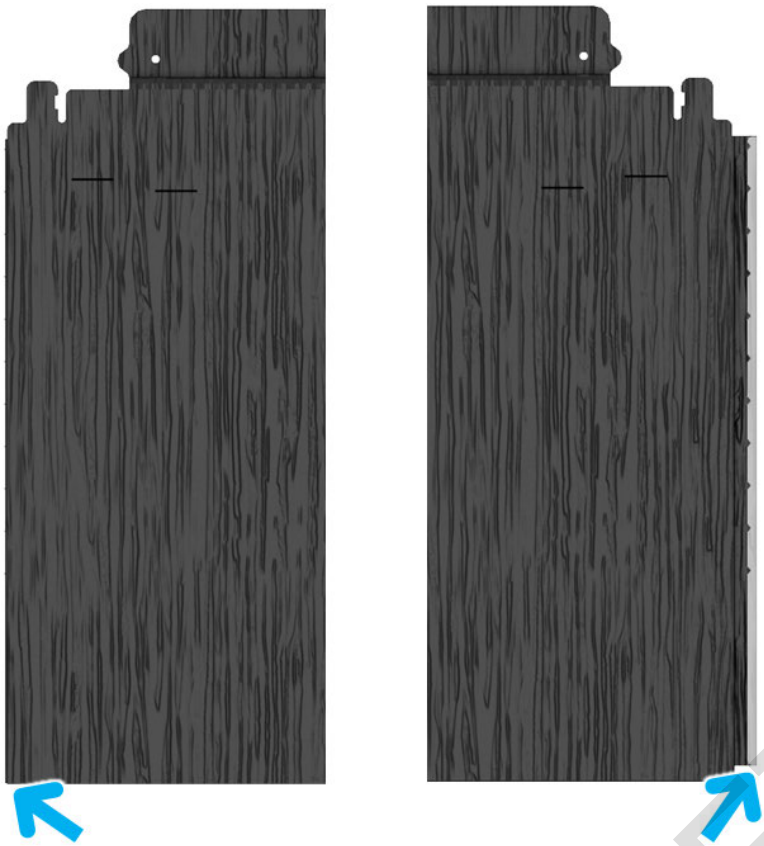




Pictured: Water channel on PV tile / footlap



Pictured: Water channel on metal tile



Rake and Sidewall Dead Zones

Overview

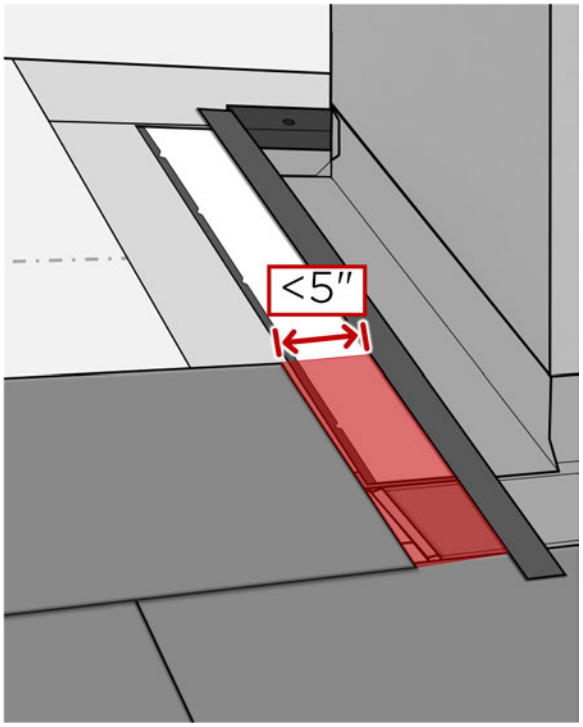
This section provides instructions for eliminating dead zones at rakes and sidewalls using tile skins (both of these roof features share the same procedure). These instructions display the steps at a sidewall. See *Tile Skin in the Part inscription Identifier on page 710* for descriptions of all tile skin features.

Tools & Equipment

- Tile skin
- Metal snips

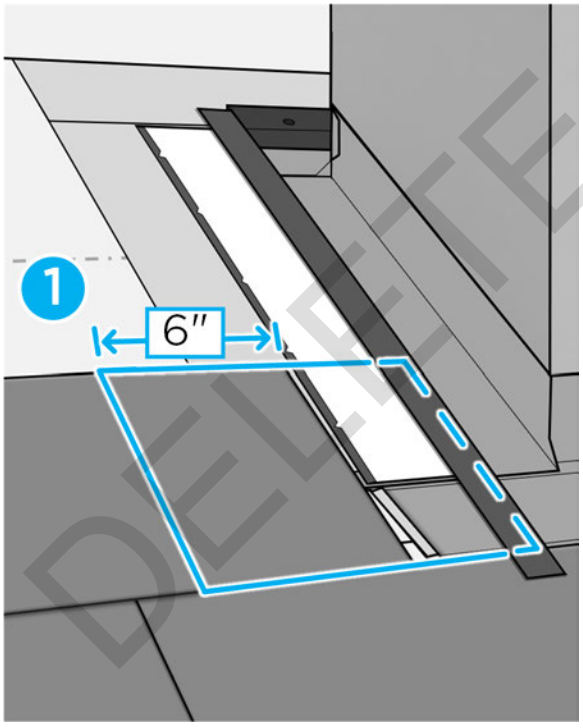
Work Instruction

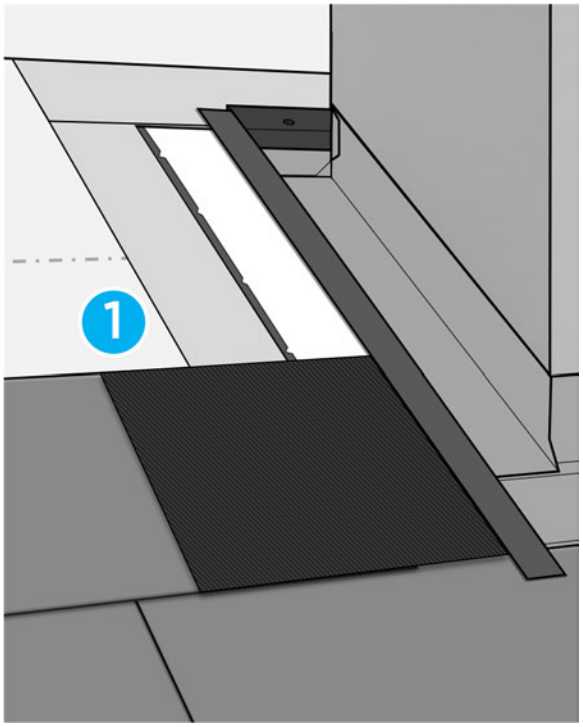
A dead zone will appear at rakes and sidewalls if the distance between a course's last tile and the channel flashing is less than 5 in. Since this is less than the allowed metal tile cutting threshold, a tile skin must be used to eliminate the dead zone.



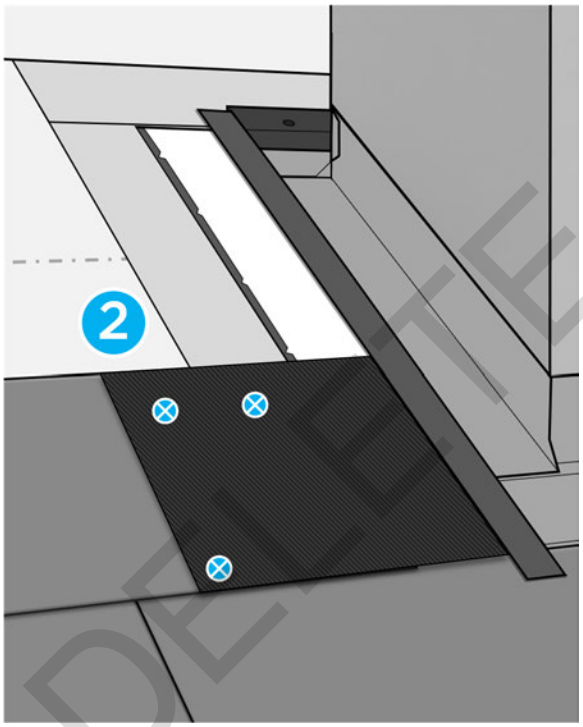
Cut and install tile skin with the following parameters **(1)**:

- The tile skin overlaps the uproof edge of the metal tile 6 in from the edge of the tile
- The tile skin extends towards the wall of the channel flashing
- The downroof edge of the tile skin fully engages with the downroof edge of the metal tile





Fasten the tile skin according to the applicable wind tier in the *Fastener Schedule on page 703* **(2)**. Leave these fasteners exposed.



Hip Dead Zone

Overview

This section provides instructions for installing tile skin to eliminate dead zones at the hip. See *Tile Skin in the Part Inscription Identifier on page 710*for descriptions of all tile skin features.

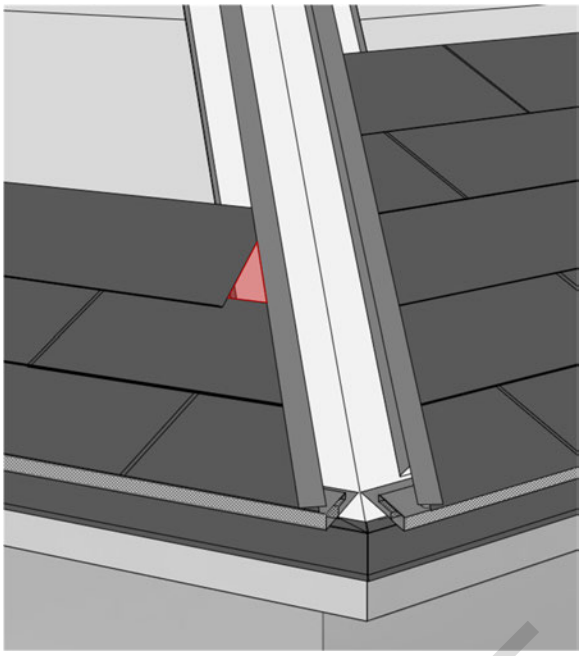
Tools & Equipment

- Tile skin
- Vented riser
- Metal snips

Work Instruction

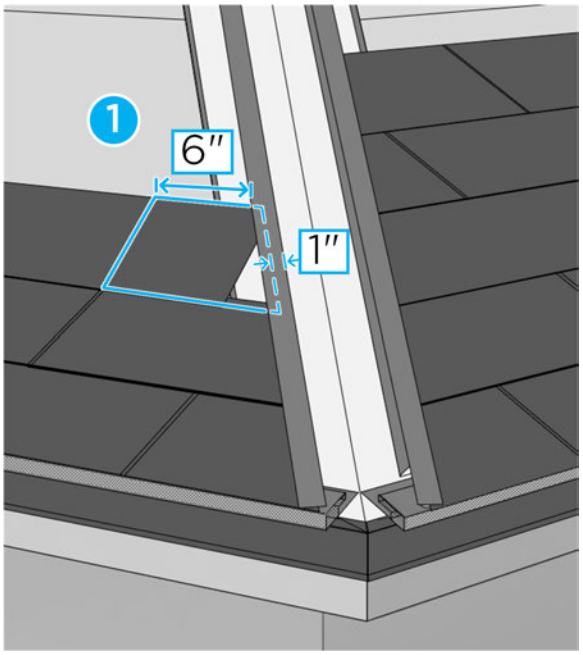
Smaller Hip Dead Zones

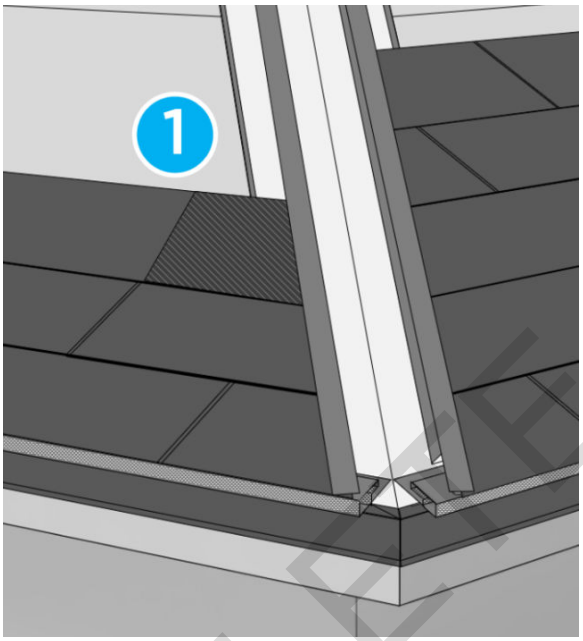
A hip dead zone will appear if the upper edge of a tile can be tucked into the channel flashing, but the lower edge falls short.



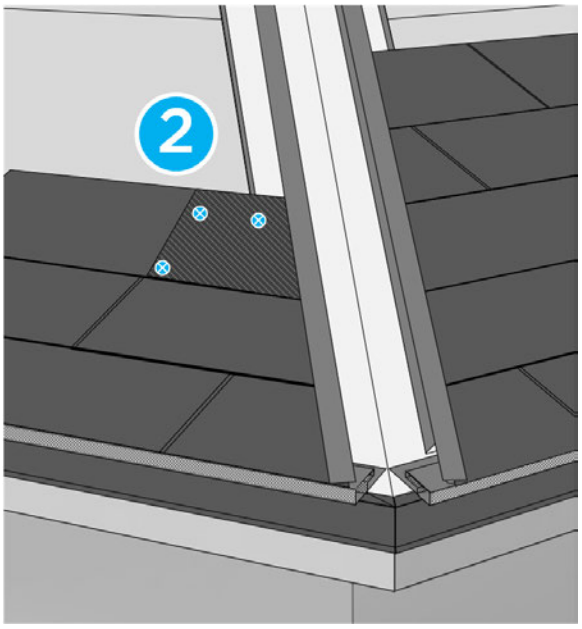
Cut and install the tile skin with the following parameters **(1):**

- The tile skin overlaps the uproof edge of the metal tile 6 in from the channel flashing
- Inside of the channel flashing, there is a 1 in gap between the tile skin and the channel flashing wall (this will prevent hip cap fasteners from reaching the tile skin, which would push the tile skin down and create a gap)
- The nose of the tile skin fully engages with the downroof edge of the metal tile



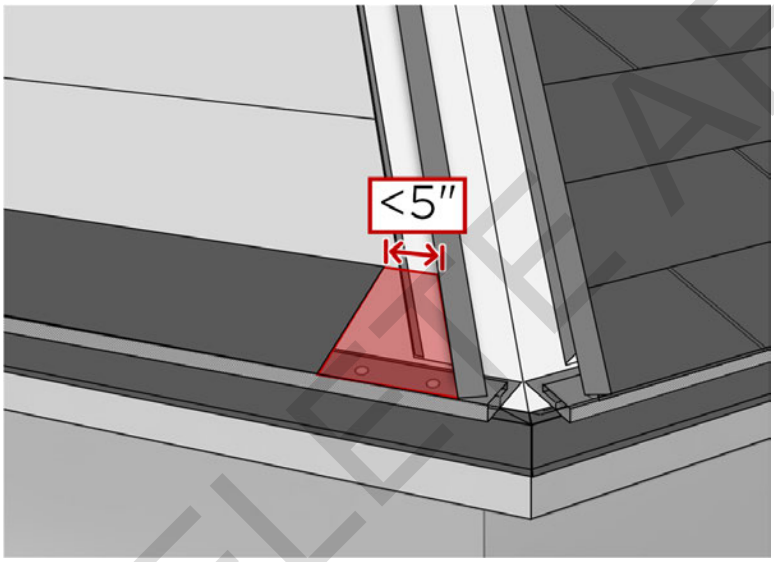


Fasten the tile skin according to the applicable wind tier in the *Fastener Schedule* **(2)**. Leave these fasteners exposed.



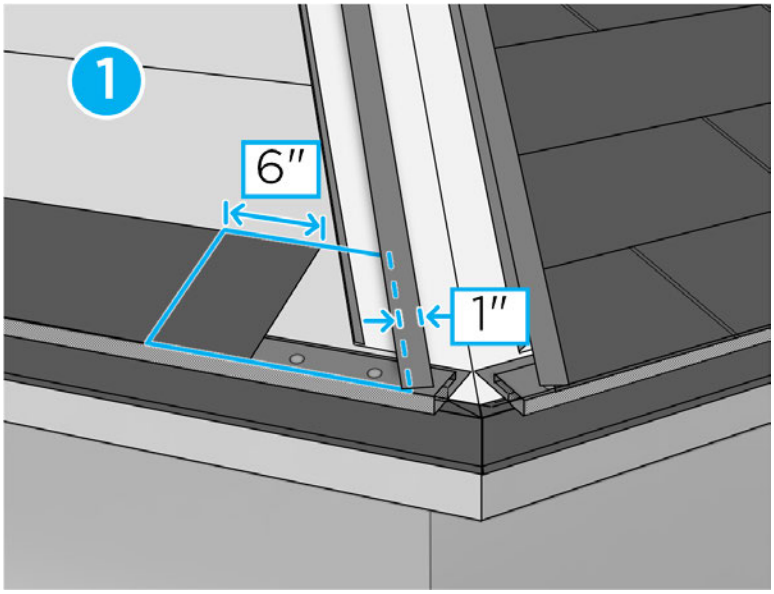
Larger Hip Dead Zones

Larger dead zones can also appear at the hip as long as the distance between a course's last tile and the channel flashing is less than 5 in. Since this is less than the allowed metal tile cutting threshold, a tile skin must be used to eliminate the dead zone.



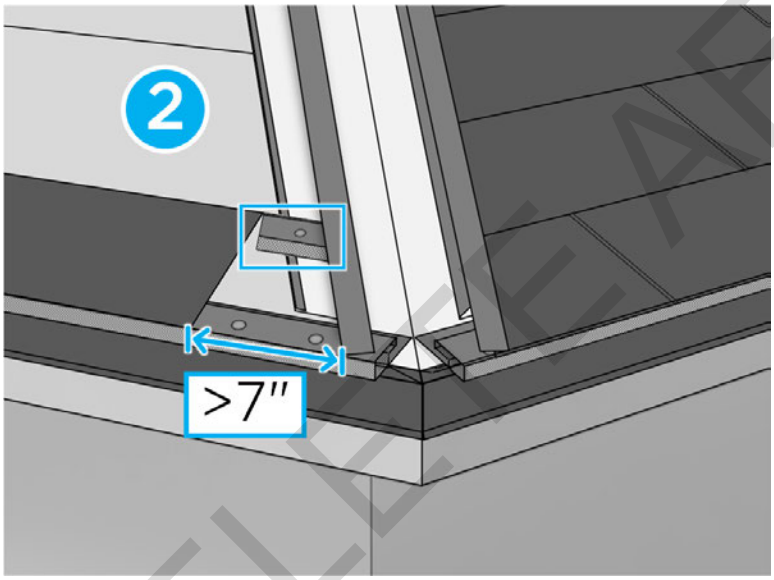
Cut the tile skin with the following parameters **(1)**:

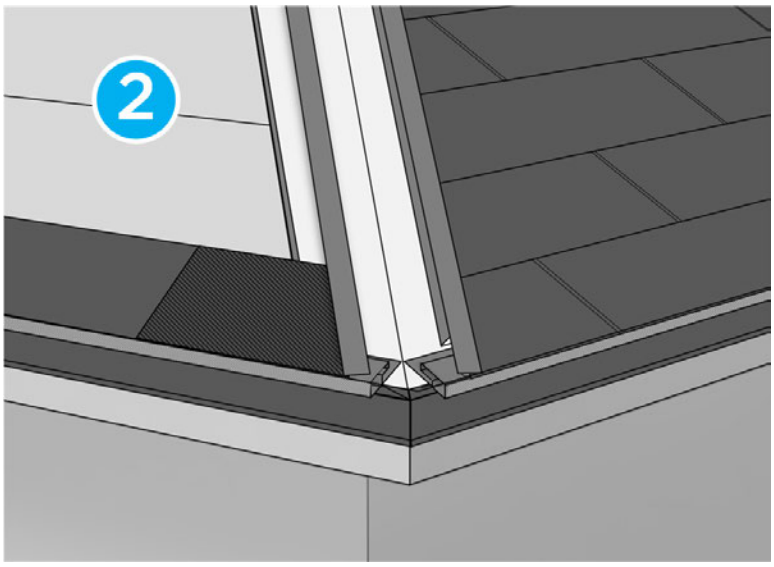
- The tile skin overlaps the uproof edge of the metal tile 6 in from the edge of the tile
- Inside of the channel flashing, there is a 1 in gap between the tile skin and the channel flashing wall (this will prevent hip cap fasteners from reaching the tile skin, which would push the tile skin down and create a gap)
- The downroof edge of the tile skin fully engages with the downroof edge of the metal tile



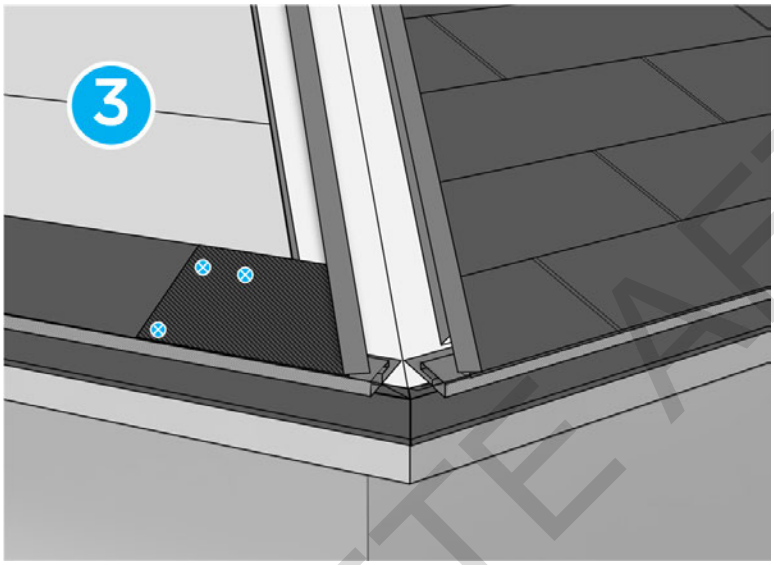
Measure the dead zone. If the dead zone measures larger than 7 in horizontally, install a piece of vented riser aligned with the tile shoulder. This riser will support the tile skin. **(2).** Proceed to install the tile skin.

PRO TIP: Keep 6 in cuts of vented riser stocked to help speed up installations and reduce bottlenecks at the cutting station.





Fasten the tile skin according to applicable wind tier in the *Fastener Schedule* **(3)**. Leave these fasteners exposed.



Cut and Trim

Overview

This section provides instructions for installing adjustable trim covers at standard valleys and rakes angled between 90 - 135°. See *Adjustable Trim Covers in the Part Inscription Identifier on page 712* for descriptions of all adjustable valley trim cover features.

Tools and Equipment

- Adjustable trim cover
- Vented riser
- Bolt cut calculator
- Measuring tape

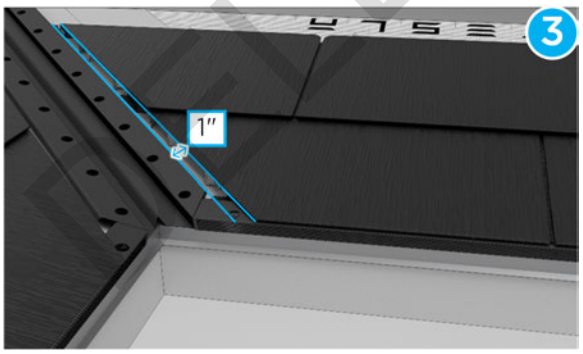
Work Instruction

Before installing the final tile of a valley course, use the Bolt cut calculator to determine whether a valley dead zone will appear. Refer to *Using the Cut Calculator in Bolt on page 721* for general guidance on accessing and using the cut calculator.

If the cut calculator calls for installing two cut tiles at the course, a valley dead zone will appear. Proceed to cut and install only one metal tile followed by a piece of vented riser aligned with the tile shoulder **(1).** Then, install an adjustable trim cover over the remaining dead zone (see steps 4 – 5).

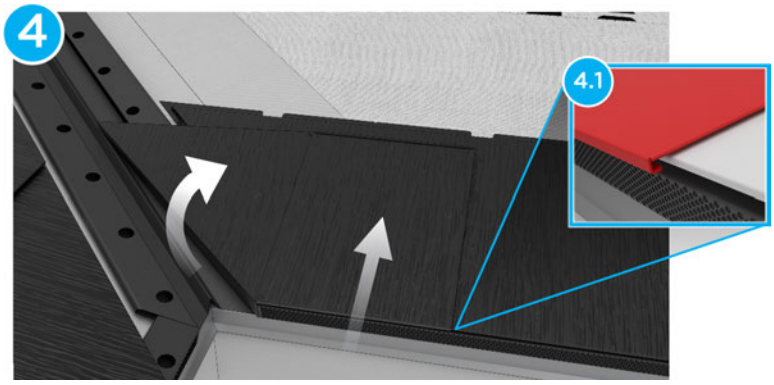
If the calculator calls for standard valley tile installation, proceed to measure and cut a metal tile at the valley riser **(2)**. Ensure there is a 1 in gap between the riser and the cut metal tile **(3)**.

NOTE: Ensure the angle does not exceed the range for the adjustable trim flashing. See the *Angle Reference Chart on page 194*.

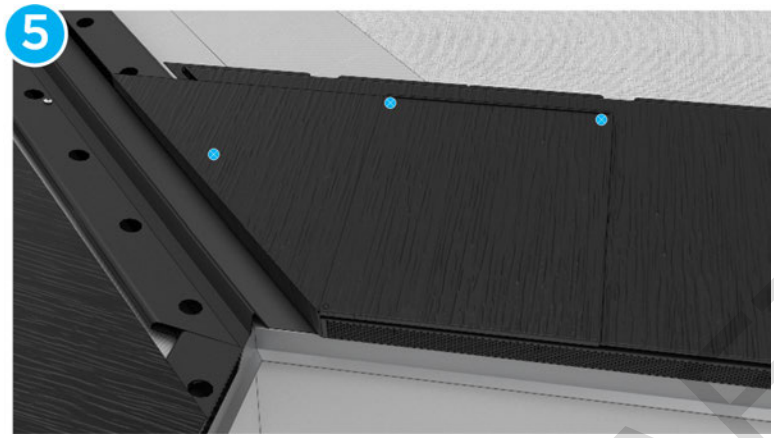


Place the adjustable flashing over the cut tile ensuring it hooks at the bottom and swing the side piece to the vertical face of the vented riser at the valley **(4)**.

Pictured: Hook engagement **(4.1)**

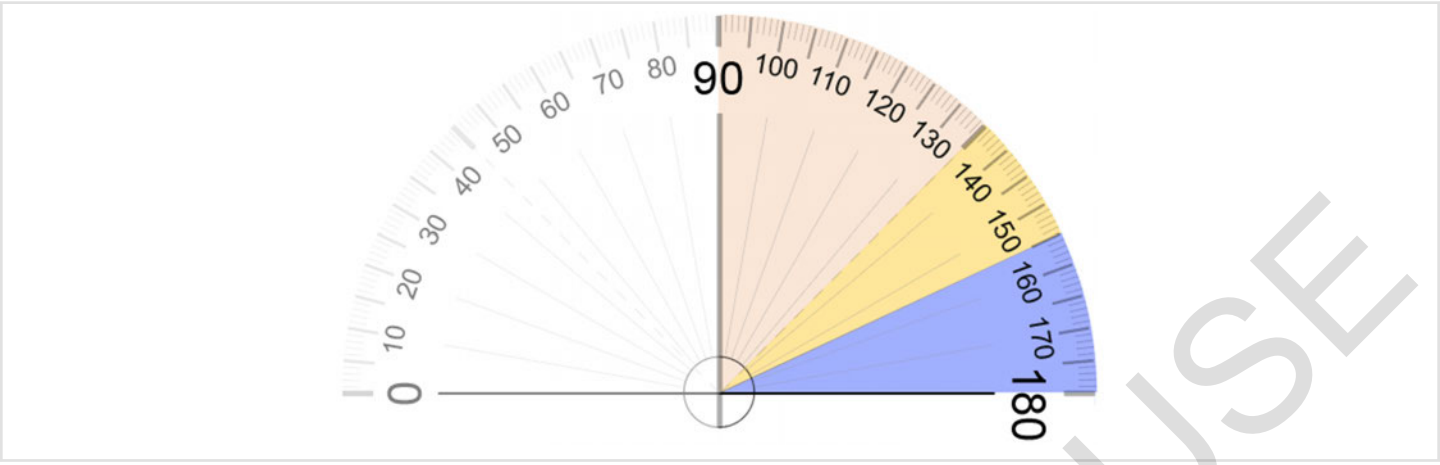


Secure the flashing to the cut metal tile and the vented riser in accordance with the applicable wind tier in the *Fastener Schedule* at the marked pilot holes **(5)**.



Angle Reference Chart

	1+ Piece Tile Skin	
	1- Piece Tile Skin	
	Adjustable Trim Cover	



On Roof Electrical Wiring

Wire Management Requirements

Cabling should comply with a bending radius of ≥ 2.36 in (60 mm) to prevent mechanical stress.

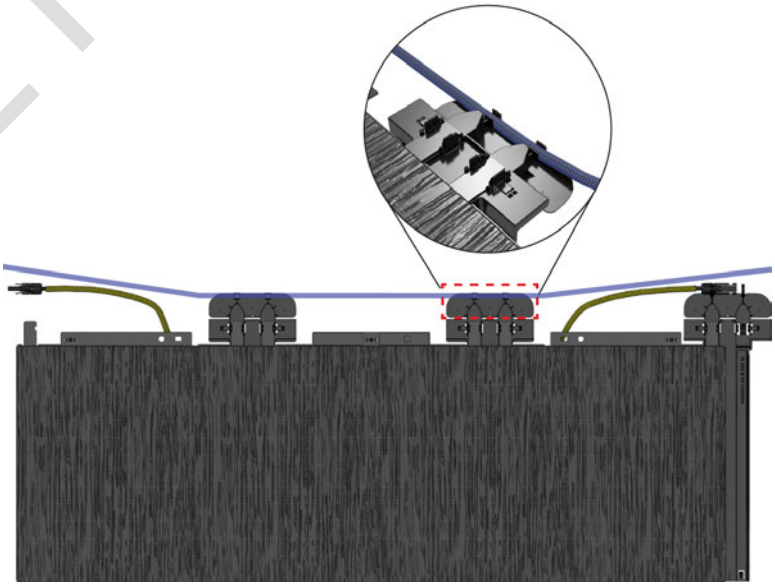
Pictured: Radius less than 2 3/8 in (60 mm) **(1)** and radius of 2 3/8 in (60 mm) **(2)**

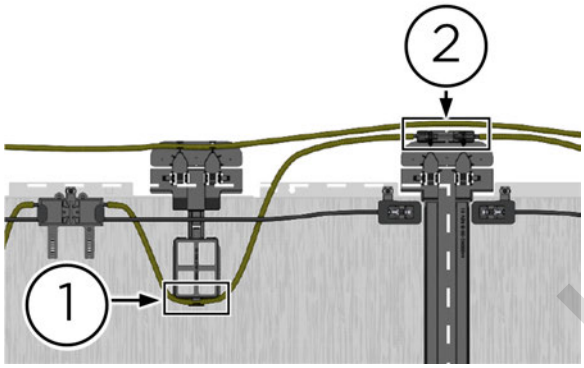
Split braided sleeves may be used to manage wires around metal flashings at transitions across hips and ridges. All sleeving that is installed underneath the tile needs to be rated to 95° C (203° F). Blue carbon sleeves or liquid-tight sleeves are not rated for Solar Roof applications and can lead to early system failures.

NOTE: Only sleeved wires / cables can sit underneath metal, all unsleeved wires must sit underneath PV Tiles.

Braided Sleeve, Split	
PUSG-17B, 171 ft	

Wire Management Hardware

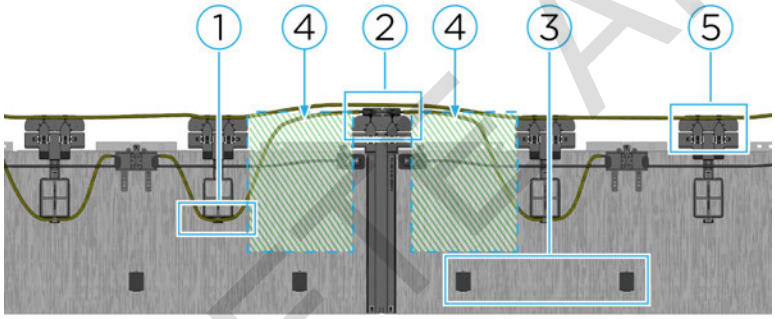
Foot Home Run / Jumper Cable Management Slots	
Description	Cable management slots that hold home run and jumper cables to the deck, preventing cables from being pinched between the tile hook and foot when another tile is installed above it.
Image	

Foot Wire Management Slots and Footlap Connector Management Slots	
Description	Wire management slots that hold PV tile wires and guide wire routing **(1)** and connector management slots that hold connectors to the deck **(2)**.
Image	

PV Tile Wire Management with Metal Tiles

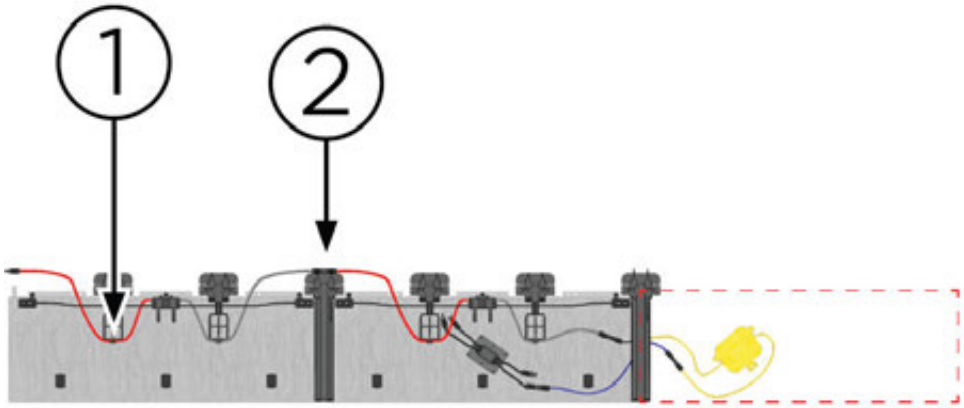
The following wire management practices are performed throughout PV tile installation:

- Wires are routed through the foot wire management slots **(1)** while home run and jumper cables are routed through the cable management slots **(5)**
- Connected leads are held to the deck by the footlap connector management slots **(2)**
- Wires and home run cables can also be routed through the dedicated clips on the PV tile hooks to route away from metal tiles **(3)**
- Excess wiring is tucked into the dedicated wire stow areas **(4)**



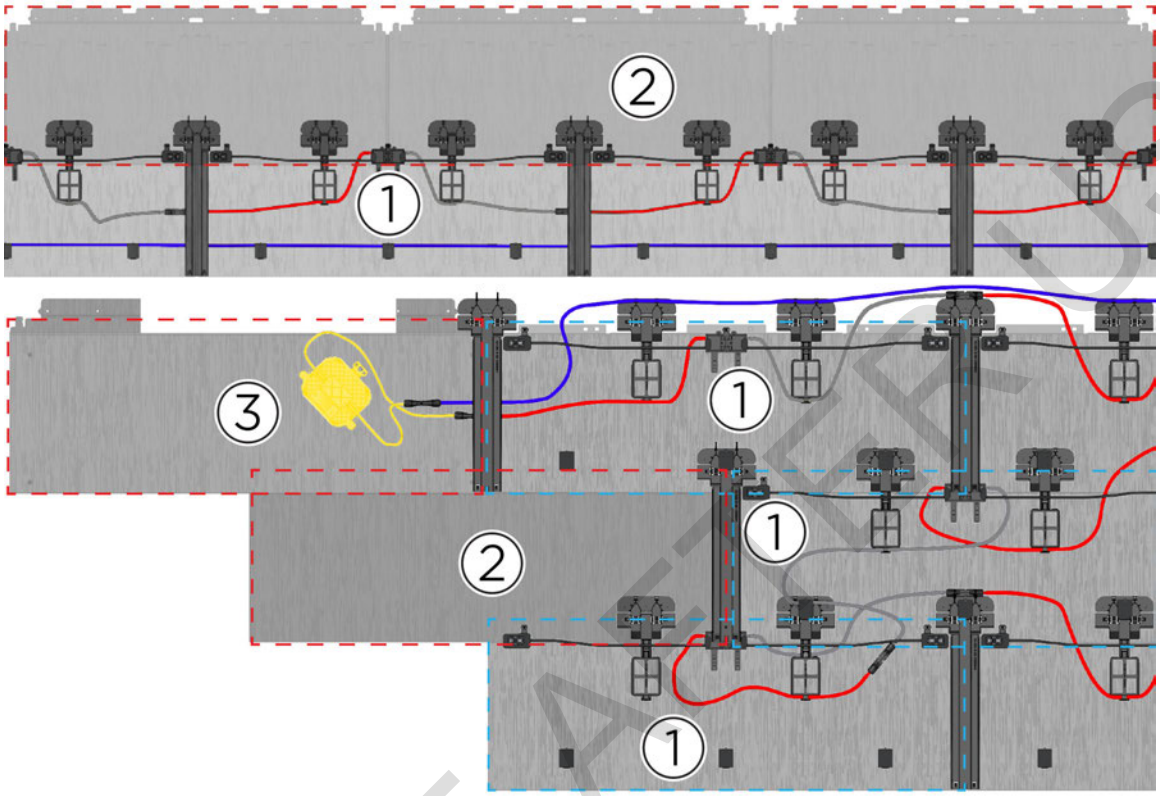
- MCIs are placed underneath "service tiles" (a combination of cut metal tiles and tile skins created to cover the MCI)

> **NOTE:** MCI-1 shown below. This also applies to MCI-2.



- Spans of PV tiles **(1)** are pre-planned such that connectors and do not land underneath metal tiles **(2)** and MCIs are placed underneath "service tiles" **(3)** (allowing for future serviceability)
- Unsleeved wires are routed away from metal tiles and through PV tiles

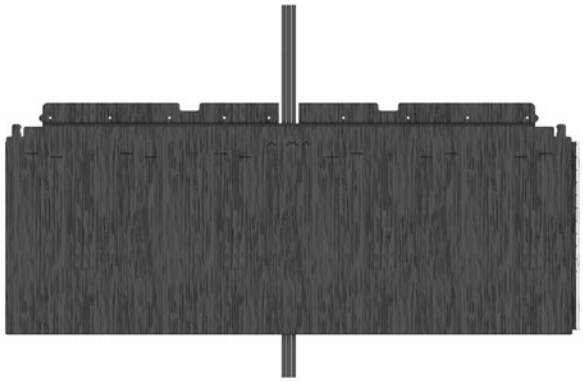
NOTE: MCI-1 shown below. This also applies to MCI-2.



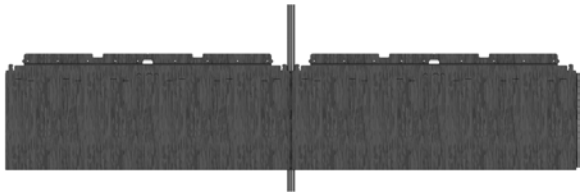
Metal Tile Cable Management

Sleeved home run and jumper cables can be routed through metal tiles in the following configurations:

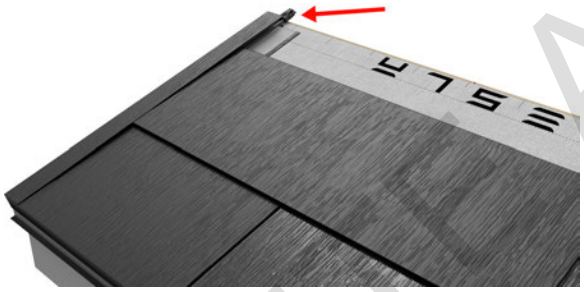
- Vertically through the middle of a metal tile after a notch is cut out of the nailing flange



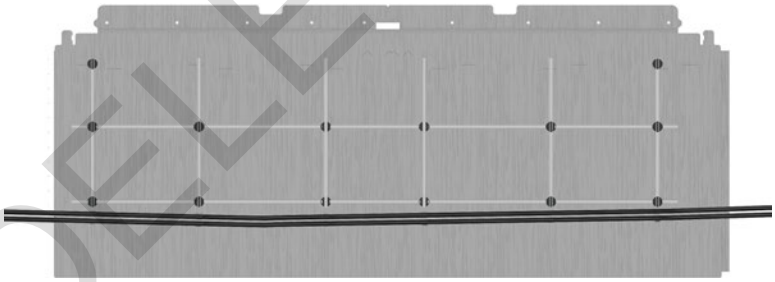
- Vertically through the water channel between adjacent metal tiles



- Vertically through channel flashing



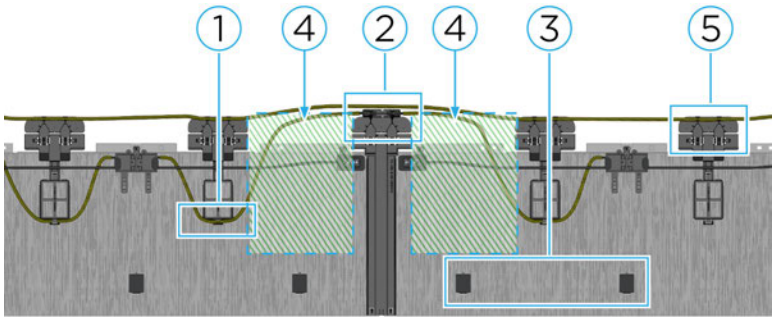
- Horizontally through the bottom channel after a raceway is cut out of the metal tile support



Side view of horizontal wiring in metal tiles:

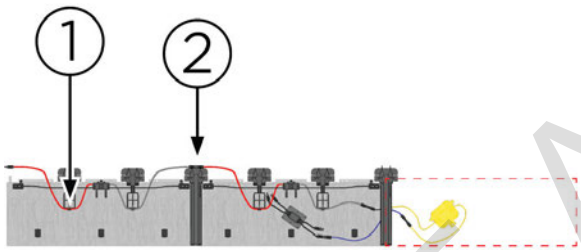
PV Tile Wire / Cable Management with Glass Tiles (HVHZ Installations)

- Wires are routed through the foot wire management slots **(1)** while home run and jumper cables are routed through the cable management slots **(5)**
- Connected leads are held to the deck by the footlap connector management slots **(2)**
- Wires and home run cables can also be routed through the clips on the PV tile hooks **(3)**
- Excess wiring is tucked into the dedicated wire stow areas **(4)**

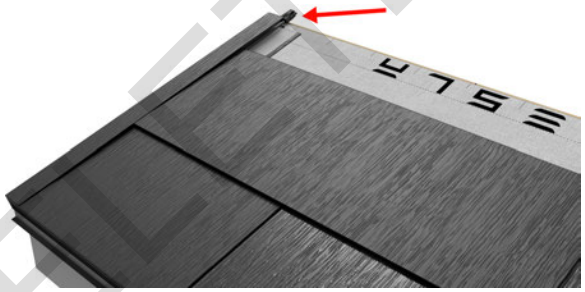


- MCI-1 is placed underneath "service tiles" (a combination of cut metal tiles and tile skins created to contain MCI-1)

> **NOTE:** MCI-1 shown below. This also applies to MCI-2.



- Home Run and Jumper cables are held to the deck by the foot / footlap cable management slots
  - Sleeved cables can be routed vertically through channel flashing



- Unsleeved wires are only routed through PV and glass tiles, never through metal

Wiring Summary

PV tiles are wired using two methods:

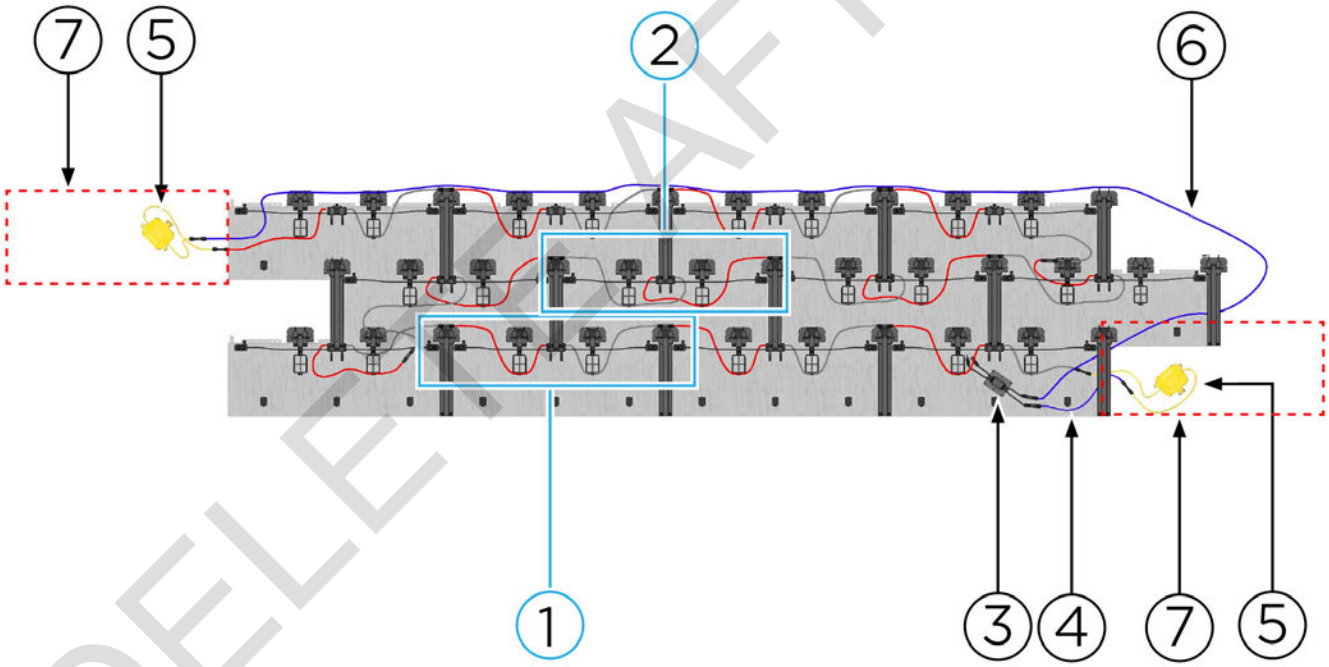
When installed with **non-crossed connections (1)**, PV tiles are linked such that the first tile of the course's positive / negative lead connects to the adjacent tile's opposing lead to form a linear, uninterrupted connection. When installed with **crossed connections (2)**, the PV tile positive and negative leads are first crossed over each other. Then, each lead is connected to the adjacent tile's opposing leads to form a non-linear, looped connection.

After a crossed connection course is completed, the remaining leads are connected with the remaining leads from the nearby non-crossed connection course, creating a closed loop.

Strings of PV tiles are completed by connecting **pass through boxes (3)** to the string via **home run cables (6)** (each pass through box can accommodate up to two strings). Branch plugs and sockets are used to make parallel connections between PV strings before entering a pass through box.

An **MCI (5)** must be connected directly to the positive and negative ends of every completed string. MCIs are also connected to pass through boxes via **jumpers (4)**. MCIs may be located adjacent to the pass through box and underneath "service tiles" composed of cut metal tiles and tile skins. However, MCIs must be connected to each individual string before strings are connected in parallel with branch plugs and sockets.

If a single series-connected string spans across two mounting planes, an additional MCI is connected to one end of the connection between mounting planes.



Where using MCI-1, a single MCI-1 may be used in each of the required locations at the ends of strings and, if applicable, between mounting planes.

Where using MCI-2, the total number of MCI-2s required in the string is dependent on the string voltage, as each individual MCI-2 has a voltage rating of 165 V but in combination (connected in the same string) their voltage ratings are additive. MCI-2s may be connected together in series at the end of the strings as needed to reach the desired string voltage rating. Two methods may be used to determine the MCI-2 count:

1. Where cold weather Voc is already calculated for each string in project design drawings, the MCI-2 count is calculated as:

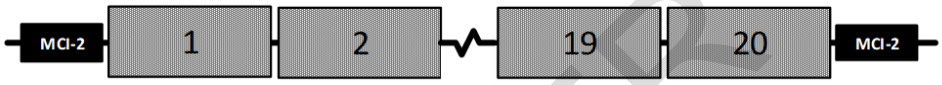
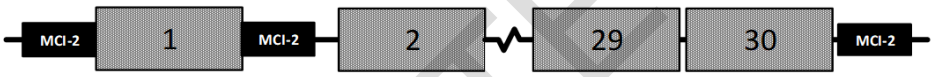
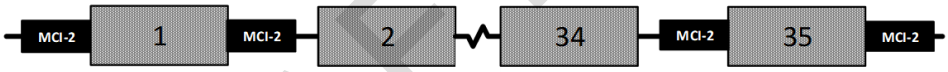
MCI-2 Count = String Voc (cold weather) / 165

(rounded up to the nearest whole number)

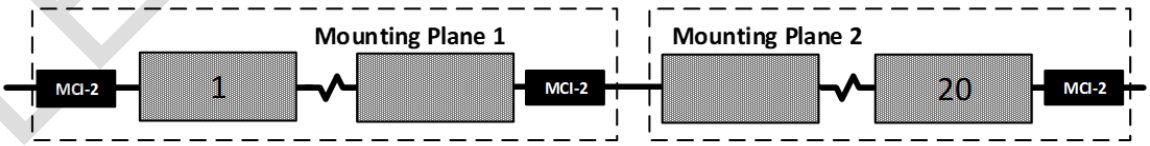
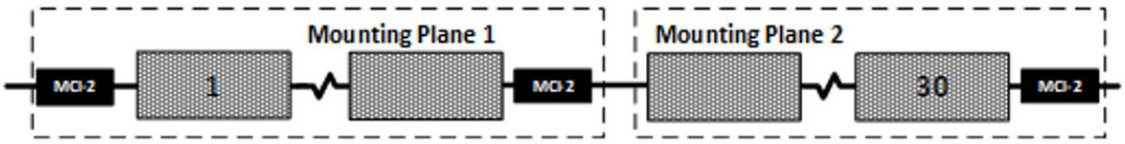
2. Using a conservative cold weather multiplier (1.15), MCI-2 counts are as follows:

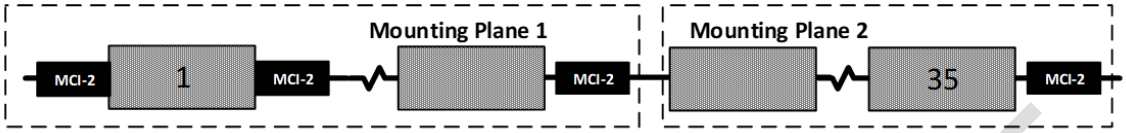
Number of Tiles in String	MCI-2 Count	Suggested Location Count
Up to 20	2	Positive end: 1, Negative end: 1
21 - 30	3	Positive end: 2, Negative end: 1
>30	4	Positive end: 2, Negative end: 2

When connecting multiple MCI-2s at the ends of the strings, connect one MCI-2 on each side of the first / last module as needed, as shown in the table below.

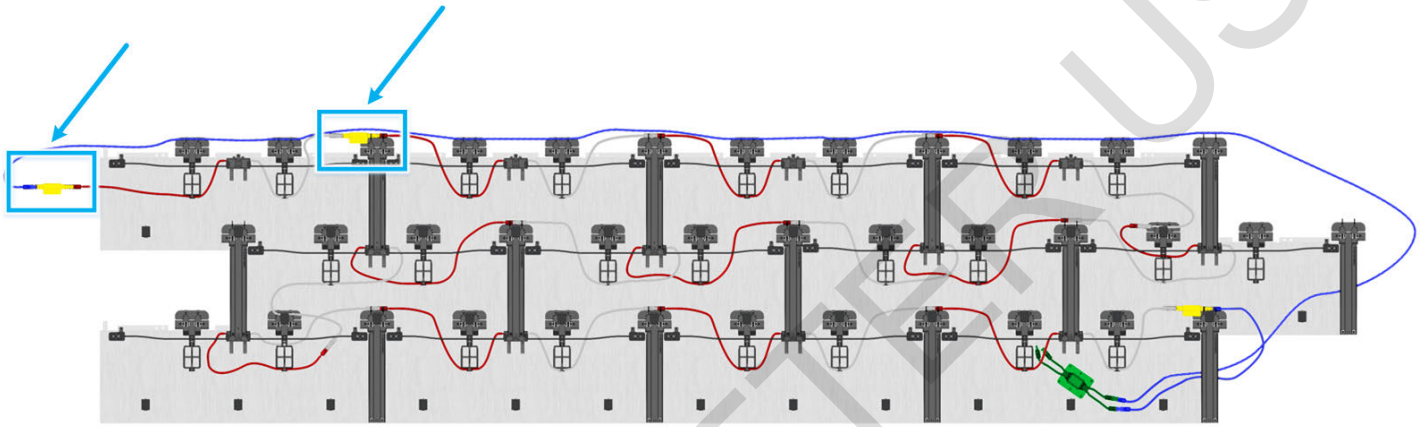
Tiles per String	Single Mounting Plane
Up to 20 **(2 MCI-2s)**	
21-30 **(3 MCI-2s)**	
> 30 **(4 MCI-2s)**	

If an MCI-2 is connected mid-string between two mounting planes, it may be counted towards the total required per string, although there still must be at least one at each end of the string.

Tiles per String	Two Mounting Planes
Up to 20 **(3 MCI-2s)**	Total MCI Count Increases from 2 to 3 
21-30 **(3 MCI-2s)**	Total MCI Count Remains 3 
> 30	Total MCI Count Remains 4

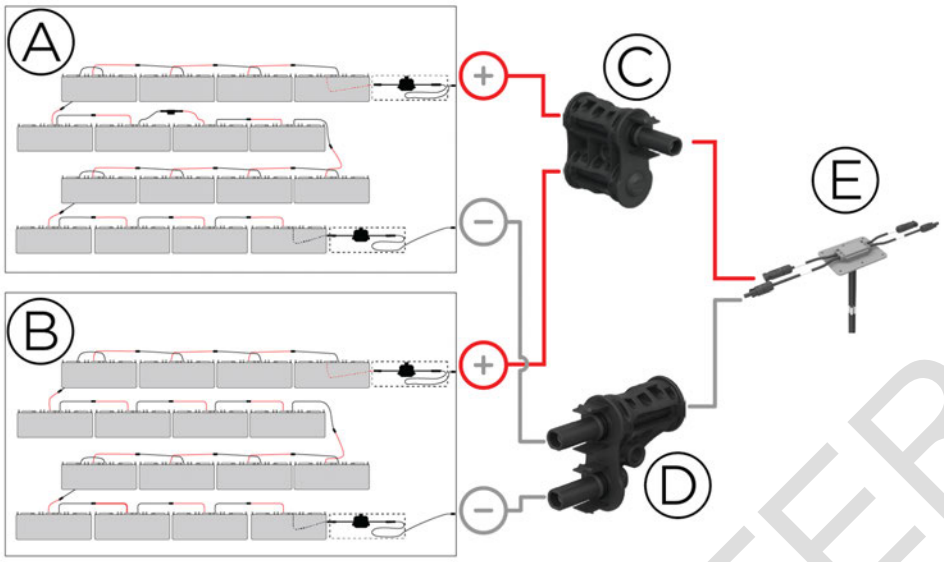
Tiles per String	Two Mounting Planes
(4 MCI-2s)	

The figure below shows an example of MCI-2s connected on each side of the first module to achieve the desired MCI-2 count.



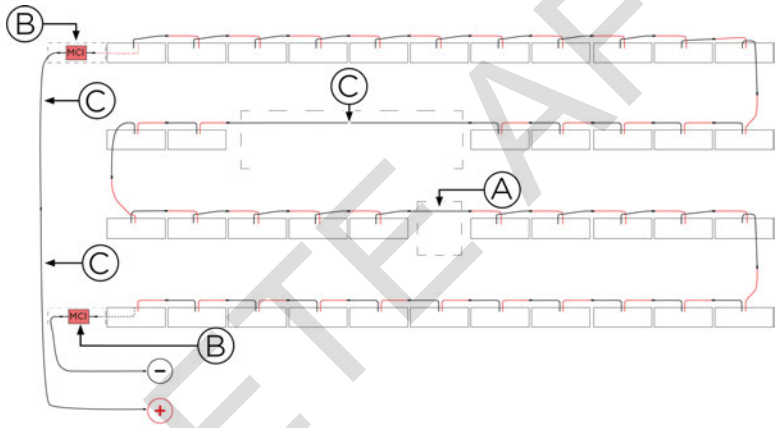
Stringing Example Layouts

Example Layout 1



Legend
(A): Array1
(B): Array 2
(C): Branch Plug
(D): Branch Socket
(E): Pass Through Box

Example Layout 2



Legend	
(A): 1x Jumper	
(B): 3x Jumper	
(C): 5x Jumper	
	Obstruction

Underlayment and Drip Metal

Overview

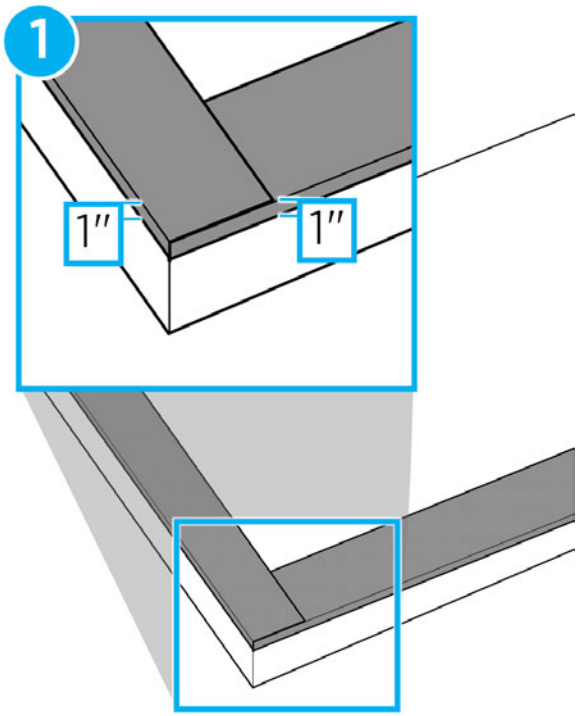
This section outlines the standard underlayment and drip edge metal installation procedure.

Tools and Equipment

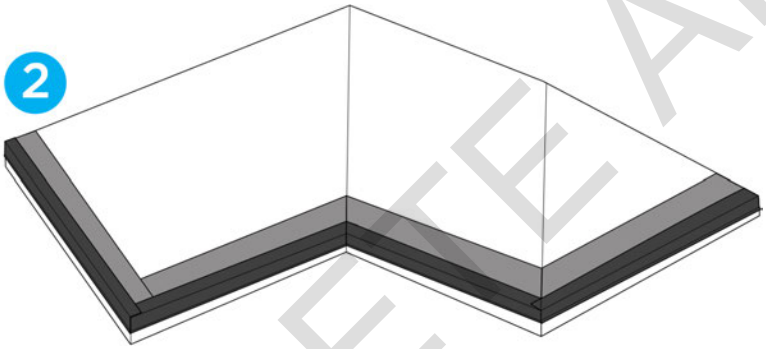
- Roller
- Underlayment
- Detail roll
- Drip edge
- Fasteners

Work Instruction

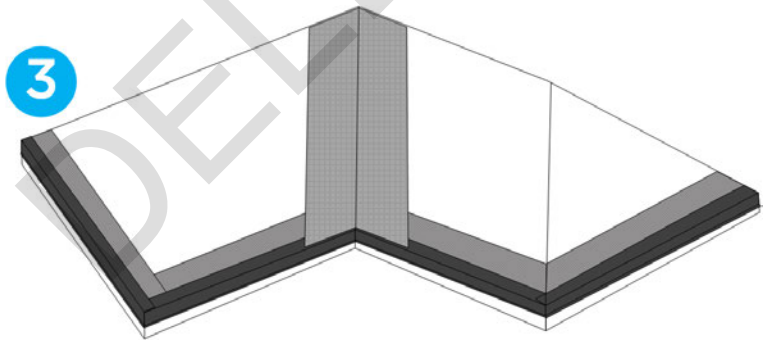
Apply detail roll along eaves and rakes, lapping 1-inch over the fascia **(1)**.



Install drip edge along eaves and rakes. Splice the drip edge and create aesthetic corners as needed **(2)**. Fasten according to the applicable wind tier in the *Fastener Schedule*.



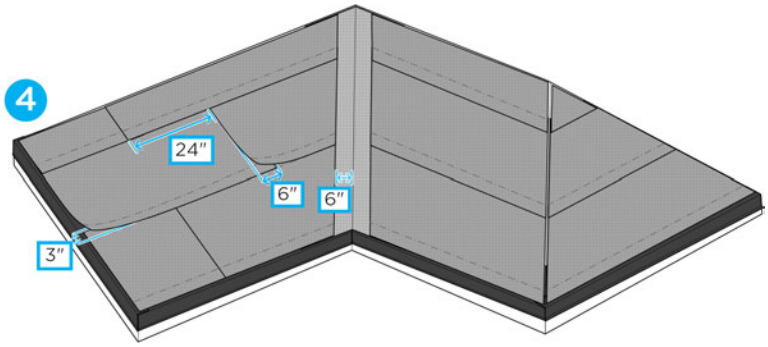
Install a full width sheet of underlayment centered in the valleys **(3)**.



Install courses of underlayment following all lapping requirements **(4)**:

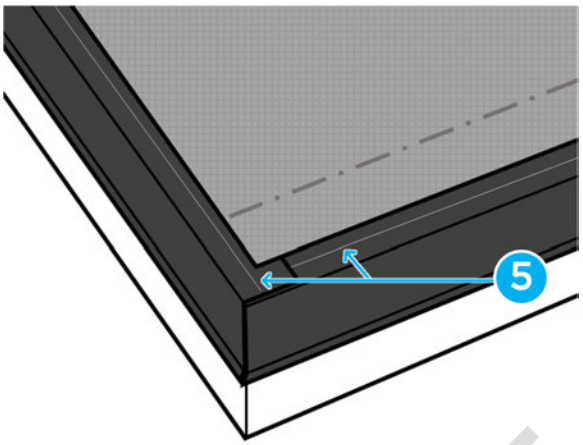
- 6-inch offset from valley centers
- 3-inch minimum side laps
- 6-inch minimum end laps

- 24-inch minimum spacing between end laps



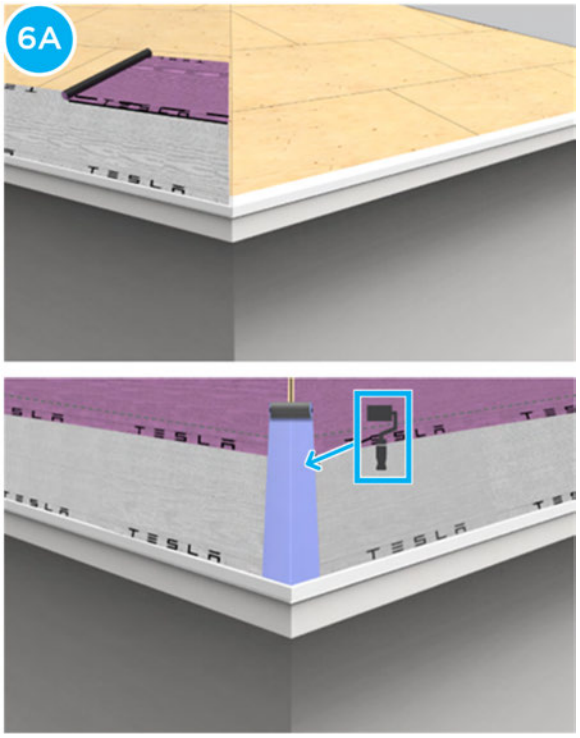
Along eaves and rakes edges, lap underlayment 2-to-3-inches on to the drip edge. Ensure that the drip edge fasteners are concealed. Do NOT install underlayment beyond the 1-inch score marks on the drip edge.

Pictured: Score mark **(5)**.

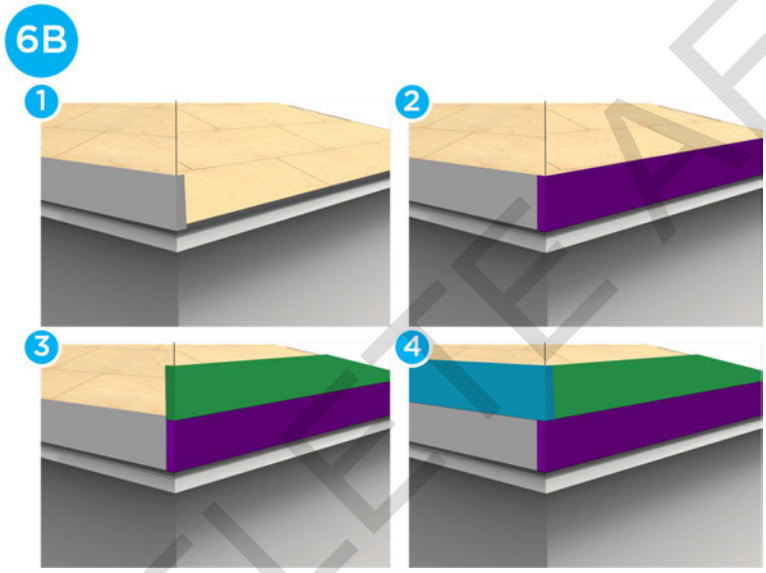


Install underlayment at hips following either method below (**6A** or**6B**):

6A: Cut courses of underlayment within 2-inches of the hip, then cap the hip with the detail roll.



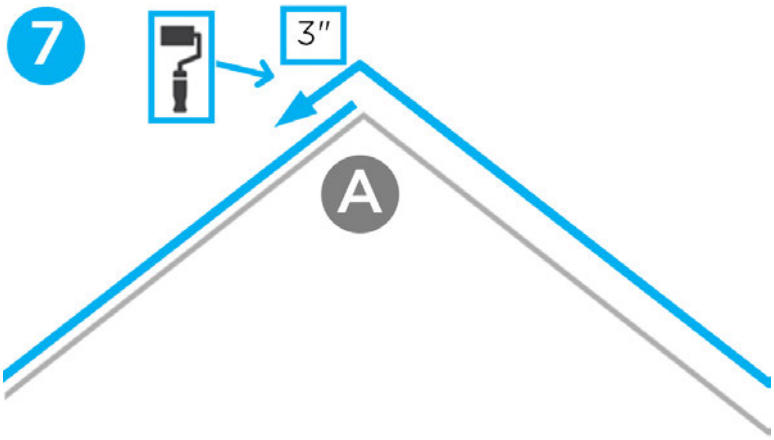
6B: Weave courses of underlayment over hips. Underlayment courses must lap a minimum of 3-inches over the hip.



At ridges, lap underlayment a minimum of 3-inches over the ridge **(7)**.

NOTE: If the ridge is vented, underlayment will need to be cut back from the vented areas before installing ridge rolls and caps.

***Pictured*:** Ridge **(A)**



Chalk Lines for Perimeter Metal

Overview

This section provides instructions for establishing chalk lines.

Tools & Equipment

- Robin jig
- Chalk line
- Tape measure

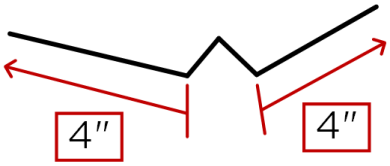
Establishing Chalk Lines

Perimeter metal chalk lines are offset 4 inches from eaves, rakes, valleys. At hips, use the *robin jig on page 603* to position chalk lines.

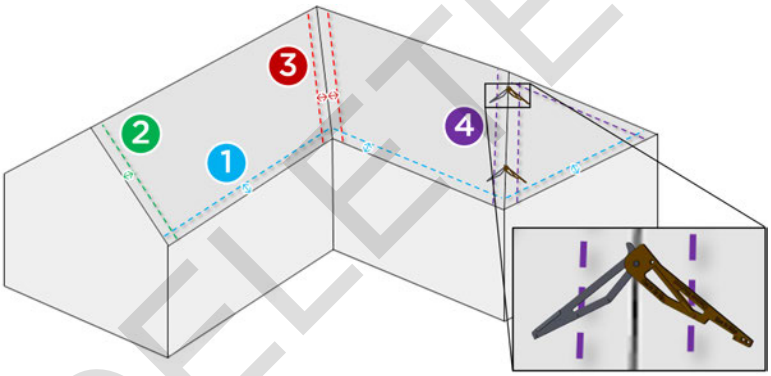
At **eaves**, snap a chalk line along the entire length of the eave 4 inches from the eave edge **(1)**.

At **rakes**, snap a chalk line along the entire length of the rake 4 inches from the rake edge **(2)**.

At **valleys**, snap a chalk line 4 inches from bottom edge of the valley pan's apex along the entire length of the valley **(3)**.



At **hips**, establish chalk lines using the channel flashing alignment marks on the *robin jig on page 603* **(4)**.



Adjusting Chalk Lines for Vented Riser Installation

After snapping chalk lines at eaves, evaluate the squareness of the eave. Check that vented risers will land within the allowable overhang when aligned with the chalk line.

If a 4 in chalk line does not meet tolerance, adjust accordingly up or down roof in order to make the actual line of the eave and edge of the riser fall within the tolerance range.

- **Allowable range vented riser:** ¾ in – ½ in

NOTE: Rules of riser adjustability: Do not overhang the eave further than ½ in to avoid sending water over the gutters. Do not adjust riser up-roof to the point of exposed underlayment.

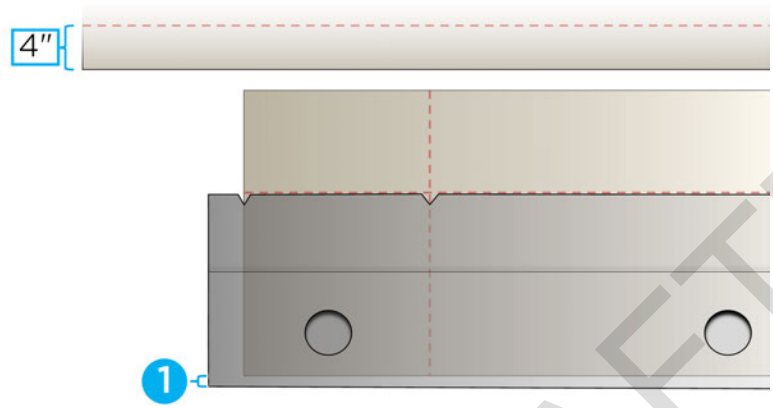
NOTE: Be cautious when installing drip edge to ensure that no exposed fasteners will be within 1 in of the turn down.

NOTE: When installing underlayment, do not encroach on the 1 in area.

In rare cases where a 4 in chalk line means the riser will not land within the allowable overhang, snap a new line for the riser along the entire edge at a distance that will satisfy these rules.

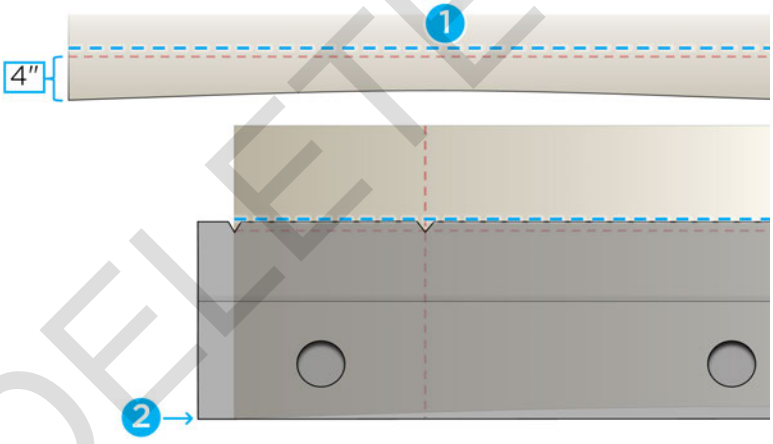
- **Eave is square** – No adjustments needed.

  Pictured: ¼ in - default overhang **(1)**.



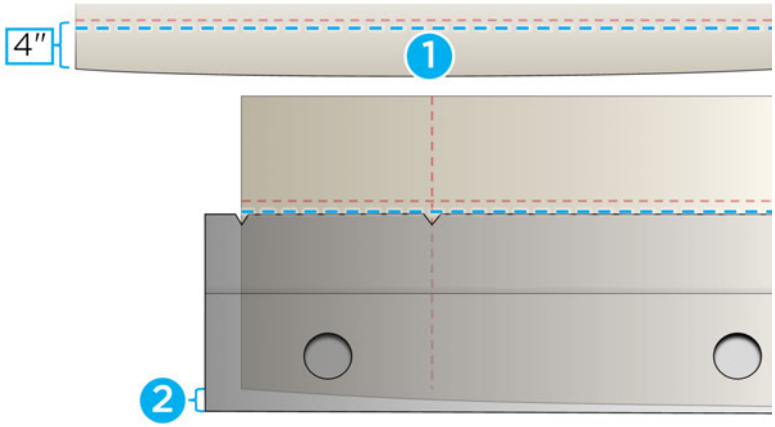
- **Eave bows up** – Adjust chalk line up if overhang is more than ½ in at any point along the eave.

  Pictured: Establish new chalk line up roof **(1)**, 0 in - minimum overhang **(2)**.



- **Eave bows down** – Adjust chalk line down if overhang is more than ½ in at any point along the eave.

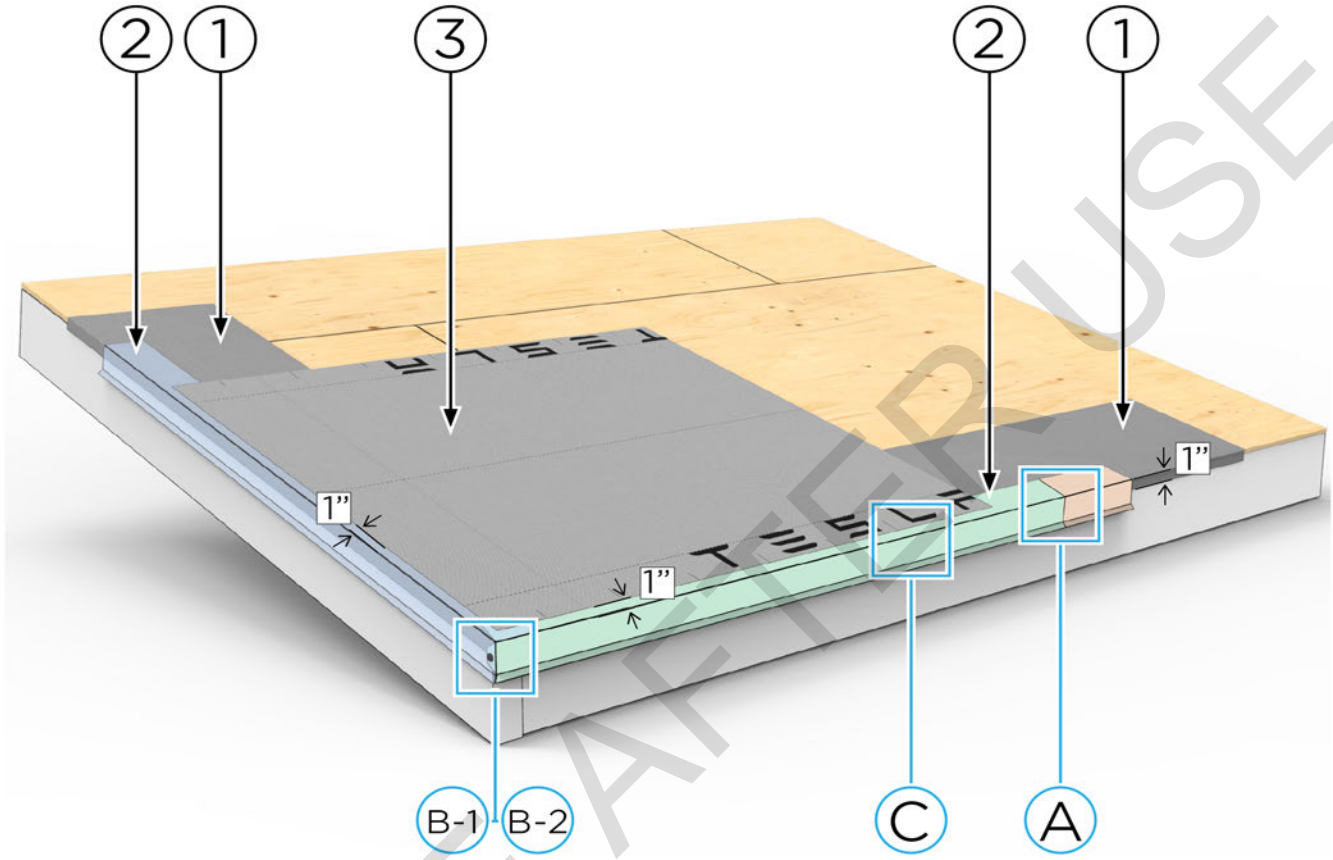
  Pictured: Establish new chalk line down roof **(1)**, 5/8 in - maximum overhang **(2)**.



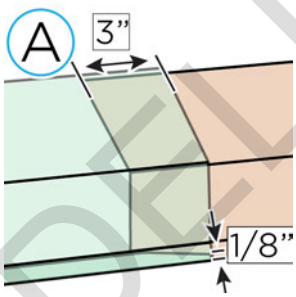
Overview of Common Edges

Eaves and Rakes

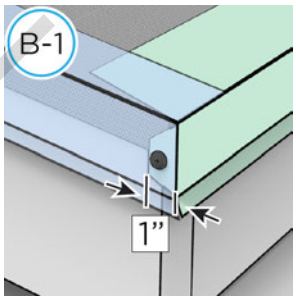
Dry In



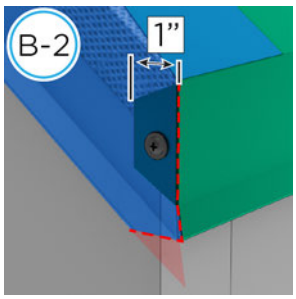
1	Detail Roll
2	Drip Edge
3	Underlayment



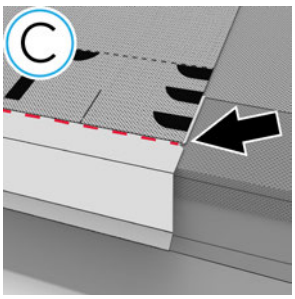
Create a drip edge splice by opening one side of the closed hem at the bottom. Make a relief cut 1/8 in from the bottom edge 3 in away.



For planes up to 6:12 pitch, cut a 1 in tab into the eave drip at the corner. Miter the drip edge of the rake and eave metal and fasten together with a self-tapping screw through the tab.

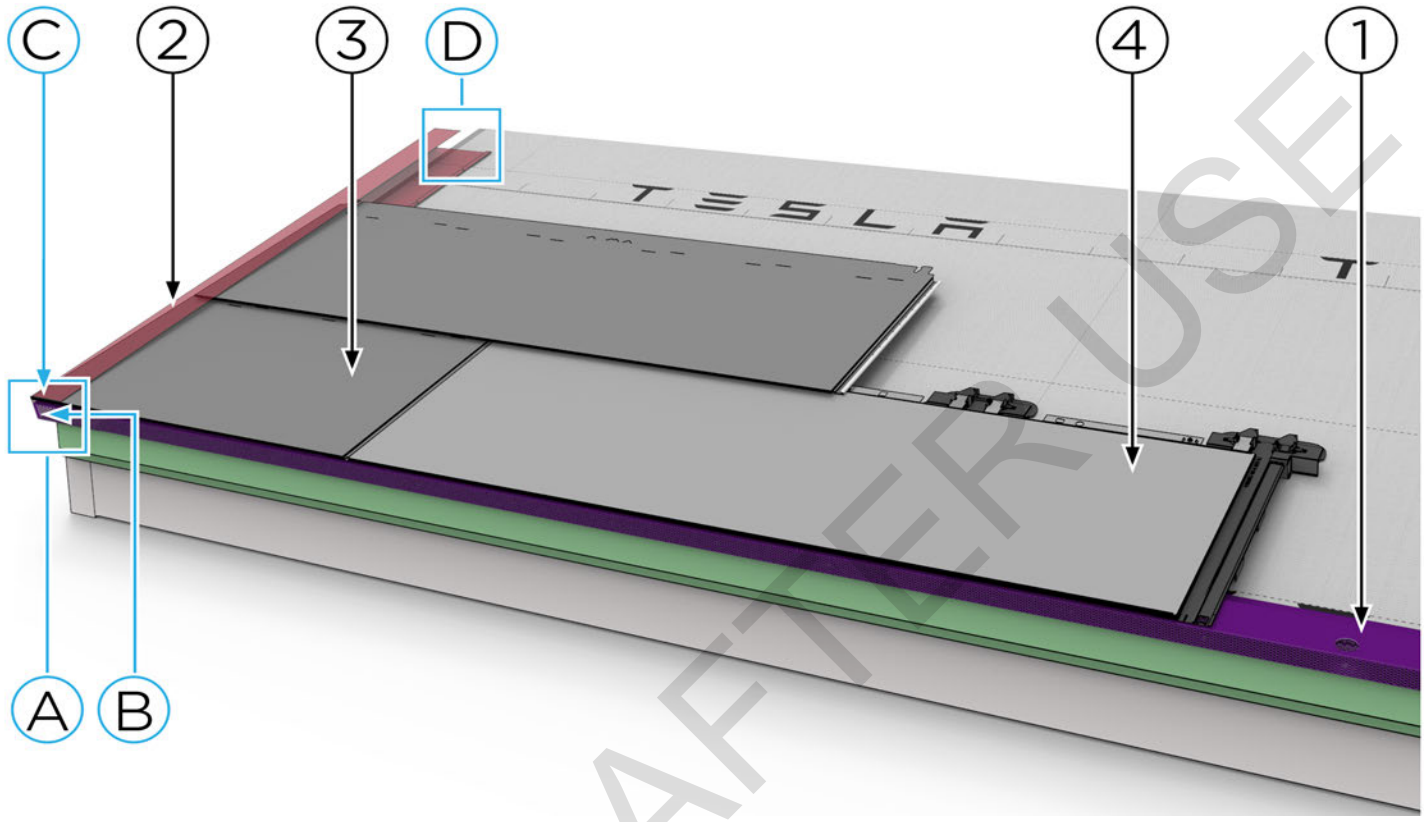


For planes at 7:12 pitch or above, an extra cut will be required on the rake drip edge to neatly mate the corner pieces.

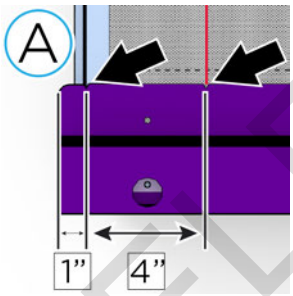
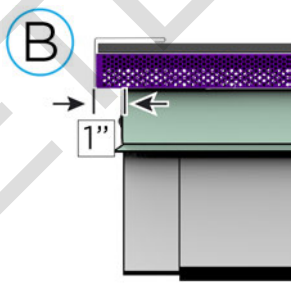
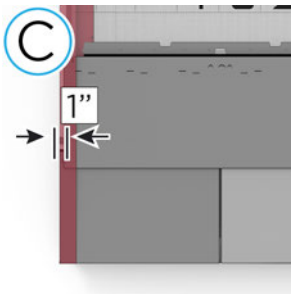
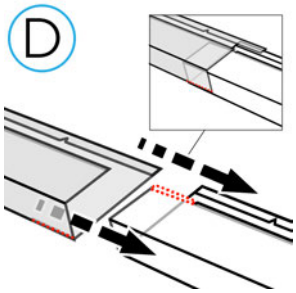


Utilize the notch on the side of the drip edge to guide underlayment placement. Align the underlayment edge with the notch (subsequent courses will align with each other).

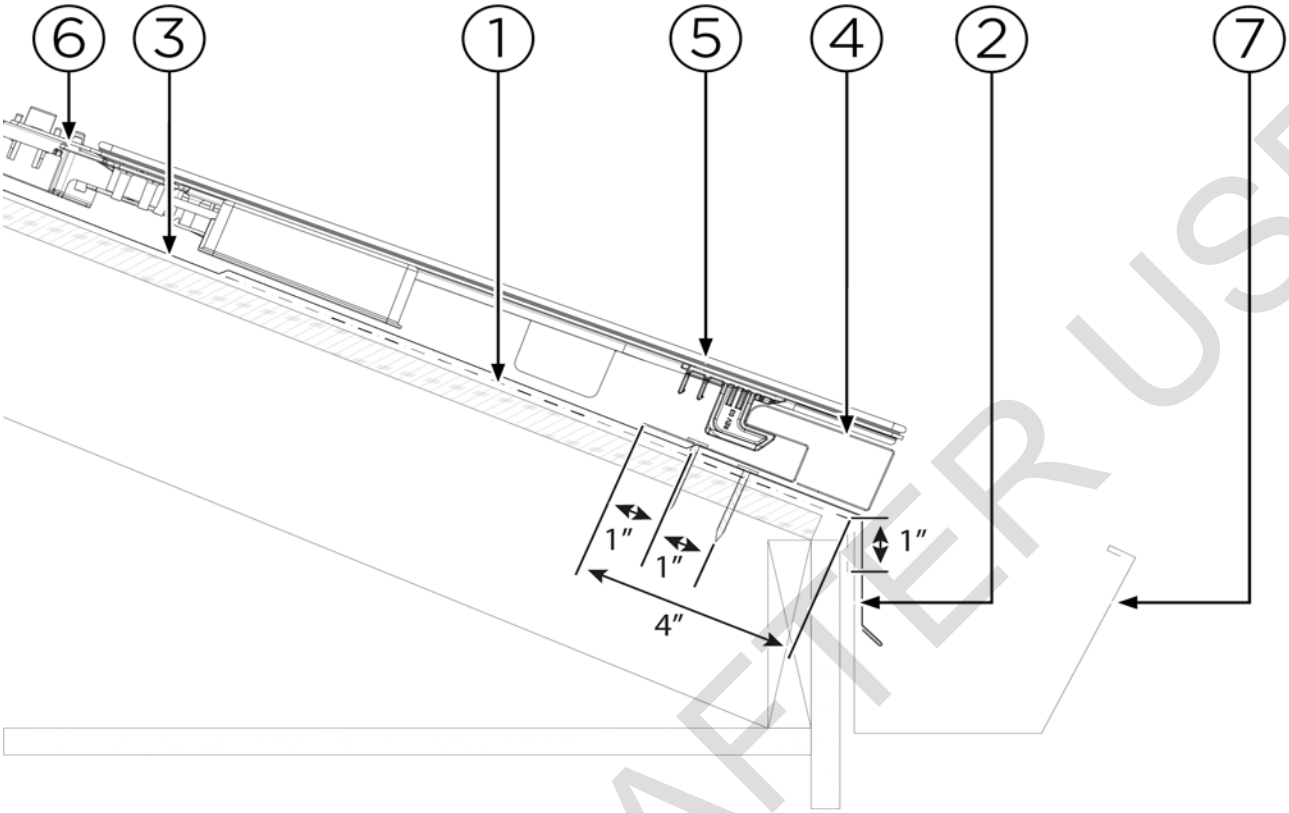
Tile Install



1	Vented Riser	**2**	Channel Flashing
3	Metal Tile	**4**	PV Tile

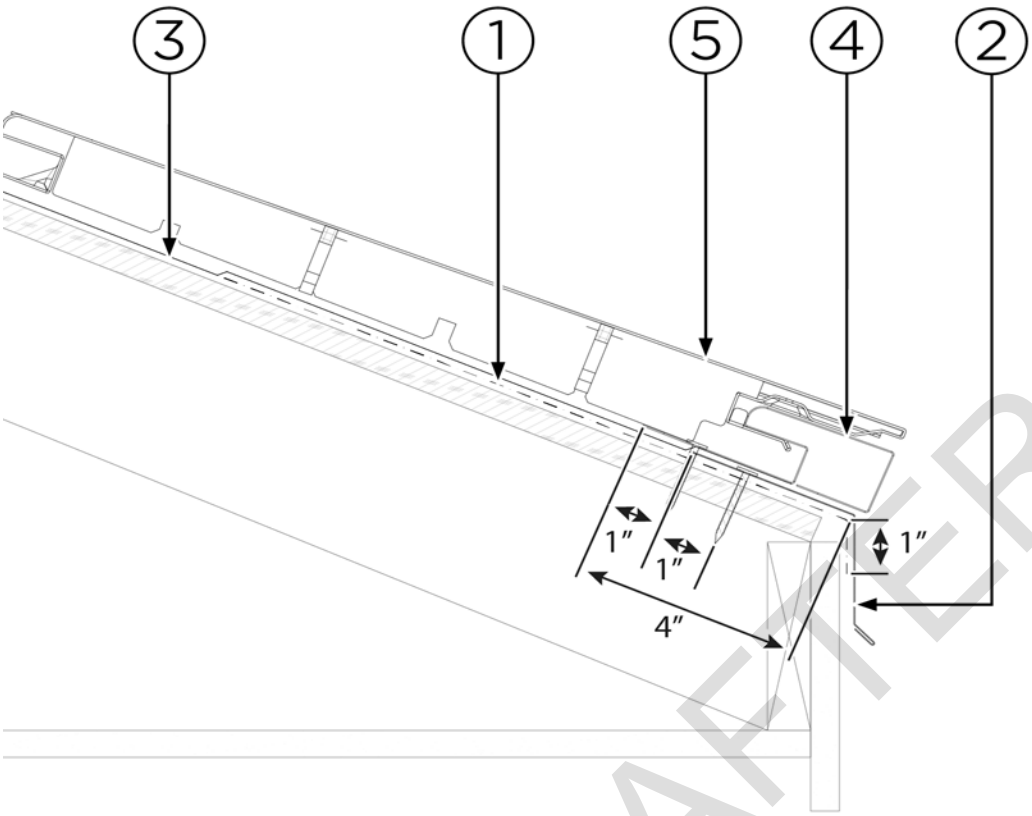
			
Align the notch on the top of the vented riser to the rake edge. The inner 4 in notch is used for the rake chalk line.	The vented riser and metal tile close any gaps at the channel flashing.	The first tile at the eave and rake adds 1 in to the cut metal tile to close the gaps at the channel flashing.	Splice channel flashing together by cutting off 2 in of the top hem on the down-roof piece and cutting a 2 in relief into the bottom corner of the up-roof piece.

Cross Section: PV Tile at Eave Starter (Gutter)



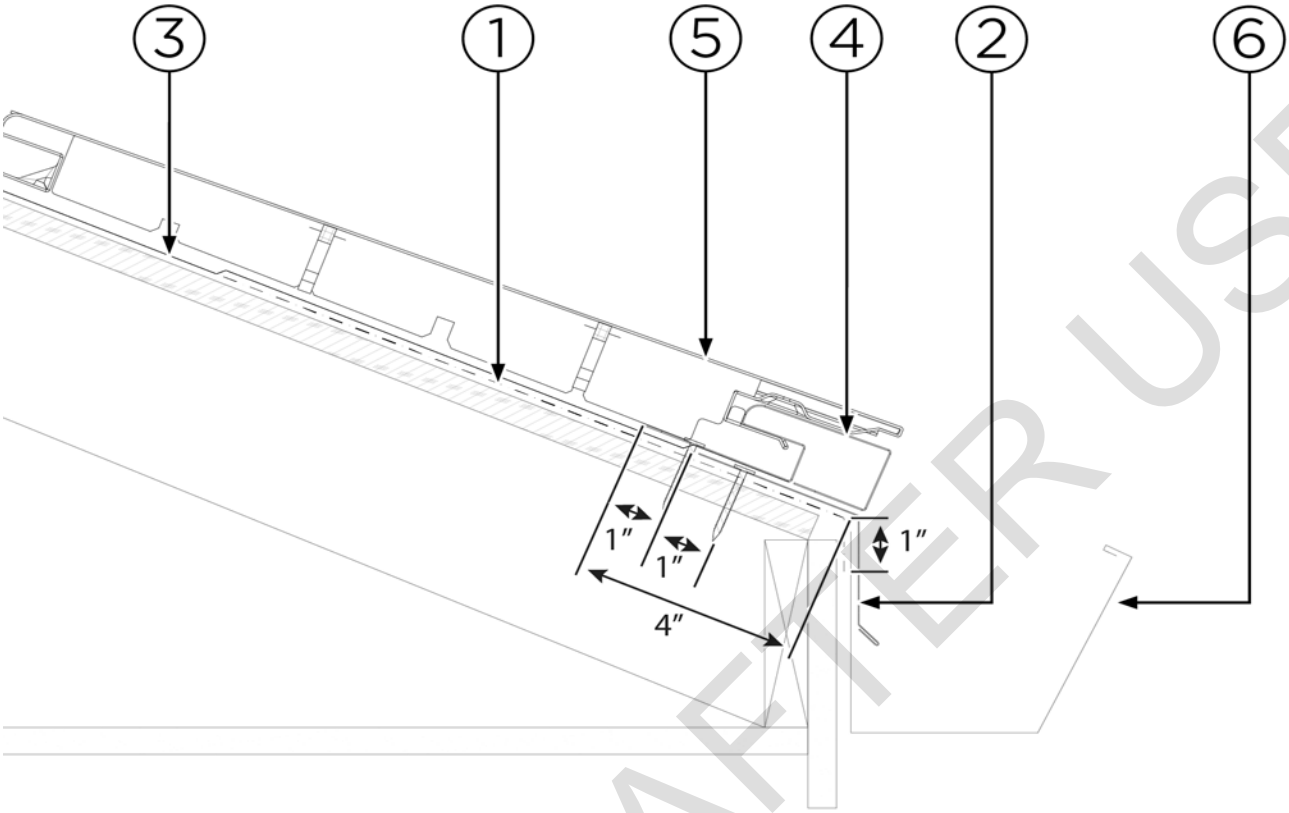
1	Detail Roll
2	Drip Edge
3	Underlayment
4	Vented Riser
5	PV Tile
6	Footlap
7	Gutter

Cross Section: Metal Tile at Eave Starter (No Gutter)



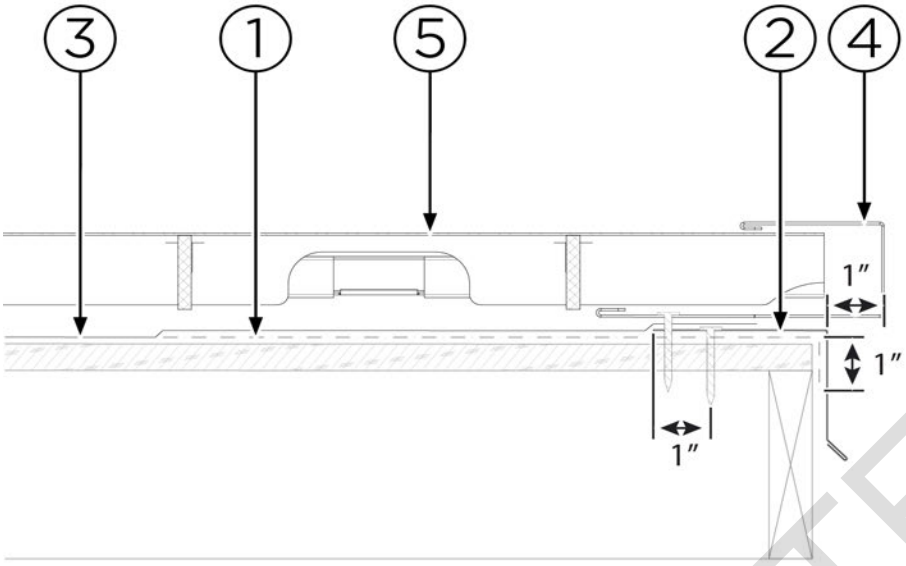
1	Detail Roll
2	Drip Edge
3	Underlayment
4	Vented Riser
5	Metal Tile

Cross Section: Metal Tile at Eave Starter (Gutter)



1	Detail Roll
2	Drip Edge
3	Underlayment
4	Vented Riser
5	Metal Tile
6	Gutter

Cross Section: Metal Tile at Rake Edge

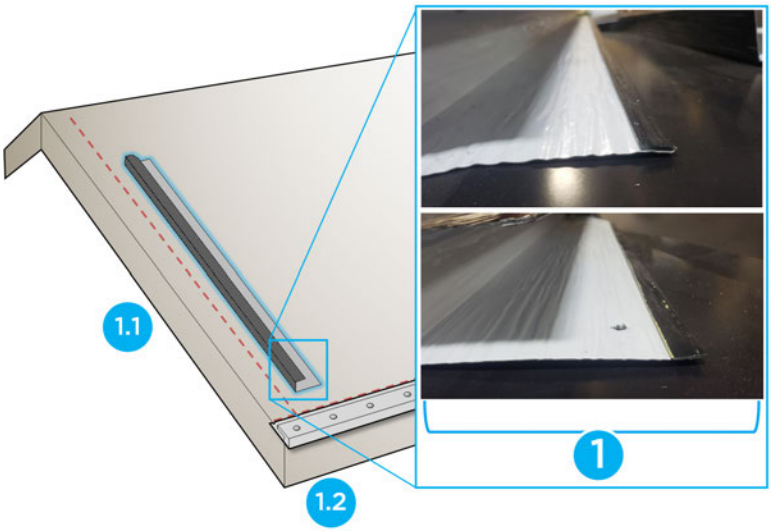


1	Detail Roll
2	Drip Edge
3	Underlayment
4	Channel Flashing
5	Metal Tile

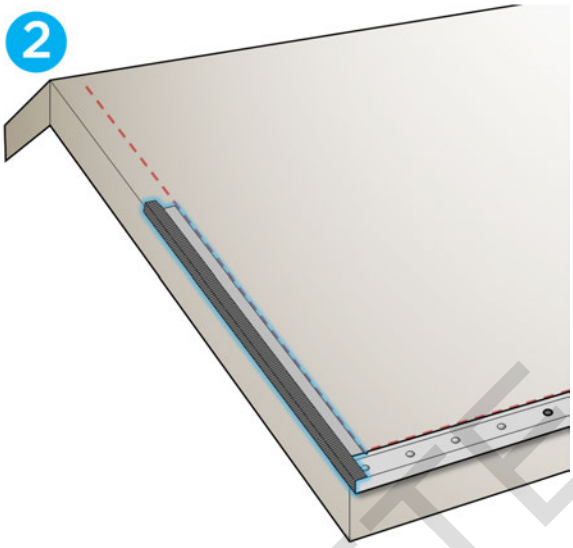
Rake Edge Installation

Flatten the hem on the bottom flange for the first 4 in so that the channel flashing can slide under the vented riser at the eave **(1)**.

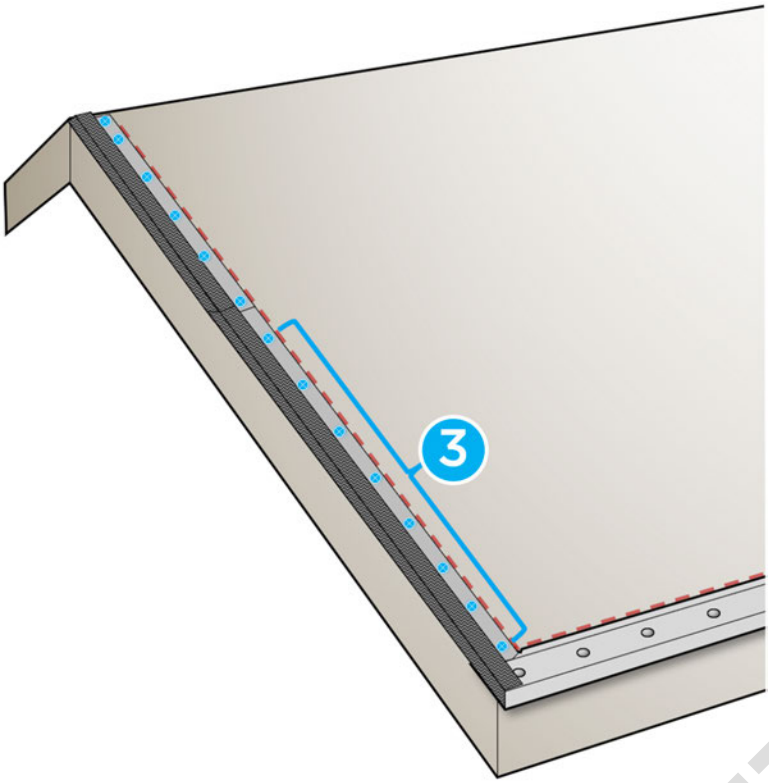
Pictured: Rake **(1.1)**, Eave **(1.2)**



Align the channel flashing's flange with the 4 in chalk line along the rake. Ensure the bottom edge of the channel flashing aligns with the front edge of the vented riser installed along the eave **(2)**.

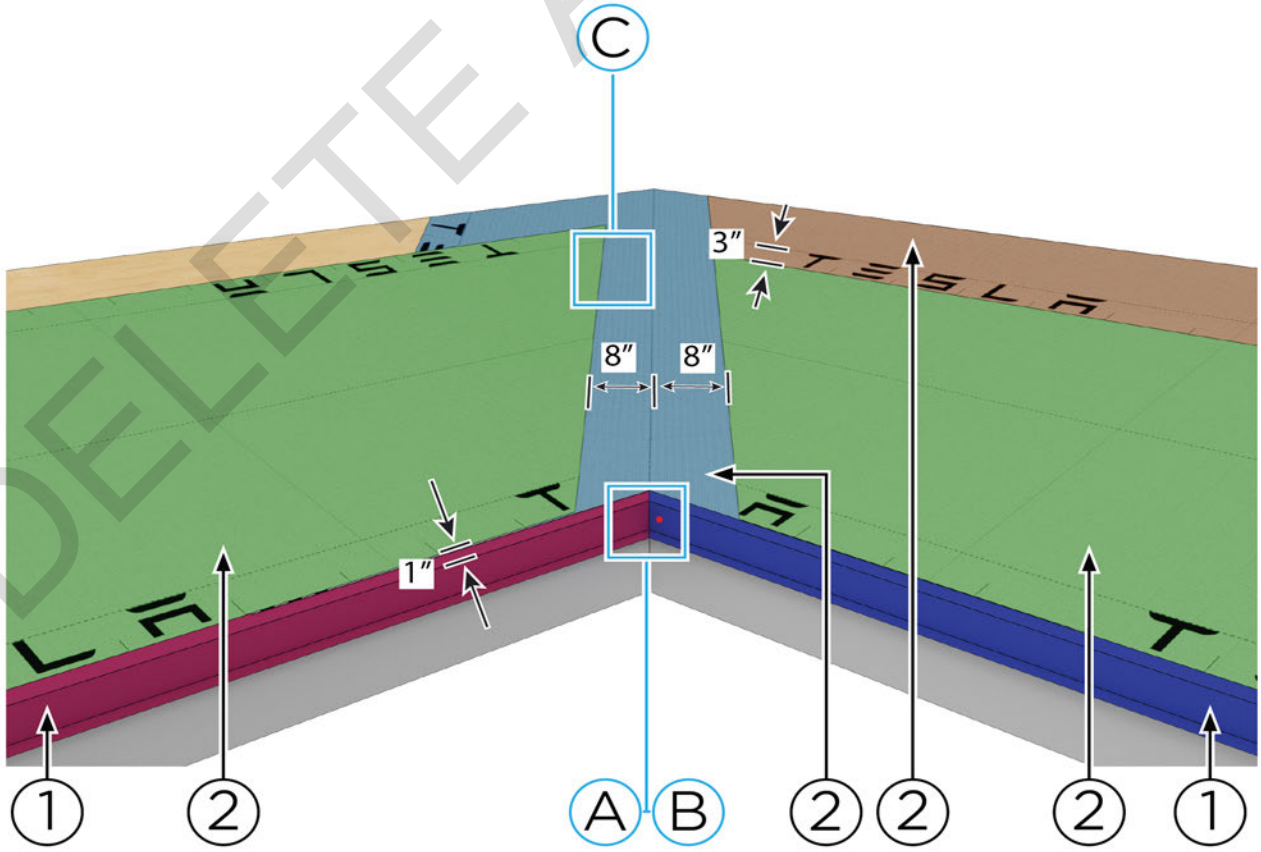


Secure the channel flashing in place per the applicable wind tier in the *Fastener Schedule on page 703* **(3)**.

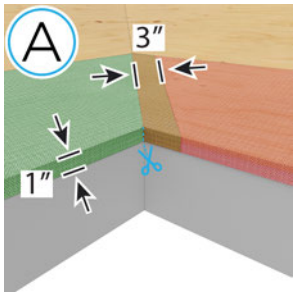
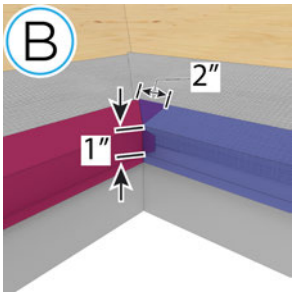
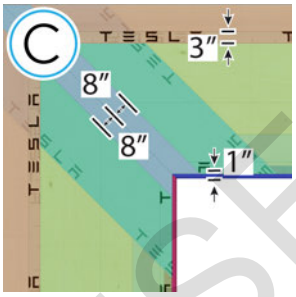


Valleys

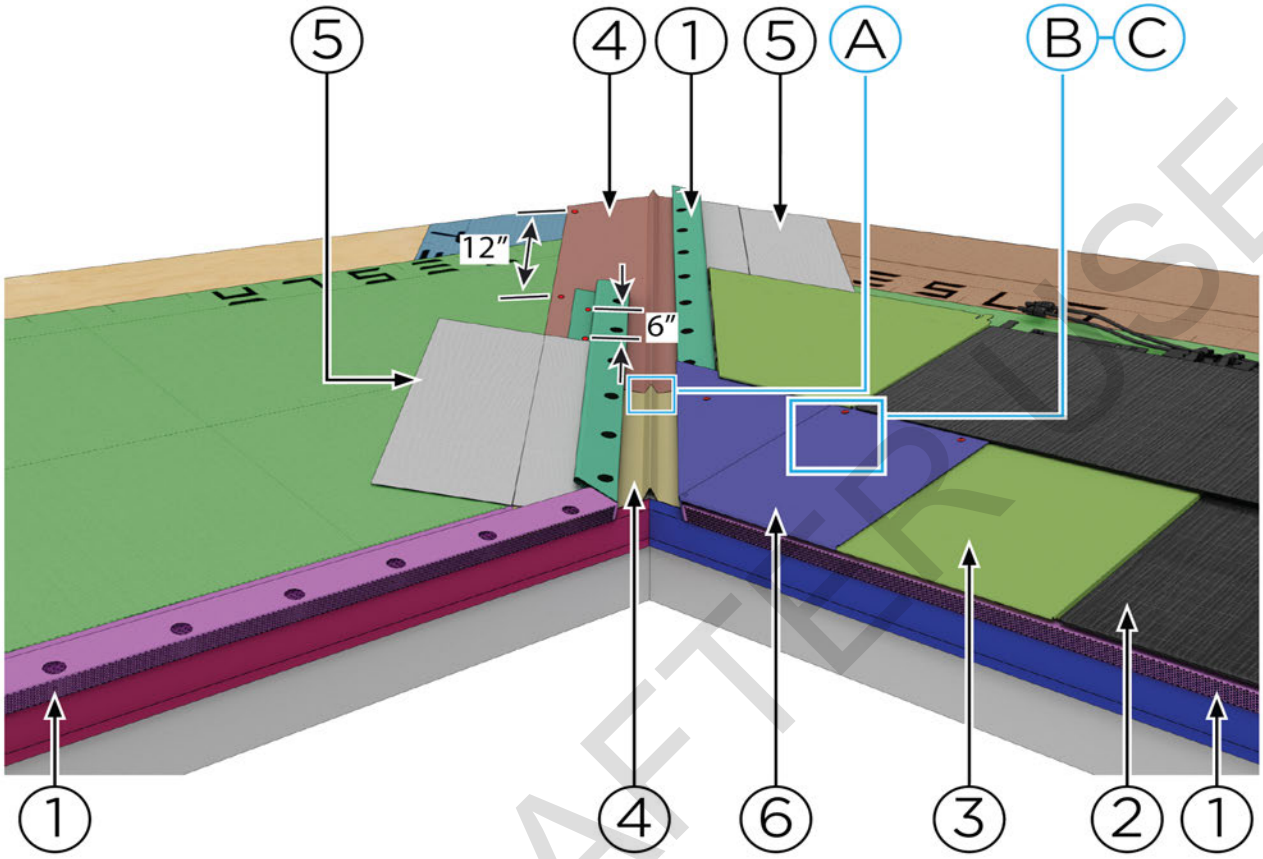
Dry In



1	Drip Edge	2	Underlayment

		
Apply detail roll along the eaves, folding over 1 in down the fascia. Detail rolls overlap a minimum of 3 in the valley corner, requiring a relief cut in the bottom layer of detail roll to wrap the roll around the corner.	Miter together the drip edge with a 1 in tab at the face and a 2 in tab at the top. Break the 2 in tab to pitch along the valley.	Apply a full roll of underlayment starting 1 in from the top of the drip edge and running up-roof along the valley. Then, apply underlayment as normal to the two planes, leaving an 8 in gap from the end of the underlayment course to the valley centerline.

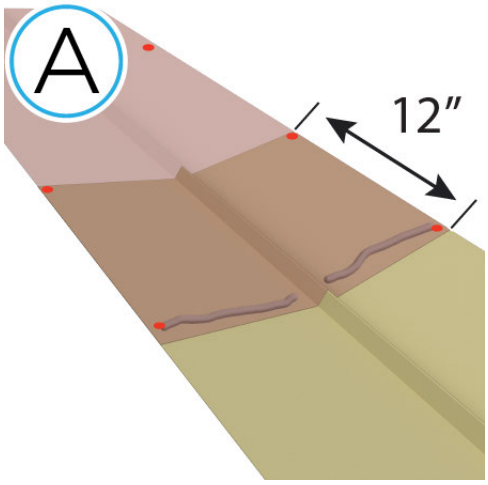
Tile Install

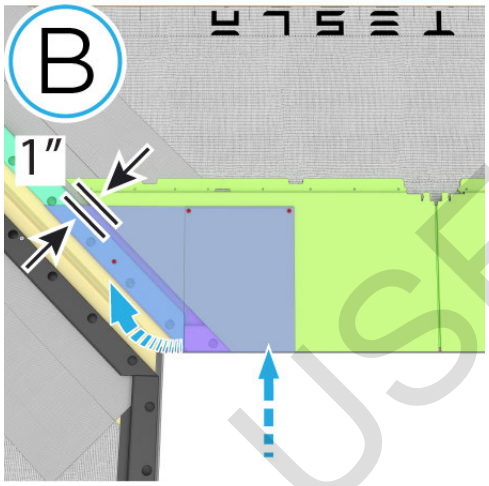


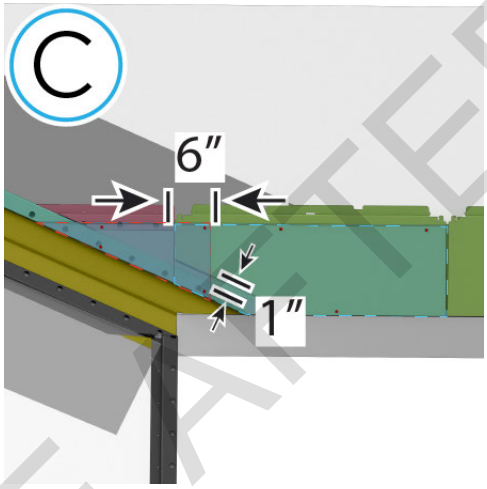
1	Vented Riser	**2**	PV Tile
3	Metal Tile	**4**	Valley Pan
5	Detail Roll	**6**	Adjustable Trim Cover

See detail images on next page.

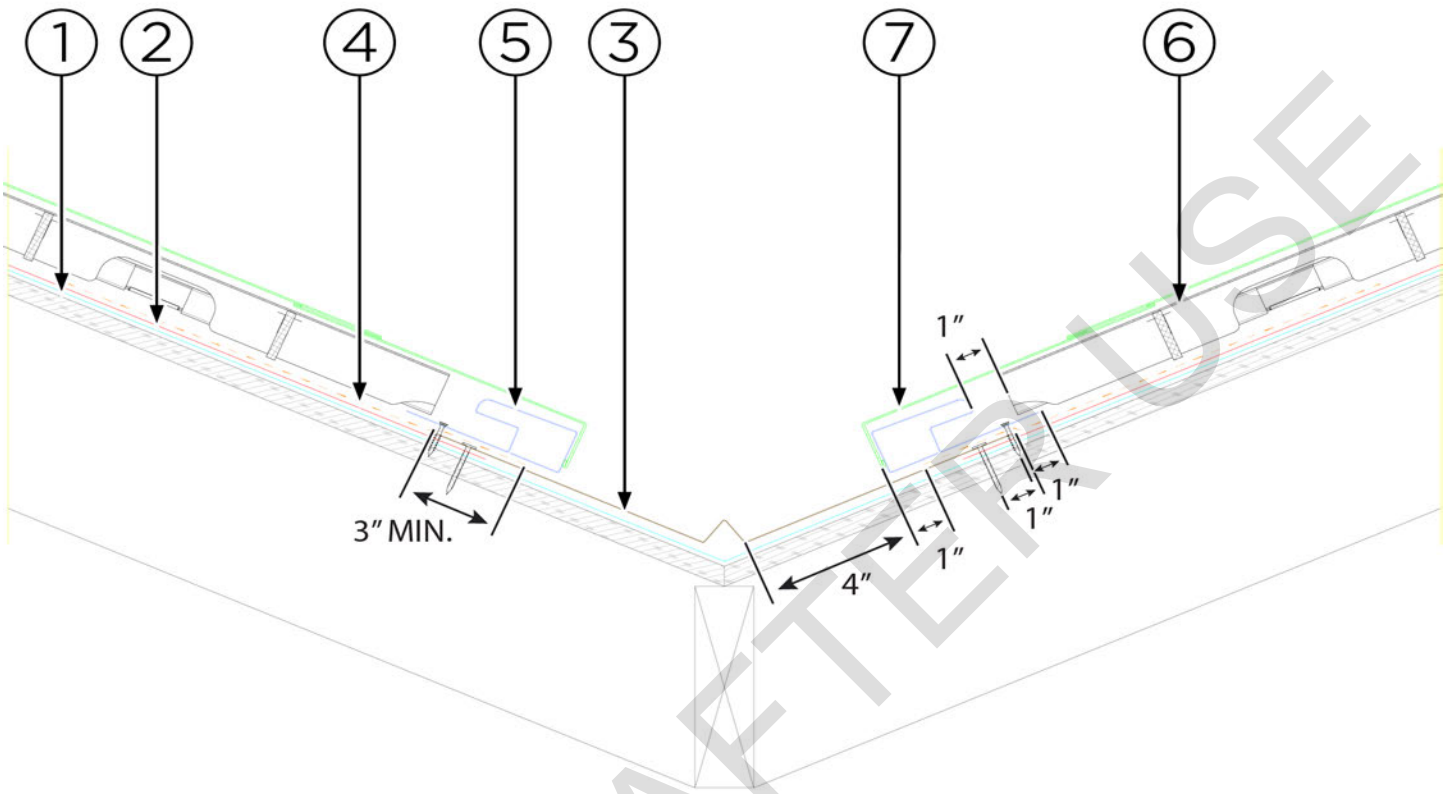
A	Splice valley pans by overlapping the up-roof pan 12 in over the down-roof pan. Apply a bead of sealant across the bottom pan 1 in away from the overlap edge.
B	Install the adjustable trim cover. First, cut back the metal tile 1 in away from the valley's vented riser flashing. The flashing then hooks over the nose of the metal tile and is angled to sit flush to the vented riser. Finally, secure the flashing to the front of the metal tile and the vented riser per the applicable wind tier in the Fastener Schedule.
C	On valleys that create angles larger than 45°, the cut metal tile may not be able to reach to the vented riser. If the space between the cut metal tile and the vented riser is greater than 6 in, place a piece of vented riser along the top edge to bridge between the metal tile and the vented riser. Create a valley trim out of a tile skin instead of using the adjustable flashing, fastening to both the metal tile and the vented riser.







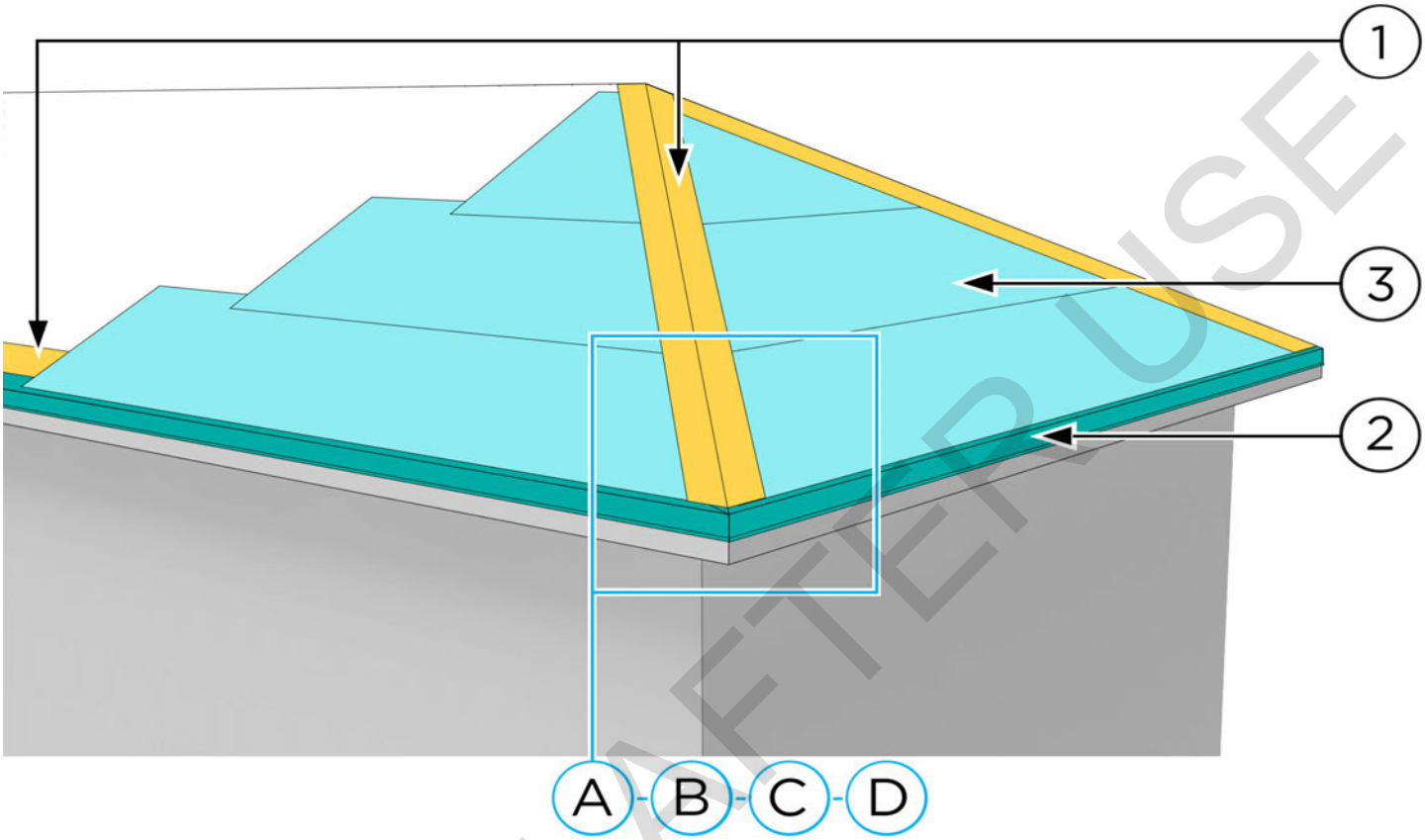
Cross Section



1	Valley Liner
2	Underlayment
3	Valley Pan
4	Detail Roll
5	Vented Riser Flashing
6	Metal Tile
7	Adjustable Trim Cover

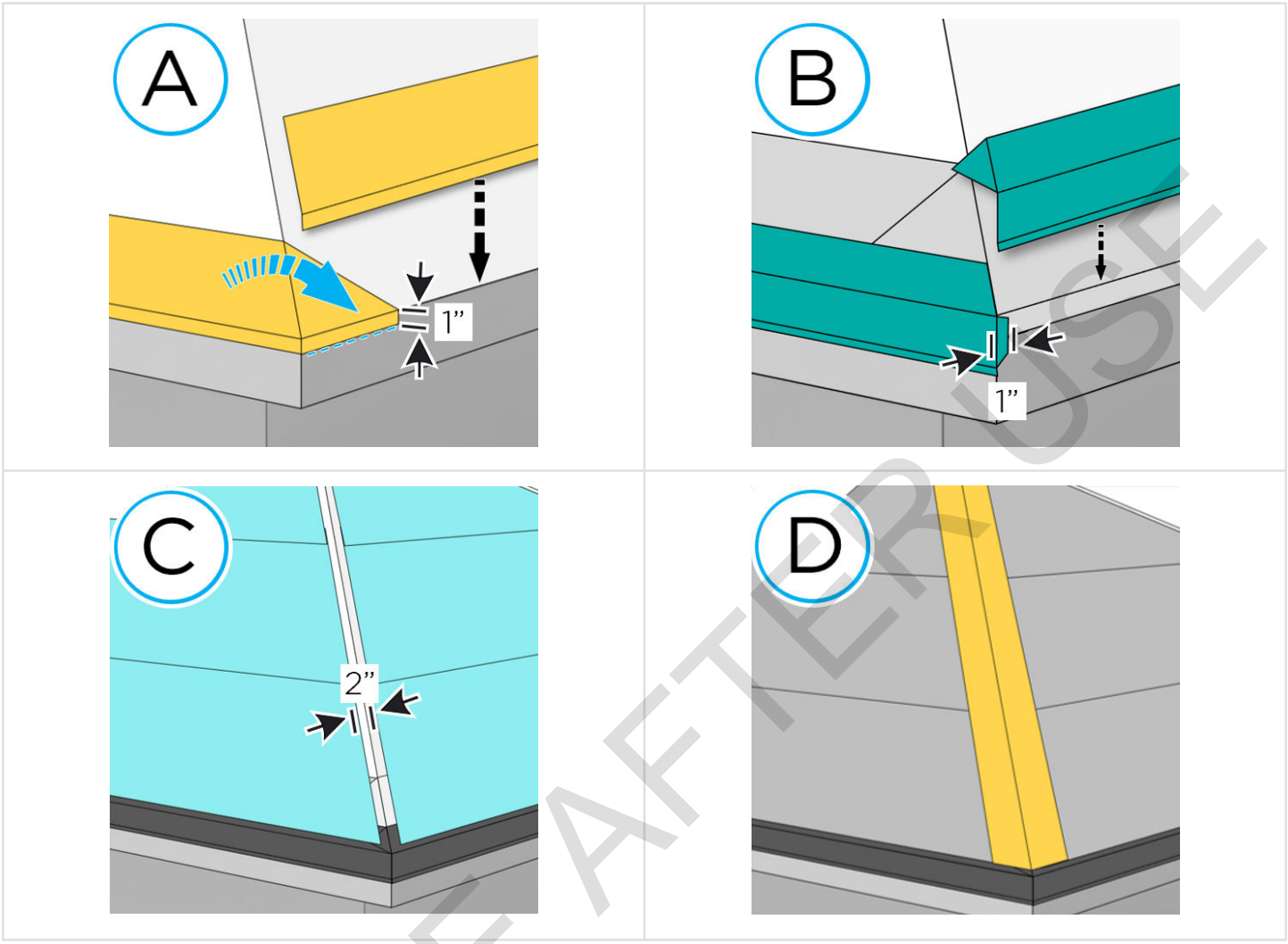
Hips

Dry In

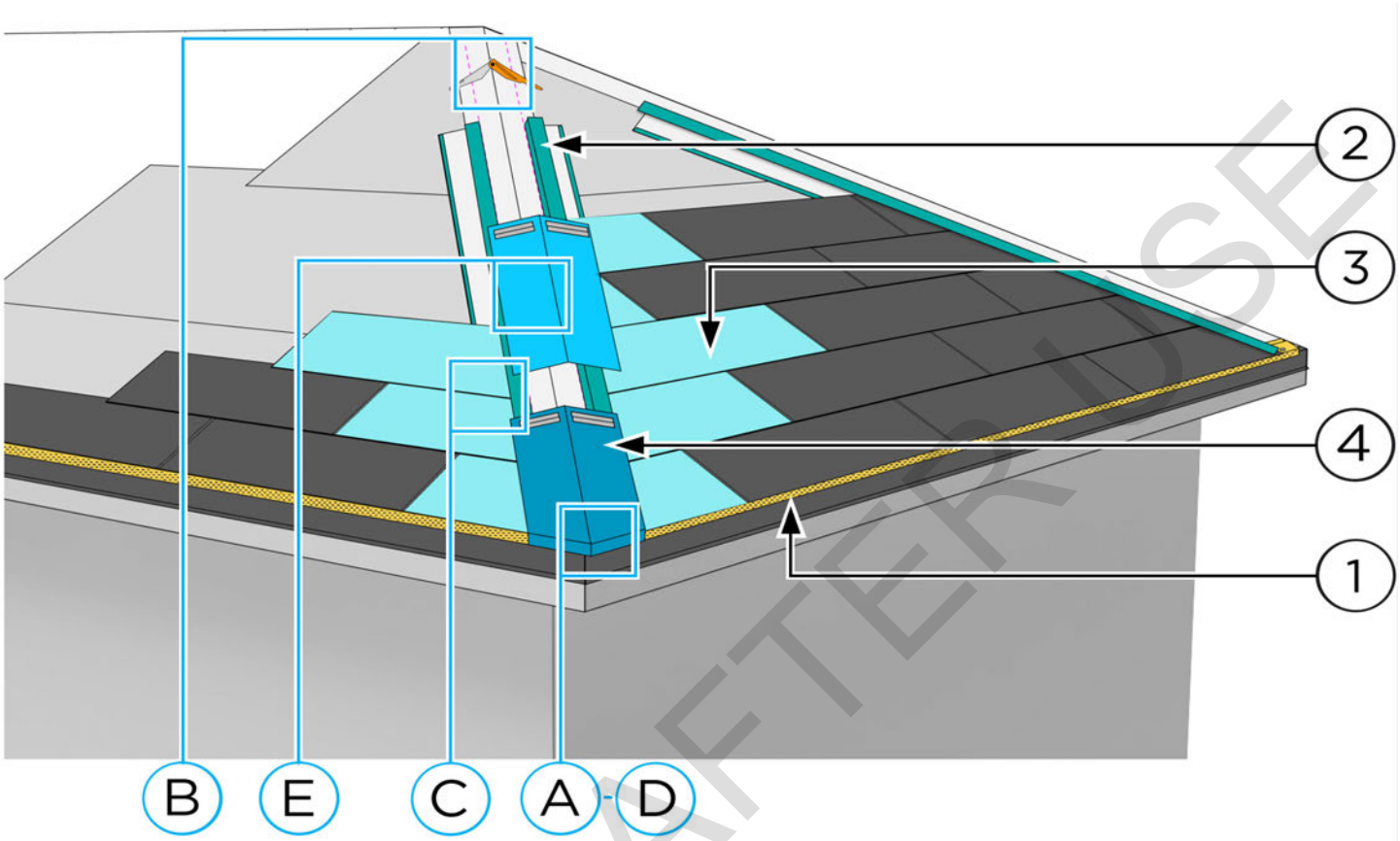


1	Detail Roll
2	Drip Metal
3	Underlayment

	See detail images on next page.
A	Install one piece of detail roll along the eave, lapping over the hip. Install another piece of detail roll cut flush with the hip.
B	Create an aesthetic joint in the two pieces of drip metal. The underlapping drip metal must a have a minimum 1 in tab around the eave corner. The deck flange of the overlapping drip metal is bent over the hip to lap over the deck flange of the first piece of drip metal.
C	Install courses of underlayment within 2 in of the hip on the hip centerline.
D	Cap the hip with detail roll (overlapping the drip metal by 1 in) to complete the hip dry in.

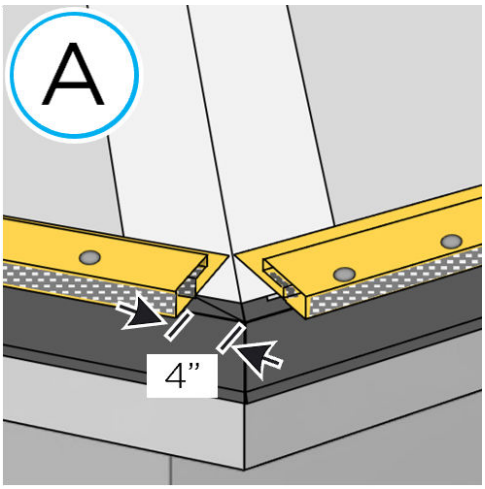


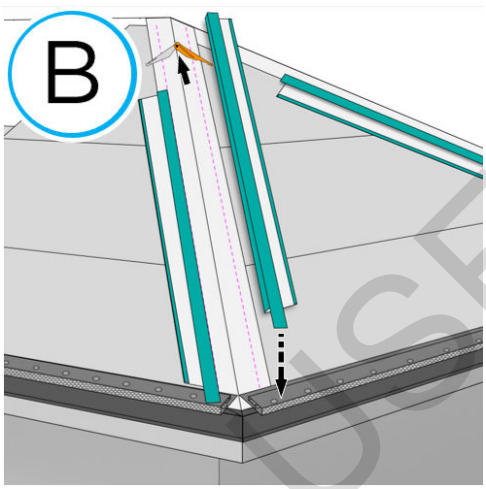
Tile Install

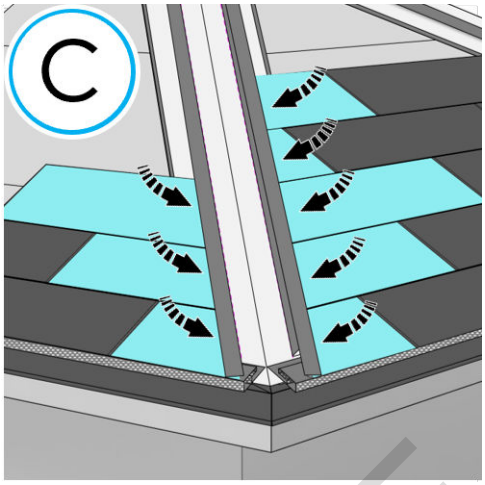


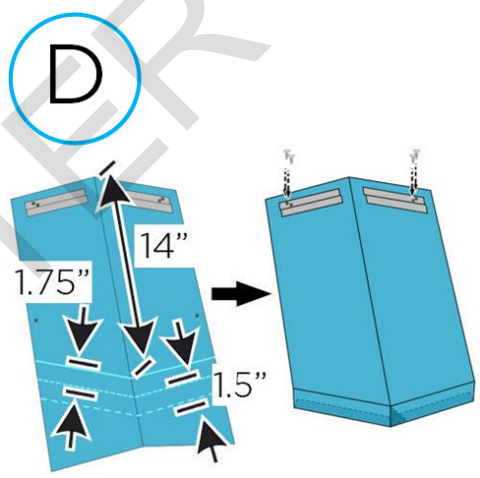
1	Vented Riser	**2**	Channel Flashing
3	Metal Tile	**4**	Caps

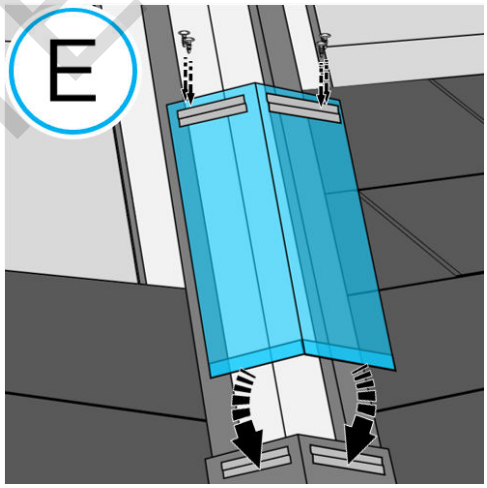
	See detail images on next page.
A	Install vented riser 4 in from bottom of the hip.
B	Use the robin jig to determine the location for channel flashing installation along the hip. Install channel flashing with the lower edge in-line with the front face of the channel flashing.
C	Cut and tuck metal tiles into the channel flashing.
D	Position the top edge of a cap 14 in up-roof from the hip corner. Scribe the eave line onto the cap. Scribe a second line 1 ¾ in below the eave line, and a third line 1 ½ in below the second. Remove metal below the third line and make a cut through the spine of the cap to the scribed eave line. Bend along the scribed eave line and the 1 ¾ in-line to form an open hook that will fit around the vented riser at the eave.
E	When installing subsequent caps, break the caps to pitch as needed and engage caps with one another via the cleats and hems. Secure caps to the channel flashing per the applicable wind tier in the Fastener Schedule.



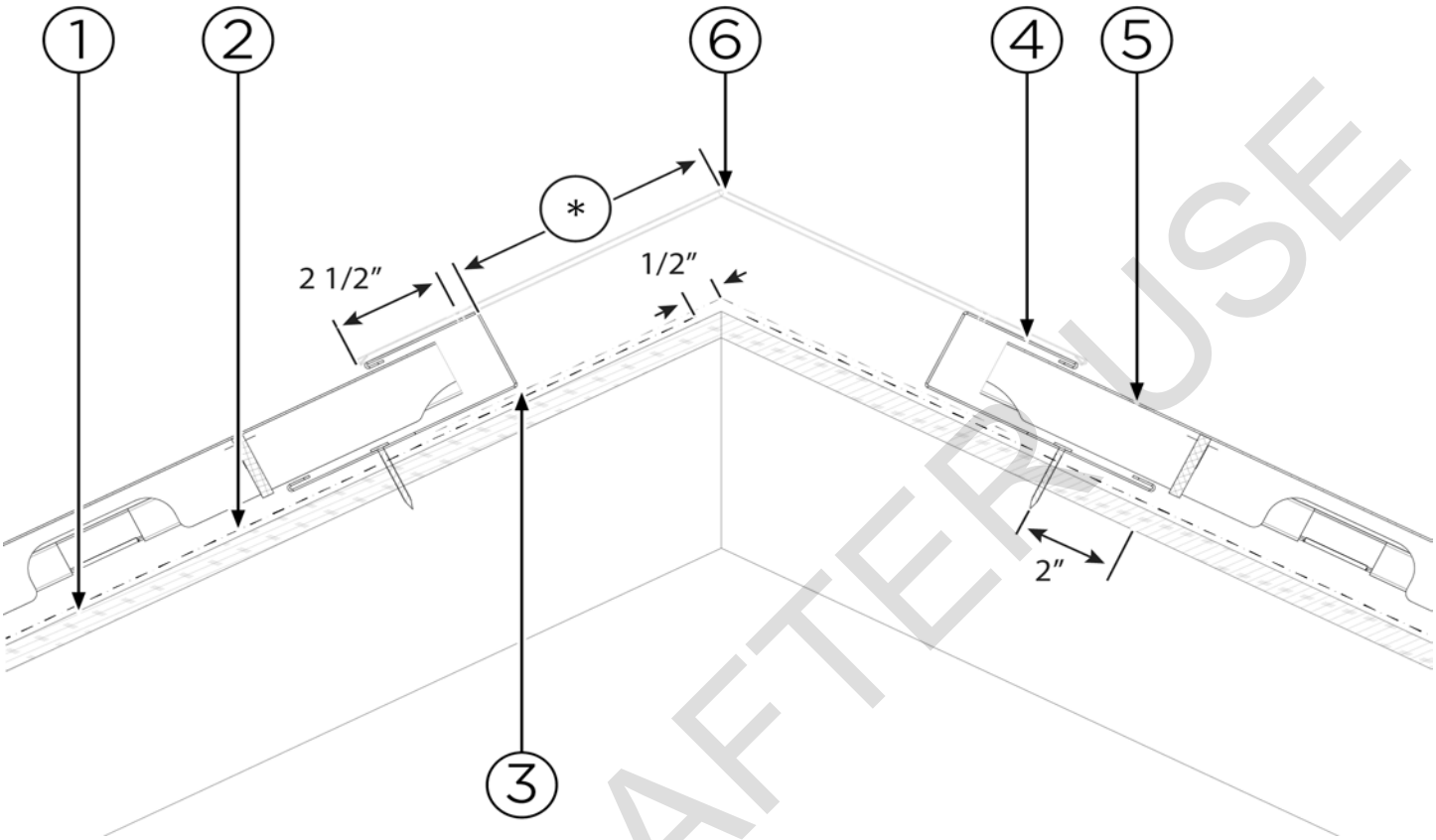








Cross Section



* Varies with roof pitch, refer to tool markings	
1	Deck Sheathing
2	Underlayment
3	Detail Roll
4	Channel Flashing
5	Metal Tile
6	Cap

Hip Starter Cap Installation

Overview

This section provides instructions for fabricating and installing hip starter caps.

Table of Contents

Tools & Equipment

- Vented riser

- Robin jig
- Channel flashing
- Hip cap
- Metal snips
- Speed square
- Flat stock (optional)

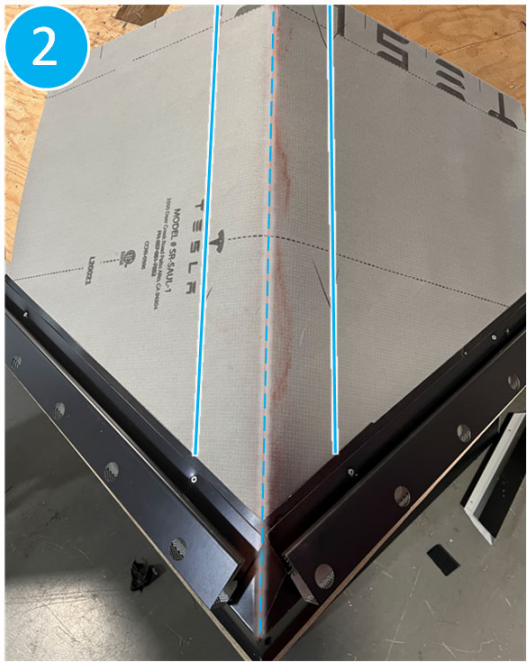
Work Instruction

Hip Assembly

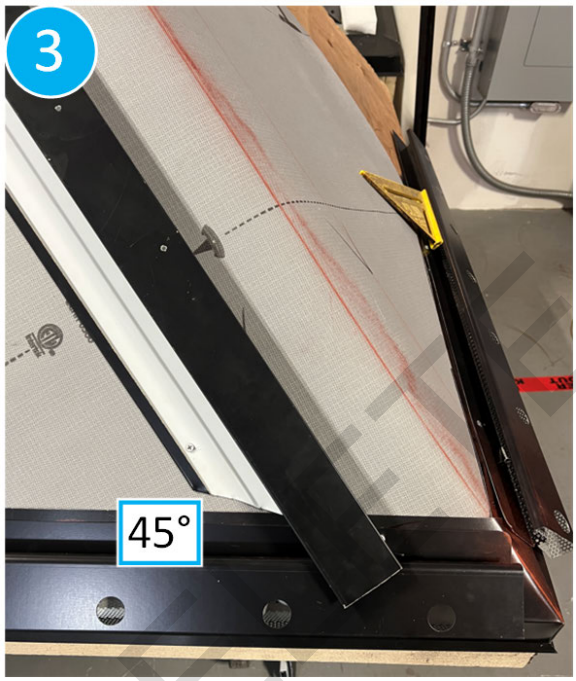
Install two vented risers. The back nailing flanges should meet at the center of the hip **(1)**.

Use the *Robin Jig on page 603* to determine the channel flashing locations and snap two layout lines **(2)**.

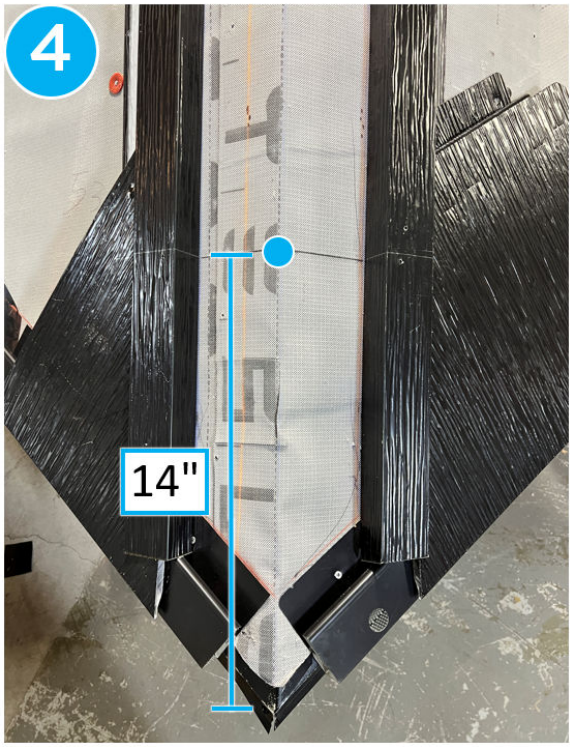
PRO TIP: Snapping a third center layout line can help guide cap alignment.



Make a 45° back cut on the bottom of the channel flashing and install over the layout lines **(3)**.



On the hip center line, measure and mark 14 in from the hip corner **(4)**.



Then, scribe a line across the channel flashing / hip at the 14 in mark **(5)**.

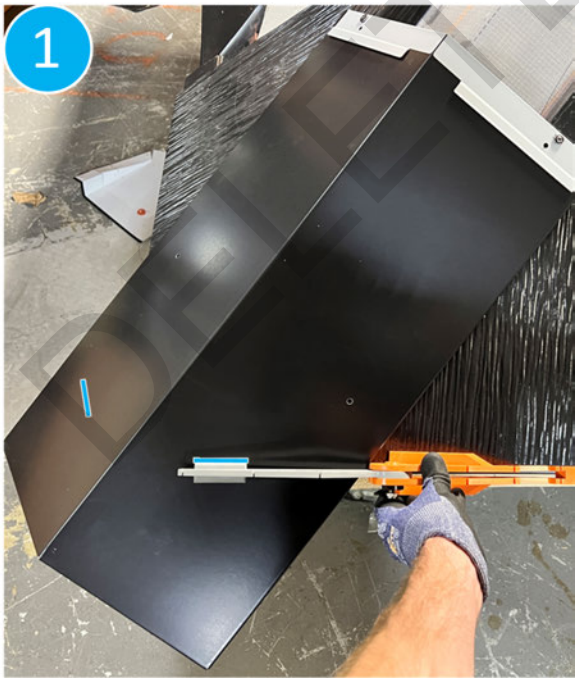
Temporarily install a cap flush and square along this line **(6)**.

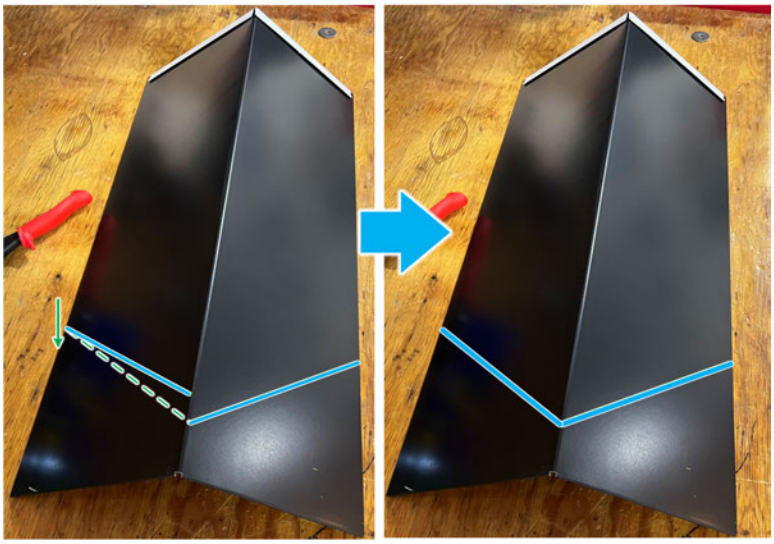
Starter Cap Fabrication

Use the *Robin Jig on page 603* to mark the edge of the eave onto both sides of the cap. Then, uninstall the cap and finish fabrication on the ground.

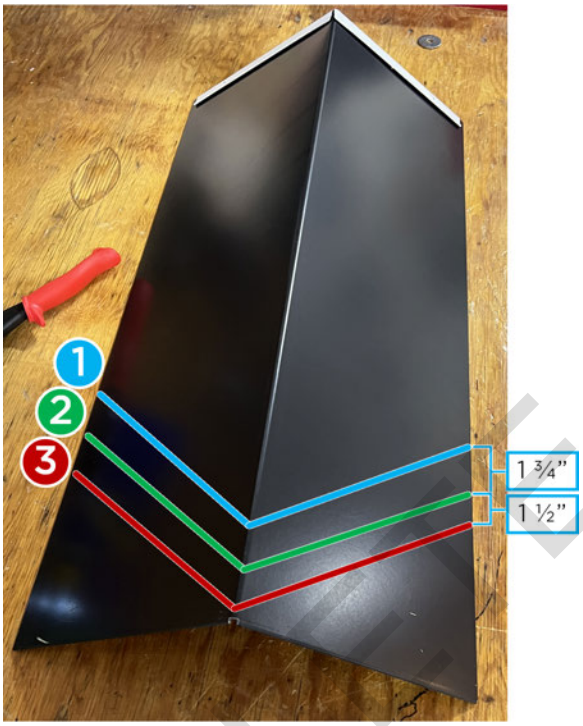
Use a straight edge to scribe the complete eave line across the cap.

PRO TIP: The eave lines on either side of the cap might not line up with each other. In that case, pivot the most up roof line down to match **(1)**.



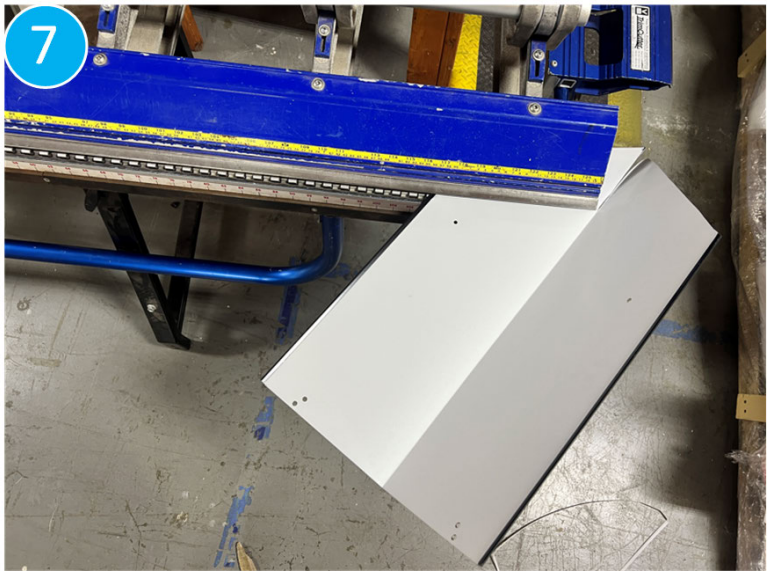


Scribe another line 1 ¾ in below the eave line **(2)** and scribe a third line 1 ½ in below the second line **(3).**



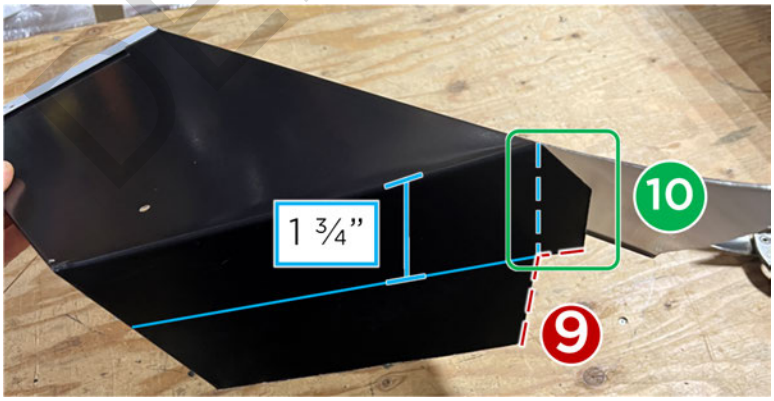
Cut along the third line to remove the corner excess metal **(4).** Make relief cuts at the edge of each remaining line on both sides of the cap **(5).** Finally, cut into the cap center and up to the line furthest up roof **(6).**

Brake the cap to 90° on the line furthest up roof **(7)**.



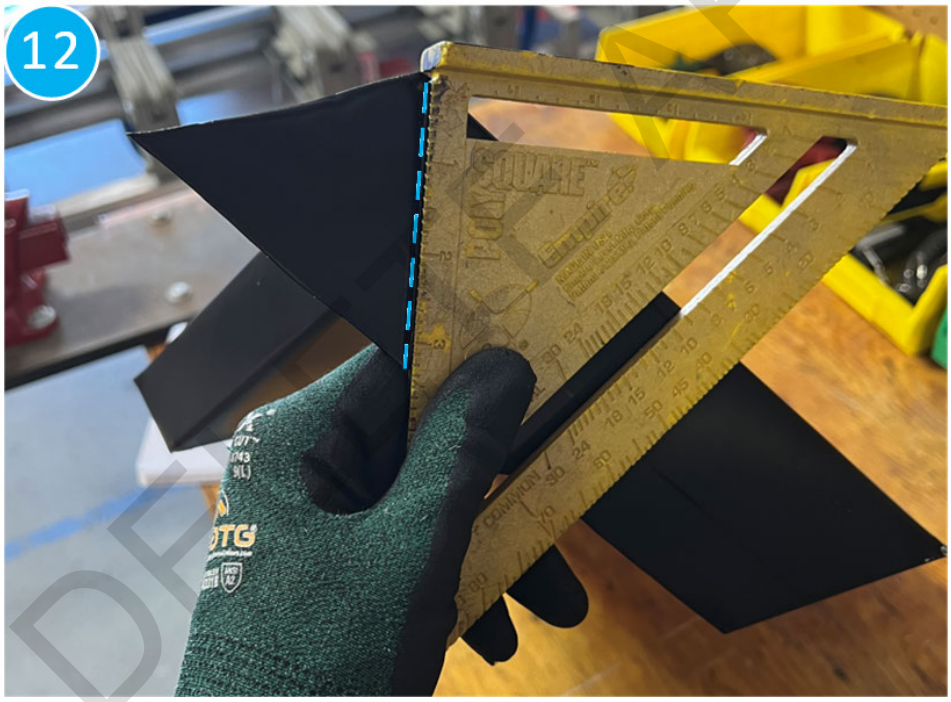
Use the hip/valley indicators on the speed square to scribe the hip miter angle **(8)**. This line should be set up based on the pitch of the roof. For example, with a 6:12 roof, line up with the 6 hip/valley indicators.

Cut away any excess metal on the bottom **(9)** and create a tab out of the 1 ¾ inch section **(10)**.

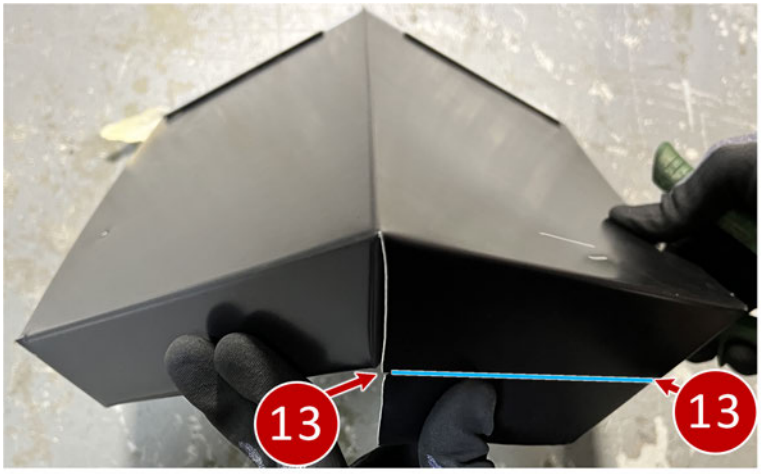


Bend the bottom line in the brake to 90° **(11)**. To achieve a full 90° bend, finish bending with 6 in seamers or by hand.

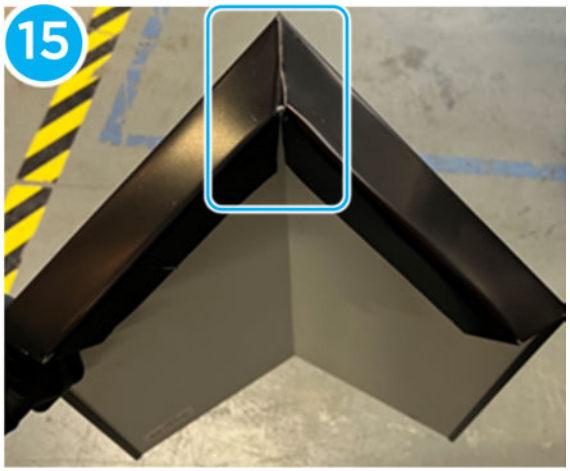
Bend the second tab to 90°. Use the hip / valley indicators on the speed square to scribe and cut a line **(12)**. This line should be set up based on the pitch of the roof.



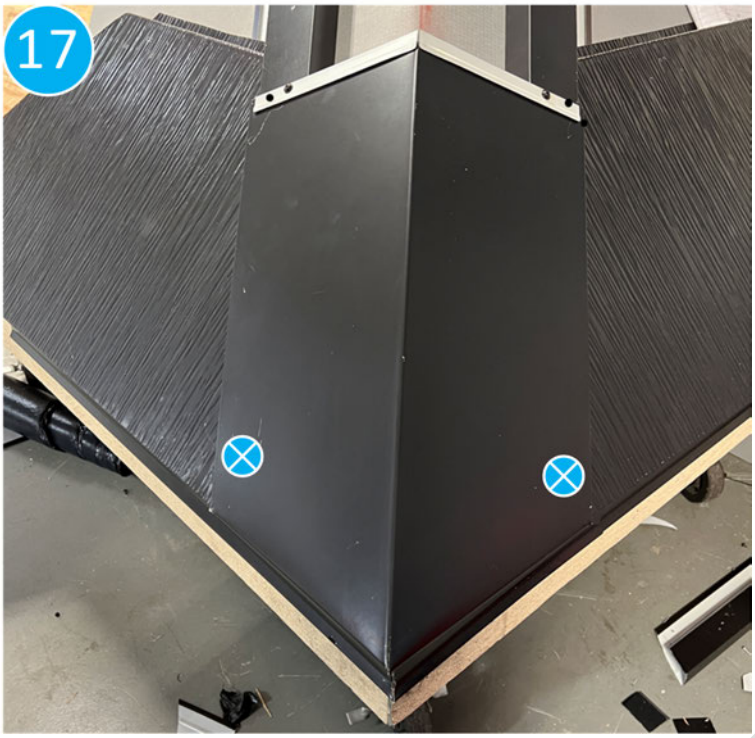
Make relief cuts at the intersection and at the opposite end of the line scribed in step 12 to mark the next bend line **(13)**. Bend the cap at 90° on the relief cuts (finish the bend by hand or with 6 in seamers to achieve 90°) **(14).**



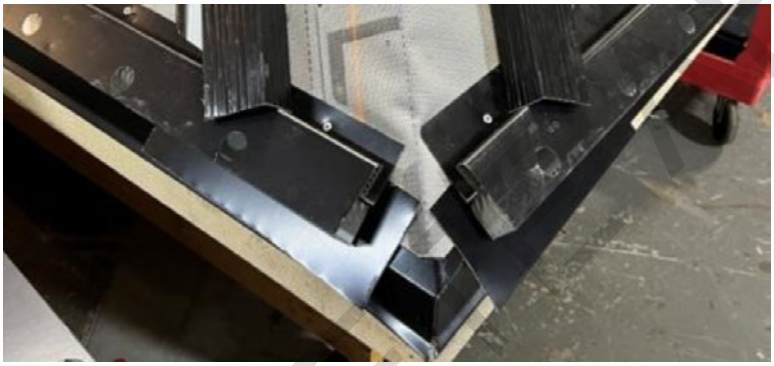
Cut into the center tab intersection so that the tabs sit next to each other and no longer overlap. Ensure the tabs form 90° bends **(15)**.



Fasten the center front face of the cap with an exposed fastener **(16)**. Install the cap and fasten with two exposed fasteners **(17).** Refer to the applicable wind tier in the *Fastener Schedule on page 703* to complete fastening.



PRO TIP: Before the starter cap is installed, cut pieces of flat stock can be inserted under the risers to be used as a guide to prevent scratches on the drip metal and make cap installation easier. Ensure all flat stock pieces are removed after use.

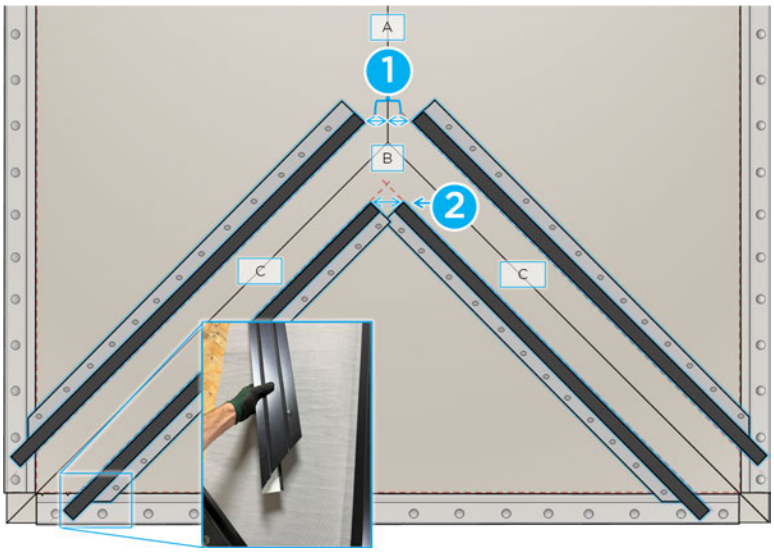


Channel Flashing at Hips

Cut a 45° wedge away from the base flange of the channel flashing to allow it to fit around the vented riser at the eave. Align the channel flashing with the chalk line along the hip.

Terminate channel flashing within 4 in of the ridge **(1)**. At the hip apex, leave a gap large enough for wire raceways as needed **(2)**. Fasten the length of the channel flashing per the applicable wind tier in the *Fastener Schedule on page 703*.

Pictured: Ridge **(A)**, Hip Apex **(B)**, Hip **(C)**



Ridges

Overview

This section outlines the procedures for identifying / eliminating ridge dead zones, installing corrugated ridge vents, assembling ridges and installing vented risers over the ridge.

Tools and Equipment

- Corrugated ridge vent roll
- Metal snips
- Vented risers
- Robin jig
- Channel flashing

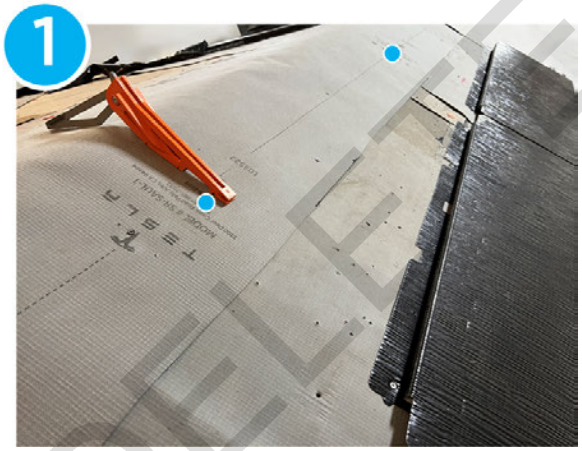
Identifying Ridge Dead Zones

When installing tiles at the ridge, two conditions must be met in order to prevent creating a dead zone and ensure that vented risers installed later during the ridge assembly will have adequate support from tiles:

- The minimum cut tile allowance of 6 in must be met
- The *robin jig on page 603* riser at ridge indicator marks cannot land above the *metal tile nominal reveal marks on page 709*

Install tiles at the ridge until the second to last course is reached. **Before** installing the second to last course, confirm if the ridge will have a dead zone.

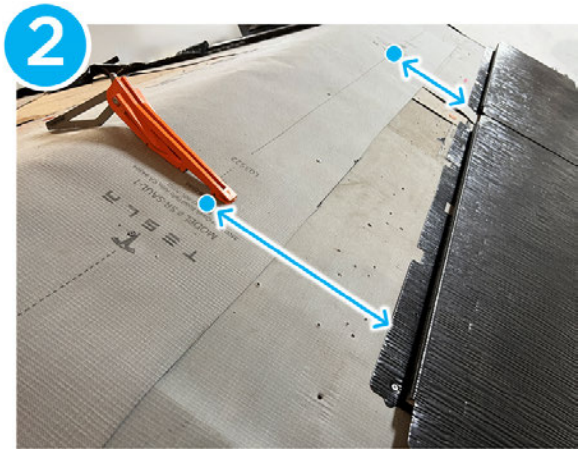
Place the *robin jig on page 603* over the ridge. Then, draw a mark at the riser at ridge indicator marks on both ends of the ridge **(1)**.



There are two measurement ranges for determining dead zones: low pitch range and high pitch range.

Measure the distance between the robin jig marks and the top of the metal tile nailing flange / PV tile foot. If the measurement falls within the ranges defined in the table below on either side of the ridge, there will be a dead zone **(2).**

Pitch Range	Measurement Minimum	Measurement Maximum
Low Pitch: (2:12 - 6:12)	9 ½ in	12 ½ in
High Pitch: (7:12 - 12:12)	9 in	



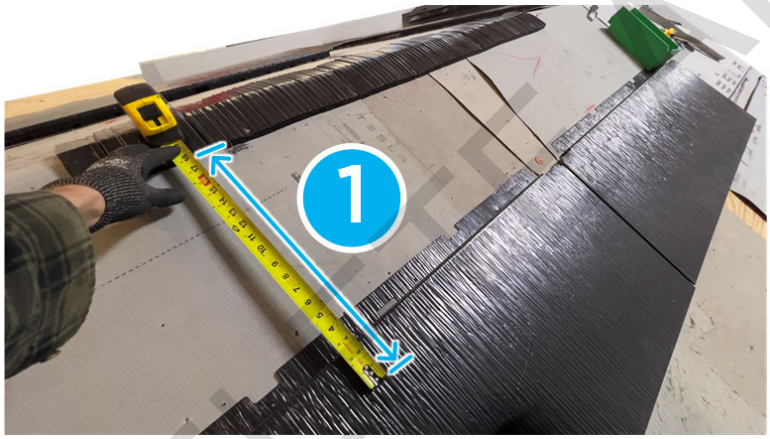
After confirming the ridge will contain a dead zone, *two courses of metal tiles must be cut and installed to remediate this. on page 243*

Eliminating Ridge Dead Zones

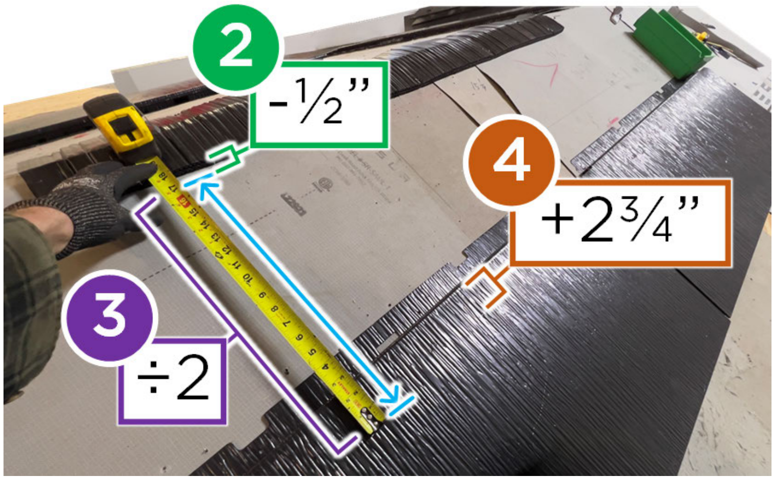
Begin by installing a corrugated ridge vent over the ridge (see *Corrugated Ridge Vent Assembly*).

The second to last and top courses of metal tiles must be cut to effectively eliminate the dead zone. Determine the dimensions of these courses.

First, measure the distance between the tile nominal reveal mark / point and the edge of the corrugated ridge vent on both sides of the ridge **(1).** If these measurements don't match, proceed with the shorter measurement (this will allow room for fanning if needed).

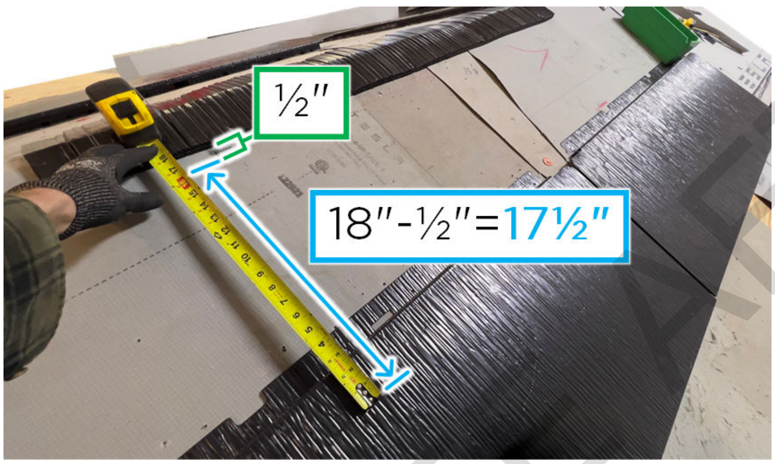


Then, subtract ½ in from this measurement to maintain proper clearance for the corrugated ridge vent **(2)**. Divide this new measurement in half to determine the **top course** measurement **(3)**. For the **second to last course**, add 2 ¾ in to the measurement from step 2 to account for the tile overlap **(4).**

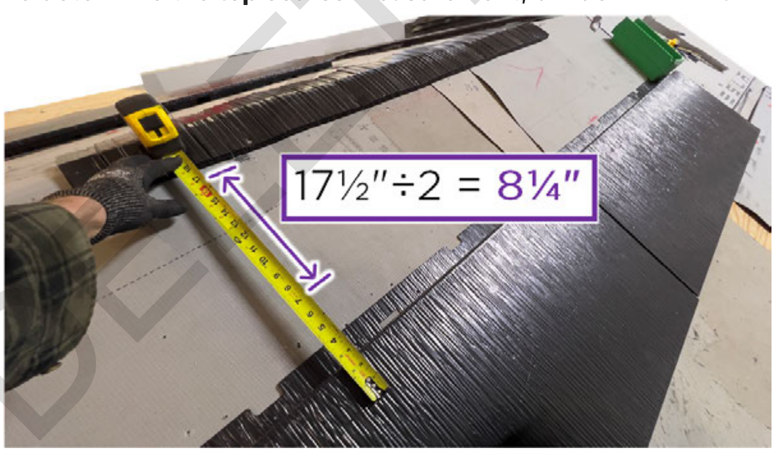


Example of steps 1 - 4:

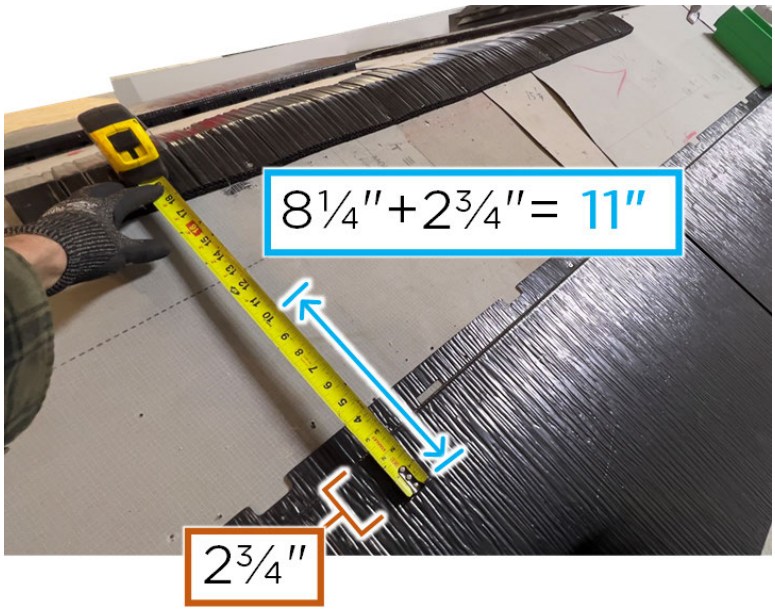
The shortest distance between the corrugated ridge vent and the tile nominal reveal mark is 18 in. Subtract ½ in from 18 to account for vent clearance = **17 ½ in.**



- To determine the **top course** measurement, divide 17 ½ in half = **8 ¼ in**

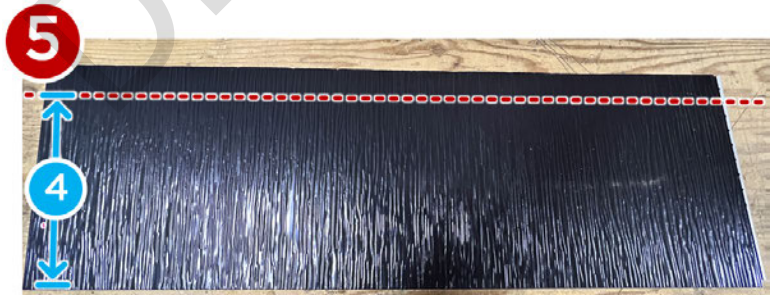


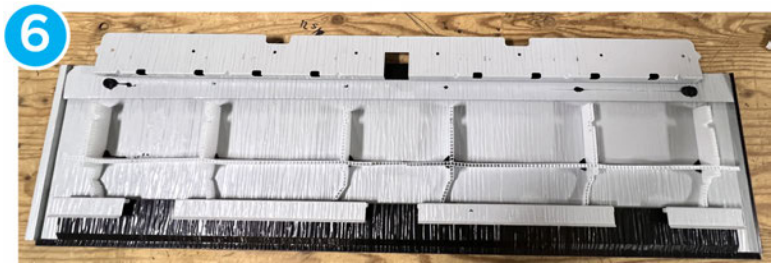
- To determine the **second to last course** measurement, add the 2 ¾ in tile overlap to the 8 ¼ in = **11 in**



Fabricate the second to last course tiles. Align the saw rail with the reveal mark of a metal tile and cut off the tile nailing flange. Then, cut off the water channel and the hook on the tile nailing flange **(5)**.

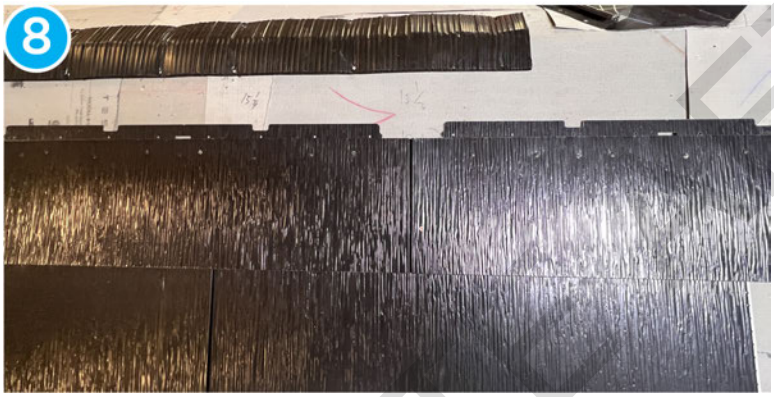
Cut the rest of the tile to the length determined in step 4 **(5)**. Remove the top-most corrugated support to allow the tile nailing flange to be re-installed under this cut tile **(6)**.





Align the cut edge of the tile to the back of the nailing flange. Fasten the nailing flange to the tile in accordance with the applicable wind tier in the metal tile section of the *Fastener Schedule on page 703*. Additionally, fasten a minimum of 1 ½ in below the nailing flange to prevent fasteners from penetrating through the nailing flange and obstructing tile engagement **(7)**.

Install the fabricated tiles in the second to last course **(8)**.



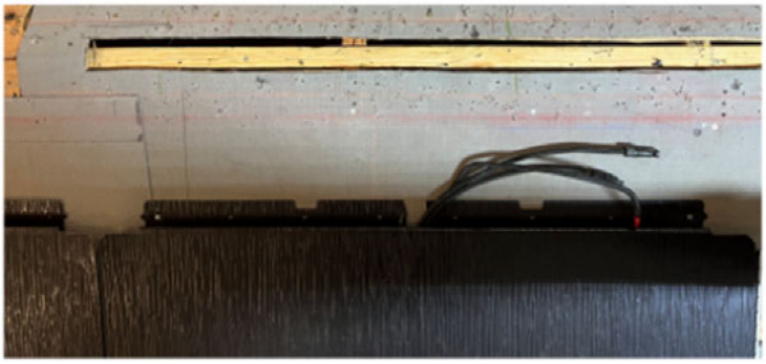
Cut the final course of tiles to the measurement determined in step 3. If the final ripped course is not square to the ridge, add more length but ensure a ½ in clearance remains between the final course and corrugated ridge vent **(9)**.

After the dead zone is eliminated, proceed with the rest of the standard ridge assembly.

Corrugated Ridge Vent Installation

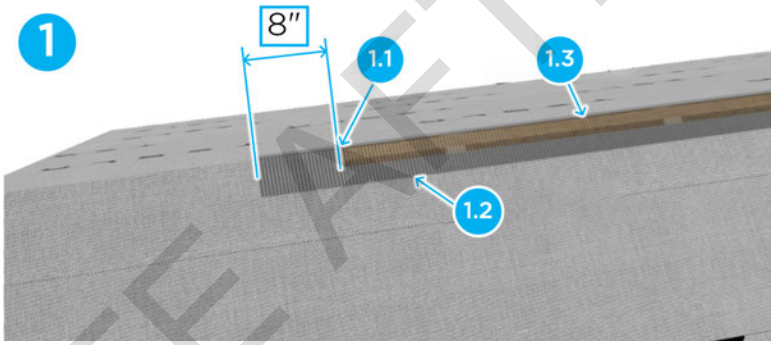
Begin by *confirming if the ridge will contain a dead zone. on page 242*

- If the ridge has a dead zone, proceed to *eliminate the dead zone. on page 243*
- If the ridge does **not** have a dead zone, proceed to install metal tiles up to the last course following standard installation methods

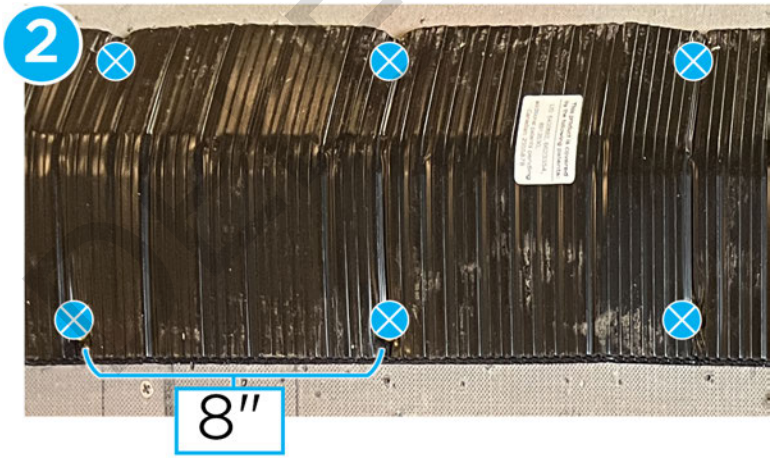


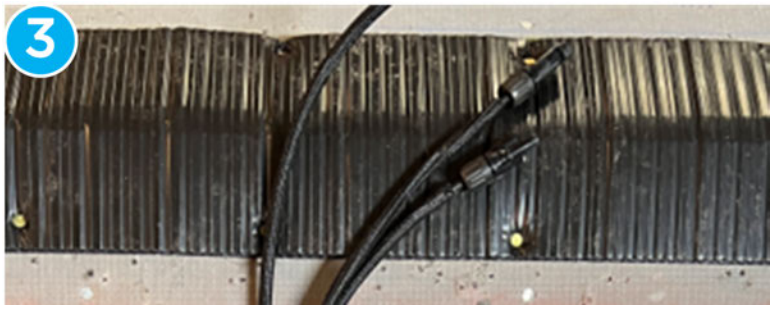
Place the first corrugated ridge vent roll piece over the ridge. Ensure 8 in of the piece extends past the edge of the cut ridge vent **(1)**.

(1.1)	Cut ridge vent edge
(1.2)	Corrugated ridge vent roll
(1.3)	Cut ridge vent

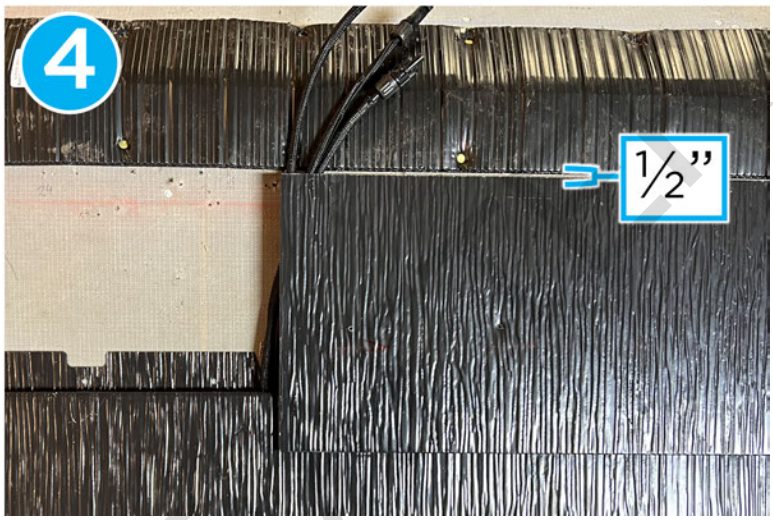
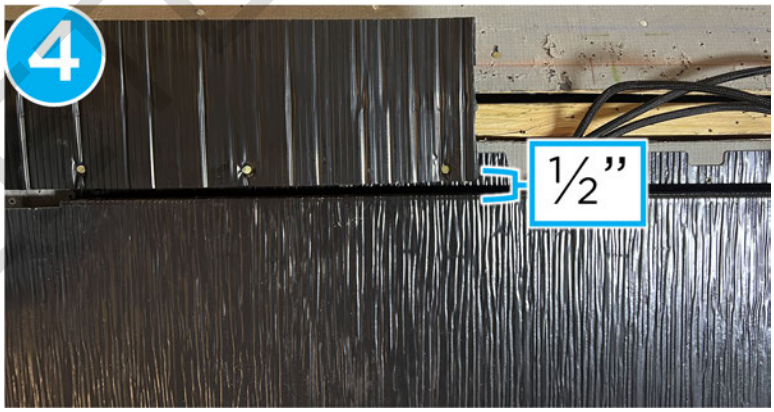


Fasten with nails every 8 in on both sides of the corrugated vent **(2)**. Ensure all pieces are installed tightly next to each other. Route all wires over the corrugated vent **(3)**.





If the ridge does **not** have a dead zone, proceed to install the top course of tiles. If full tiles are too large, cut them to size. Always maintain a ½ in gap between the tiles and corrugated vent to allow for ventilation **(4)**. Fasten tiles according to the applicable wind tier in the *Fastener Schedule on page 703*.

Cut Tile

Full Tile


If the ridge **does** have a dead zone, install tiles as directed in the *ridge dead zone elimination procedure on page 243*.

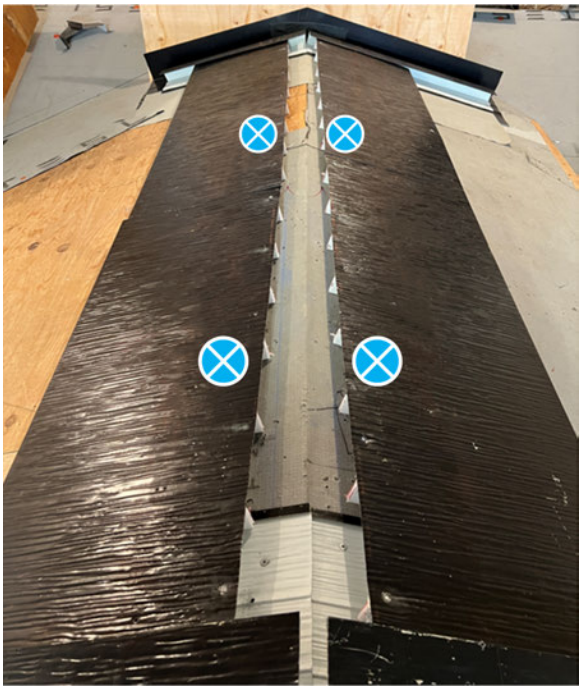
Ridge Assembly

If venting **IS required,** see *Corrugated Ridge Vent Installation on page 246* for in-depth guidance on installing a corrugated ridge vent.

If venting is **NOT required**, continue here.

The back of the metal tiles must land within 4 in of the apex of the roof. Secure tiles in place with one 2 ½ in screw per tile. Fasten at the center of the tile 1 in down from the top of the edge. This will prevent tiles from shifting while installing vented risers.

Secure tiles in place with one 2 ½ in screw per tile located 1 in down from the top of the tile. This will prevent tiles from shifting while installing vented risers.



NOTE: No Fastening Danger Zones must be located and clearly marked to indicate wire locations at the ridge and prevent wire penetration when installing vented risers.

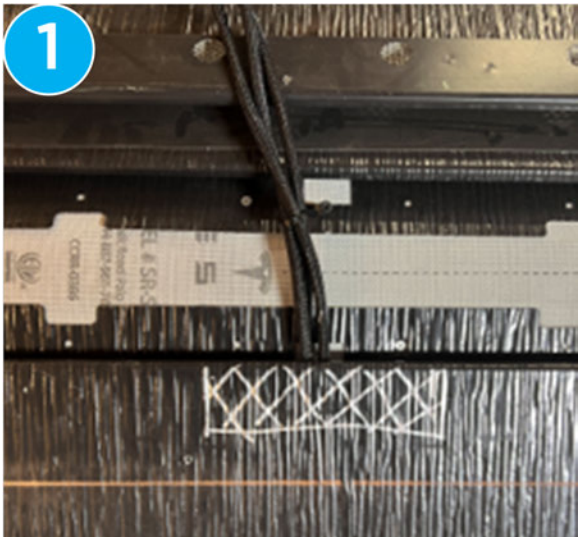
Proceed to *Installing Vented Risers Over the Ridge on page 249*.

Installing Vented Risers Over the Ridge

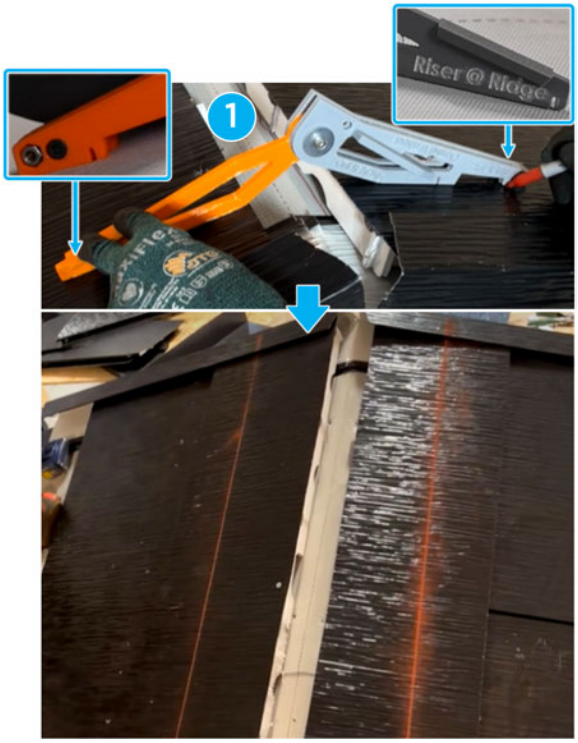
No Fastening Danger Zones

WARNING: Before installing vented risers over the ridge, **No Fastening Danger Zones** must be located and clearly marked to indicate wire locations at the ridge and prevent wire penetration when fastening the risers.

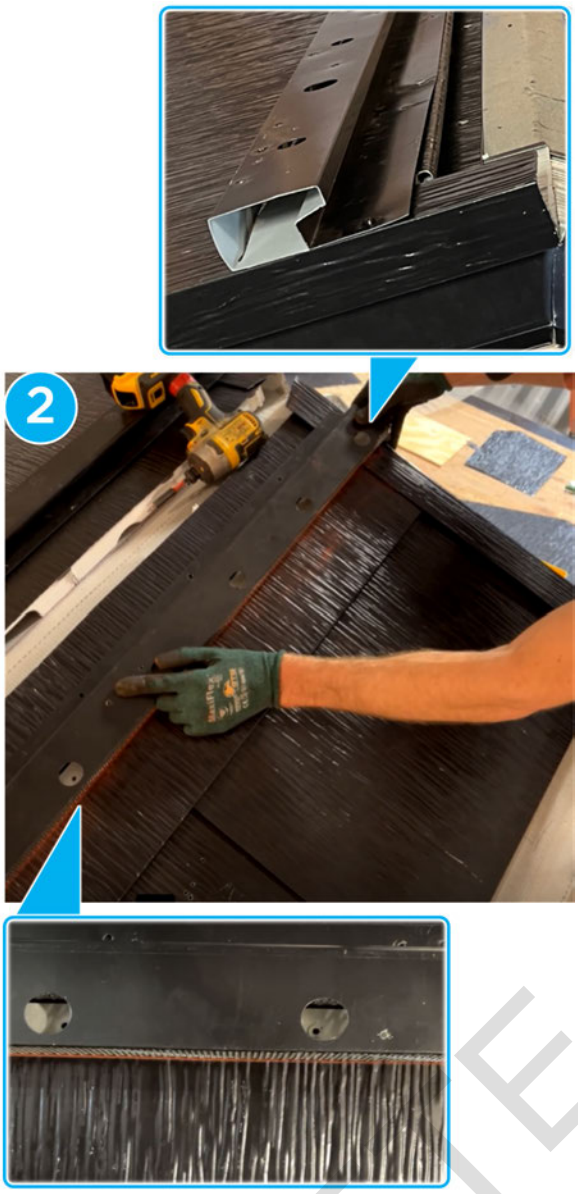
Mark a 6 in area around the wires with a metallic sharpie **(1)**. Repeat this step at the same location on the vented riser before fastening **(2)**.



To begin riser installation, use the *robin jig on page 603* to lay out vented risers over the ridge **(1)**.



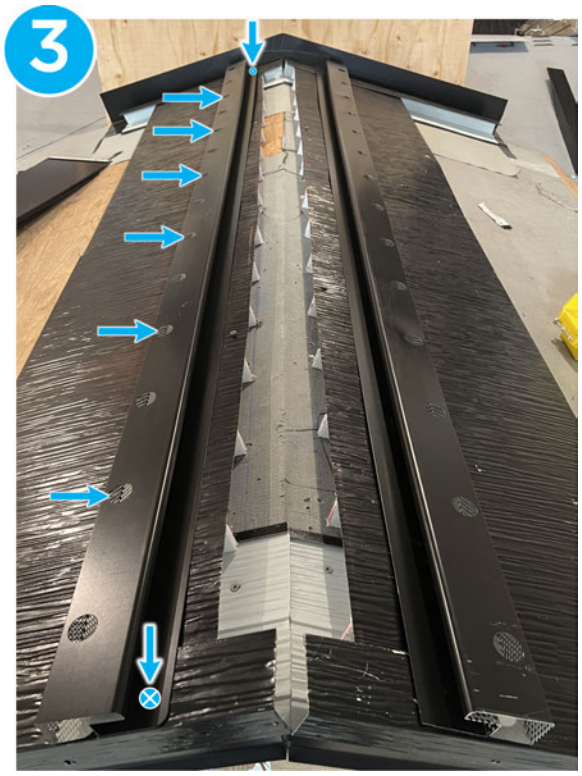
Align the front of each riser with the snapped control line and ensure the riser's factory edge is flush with the rake edge of the channel flashing **(2)**.



WARNING: Mark No Fastening Danger Zones on the risers. **Do NOT fasten through these Danger Zones.**

To tack the riser in place, fasten through the back flange at both ends of the riser with two self-tapping screws. Then, fasten the riser to the deck through the front holes of the riser according to the applicable wind tier in the *Fastener Schedule on page 703* **(3)**.

NOTE: When fastening with screws, stop impact once the screw head meets the vented riser to prevent over-driving.



Ridge Cap Installation

Overview

This section provides instructions for fabricating and installing ridge caps.

Tools & Equipment

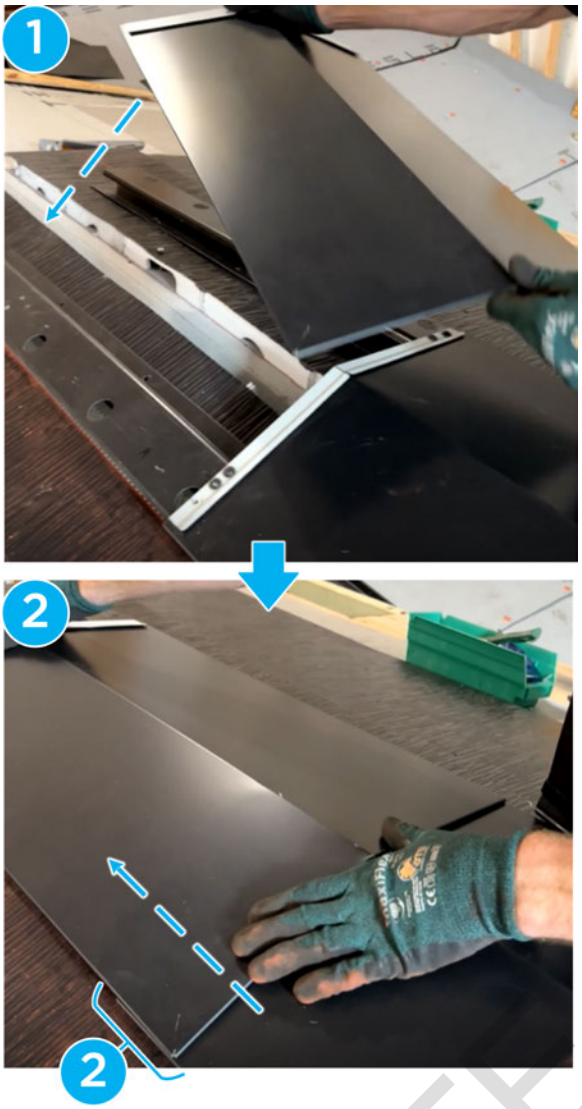
- Angle finder
- Brake
- Ridge cap

Bend the ridge cap at the center seam to the pitch of the roof (this step can be skipped for 3:12 and 4:12 pitches). Use the *Solar Roof Flashing Bend Angles chart on page 705* to determine the correct angle based on the pitch of the roof.

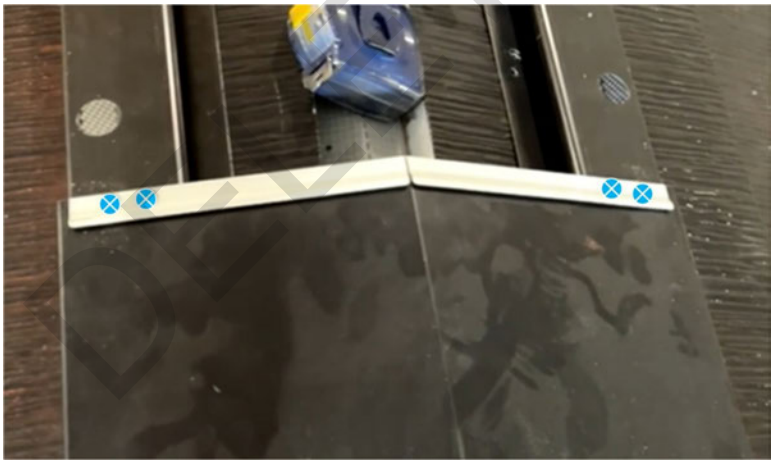
Before making the bend, ensure the cap's open hem remains outside of the brake during the bend to prevent deformation. Use the angle finder to help guide the bend.

Begin by installing a ridge end cap.

Place the following ridge cap over the ridge / risers **(1)** and engage the cleat hook of the previous cap **(2)**.

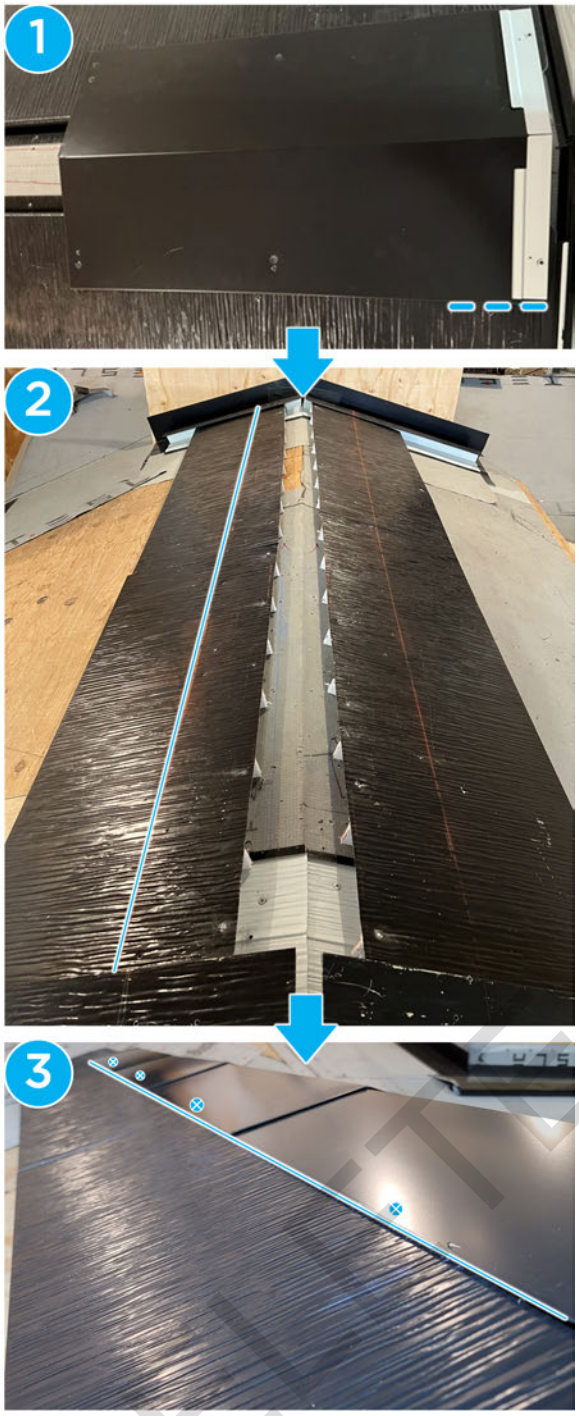


Ensure the cap is centered on the ridge and sits flat over the vented risers. Fasten the cap and cleat through the pilot holes according to the applicable *Fastener Schedule wind tier. on page 703*



Installing Caps Over Ridges without Vented Risers

Place a cap at the front of the ridge and mark the edge on either side of the ridge. Repeat this step on the opposite end of the ridge **(1)**. Snap a control line between the two marks **(2)**. Finally, install caps aligned with the control line and centered over the ridge **(3)**. Fasten caps through the pilot holes with exposed fasteners in accordance with the applicable wind tier in the *Fastener Schedule on page 703*.



Ridge Splice

Overview

A ridge splice is used at the void in the ridge assembly where both caps intersect. This procedure goes over how to properly fabricate and install a ridge splice.

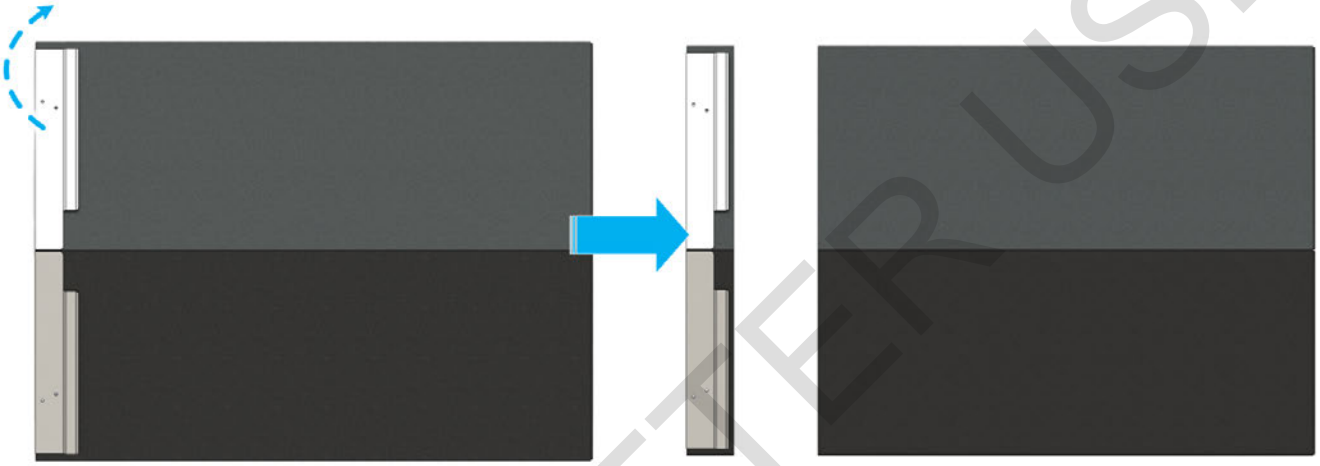
Tools and Equipment

- Cap
- Snips

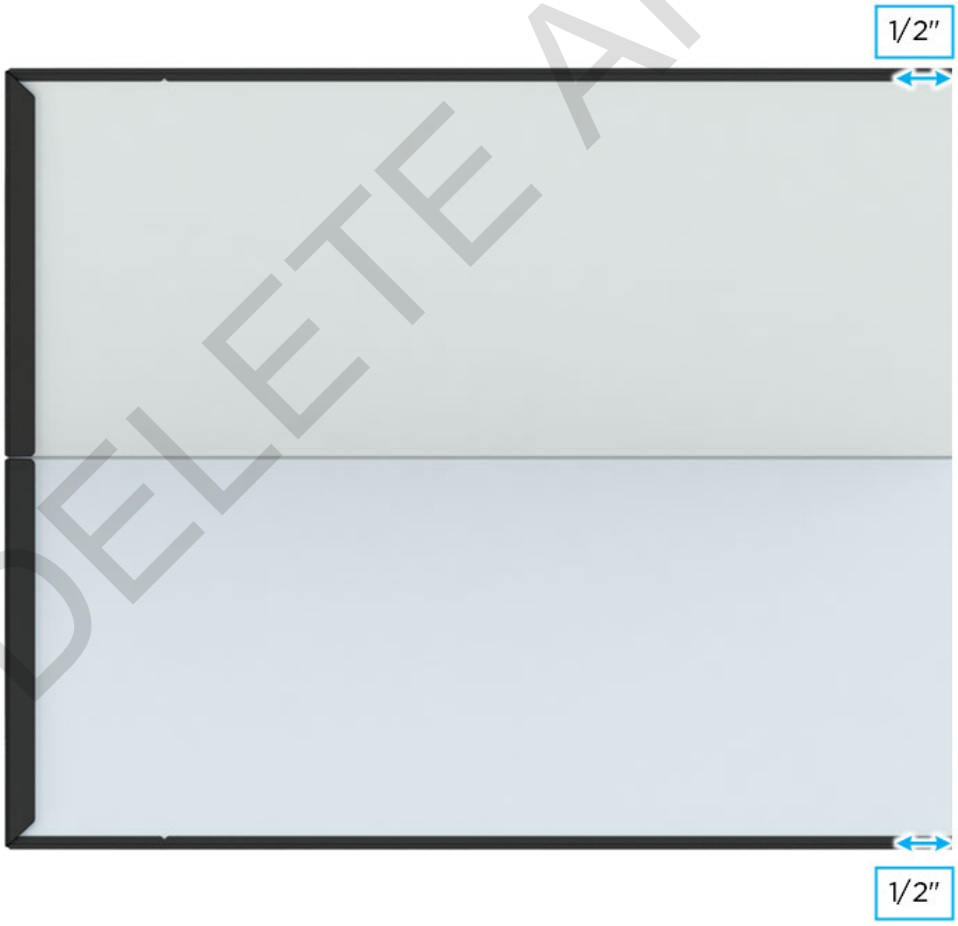
- Square
- Pencil/Marker
- Impact Driver
- Self-tapper
- Break

Work Instructions

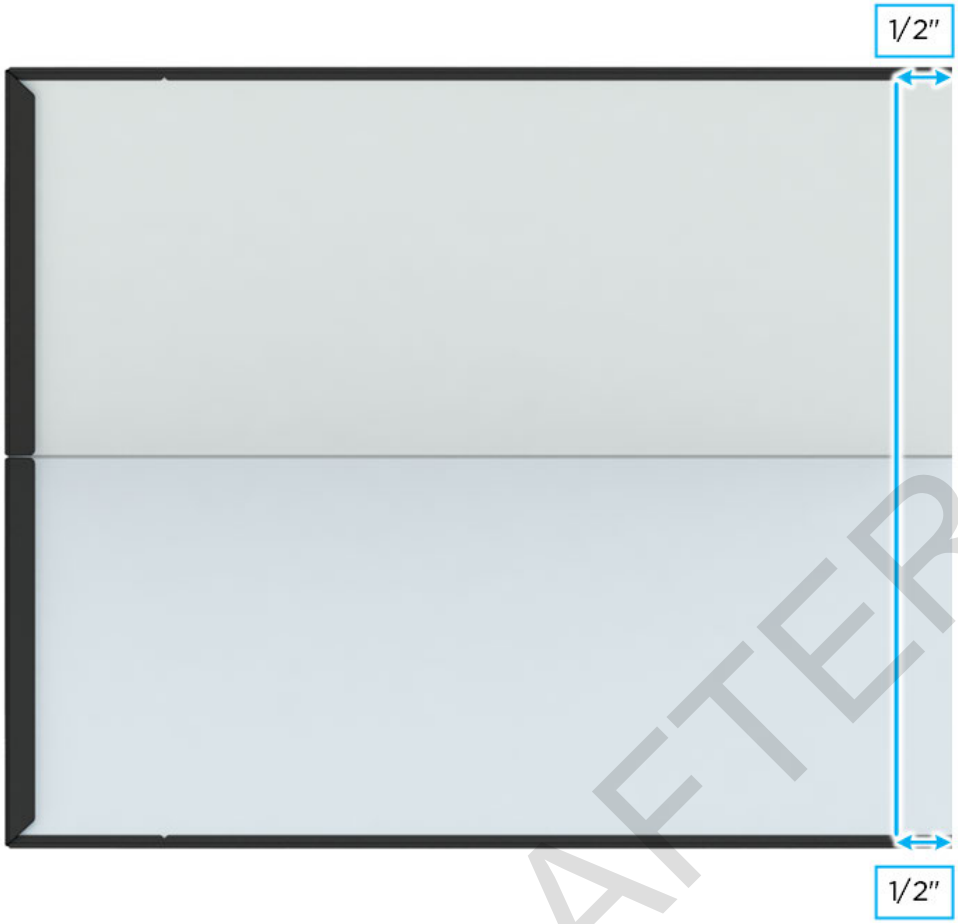
1. The first thing to do when creating a ridge splice is to snip away the engagement cleat on the cap.



2. Use the square to measure ½ inch on both the left and the right sides of the cap.

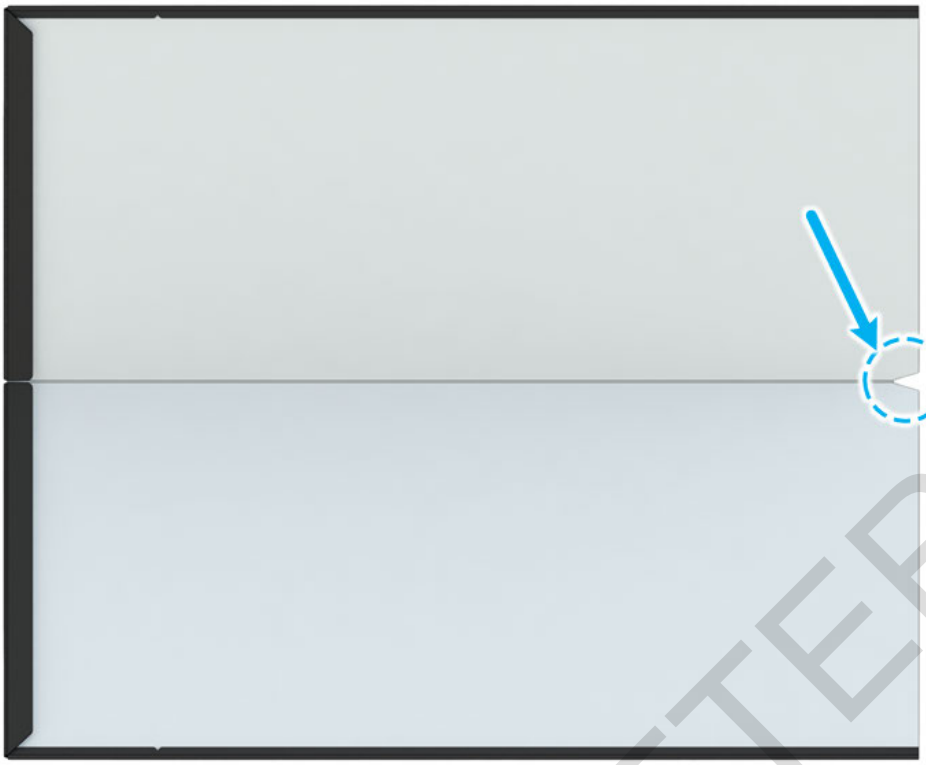


3. Using the square, mark lines at both ½ inch sections meeting at the center line of the cap.

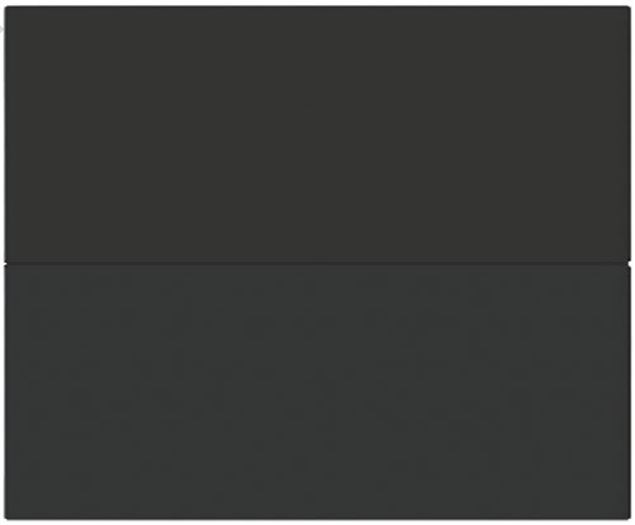


4. Create a relief cut down the center line of the cap, stopping at the ½ inch line created in the previous step.

5. Cut a small angle out of the relief cut. This prevents the material from stacking up when creating the hem.

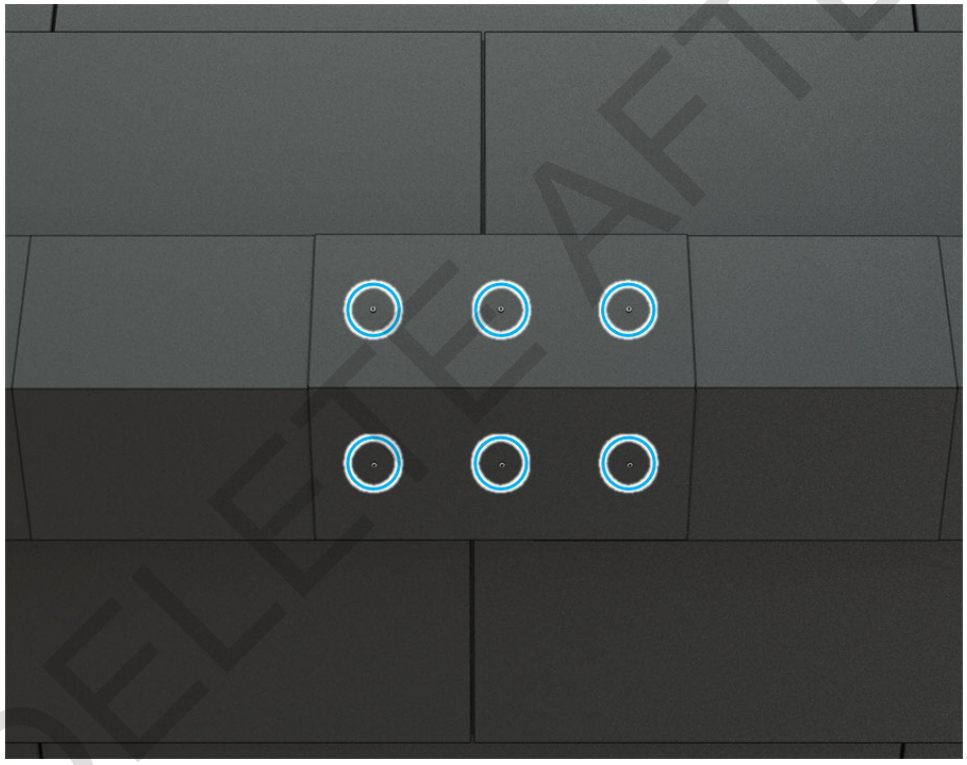


6. Use a break to create a closed hem on the ½ inch line created in step 3.



7. Use the ridge splice just fabricated to cover the void in the ridge assembly, making sure that the splice is centered over the other caps as evenly as possible.

8. Fasten the ridge splice using 6 self-tapping screws.
    - 2 in the pre-existing divot, as normal,
    - 2 placed 1½ in from the opposite edge, in line with the divot,
    - 2 placed evenly between the edge fasteners.



Finished Ridge Splice:

Splicing Perimeter Metals

Splicing Drip Edge Metals

A drip edge splice is used when adjoining a new full or partial course of drip edge flashing at the deck level during phase 1.

Tools and Equipment:

- Carpenter's pencil
- Speed square
- Right & left-handed offset snips
- Hand seamers
- Utility knife

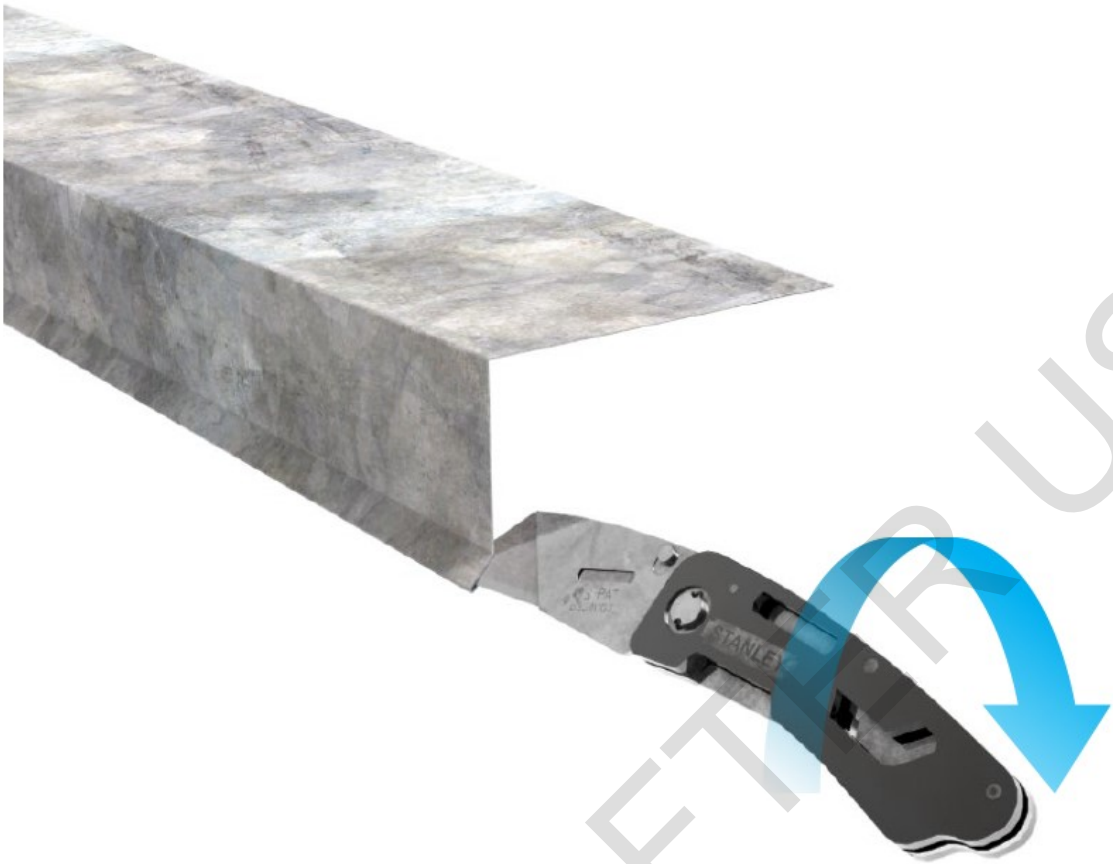
Components:

- FLASHING, Peakwall, Drip Edge, 1559032-00-B
- FLASHING, Drip Edge, 1145619-21-A

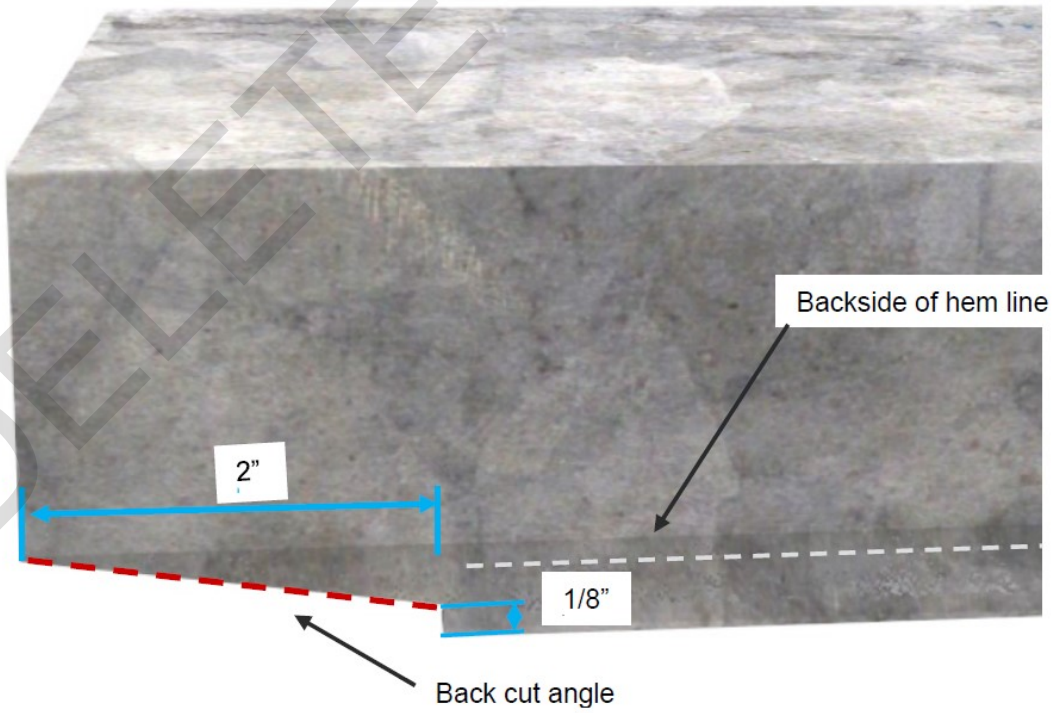
PPE:

- Safety glasses
- Cut-resistant gloves
- Fall protection

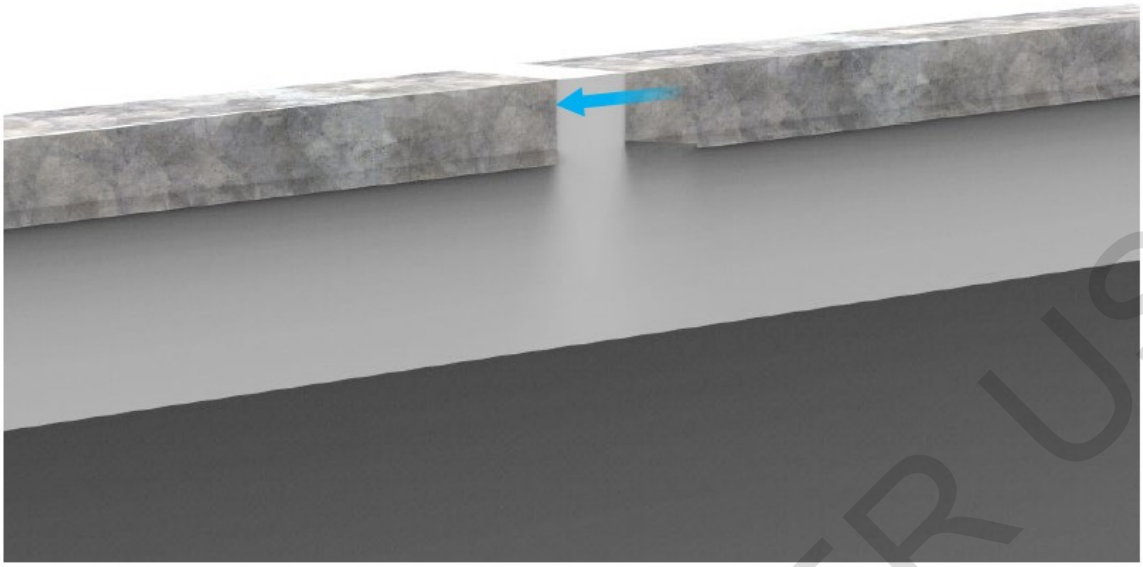
1. Open up the closed hem with a utility knife on the side you want to splice.



2. Next, take a new whole stick of the drip edge flashing and mark out 1/8 in up from the edge of the drip flange and 2 in off the edge.

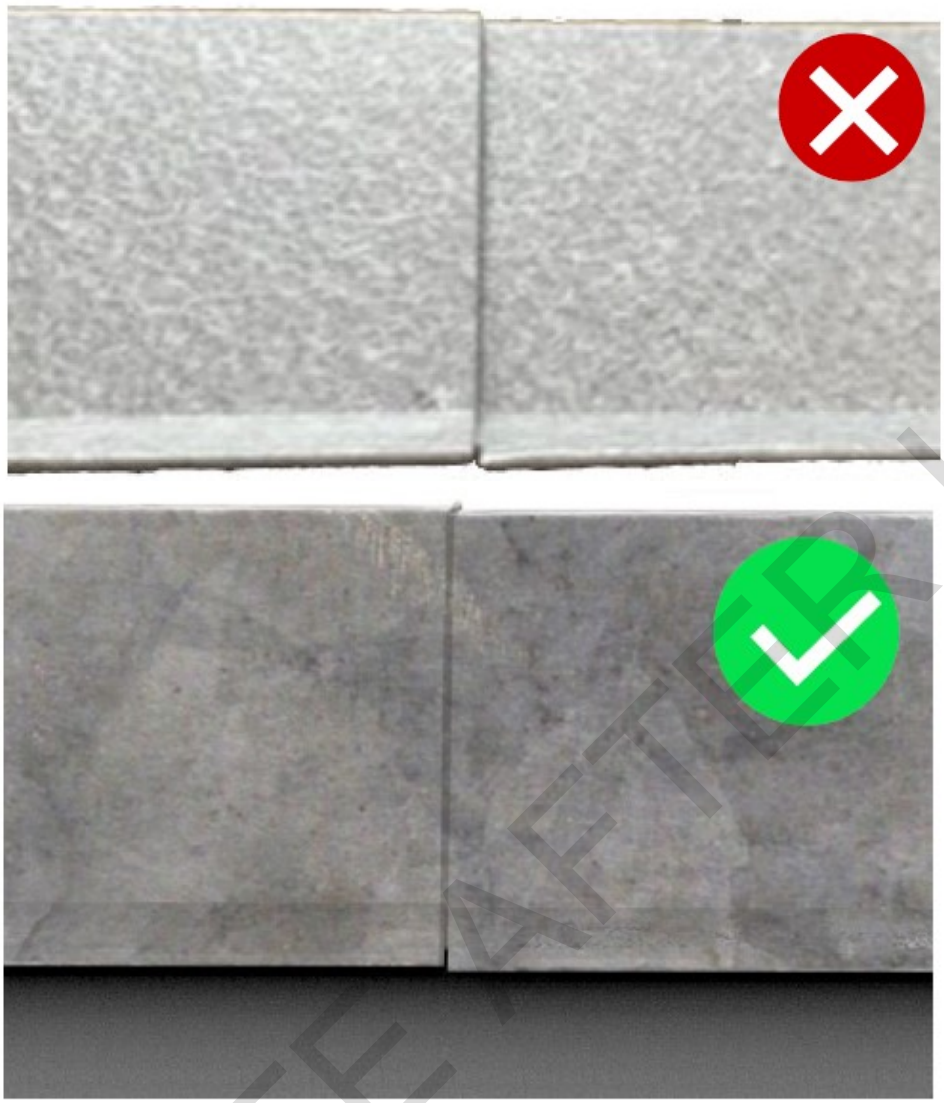


3. Slide the cut drip edge into the opened hem.



NOTE: Ensure a tight fit by closing the hem with hand seamer.

a. Ensure the splice is even and not stepped.

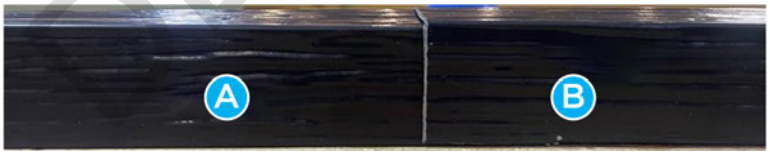


Splicing Channel Flashing

Overview:

This section provides instructions for splicing two pieces of channel flashing together by creating a down roof and up roof splice.

Pictured: Down roof splice **(A)**, up roof splice **(B)**



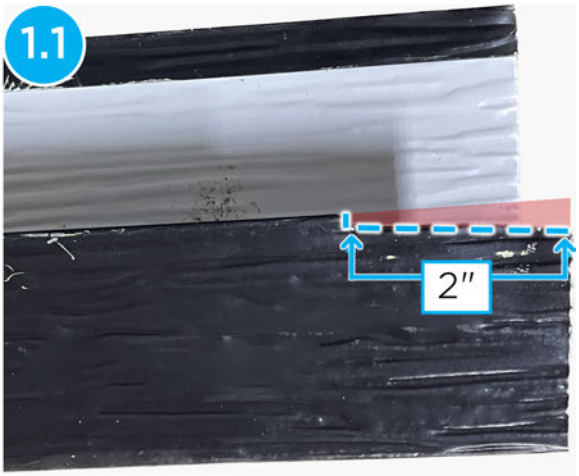
Tools & Equipment:

- Metal snips

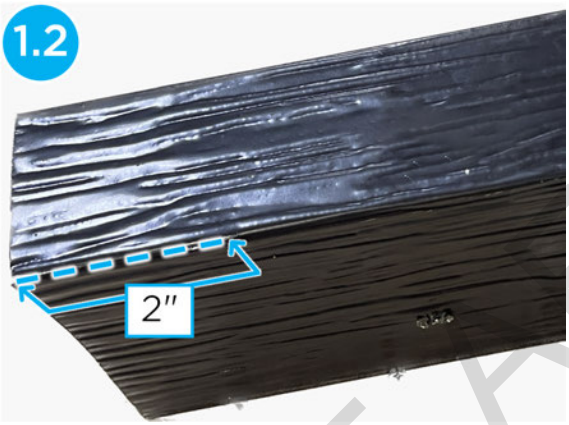
Work Instructions:

1. Cut channel flashing to create a down-roof and up-roof splice **(1)**.

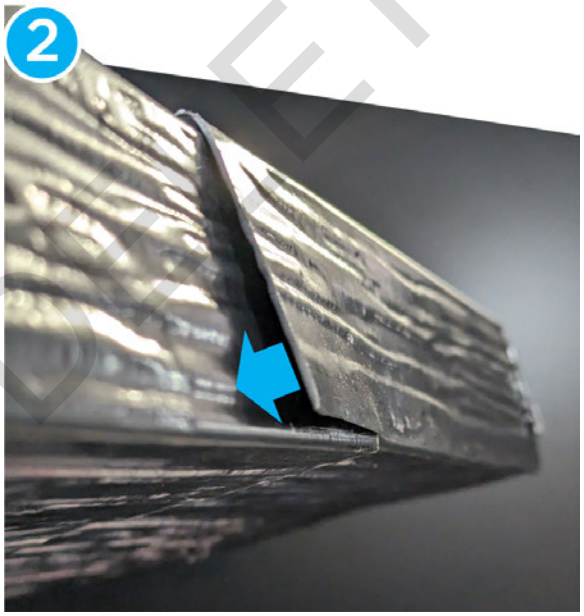
- **Down-roof splice:** Cut the upper flange's hem back 2 in **(1.1)**.

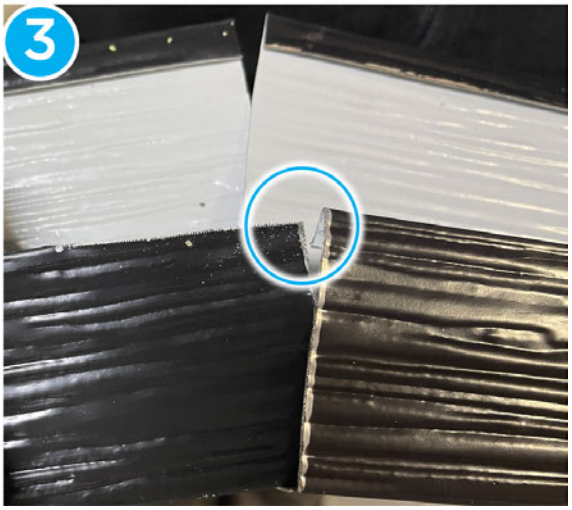


- **Up-roof splice:** Make a 2 in cut along the lower bend **(1.2)**.



2. Before splicing the down-roof splice and up-roof splice together, bend the vertical face of the up-roof splice inwards to prevent the metal from sticking out after the splice is made **(2)**. Then, open the hem of the up-roof splice's upper flange with a flat tool to allow the down two pieces of channel flashing to slide together **(3)**.





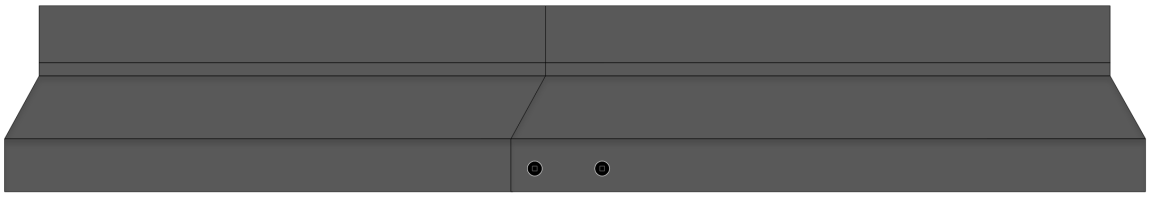
3. Slide the down roof splice **(A)** and the up roof splice **(B)** together. Ensure that the lower flange of the up roof splice laps over the lower flange of the down roof splice **(4)**.

Splicing Transition Flashing

Overview:

This section provides instructions for splicing two pieces of transition flashing together.

Pictured: Spliced transition flashing for reference.



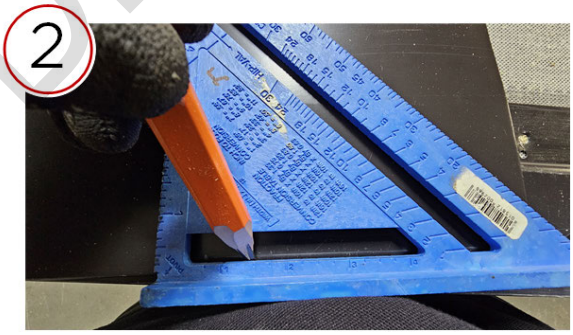
Tools & Equipment:

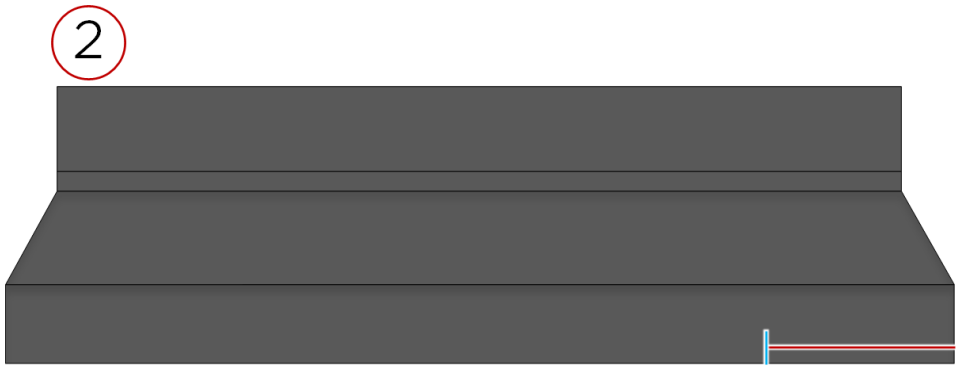
- Transition flashing
- Metal snips
- Speed square

Work Instructions:

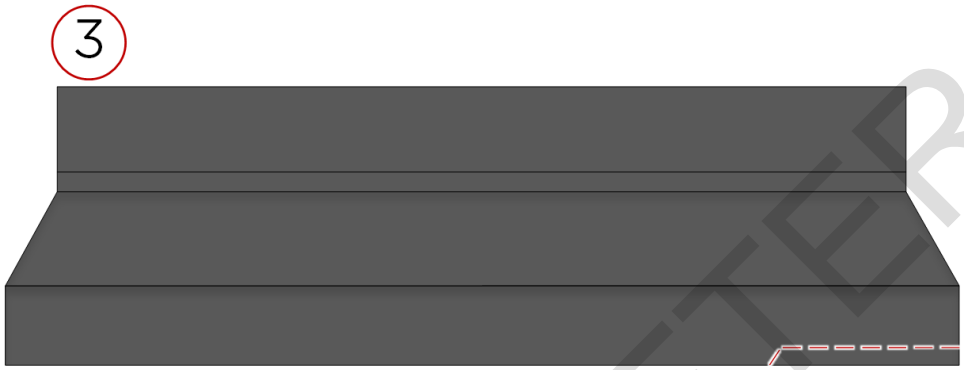
1. Begin by measuring 6 in from the edge of the bottom flange on the transition flashing requiring splicing. Mark this 6 in point with a vertical line **(1)**.

2. Press the speed square flush to the front hemmed edge of the bottom flange and trace a horizontal line from the edge to the mark made in step 1 **(2)**.
Pictured: Speed square flush against the front hemmed edge.

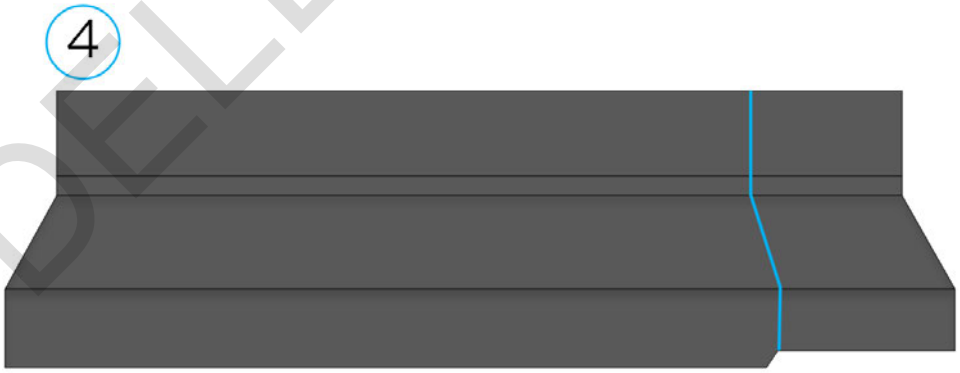




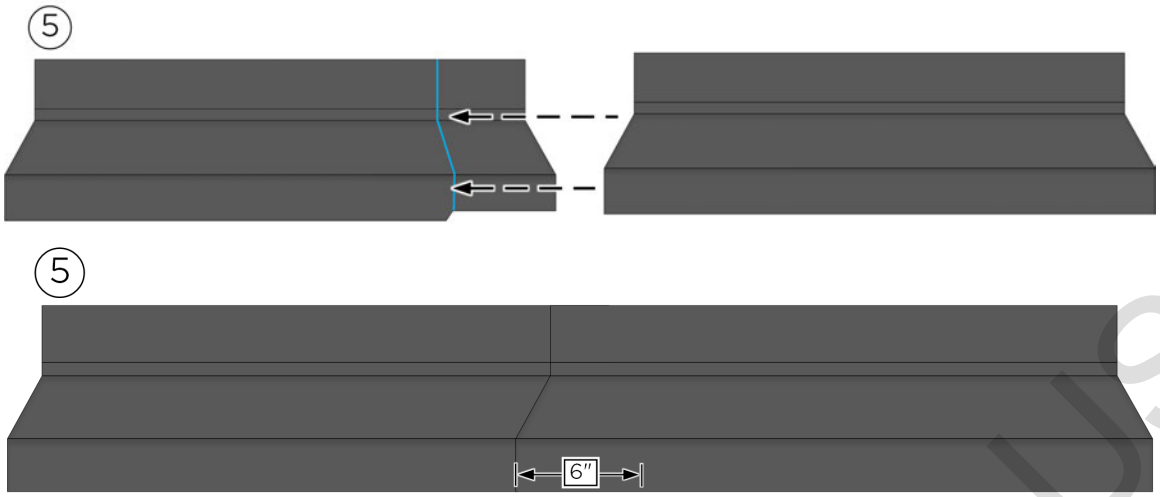
3. Cut along the horizontal line and make an angled cut close to the 6 in vertical mark **(3)**.



4. Apply a line of sealant across the cut transition flashing towards the angled cut **(4)**.

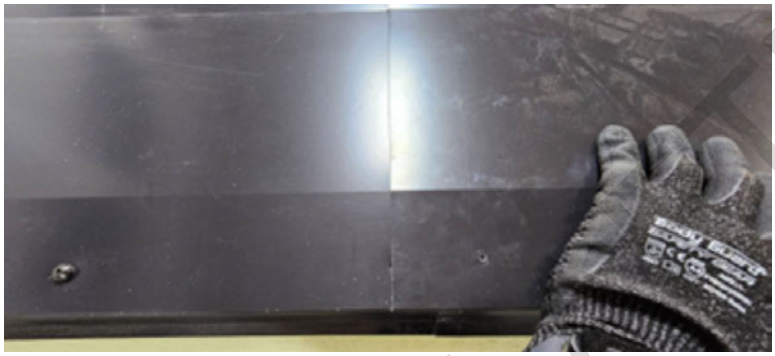


5. Then, slide the next piece of transition flashing over the first until it aligns with the cut. This second piece of transition flashing will overlap the first by 6 in **(5)**.

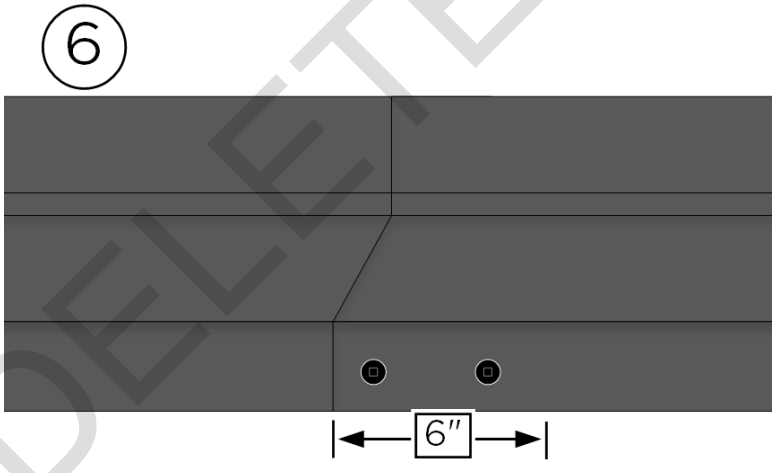


If an ideal cut is made, it will not be visible once spliced.

Pictured: Successful transition flashing splice, cut is not visible.



6. Fasten the splice with 2 gasketed self-tapping screws. Ensure both fasteners land within the 6 in flashing overlap **(6)**.



Round Obstructions

Drain Waste Vent (DWV)

Dry In - Drain Waste Vents (DWV)

Overview

This section provides instructions for drying in drain waste vents (DWV) and cast iron pipes by installing underlayment and DWV flashing.

Tools and Equipment:

- Utility knife
- Underlayment
- DWV - Flashing
- Flexible flashing (only for cast iron pipes)

Flashing Cut Parameters

Refer to the table below for guidance on cutting the DWV flashing to size.

DWV Pipe Size (inches)	How to Cut with Utility Knife
1-¼ - 1-½	Cut and remove the inner most circle.
2	Cut and remove the second inner most circle.
3	Cut and remove the third inner most circle.
4	Cut and remove the outermost circle.

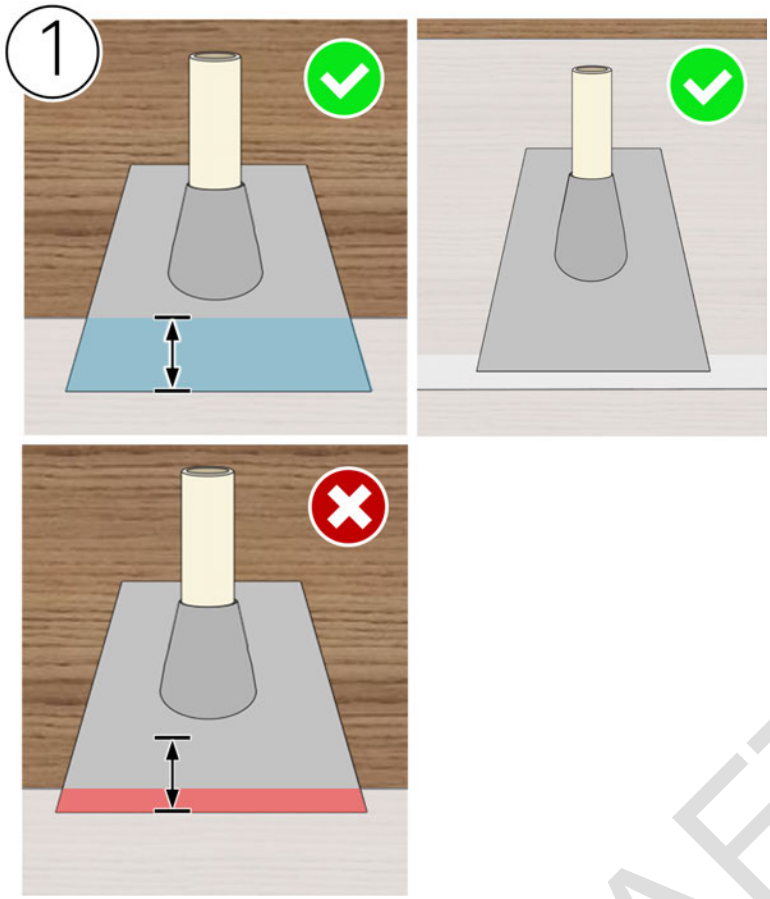
NOTE: To avoid ripping the rubber while cutting the DWV flashing, make a small cut on the flat portion of the appropriate ring **(1)**, press down **(2)** and then pull alongthe curve of the guideline inwards of the boot **(3)**.

PRO TIP: To achieve the best quality tear, pull the tab in a circular motion, tracing the edge of the circle. Pulling in a straight line may result in a poor-quality tear.

IMPORTANT: If the tear exceeds the ring for the appropriate pipe size, the boot will no longer properly seal against the pipe. Discard and replace any parts that tear outside of the proper ring.

Drain Waste Vent (DWV) Dry In

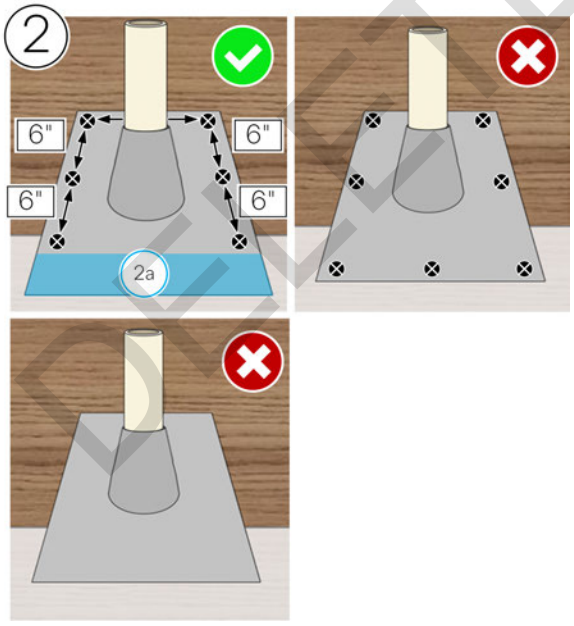
Lap the bottom edge of the DWV flashing over the underlayment a minimum of 3 in **(1)**.



Every 6 in, fasten 1 in from the flashing edge **(2)**.

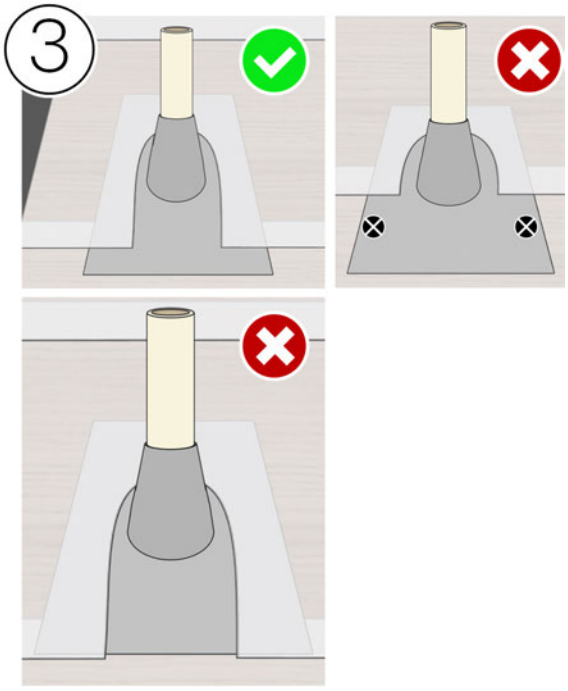
NOTE: Do NOT install fasteners along the bottom edge.

Pictured: No fastener zones **(2a)**.

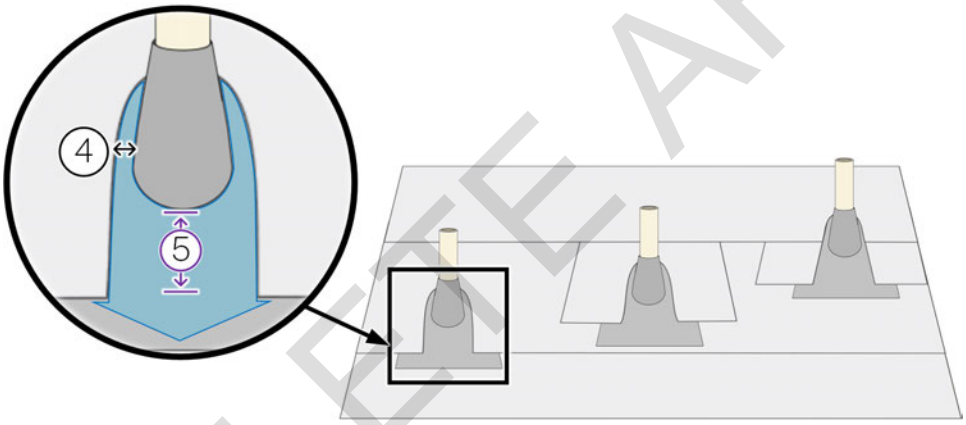


Lap underlayment over the DWV flashing, ensuring that all fasteners are covered **(3)**.

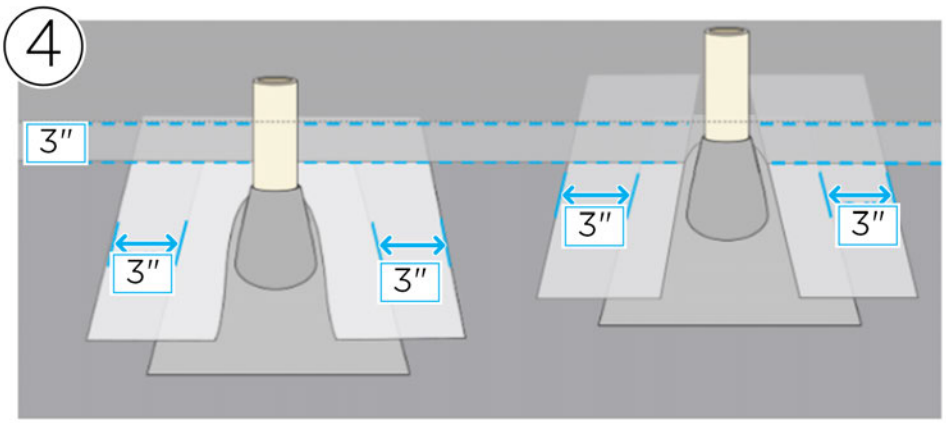
NOTE: Do NOT lap underlayment beyond the bottom of the DWV flashing.



Ensure that a ½ in to 1 in washout is maintained around the bell mouth of the pipe flashing **(4)**, and that the underlayment extends at least 1 in below the bottom of the bell mouth **(5).**



If the pipe sits between courses of underlayment (causing a gap in coverage over the pipe flashing), use underlayment patches. Patches must extend a minimum of 3 in beyond the left and right edges of the flashing. Patches must be integrated properly with the underlayment courses above to avoid bucking edges, using a 3 in minimum overlap with the next course of underlayment).



Cast Iron Pipe Dry In

When drying in a cast iron pipe, flexible flashing is installed around the pipe in addition to the DWV flashing.

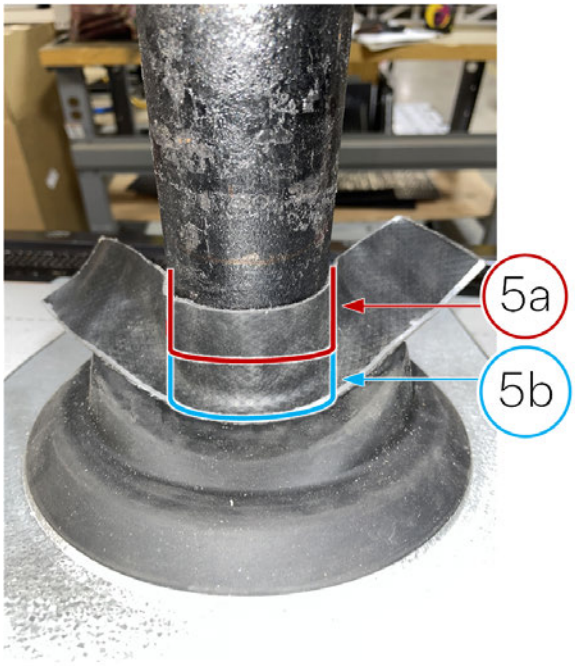
Pictured: Dried in cast iron pipe.

Cut a 2 in strip of flexible flashing from the roll **(1)**.

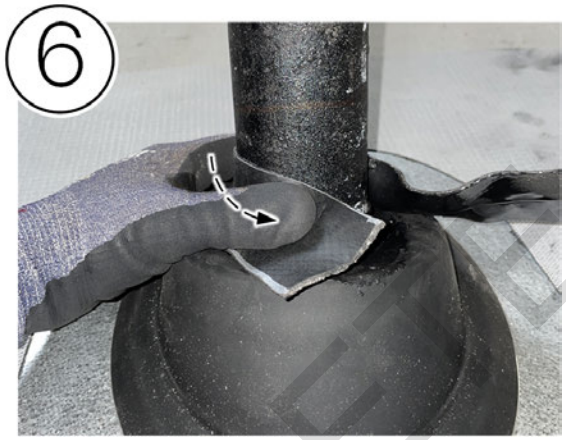
Do **not** remove the flexible flashing backing at this point. Position the flexible flashing piece on the up roof-facing side of the pipe **(2)** and form the piece to the shape of the pipe **(3)**.

Remove the flashing's backing **(4)** and apply the flexible flashing piece to the up roof-facing side of the pipe **(5)**.

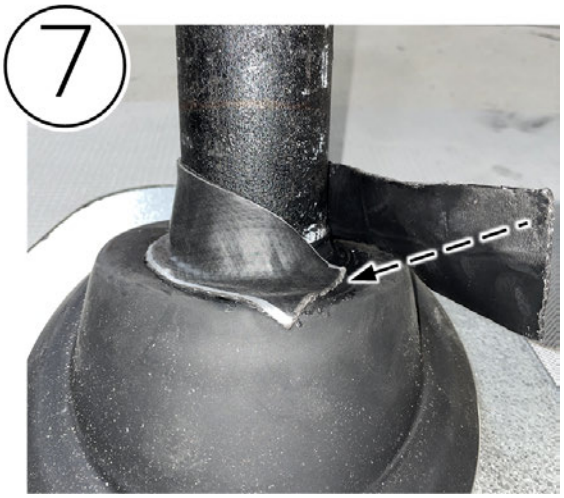
NOTE: Ensure the flexible flashing overlaps **both** the pipe **(5a)** and DWV flashing **(5b)** to create a watertight seal.

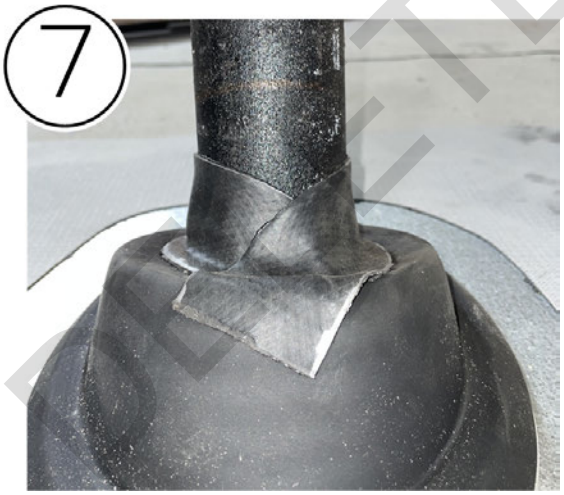


Press one side of the flexible flashing piece tight to the pipe until it is fully stuck to both the pipe and the DWV flashing **(6)**.



Press the remaining side of the flexible flashing tight to the pipe and overlap the first side applied in step 6 **(7)**.

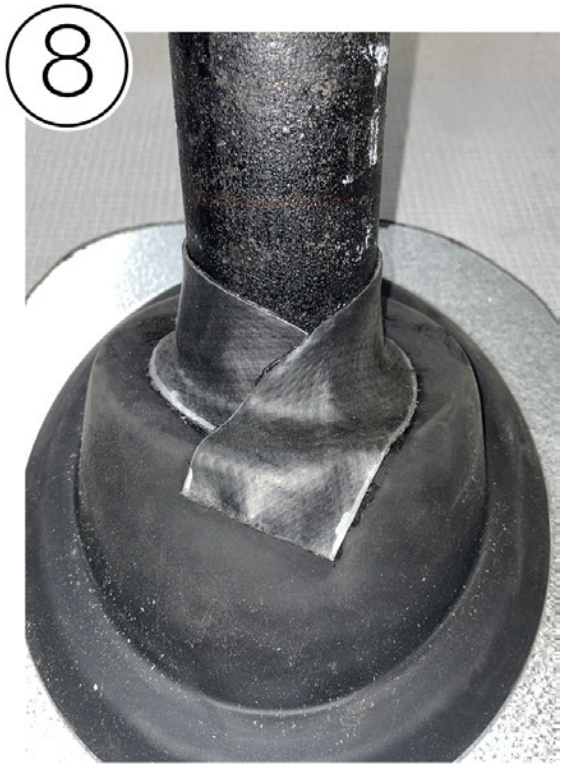




Firmly press all around the flexible flashing (especially in the crease) to smooth out any wrinkles and ensure the flexible flashing is pressed tightly to both the pipe and DWV flashing **(8)**.

8

8



SRI - Drain Waste Vents (DWV)

Overview

This section provides instructions for installing tiles and flashing around drain waste vents (DWV).

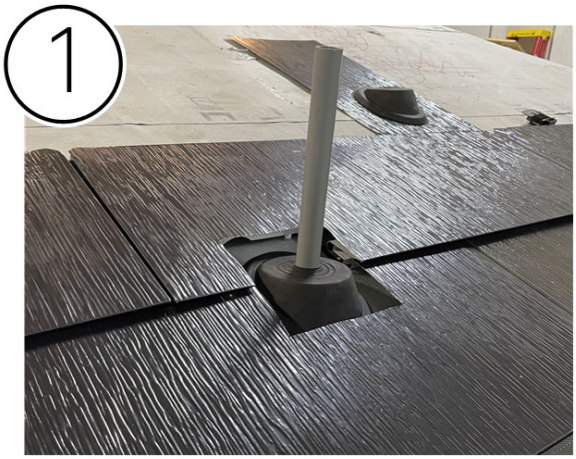
Tools & Equipment

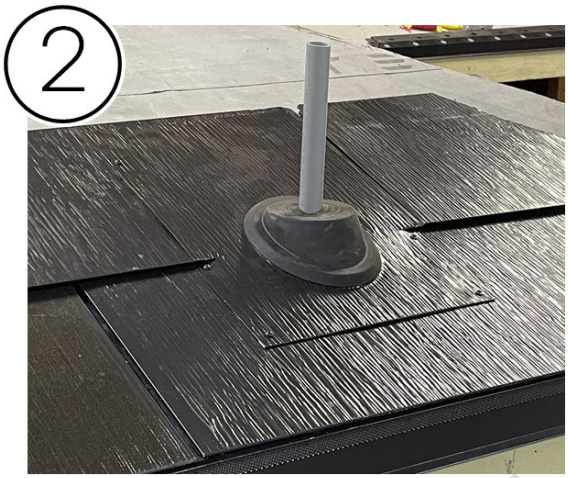
- Metal snips
- Metal tiles
- DWV - Flashing
- Utility knife

Refer to the "Flashing Cut Parameters" section above for guidance on cutting the DWV flashing to size.

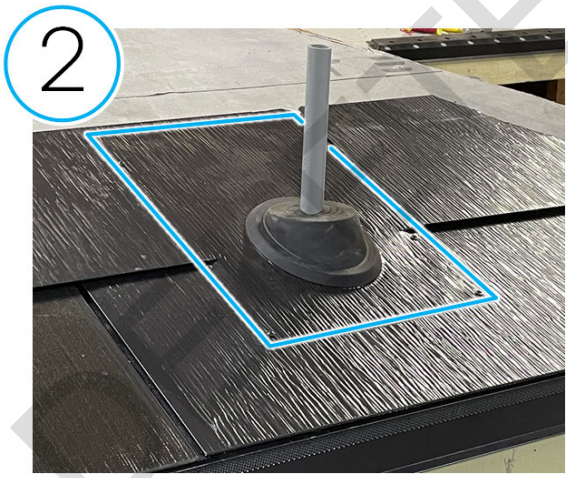
Work Instructions

Cut and install tiles around the deck-level flashing **(1)**. A 1 in gap between the bell mouth of the deck-level flashing and the cut tile edges is ideal. Install the tile-level flashing **(2)**.

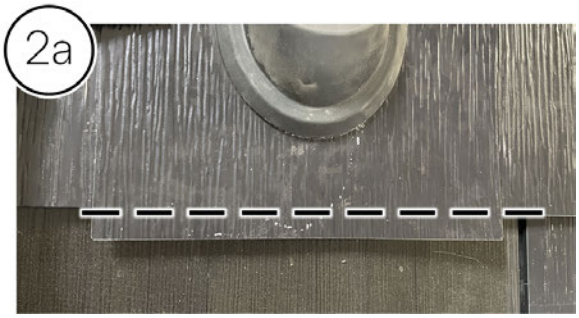


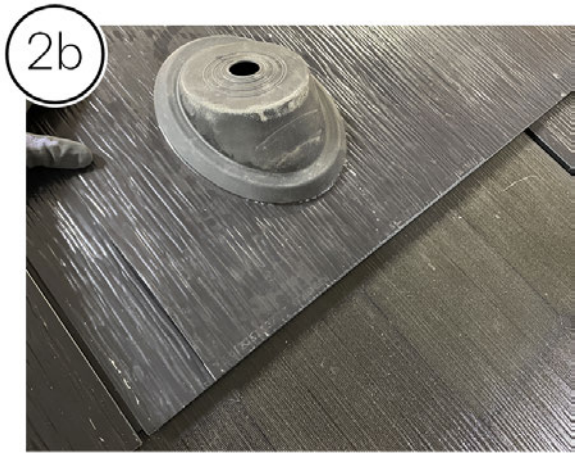


Pictured: Flashing edges highlighted for visibility.

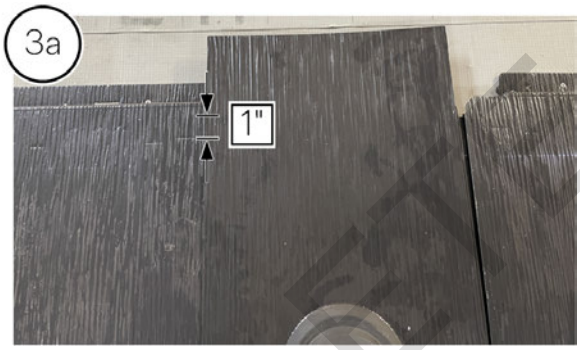


If the front flange of the flashing below the boot overhangs the leading edge of the tile **(2a)**, hem the flashing edge to align with the tile **(2b)**.

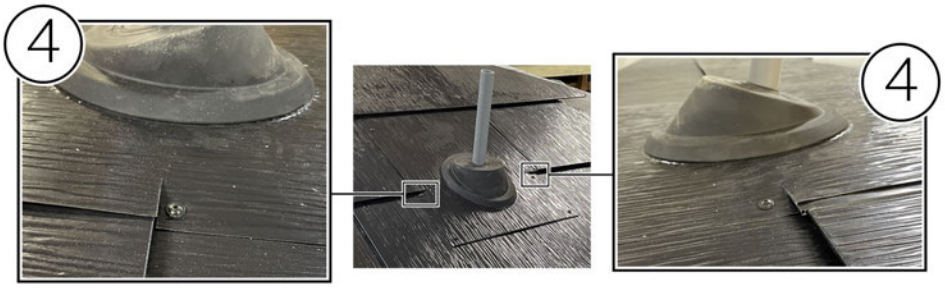


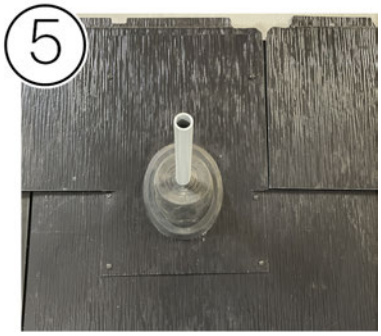


The DWV flashing up roof flange must lap underneath the drip edge of the upper tile course. To achieve this, measure and mark the DWV flashing at 1 in from the reveal lines of the metal tile installed underneath the DWV flashing **(3a)**. Cut along this point to remove excess material. Ensure the flashing terminates at just below the metal tile nailing flange **(3b).**

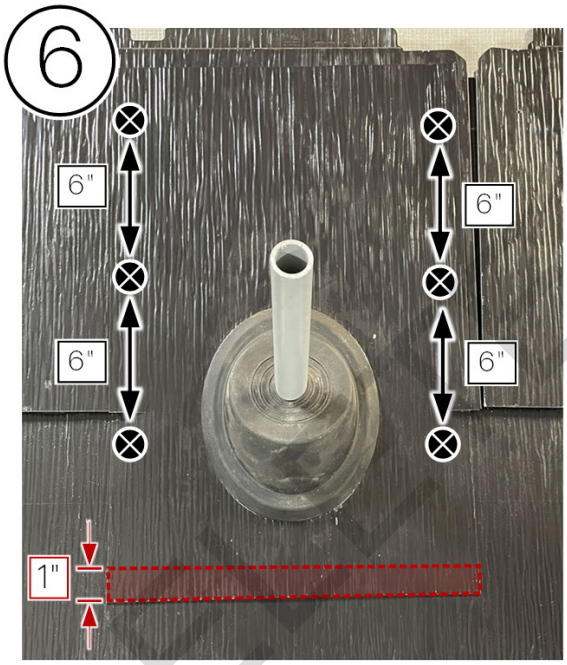


If the tile-level flashing must lap over a tile's drip edge, make 1 in relief cuts on both sides of the flashing flange **(4)**, then secure the flashing with self-tappers **(5)**.



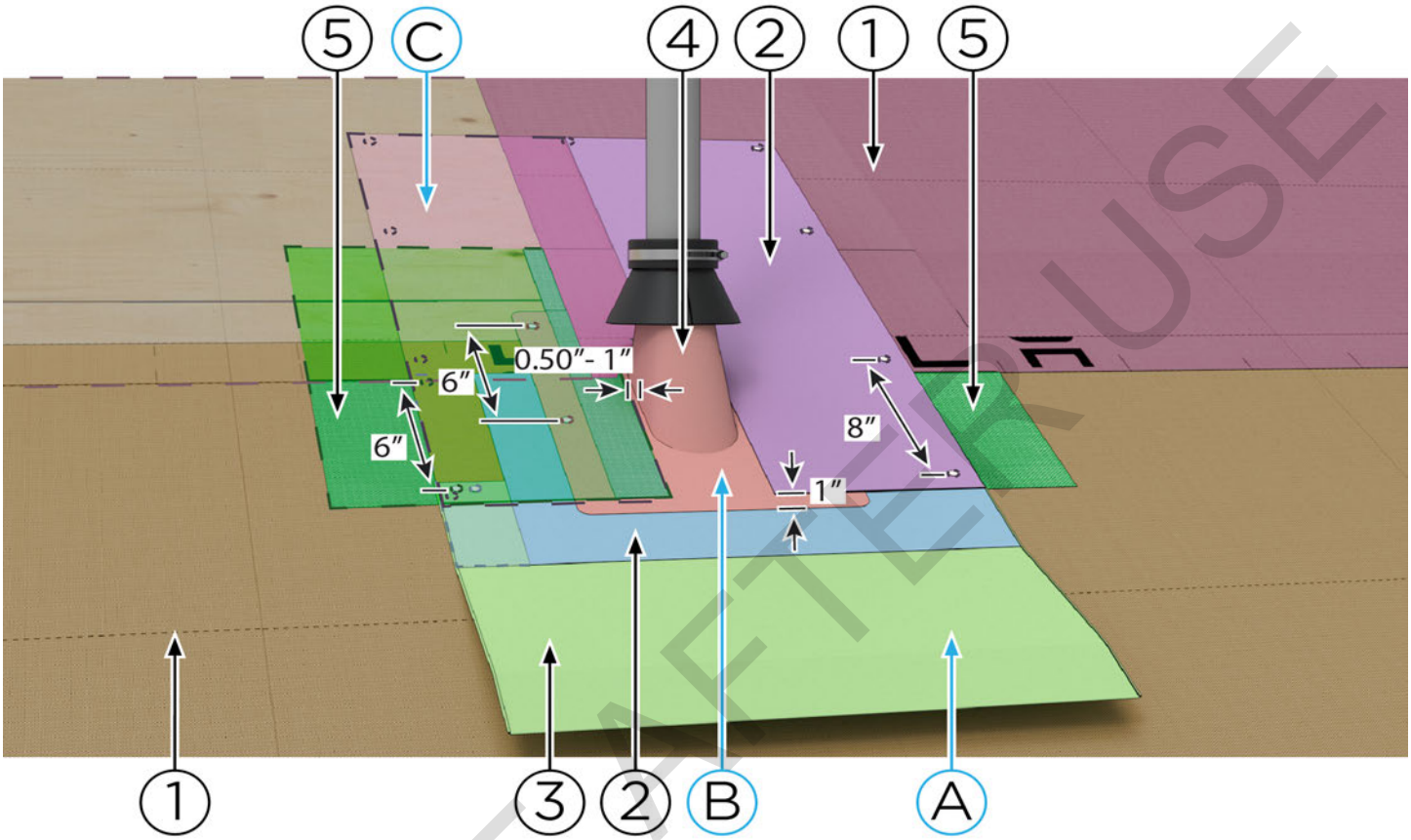


Install additional fasteners as needed along the sides of the DWV flashing to achieve a 6 in O.C. maximum spacing. Do **not** fasten within 1 in of the down roof edge of the DWV flashing **(6)**.



Overhead Service Drop

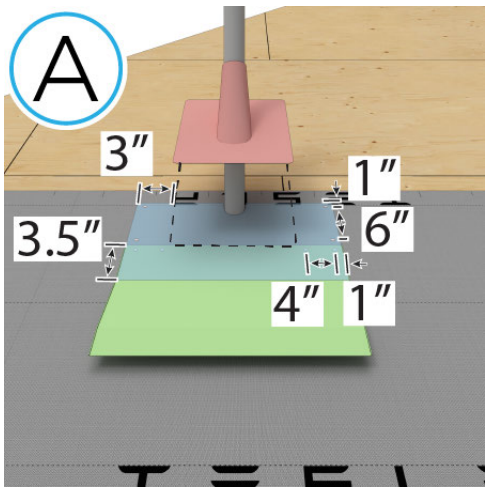
Dry In

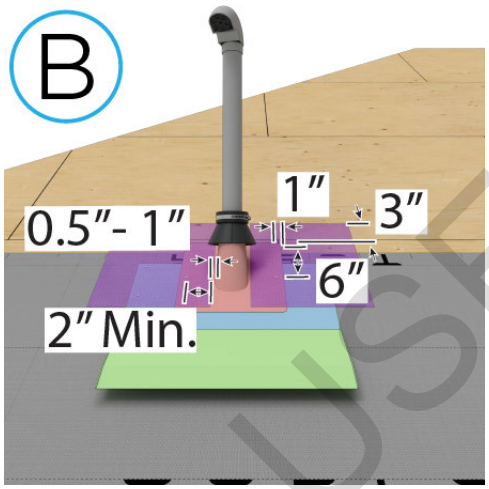


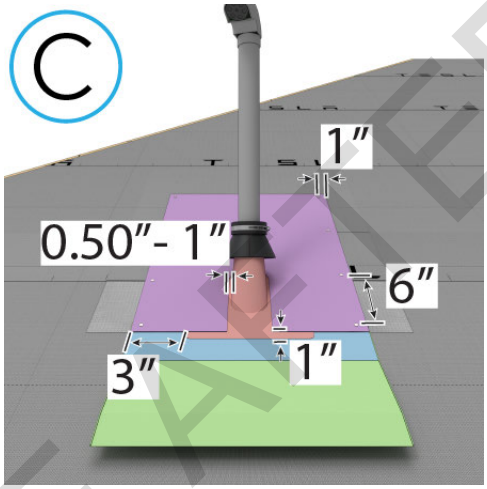
1	Underlayment	**2**	Flat Stock
3	Transition Flashing	**4**	Existing Overhead Service Drop Flashing
5	Detail Roll		

See detail images on next page.

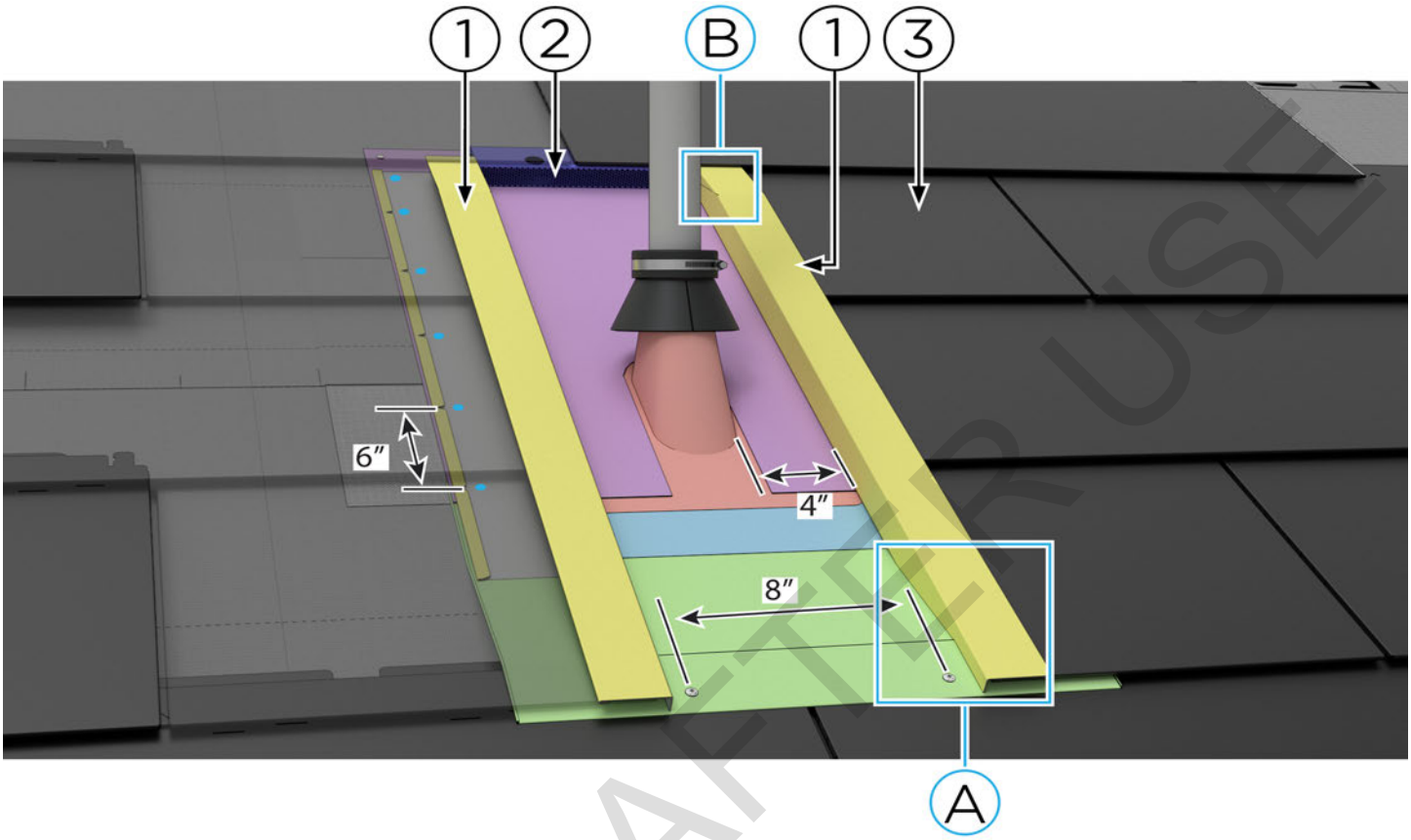
A	Apply underlayment up to the overhead service drop and install transition flashing cut 3 in wider than the service drop flashing against the down-roof edge of the service drop flashing. Fasten the transition flashing 1 in and 5 in from the left and right edges. Use flat stock to seal between the transition flashing and service drop flashing by making a bib facing up-roof. The bib should be 3 in wider than the service drop flashing on both sides, and extend up-roof 1 in past the service drop, overlapping the transition flashing on the down-roof side by 3 ½ in. Fasten the bib at 1 in and 7 in down from the top edge on both sides. Do NOT fasten the flat stock to the transition flashing.
B	Place the existing overhead service drop flashing over the flat stock and fasten it at 1 in from the top edge and every 6 in from there. Apply two pieces of detail roll that each sit ½ - 1 in away from the overhead service drop, extend 3 in past the top edge of the existing service drop flashing and cover the existing service drop flashing a minimum of 2 in.
C	Create a down-roof-facing flat stock bib over the existing service drop flashing that leaves a ½ - 1 in gap around the overhead service drop, terminates 1 in from the down-roof edge of the existing service drop flashing and covers the previous flat stock by 3 in from the existing service drop flashing.



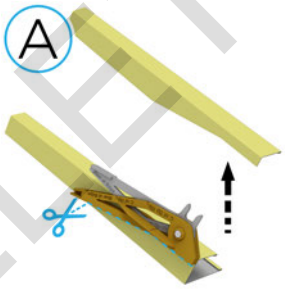




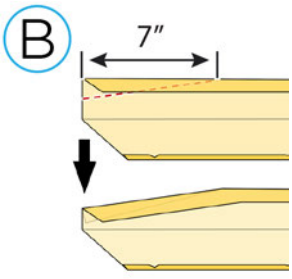
Tile Install



1	Channel Flashing
2	Vented Riser
3	Metal Tile

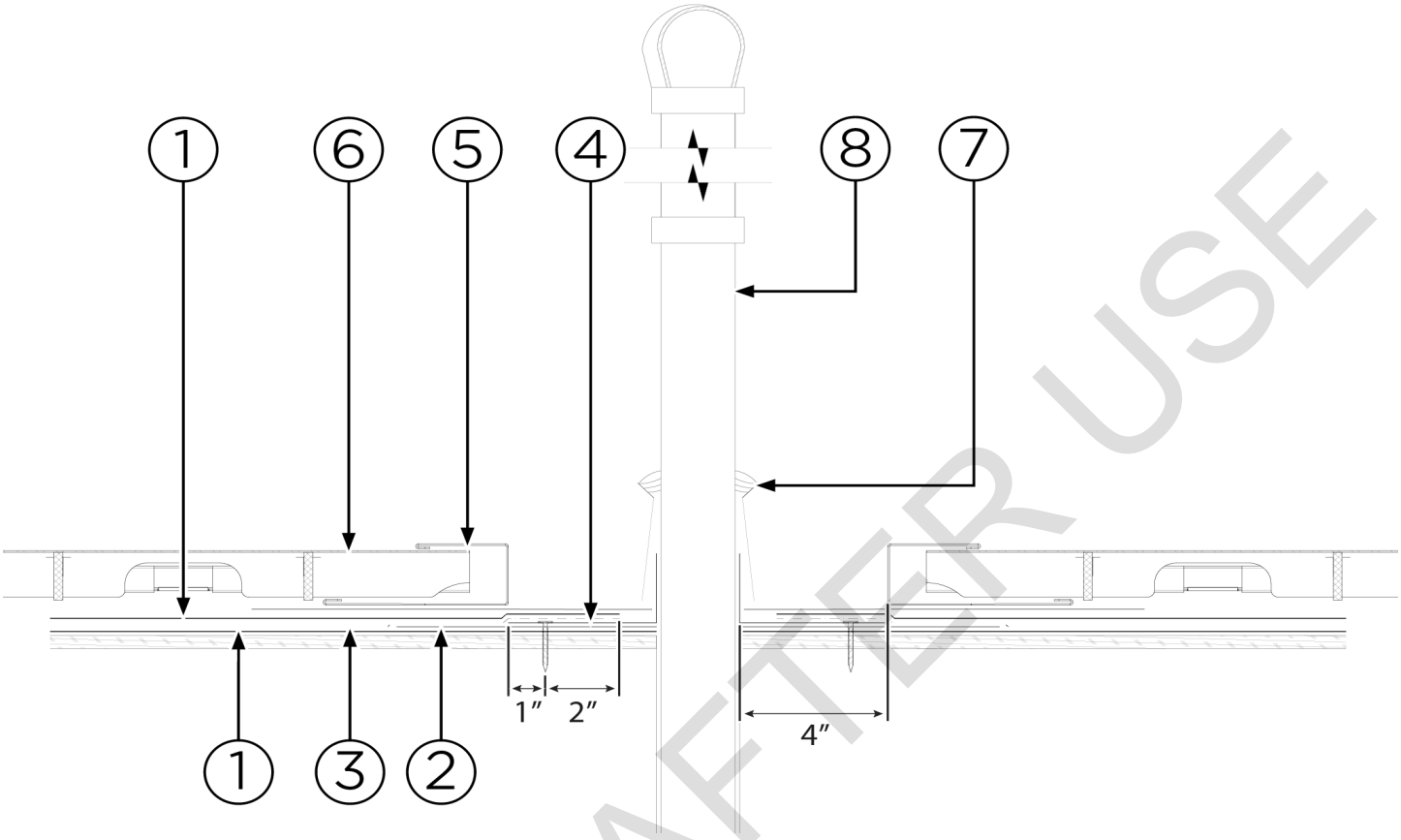


Install channel flashing 4 in from the edge of the overhead service drop neck. Where the channel flashing laps over the transition flashing, cut material away from the deck flange and vertical face of the channel flashing to fit the profile of the transition flashing. The robin jig can be used to trace this profile.



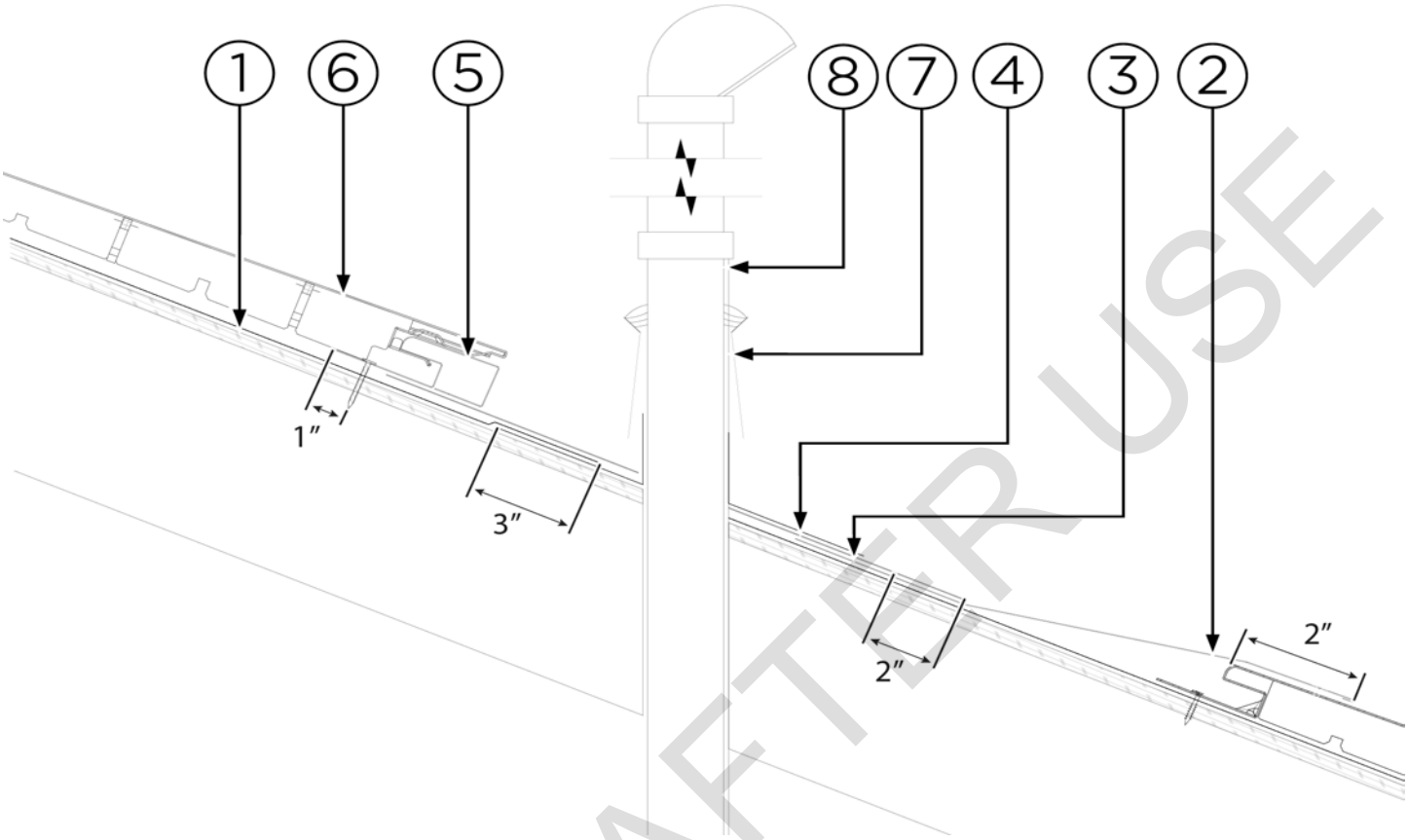
Make a 7 in relief cut along the vertical face of the channel flashing to allow the channel flashing to lap under the tile course installed up-roof.

Cross Section: Overhead Service Drop A



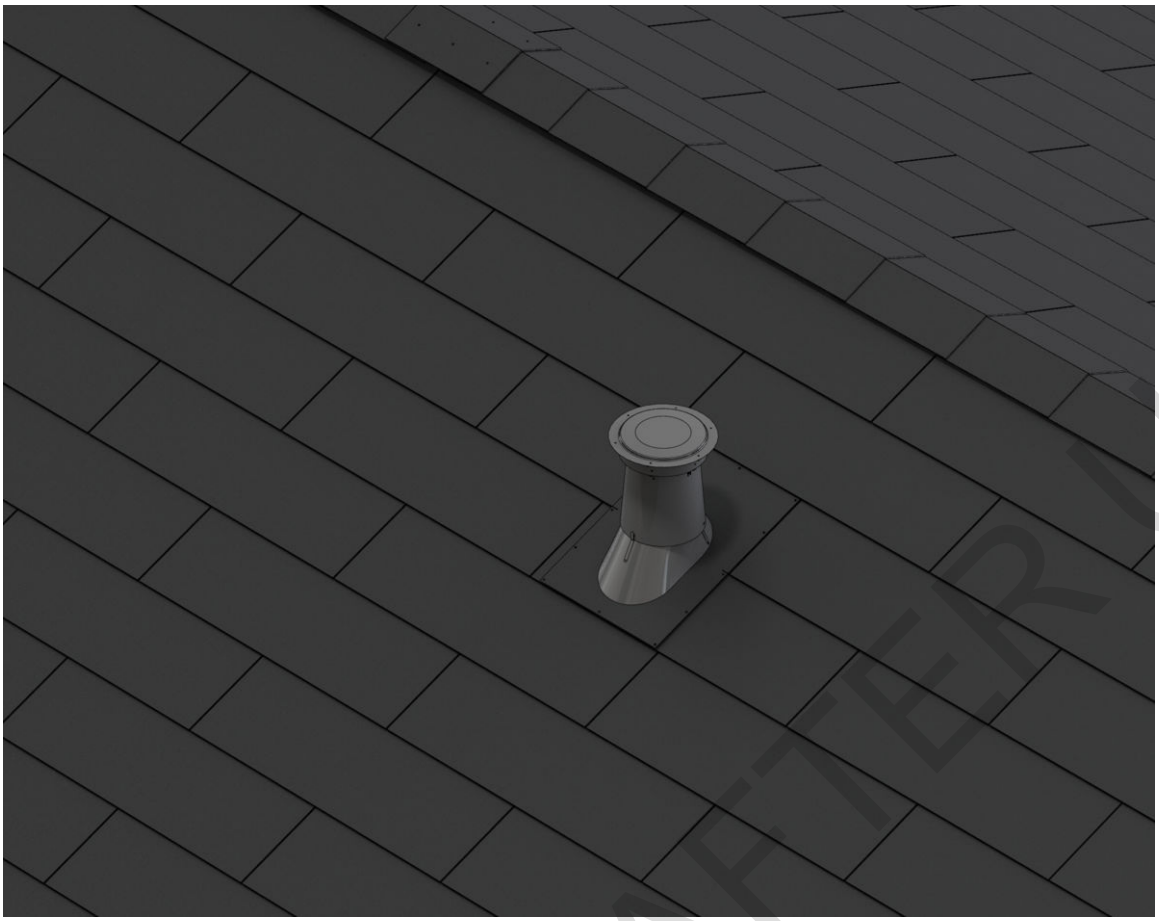
1	Underlayment
2	Flat Stock
3	Detail Roll
4	Existing Flashing
5	Channel Flashing
6	Metal Tile
7	Rain Collar
8	Overhead Service Drop

Cross Section: Overhead Service Drop B



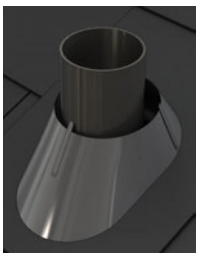
1	Underlayment
2	Transition Flashing
3	Flat Stock
4	Existing Flashing
5	Channel Flashing
6	Metal Tile
7	Rain Collar
8	Overhead Service Drop

Circular Vents



Heat Vent

This section goes over the process of installing the heat vent and heat cap.

Deck Level Heat Vent Flashing	Tile Level Heat Vent Flashing	Tile Level Heat Vent Cap
	 	

Tools and Materials

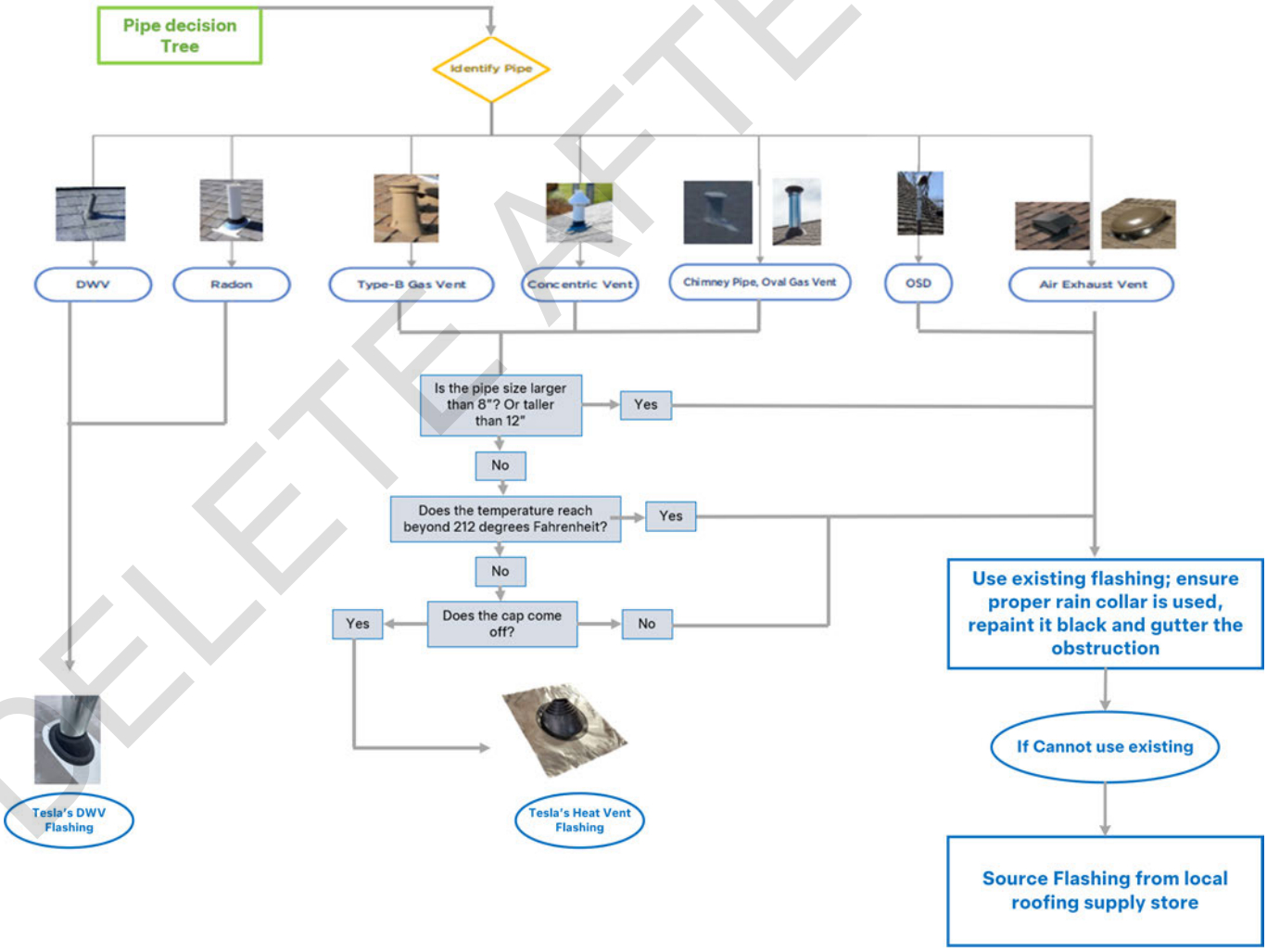
- Deck Level Heat Vent Flashing
- Tile Level Heat Vent Flashing

- Tile Level Heat Vent Cap
- Metal Snips
- Speed Square
- Pencil/Marker
- Knife
- Impact/Nail Gun
- Self-Tapper
- Level

Pipe Decision Tree

First, determine if the deck level and tile level heat vent is compatible with the existing vent on the roof.

1. Tesla deck level covers vents from 3 to 8 in.
2. Tesla tile level heat vents come in two different sizes: 4 in and 8 in.
    a. These two sizes will cover most common heat pipe sizes.
    b. All other sizes need to be sourced from a local roofing supply store.



Type B Gas Vent Pipes and Air Exhaust Vents 8 in or Smaller in Diameter

Ensure that all vent pipes are Type B only!

Chimney pipes or other high temperature vent pipes will not work with the deck level heat vent flashing.

The deck level heat vent flashing may only be used when temperatures of the pipe do not reach above 212° Fahrenheit.

NOTE: Pipe sizes and types that do not meet the adjustable deck level heat vent flashing parameters must be sourced from local roofing retailers.

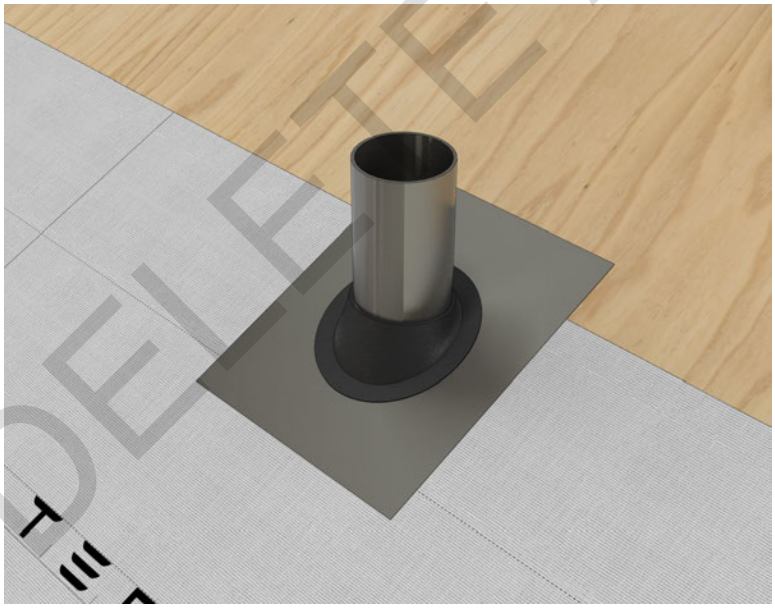
Double Wall Heat Vent

Single or Triple Wall Heat Vent

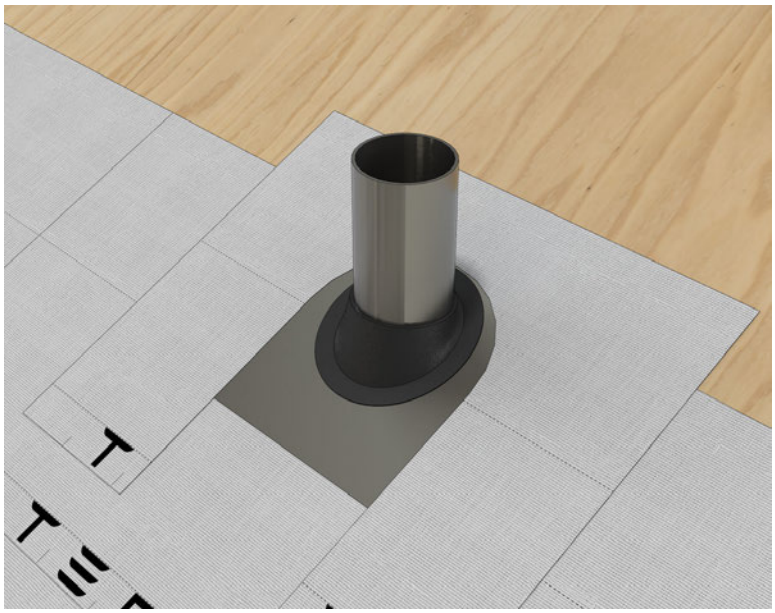
Dry In Process

This is the same procedure used in *Drain Waste Vent (DWV) on page 271*.

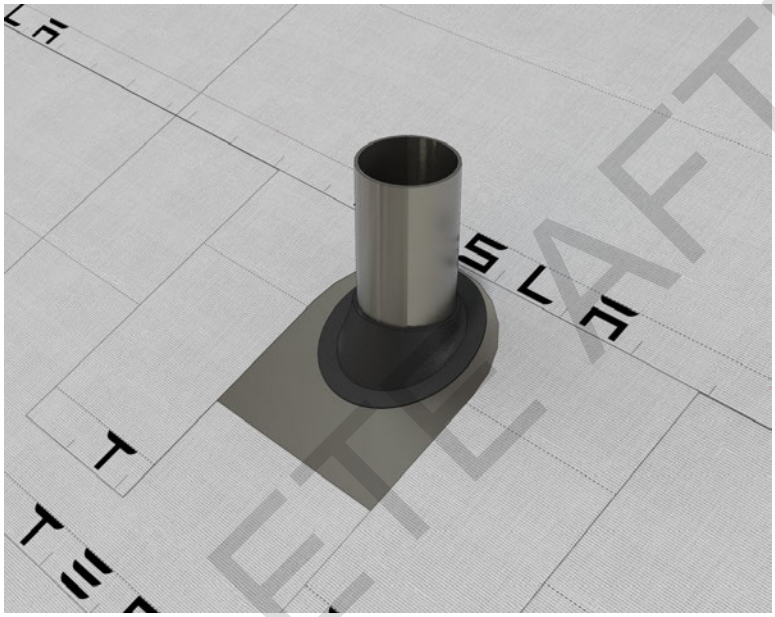
1. Install the deck level heat vent flashing.



2. Install the underlayment "saddle" over the top of the deck level heat vent flashing.



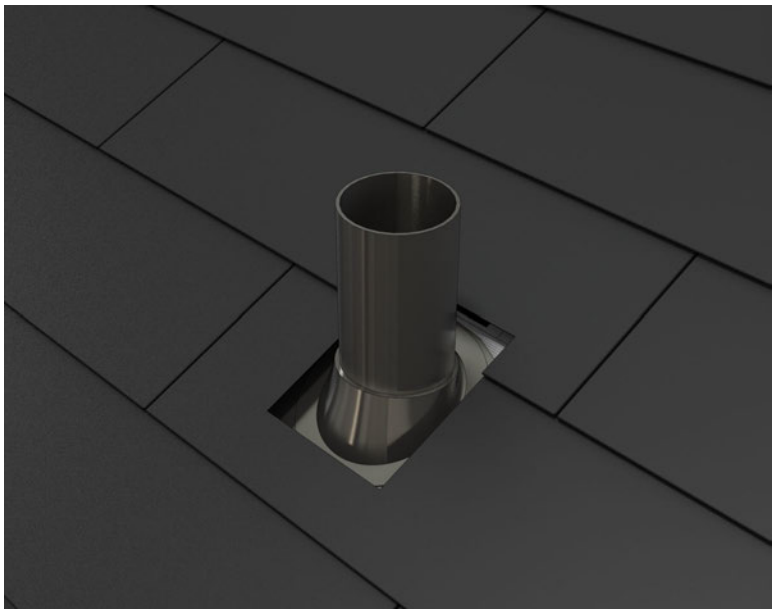
3. Install the next course of underlayment.



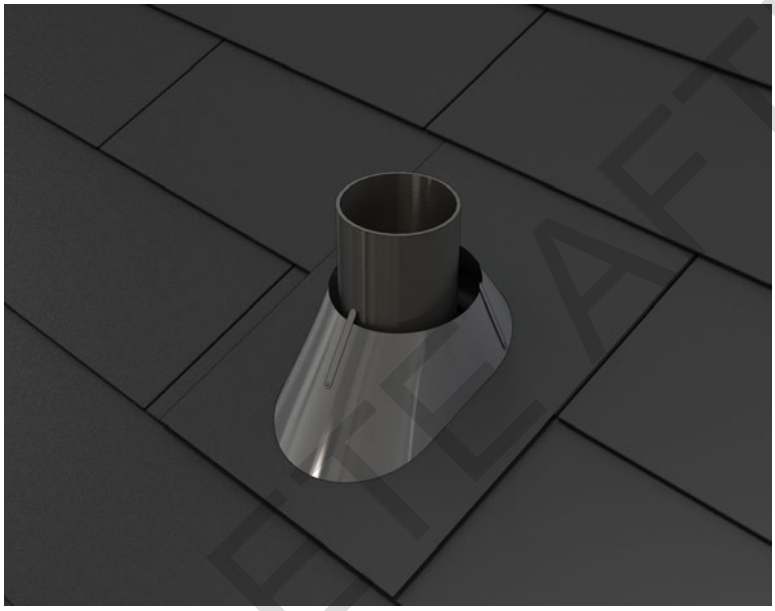
Tile Level Process

This is the same procedure use in *Drain Waste Vent (DWV) on page 271* (except the heat vent cap).

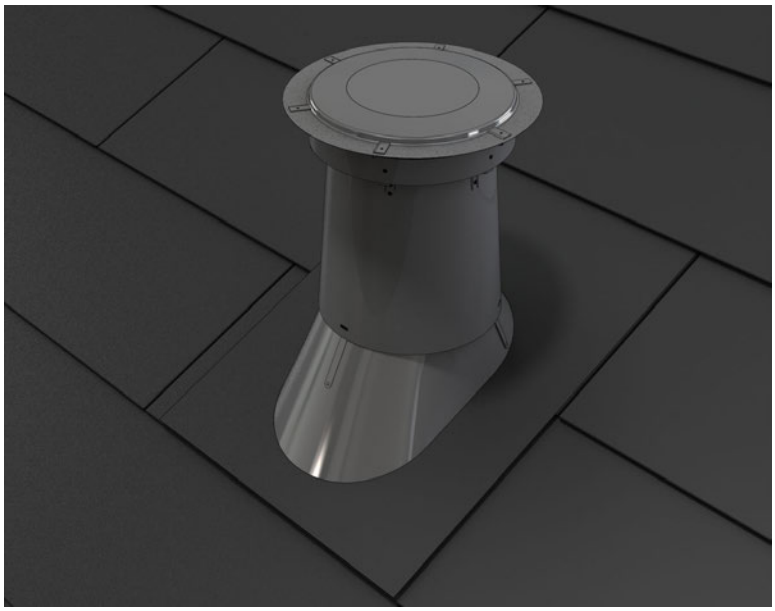
1. Cut and install the metal tiles around the deck level heat vent flashing.



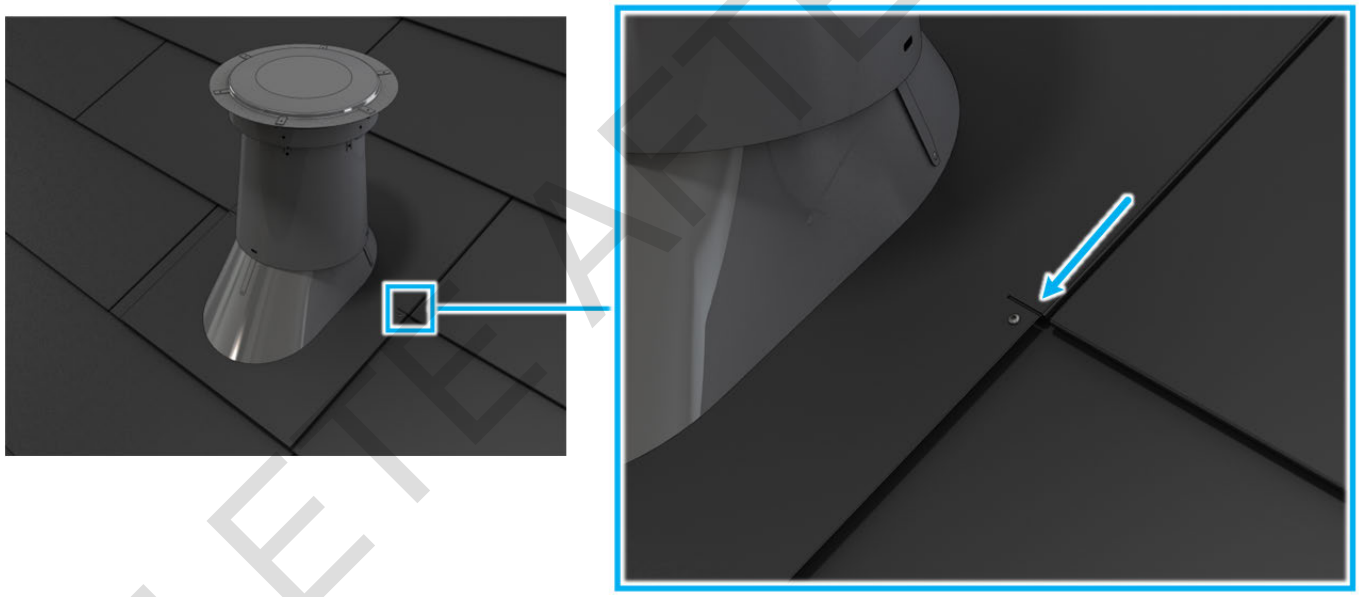
2. Install the tile level heat vent flashing to cover the rough cuts in the tiles.



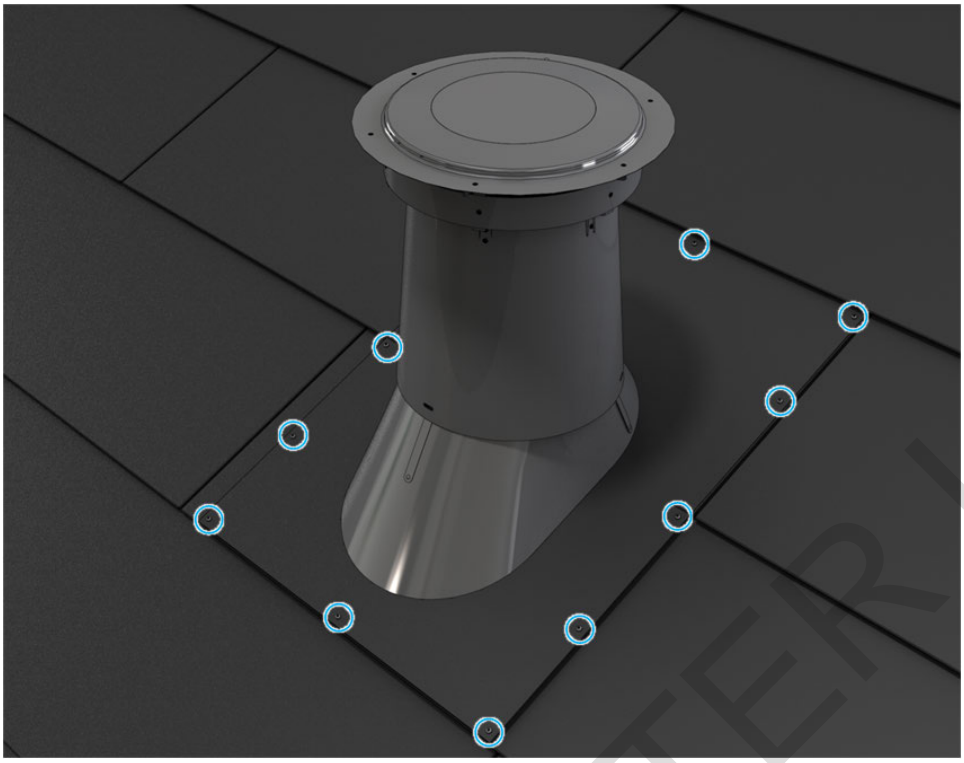
3. Install the heat vent cap.



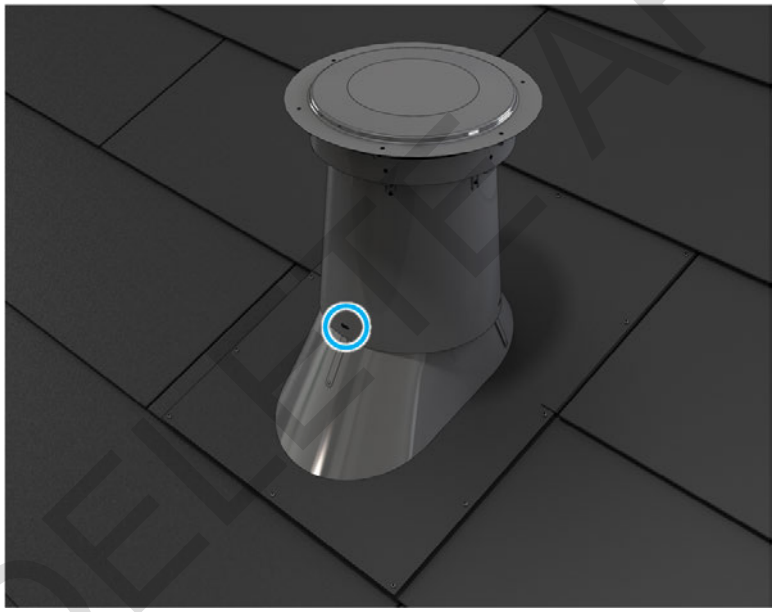
4. At leading edge of the tile course, use metal snips to make a 1 in relief cut on both sides of the flashing flange and fasten the lower tab with self-tapping screws.



   a. Refer to the *Fastener Schedule on page 703* for appropriate fastener locations.

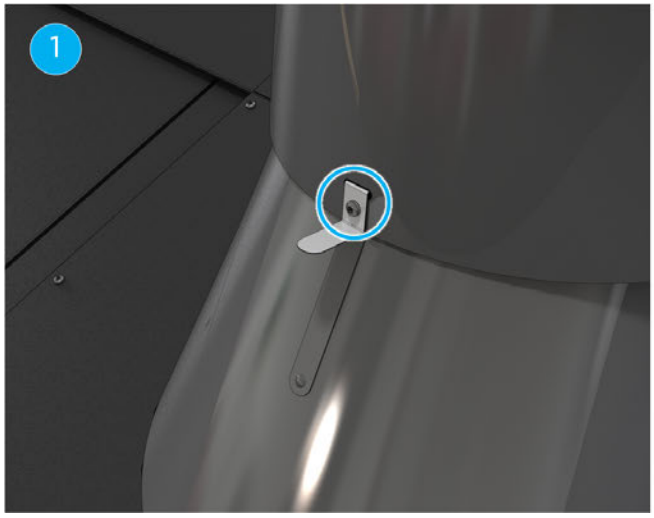


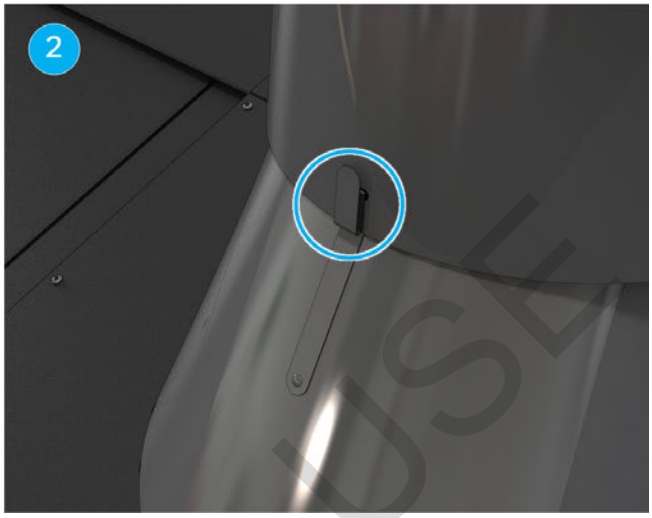
5. Once both deck level and tile level vent flashings are installed, place the cap over the opening of the vent, making sure to feed the tabs on the vent through the designated openings in the cap.



   a. Use the level to make sure the cap is plumb with the ground.
   b. Pull down on the tabs.

6. Use the self-tapper screws to fasten the tabs and fully secure the cap.
   Then, fold the tabs back up on themselves, making sure the white part of the tab is no longer visible.

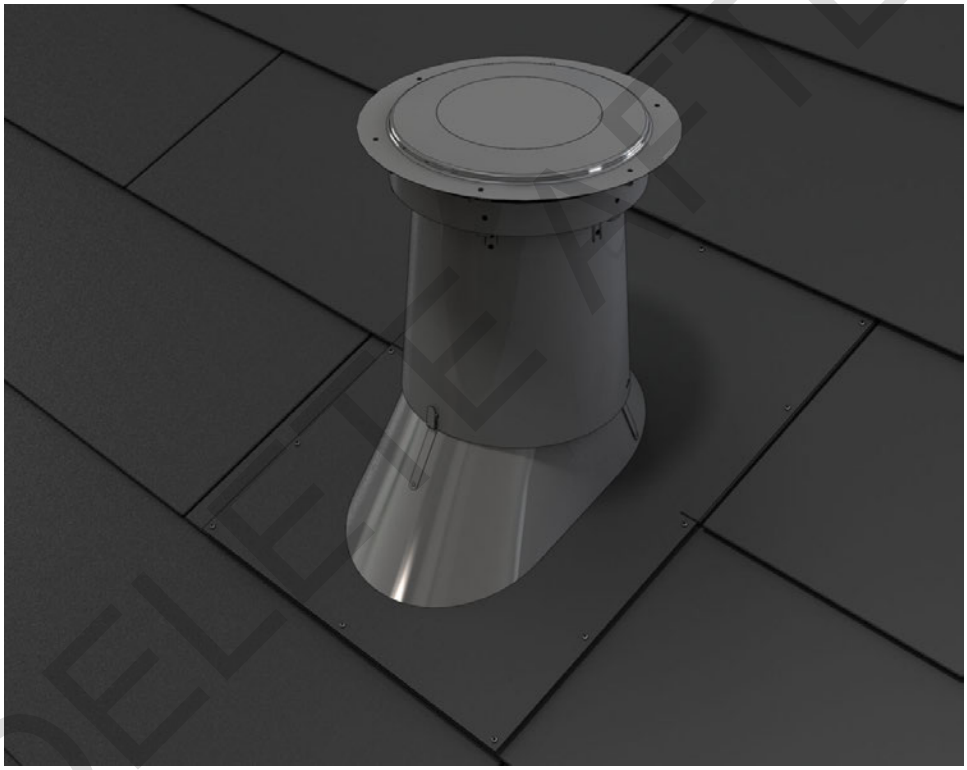


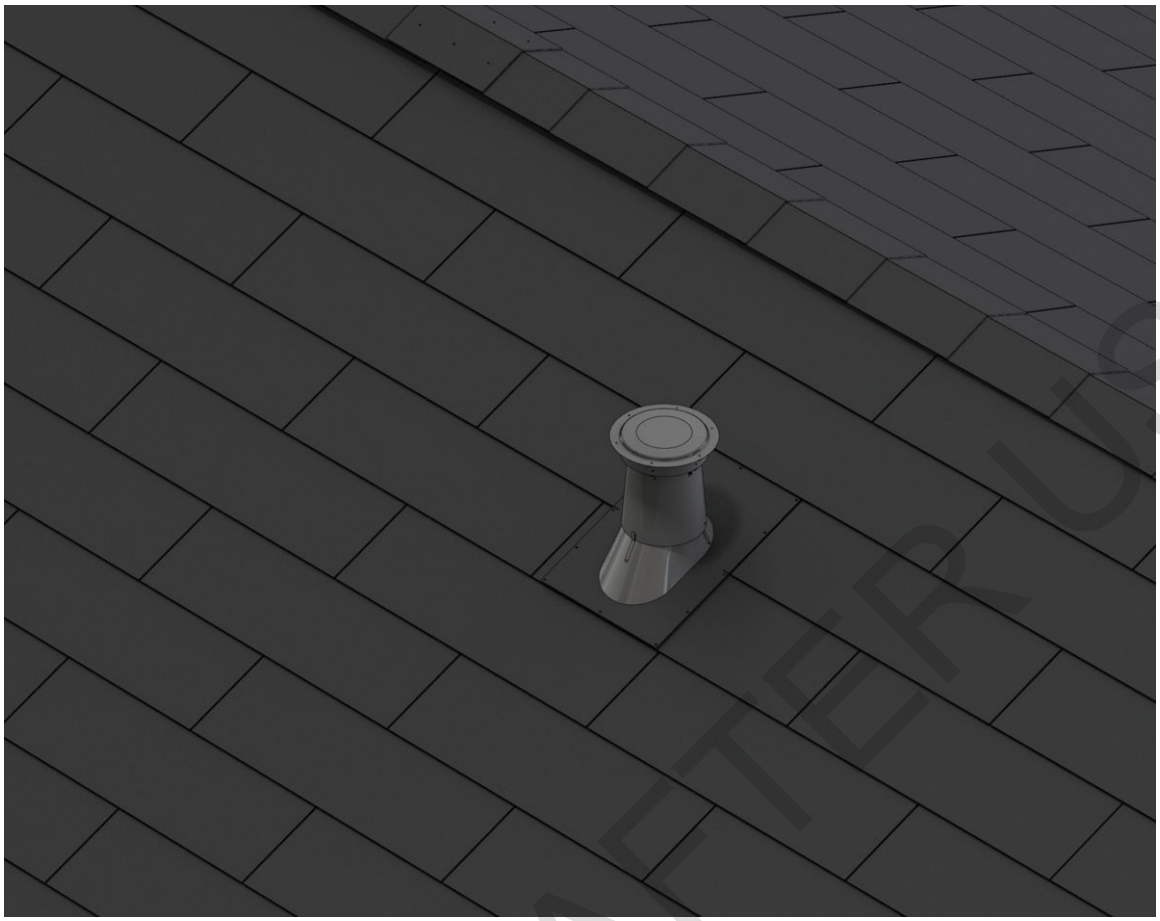


1 - Self-tapper in tab

2 - Tab folded back over

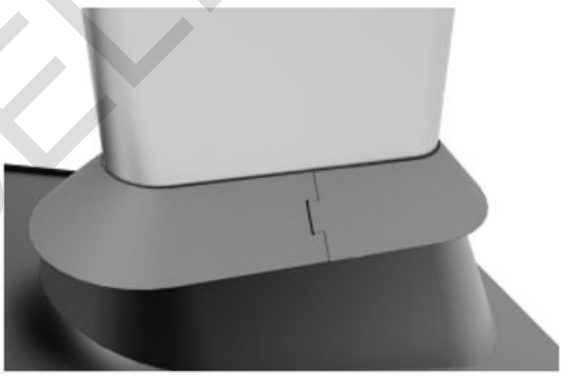
7. Installation is complete.



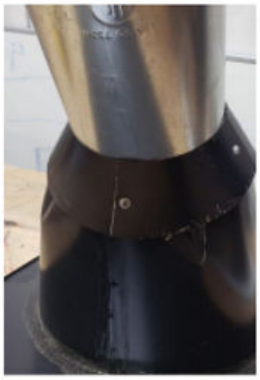


Gas Vent Pipes Taller than 12 in/Chimney Pipes/Oval Heat Vent Pipes

1. Make sure an appropriate tile level flashing and rain collar are on site. Parts may be left from dry-in or may need to be sourced from a local roofing supply or hardware store.
2. Use high heat touch-up paint to color the exposed surfaces black at the tile level.
3. Install the rain collar per manufacturer's instructions.
4. Gutter the obstructions. (See *Guttered Obstructions on page 347*)



Oval Rain Collar



Round Rain Collar

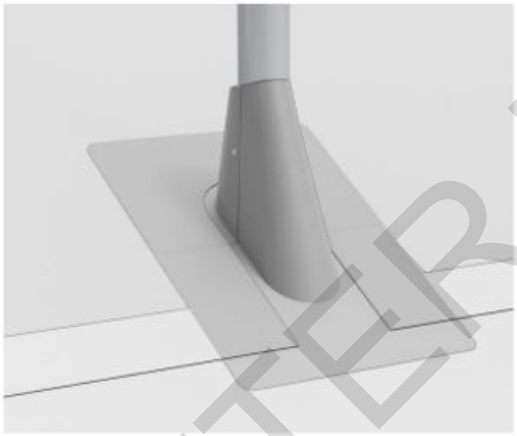
Concentric Vents

There are two different methods for drying in a concentric vent:

1. If the vent cap is glued down and the pipe flashing is not in good condition, flash in with the 2-piece pipe flashing. See *Overhead Service Drop on page 284*.
    a. If the flashing is in good condition, use the existing flashing.

Deck Level Pipe Flashing Splice

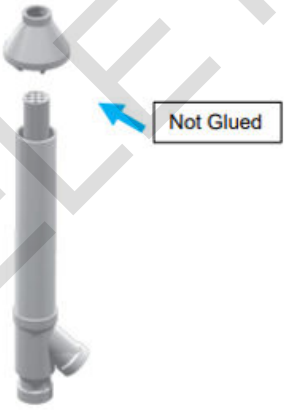
- 2-piece flashing cut the flashing in half as the same process for the OSD (Overhead Service Drop).

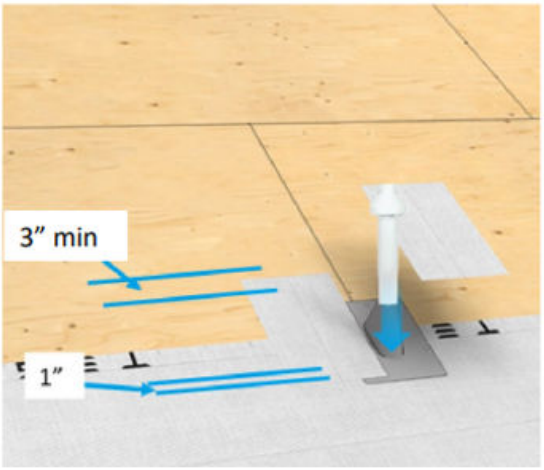


2. If the vent cap can come off and the existing flashing is not in good condition, source new metal flashing from a local roofing supply store.
    a. If the flashing is in good condition, use the existing flashing.
    b. Use high heat touch-up paint to color the exposed surfaces black at the tile level.
    c. Gutter the obstructions. (See *Guttered Obstructions on page 347*)

Deck Level Rubber Boot Flashing

- 1-piece flashing, remove the rain collar, and install a 1 piece deck level pipe flashing installed the same way as the heat vent 1 piece flashing.





Square Obstructions and Wall Interactions

Underlayment at Square Obstructions

Overview

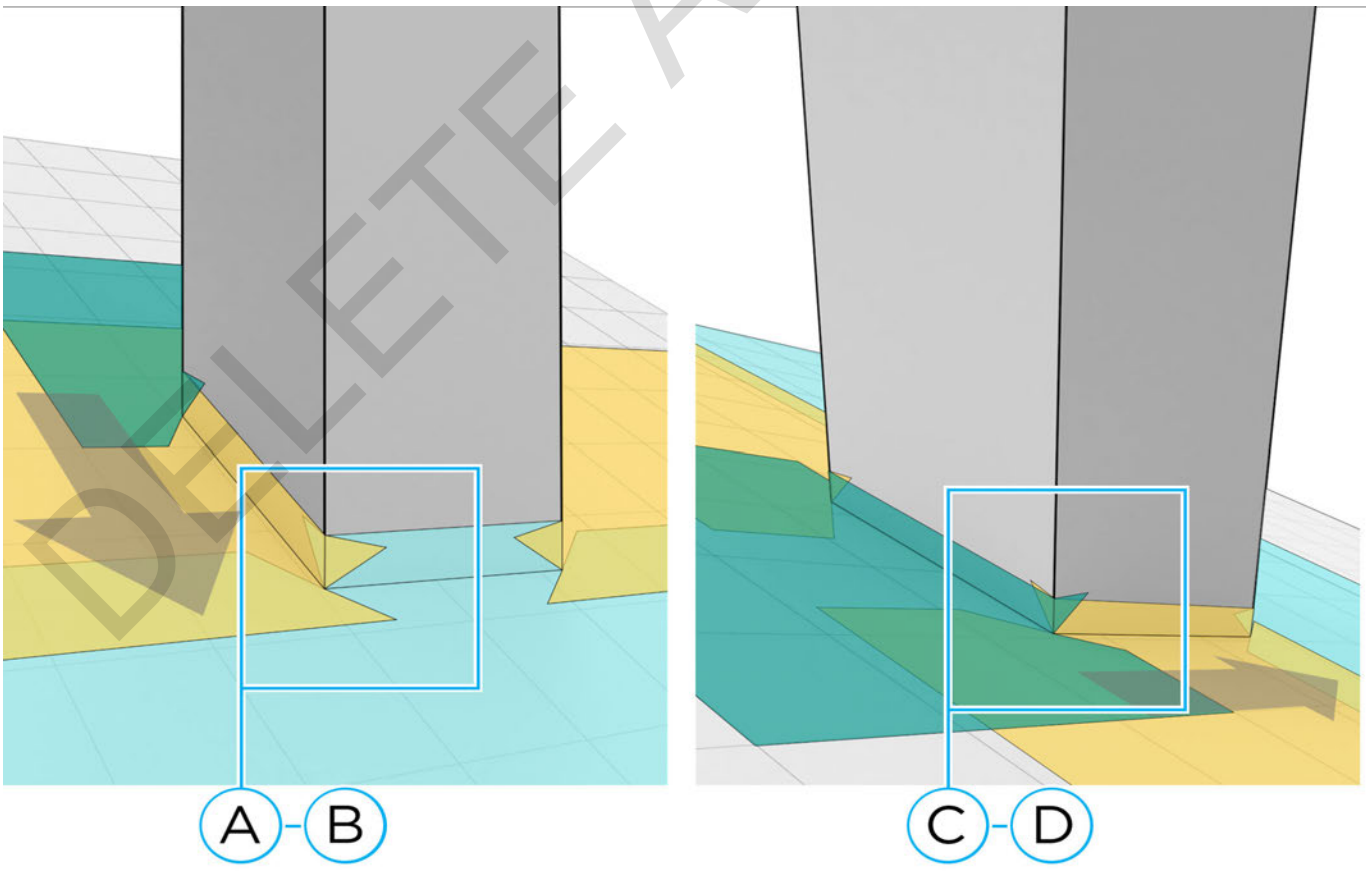
This section outlines the procedure for installing underlayment around guttered obstructions.

Tools & Equipment:

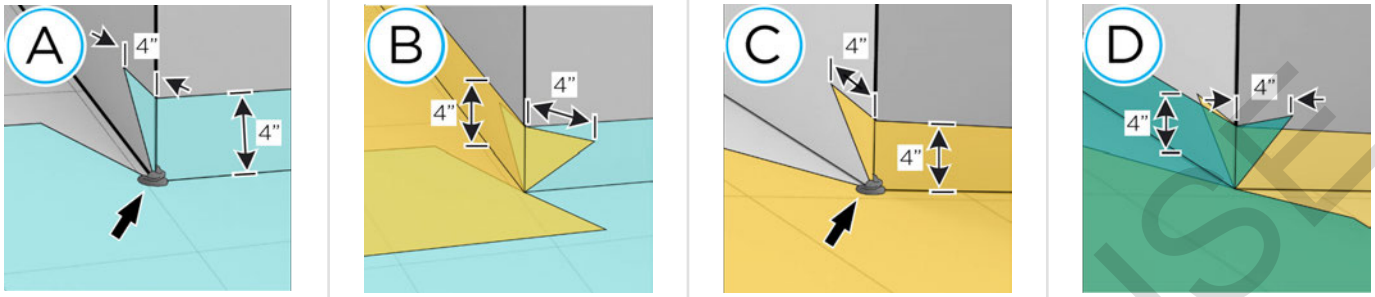
- Underlayment
- Sealant

Please take note of the high-level sequence of this procedure:

Installing Underlayment	
STEP 1 On Roof	Lap underlayment up and around the headwall.
STEP 2 On Roof	Lap underlayment up and around sidewalls.
STEP 3 On Roof	Lap underlayment up and around endwalls.

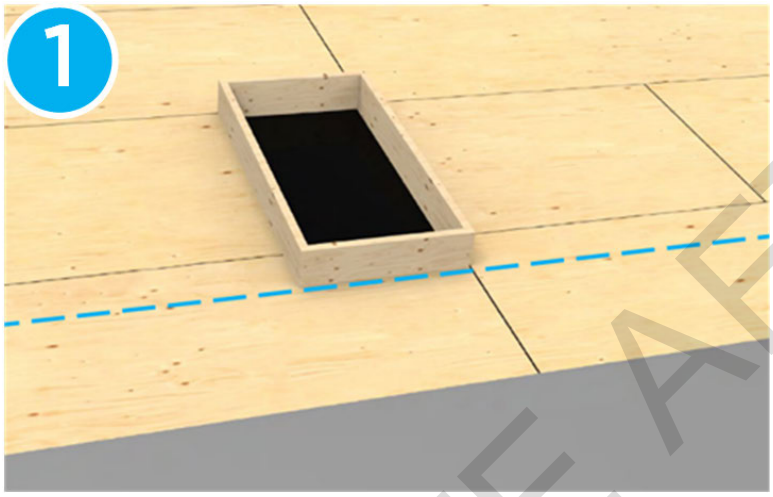


Lap courses of underlayment a minimum of 4 in up obstruction walls. At outside corners, underlayment should be cut at a slight angle to create tabs a minimum of 4 in in both directions around obstruction corners. Apply a dollop of sealant at obstruction corners to seal any potential pinholes at underlayment overlaps.



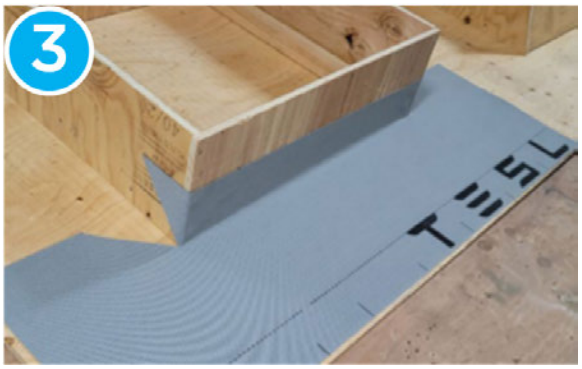
Work Instruction

Install courses of underlayment up to the obstruction headwall **(1)**.

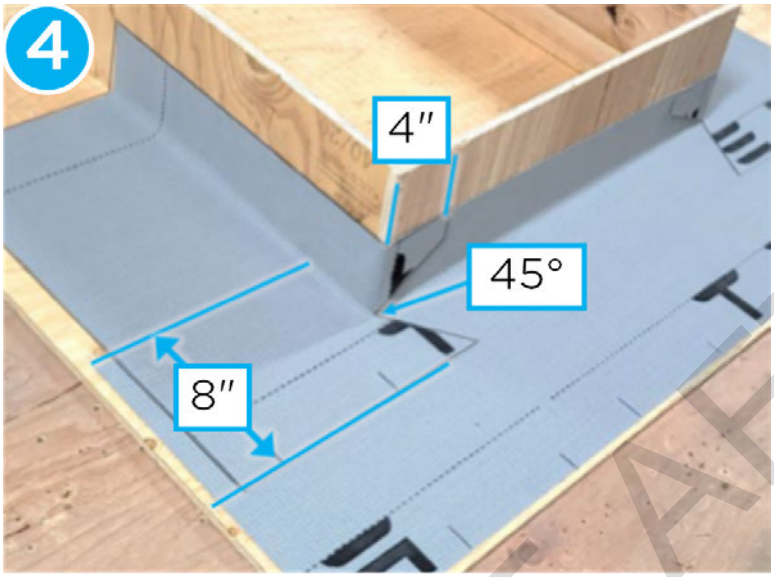


Lap underlayment up the headwall as much as possible (minimum of 1 in) **(2)**.

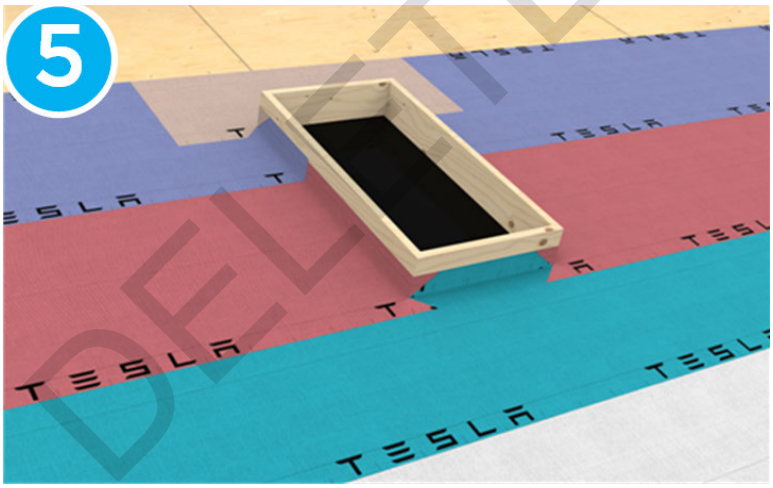
Cut underlayment at the headwall corners so that it wraps around the obstruction sidewall as much as possible (minimum of 1 in). Fold the remaining underlayment down to the deck **(3)**.



Continue lapping underlayment along the sidewall with as much coverage up the wall as possible (minimum 1 in). At corners, cut underlayment to wrap around the corner as much as possible (minimum of 1 in) **(4)**.

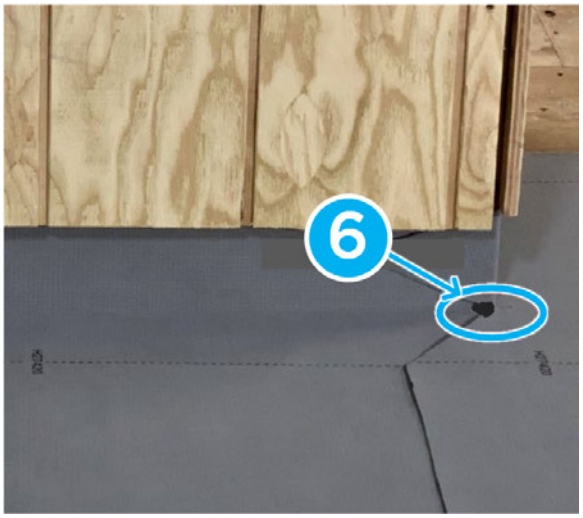


After the sidewall is complete, continue lapping underlayment at the endwall with as much coverage up the wall as possible (minimum 1 in) and tabs around the corners **(5)**.

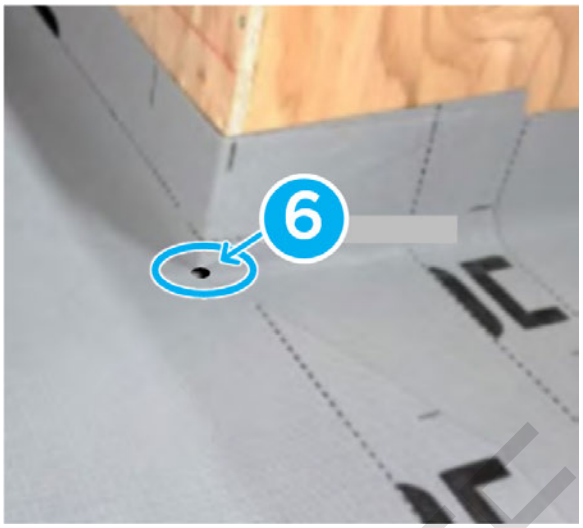


Lastly, add sealant to the pinhole gaps at the obstruction corners **(6)**.

Example: Sealant at headwall corner



Example: Sealant at endwall corner



NOTE: At this point, return to the bottom of the obstruction to begin installing wall metals.

Transition Flashing at Headwall

Overview

This section provides instructions for fabricating and installing transition flashing at headwalls.

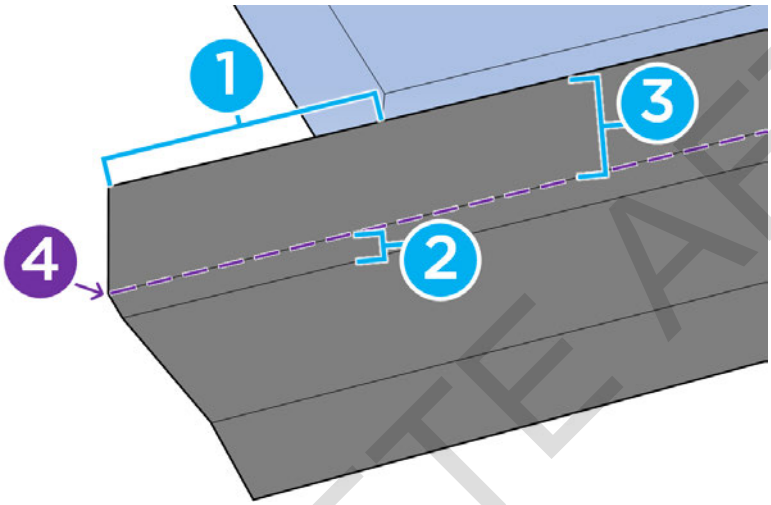
Tools & Equipment

- Transition flashing
- Metal snips
- Vented riser (optional)

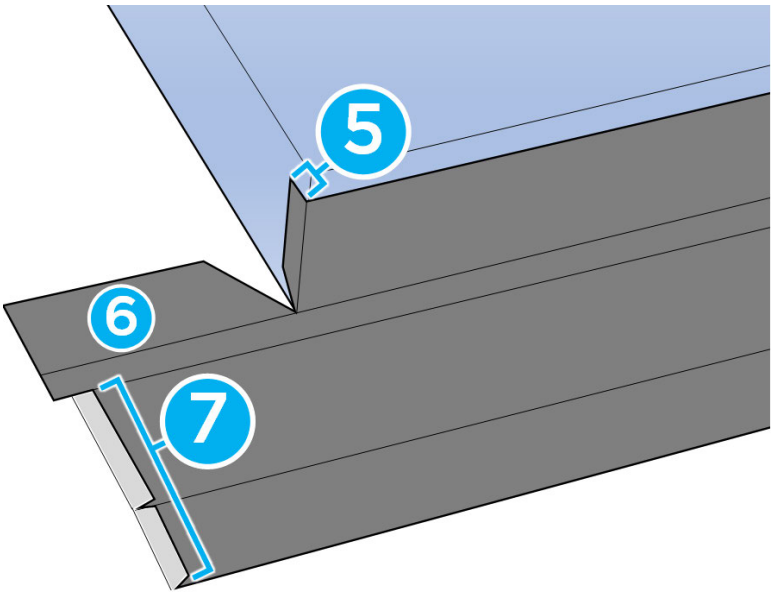
Work Instruction

Cut the transition flashing so it extends 10 in beyond the headwall corner(s) **(1)**. Maintain the 1 ½ in washout, and brake the transition flashing to pitch at up-roof seam **(2)**. Make sure the turn up extends 4 in up the headwall or the entire height of the headwall, whichever is lower **(3)**.

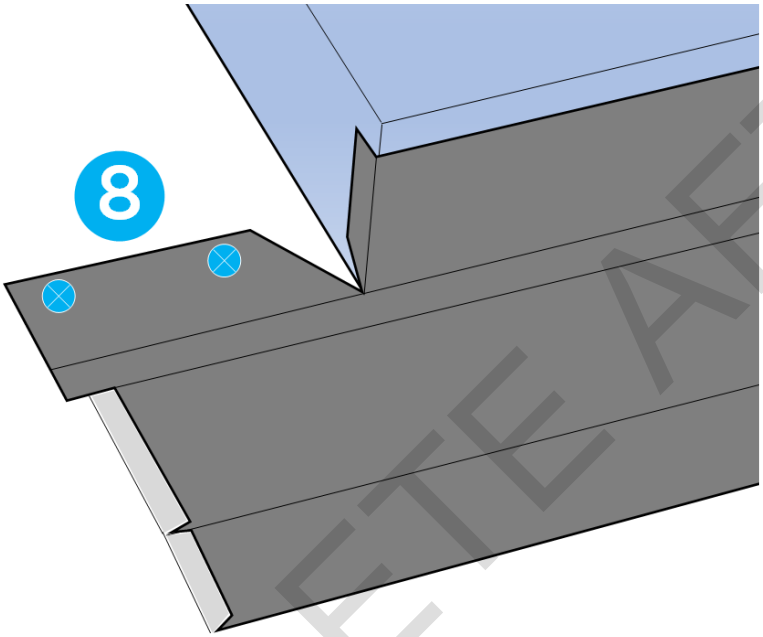
Pictured: Up-roof seam **(4)**



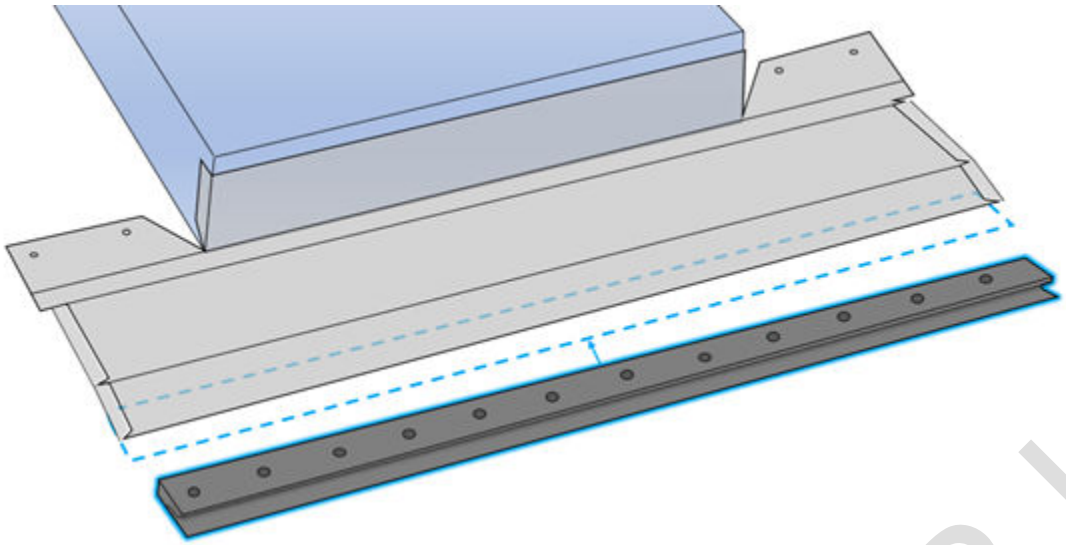
Cut and bend a 1 ¼ in tab around the outside corner of the headwall **(5)**. Fold the remaining flange down to the deck **(6)**. Bend a 1 in open hem along the transition and lower flange **(7)**.



Secure the transition flashing in place **(8)**.



PRO TIP: Cut a vented riser to the transition flashing dimensions and set it aside. If the tile does not fall within the *allowed threshold on page 167*, install the vented riser backwards beneath the down-roof flange of the transition flashing for support.



Transition Flashing - Creating a "Turn Down and Out"

Overview

This section provides instructions for creating a "turn down and out" in transition flashing. This procedure is part of several transition flashing work instructions.

Tools and Equipment

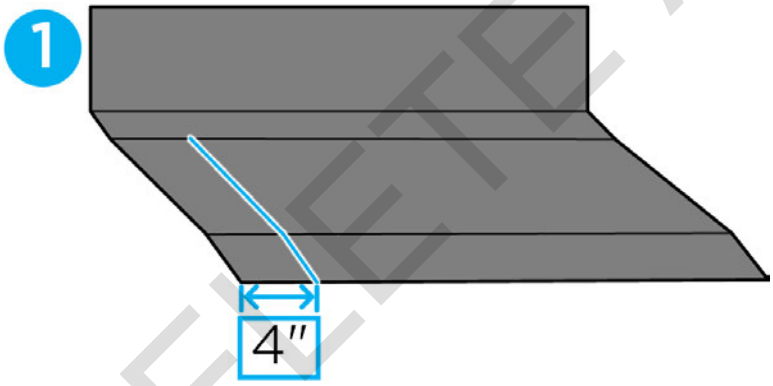
- Transition flashing
- Metal snips

Finished installation for reference:

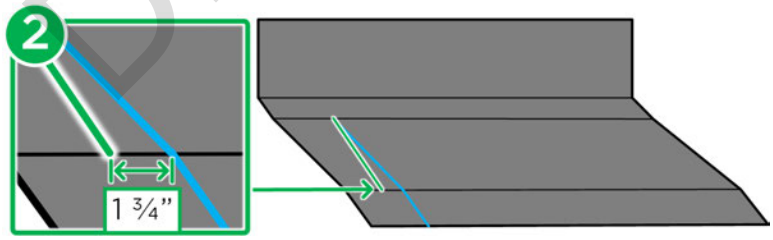
Work Instruction

Begin by marking the transition flashing with fabrication guides: two bend lines and two cut lines.

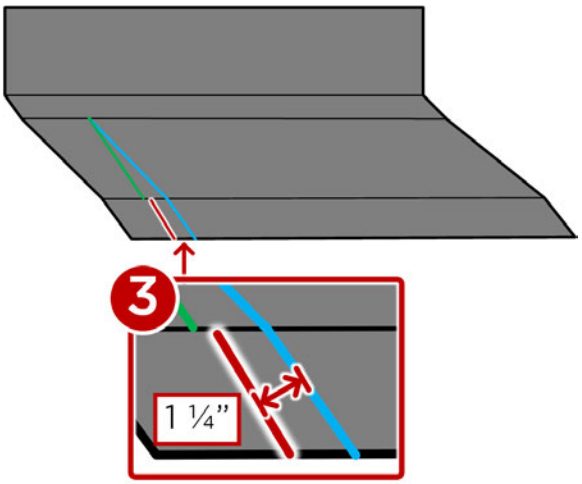
Draw a line 4 in from the transition flashing edge spanning across the middle and lower flanges **(1)**. This creates the first bend line.



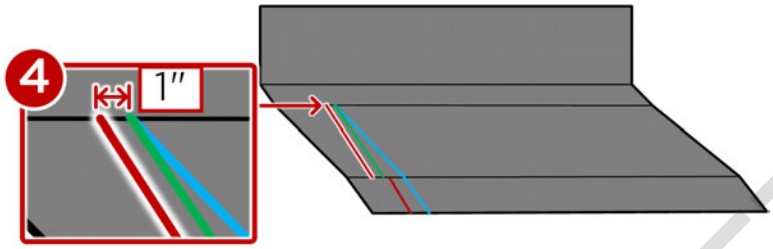
Then, draw a diagonal line on the middle flange that starts 1 ¾ in away from the first line and connects with the top of the first line **(2)**. This creates the second bend line.



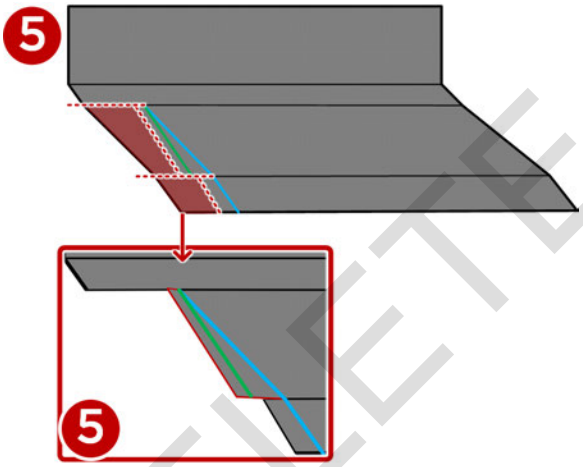
Draw a third line on the lower flange 1 ¼ in away from the line in step 1 **(3)**. This creates the first cut line.



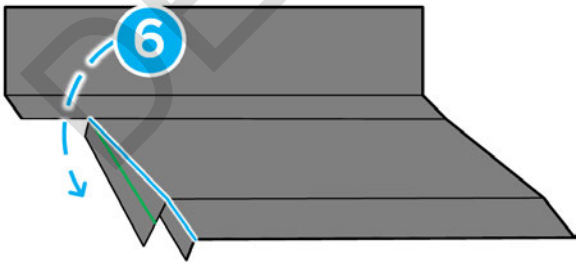
Finally, draw a fourth parallel line 1 in away from the line in step 2 on the middle flange **(4)**. This creates the second cut line.

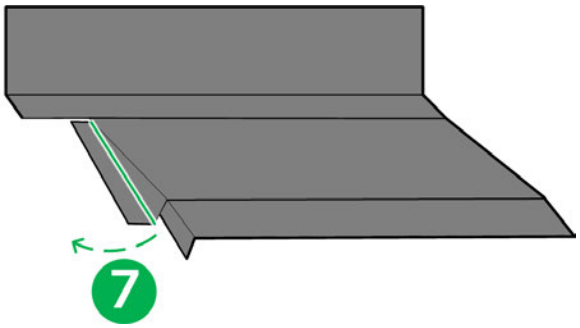


Make relief cuts into the transition flashing's first and second break points up to the line from step 1. Then, cut into the cut lines and remove the excess metal **(5)**.



Bend the line from step 1 to 90° **(6)**. Then, bend the line from step 2 to 90° **(7)**.





Headwall Dead Zone

Overview

When a dead zone appears between headwall transition flashing and a course of metal tiles, additional metal tiles are cut and installed to conceal the gap. The steps in this work instruction can be applied to any headwall junction.

Finished installation for reference:

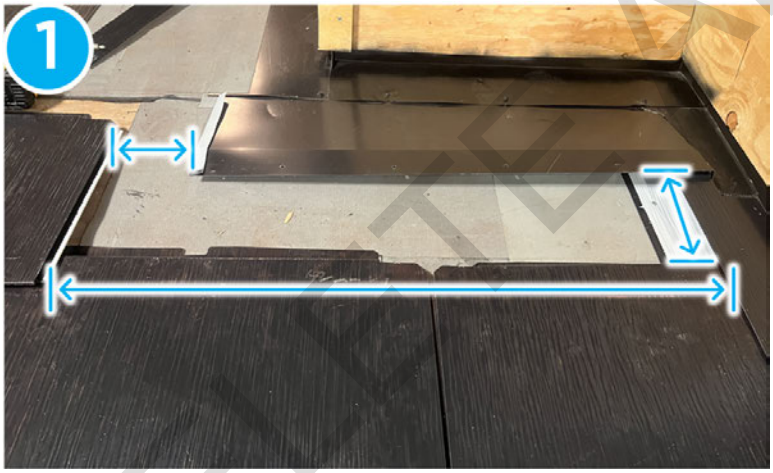
(1)	Transition flashing
(2)	Cut metal tiles

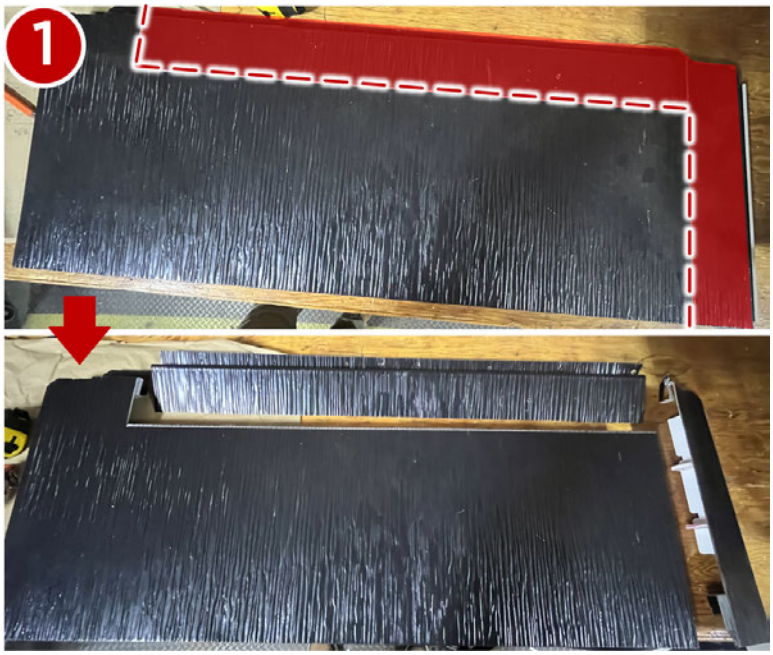
Work Instruction

Begin by measuring the dead zone.

If the gap measures larger than the *allowed cutting threshold of 6 in on page 167* in any dimension, proceed with standard metal tile installation up to the transition flashing (see *Installing Endwall Concealer Pans, Channel Flashing, Metal Tiles and Tile Covers on page 352* and *Cut and Tuck at Square Roof Features on page 178*).

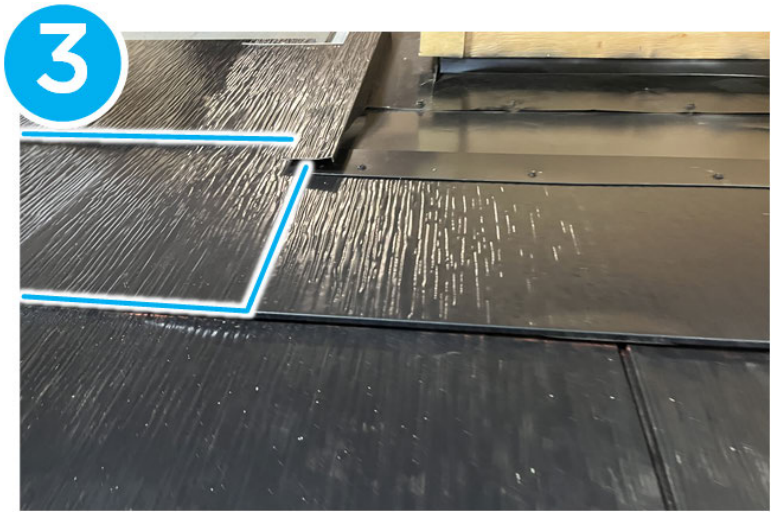
If the gap measures smaller than 6 in, create a transition flashing extension out of a metal tile. Transfer the dead zone measurements onto a metal tile and cut accordingly. Ensure 2 in of the metal tile will sit underneath the transition flashing **(1)**.





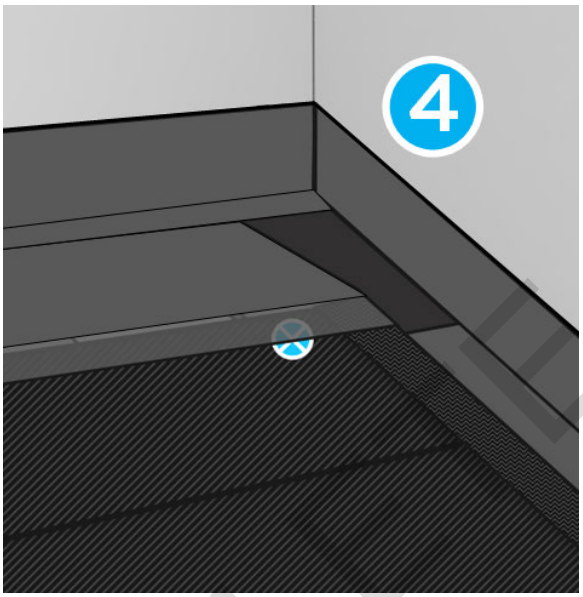
Lift the transition flashing and slide the cut tile into place. Secure the cut tile with 2 ½ in self-tapping screws in accordance with the applicable wind tier in the *Fastener Schedule on page 703***(2a)**. Secure the lower flange of the transition flashing to the cut metal tile with ¾ in self-tapping screws in accordance with the applicable wind tier in the *Fastener Schedule on page 703* **(2b)**.

Cut and install tile skin as needed to cover any gaps around the extension tile as well as the exposed white metal from the transition flashing hem **(3)**.

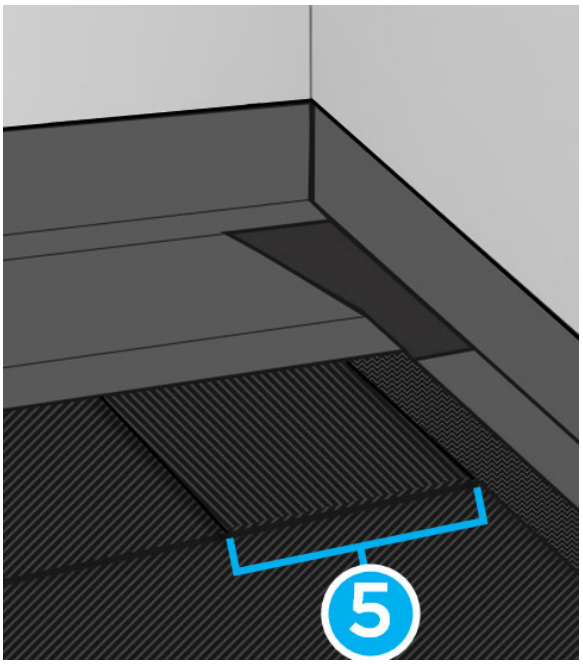


PRO TIP: At a headwall to sidewall inside corner, the transition flashing cannot be fully lifted due to being held down by flexible flashing at the gutter. In this case, face fasten the cut tile at the inside corner **(4)**and then conceal the exposed fastener with a tile skin **(5)**.

Pictured: Exposed fastener through tile at the inside corner.

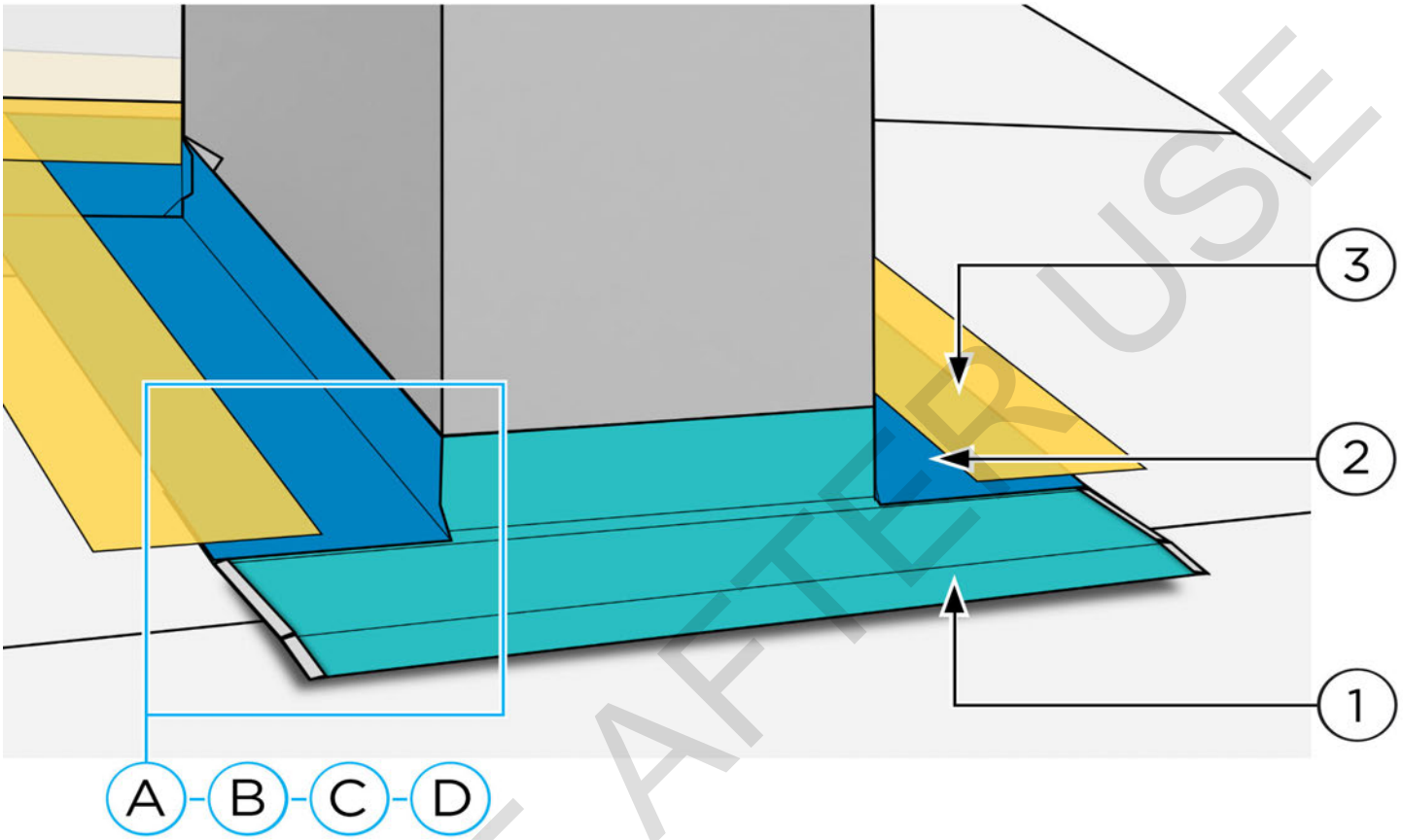


Pictured: Cut tile skin tucked under transition flashing and channel flashing to conceal exposed fastener.



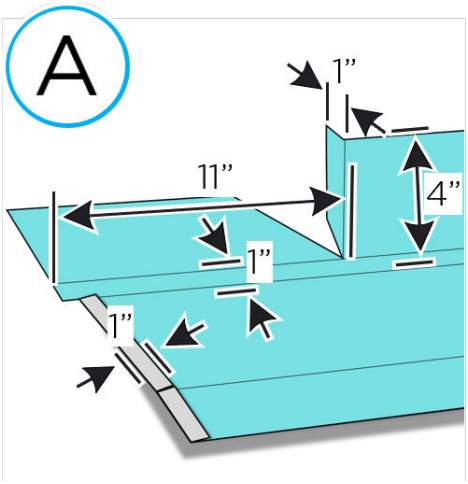
Headwall-Sidewall Outside Corners

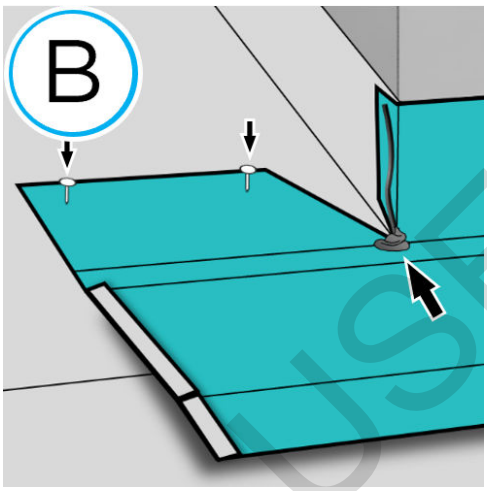
Dry In

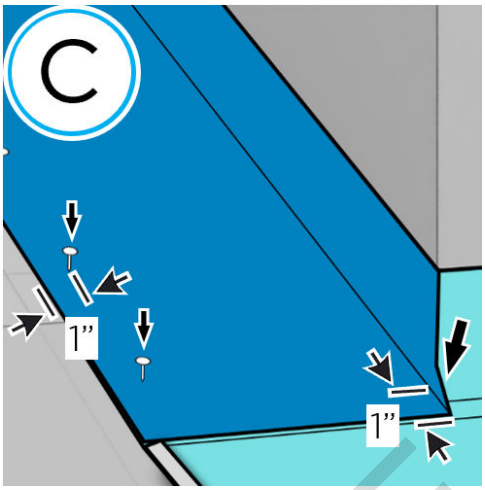


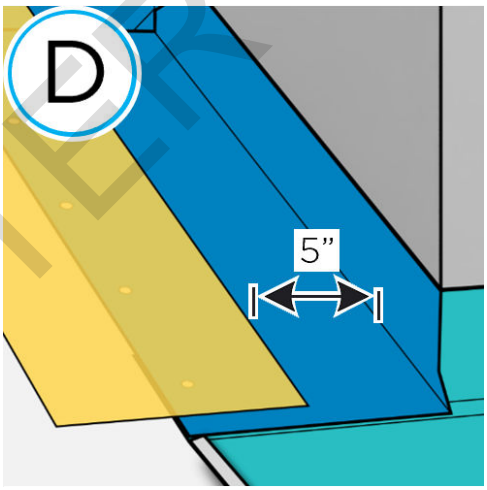
1	Transition Flashing
2	Wall Flashing
3	Detail Roll

	See detail images on next page.
A	Cut transition flashing so that it extends 11 in past the edge of the wall of obstruction. Cut and bend 1 in open hems on the outer edge of the transition flange and down-roof flange. Create a 1 in tab around the obstruction's corner. Bend the remaining portion of the up-roof flange down to the deck.
B	Fasten through the up-roof flange of the transition flashing. Apply a dollop of sealant at the corner to create a seal between the transition flashing and the wall flashing.
C	Craft a water diverter with an aesthetic fold into the down-roof edge of the wall flashing at the headwall-sidewall corner. Cut and bend a 1 in tab around the sidewall-endwall corner. Fasten 1 in from the outer edge of the wall flashing.
D	Apply detail roll 5 in from the wall(s) to strip in the wall flashing, protect the flashing edge and conceal the fasteners. Do NOT close off or block drainage at the bottom of the wall flashing with the detail roll.

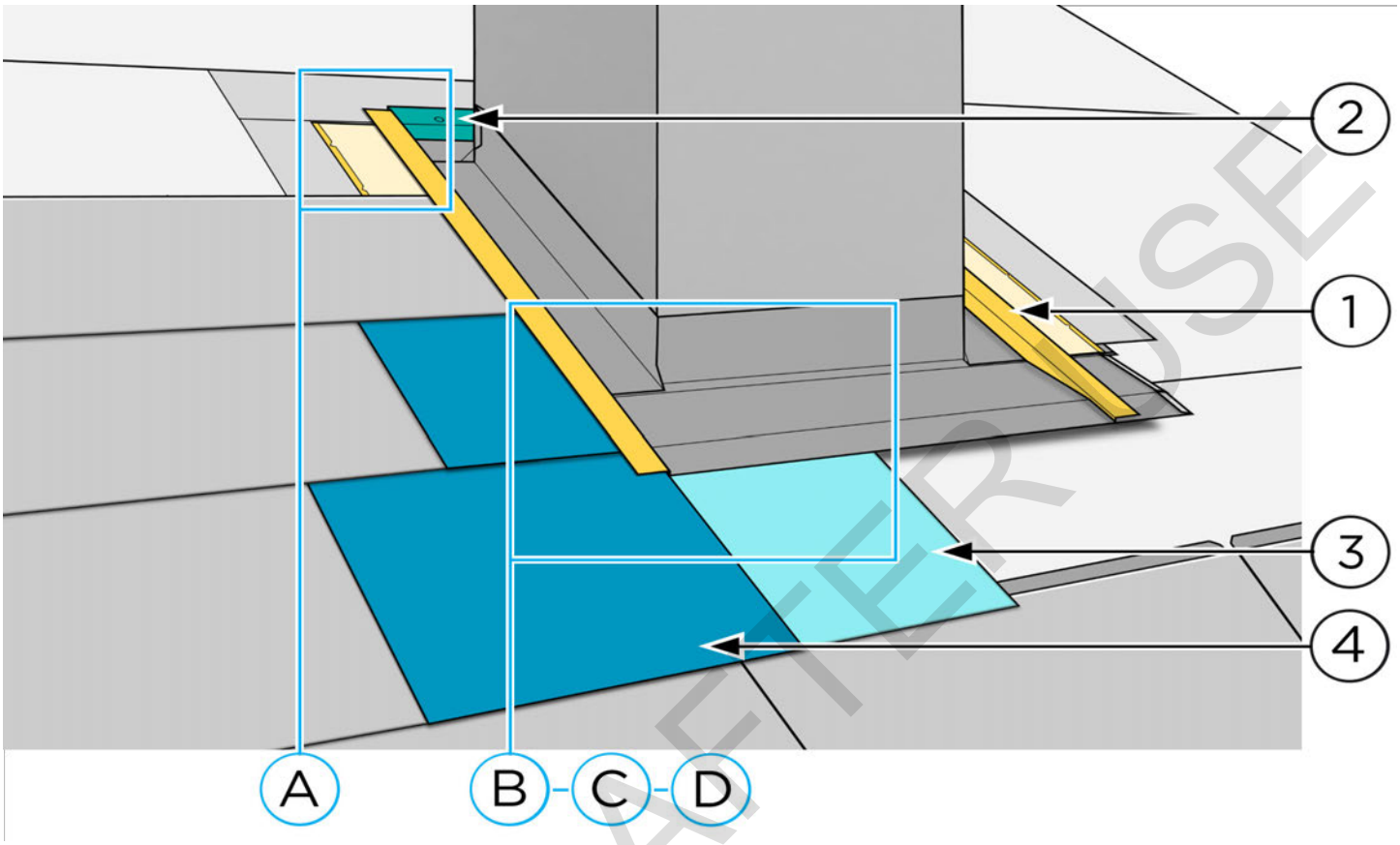






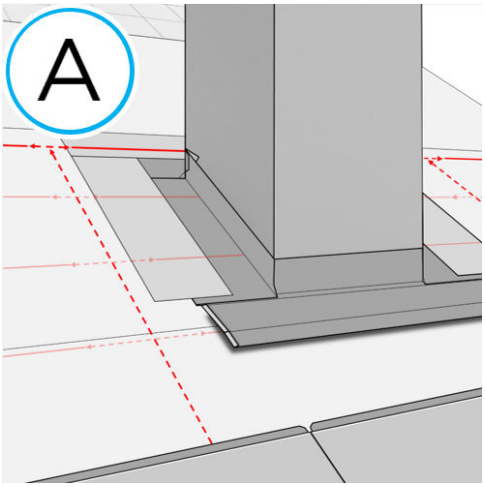


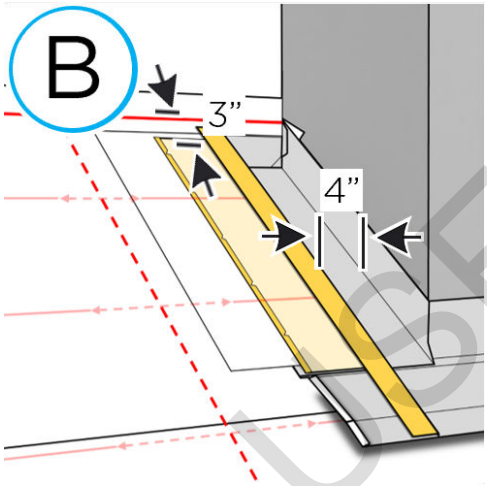
Tile Install

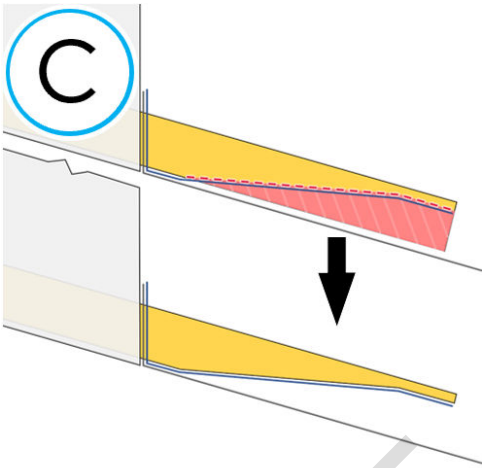


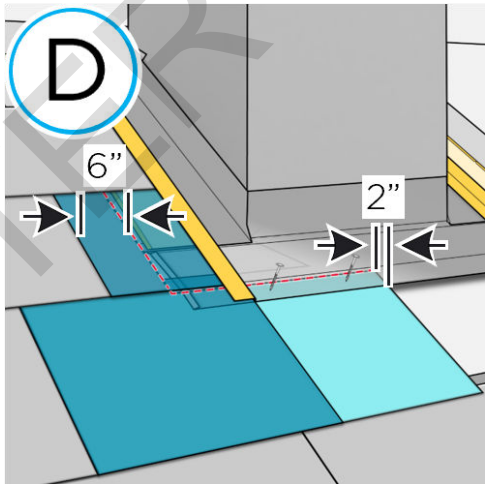
1	Channel Flashing
2	Vented Riser
3	Metal Tile
4	Tile Skin

	See detail images on next page.
A	Measure and mark tile rows up-roof to determine the tile row that will span across the top of the obstruction. Channel flashing length and vented riser placement are set by this row's location.
B	Install channel flashing 4 in from the sidewall. The bottom of the channel flashing terminates at the down-roof edge of the transition flashing. The top of the channel flashing terminates 3 in above the previously marked tile row.
C	Where channel flashing laps over transition flashing, cut material away from the deck flange and vertical face of the channel flashing to fit the profile of the transition flashing. The robin jig can be used to trace this profile.
D	Cut and tuck metal tiles to fit around the obstruction. Metal tiles may be ripped to tuck under transition flashing with a minimum 2 in lap. Cover metal tiles with tile skins where cut edges remain exposed around the transition flashing. Tile skins must lap a minimum of 6 in over the metal tiles.



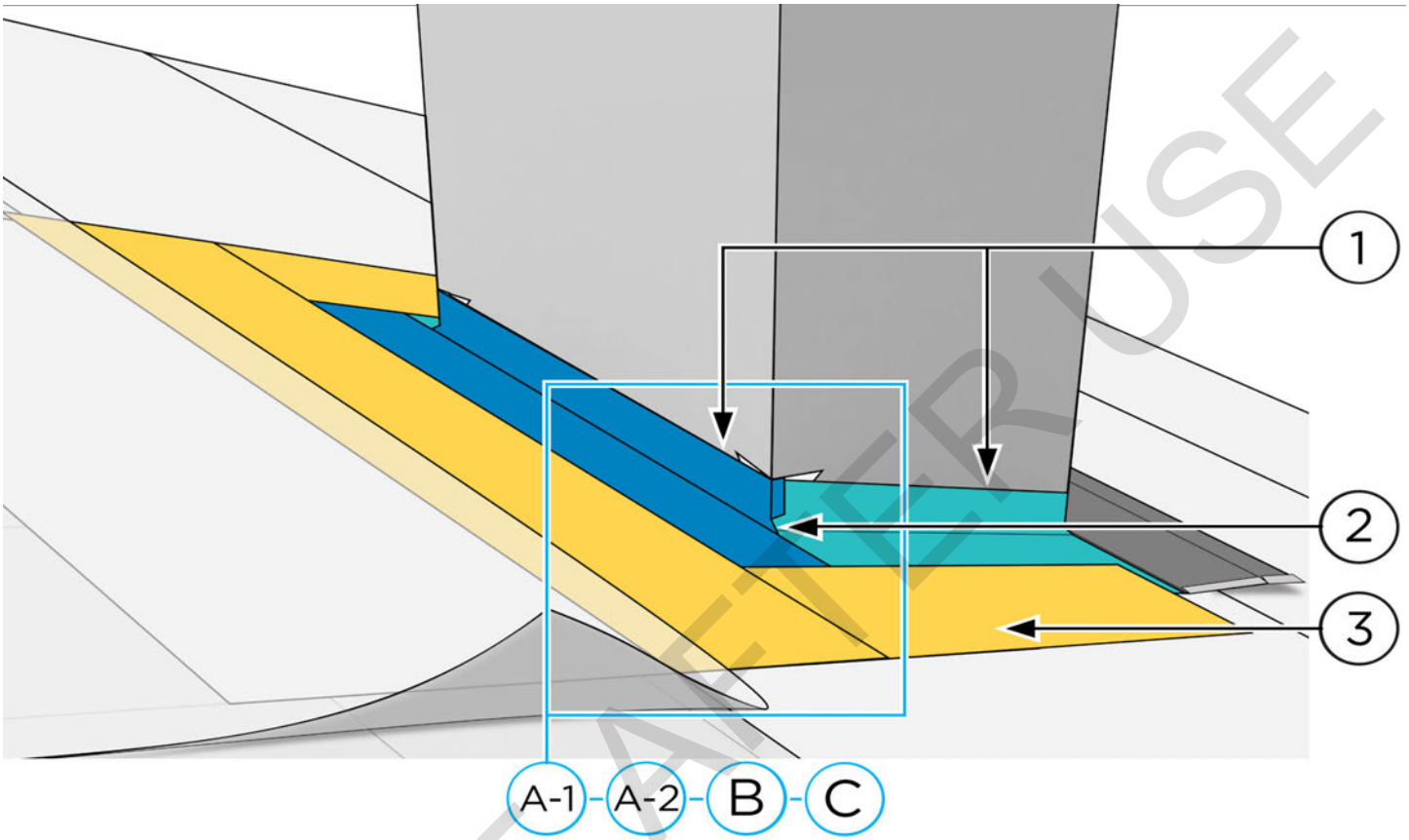






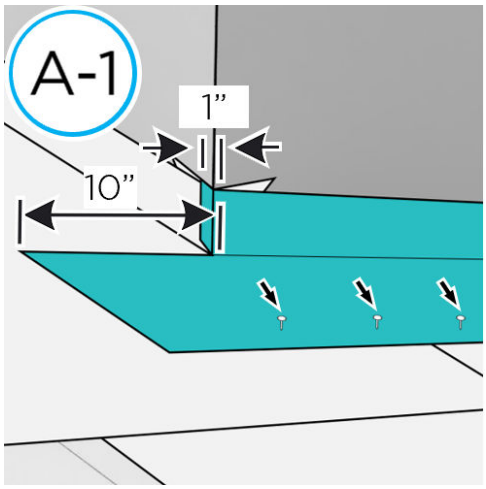
Sidewall-Endwall Outside Corners

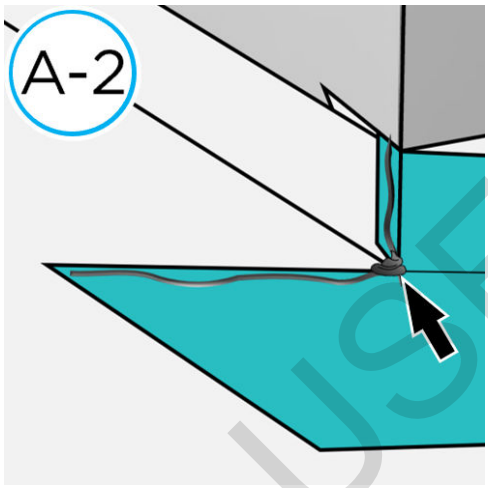
Dry In

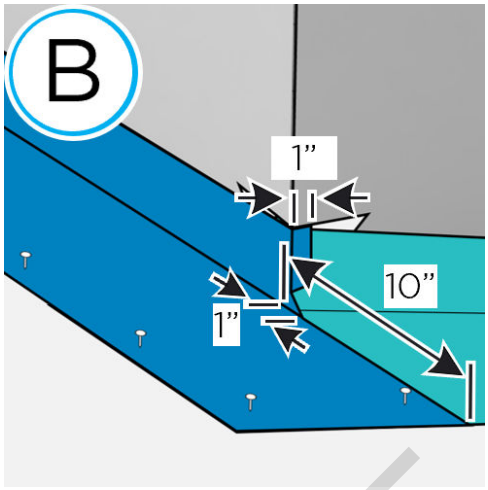


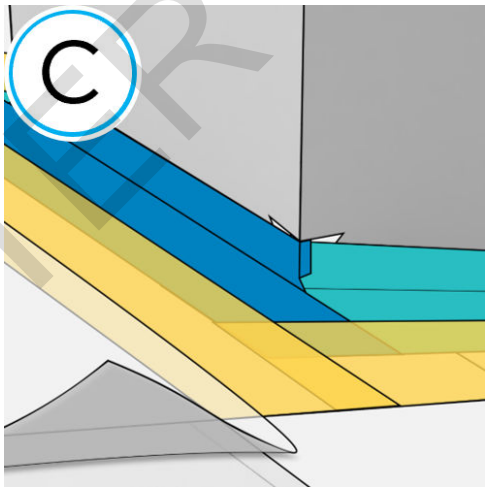
1	Wall Flashing
2	Sealant
3	Detail Roll

	See detail images on next page.
A-1	Cut and bend wall flashing so that a 1 in tab wraps around the sidewall-endwall corner and the deck flange extends 10 in beyond the corner. Apply a dollop of sealant (see detail **A-2**) before installing fasteners 1 in from the outer edge of the wall flashing.
A-2	Before fastening the first wall flashing, apply a dollop of sealant at the obstruction's corner to create a seal between the second wall flashing installed in the next step.
B	Cut wall flashing to extend 10 in beyond the obstruction's sidewall-endwall corner(s). Cut and bend a 1 in tab and 1 in water diverter with an aesthetic fold at the endwall-sidewall corner.
C	Apply detail roll 5 in from the sidewall(s) and endwall to strip in the flashing (ensure all fasteners are covered). Integrate the obstruction's flashing and underlayment with underlayment courses installed up-roof. Ensure that positive laps are maintained and no bucking edges are created.

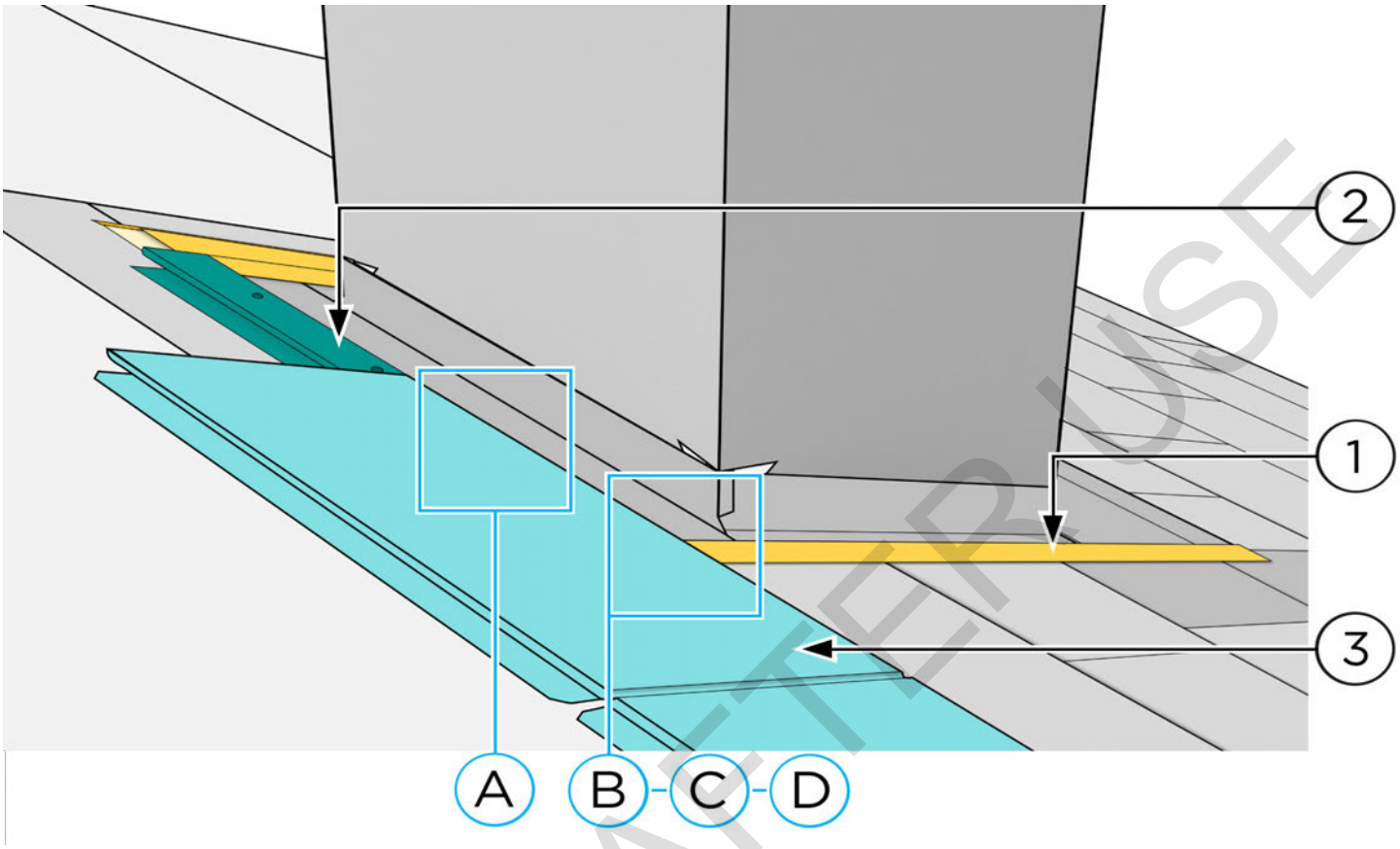






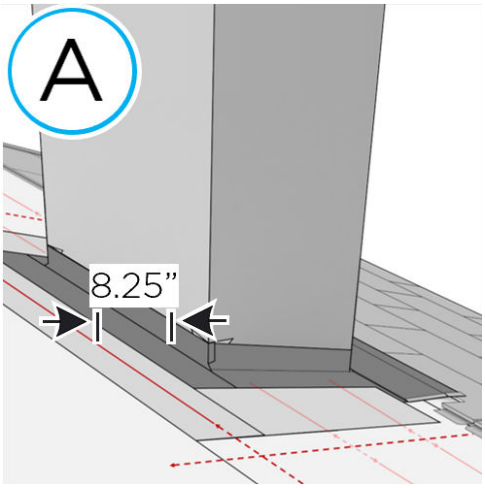


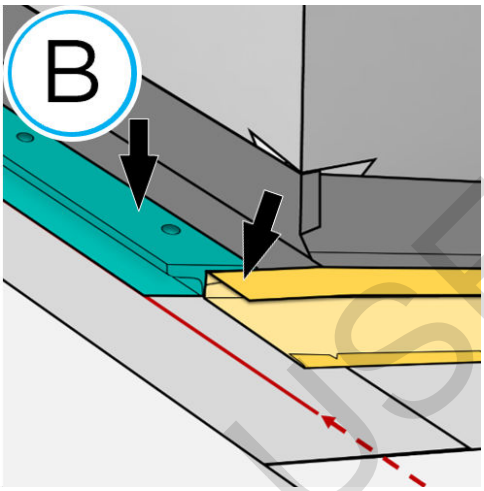
Tile Install

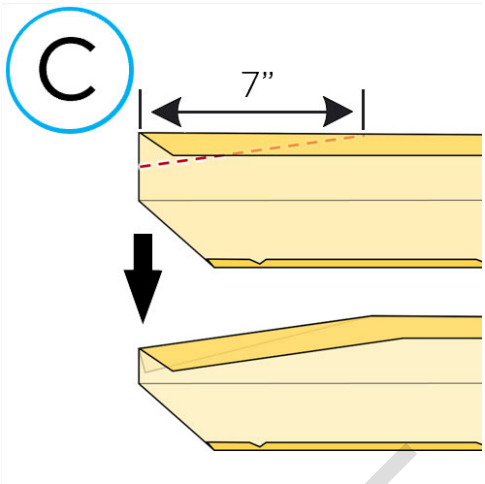


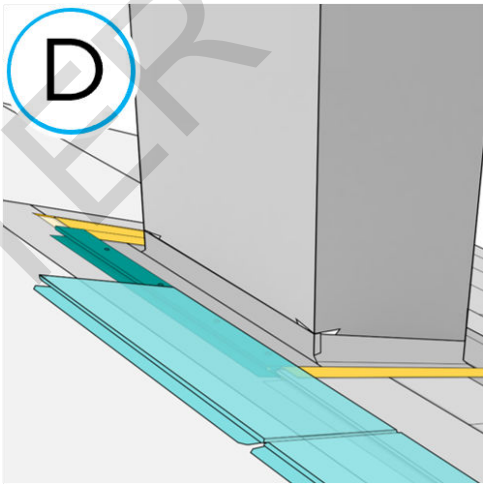
1	Channel Flashing
2	Vented Riser
3	Metal Tile

	See detail images on next page.
A	Measure and mark tile rows up-roof to determine the row of tiles that will span across the top of the obstruction. If this mark lands within 8 ¼ in of the endwall, move up to the next tile row. Otherwise, the vented riser will fall within the 4 in gutter. Install flat stock as needed to conceal underlayment below this mark.
B	Make a relief cut in the channel flashing (see detail **C**) to lap under the tile drip edge. Install a vented riser with the nailing flange aligned with the tile row mark.
C	Make a 7 in relief cut along the vertical face of the channel flashing to allow the channel flashing to lap under the tile course installed up-roof.
D	Install tiles across the top of the obstruction. Ensure the tile cleats engage with the vented riser.

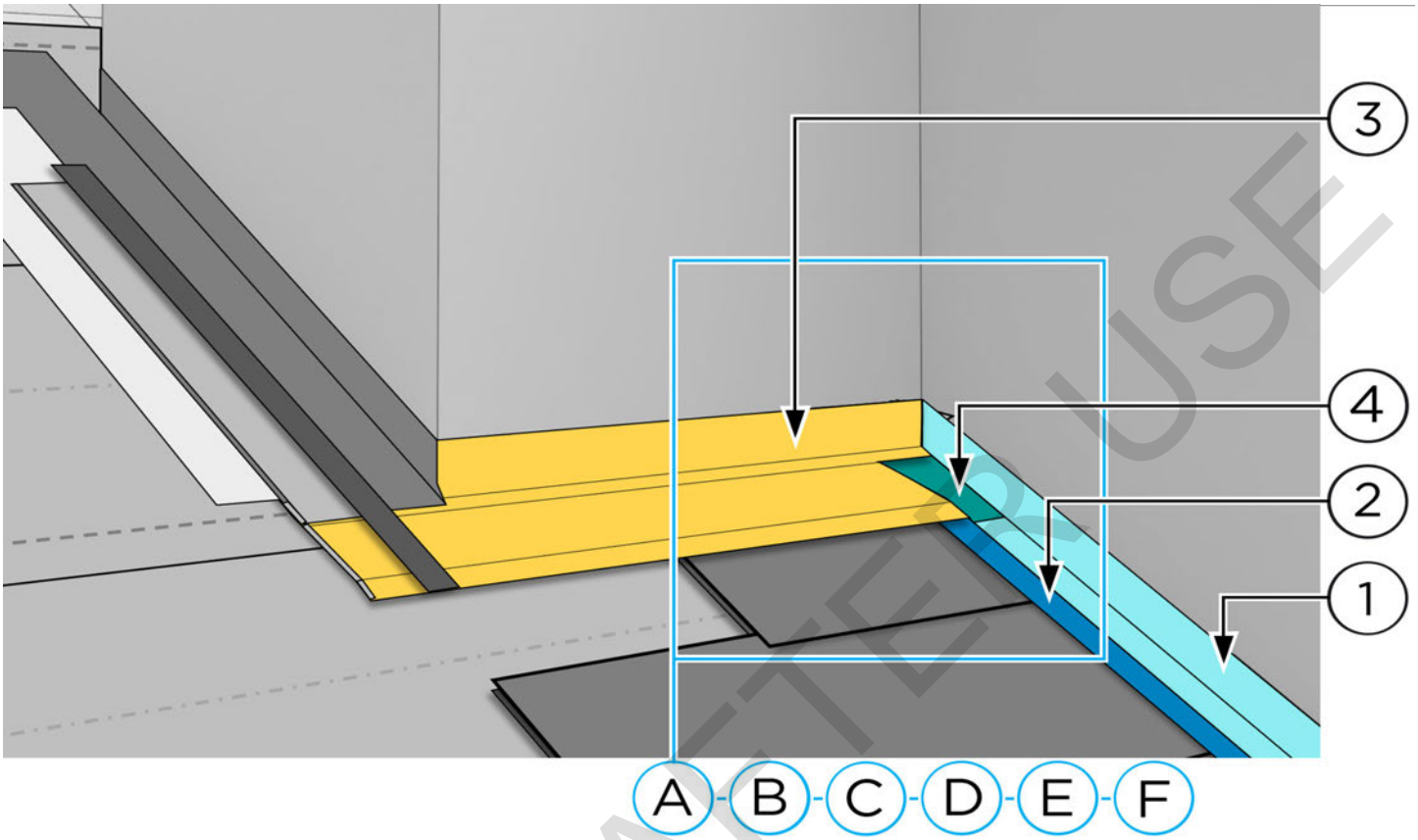






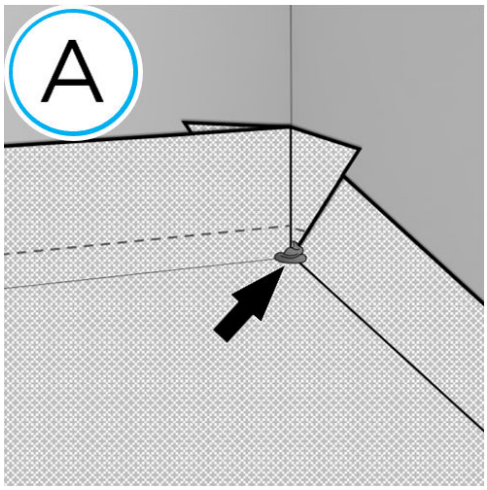


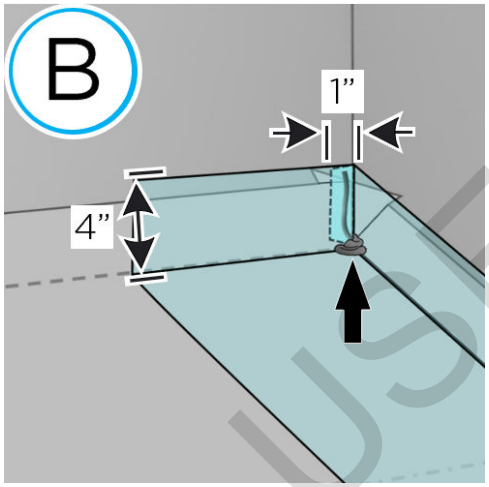
Sidewall-Headwall Inside Corners

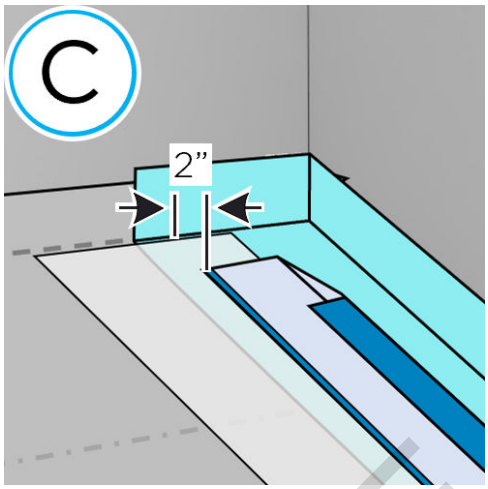


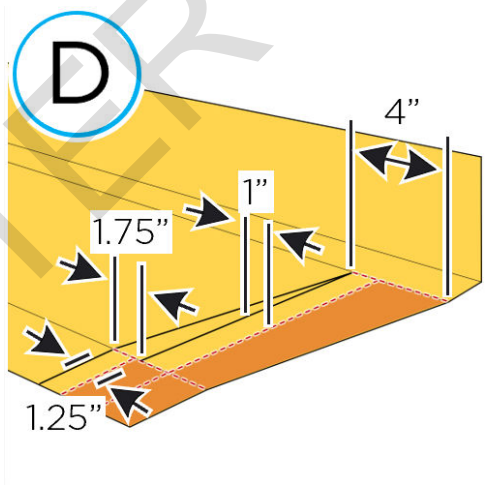
1	Wall Flashing
2	Channel Flashing
3	Transition Flashing
4	Flexible Flashing

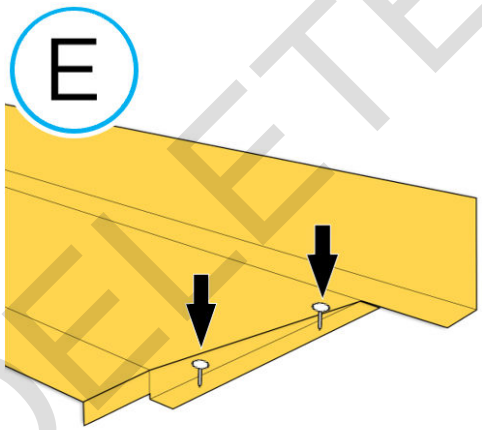
	See detail images on next page.
A	Underlayment should have a minimum 4 in upturn at the base of the wall. Make a 45-degree cut at the underlayment inside corner, then fold the tabs to fit in the corner. Apply a dollop of sealant at the inside corner to eliminate potential pinholes.
B	Install wall flashing along the base of the wall. At the inside corner, craft a 1 in tab that will sit behind the wall flashing's 4 in deck flange turn up. Apply a dollop of sealant at the inside corner to eliminate potential pinholes.
C	Install channel flashing, terminating 2 in from the headwall. Make an angled cut in the vertical face of the channel flashing to match the transition flashing edge.
D	Mark transition flashing with cut and bend lines to create a "turn down and out" feature.
E	Fasten through the deck flange of the “turn down and out" feature.
F	Install the transition flashing at the inside corner. Apply flexible flashing to the deck flange of the transition flashing's "turn down and out" feature. Ensure the remaining portion of the transition flashing positively laps over the up-roof side of the channel flashing.

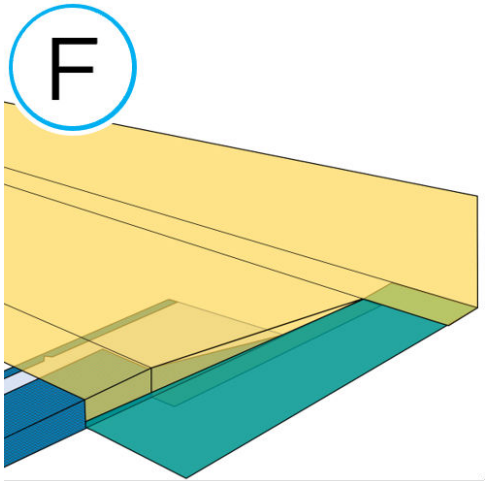












Eave-Sidewall with Diverter

Overview

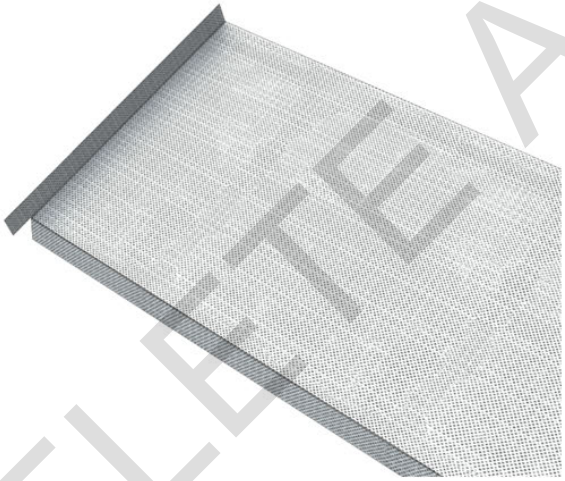
This section provides instructions for installing wall flashing at the eave to sidewall junction.

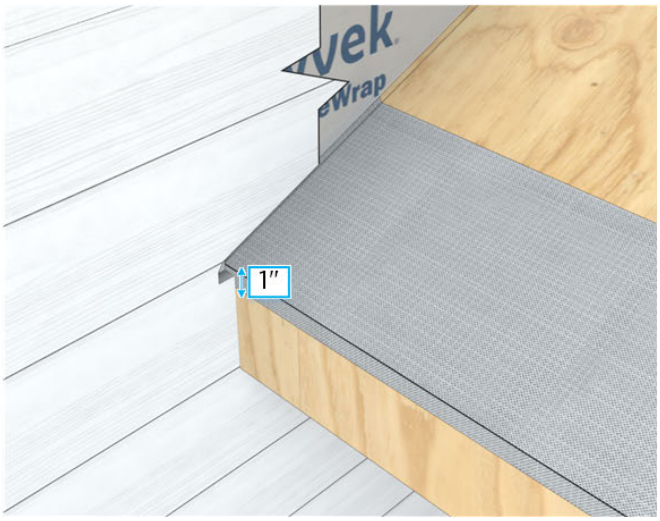
Tools & Equipment

- Wall flashing
- Channel flashing/Riser
- Underlayment
- Detail roll
- Metal snips

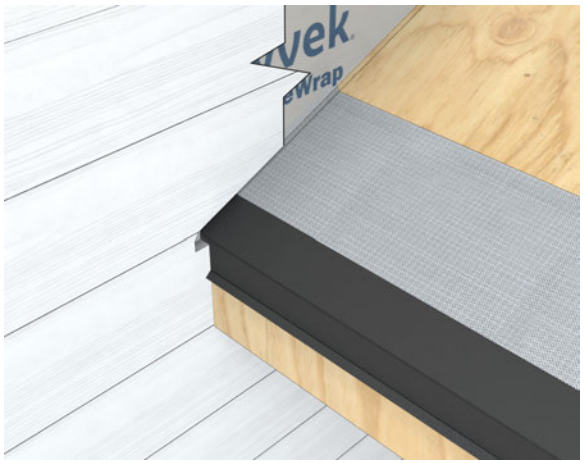
Work Instruction

1. Start by installing the detail roll. When possible, install the detail roll **at least**:
    - 1 in up the wall,
    - 1 in past the wall,
    - 1 in turning down on the eave/fascia, and
    - all behind the building paper.

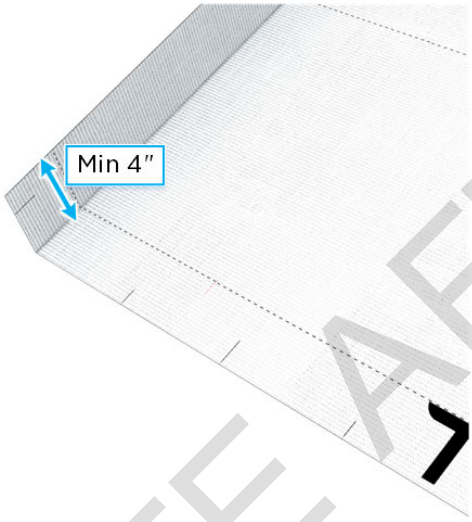


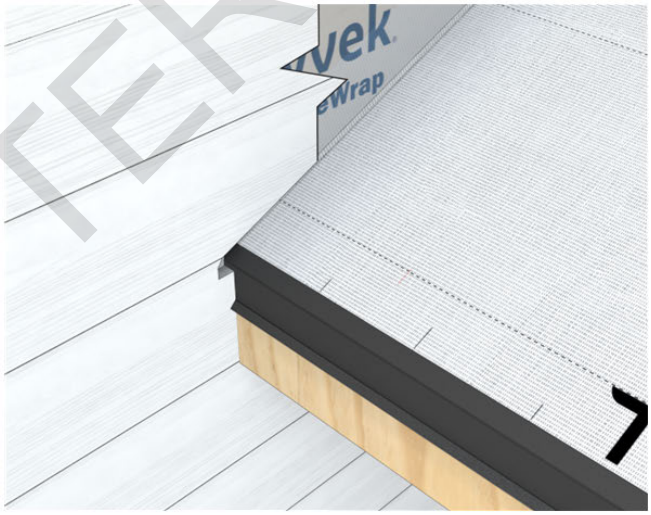


2. The drip edge needs to be modified to fit the eave/wall interaction. The side that needs to be modified depends on which side the wall is on.
3. Measure at least 1 ½ in on the top, face and the kick of the drip edge. The 1 ½ in portion of the bottom kick flange can be cut back - it may need to be cut back further depending on the siding.
    a. Next, make a relief cut to the 1 ½ in mark, separating the top and the face flanges of the drip edge. Then bend the 1 ½ in flanges up and out to 90 degrees.
    b. Install the drip edge behind the paper.

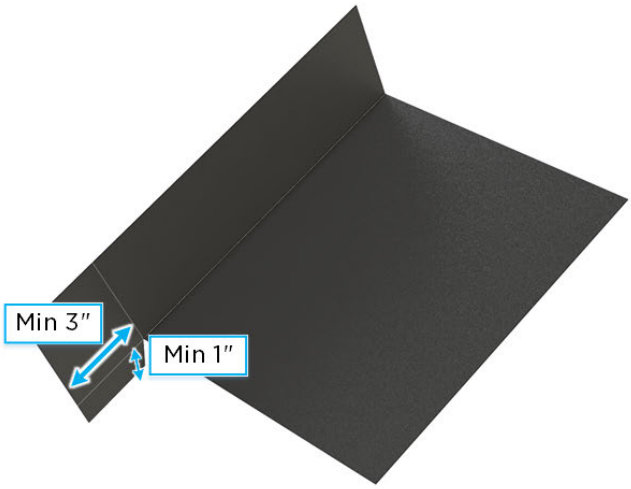


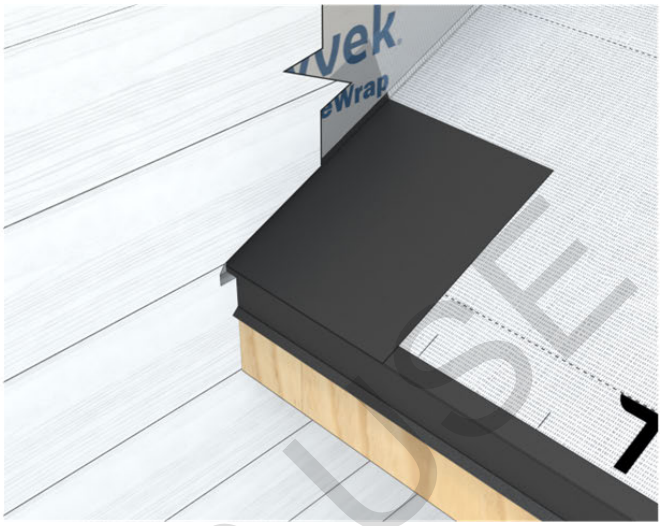
4. Next, install the underlayment. The underlayment should turn up the wall for a minimum of 4 in and be overlapped by the building paper by at least 1 in.



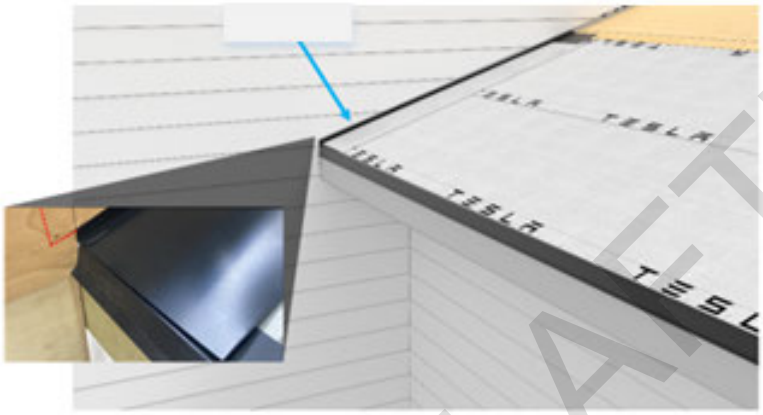


5. Continue with a 1 ft section of wall flashing. Installing the wall flashing in this step is very important as this will be what protects the eave to wall interaction. In addition, the next piece of wall flashing will have a kick out and it will fold away from the wall, exposing any gaps that may be present. This 1 ft section of the wall flashing will cover that gap.
    a. Measure and mark a 3 in line on the side closest to the eave.
    b. Then, fold down the bottom flange on the 3 in mark and cut it to 1 in. This part may not always be available depending on the siding.
    c. Install it behind the building paper. Make sure this part extends past the eave at least 3 in and down below the eave at least 1 in.

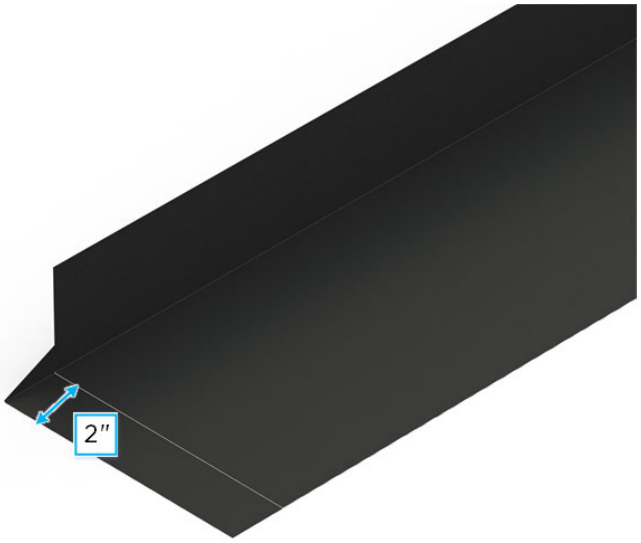




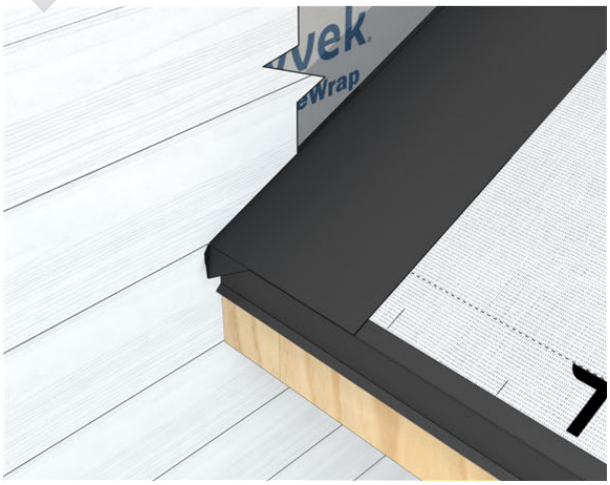
Pictured: Flashing behind building paper.



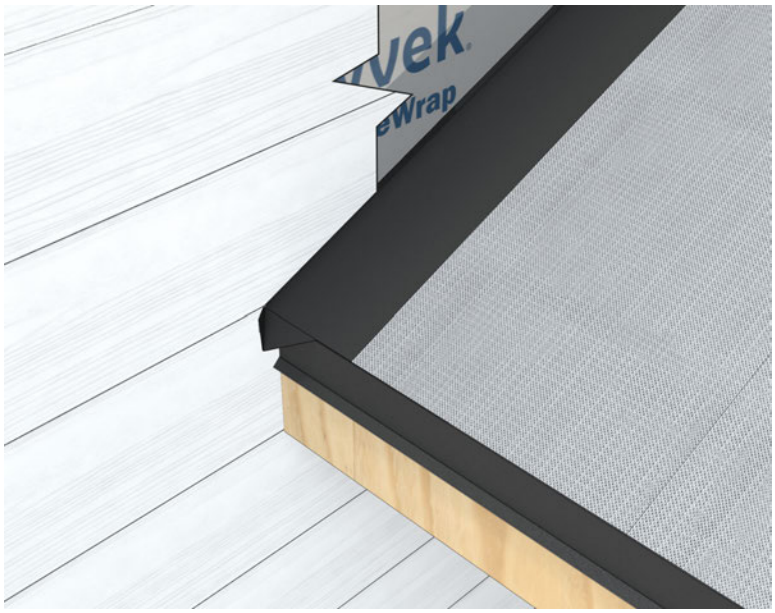
6. Next, fabricate the diverter for the wall flashing. The diverter is 2 in wide and 1 in tall and will help route the water away from the wall and into the gutter.
    a. Add another piece of wall flashing over the first one. Make a 2 in line from the edge of the wall flashing closest to the eave.
    b. Cut the bottom flange on the 2 in line.
    c. From the 2 in cut, make a plum line to match the pitch of the roof on the wall portion of the wall flashing. The steeper the pitch, the steeper the angle will be and this will slightly change the shape of the diverter.
    d. Trace the shape of the diverter using the 1 in height mark and taper the line to zero to the end of the 2 in line previously made.



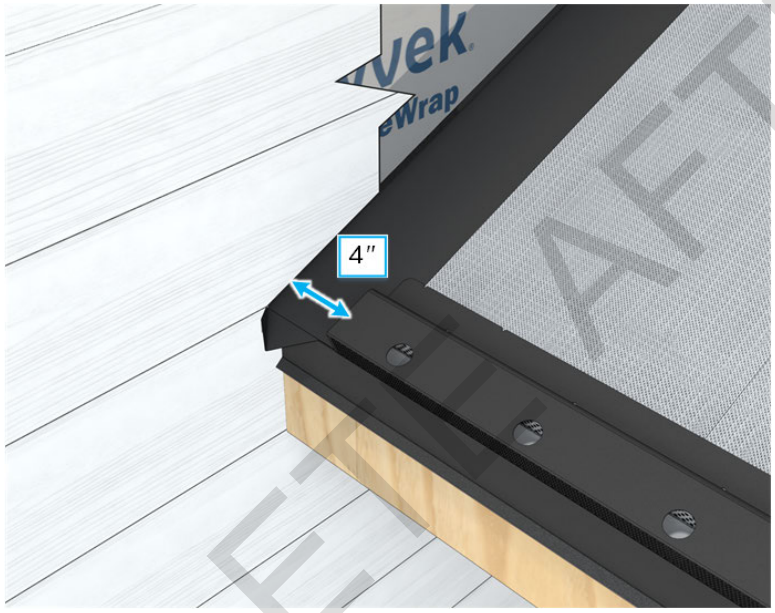
7. Cut a 45° line from the top of the 1 in kick, up and away toward the end of the wall flashing.
    a. Fold it on top of the kick and cut the excess metal sticking out below the wall flashing.
    b. Cut on your plum line to the top of the kick to get rid of the extra metal.
    c. Bend the kick under and in, away from the wall.



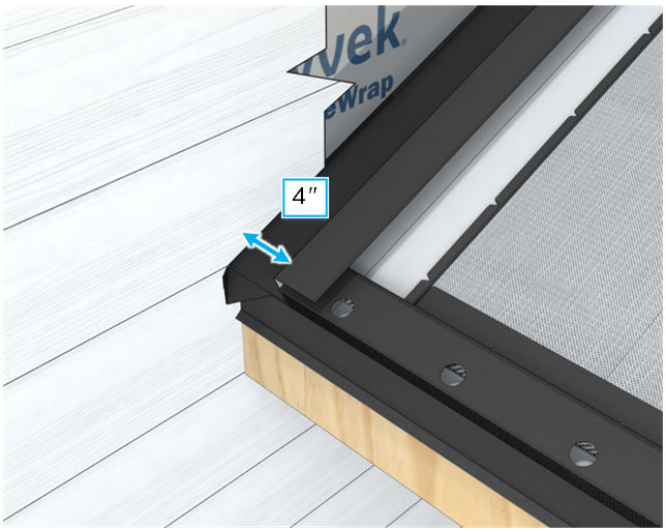
8. Install the wall flashing with the kick so the kick sits at least 1 – 1 ½ in away from the wall/siding and only overhang the eave 1 – 1 ½ in. It should be installed behind the building paper.

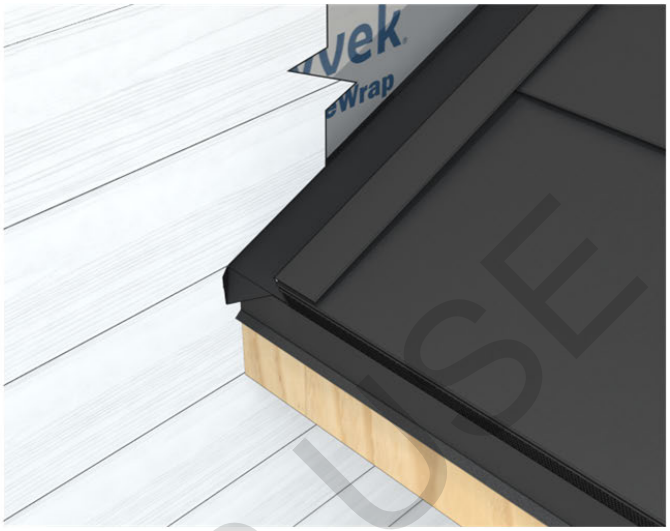


9. The wall flashing with the kick gets stripped in and the riser will be installed 4 in away from the wall.

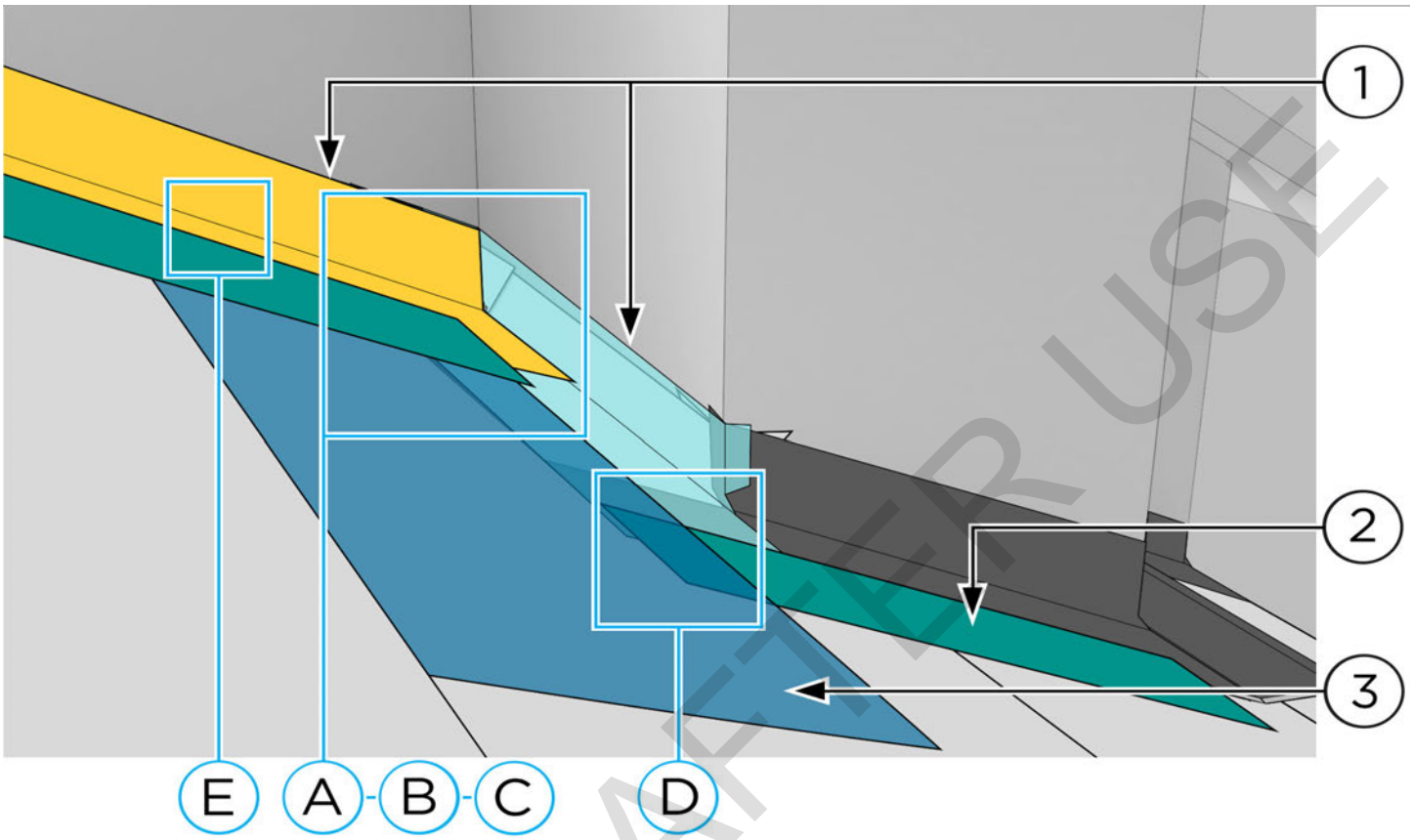


10. The channel flashing also gets installed 4 in away from the wall and the area is now ready for installing the tiles.



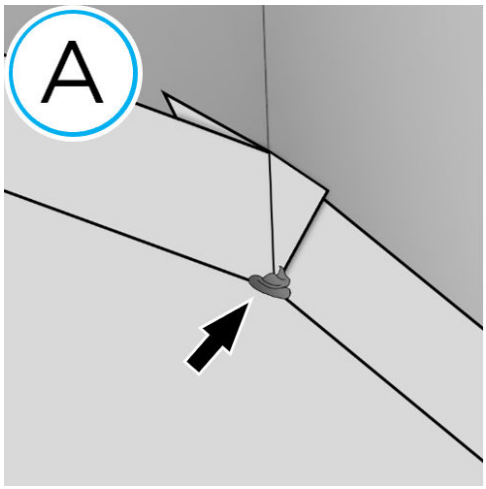


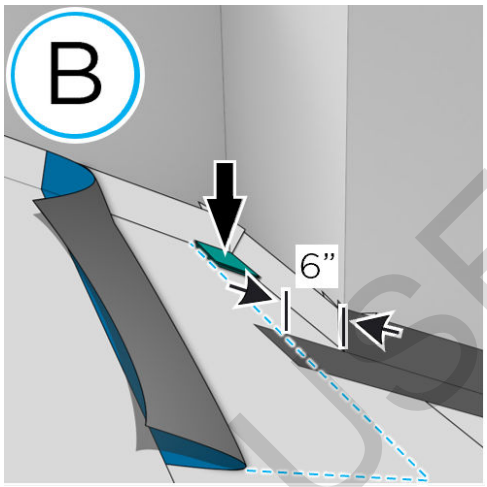
Endwall-Sidewall Inside Corners

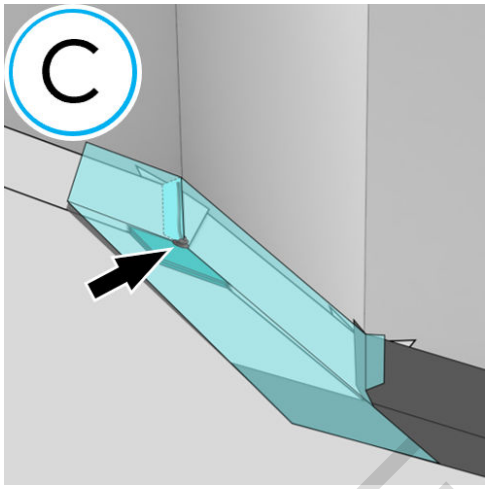


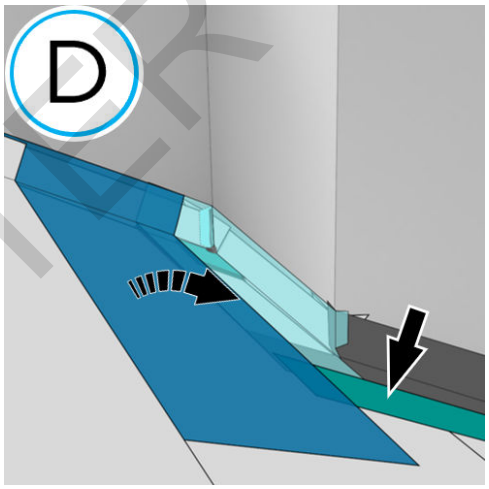
1	Wall Flashing
2	Underlayment
3	Detail Roll

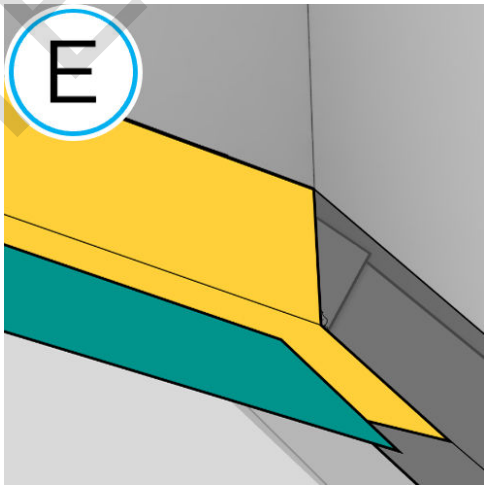
	See detail images on next page.
A	Underlayment should have a minimum 4 in upturn at the base of the wall. Make a 45° cut at the underlayment inside corner, then fold the tabs to fit in the corner. Apply a dollop of sealant at the inside corner to eliminate potential pinholes.
B	Stack underlayment patches at the inside corner to create a slope that diverts water flow from the roof at the inside corner. Install additional underlayment to provide positive lapping to future flashing. Field underlayment should positively lap over the stacked underlayment.
C	Cut and bend wall flashing to fit the inside corner. Ensure that a minimum 1 in tab laps from the endwall to the sidewall and is tucked behind the sidewall turn up.
D	Ensure that the wall flashing installed at the endwall contains a minimum ¼ in of deflection per 12 in away from the inside corner to promote drainage. Positively lap target underlayment over the leading edge of the wall flashing.
E	Install wall flashing at the remaining sidewall. Strip in the wall flashing with detail roll.











Counterflashing for Natural Stone

Overview

This section outlines the procedures for installing counterflashing at natural stone surfaces.

Tools & Equipment

- Segment cup grinding wheel
- Wire brush
- Counterflashing
- Sealant
- Metal snips

Tear Off and Deck Prep Overview

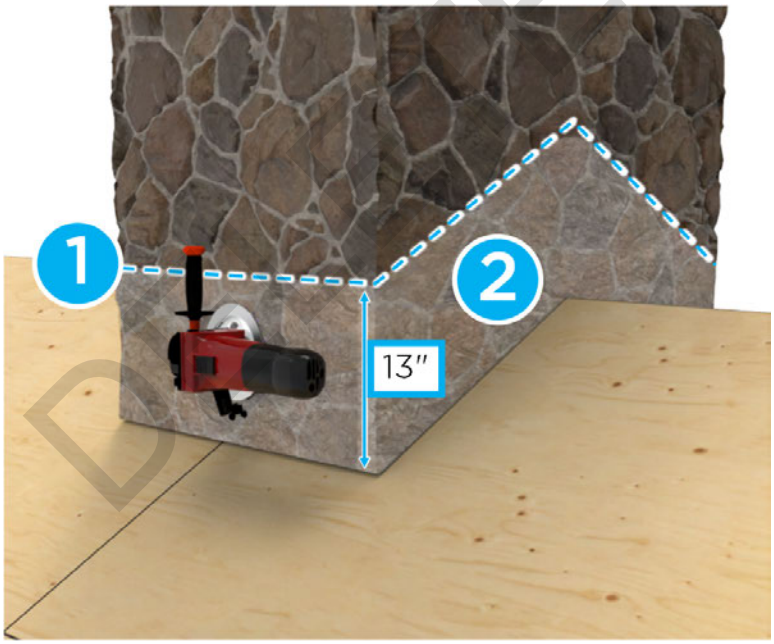
This procedure outlines how to prep natural stone surfaces for the installation of counterflashing. This process should be completed prior to the installation of underlayment and deck metals.

CAUTION: Silica dust created when cutting or drilling into certain materials (brick, concrete, mortar, etc.) is a respiratory hazard. Use a grinder equipped with dust collection attachments to mitigate this hazard.

NOTE: If existing kerfs are in good condition and meet the height and depth requirements outlined in this process, they may be re-used.

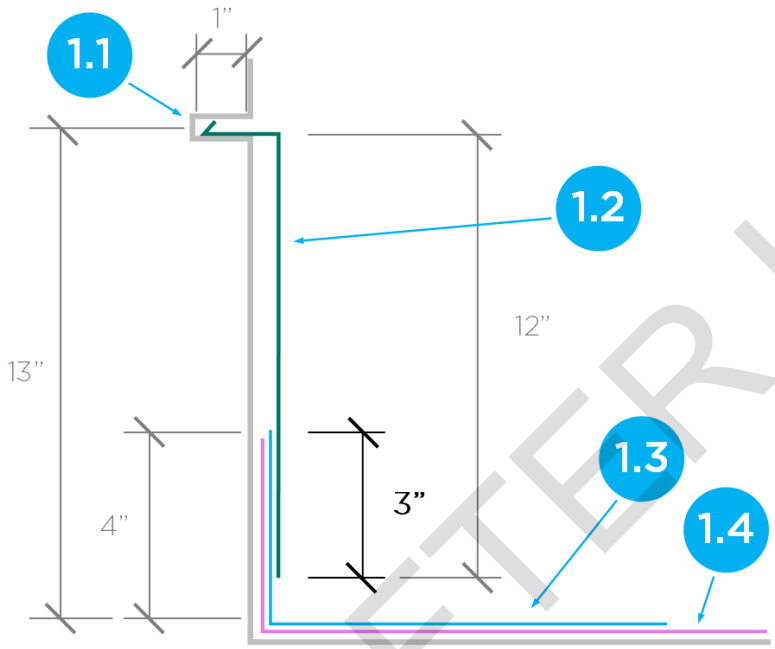
Tear Off and Deck Prep Work Instruction

Mark a kerf line up the chimney or wall 13 in from the deck **(1)**. Below the marked kerf line, level the low and high points in the stone with a segment cup grinding wheel, so that the difference between low points and high points a ½ in or less **(2)**.

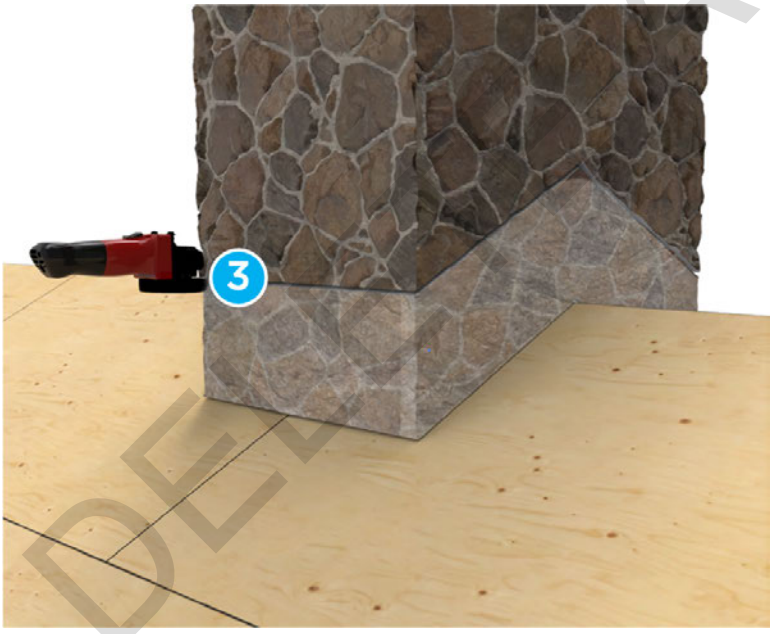


NOTE: A 13 in kerf height ensures that counterflashing laps 3 inches over the vertical portion of underlayment, transition flashings and wall flashing.

(1.1)	Kerf
(1.2)	Counterflashing
(1.3)	Wall Flashing
(1.4)	Underlayment



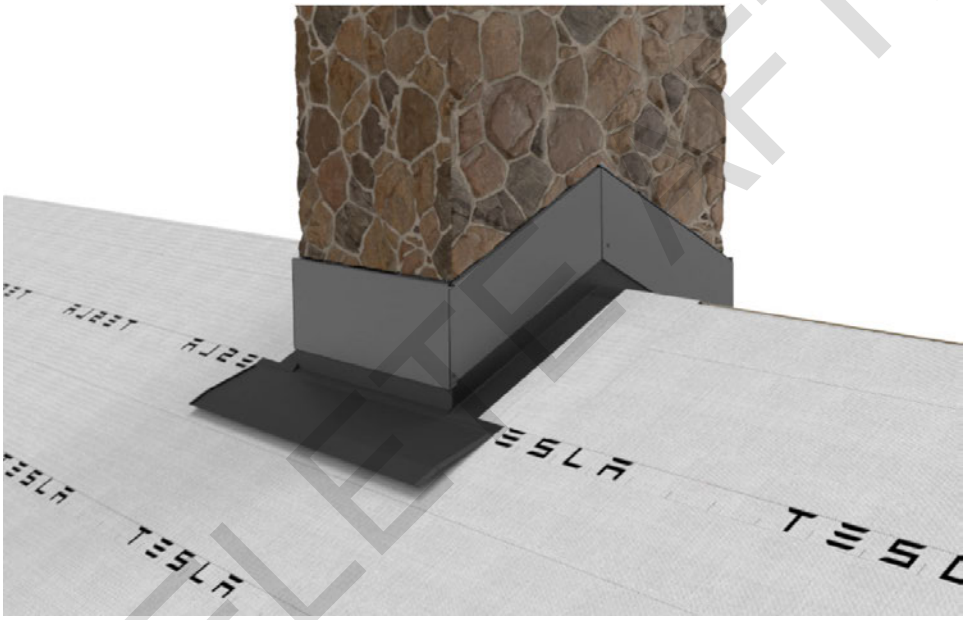
Next, cut the kerf 1 in deep along the marked line **(3)**.



Use a wire brush to clean the kerf (groove) by removing all dust/debris **(4)**.

Dry-In Overview

This procedure outlines how to install counterflashing on natural stone surfaces after underlayment and deck metals are installed.



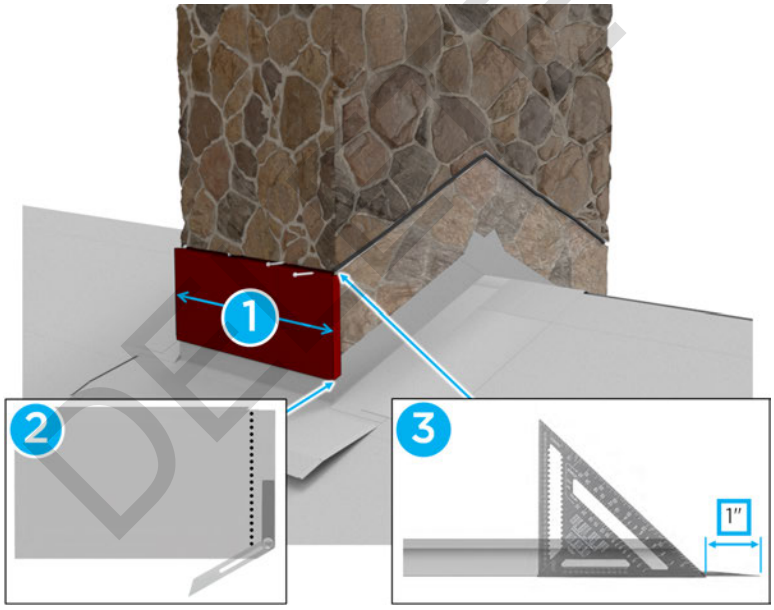
NOTE: Prior to installing counterflashing, apply a bead of sealant inside the kerf. Best practice is to fabricate and test fit the counterflashing, then apply sealant once you know the counterflashing fits.

NOTE: Fasten all counterflashing 1 in from the obstruction corners and every 6 in on center with concrete screws.

Dry-In Work Instruction

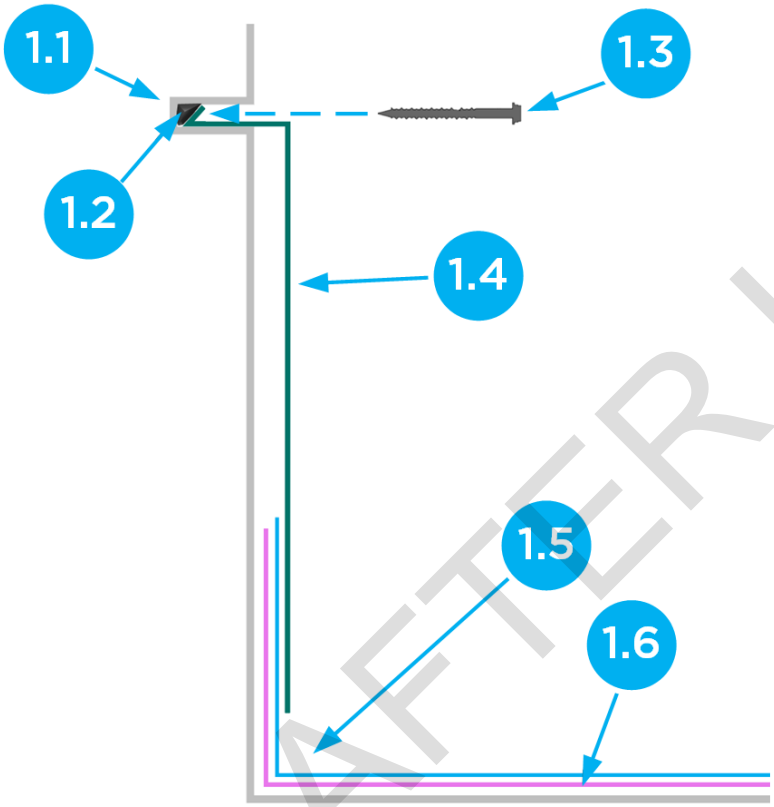
Headwalls

Cut the counterflashing to size, including 1 in tabs at headwall-sidewall corners **(1)**. Cut the bottom of the 1 in tab(s) to the roof's slope to avoid interference with the roof **(2)**. Miter cut the top groove of the counterflashing as needed to form clean joints with adjacent pieces of counterflashing on sidewalls **(3)**. Position and secure the counterflashing.



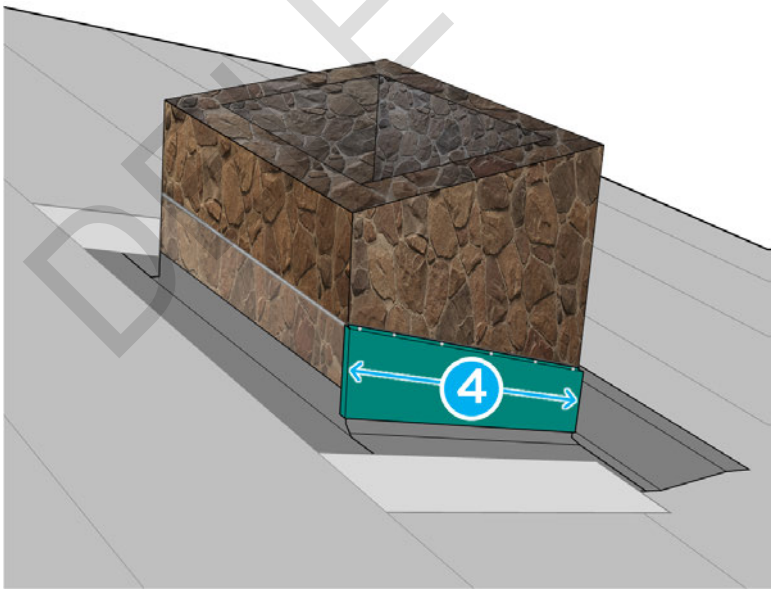
(1.1)	Kerf
(1.2)	Sealant
(1.3)	Concrete Screw

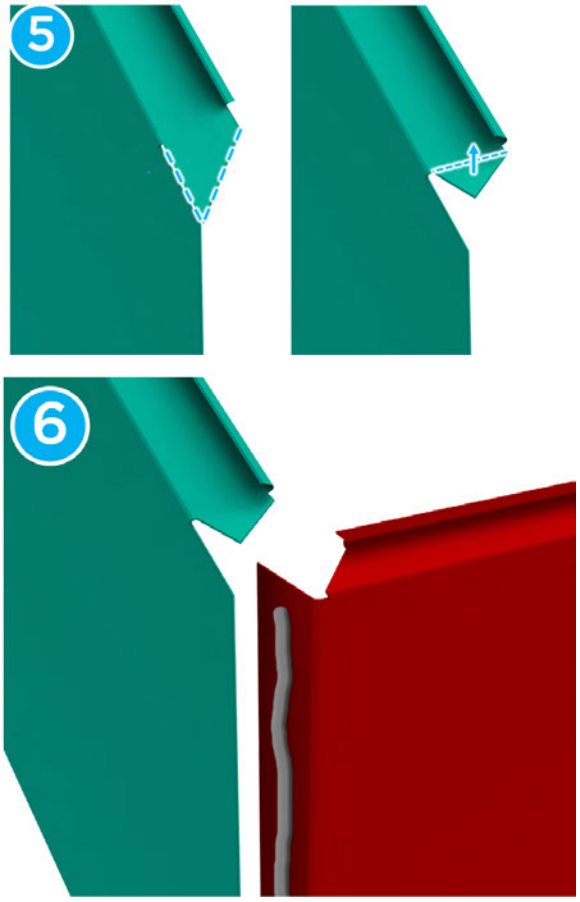
(1.4)	Counterflashing
(1.5)	Wall Flashing
(1.6)	Underlayment



Sidewalls

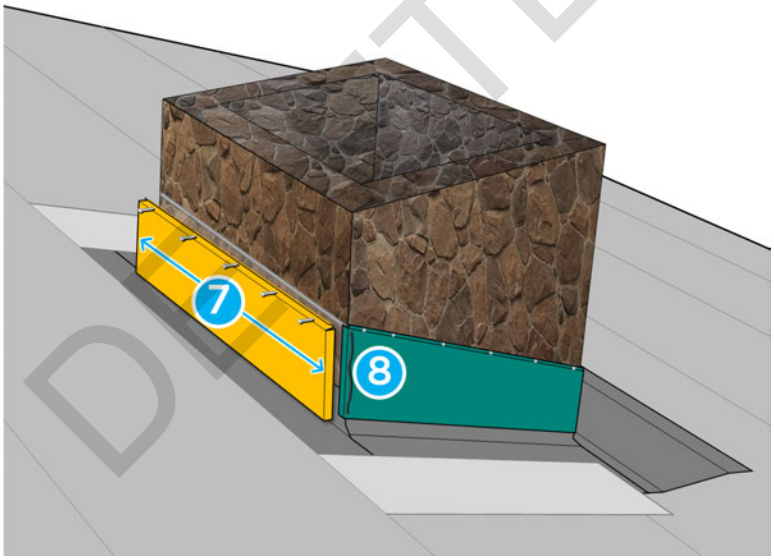
Cut counterflashing to size including a 1 in tab at sidewall-endwall corners **(4)**. No tab is needed at headwall-sidewall corners. Miter cut and bend the top groove of the counterflashing as needed to form clean joints with adjacent pieces of counterflashing on headwalls and endwalls **(5).** Add sealant to the headwall counterflashing's tab **(6)**. Position and secure the sidewall counterflashing.





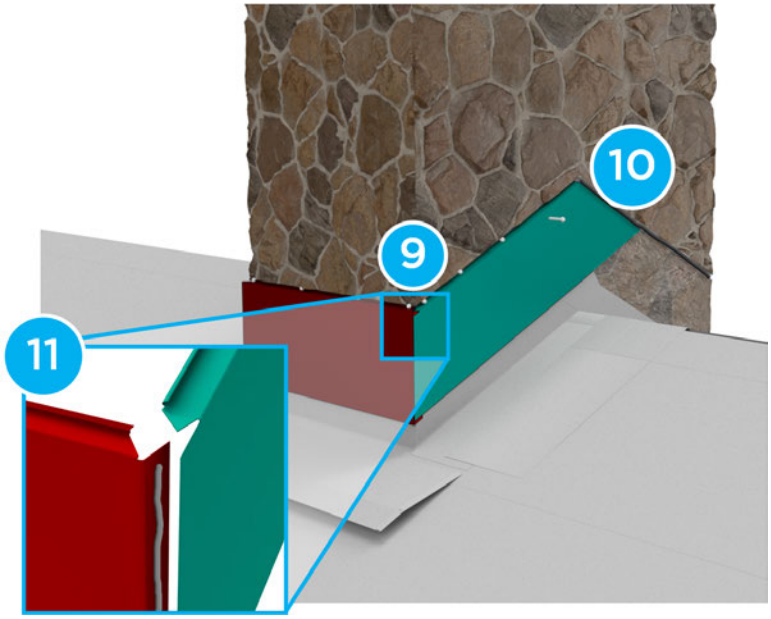
Endwalls

Cut counterflashing to size including 1 in tabs around sidewall-endwall corners **(7)**. Miter cut the top groove as needed to form a clean joint with adjacent counterflashing on sidewalls. Apply sealant where the endwall tabs will overlap the sidewall counterflashing **(8)**. Position and secure the counterflashing.

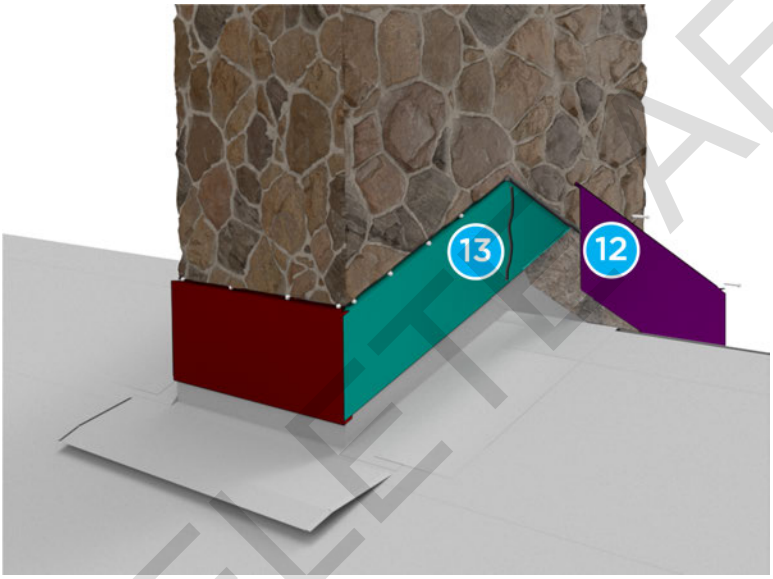


Sidewall-Sidewall-Ridge

On one side of the sidewall, cut counterflashing so that it covers the tab on the headwall counterflashing **(9)**. Cut the opposing end of the sidewall counterflashing at the kerf line **(10)**. Add sealant to the headwall tab **(11)**, then position and secure the counterflashing.

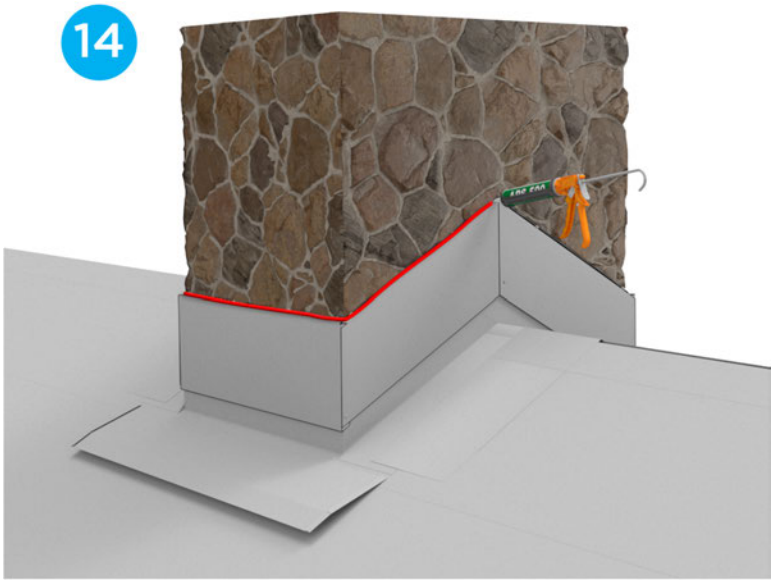


On the opposite sidewall, cut the sidewall counterflashing plumb with the ridge **(12)**. Add sealant at the overlap between the two pieces of sidewall counterflashing **(13)**. Position and secure the counterflashing in place.

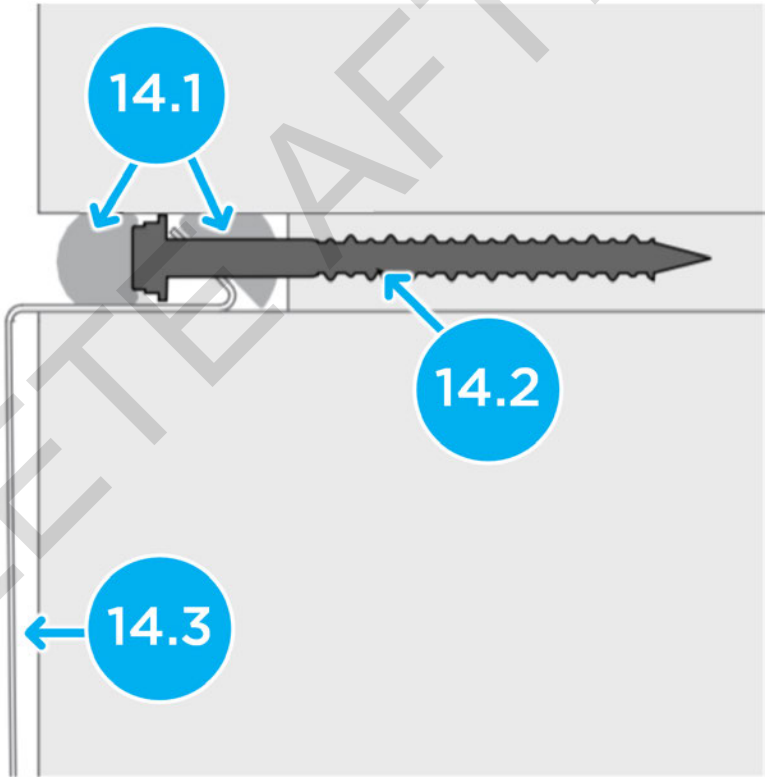


Final Sealant Application

After all counterflashing is installed, apply a bead of sealant inside the kerf lines that fills the kerf and covers all fasteners **(14)**.

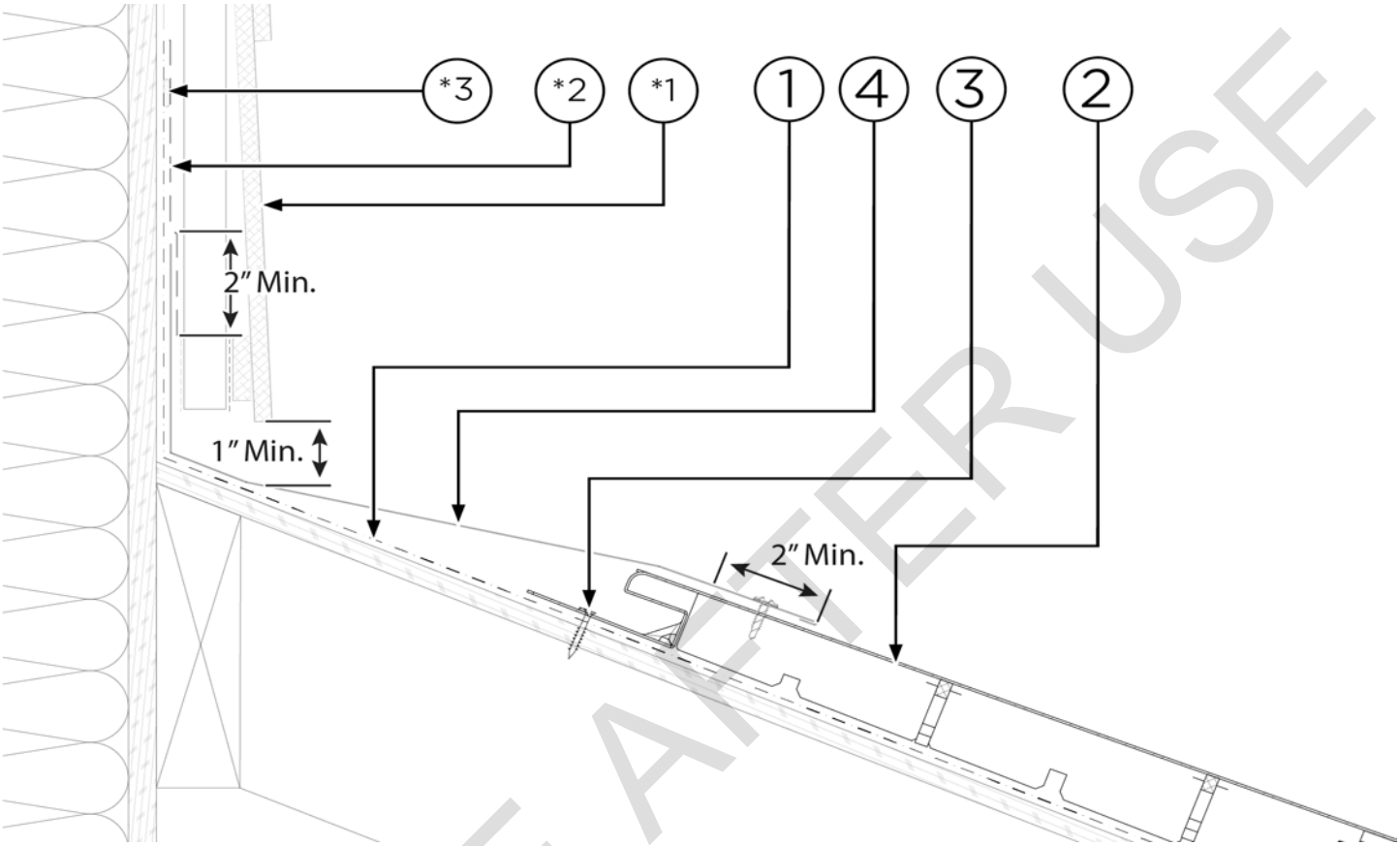


(14.1)	Sealant
(14.2)	Concrete fastener
(14.3)	Reglet flashing



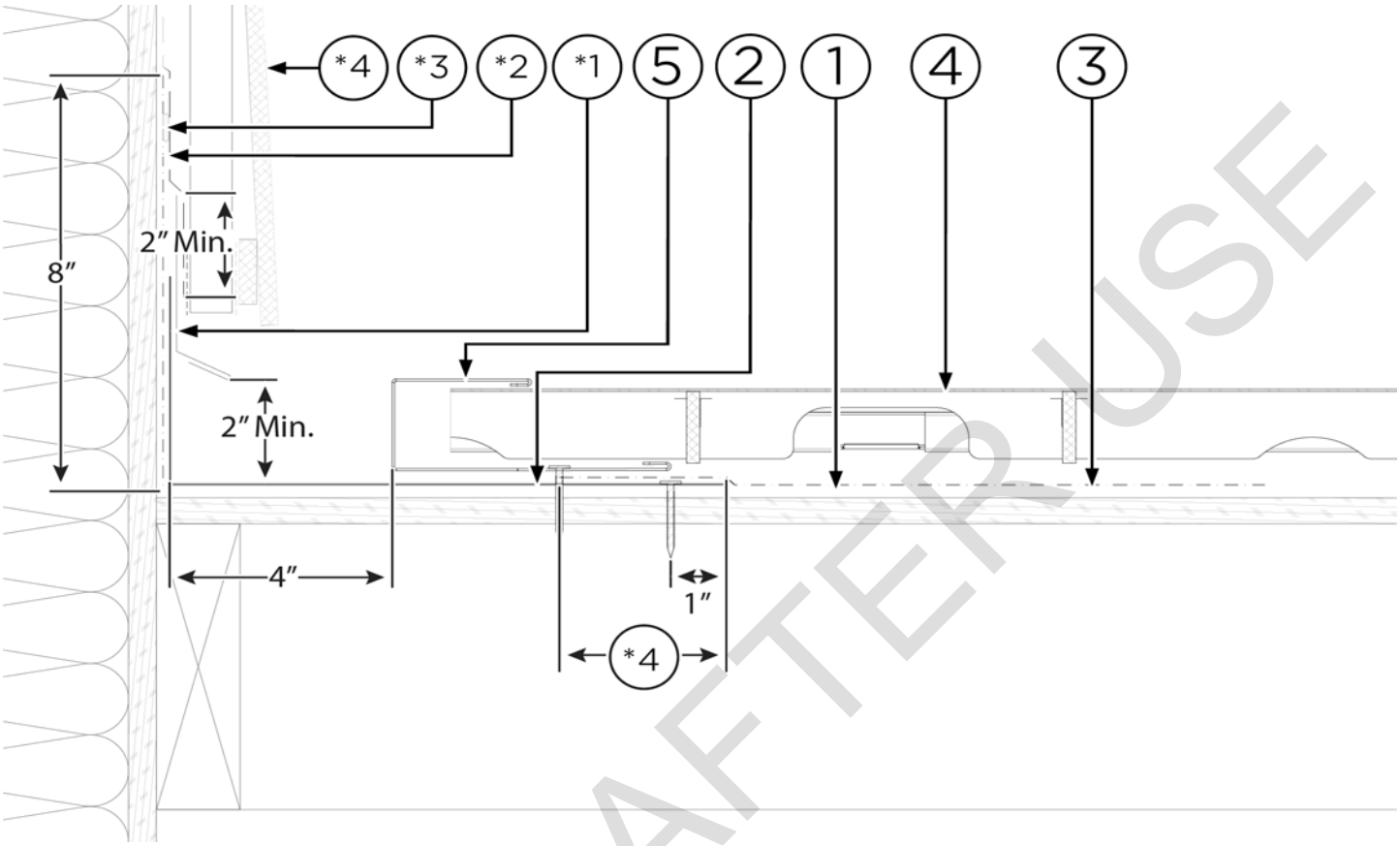
Wall Interactions and Square Obstructions Cross Sections

Cross Section: Headwall



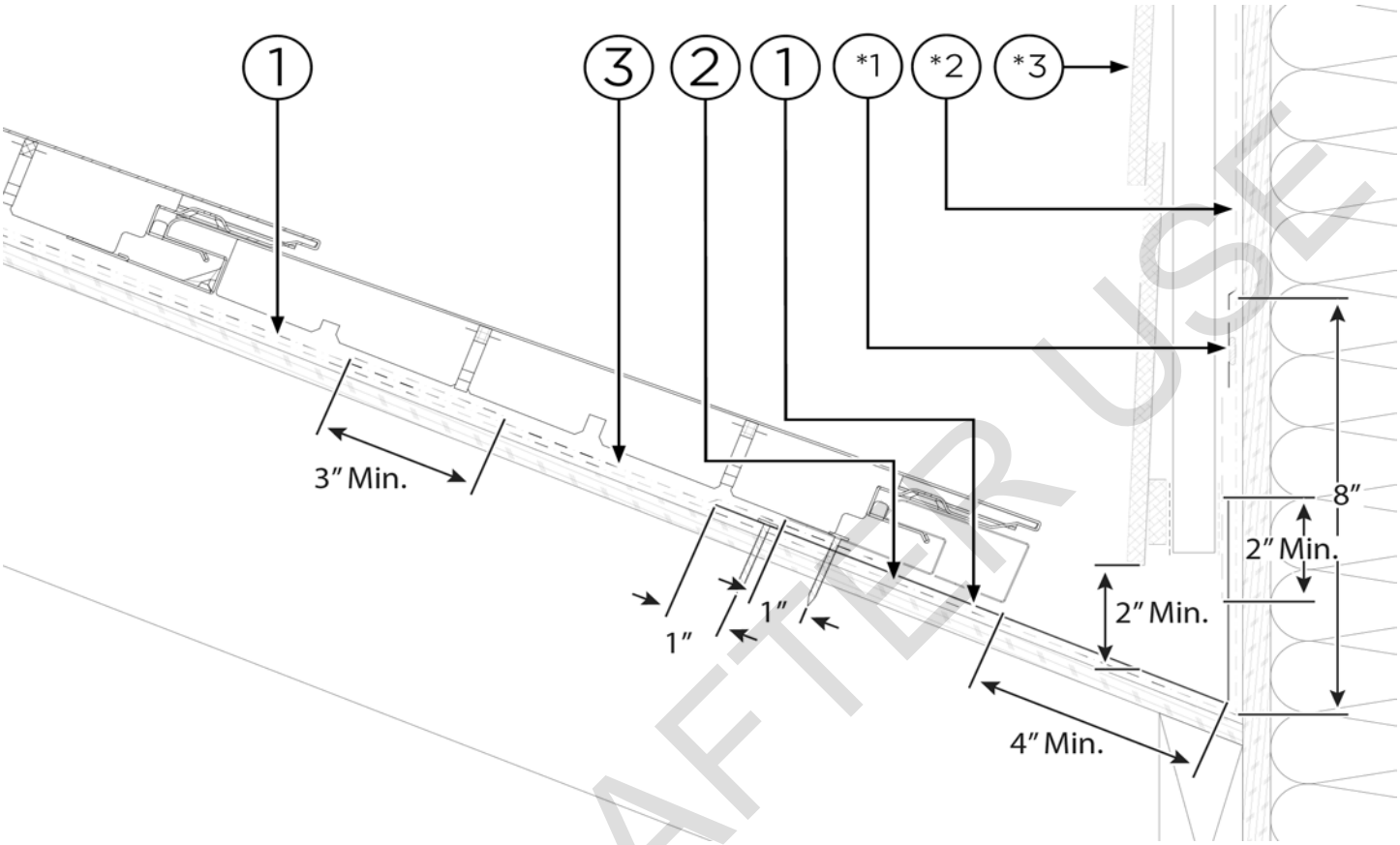
***1**	Air barrier sealant by others (optional)
***2**	Weather Resistive Barrier (WRB) by others
***3**	Cladding over furring with continuous insect screen by others
1	Underlayment
2	Metal Tile
3	Fastener
4	Transition Flashing

Cross Section: Sidewall



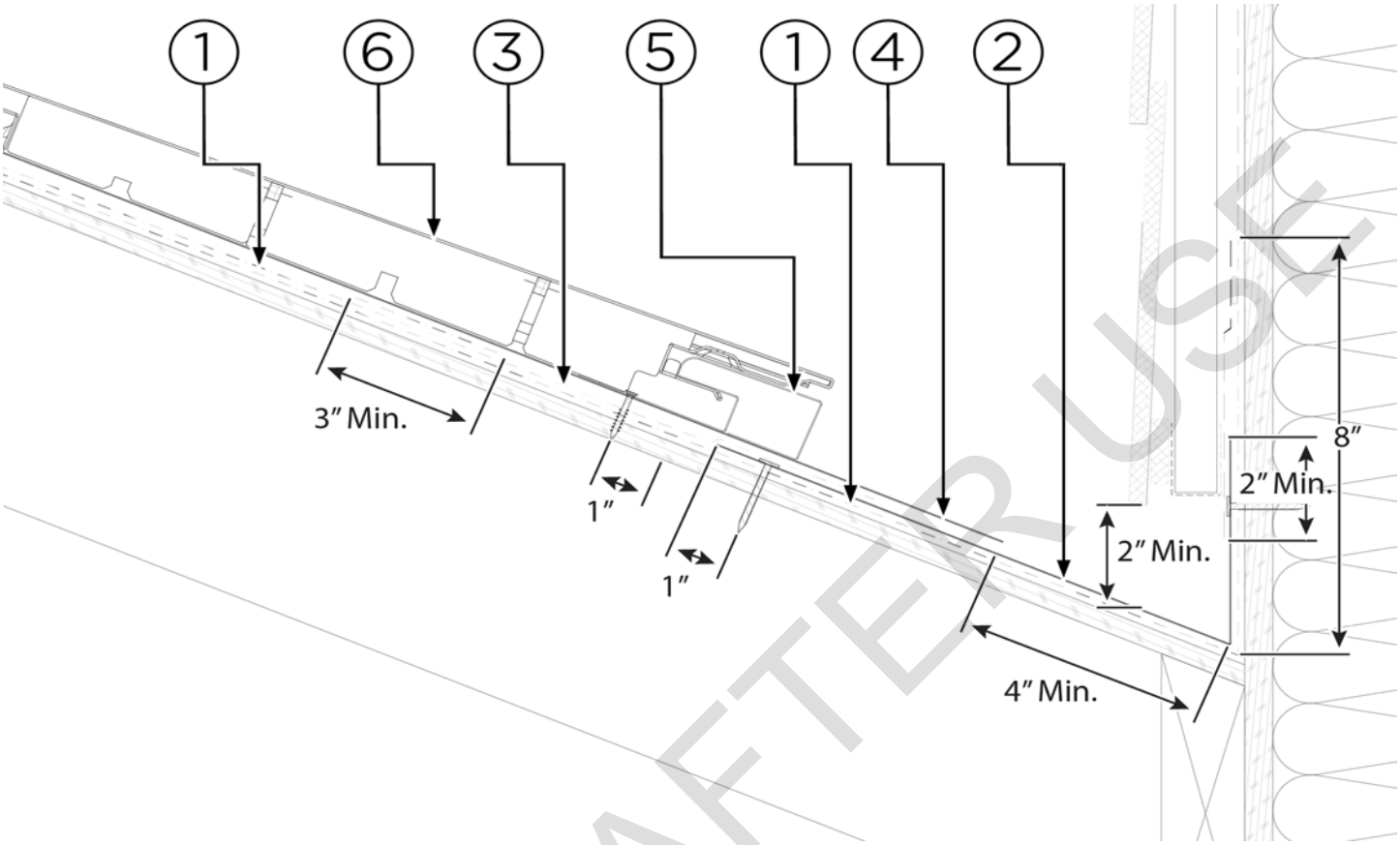
***1**	Base of wall flashing by others
***2**	Weather Resistive Barrier (WRB) by others
***3**	Air barrier sealant by others (optional)
***4**	Cladding over furring with continuous insect screen by others
***5**	3-inch minimum overlap
1	Underlayment
2	Wall Flashing
3	Detail Roll
4	Metal Flashing
5	Channel Flashing

Cross Section: Endwall



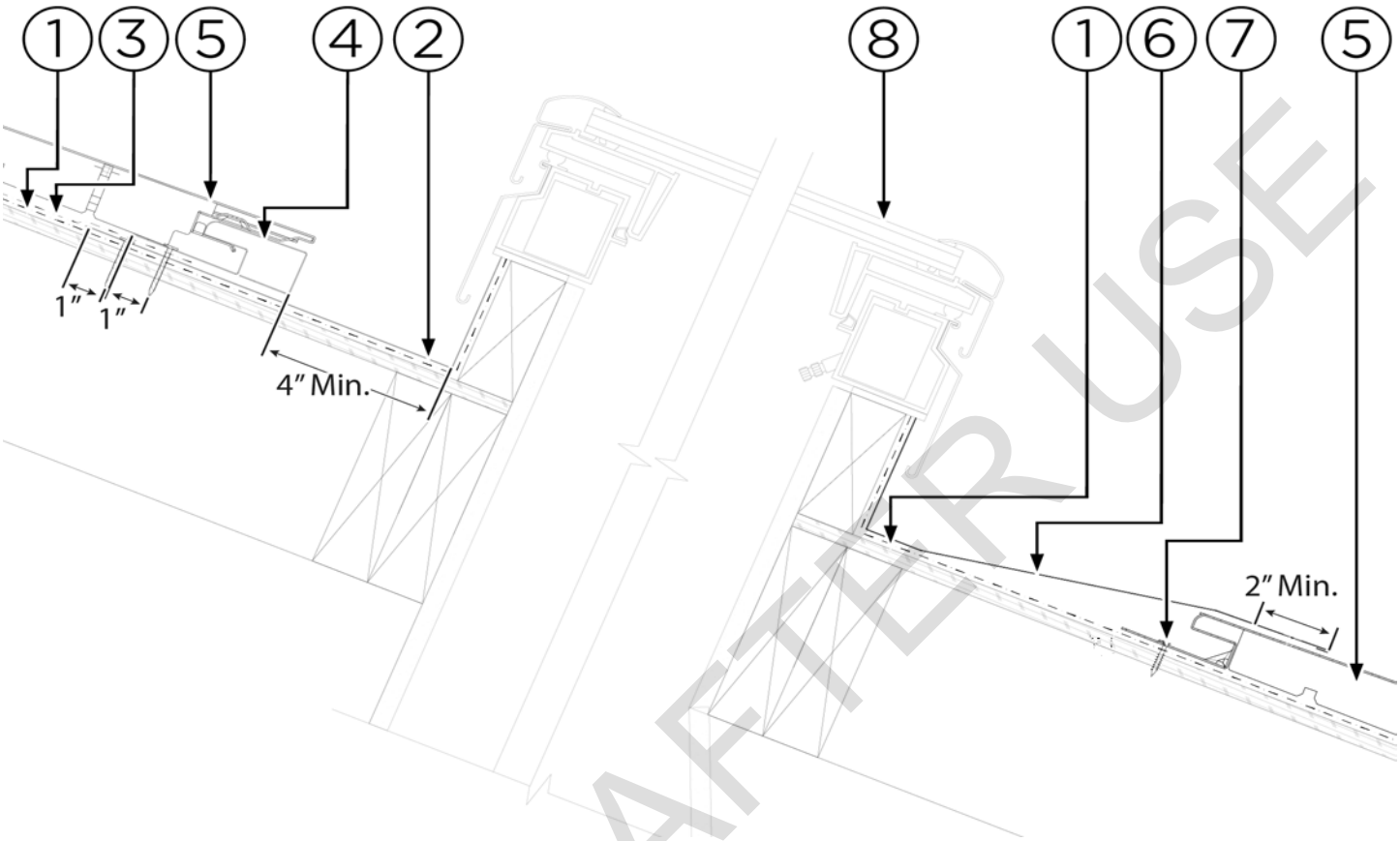
***1**	Air barrier sealant by others (optional)
***2**	Weather Resistive Barrier (WRB) by others
***3**	Cladding over furring with continuous insect screen by others
1	Underlayment
2	Wall Flashing
3	Detail Roll

Cross Section: Endwall (Metal Tile, not aligned with 4-inch gutter)



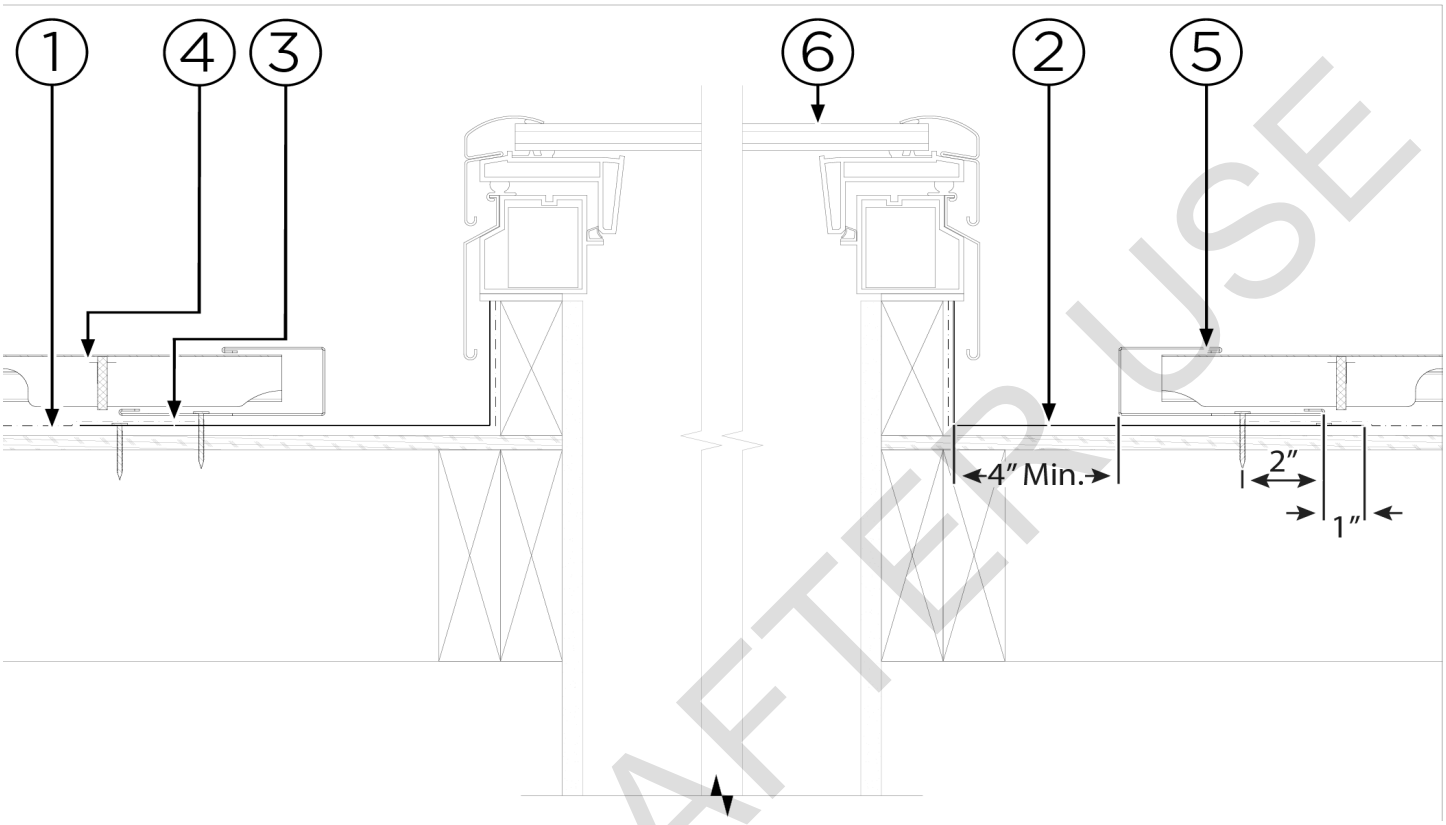
1	Underlayment
2	Wall Flashing
3	Detail Roll
4	Flat Stock
5	Vented Riser
6	Metal Tile

Cross Section: Curb-Mounted Skylight A



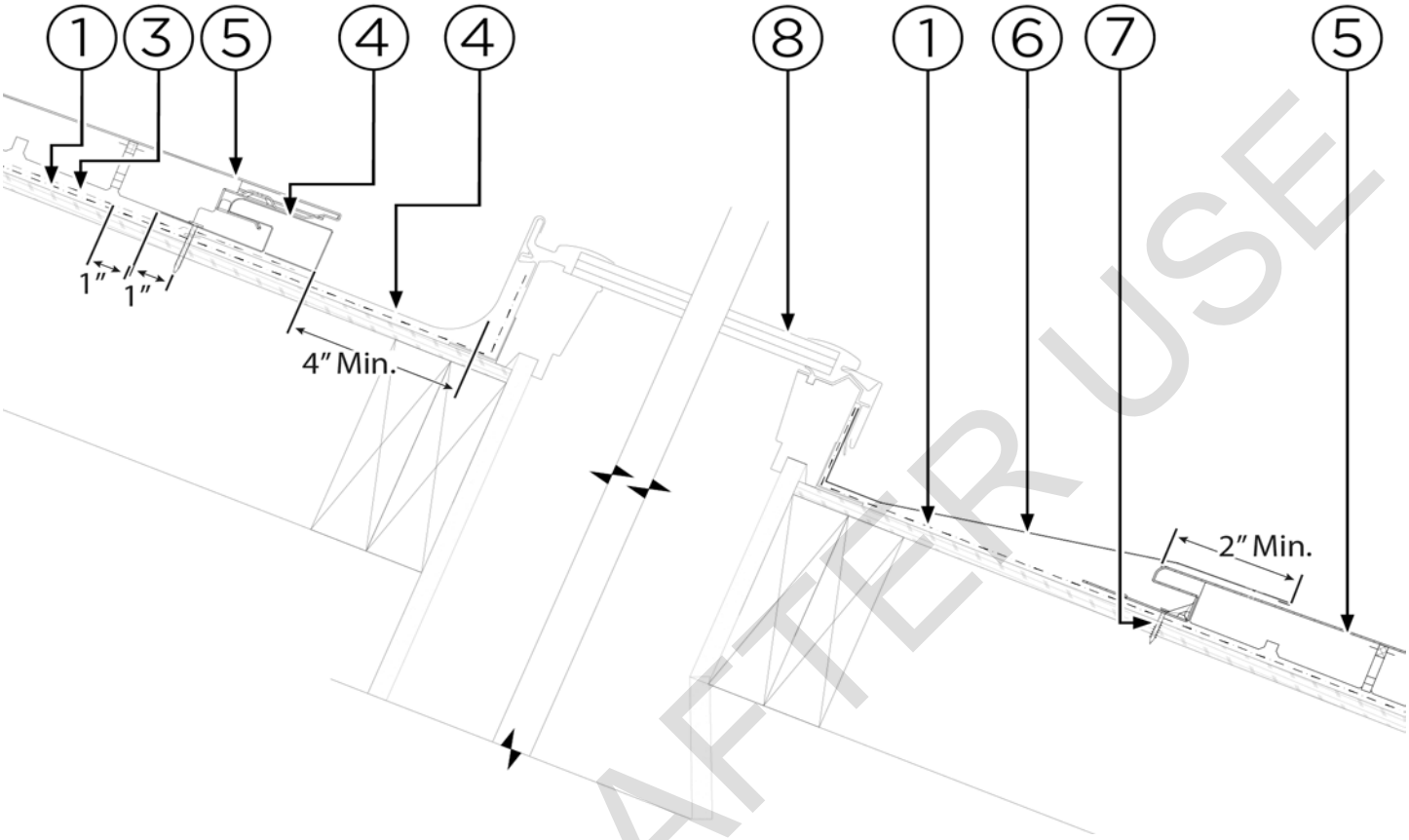
1	Underlayment
2	Wall Flashing
3	Detail Roll
4	Vented Riser
5	Metal Tile
6	Transition Flashing
7	Fasteners
8	Skylight by others

Cross Section: Curb-Mounted Skylight B



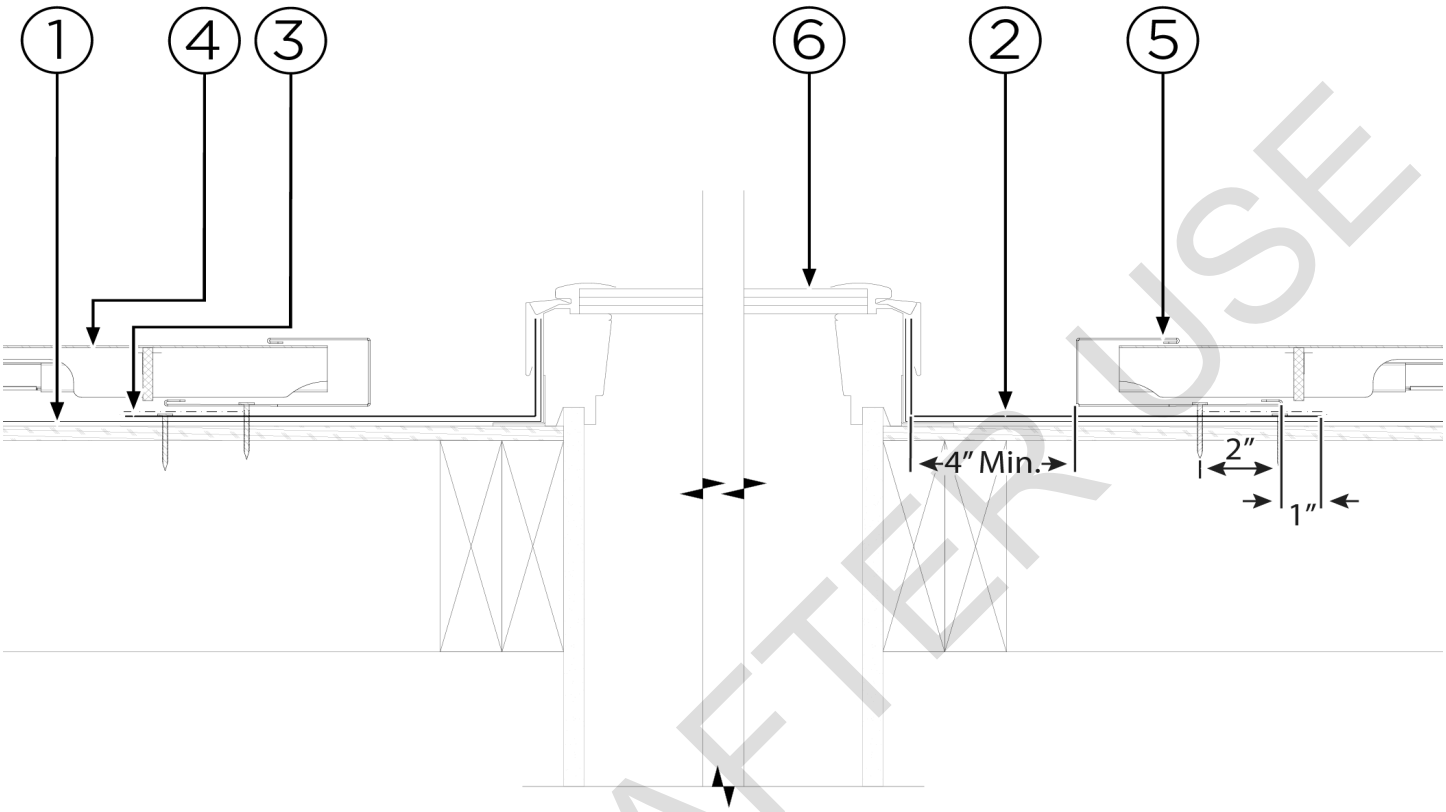
1	Underlayment
2	Wall Flashing
3	Detail Roll
4	Metal Tile
5	Channel Flashing
6	Skylight by others

Cross Section: Deck-Mounted Skylight A



1	Underlayment
2	Flashing by others
3	Detail Roll
4	Vented Riser
5	Metal Tile
6	Transition Flashing
7	Fasteners
8	Skylight by others

Cross Section: Deck-Mounted Skylight B



1	Underlayment
2	Wall Flashing
3	Detail Roll
4	Metal Tile
5	Channel Flashing
6	Skylight by others

Guttered Obstructions

Solar Tube

Overview

This section outlines the process for guttering solar tubes. Such obstructions contain unique flashings, flashings that cannot be replaced or physical characteristics that inhibit a new flashing being installed without excessive time and labor.

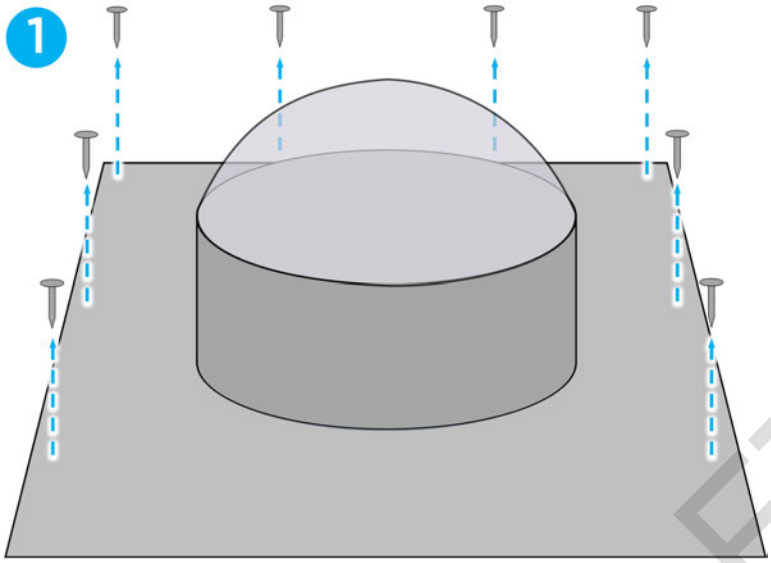
Tools & Equipment

- Underlayment
- Metal snips
- Transition flashing

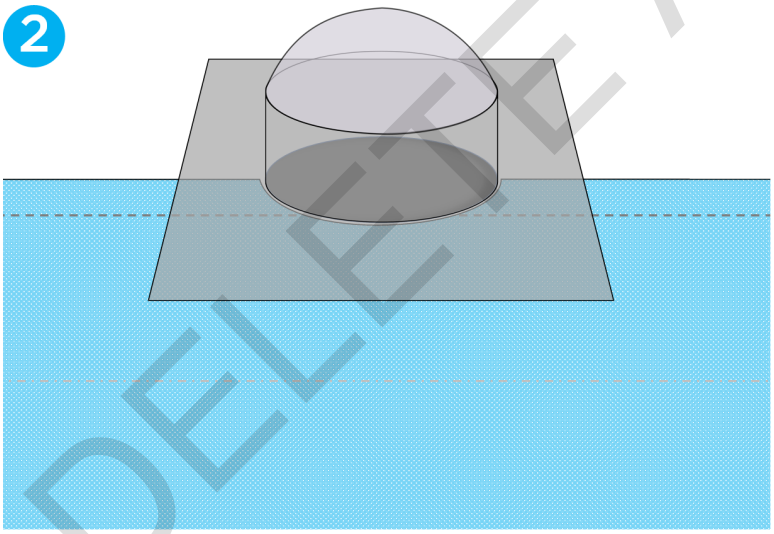
- Channel flashing
- Flat stock
- Detail roll
- Vented riser

Work Instruction

Remove deck fasteners from the existing flashing **(1)**.

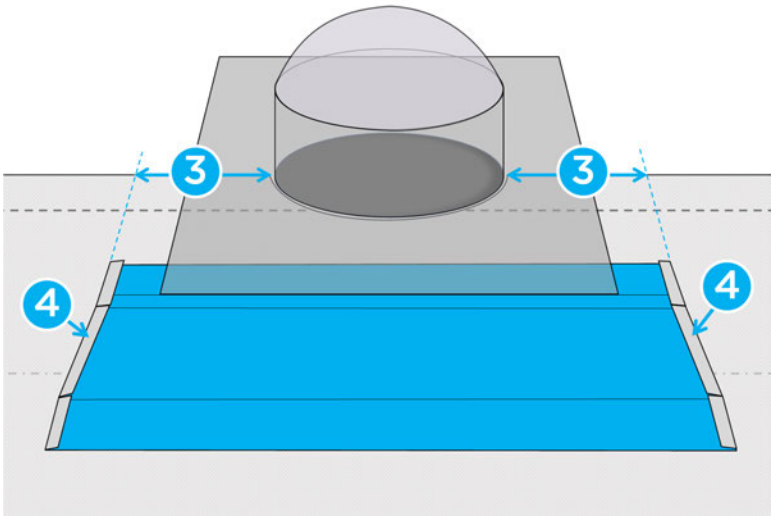


Lap underlayment under the bottom of the existing flashing. Underlayment should be installed as close to the base of the obstruction's penetration through the roof deck as possible. Cut the underlayment as needed to fit around the obstruction's penetration **(2)**.

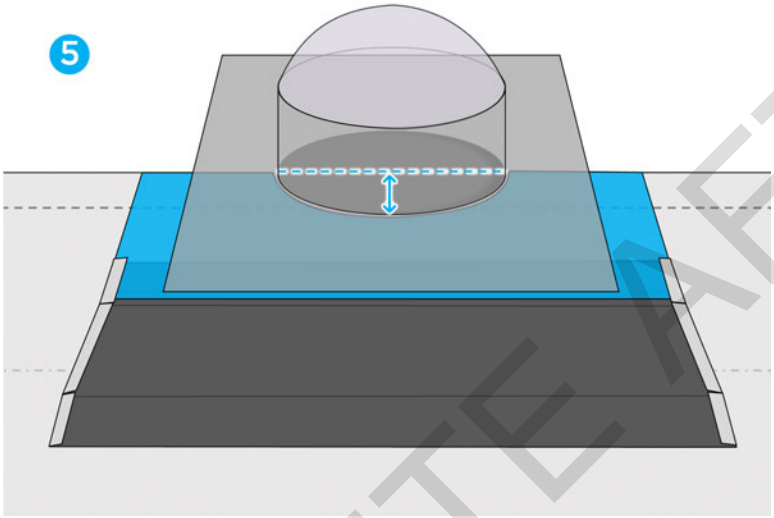


Cut and bend transition flashing to fit under the obstruction's existing flashing. The up-roof flange of the transition flashing is bent flat down to the roof deck and laps under the existing obstruction flashing. The transition flashing must extend 9 in beyond the outer diameter of the obstruction's bell **(3)** and contain 1 in open hems on either side **(4)**.

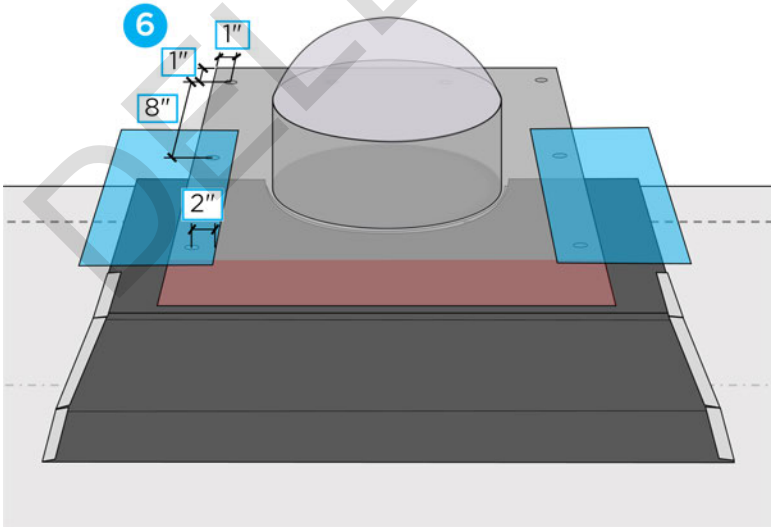
NOTE: Transition flashing must extend 9 in beyond the obstruction's bell, so that channel flashing can be installed to create a nominal 4 in gutter along the obstruction later in this process.



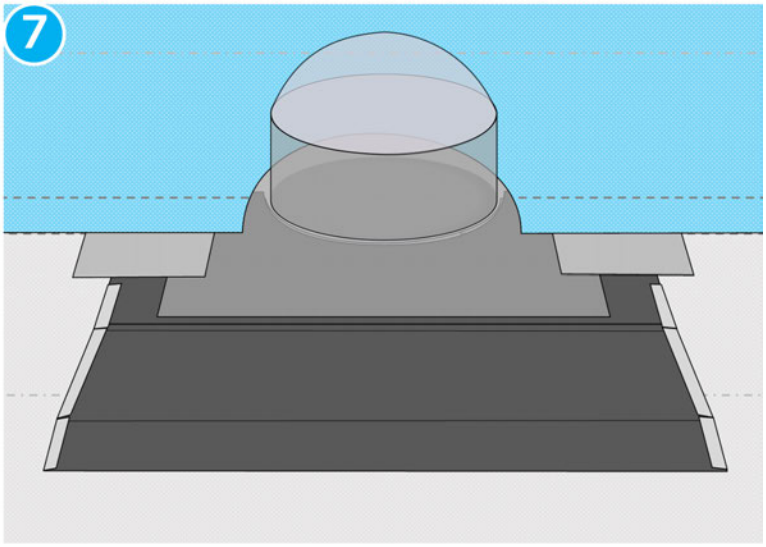
Cut flat stock to create an upper extension bib for the transition flashing. The upper extension bib must extend at least halfway up the diameter of the obstruction. The extension bib must lap over the transition flashing and under the existing obstruction flashing **(5)**.



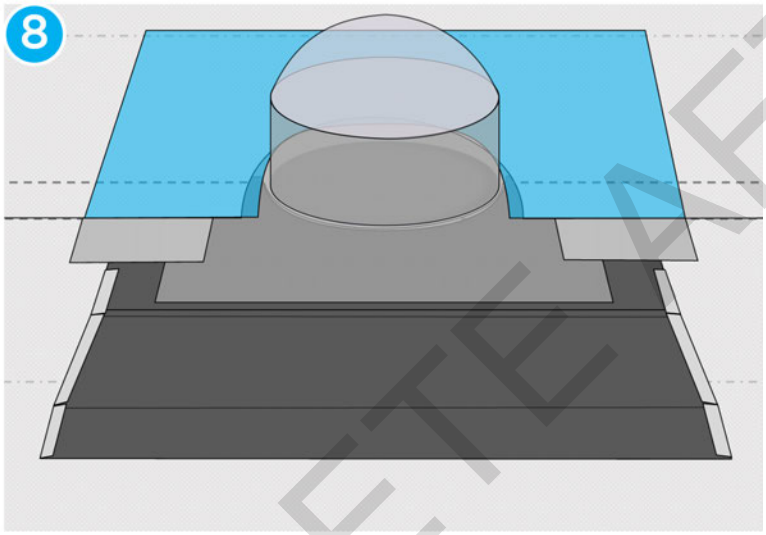
Secure the sides and top of the obstruction's existing flashing with deck screws positioned 1 in from the flashing edges and every 8 in O.C. Do NOT place fasteners within 3 in of the flashing's lower edge. Strip-in the sides of the existing flashing with the detail roll lapping a minimum of 2 in beyond the fasteners **(6)**.



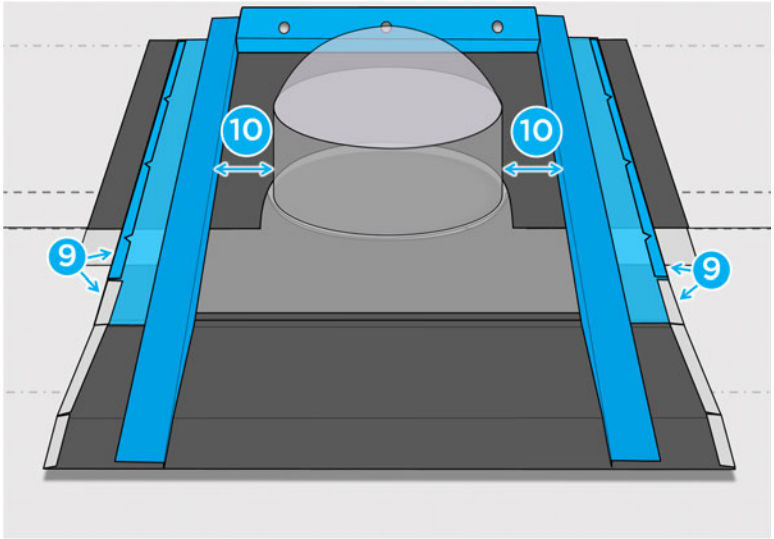
Integrate the obstruction with the courses of underlayment up-roof. Make a relief and remove material as needed to fit around the flashing's bell **(7)**.



Cover underlayment around the obstruction that will be visible after tiles are installed with a concealer pan fabricated from flat stock **(8)**.



Install channel flashing along the sides of the obstruction and vented riser along the top of the obstruction. Align the outer edge of the channel flashing's deck flange with the outer edge of the transition flashing **(9)**. This will create a 4 in gutter between the vertical face of the channel flashing and the obstruction's bell **(10)**. The length of channel flashing and location of the vented riser, above the obstruction, are determined by the tile reveal above the obstruction.



The assembly is now complete and ready for tile installation.

Guttered Square Obstructions

Overview

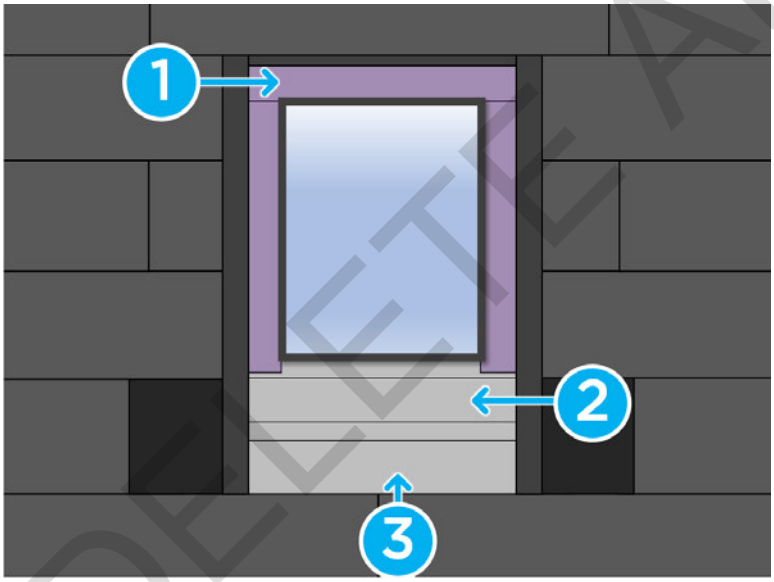
This process covers how to install concealer pans, channel flashing, metal tiles and tile covers around guttered obstructions.

Tools & Equipment

- Measuring tape
- Flat stock
- Chalk line
- Channel flashing
- Robin jig
- Transition flashing
- Tile skin
- Vented riser

Note the following features seen throughout this work instruction:

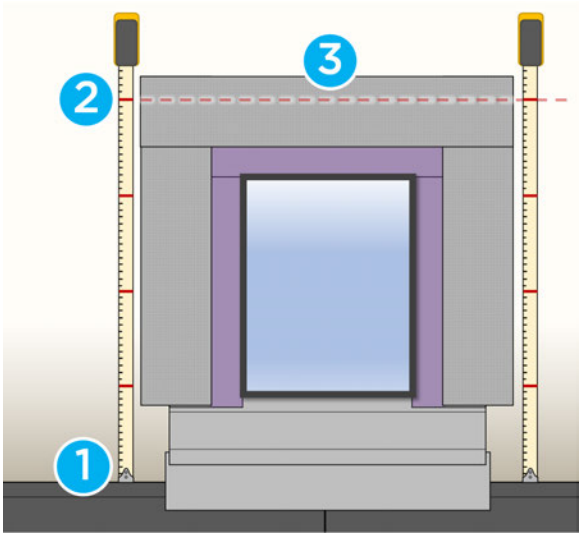
- **(1):** 4 in gutter
- **(2):** Transition flashing
- **(3):** Deadzone flashing



Work Instruction

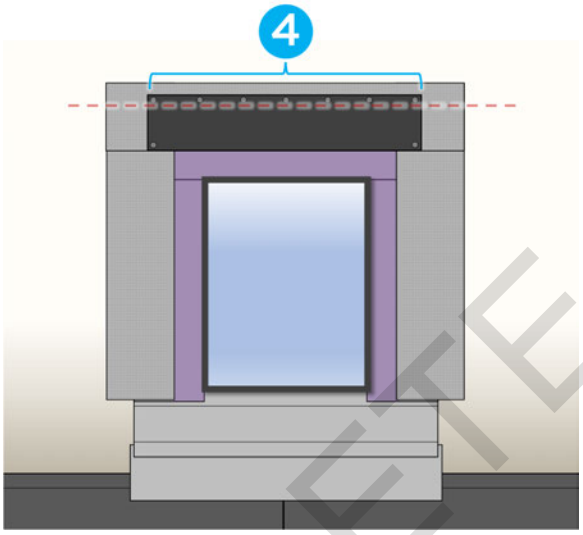
Using a measuring tape with the marked reveal points (see *work instruction on setting up a measuring tape on page 731*), measure from the nailing flange or footlap below the guttered obstruction **(1)** to the closest nailing flange location above the obstruction **(2)** and snap a chalk line **(3)**.

NOTE: If the closest layout line above the obstruction lands within the 4 in wide endwall gutter, move up-roof to the next layout mark on the tape measure.

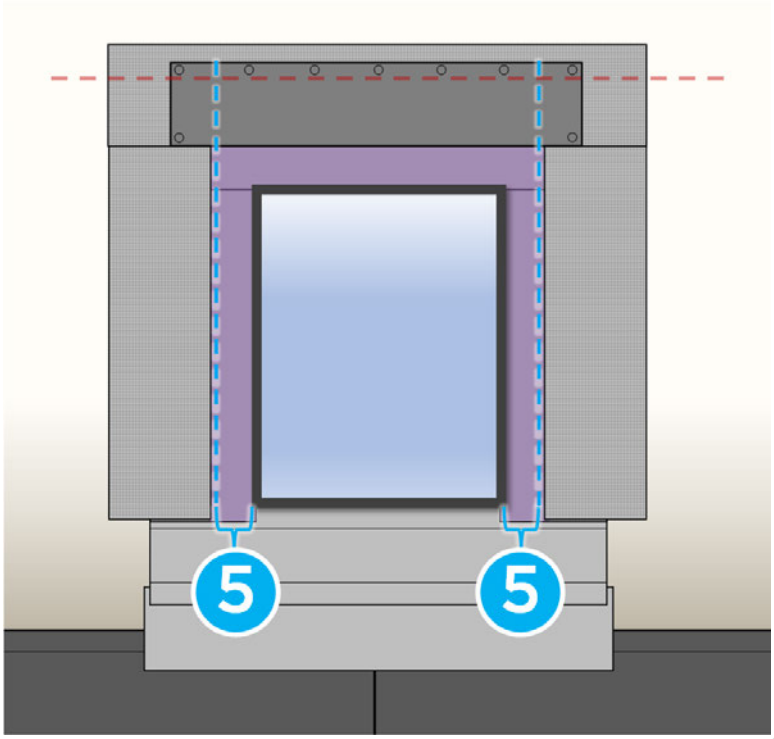


Measure and cut a piece of flat stock larger enough to cover the underlayment that is visible below the chalk line. Fasten this concealer pan 8 in on center **(4)**.

NOTE: The goal is to ensure that the black metal aesthetic around the guttered obstruction merges with the tile level components.

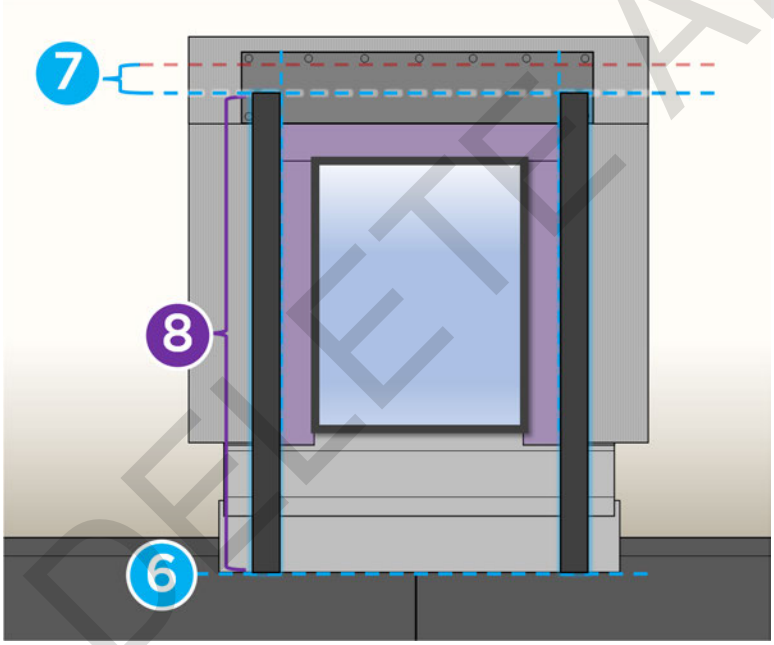


Snap chalk lines 4 in from the guttered obstruction's sidewalls **(5)**.

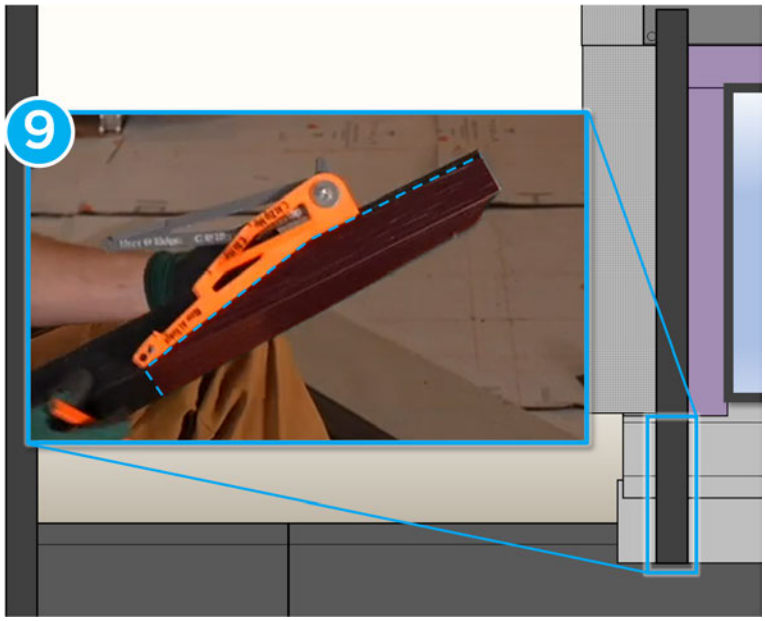


Measure from the bottom of the deadzone flashing **(6)** to 3 in below the nailing flange layout line above the endwall **(7)**. This measurement will be the length of the channel flashing installed along the sidewall **(8)**.

NOTE: Metal tiles will be cut and tucked into the channel flashing.

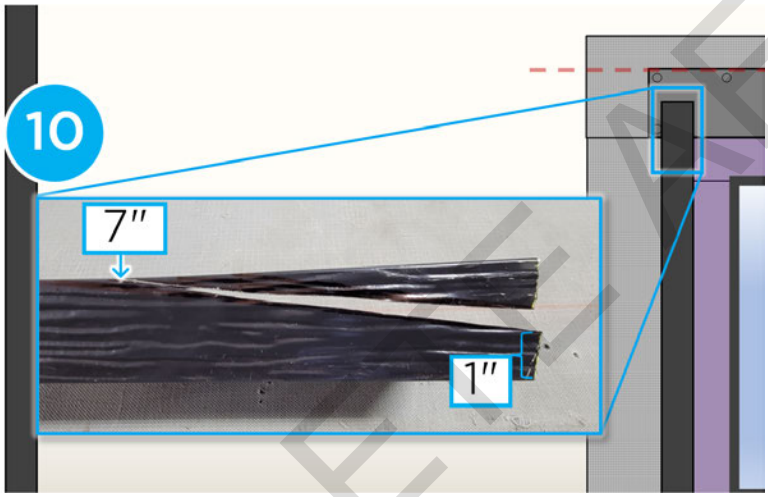


At the down-roof end of the channel flashing, use the *robin jig on page 603* to mark the profile of the transition flashing and deadzone flashing and cut away the material below that profile line **(9)**.

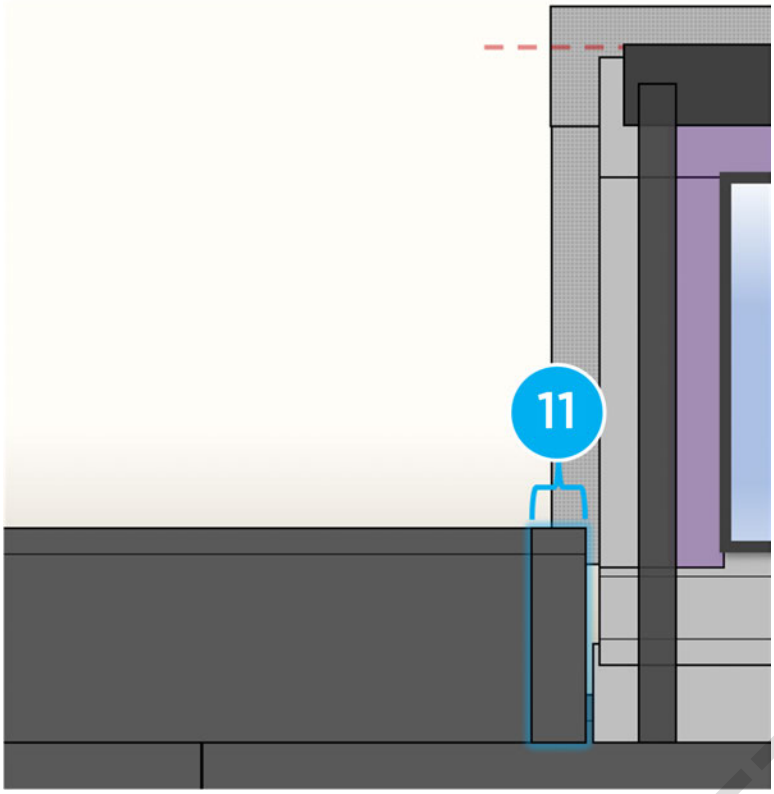


Make a relief cut in the vertical portion of the up-roof end of the channel flashing 1 in up from the base flange to 7 in across the top of the channel flashing **(10)**.

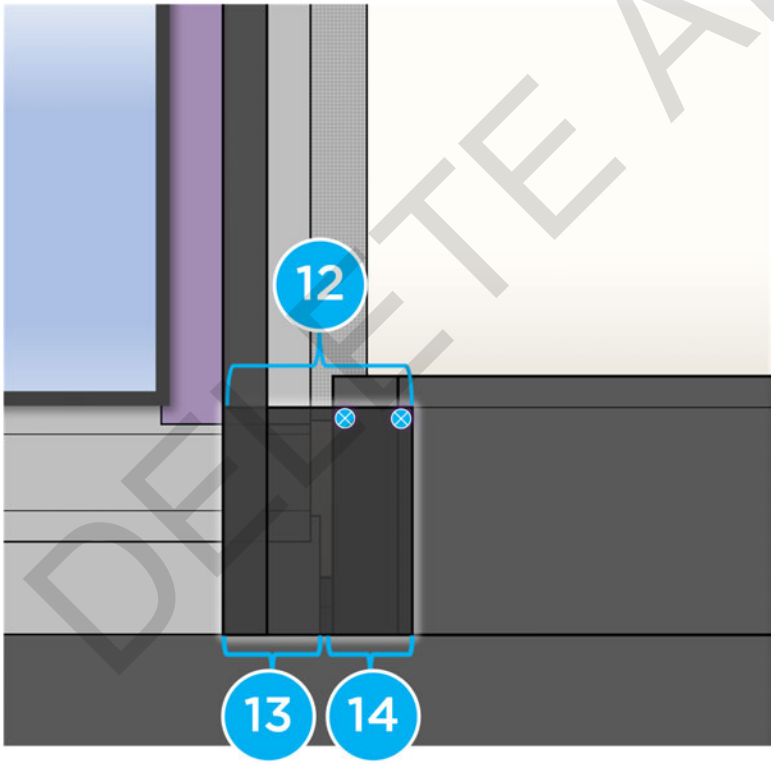
NOTE: This relief cut will allow the channel flashing to tuck underneath the up roof tile course.



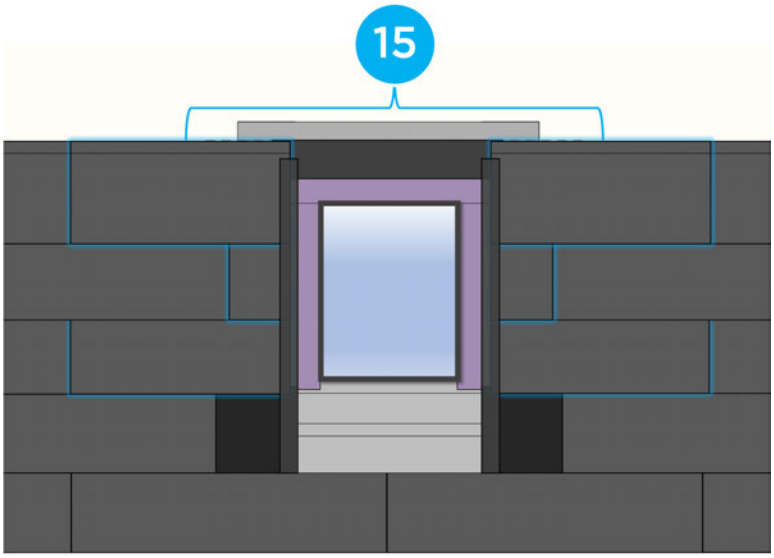
Install metal tiles within 1 in of the deadzone flashing and transition flashing **(11)**.



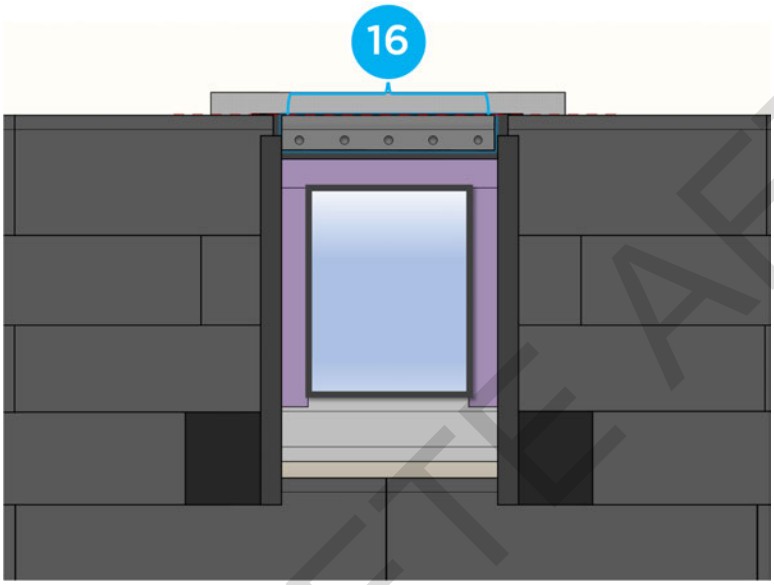
Cut a tile skin wide enough to lap 6 in over the metal tiles and tuck into the channel flashing **(12)**. Engage the tile skin's hem with the metal tile drip edge **(13)**. Where the tile skin crosses over the dead zone pan and the transition pan, remove the hem **(14)**.



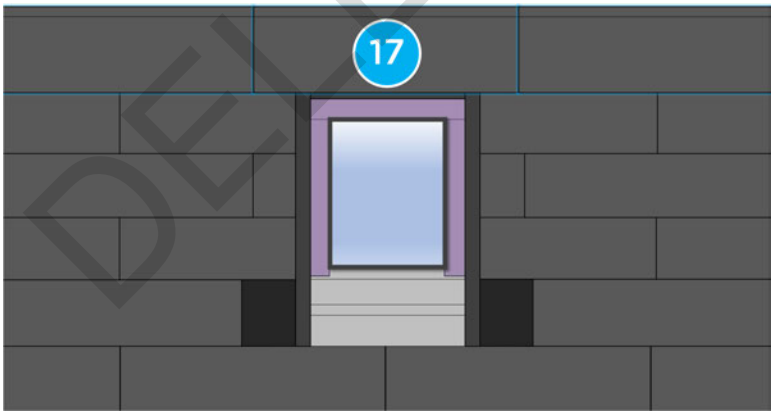
Install metal tiles up roof following the cut and tuck process **(15)**.



Install vented riser above the obstruction **(16)**.



Continue installing tiles up roof **(17)**.



Overview of Common Junctions

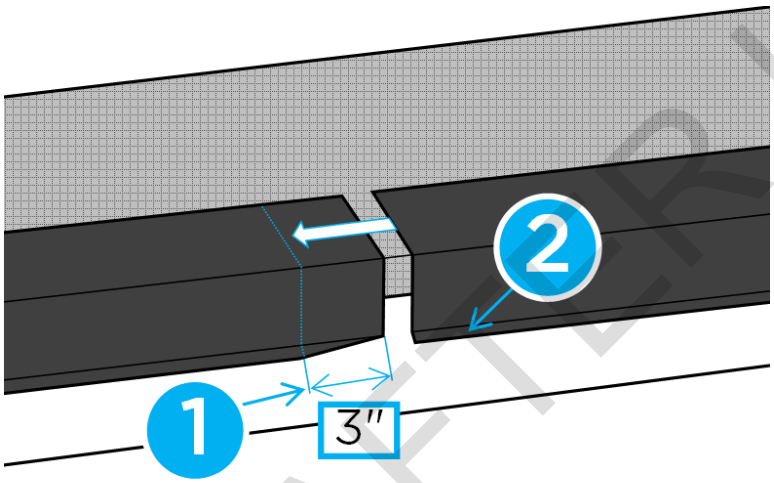
Drip Metal Junctions

Overview

This section contains details for common drip metal junctions.

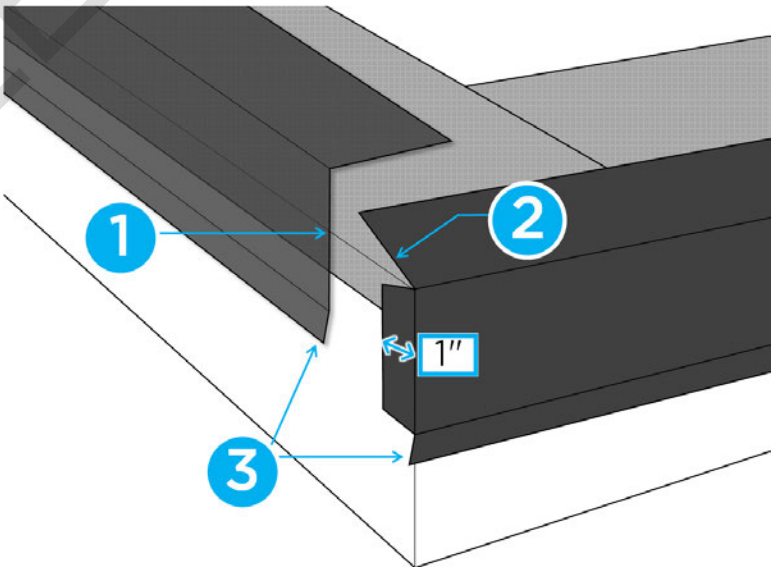
Splice

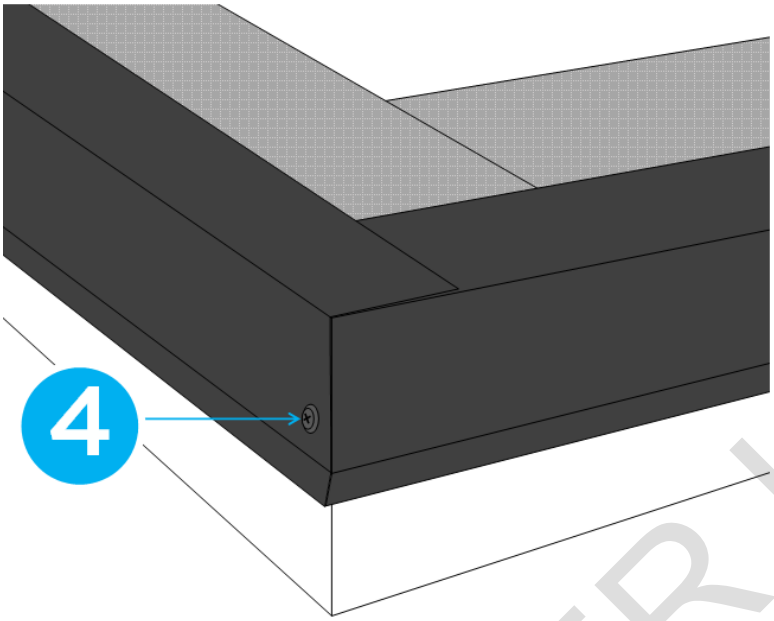
(1)	Cut lower hem back
(2)	Engage lower hem



Eave - Rake (2:12 - 6:12, Low Slope)

(1)	Cut to eave fascia angle
(2)	Back cut from rake edge
(3)	Aesthetic joint
(4)	¾ in self-tapping screw

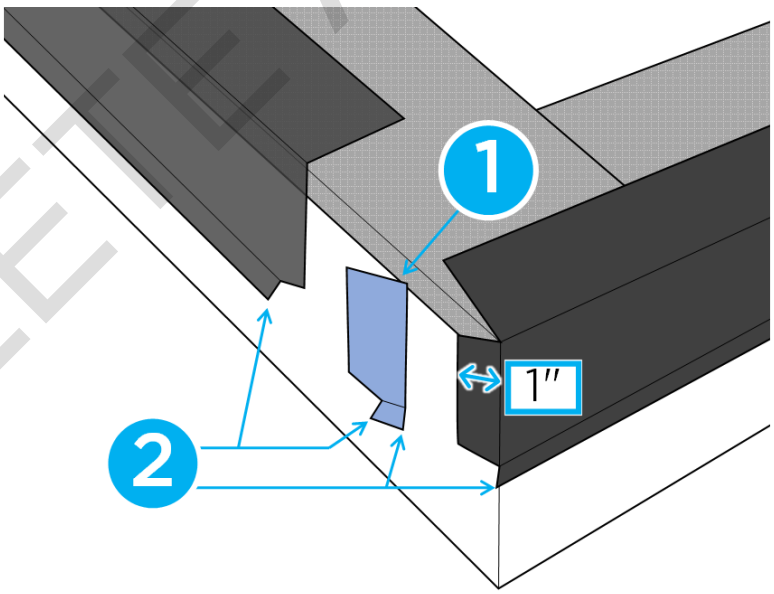


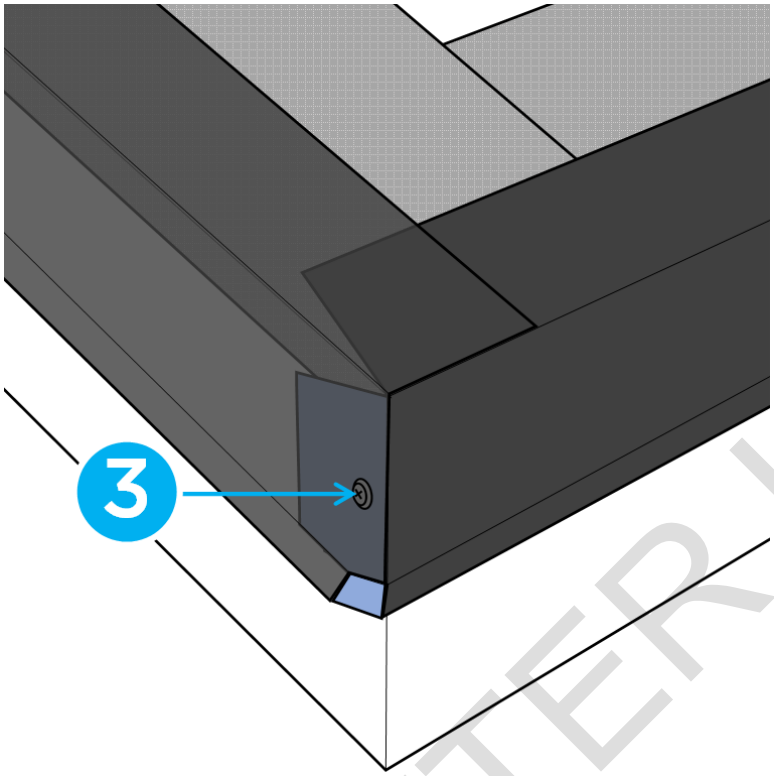


Eave - Rake (7:12 - 24:12, Steep Slope, Dog Ear)

For roof slopes greater than 7:12, craft a dog ear tab to create an aesthetic splice between the eave and rake drip metal.

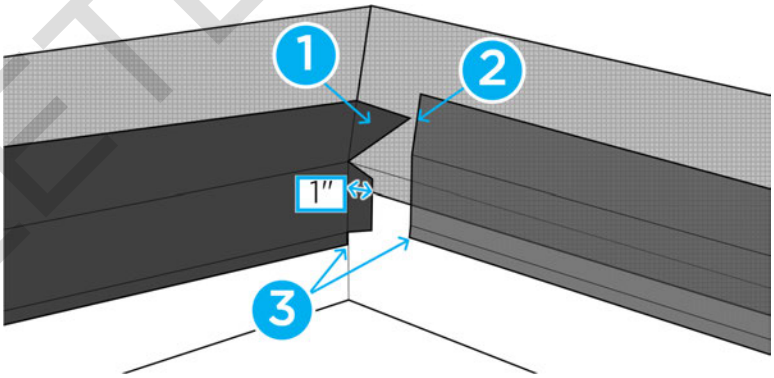
(1)	Dog ear tab
(2)	Aesthetic joint
(3)	¾ in self-tapping screw

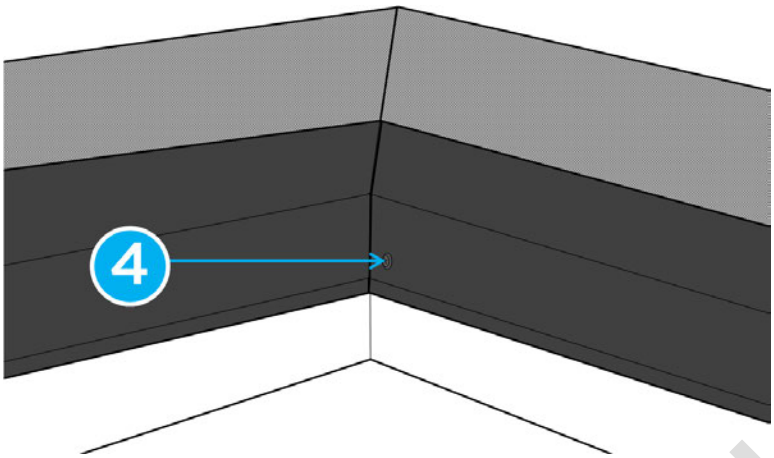




Eave - Eave (Inside Corner - Valley)

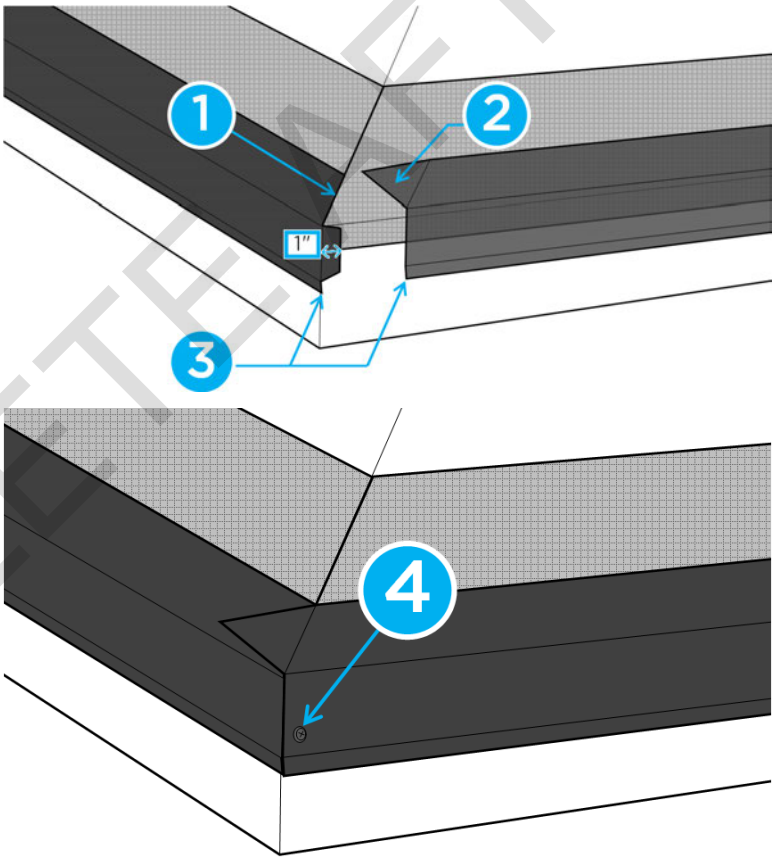
(1)	Tab onto adjacent plane
(2)	Cut to valley angle
(3)	Aesthetic joint
(4)	¾ in self-tapping screw





Eave - Eave (Outside Corner - Hip)

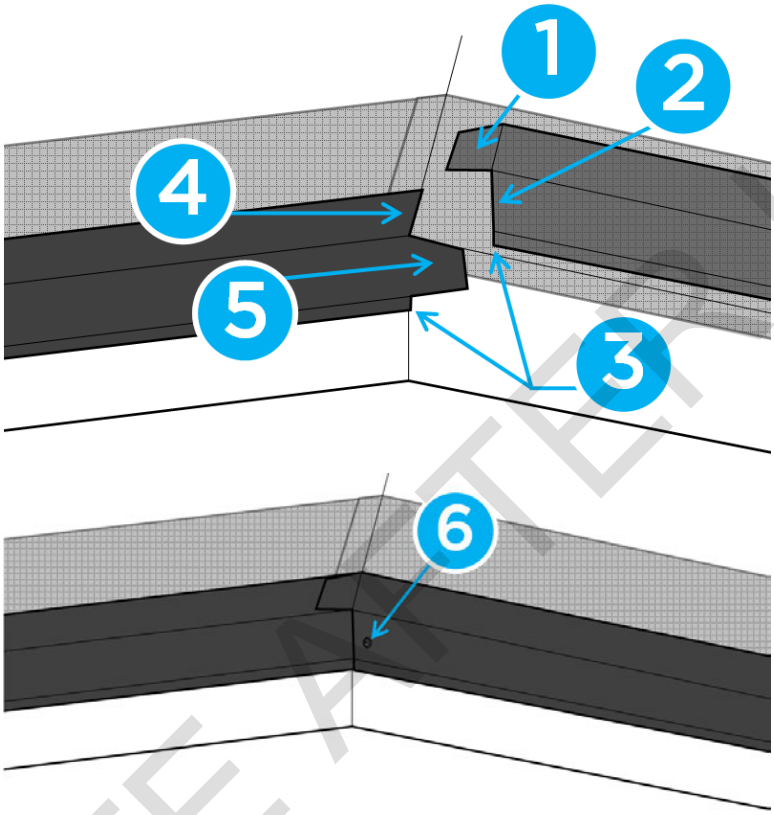
(1)	Cut to hip angle
(2)	Tab over hip
(3)	Aesthetic joint
(4)	¾ in self-tapping screw



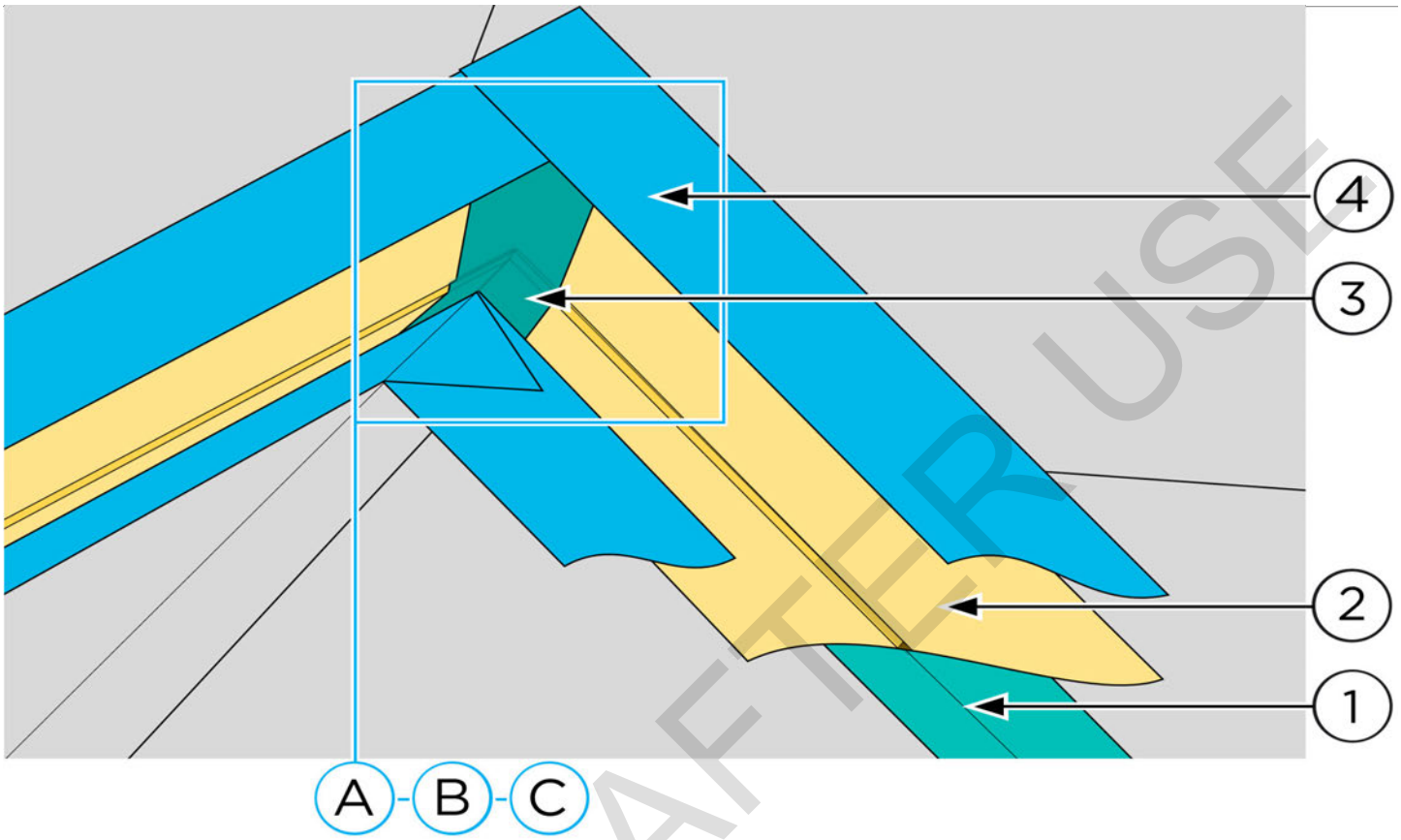
Rake - Rake (Ridge)

(1)	2 in tab over ridge

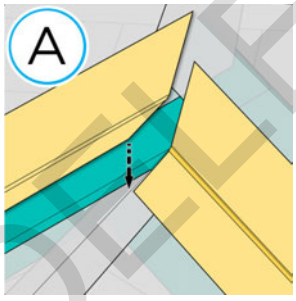
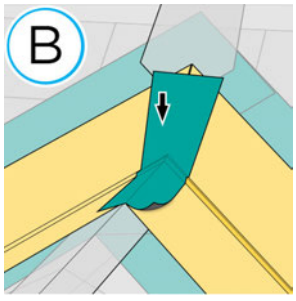
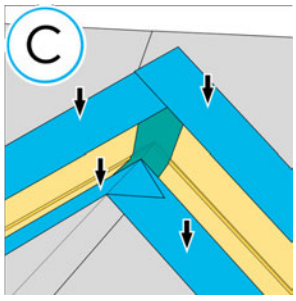
(2)	Plumb cut at ridge line
(3)	Aesthetic joint
(4)	Cut square to ridge
(5)	2 in tab
(6)	¾ in self-tapping screw



Valley-Valley-Ridge

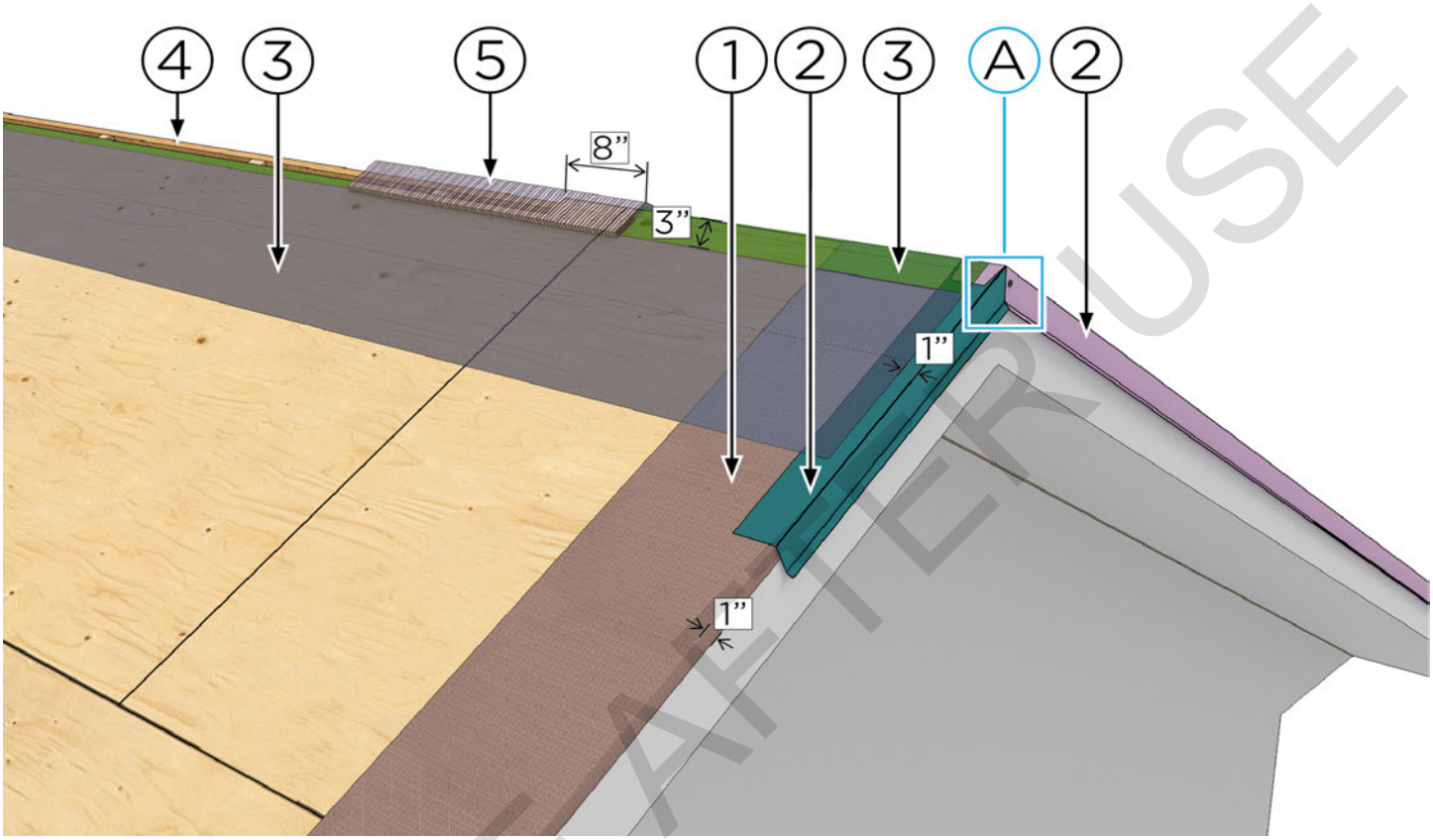


1	Underlayment
2	Valley Pan
3	Flexible Flashing
4	Detail Roll

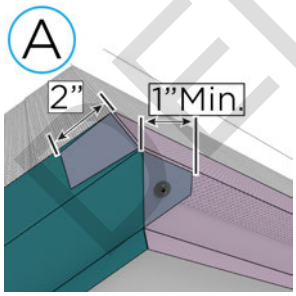
		
After applying underlayment, install valley pans. Cut valley pans along the ridge line.	Install flexible flashing over the valley apex and ridge to cap off the valley pans.	Strip in the valley pans and flexible flashing with detail roll to complete the dry in process.

Rake-Rake-Ridge

Dry In

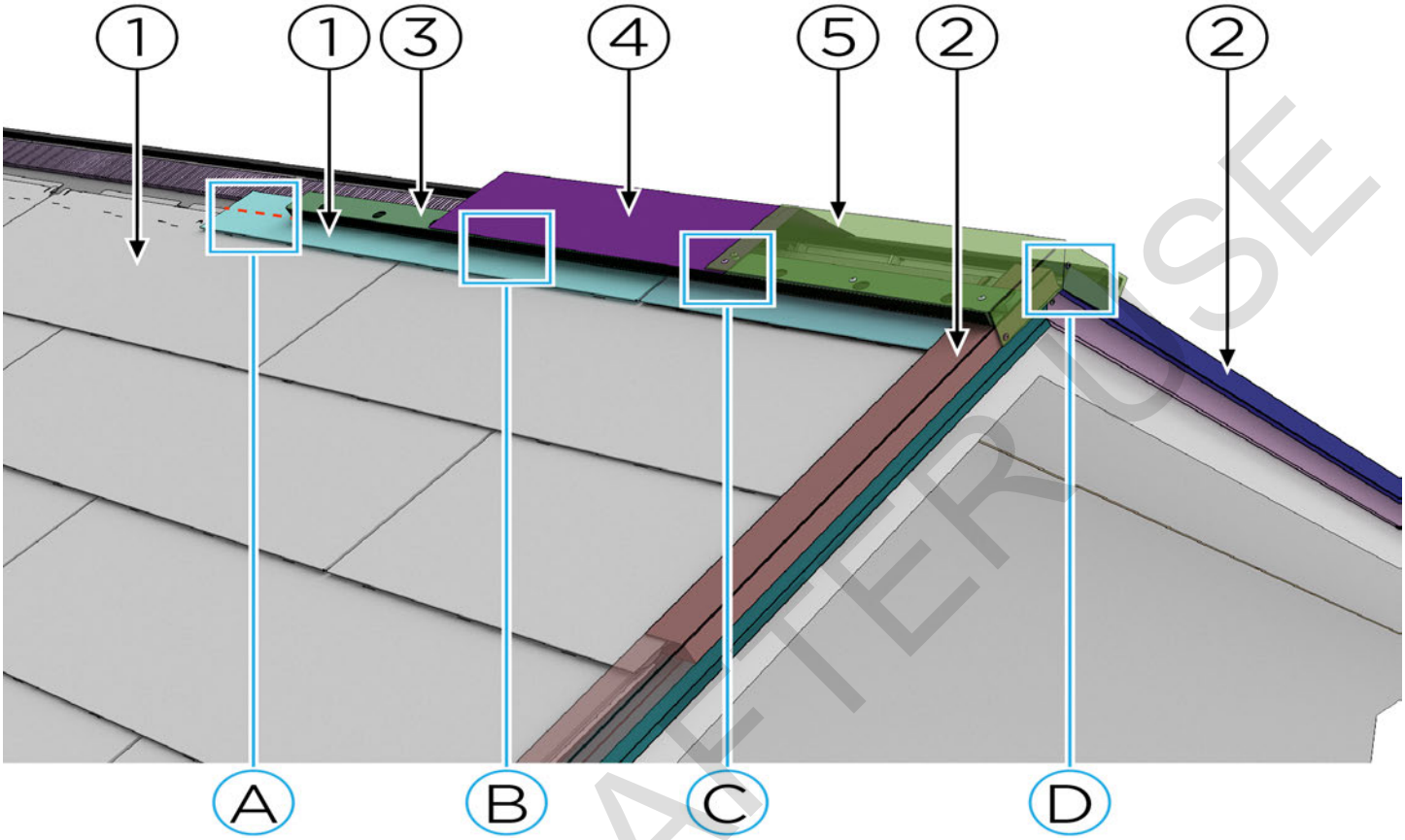


1	Detail Roll
2	Drip Edge
3	Underlayment
4	Vented Riser
5	Ridge Roll

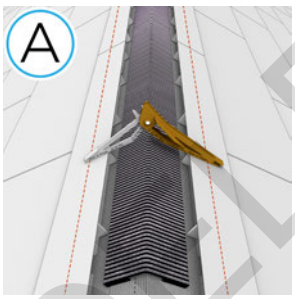
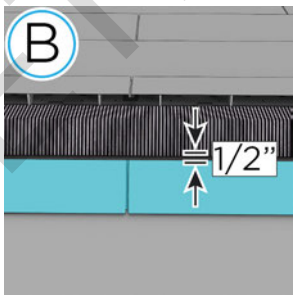
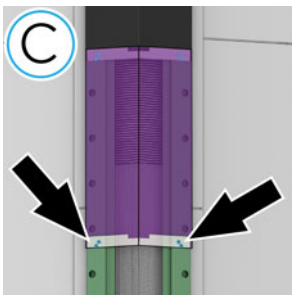
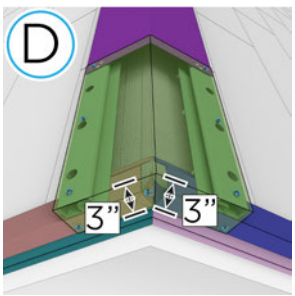


Cut the deck-mounted flange of the bottom drip flush with the ridge, while leaving a minimum 1 in tab on the front face, cut square to the opposite rake. Cut off 2 in from the front face of the top drip edge plumb from the ridge line, and fold the resulting tab over the ridge, fastening down through the bottom piece of drip. Both flashings will have mitered cuts in the drip edge to mate flush. Fasten the top and bottom flashings together with a self-tapping screw through the front tab.

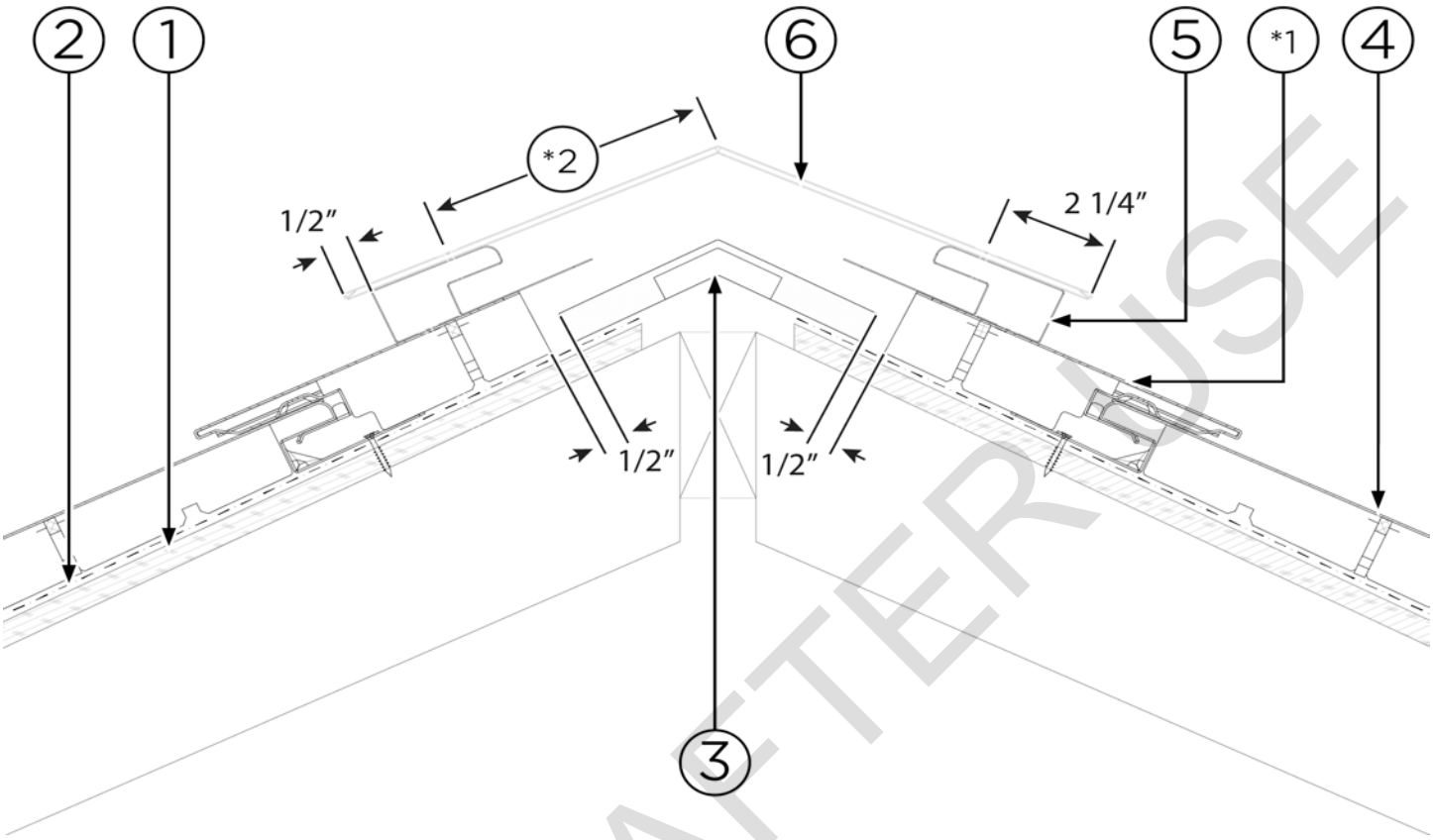
Tile Install



1	Metal Tile	**2**	Channel Flashing
3	Vented Riser	**4**	Cap
5	End Cap		

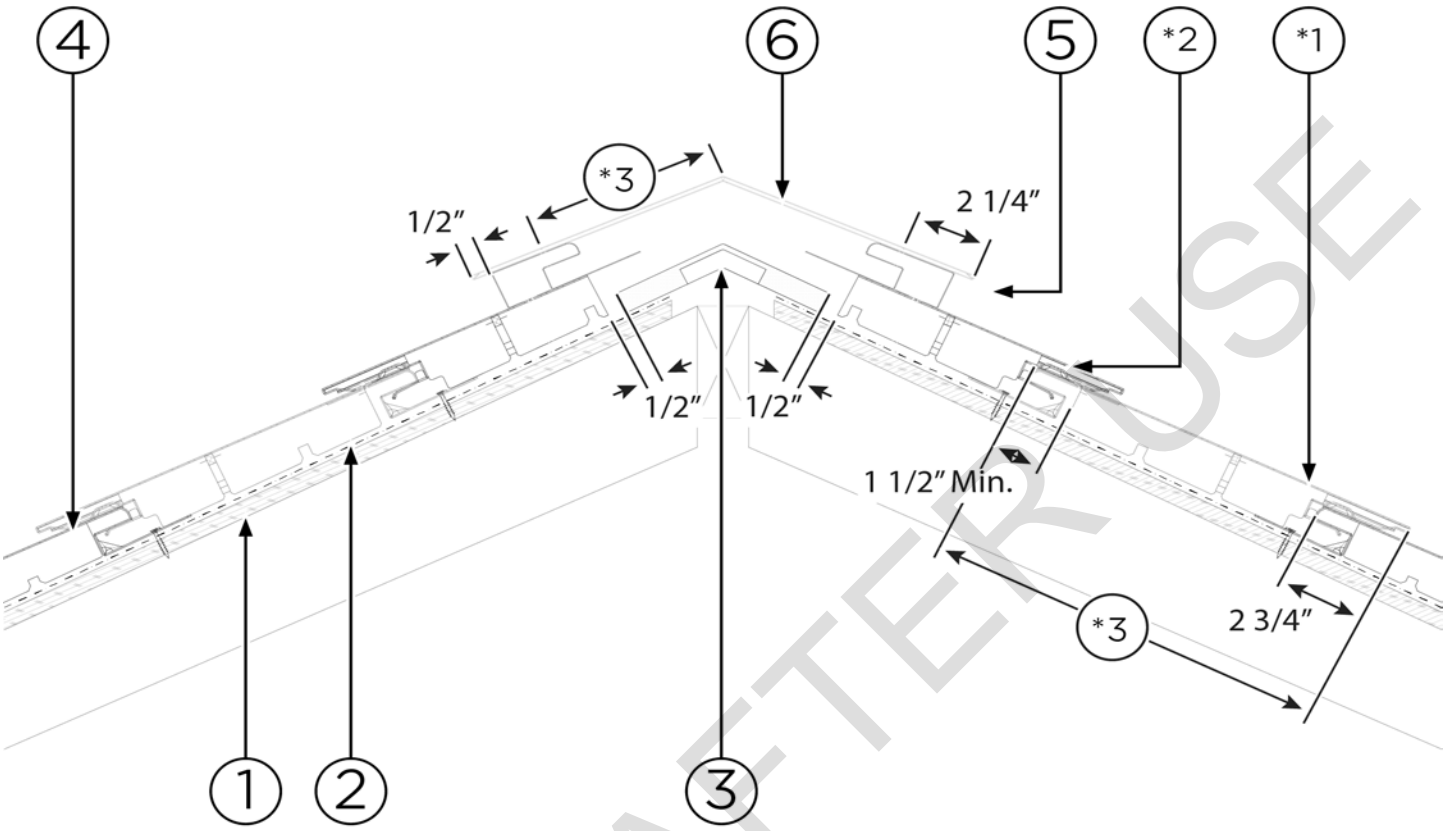
			
Center the robin jig over the ridge. The riser at ridge markers indicate the vented riser location.	Ensure the cut metal tile at the riser is ½ in away from the ridge roll. Secure the tile per the applicable wind tier in the Fastener Schedule.	When installing ridge caps, break the caps to pitch (skip this step for 3:12 and 4:12 pitches) and engage caps with one another via the cleats. Secure ridge caps to the vented riser through the cleats per the applicable wind tier in the Fastener Schedule.	Craft ridge end caps by adding 3 in to the ridge length for the down flange. A 3 in cut along the top allows the 3 in flanges to bend into themselves. Cut the top flange plumb with the ridge and fasten through the metal overlap per the Fastener Schedule.

Cross Section: Metal Tile at Ridge (Vent)



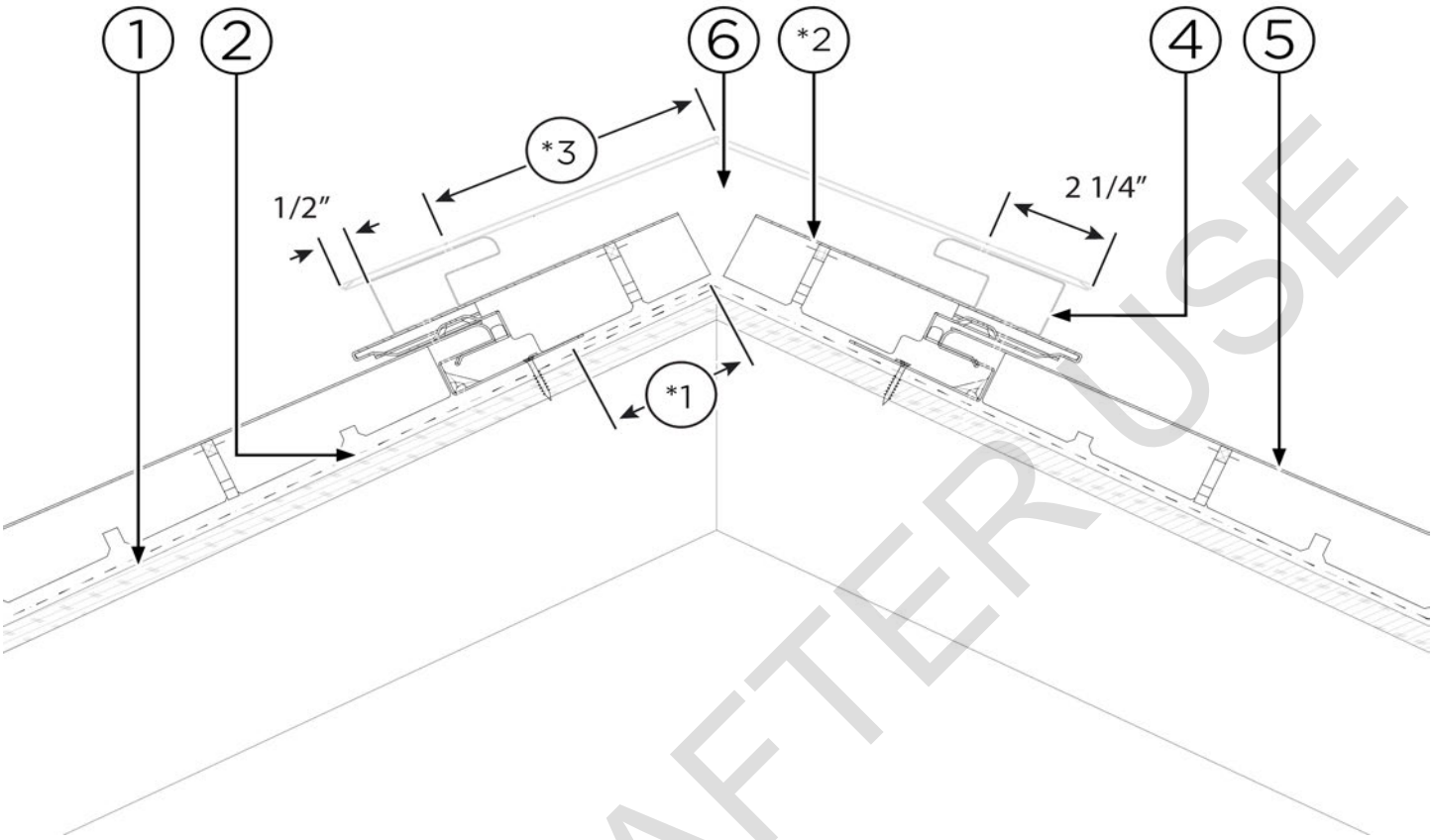
***1**	Ripped Metal Tile, minimum 5 in
***2**	Varies depending on pitch angle
1	Deck Sheathing
2	Underlayment
3	Ridge Roll
4	Metal Tile
5	Vented Riser
6	Cap

Cross Section: Metal Tile at Ridge Dead Zone



***1**	Ripped Metal Tile with reattached shoulder, minimum 5 in
***2**	Ripped Metal Tile, minimum 5 in
***3**	Varies depending on pitch angle
1	Deck Sheathing
2	Underlayment
3	Ridge Roll
4	Metal Tile
5	Vented Riser
6	Cap

Cross Section: Metal Tile at Ridge (No Vent)

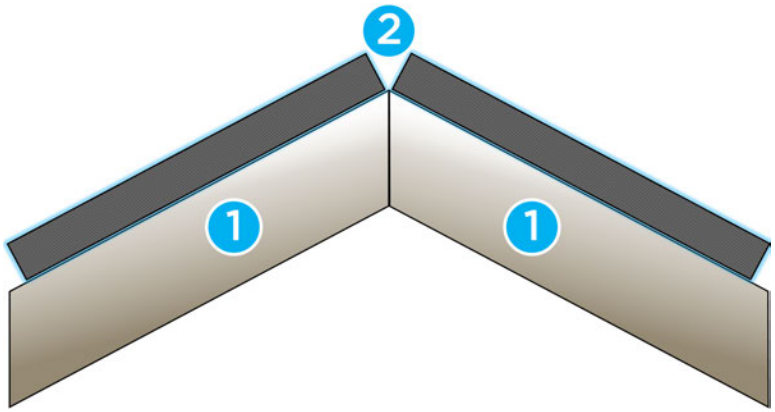


***1**	3 in minimum overlap
***2**	Ripped Metal Tile, minimum 6 in
***3**	Varies depending on pitch angle
1	Deck Sheathing
2	Underlayment
3	Metal Tile
4	Vented Riser
5	Cap

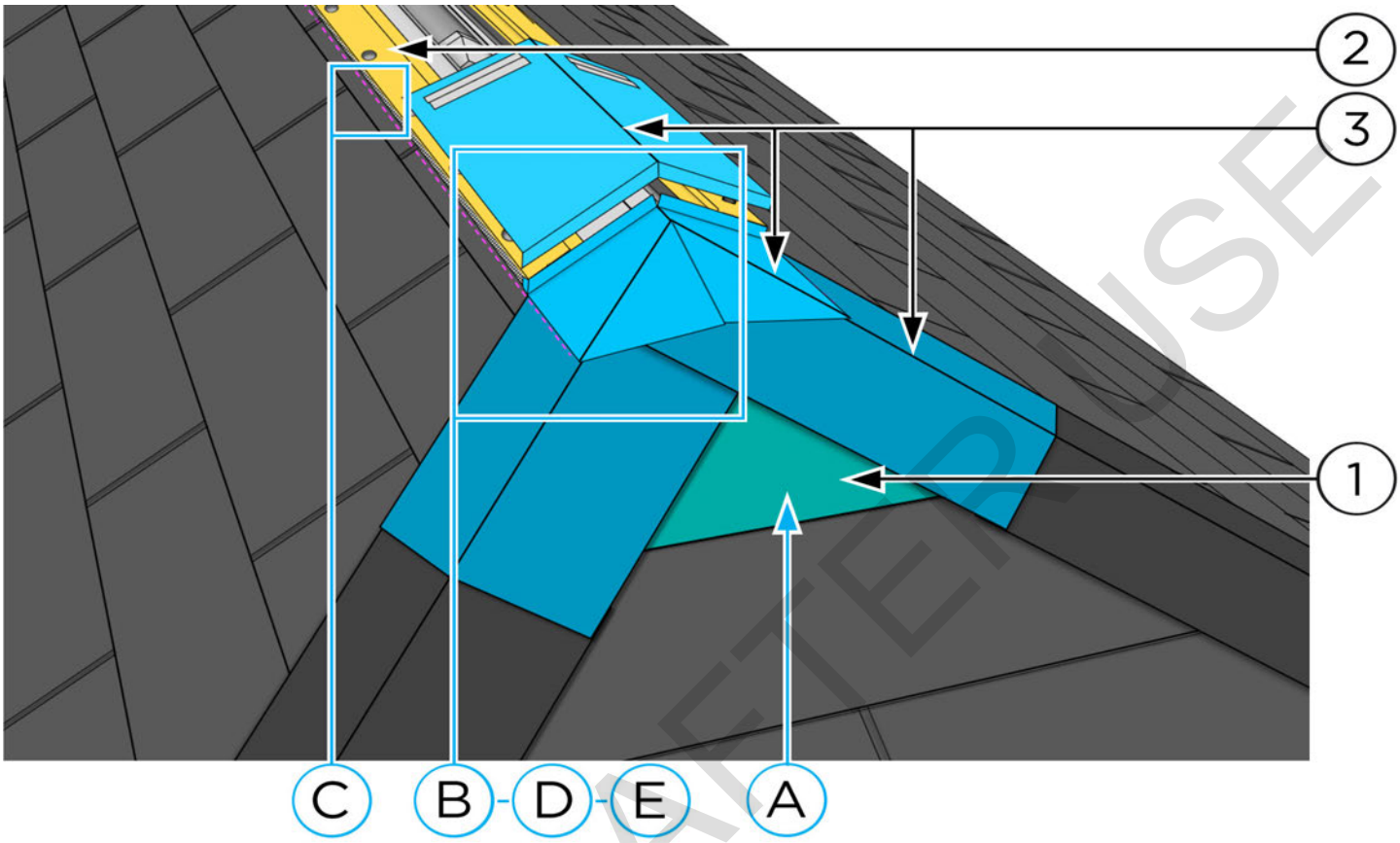
Rake-Rake-Ridge Junction

Install channel flashing with squared edges at ridges.

Pictured: Rake **(1)**, ridge **(2)**

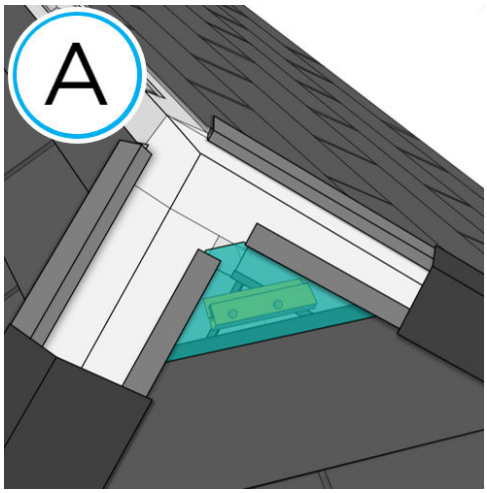


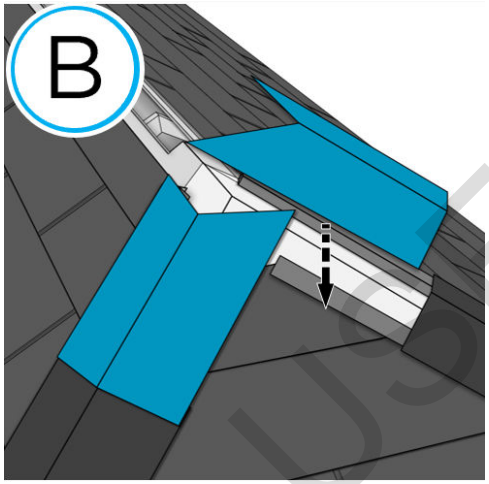
Hip-Hip-Ridge

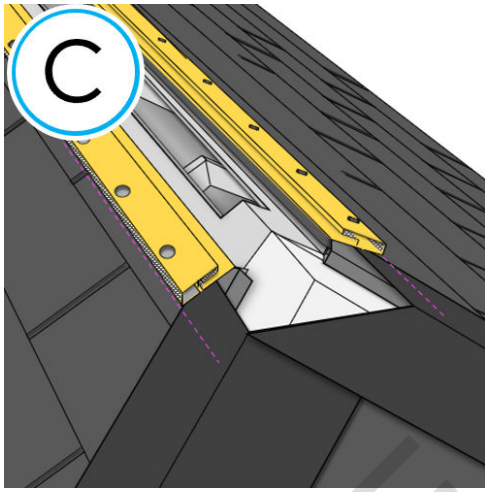


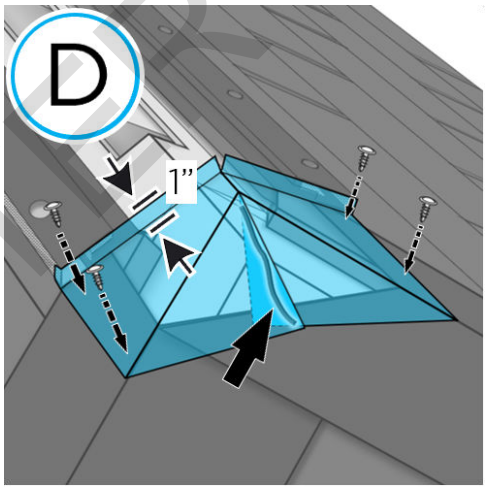
1	Tile Skin
2	Vented Riser
3	Caps

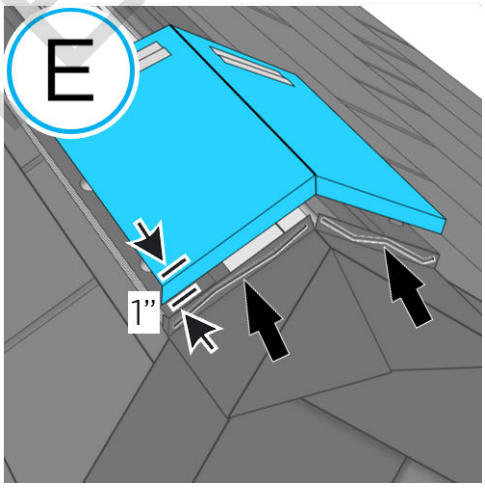
	See detail images on next page.
A	Install a tile skin as needed to fill the void at the hip apex where a full metal tile will not fit. Support the tile skin with a small section of vented riser and secure according to the applicable wind tier in the Fastener Schedule.
B	Install caps up to the hip apex. Cut the caps at the hip apex in-line with the last row of metal tiles at the ridge.
C	Install vented risers at the ridge. Vented risers must lap over the caps such that no voids remain between the risers and caps.
D	Cut and bend a cap to fit at the top of the hip apex. Apply sealant where the cap laps under itself. Create a 1 in turn up to rest against the side of the vented riser.
E	Fabricate a cap with a 1 in turn down to lap over the previous cap's 1 in turn up. Apply a ¼ in bead of sealant to create a seal between the cap's vertical overlap.



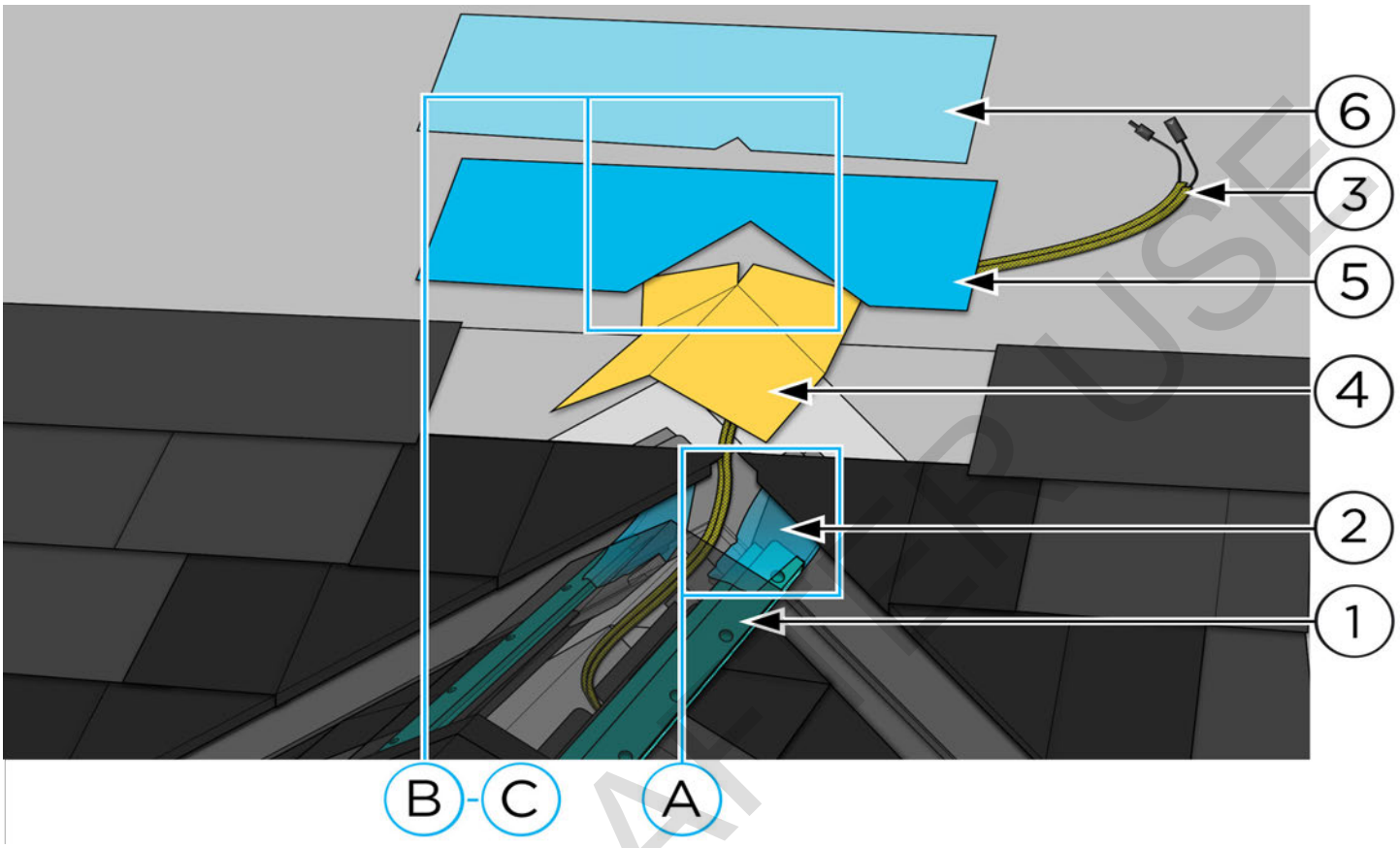




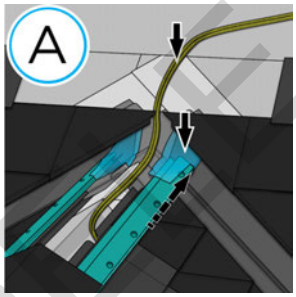




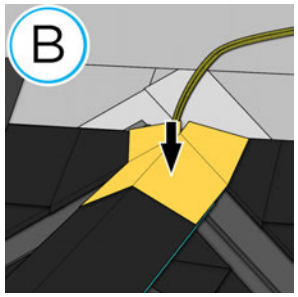
Ridge to Mounting Plane



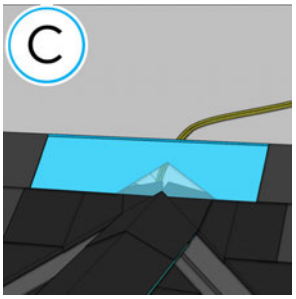
1	Vented Riser	**2**	Screen Mesh
3	Sleeved Jumper Cables	**4**	Cap
5	Metal Tile	**6**	Tile Skin



Install vented riser along the ridge as far into the valley as possible. Close off gaps between the vented riser, valley pan and tiles with screen mesh to prevent pest and debris ingress. Route sleeved jumper cables through the ridge to MP junction as needed to make PV connections by notching adjustable trims at the valley apex.



Install caps towards the ridge to MP junction. The final cap must be cut and bent to fit and form to the ridge to MP junction.



Cut a metal tile and tile skin as needed to create an aesthetic and positive lap over the ridge cap installed at the ridge to MP junction.

Rake to Endwall

Tools and Equipment:

- Detail Roll
- Underlayment
- Speed Square
- Metal Snips
- Touch Up Paint
- Marker
- Measuring Tape
- Wall Flashing
- Sealant

Work Instructions:

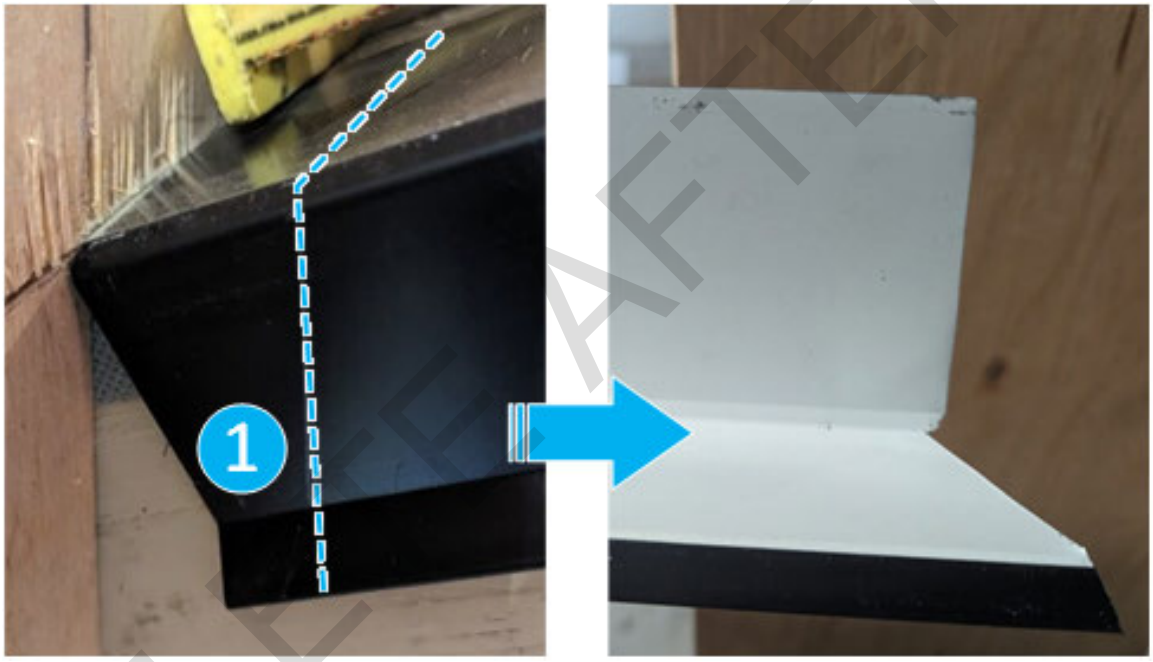
Step 1: Detail Roll and Drip Edge

1. Apply the detail roll so that it overhangs the rake edge for 1 in and runs up the endwall for 4 in.

   Make sure that the detail roll on the roof to wall interaction is tight in the corner to prevent material stack up or interference.

2. Use a speed square to scribe a plumb line on the drip edge, ensuring a tight fit.

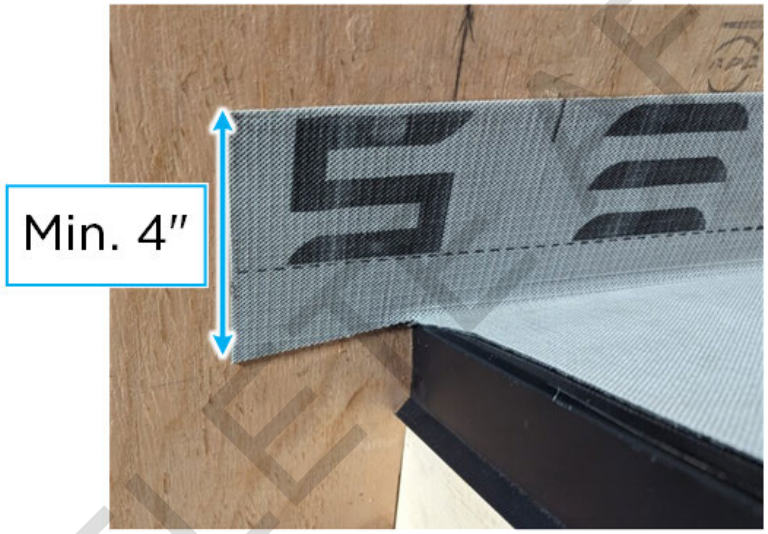
3. Then cut a clean line with snips, using touch up paint on the cut edge as needed.



4. Install the drip edge tight to the wall.

Step 2: Install Underlayment

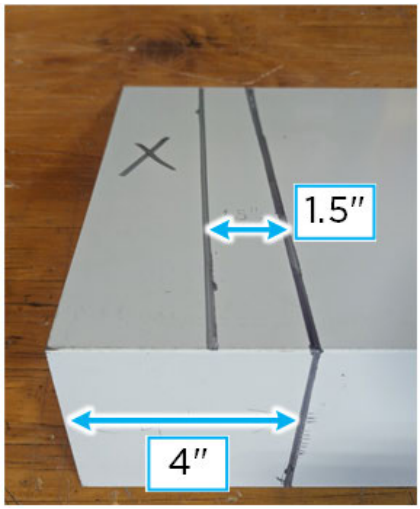
5. Apply the underlayment, ensuring that it goes a minimum of 4 in up the wall and behind the building paper and siding. See *Required Clearance for Wall Integration on page 104*.

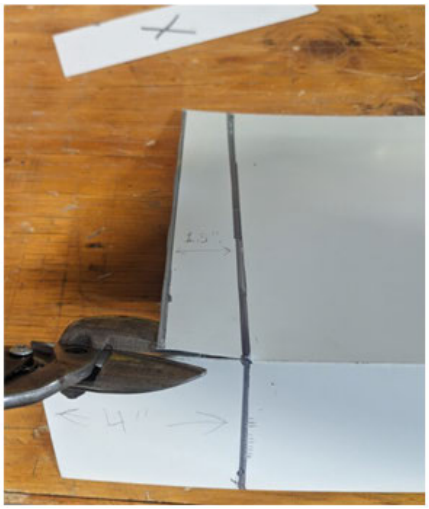


Step 3: Fabricate Endwall at Rake Detail

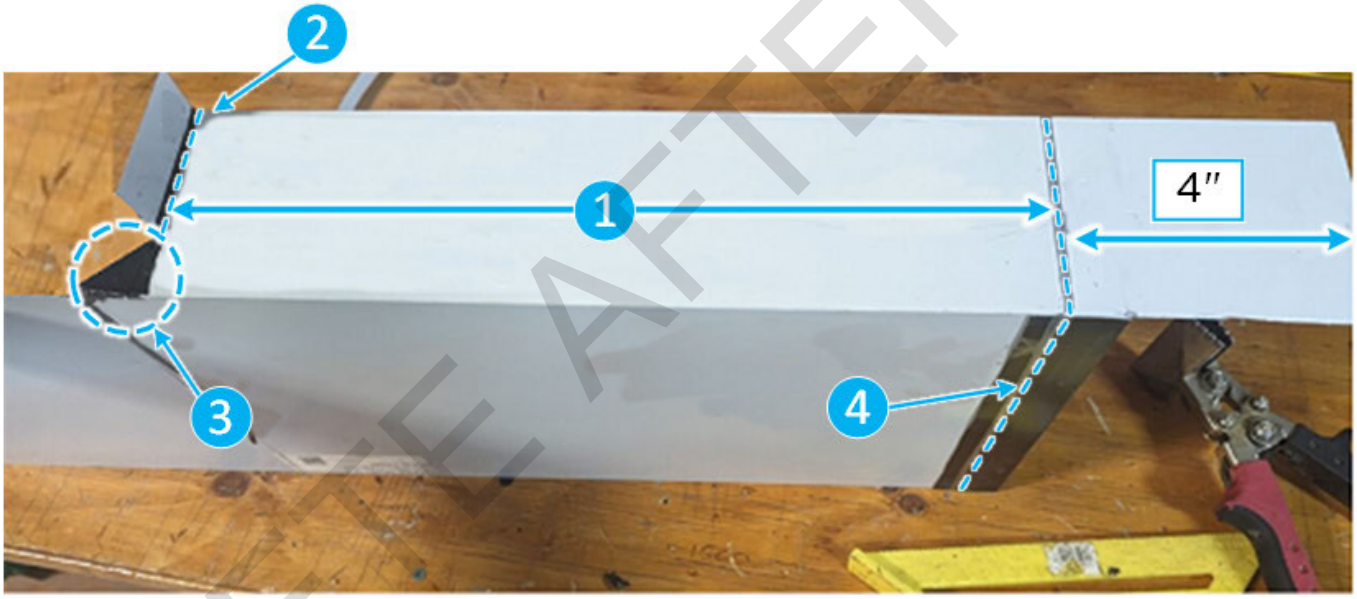
6. Mark 4 in on the wall flange, following the line through on the deck side.
7. From the 4 in mark, mark 1 ½ in on the deck side.

   Cut the flashing through the bend and up to the 4 in mark. Leave the 1 ½ in section. This will be hemmed under, so no white metal is exposed on the rake.

8. 




Process Definition:



1 - Width of Obstruction

2 - Sidewall Tab

3 - Diverter

4 - 1 in Rake Overhang

Step 4: Install Endwall Flashing

9. Install the endwall flashing tight to obstruction, with deflection towards the rake. Use underlayment stacked if necessary.
   Apply sealant to rake edge before installing the flashing.

10. Overhang the rake edge by 1 in with endwall flashing. Hem under so that only black shows from below.

11. Ensure all fasteners are installed greater than 4 in up-roof of the endwall and overlapped by underlayment.

Notes:

NOTE: Make sure the endwall flashing is integrated into the underlayment above.

Leave 4 in of black metal exposed on the deck portion of the endwall flashing.

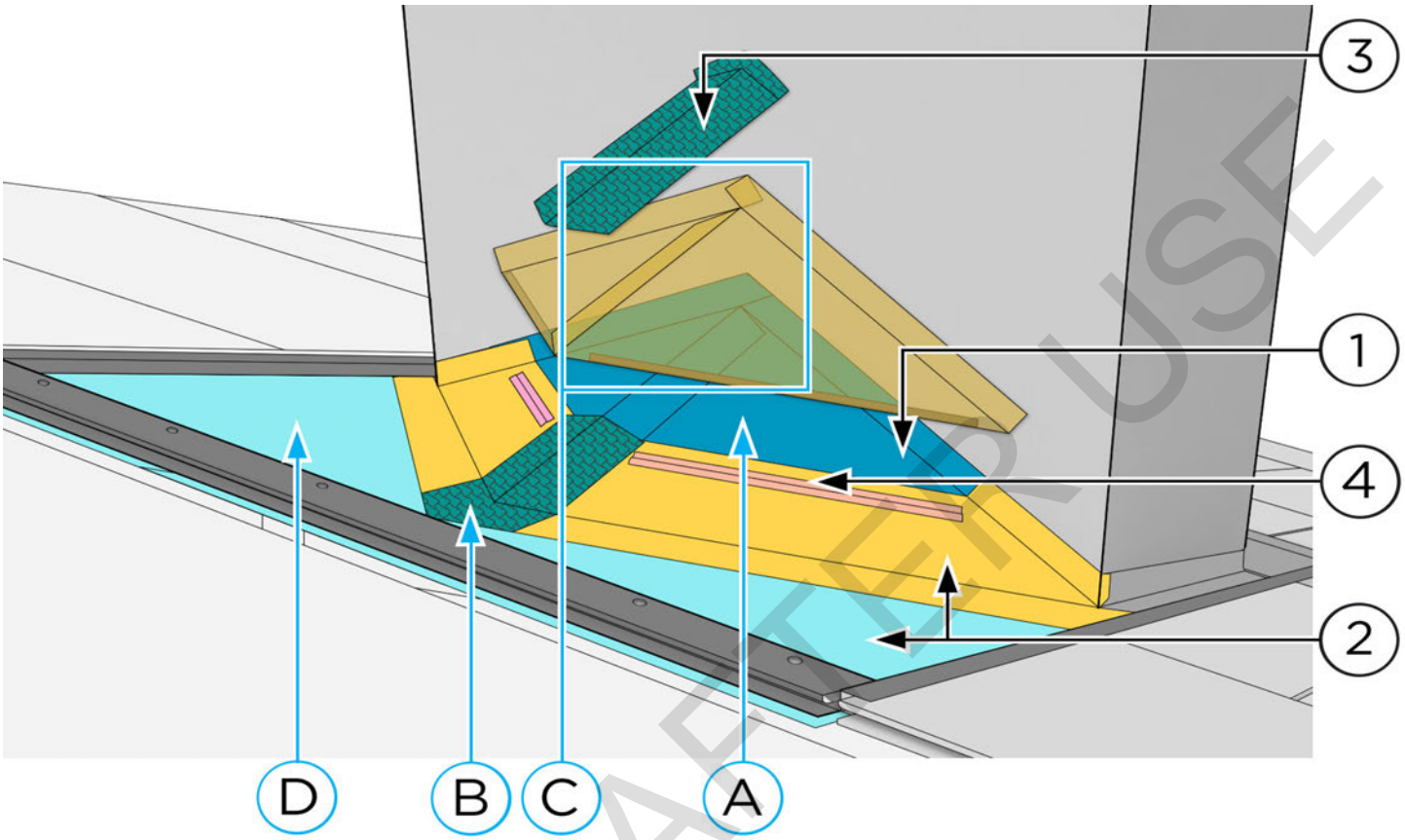
If necessary, use a concealer flashing during tile installation.

Install the riser 4 in or more up roof of endwall.

Make sure the endwall has deflection towards the rake.

Other Roof Features

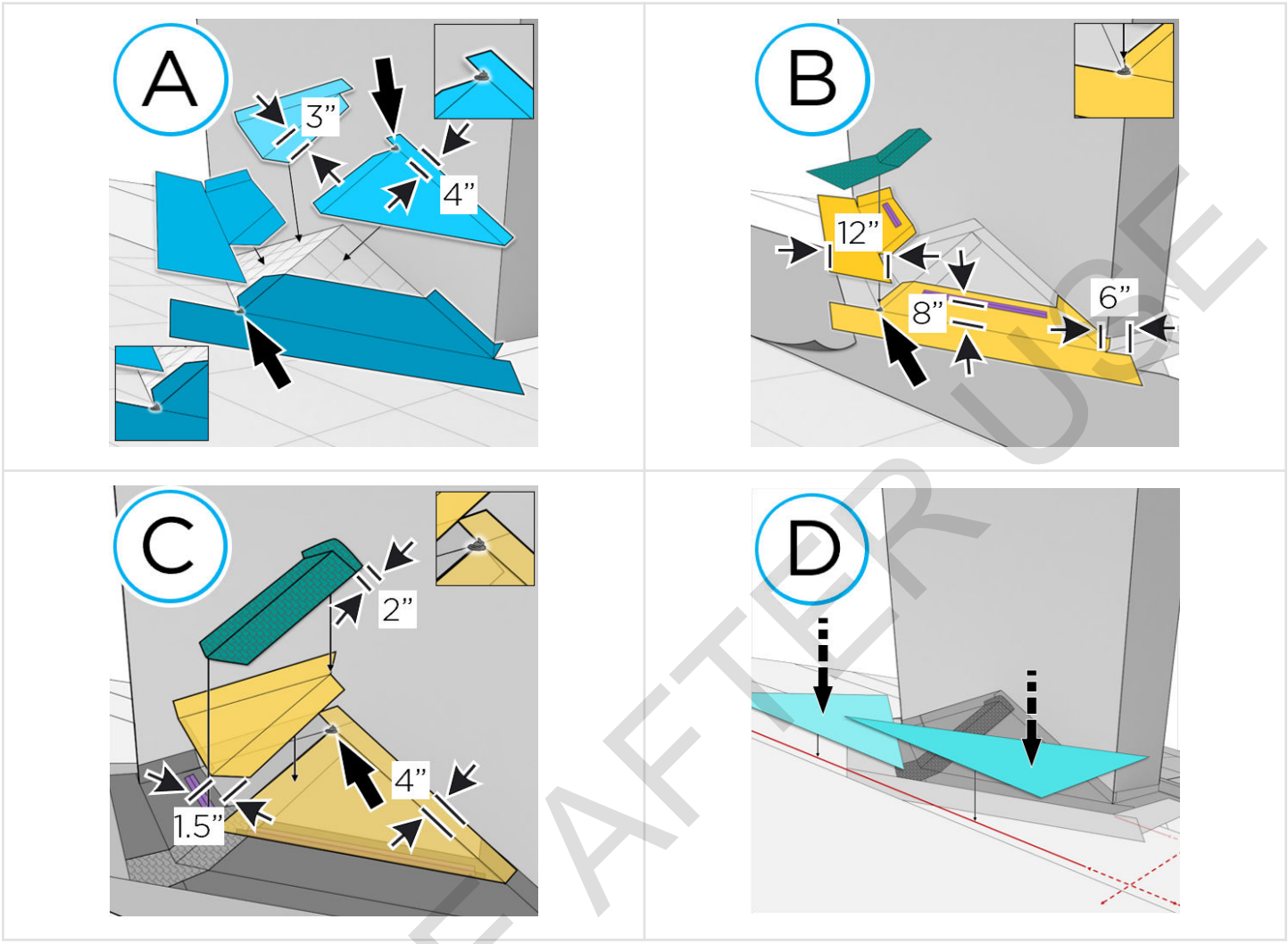
Chimney Cricket



1	Underlayment	**2**	Flat Stock
3	Flexible Flashing	**4**	Cleat

See detail images on next page.

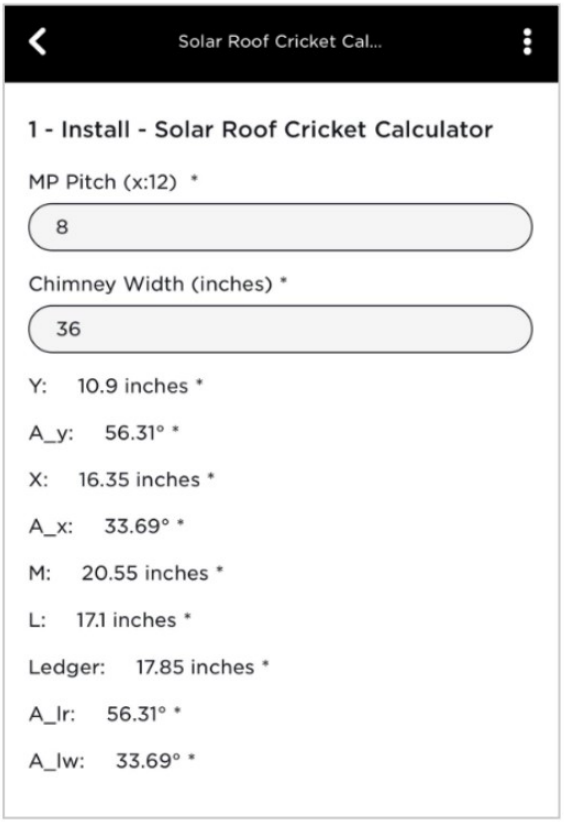
A	Install underlayment over the cricket starting in the cricket's valley. Lap underlayment a minimum of 4 in over the cricket's ridge and up the obstruction's walls. Apply sealant as needed to seal any potential pinholes created between sections of underlayment.
B	Craft valley pans from flat stock. Metal must lap a minimum of 4 in up the obstruction's walls, tab a minimum of 1 in around the obstruction's corner and extend a minimum of 6 in beyond the lower end of the valley. The valley pans should extend a minimum of 12 in above the valley. Apply a dollop of sealant at potential pinhole locations created between overlapping pieces of valley pan flat stock. Install cleats 8 in from the valley centers to hold down the leading edge of additional flat stock needed for the valley pans to cover the rest of the chimney's cricket.
C	Install additional flat stock to cover the rest of the chimney cricket. Bend slightly open hems into the leading edge of the flat stock to engage with the cleats installed on the previous pieces of flat stock. Apply a dollop of sealant at potential pinhole locations created between the overlapping pieces of flat stock.
D	Install flat stock above the chimney cricket to conceal any underlayment exposed below the location of installed tiles.



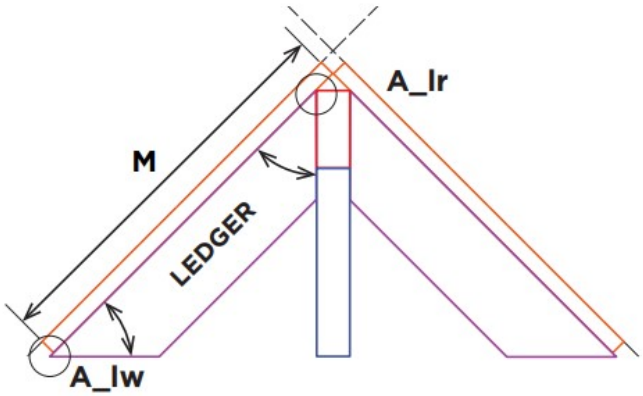
Building the Cricket Framing

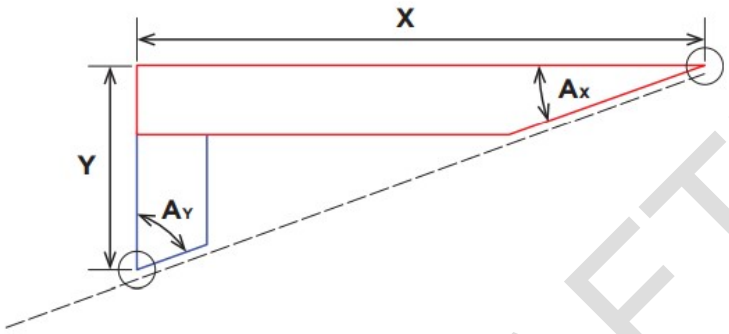
Chimneys wider than 30 in are installed with a cricket at the endwall. The cricket is built using 2x4s framing with plywood decking material. The cricket frame is pitch dependent and the sizes can be found from the Cricket Framing Cut Guide (up to 12:12) or by using the Bolt Form “Solar Roof Cricket Calculator” to determine dimensions.

1. Enter the pitch and width into the Bolt App.



2. Bolt will display the length values for the 2x4 framing dimensions as "X" and "Y" and the length values for the sheathing dimensions as "M" and "L". The angle values for the 2x4 dimensions will be displayed as "A_Y" and "A_X". The length of the 2x4 ledger dimensions will be displayed as "Ledger" and the angle cuts will be displayed as "A_{lr}" and "A_{lw}".





Non-Ridge Vents

This document covers the basics of installing a non-ridge vent at the mounting plain to allow for adequate venting when the length of the ridge is broken up into short spans. Other use case examples are using it for a vent at headwalls or an intake vent near the eave when no soffit vent is present. The Deck Level Flashing for non-ridge vent will provide a maximum of 66 SQIN NFA.

This procedure requires some layout before dry in, with the rest of the steps occurring during dry in and tile installation.

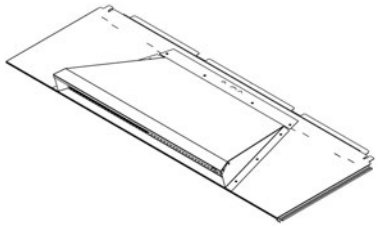
Tools and Equipment:

- Utility knife
- Marker
- Cordless circular saw

- Cordless impact driver drill
- Cordless roofing nailer

Components:

- Self-Adhered Underlayment Class A, 1613738-03-A or (if permitted) Class C 1751844-00-A
- Flashing, Deck, Vent, 1606873-00-A
- Tile Vent Part number: 1840821-01-F

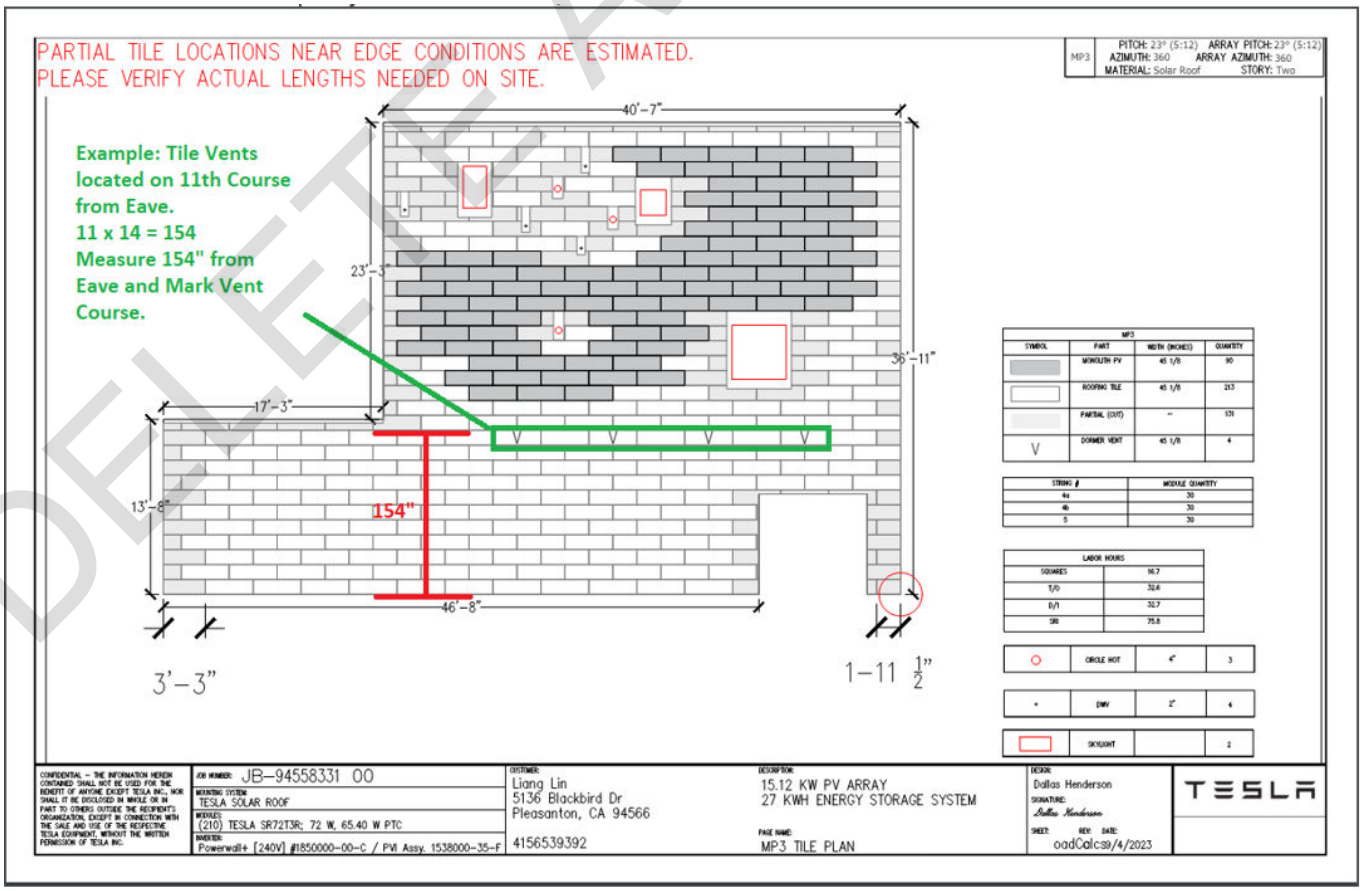


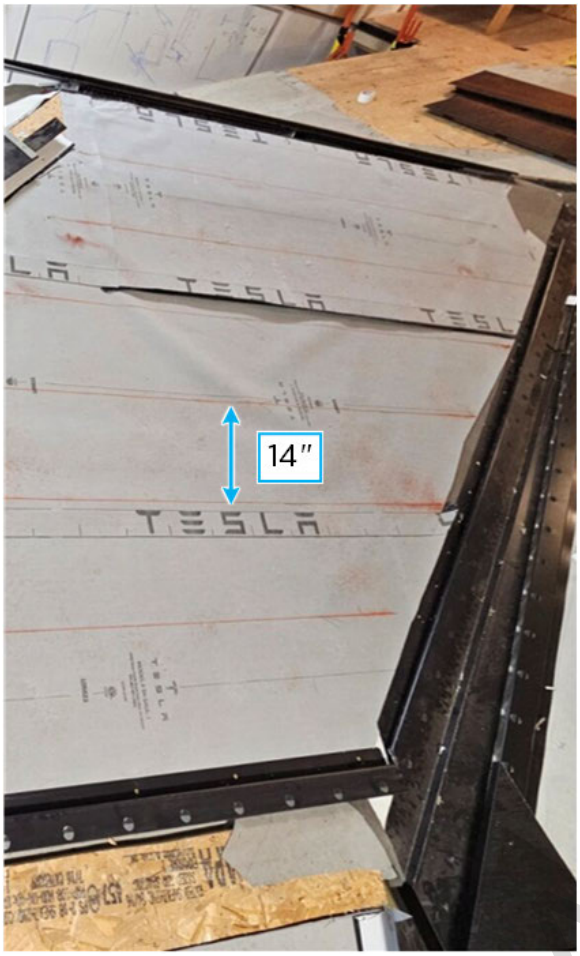
PPE:

- Safety glasses
- Cut resistant gloves
- Fall protection

NOTE: It is important to reference the construction drawings and venting calculations to ensure accurate ratio of venting and proper vent placement.

1. Start by laying out the approximate location of the vent(s). The construction drawings will show which courses of tile vents need to be installed. Multiply the course number by 14 (Example: vents on the 5th course from the eave, 5x14 = 70). Then, measure from the eave up to your vent location and mark the location on the roof deck.

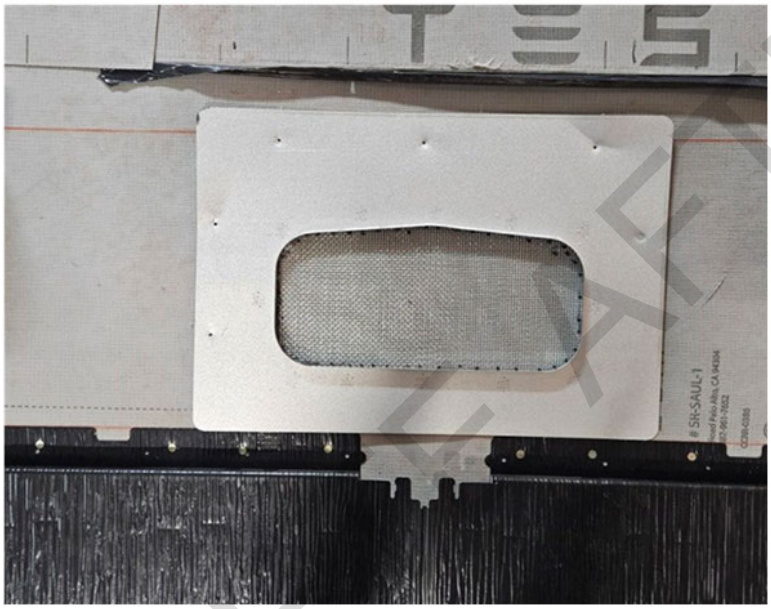




2. Next, install the underlayment on the roof surface.

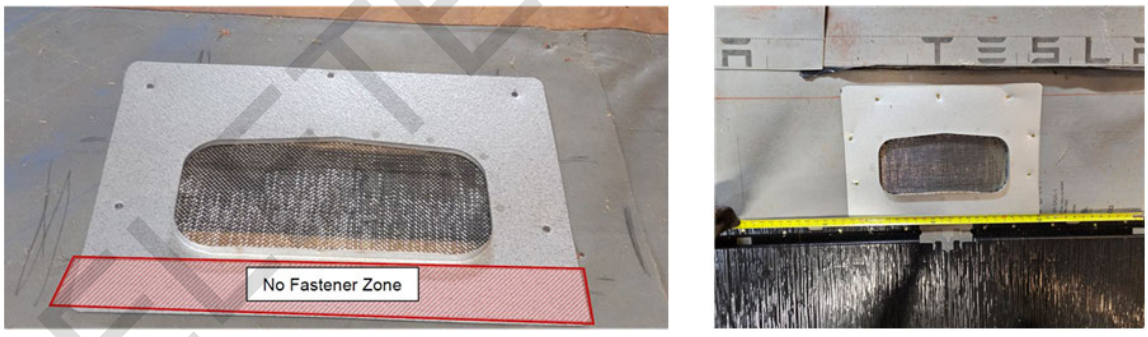
> **NOTE: Important:** When installing the first course of underlayment up-roof from your tile vent course, leave the backer sheet on the lower half of the underlayment un-peeled. This will allow you to properly integrate your deck level vents into the underlayment.

3. Install the tiles up to the course just below your tile vent course. This will allow you to accurately place the deck level vent where the tile level vent can be installed directly above it. Position your deck level vent centered on the water channel of the course below.
    a. Use a marker to mark your cut location on the deck.

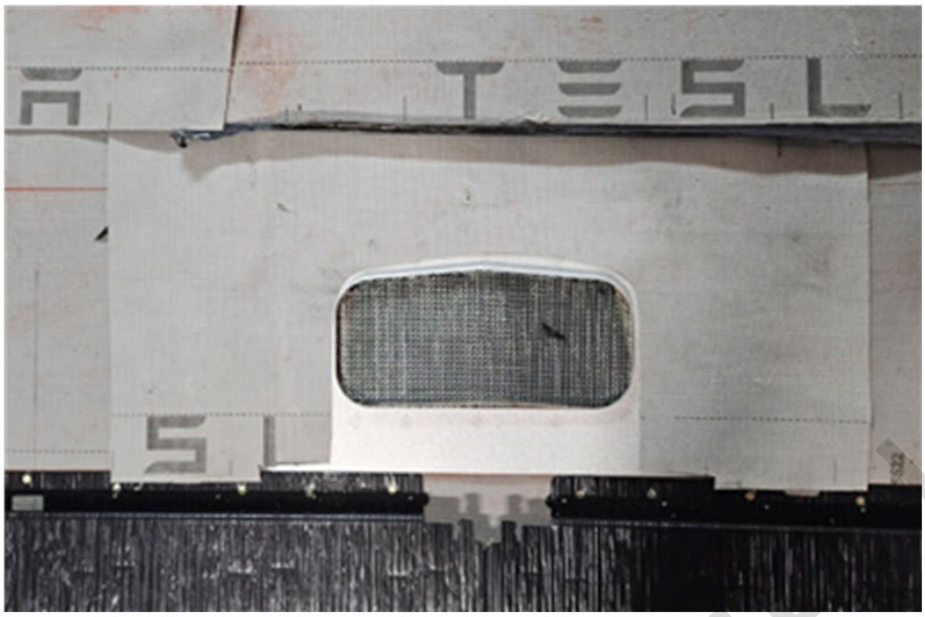


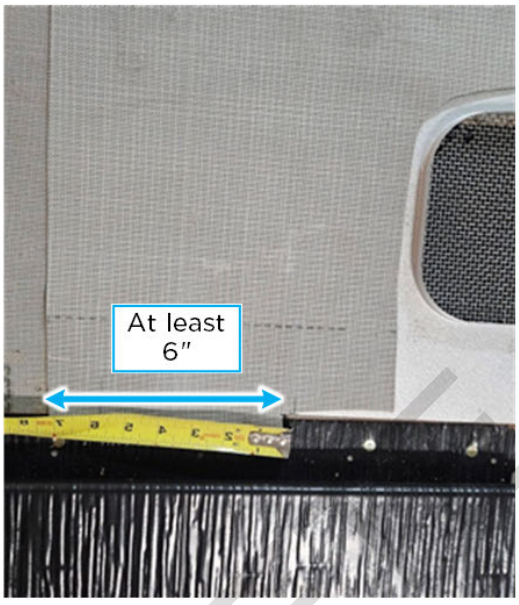
4. Make sure to set the depth of the circular saw correctly so nothing besides the decking gets cut. There should be no damage to the rafters/trusses. Use the circular saw to cut the decking on your marks. Remove the cut decking and clean any debris. Install the flashing with nail spacing as shown.

NOTE: Do not place fasteners below the vent flange.

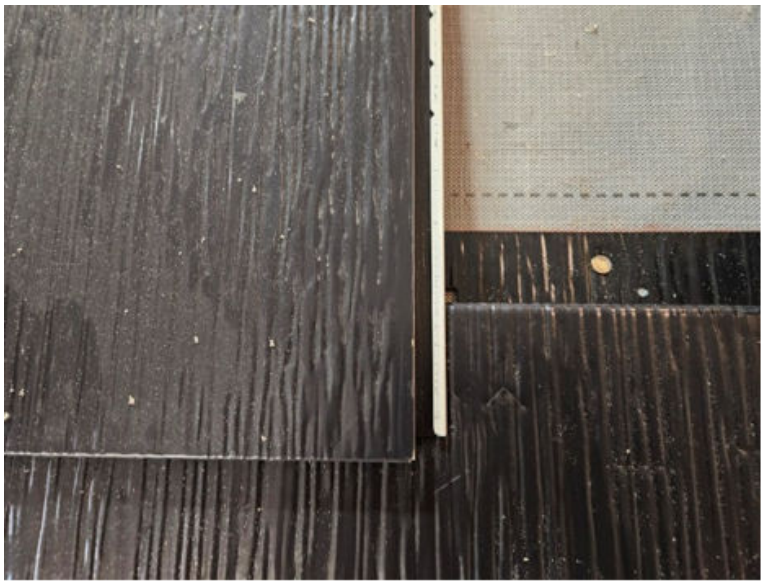


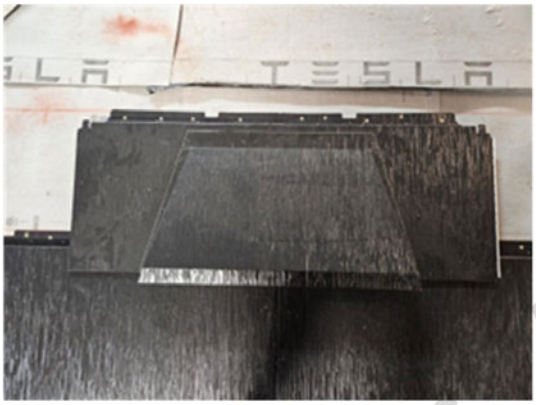
5. Cut a piece of underlayment at least 36 in long so that the vertical edges of the deck level vent flashing have at least 6 in of underlayment coverage. Cut the underlayment to the proper height, allowing the up-roof edge to be tucked 3 in underneath the course of underlayment above, as well as cover the deck level vent.
   a. Install the underlayment.

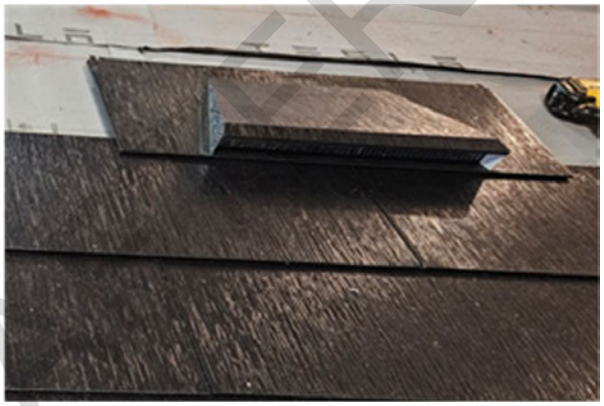




6. Install the tile level vent flashing similar to a standard metal tile. Use the alignment marks to ensure proper spacing of water channels.







Undershots

This section outlines the procedure for undershots, which includes dry-in and tile level:

Undershot - Dry-In

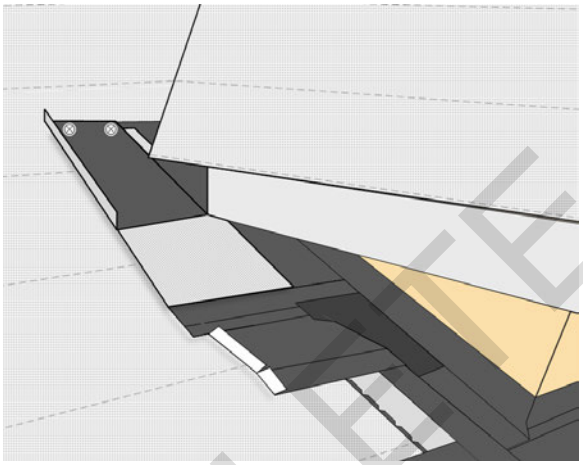
Overview:

This section outlines the procedure for drying in undershots. Once these procedures are complete, refer to *Undershot - Tile Level on page* for guidance on installing tiles around undershots.

Tools & Equipment:

- Wall flashing
- Detail roll
- Vented riser
- Transition flashing
- Flexible flashing
- Flat stock
- Metal snips
- Speed square

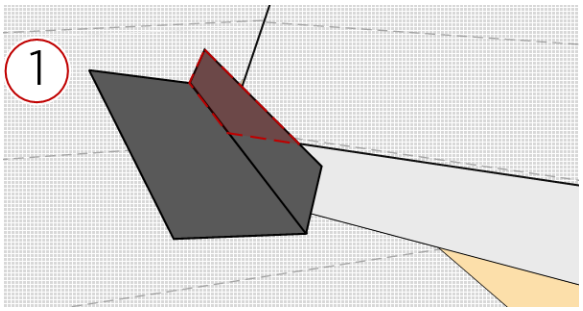
Finished installation for reference:



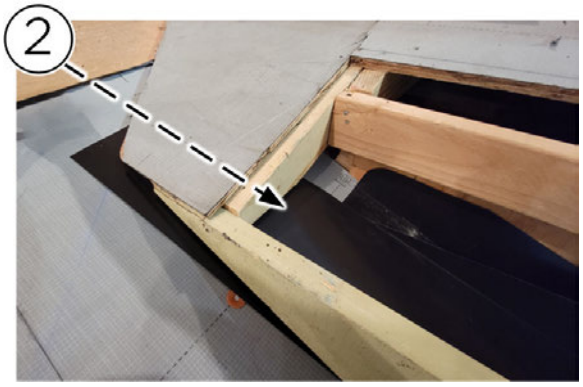
Work Instructions:

Wall Flashing Fabrication & Installation

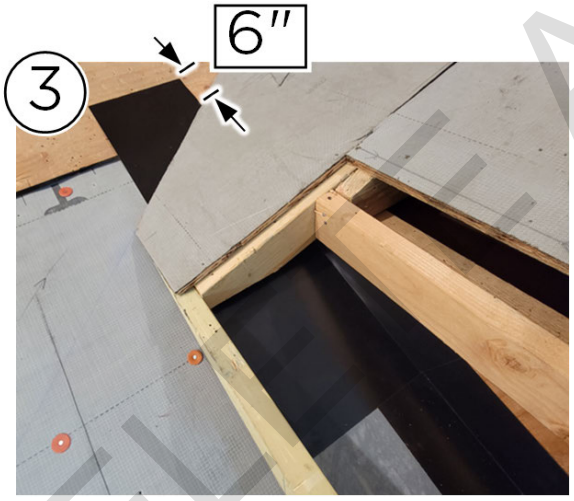
1. Press wall flashing against the fascia board and trace the eave line onto the vertical flange **(1)**. Cut off the excess to prevent any flashing from hitting the soffit.



2. Pry the deck up and slide the wall flashing into the undershot **(2)**. Pull out any nails or screws in the way of the flashing.



3. Position the wall flashing so that it protrudes out from the undershot and 6 in past the valley center **(3)**.



4. Fasten the wall flashing through both top corners. Then, fasten the long side in accordance with the applicable wind tier for the wall flashing section of the *Fastener Schedule*. Strip in the wall flashing with detail roll (ensure the detail roll does not come within 4 in of the wall) **(4)**.

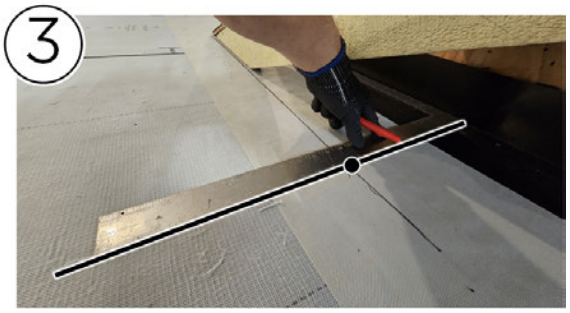
Undershot Layout

In this section, various marks are made at the undershot to guide *transition flashing on page 395* and *concealer pan on page 396* installation.

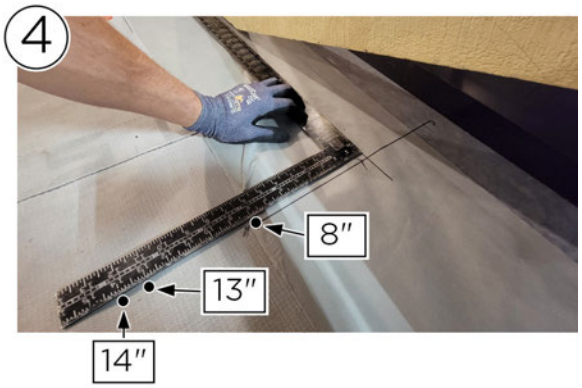
1. Mark a line on the deck that matches the upper eave with a straight edge **(1)**.

2. Use a speed square to scribe a plumb line on the decking and measure 12 in to the lower deck. Mark this 12 in point **(2)**.

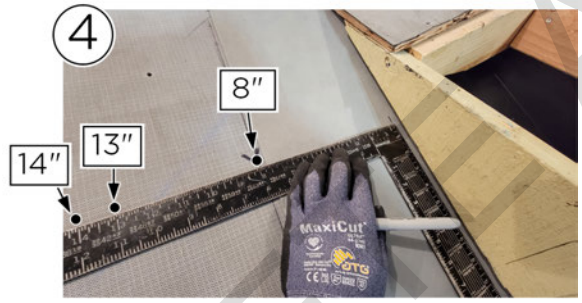
3. Draw a straight line beginning from the wall that intersects with the mark made in step 2. Extend this line out by 2 ft **(3)**.



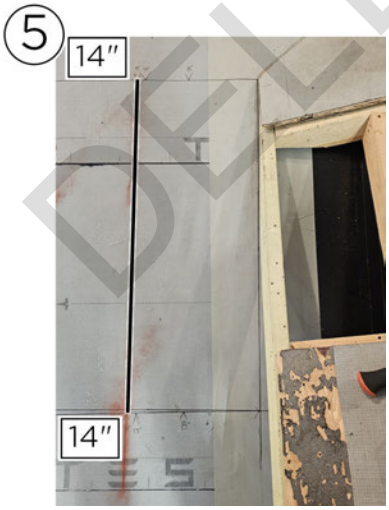
4. Measure and mark 8-, 13- and 14 in from the wall on the line drawn in step 3 and at the top of the undershot **(4)**. These marks will be used as guides throughout this work instruction.
   Pictured: Lower marks.



Pictured: Upper marks.

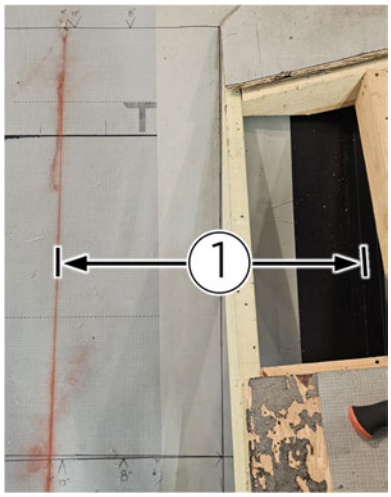


5. Snap a chalk line between the 14 in marks **(5)**.

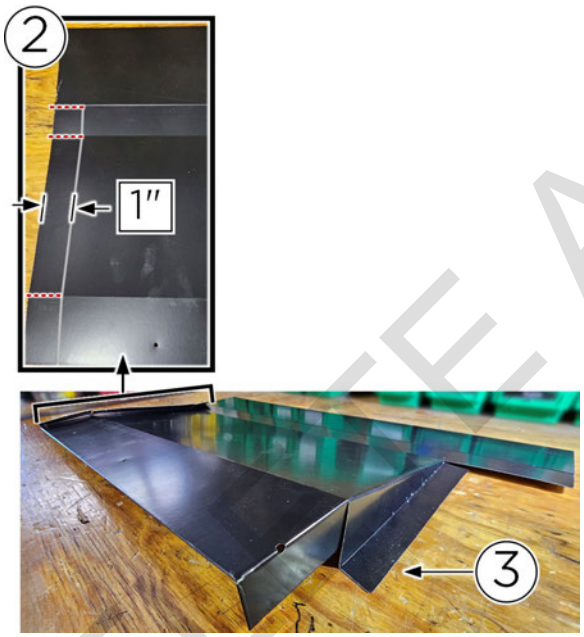


Transition Flashing Fabrication & Installation

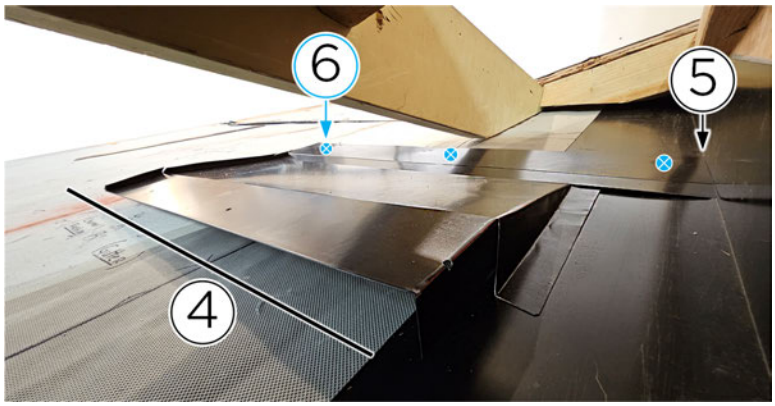
1. Measure the distance between the wall and the chalk line snapped in *Undershot Layout on page 393* **(1)**. Cut a piece of transition flashing to this length.



2. Cut and bend 1 in open hems into one end of the transition flashing **(2)**. On the opposite end, craft a "turn down and out". (See *Transition Flashing - Creating a "Turn Down and Out" on page 307*)**(3).**



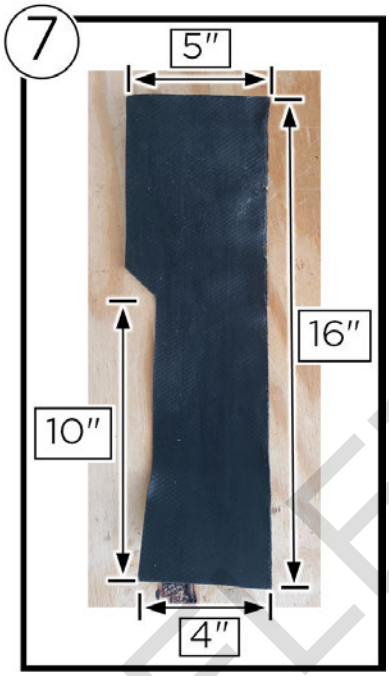
3. Position the transition flashing so that the lower edge aligns with the 12 in line drawn in step 3 of *Undershot Layout on page 393* **(4)**. Align the upper flange to be flush against the wall **(5)**. Fasten through the upper flange according to the applicable wind tier in the *Fastener Schedule*(6).



4. Cut a piece of flashing tape to cover the "turn down and out" and the pinhole that was created after the transition flashing was installed. The tape must also fit tightly from the corner of the wall to the corner of the base flange **(7)**.

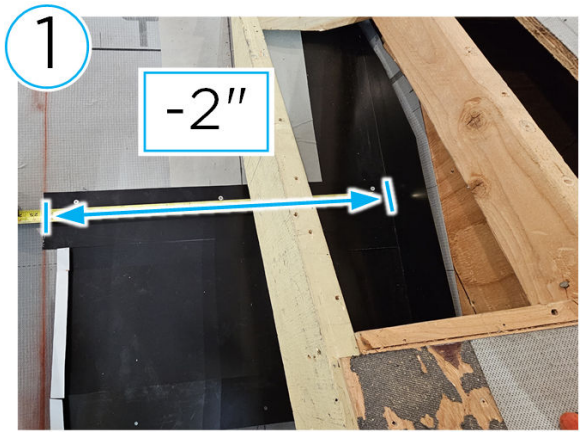
Pictured: Flashing tape dimensions:

- Flashing tape is a total of 16 in long
- 4 in wide at the bottom
- At 10 in, the tape must widen to 5 in to **effectively cover the pinhole**

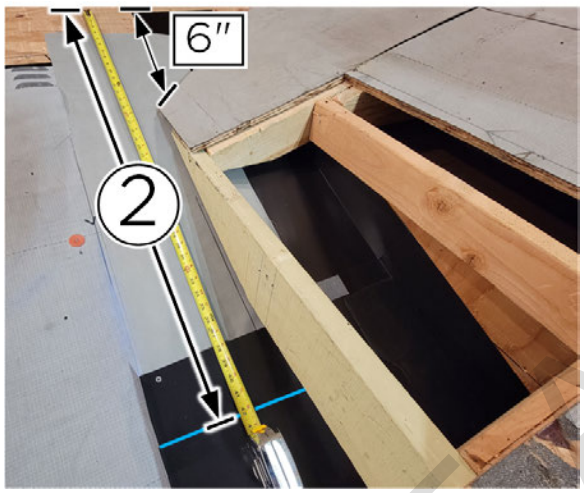


Concealer Pan Fabrication & Installation

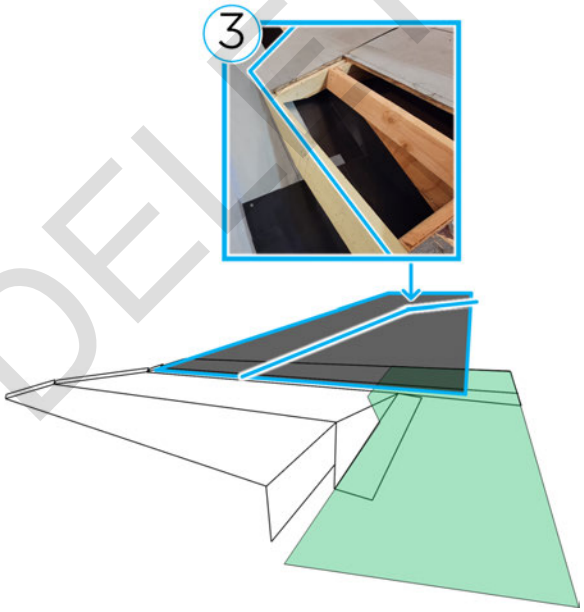
1. After the transition flashing is installed, a concealer pan must be installed to cover the remaining exposed underlayment in the undershot.
   Take the transition flashing measurement from step 1 of *Transition Flashing Fabrication & Installation on page 395* and subtract 2 in. This will determine the width of the concealer pan **(1)**.



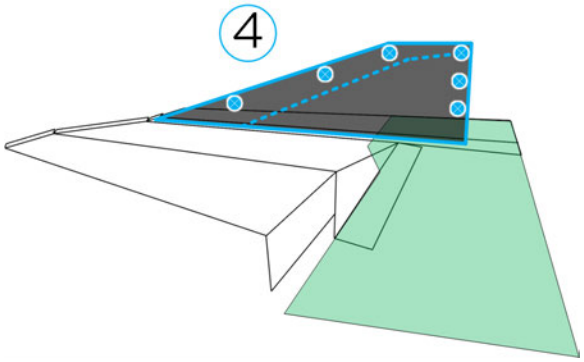
2. Measure the distance between the point where the transition flashing touches the deck and up to 6 in past the valley **(2)**. This will determine the length of the concealer pan.



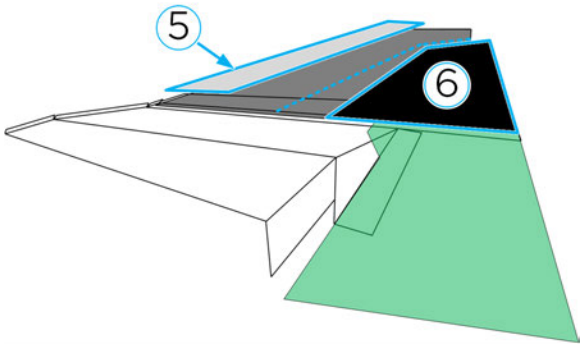
3. Cut a concealer pan with the dimensions determined in steps 1 and 2. Lay the concealer pan in place and note the location of the dormer valley / eave edge on the pan **(3)** – this will guide the flexible flashing placement in step 6.



4. Fasten the concealer pan 8 in on-center **(4)**.



5. Cover the fasteners on the left side of the concealer pan with detail roll **(5).** Cover the remaining fasteners with flexible flashing. The flexible flashing should meet the edge of the valley and without extending past it, use the edge noted in step 1 as guidance **(6)**.



Valley Washout Pan Fabrication & Installation

Refer to the labels below to understand which parts of the roof are being worked on at this point of undershot dry-in.

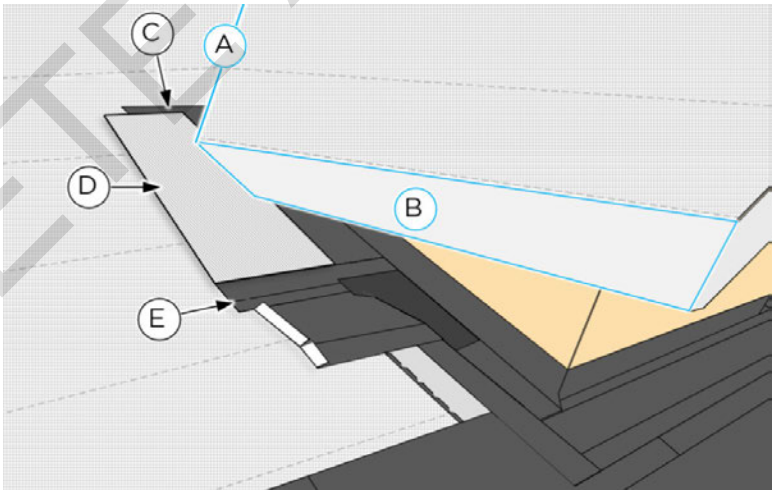
A: Valley

B: Fascia board

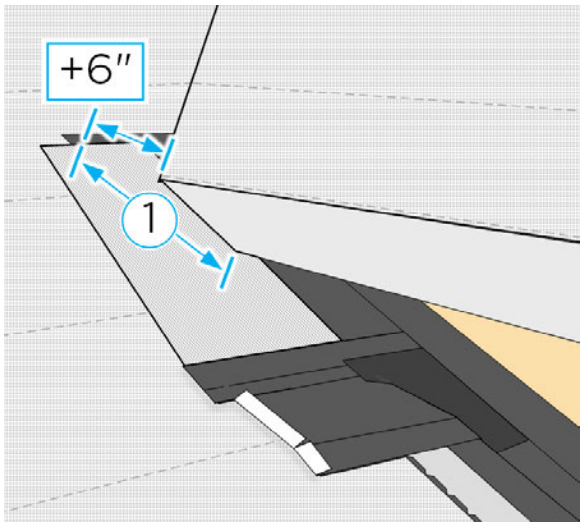
C: Concealer pan

D: Detail roll

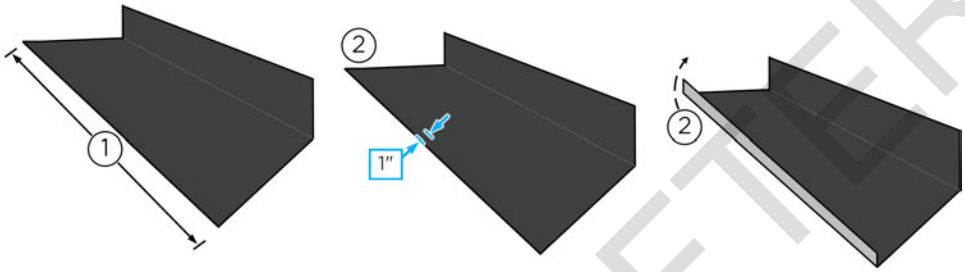
E: Transition flashing



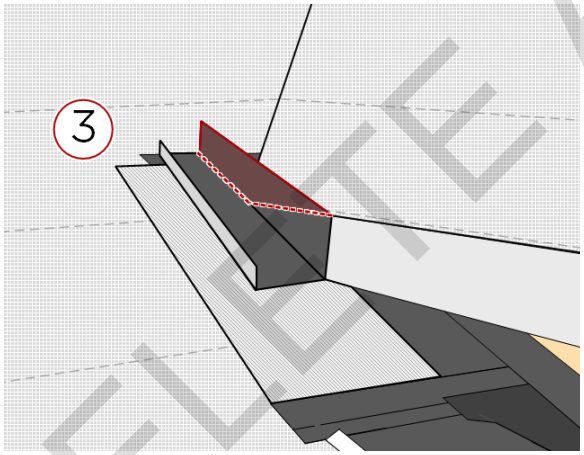
1. After completing all undershot dry-in procedures, craft a valley washout pan.
   Starting 6 in past the valley line, measure the distance to the bottom edge of the fascia board **(1)**.



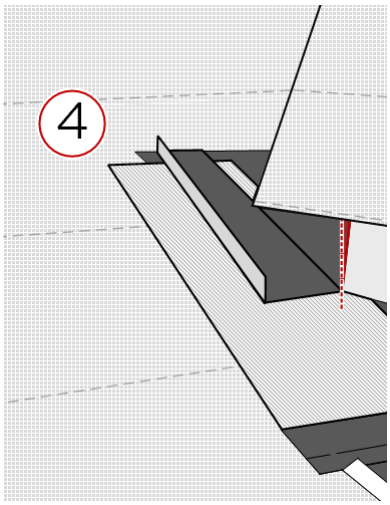
2. Cut a piece of wall flashing to the measurement found in step 1 and bend a 1 in turn up into the deck flange **(2)**.



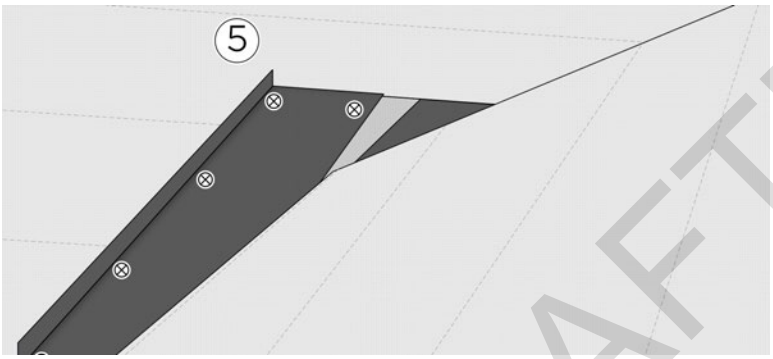
3. Place the wall flashing against the fascia board and trace the edge of the fascia board and valley deck onto the back of the wall flashing. Cut along this line and remove the excess **(3)**.



4. Use a speed square to mark a plumb line at the down roof edge and cut away the excess material **(4)**.



5. Fasten the valley washout through both top corners. Then, fasten the long side of the washout in accordance with the applicable wind tier for the wall flashing section of the *Fastener Schedule*(5).



Undershot - Tile Level

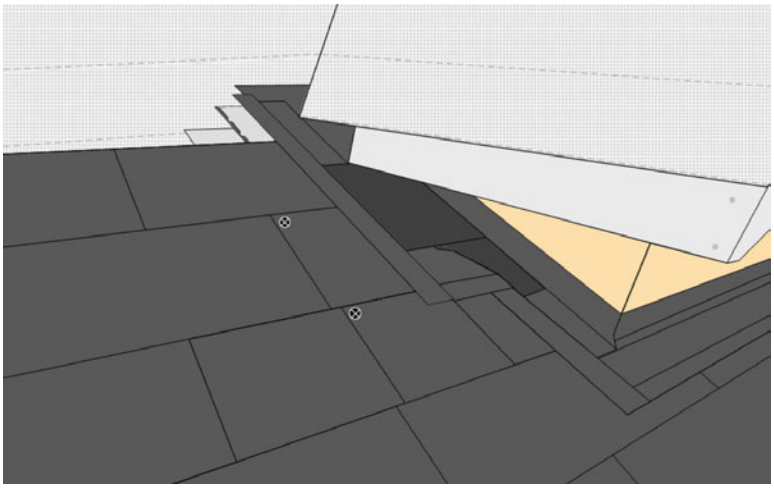
Overview:

This section outlines the procedures for installing perimeter metals and tiles at undershots and valley washouts. These procedures begin after all undershot dry-in procedures are completed (*Undershot - Tile Level on page*).

Tools and Equipment:

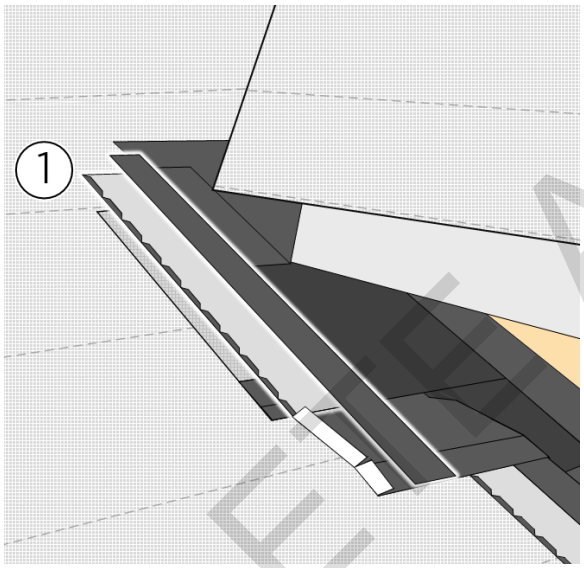
- Channel flashing
- Metal snips
- Metal tiles
- Tile skins
- The Cut Station

Finished undershot and valley washout installation for reference:

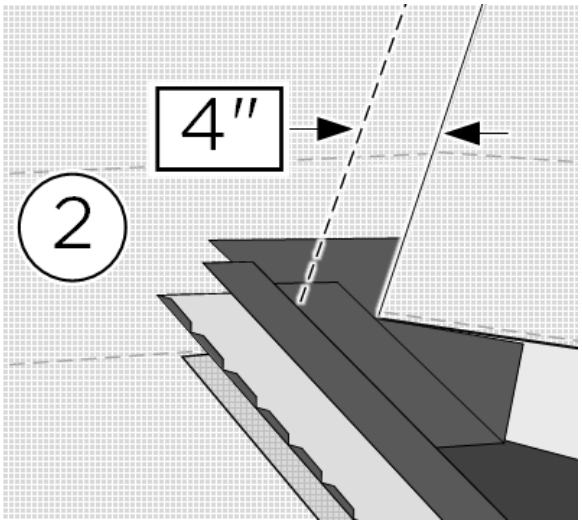


Work Instructions:

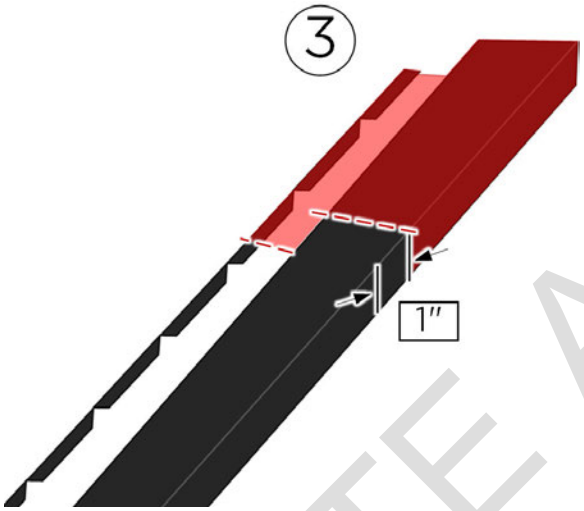
1. Once all undershot dry-in procedures are completed, install channel flashing in line with the concealer pan and the transition flashing **(1)**.
   Additionally, cut the channel flashing so that the deck flange terminates at the transition flashing middle flange and the top flange terminates with the transition flashing bottom flange.



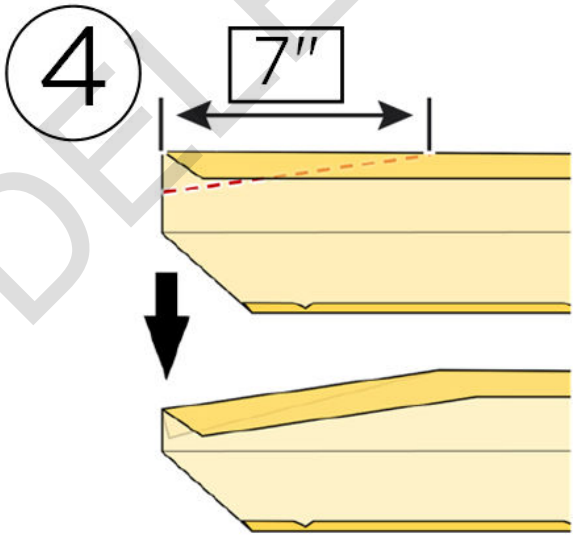
2. Mark the channel flashing at the point where it will intersect with the valley vented riser (valley risers are placed 4 in from the valley) **(2)**.



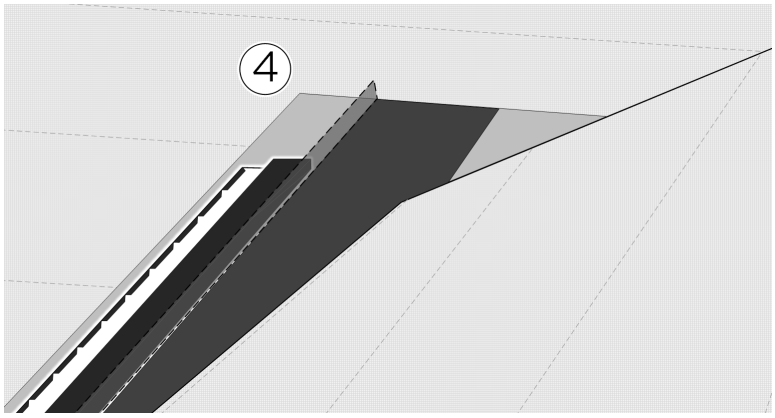
3. Mark an additional 1 in from the mark made in step 2 (this will ensure no gap will be left between the channel flashing and valley vented risers) and trim off the excess metal **(3)**.



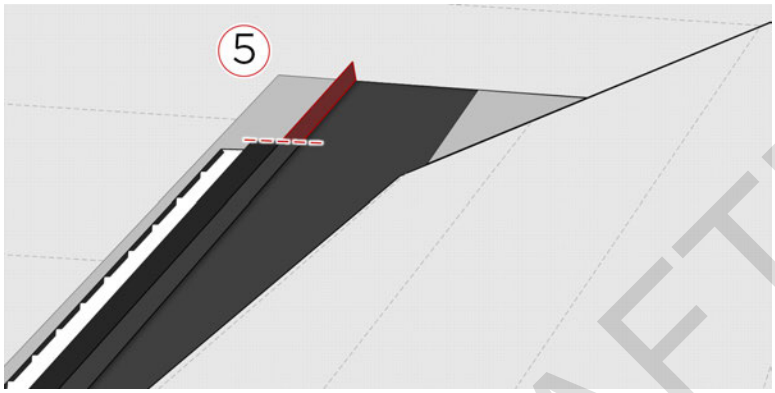
4. Then, make a 7 in relief cut on the channel flashing and push the top flange downwards to allow the channel flashing to later lap under the valley riser **(4)**. Place the channel flashing back in place against the valley washout pan.



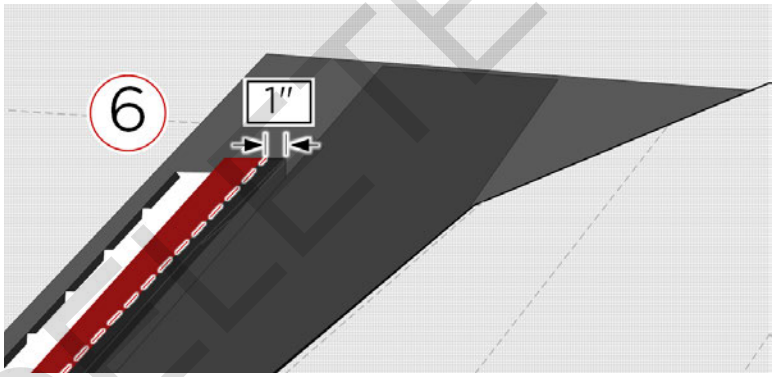
Pictured: Cut channel flashing placed against the valley washout pan.



5. Trim the valley washout pan 1 in turn up to terminate with the channel flashing **(5)**.



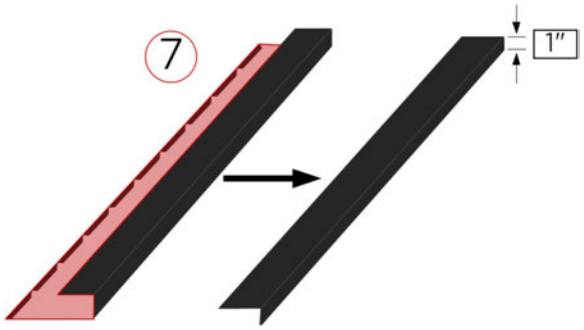
6. Determine where the tile reveal lands along the channel flashing. Then, remove a portion of the channel flashing top flange spanning from the top of a tile to the down-roof edge of the valley washout pan. This will prevent material stacking up as tiles are installed. However, leave 1 in of the top flange material in place which will be fastened in the next step **(6)**.

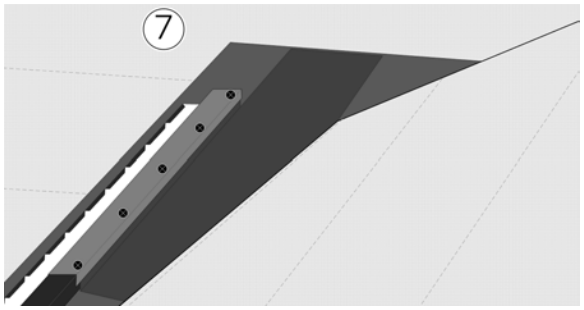


7. Fabricate a channel flashing cap to ensure proper waterproofing of the valley washout flashing's 1 in turn up against the channel flashing.

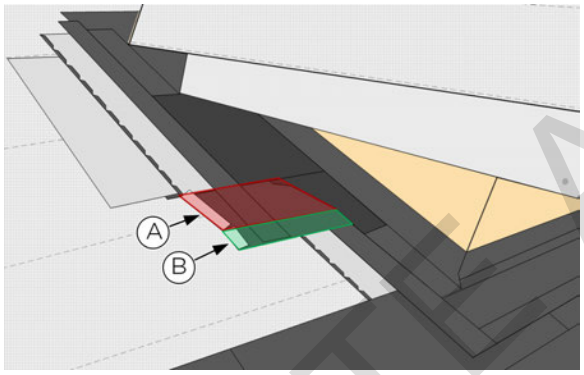
   Remove the deck flange from another piece of channel flashing to create a cap. Trim the vertical flange of this cap down to 1 in to prevent scratching the valley washout flashing.

   Place the cap over the channel flashing gap and fasten 8 in on center through the remaining 1 in of metal **(7)**. Ensure the cap also laps over the valley washout flashing turn up.

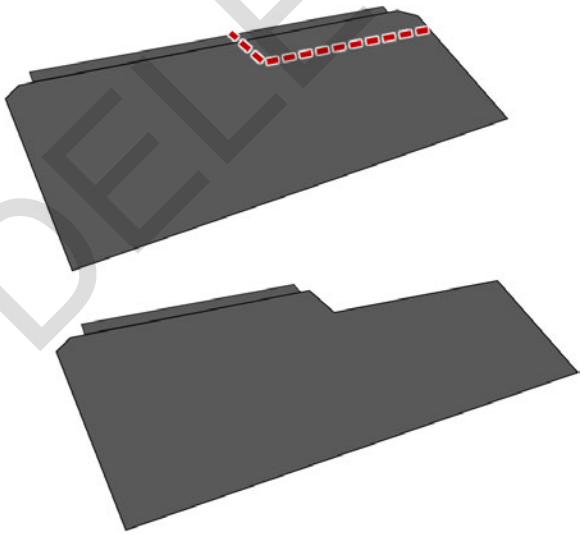


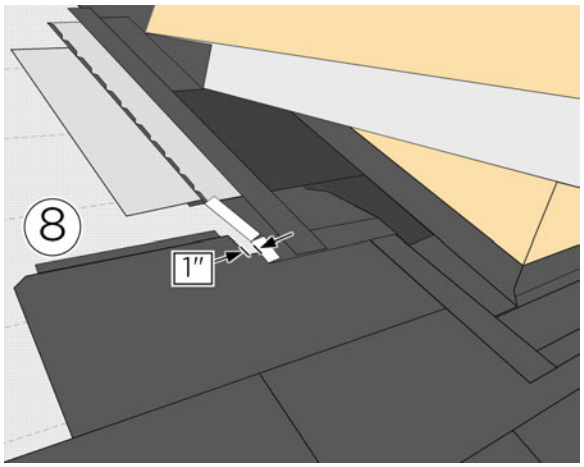


8. Proceed to install tiles around the undershot and valley washout.
   When installing a metal tile up to the undershot transition flashing, the tile must not land underneath the middle flange **(A)**. However, the tile should terminate underneath the lowest flange **(B)**.

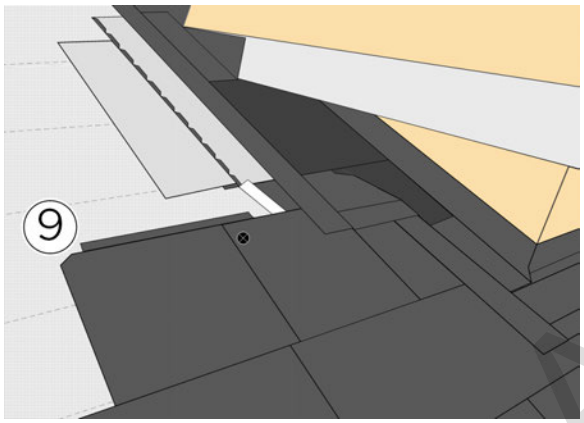


Trim the tile to meet these conditions and leave a 1 in gap from the transition flashing edge **(8)**.

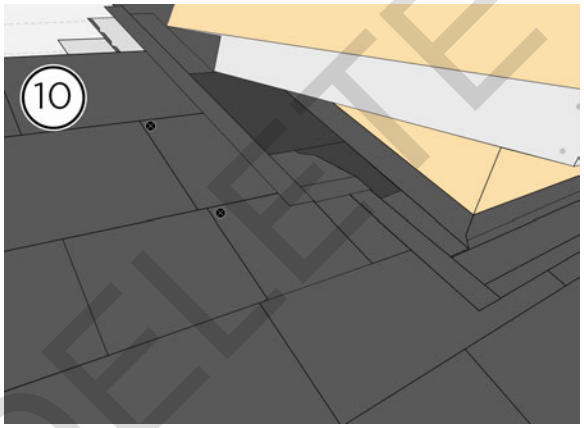




9. Tuck a tile skin into the channel flashing and cover the gap. Fasten the tile skin through the metal tile in accordance with the applicable wind tier in the *Fastener Schedule* **(9)**.



10. Continue installing tiles up roof and cover any gaps with tile skins **(10)**.



Valleys Over 135°

Overview

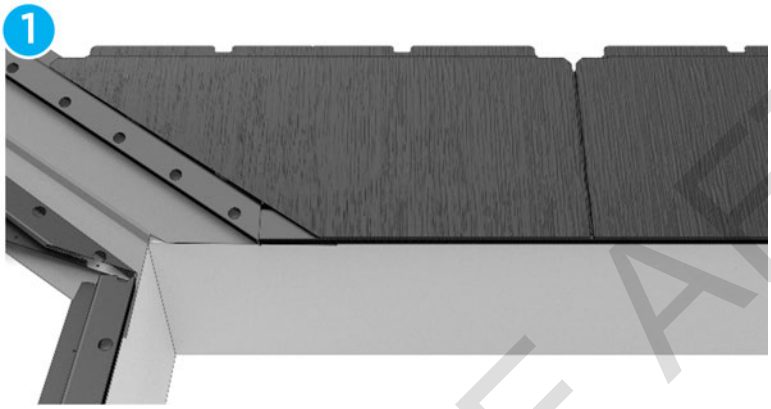
This section outlines the procedures for fabricating valley trim cover for angles above 135° where an adjustable trim flashing will not fit.

Tools & Equipment

- Measuring tape
- Metal tile
- Digital angle finder
- Tile skin

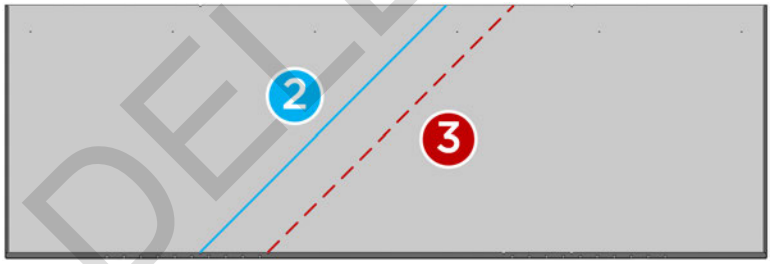
Work Instruction: One Piece Flashing, for Angles 135° to 155°

Measure and cut a metal tile at the valley riser as usual. Refer to *Cutting Standards on page 716* for guidance on how to properly measure the angle for valley trims **(1)**.

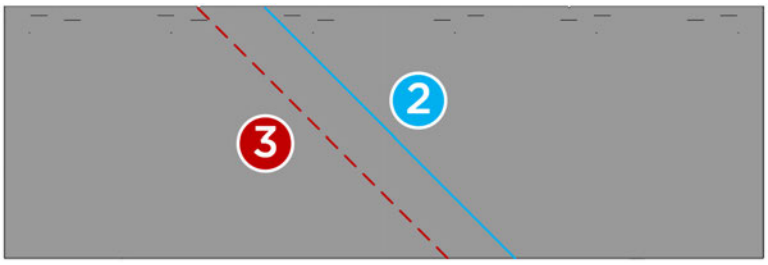


On a tile skin, scribe a **bend line (2)** from the first caret in the down-roof hem, at the angle measured in the previous step (see *Part Inscription Identifier on page 709* for exact caret locations). Scribe a second **cut line (3)**starting from the second caret and offset from the bend line. The flange created by this bend will allow water to shed properly in the valley.

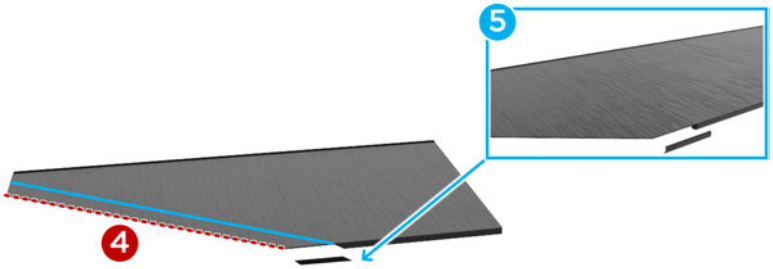
Back view of tile skin:



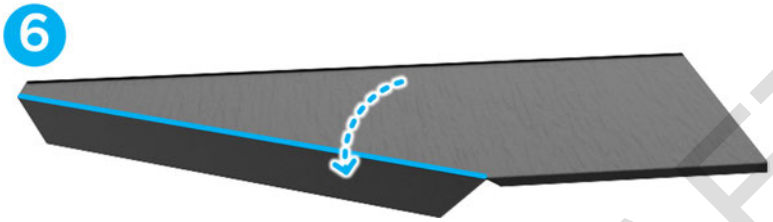
Front view of tile skin:



Cut along the marked cut line with offset metal snips **(4)** and remove the vertical face at the drip edge so that the metal can bend **(5)**.



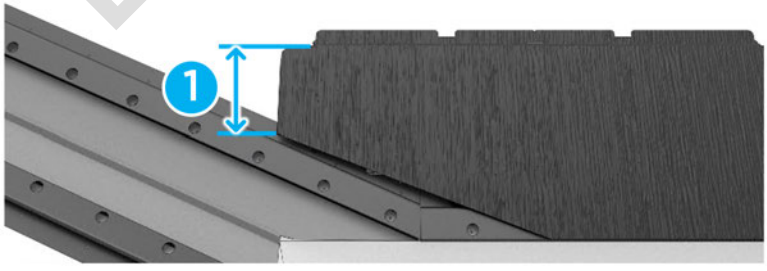
With a metal brake, fold along the bend line to a 90° angle **(6)**.



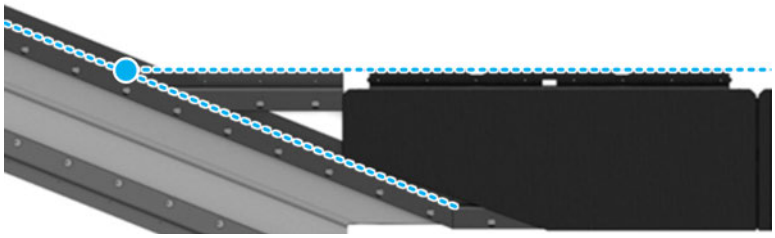
Hook the modified skin over the metal tile and secure it in place with four self-tapping screws, two along the top and two into the vented riser **(7)**.

Work Instruction: 2+ Piece Valley Flashing, for Angles Above 155°

When the valley angle is large, multiple cut metal tiles will be needed in a single course. After cutting and installing the first cut metal tile, measure the height of the short end facing the valley and ensure it is larger than 7 in before measuring and cutting the next cut tile **(1)**.

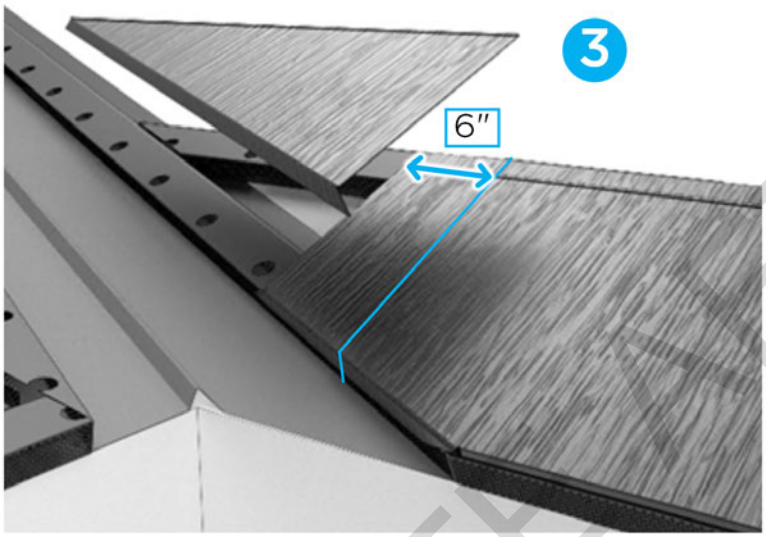


- If the height of the metal tile is less than 7 in, use vented riser instead. To determine the cut length of vented riser, layout a line that extends from the top of the metal tile nailing flange to where it intersects with the valley vented riser.

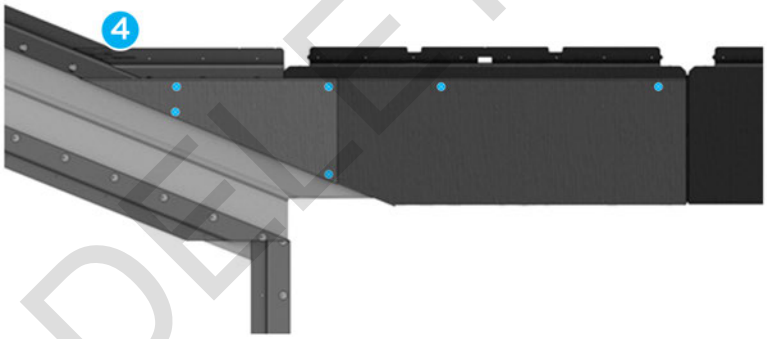


Follow the same procedure for measuring and bending a tile skin outlined in *Work Instruction: One Piece Flashing, for Angles 135° to 155° on page 406*.

Place the first cut tile skin over the cut metal tile and secure it with three fasteners. Install the second tile skin in the same process as the one-piece valley flashing, but overlap the first skin by a minimum of 6 in **(3)**.



Secure to the cut vented riser and valley riser with two self-tappers at the overlap, two along the top of the cut vented riser, and one at the valley vented riser **(4)**.



Zipper Hip

Overview

This section outlines two metal installation methods for zipper hips:

- *Flat Stock Method on page 410*
- *Cut and Tuck Method on page 416*

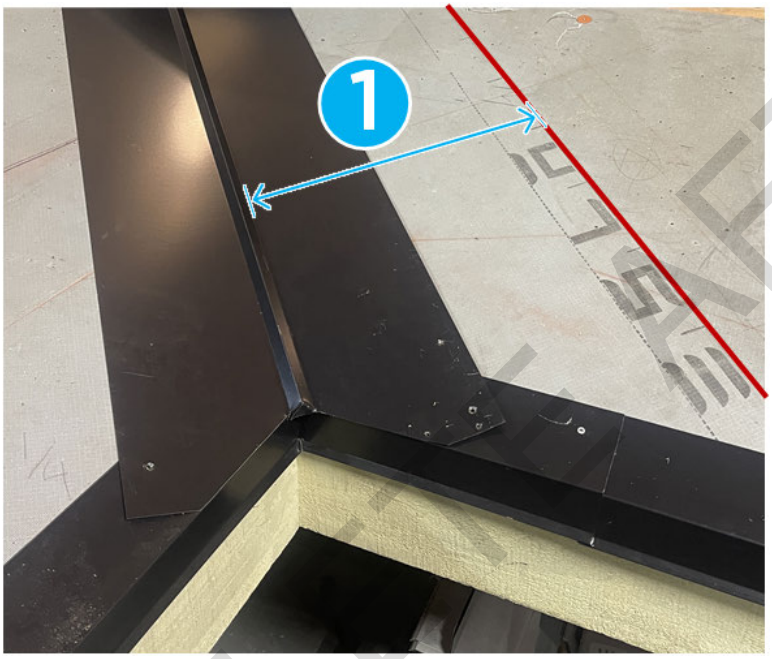
At this point of installation, the valley pan has been installed during dry-in.

To determine which method to use, measure the distance between the base of the valley flashing and the hip center **(1)**.

PRO TIP: Ensure to measure from the base of the triangle in the valley flashing, not the center.

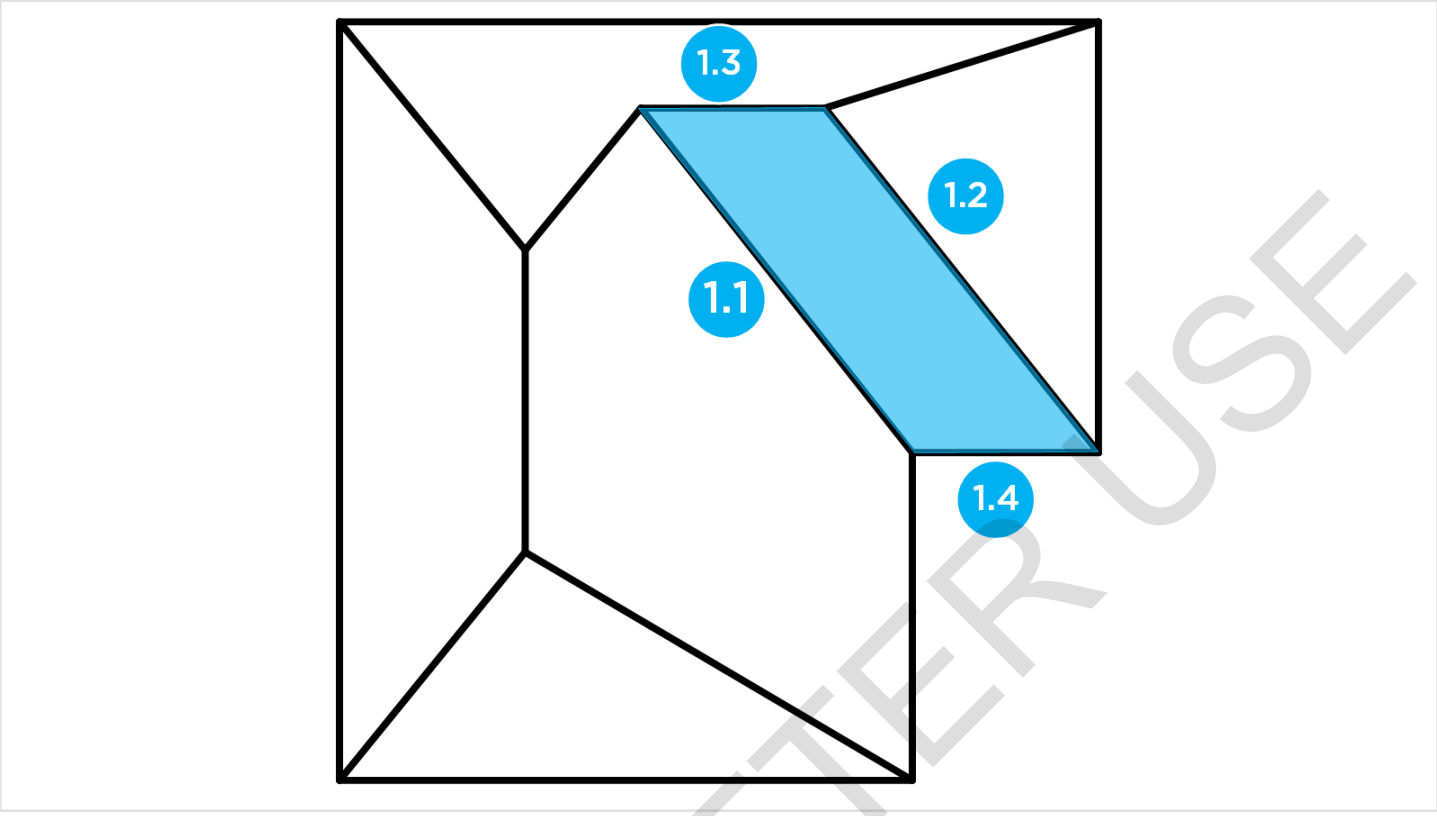
If the distance is **less than 29 in**, proceed with the **flat stock method**.

If the distance is **greater than 29 in and less than the width of a tile (45 in)**, proceed with the **cut and tuck method**.



Pictured: Top-down view of roof with a zipper hip, refer to the labels on this diagram to understand which parts of the roof are being worked on throughout these instructions.

1.1	Valley
1.2	Hip
1.3	Ridge
1.4	Eave



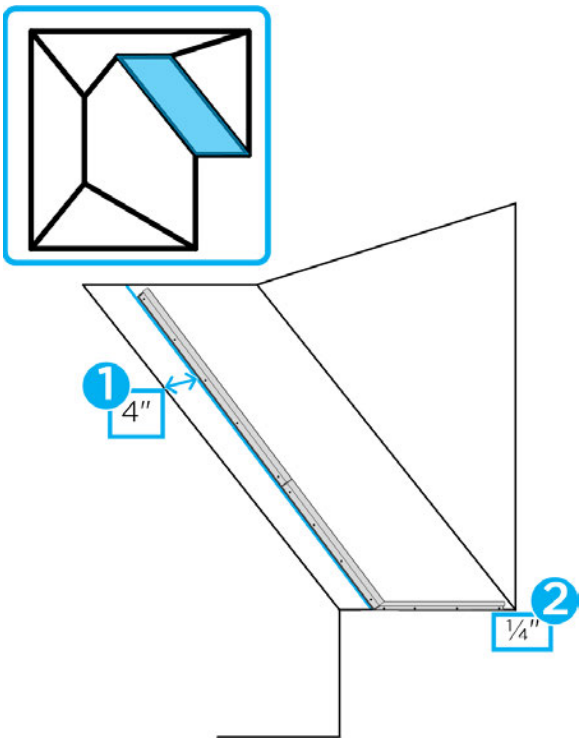
Tools & Equipment

- Angle finder
- Flat stock
- Channel flashing
- Metal tiles

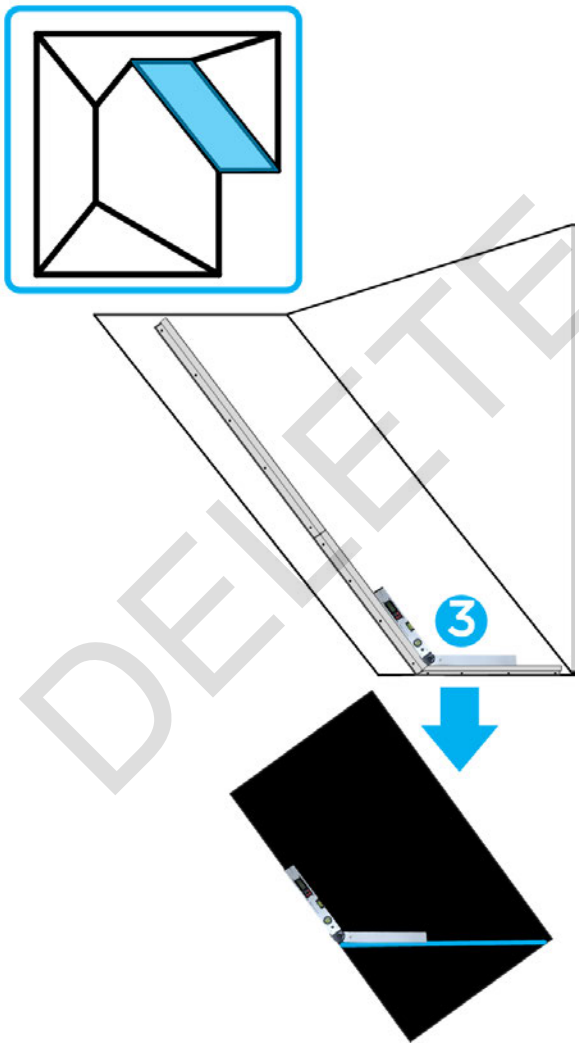
Flat Stock Method

Measure and mark 4 in from the valley flashing base. Chalk a line across the valley at this point and install a cleat over the line **(1)**.

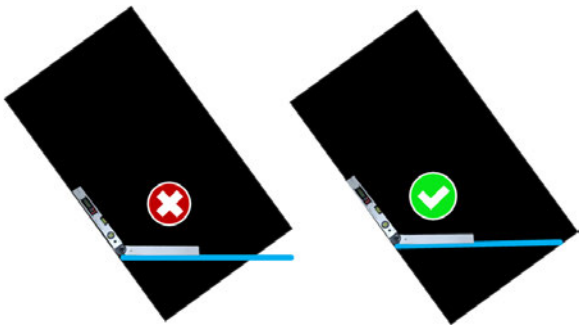
Then, install another cleat at the eave with a ¼ in overhand **(2)**. Ensure these two cleats meet at a miter.



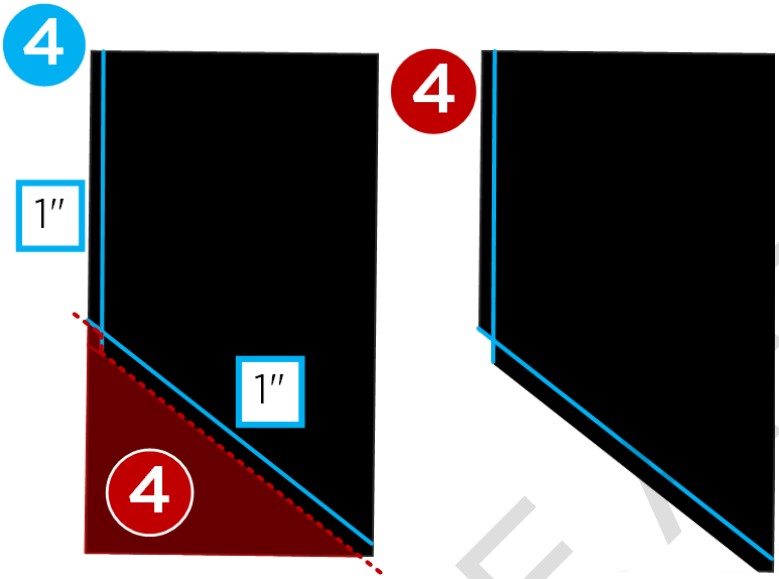
Determine the valley angle with an angle finder. Then, transfer and mark this angle onto a piece of flat stock **(3)**.



NOTE: Ensure the entire angle line is marked onto the flat stock, move the angle finder upwards as needed.



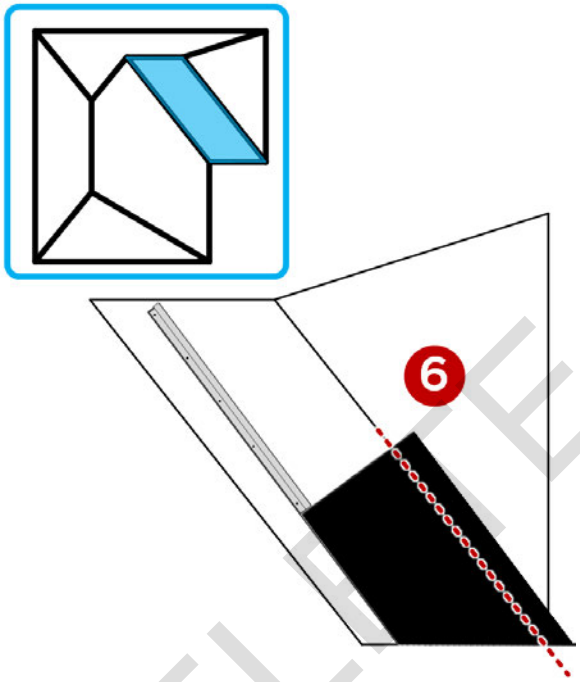
Measure and mark 1 in away from the flat stock edge and the angle line marked in step 3 (these new lines will be used to make hems). Cut off the excess metal **(4)**.



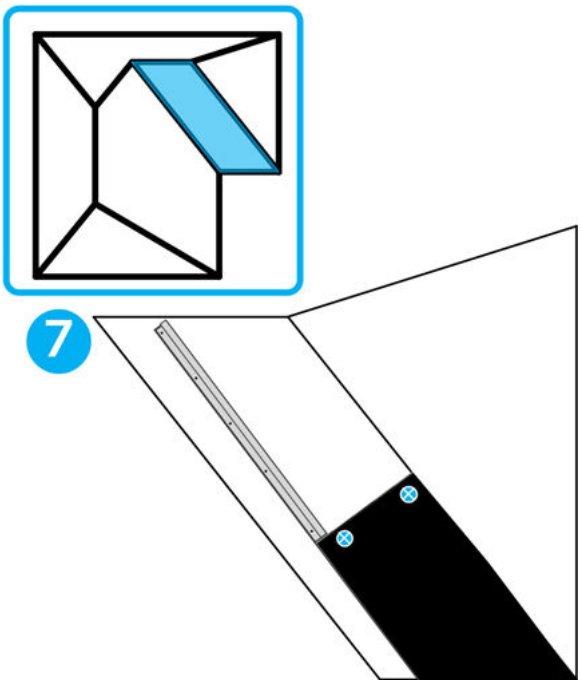
Proceed to bend 1 in open hems into the flat stock **(5)**. These hems must be open to ensure the flat stock will properly engage the cleats.

PRO TIP: Use another piece of flat stock as a spacer in the brake to help maintain uniform open hems and prevent overbending.

Place the hemmed flat stock over the valley side and engage the cleats. Measure the distances between the valley cleat and the hip. If the flat stock extends into the hip, trim the excess **(6)**.

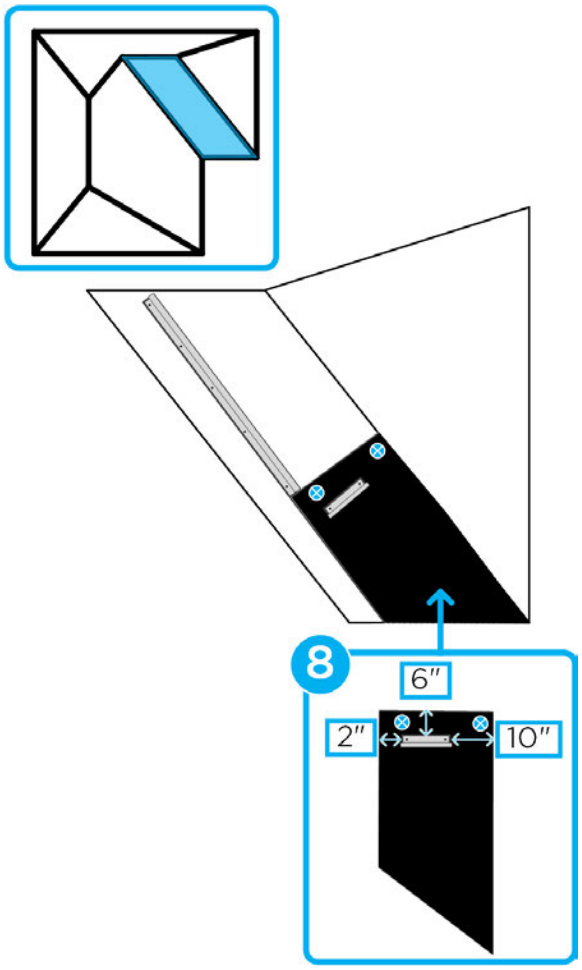


Fasten the flat stock in accordance with the applicable wind tier in the *Fastener Schedule on page 703* towards the upper corners. However, do **not** fasten through the cleat. **(7)**.

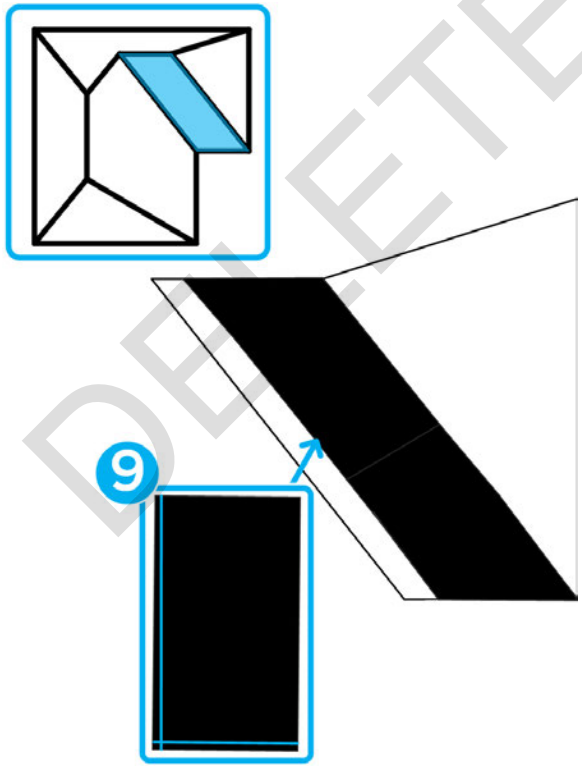


Install another cleat over the flat stock to engage with the open hems of the next flat stock piece **(8)**. This cleat placement is determined by the following measurements:

- 2 in from the valley-facing edge of the flat stock (to prevent stacking around the existing cleat)
- 6 in from the up roof edge of the flat stock
- 10 in from the hip (to ensure channel flashing will not be installed over the cleat)



All flat stock pieces that follow will be squared off rather than cut to match the eave angle. Create open hems at the valley-facing and down roof sides of the new flat stock **(9)**.

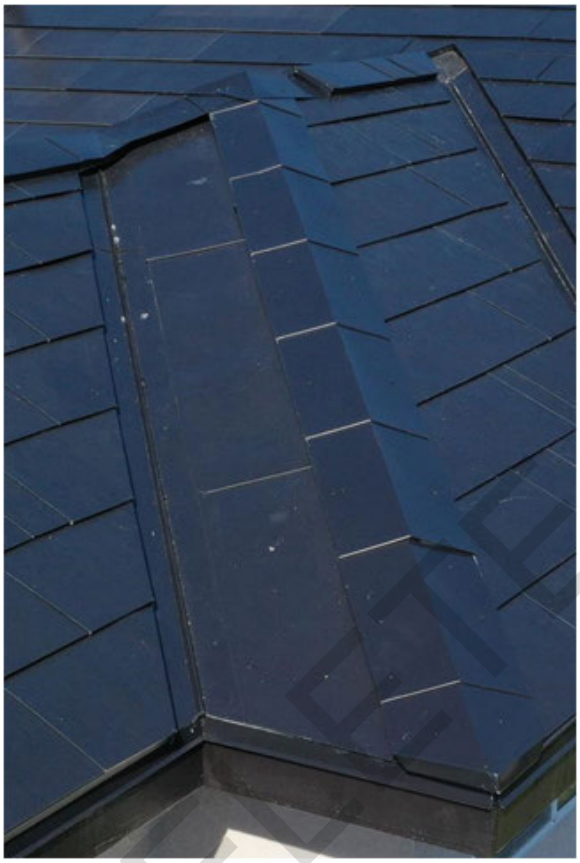


Proceed to cut and install channel flashing to support hip caps. Cut a gap less than 45° in the channel flashing to allow an overlap / bend **(10).**

PRO TIP: Use the *Robin Jig on page 603* "C at Zip Hip" marks to determine exact channel flashing placement.

Proceed to install a starter cap followed by hip caps and metal tiles at the zipper hip.

Finished flat stock method installation for reference:



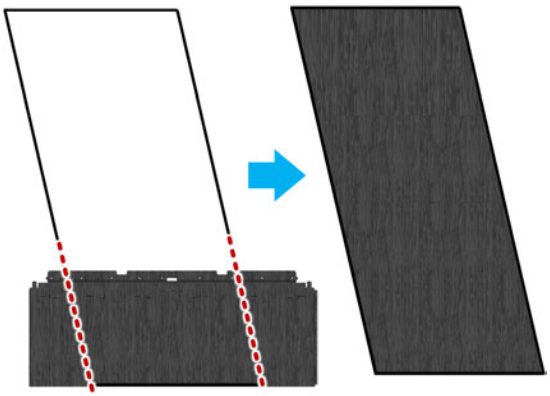
Cut and Tuck Method

In this installation method, metal tiles are cut and tucked into channel flashing. However, the metal tile layout is determined by the width of the hip side.

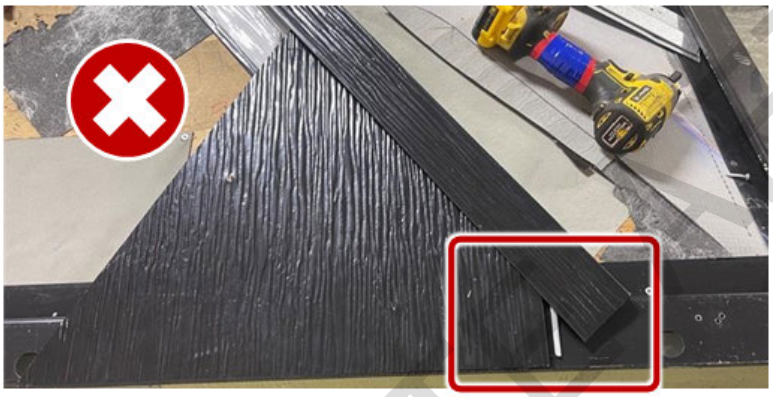
If the hip is **37 in or wider**, follow standard metal tile installation procedures (see *Cut and Tuck at Square Roof Features on page 178*).

If the hip is **less than 37 in wide**, metal tiles are instead centered and trimmed at the zipper hip and installed without a stagger.

PRO TIP: With this method, all metal tiles can be pre-cut together as they will be identical sizes due to being installed without stagger.



NOTE: When trimming tiles, always trim off the entire side that sits next to the hip to prevent exposing the water channel.



Finished cut and tuck method installation for reference:

Mixed Pitch Hips

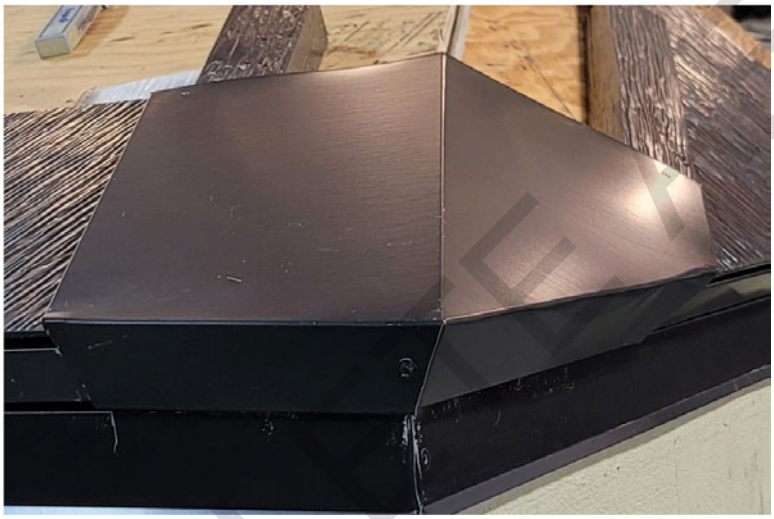
Overview

This document outlines the steps for fabricating and installing starter caps for hips with mixed pitches. The majority of this procedure mimics the Hip Starter Cap procedure (see *Hips on page 225*) with some modified steps to accommodate the differing hip pitches.

Tools & Equipment

- Digital angle finder
- Robin jig
- Hip cap
- Vented riser
- Channel flashing
- Speed square
- 6 in seamers
- Metal snips
- Flat stock (optional)

Finished installation for reference:



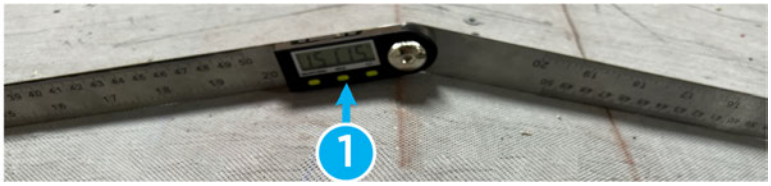
Work Instruction

Hip Assembly

Measure the hip angle with a digital angle finder. Then, subtract this number from 180 to determine the hip cap bend angle **(1)**.

Example:

1. The measured angle is **151°**.
2. Subtract **180 - 151**.
3. The final hip cap bend angle = **29°**



Proceed to follow all Hip Assembly steps outlined in the Hip Assembly section of the standard Hip Starter Cap work instructions.

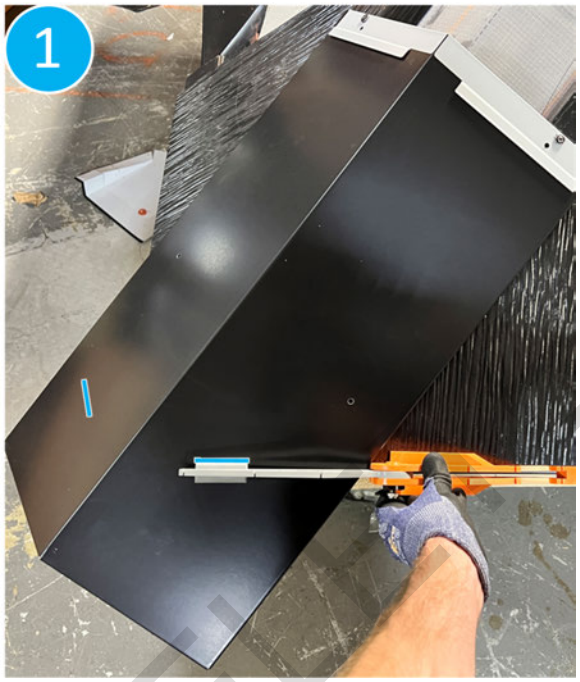
NOTE: The images in these instructions feature a standard hip, but all steps can be applied to a mixed pitch hip.

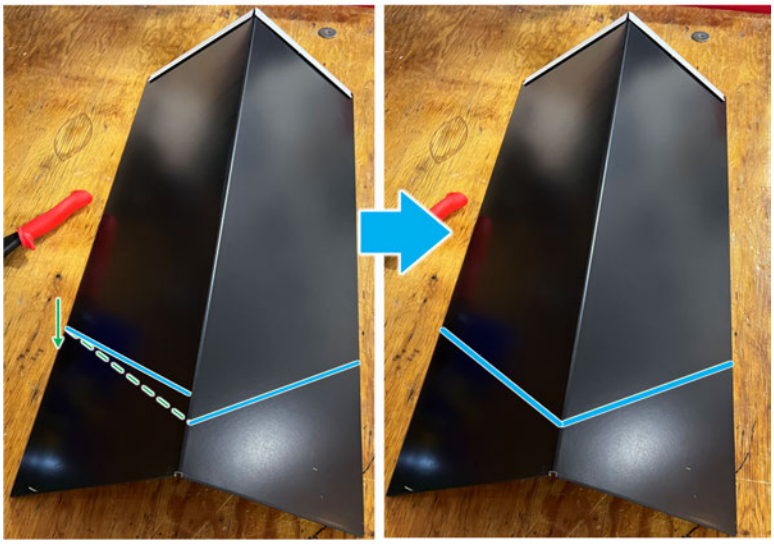
Mixed Pitch Starter Cap Fabrication

Use the *Robin Jig on page 603* to mark the edge of the eave onto both sides of the cap. Then, uninstall the cap and finish fabrication on the ground.

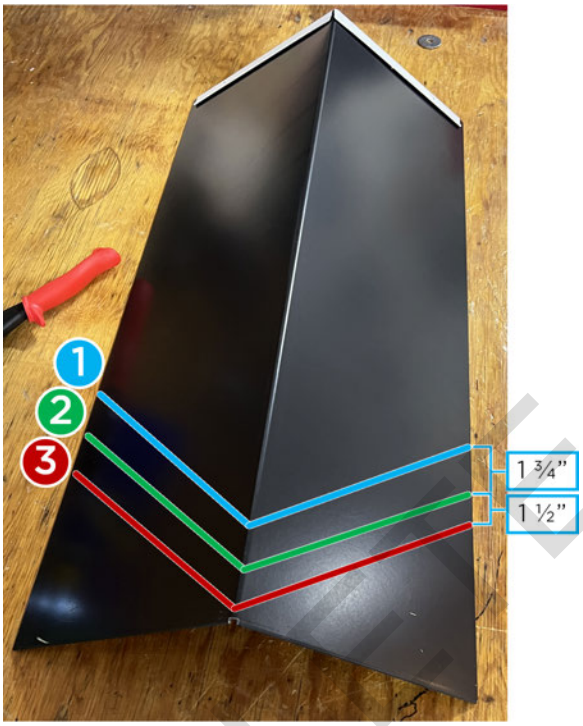
Use a straight edge to scribe the complete eave line across the cap.

PRO TIP: The eave lines on either side of the cap might not line up with each other. In that case, pivot the most up roof line down to match **(1)**.

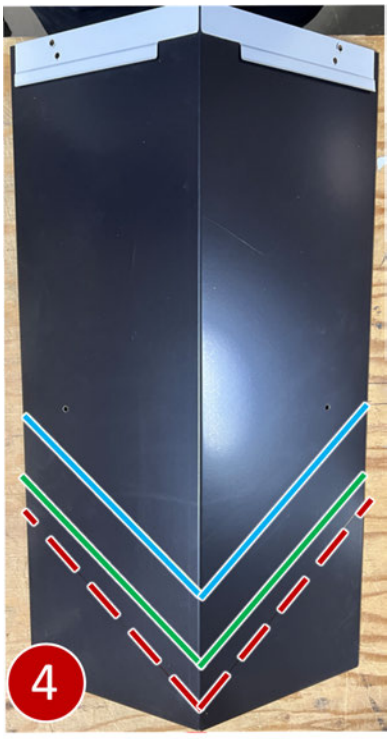




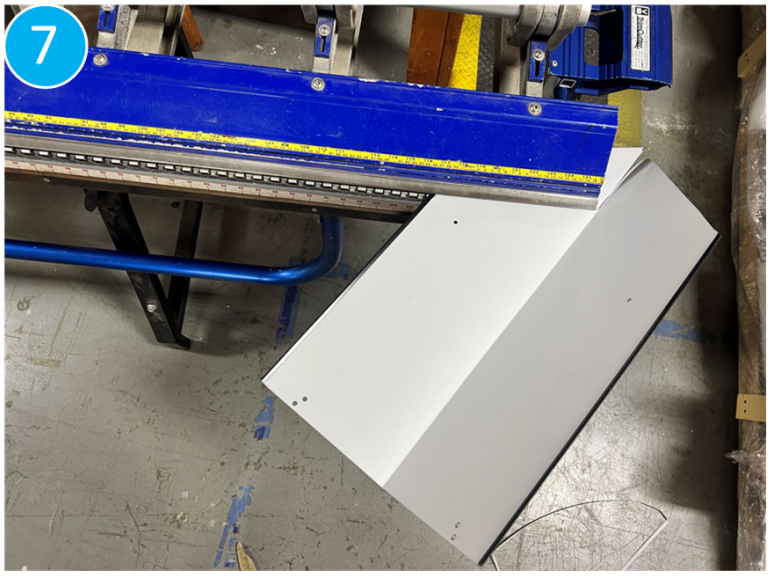
Scribe another line 1 ¾ inches below the eave line **(2)** and scribe a third line 1 ½ inches below the second line **(3).**



Cut along the third line to remove the corner excess metal **(4)**. Make relief cuts at the edge of each remaining line on both sides of the cap **(5)**. Finally, cut into the cap center and up to the line furthest up roof **(6)**.



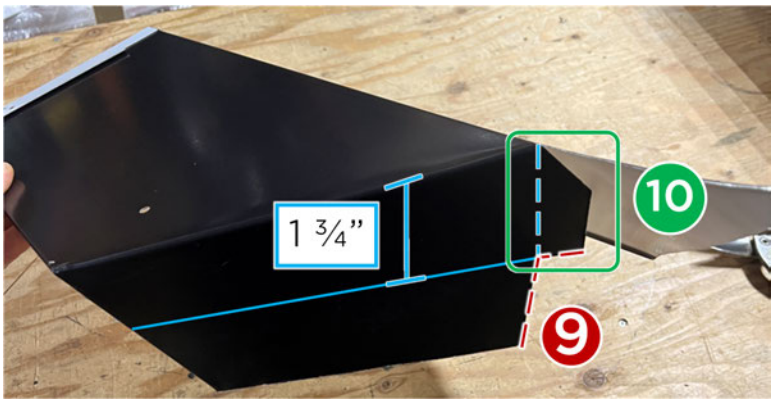
Brake the cap to 90° on the line furthest up roof **(7)**.



Use the hip / valley indicators on a speed square to scribe the hip pitches onto the cap **(8)**.

- Scribe the steeper pitch hip / valley angle onto the cap side that will sit over the lower pitch side of the hip
- Scribe the lower pitch hip / valley angle onto the cap side that will sit over the steeper pitch side of the hip

Cut away any excess on the bottom **(9)** and create a tab out of the 1 ¾ in section **(10)**.

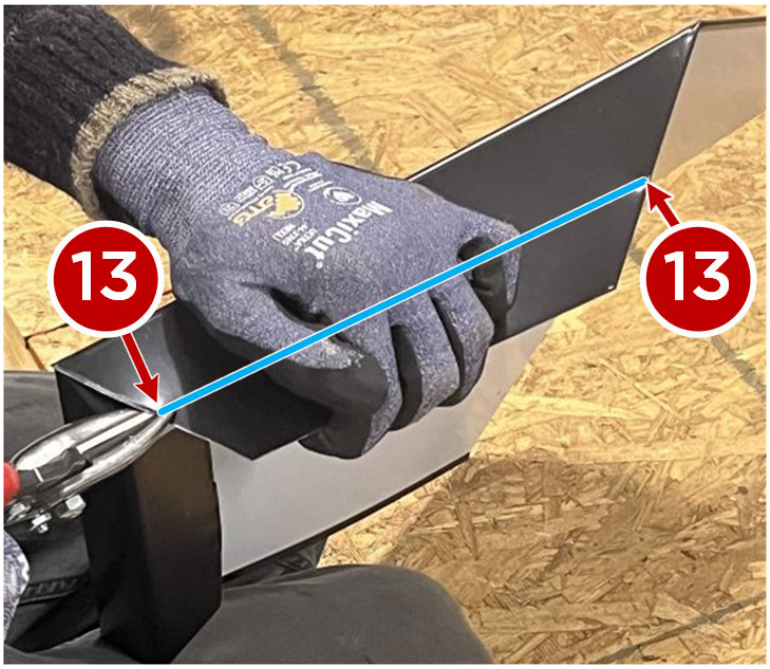


Bend the bottom line in the brake to 90° **(11)**. To achieve a full 90° bend, finish bending with 6 in seamers or by hand.

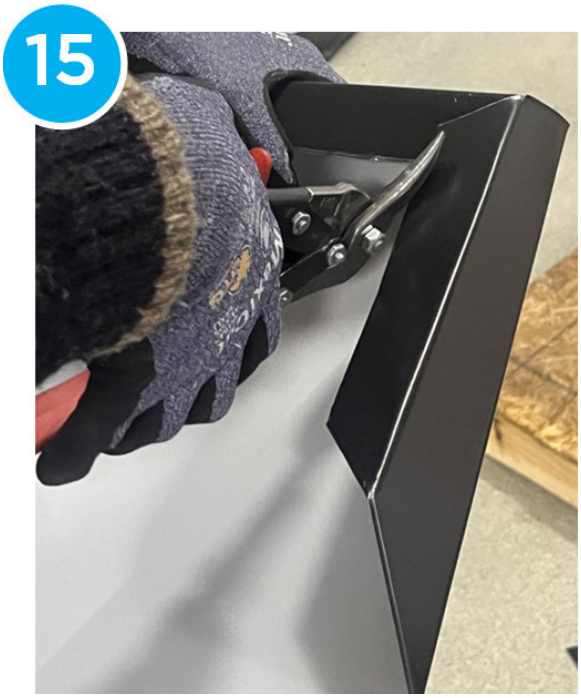
Bend the second tab to 90°. Use the hip / valley indicators on the speed square to scribe and cut lines on both sides of the cap based on the hip pitch **(12)**.

- Scribe and cut the steeper pitch hip / valley angle on the cap side that will sit over the lower pitch side of the hip
- Scribe and cut the lower pitch hip / valley angle on the cap side that will sit on the steeper pitch side of the hip

Make relief cuts at the intersection and at the opposite end of the line scribed in the previous step to mark the next bend line **(13)**. Bend the cap at 90° on the relief cuts (finish the bend by hand or with 6 in seamers to achieve a full 90°) **(14)**.



Cut into the center tab intersection so that the tabs sit next to each other and no longer overlap. Ensure the tabs form 90° bends **(15)**.



Fasten the front face of the cap with an exposed fastener **(16)**. Install the cap and fasten it with two exposed fasteners at the bottom **(17)**.

NOTE: Install the cap that follows this starter with exposed fasteners instead of engaging into the cleat. This allows for re-centering the cap over the hip as needed.

16

17

PRO TIP: Before the starter cap is installed, cut pieces of flat stock can be inserted under the risers to be used as a guide to prevent scratches on the drip metal and make cap installation easier. Ensure all flat stock pieces are removed after use.

Skillion Roof

Overview

This section provides instructions for installing channel flashing at skillion roofs that contain rakes on both sides.

What is a skillion roof?

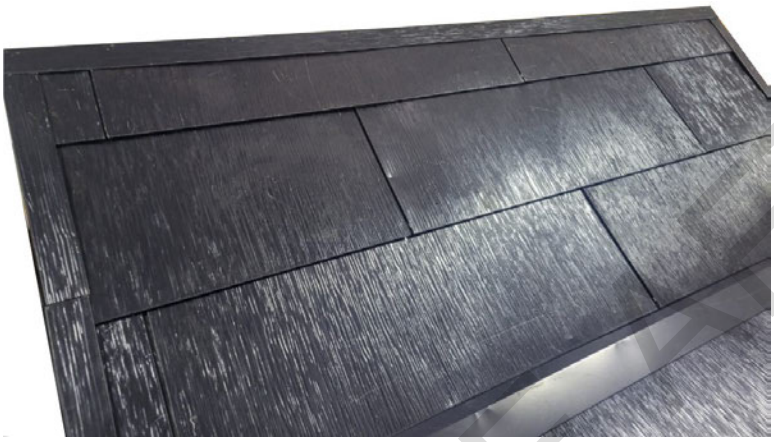
A skillion roof, also known as a shed roof or a mono-pitched roof, is a type of roof that has a single, sloping surface.

Unlike traditional gable roofs, which have two sloping sides, a skillion roof consists of just one flat surface that is angled away from the building.

This style of roof is often used in modern architecture.

The slope can vary from a slight angle to a steep pitch, depending on the design needs and local climate conditions.

Finished installation for reference:



Tools and Equipment

Parts:

- C Channel Flashing
- Vented riser (optional)
- Transition Flashing (if headwall present)
- Wall Flashing (if sidewall present)
- Underlayment
- Detail Roll
- 2 ft X 5.5 ft Flat Stock
- Drip Edge Metal

Tools:

- Metal Snip
- Hand Break
- 10 ft Metal Break
- Sealant/ Sealant gun

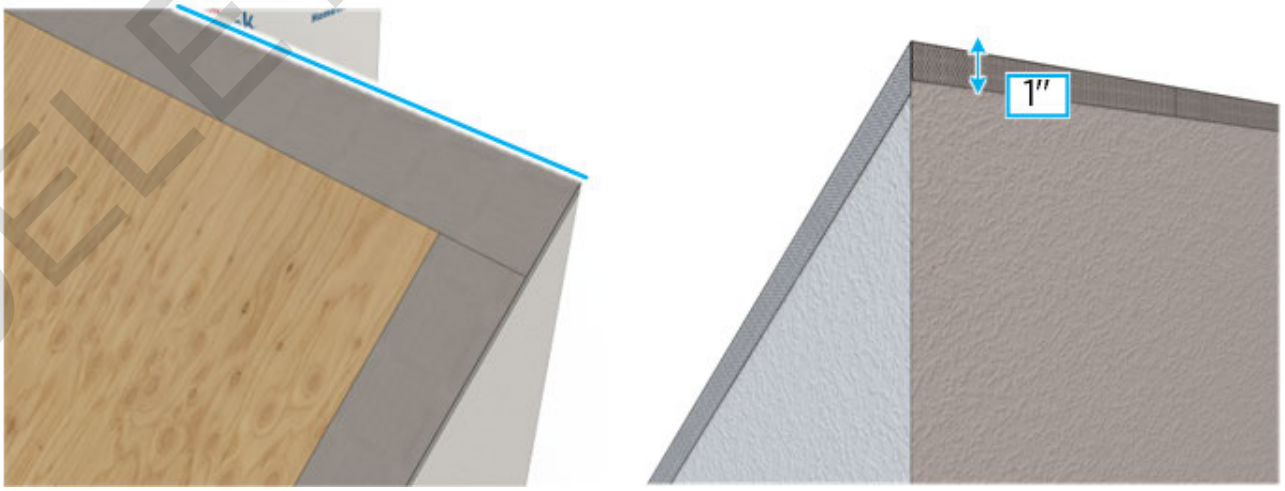
- Measuring Tape
- Pencil
- Knife
- Circular Saw (with appropriate blade)
- Nail Gun/ Impact Driver

Skillion Roof Dry In - Work Instructions

1. Start by installing the down-roof detail roll, working your way up-roof.
   The detail roll should wrap over the fascia for 1 in; starting at the eave, then the rakes and finally the peak of the skillion roof.

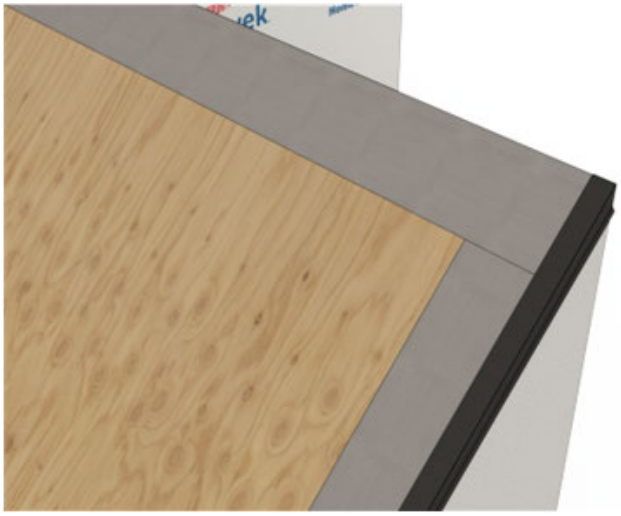
Rake: Detail roll wraps over the rake edge by 1 in

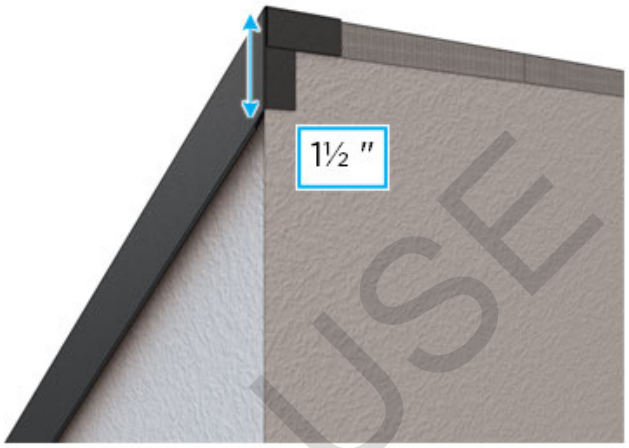
2. Wrap the detail roll over the peak of the skillion roof as well, with a 1 in overhang.
   a. If the skillion roof has a headwall/sidewall, stop the detail roll when the peak of the skillion roof meets the headwall/sidewall and turn up the wall for 1 in.



When reaching the peak, the detail roll wraps down 1 in

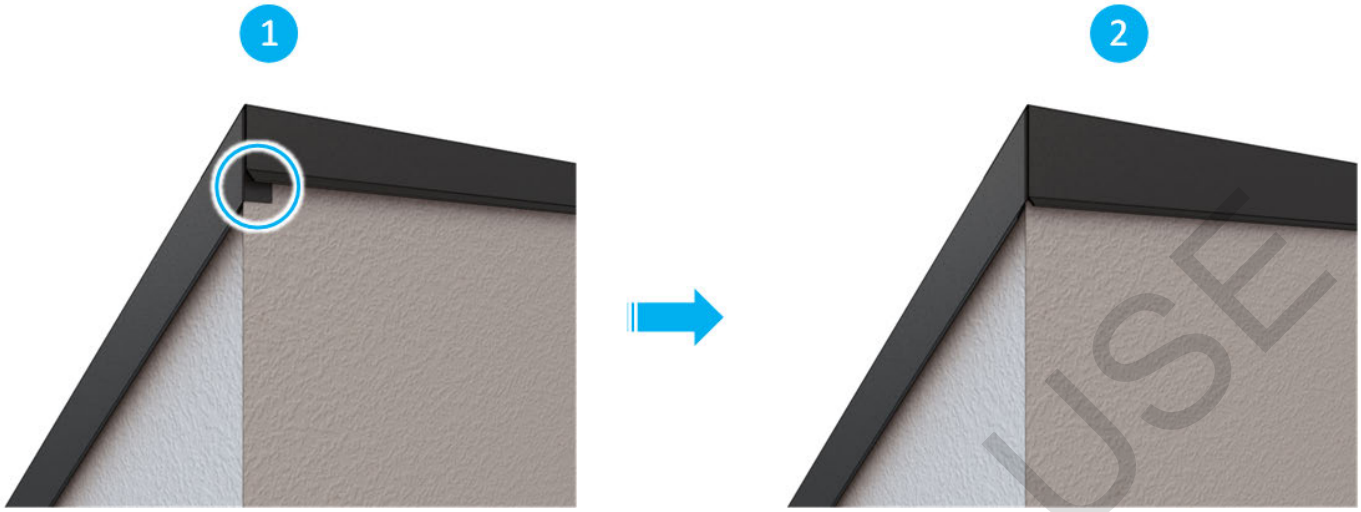
3. Next, install the drip edge at the top of the rake, wrapping it around and down the rake for at least 1½ in.





4. Install the underlayment next. If there is a headwall/sidewall present, follow the proper guidelines for installing underlayment for those features.

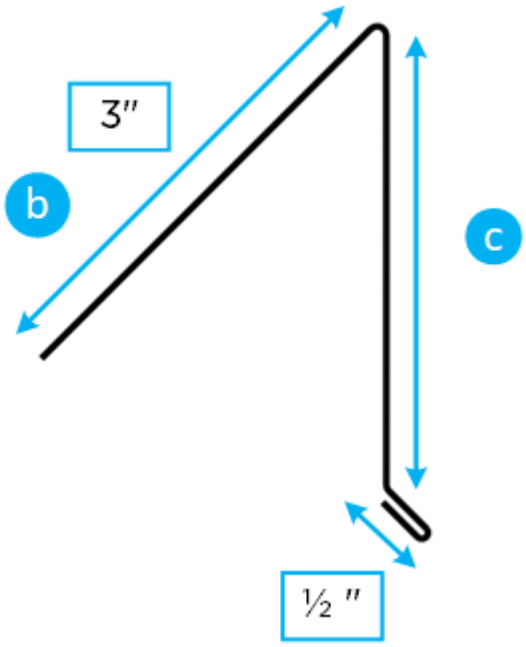
5. Once the underlayment is installed, the drip edge for the peak of the skillion roof can be installed.
    a. When installing this piece, notice that the two drip edge pieces will not align (image 1 below). For aesthetic purposes, it is recommended to fabricate the peak drip edge from scratch, using flat stock (image2).



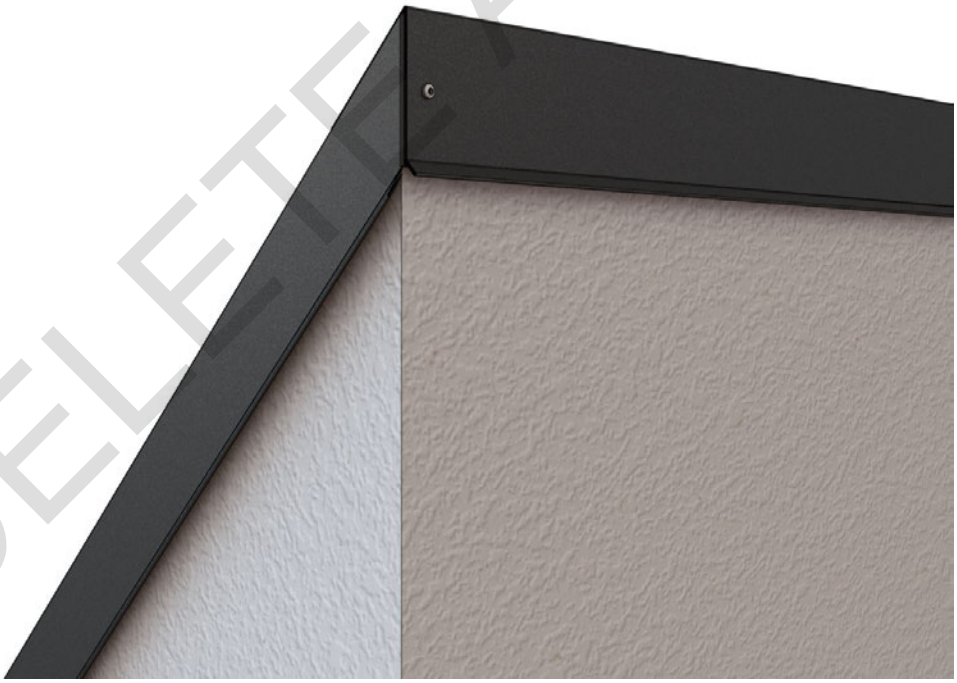
a. Use flat stock to fabricate a new drip edge long enough to match the rake drip. Measure and cut the piece, then bend to the appropriate pitch.

   It is recommended to bend the hem first.

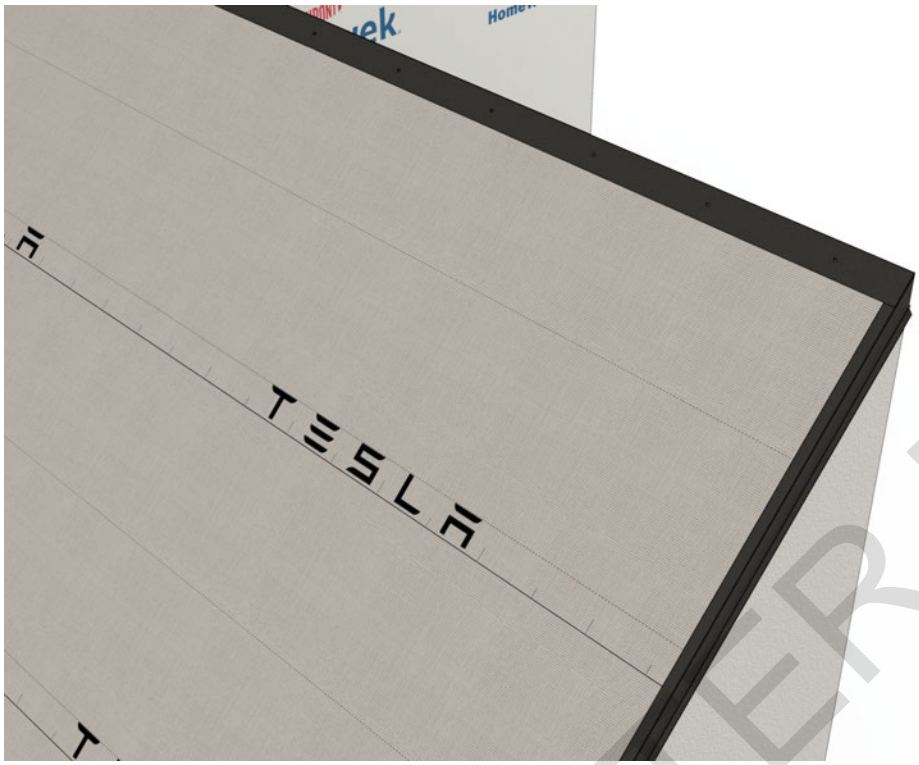
b. The top flange of the drip edge should be 3 in.
c. The length of the front face of the drip edge will vary, depending on the pitch.
d. The hem is ½ in long, with a 45° bend.



6. Install the newly fabricated drip edge with the appropriate fasteners along the entire peak of the skillion roof based on the *Fastener Schedule on page 703*. If needed, use self-tapper screws to hold the front face of the drip edge.
    a. If there is a headwall/sidewall present, follow the proper guidelines for installing the drip edge at those features and use appropriate sealant.



    b. If the skillion roof does not have a headwall/sidewall, repeat the dry in steps for the other side.

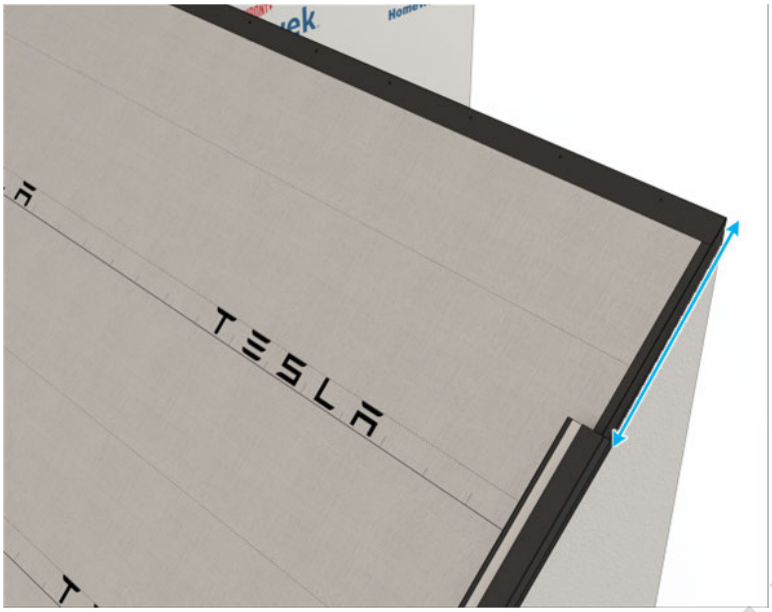


Rake Channel Flashing Fabrication and Installation - Work Instructions

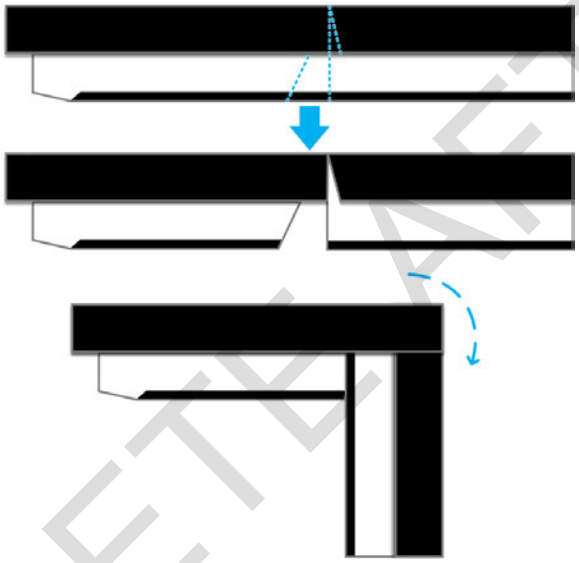
1. Begin installing channel flashing along the rake of one side of the feature. Refer to Installing Channel Flashing for general guidance.

   NOTE: In general, the metal flashings that come in 10 foot lengths should not be cut to less than 2 feet. This is to ensure that they can be adequately fastened.

2. Install the channel flashing on the rake edge, starting flush with the vented riser at the eave and 1 in overhang on the rake. Install the 10 foot channel flashings with the factory edge on the down roof side, splicing as going up roof. (See *Splicing Perimeter Metals on page 262*)
   a. **Scenario 1:** Approaching the peak of the skillion roof, measure the distance between the top of the last piece of the installed channel flashing and the peak (shown below).

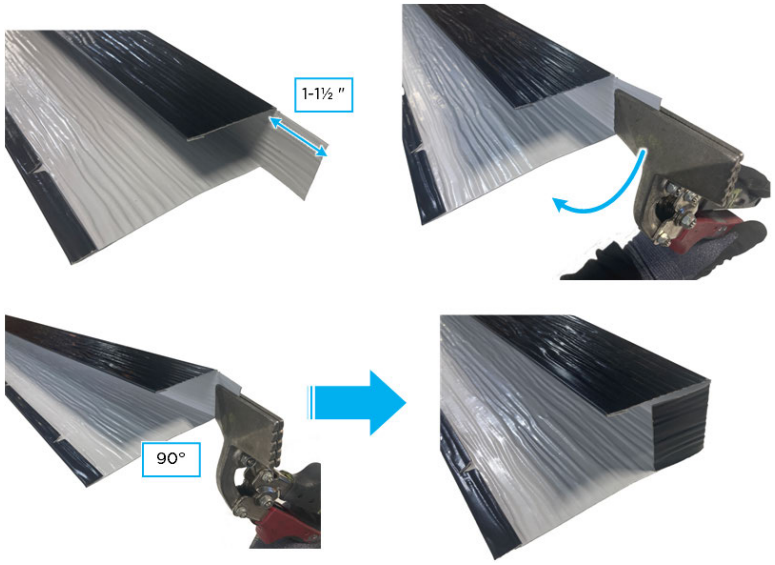


- If this distance is greater than 2 feet, take another 10 foot stick of channel flashing, and use the cut and bend method to turn the corner and continue installation at the peak/ridge of the skillion.



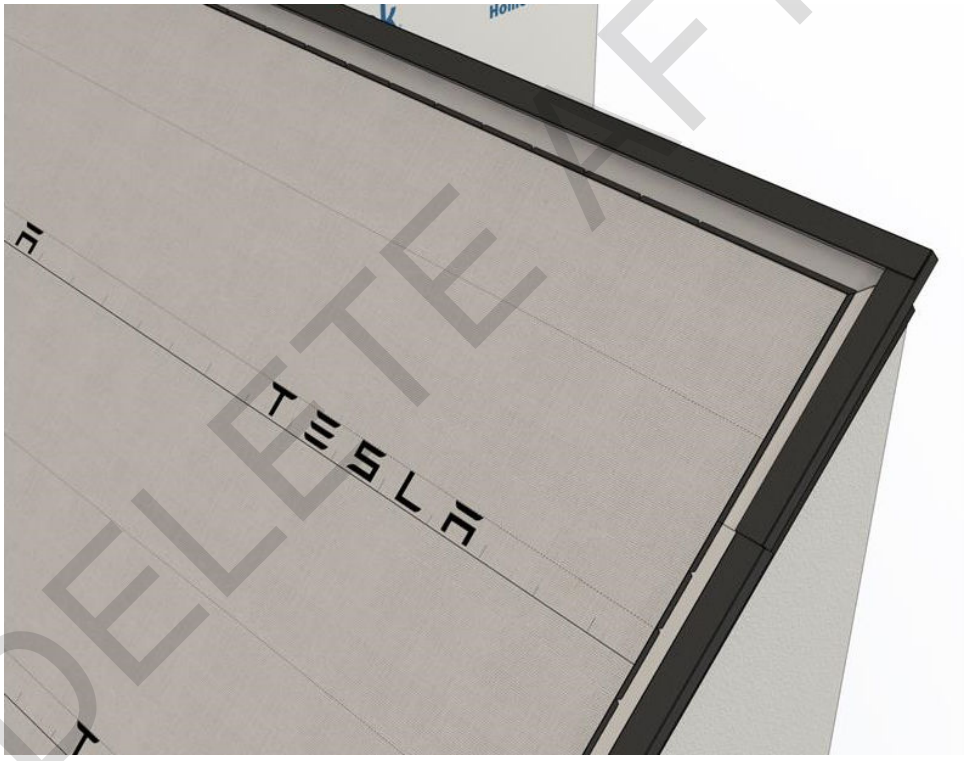
- If this distance is less than 2 feet, cut the channel flashing back to the 2 foot mark, splice a new 10 foot stick of channel flashing, and use the cut and bend method to turn the corner and continue installation at the peak/ridge of the skillion.

b. **Scenario 2:** Approaching the peak of the skillion roof, the top of the last piece of installed channel flashing is extending past the peak less than 2 feet. In this case:
   - Use the cut and tab method to wrap the corner, and install a new 10 foot piece of channel flashing at the peak.

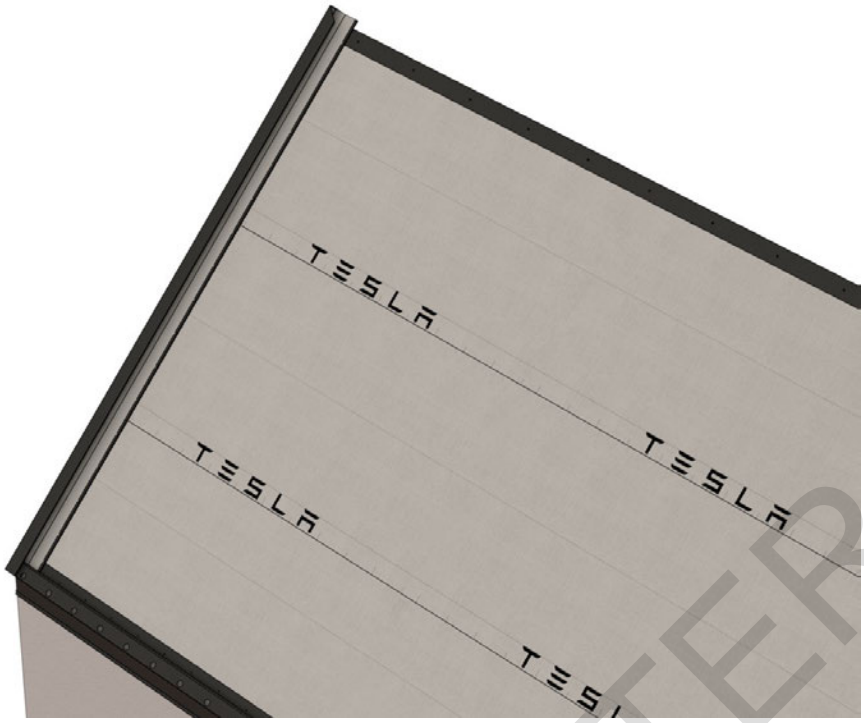


c. **Scenario 3:** Approaching the peak of the skillion roof, the top of the last piece of installed channel flashing is extending past the peak greater than 2 feet. In this case:
   - Use the cut and bend method (shown above) to wrap the corner, and continue installation at the peak/ridge of the skillion.

Modified channel flashing installed:

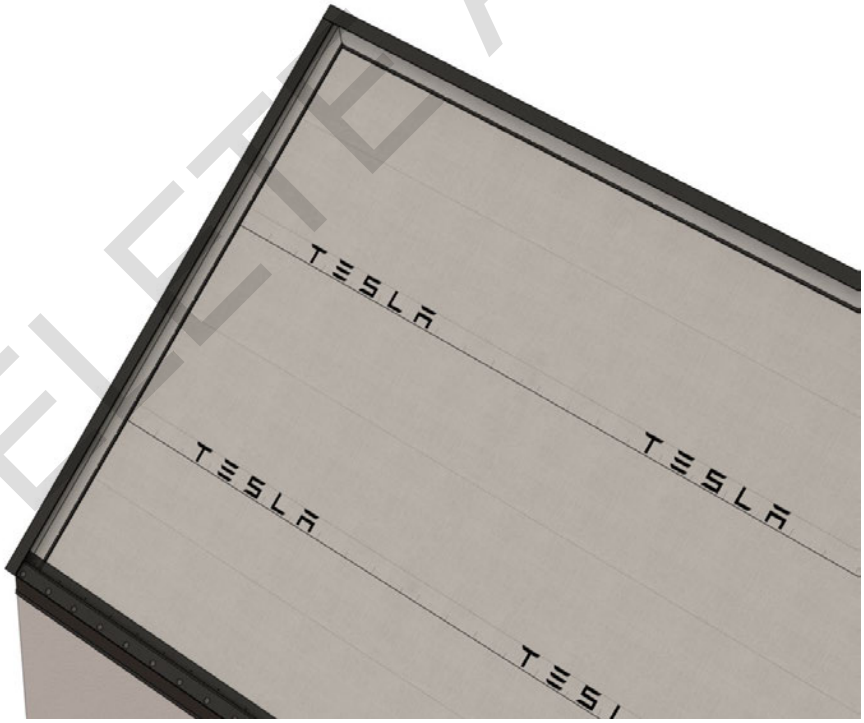


3. Fasten all channel flashing in accordance with the applicable wind tier in the *Fastener Schedule on page 703*.

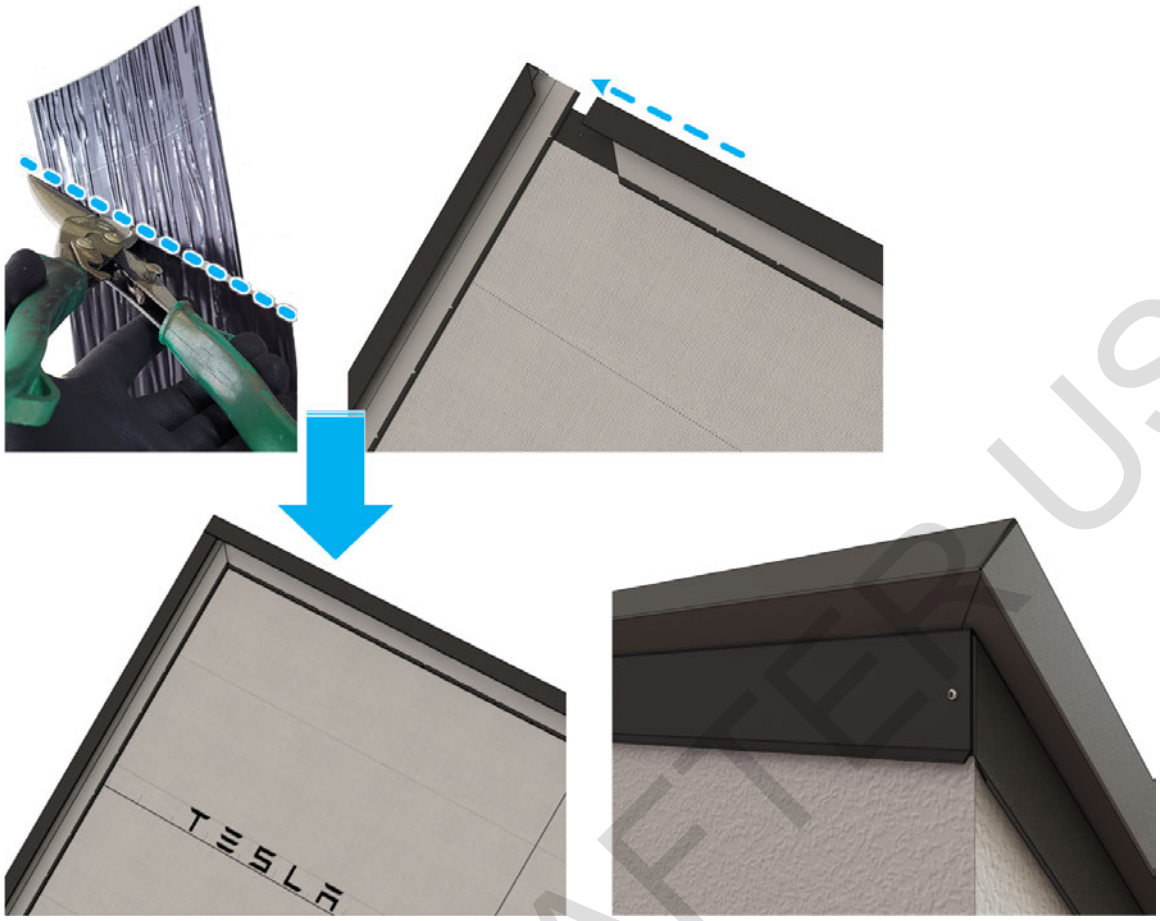


Skillion Roof Channel Flashing Installation - Work Instructions

1. After all rake channel flashing is installed, continue installing flashing across the skillion roof (beginning from the rake with the bent piece of flashing).



2. Before installing the final piece of flashing, make an angled back cut on the bottom flange to avoid overhanging metal. Install the final skillion roof piece by sliding the bottom flange underneath the tabbed rake flashing.



Skillion Roof Metal Tiles Installation - Work Instructions

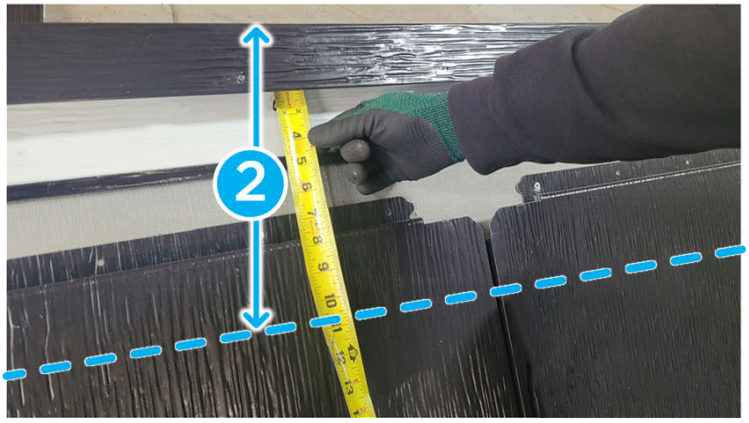
NOTE: While installing tiles at the skillion roof, position **all** tiles into their final positions per the directions below **before** fastening.

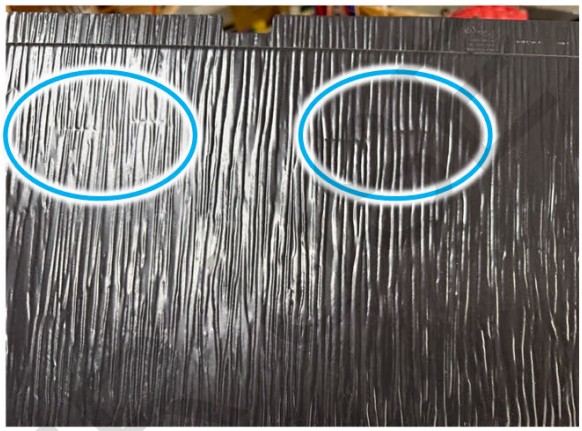
1. After the channel flashing is installed, begin installing tiles up to the skillion roof **(1)**. Refer to *Cut and Tuck at Square Roof Features on page 178* for an overview of cutting / tucking tiles into channel flashing.

2. Once the last course of full metal tiles is installed, measure the gap between the tile reveal and the skillion roof channel flashing wall **(2)**. Cut the final course of tiles in accordance with this measurement and ensure that a 1 ½ in gap will remain between the final course and the channel flashing wall (this ensures tiles will fit properly within the flashing).

NOTE: If the gap requires tiles smaller than 5 in, add support to the channel flashing and cover the gap with concealer flashing. Refer to *Installing Endwall Concealer Pans on page 352* for specific guidance.

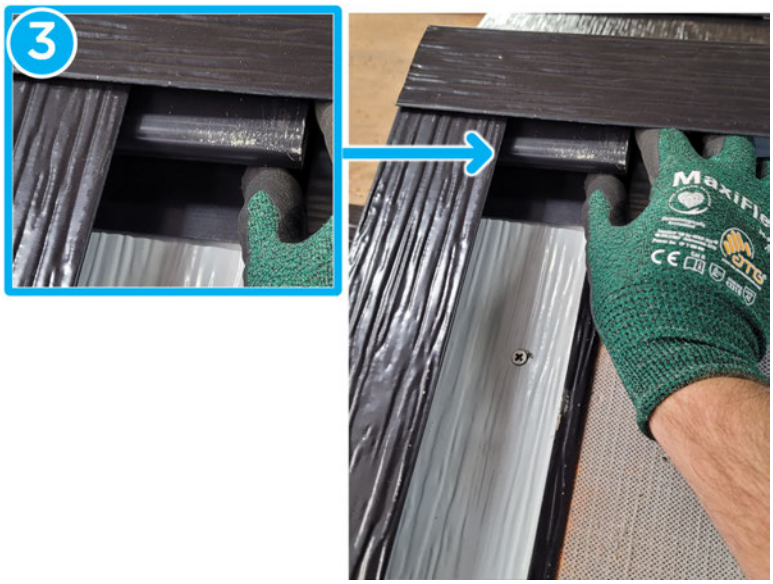
The dashes are on the tile reveal marks and show where the bottom edge of the course above it will fall.





3. **OPTIONAL:** If no corrugated supports remain in the corners of the skillion roof flashing after cutting tiles, install a piece of riser in the flashing corners as a replacement (this ensures proper fastening by preventing instances of unsupported metal). Size the riser piece so that it is long enough to properly accommodate tiles lacking supports (approximately 4 to 6 in) **(3)**.
    - **PRO TIP:** Install the riser piece upside down (flange facing down roof) to allow for easier installation and proper fastening.

Instance of an unsupported metal:

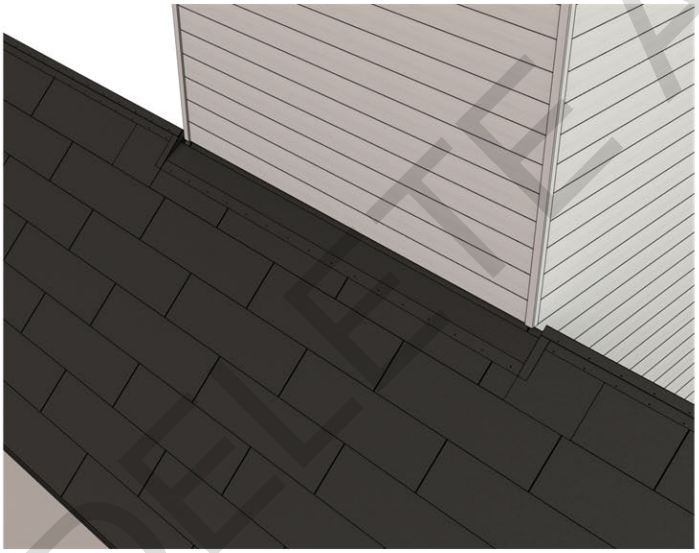


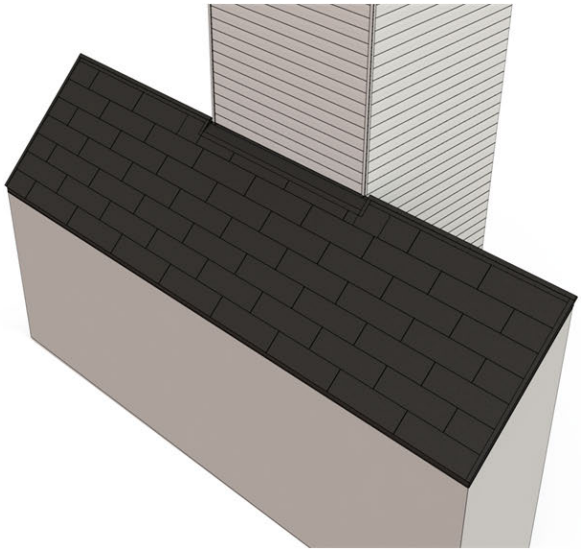
4. Install the final course of tiles **(4)**.

5. Once all the tiles are positioned, fasten the tiles through the channel flashing 4 in away from water channels and in accordance with the applicable *Fastener Schedule on page 703* wind tier **(5)**.

Skillion Headwall/Sidewall Interaction - Work Instructions

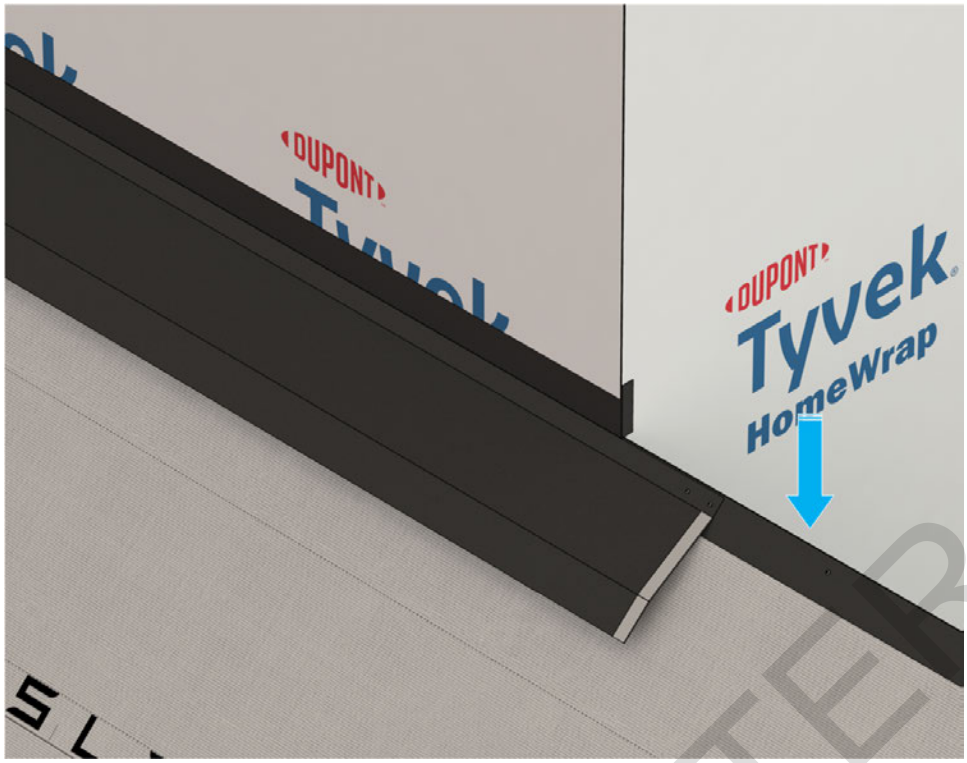
Complete assembly:



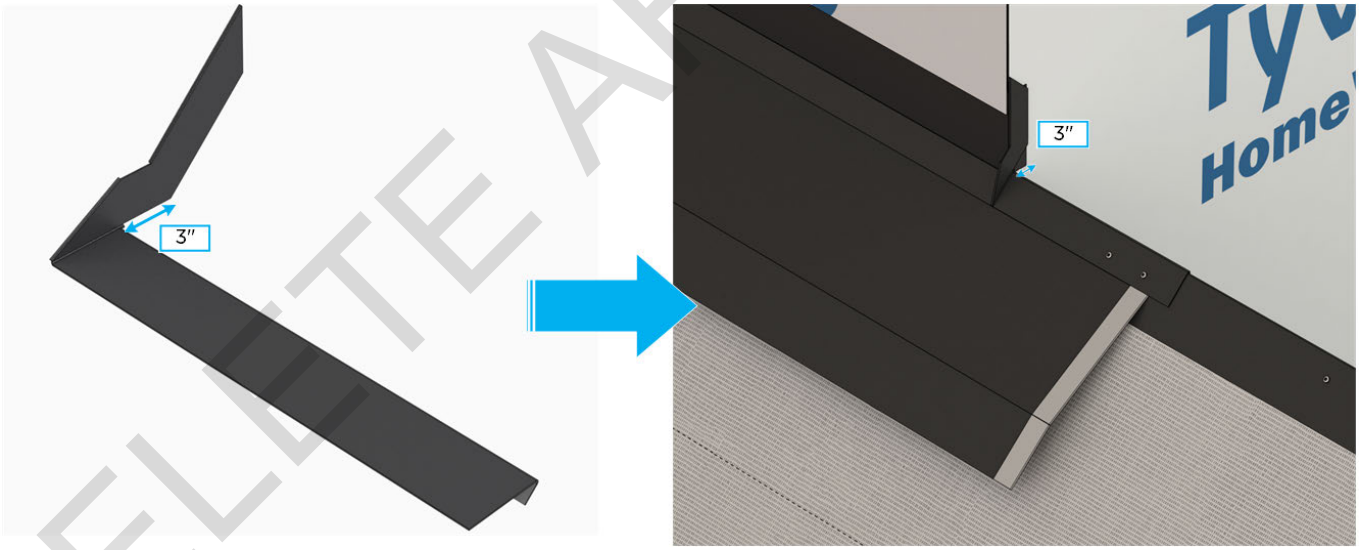


For the dry-in phase, please refer to: *Square Obstructions and Wall Interactions on page 300*.

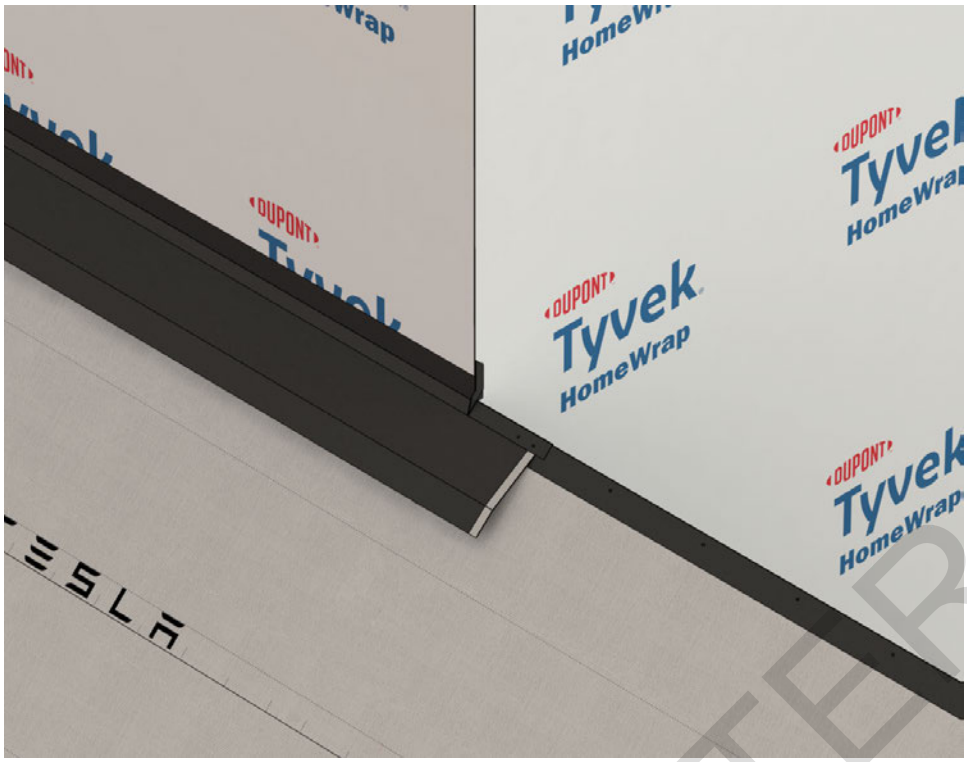
1. This interaction is different only in that the transition flashing needs to be bent down and over the peak of the skillion roof.



a. If there is a sidewall, measure 3 in past the peak of the skillion roof to get the length of the piece. This way there is appropriate coverage on the wall side and the deck side will be cut off and hemmed.

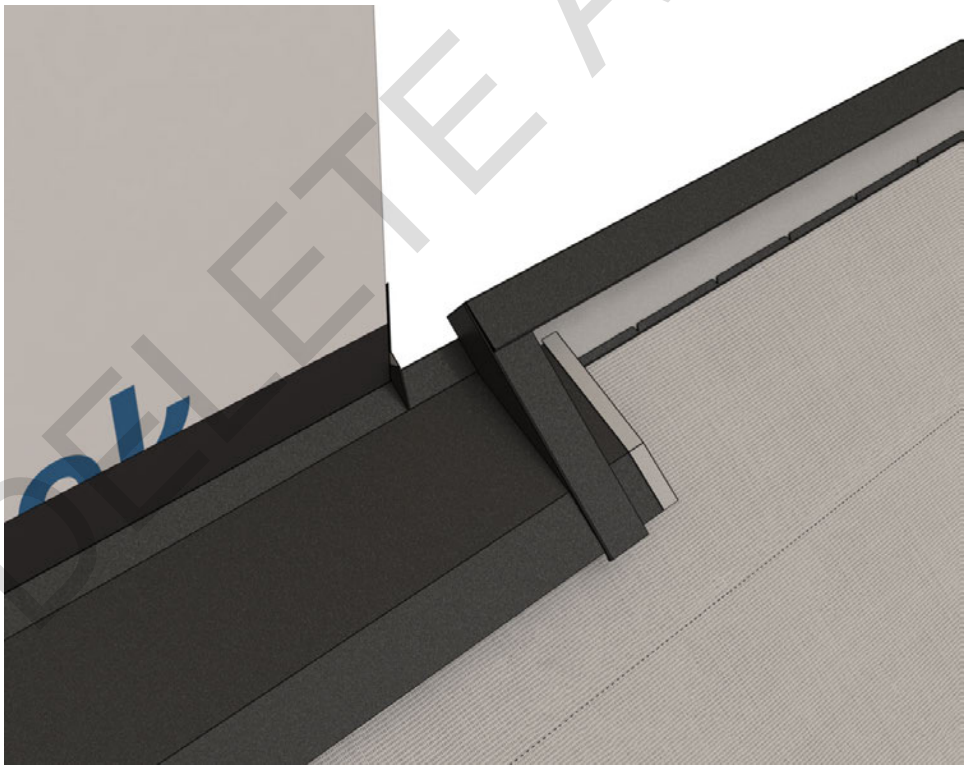


Here is an example of a skillion roof interaction. Before the tile installation phase, install the C channel flashing first.



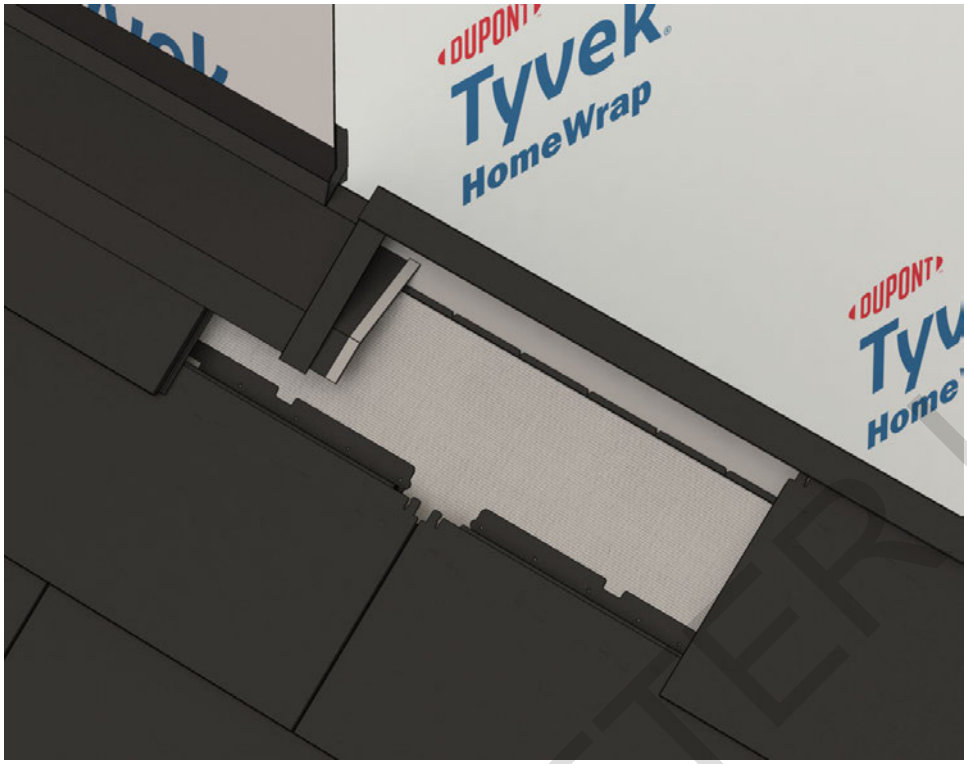
2. Install the C channel in the same manner as *Guttered Square Obstructions on page 352*.

> **NOTE:** When possible, fabricate all pieces of the C Channel out of one continuous stock. This way the C Channel that sits on top of the transition flashing can be more secure. If it is fabricated separately, there may be a small area left for fastening.

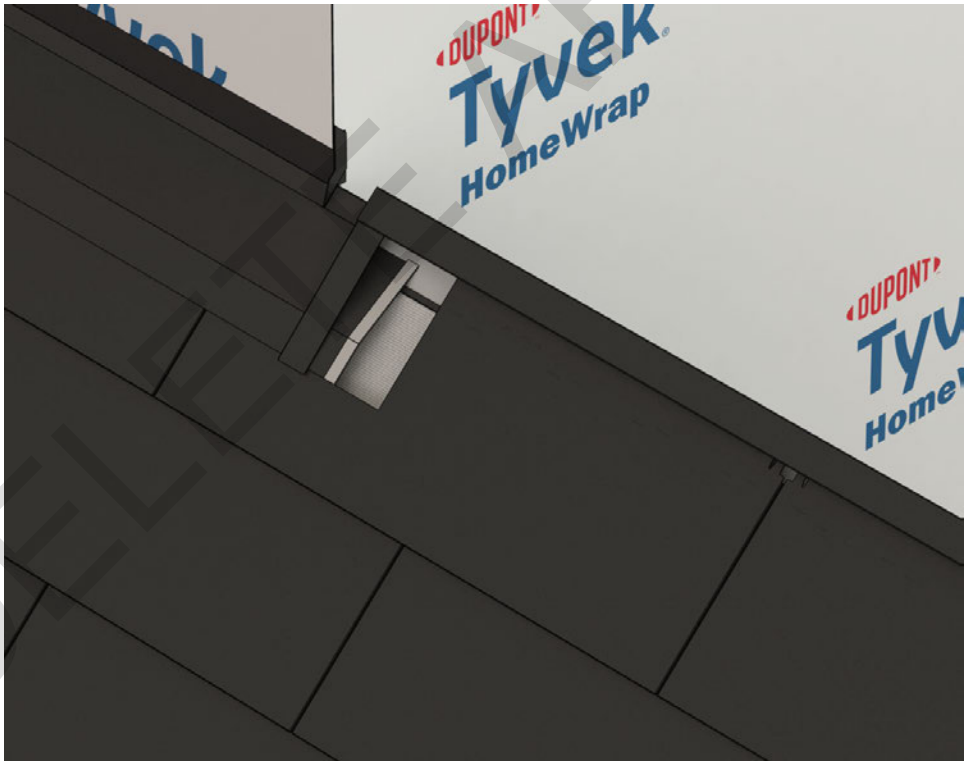


3. Install the tiles next. Continue to use the *Guttered Square Obstructions on page 352* guide for proper tile installation.

a. Install the tiles.

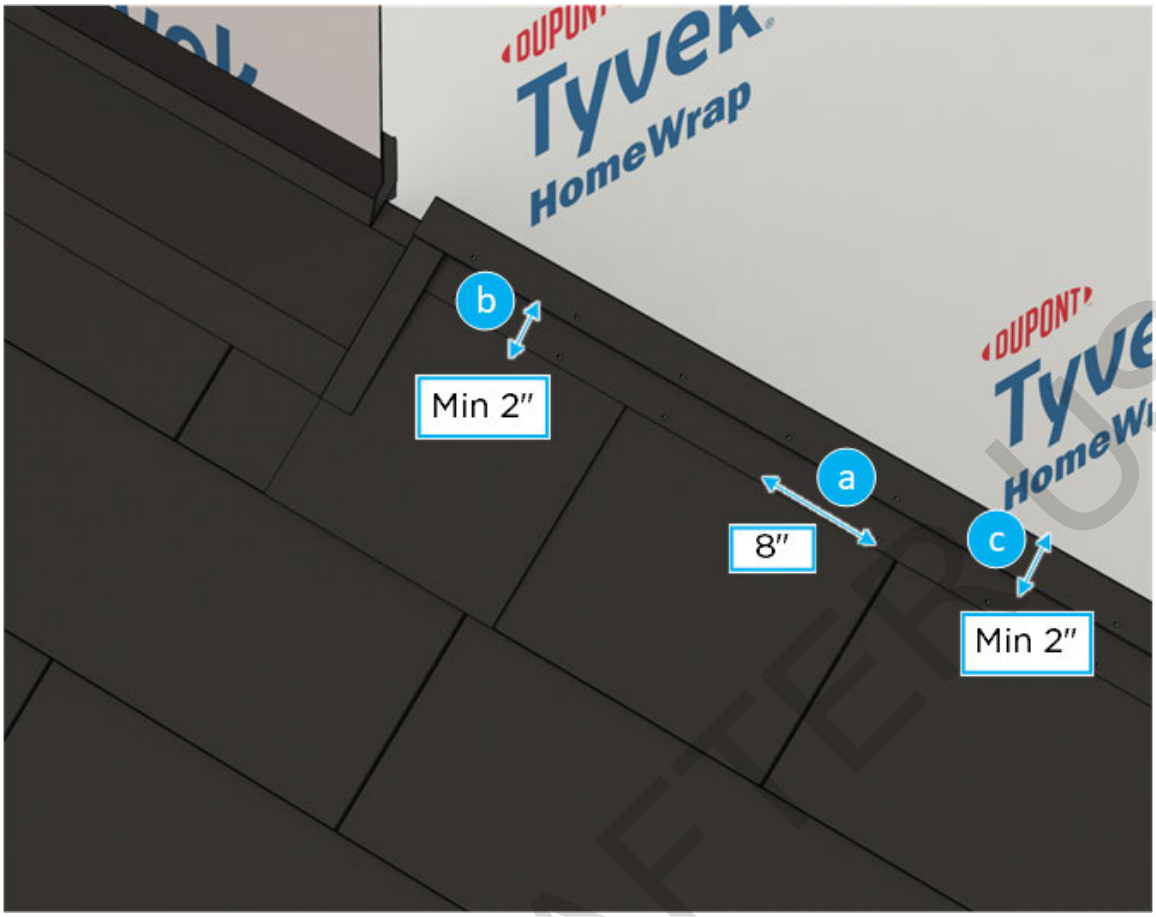


b. Cut and tuck around the obstruction.



c. Add tile skin.

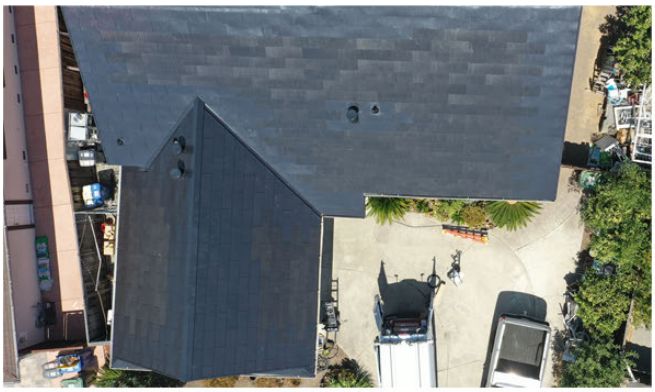
4. In some cases, the tiles may not be adequately covered by the C channel, in which case a concealer flashing is needed. Refer to *Installing Endwall Concealer Pans on page 352* for specific guidance.
    a. Fasten at 8 in on center.
    b. Overlap the tiles by minimum of 2 in.
    c. Covered by the C channel by minimum of 2 in.



Stepped Eave

Overview

A stepped eave is a common roof feature. There are multiple ways to approach this detail. The following procedure goes over one approach which can be used in most stepped eave situations.



Tools and Equipment:

- Measuring Tape
- Chalk/Pencil
- Metal Snips
- Saw
- Fasteners
- Self-tappers
- Impact Driver
- Nail Gun

NOTE: Please note that any mentions of the term "ripping" a tile in this document is to indicate making a horizontal cut to the tile to make it shorter.

Preparation

When prepping the mounting plane, it is important to measure the distance between the two eaves before installing the perimeter metal.

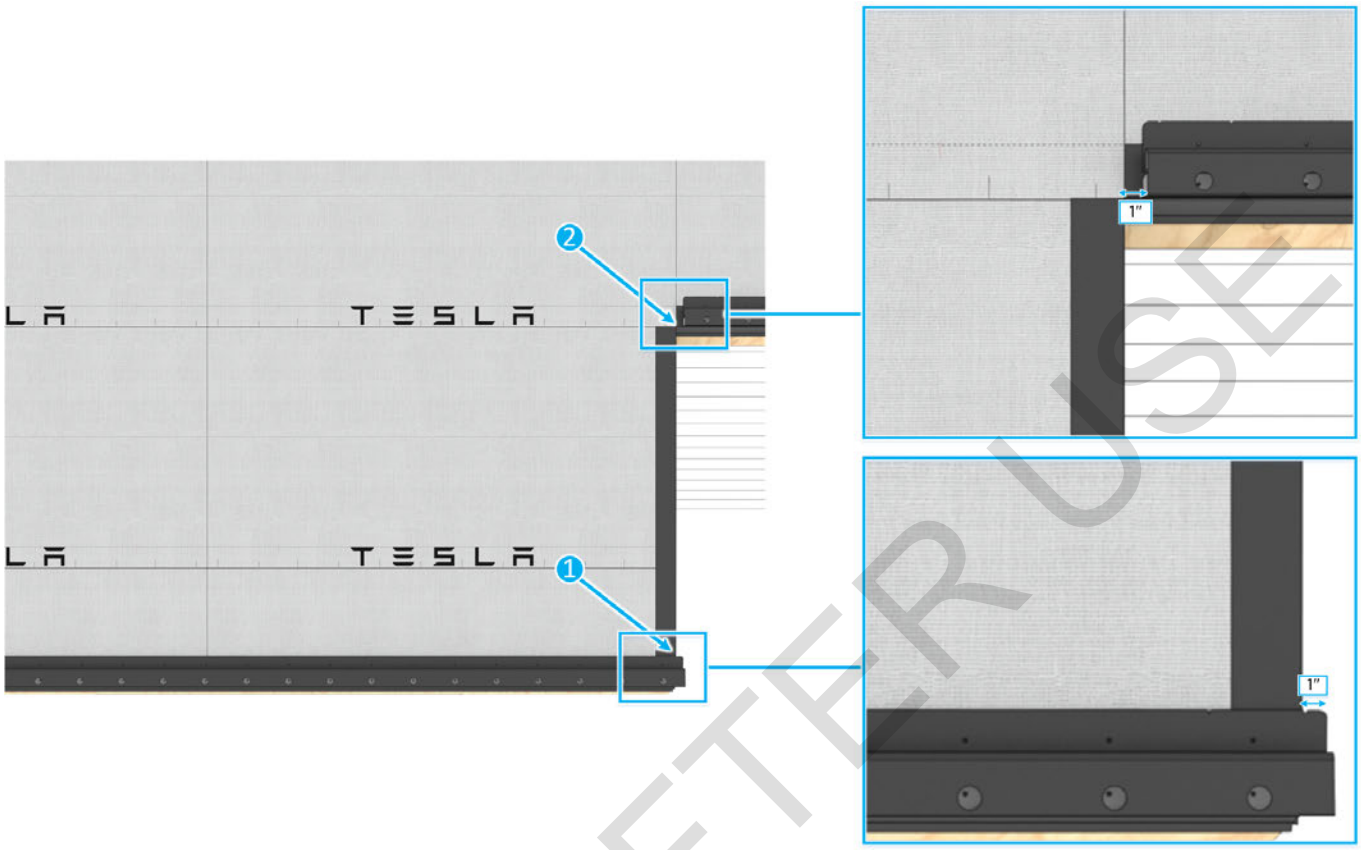
There will be 3 options for installing the metal tiles depending on the measurement:

1. "Rip" the first course of metal tiles.
2. "Rip" the first two courses of metal tiles.
3. The measurement is within the allowed tolerance and metal tiles can be installed as is.

The perimeter metal will be fabricated and installed the same way in all scenarios.

Work Instructions

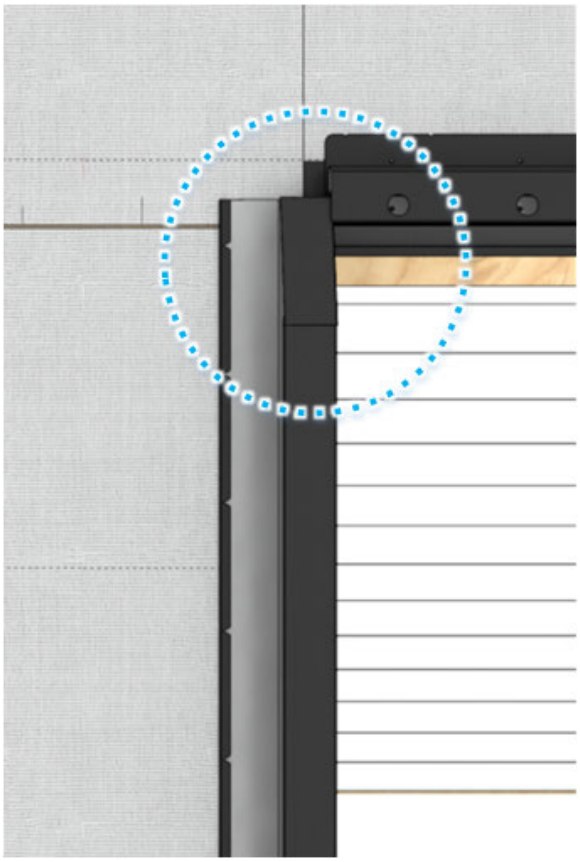
1. First, install the vented riser at the down-roof eave. Install the second vented riser next, but keep in mind that as the C channel overhangs the rake for 1 in, the second vented riser up-roof should be installed 1 in away from the rake.



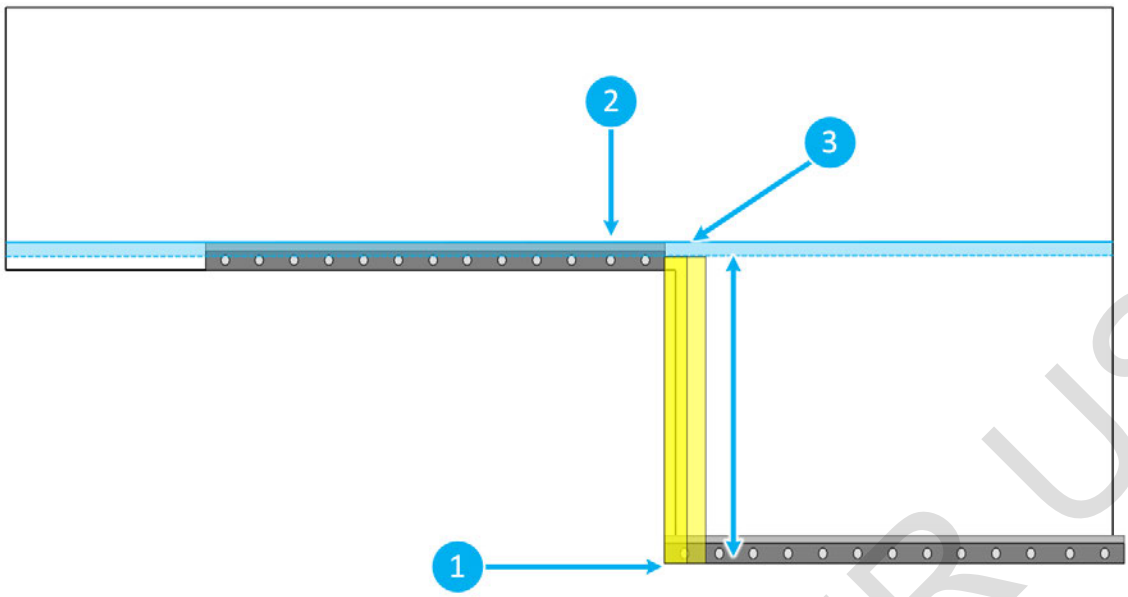
1 - Down-roof vented riser has a 1 in overhang and is installed first.

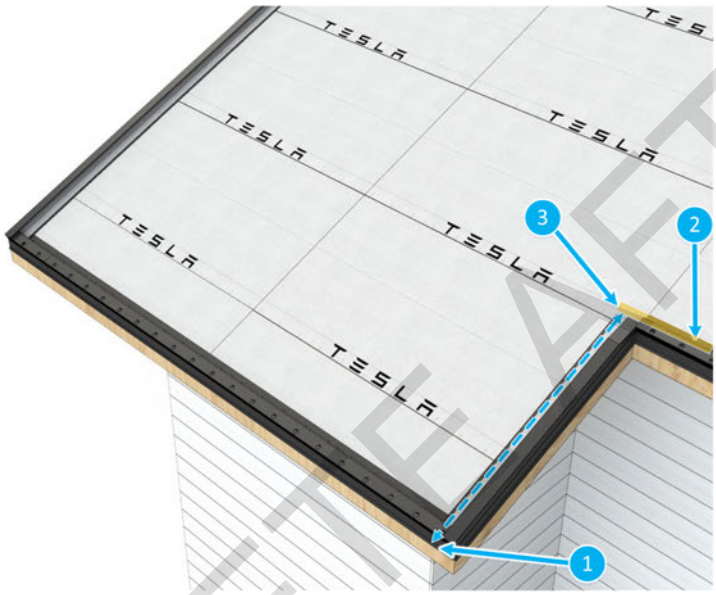
2 - Up-roof vented riser is installed 1 in away from rake to give C Channel space to be installed next to it.

2. It is important to use the "Channel Flashing under Riser" method when installing the channel flashing at the section where the rake intersects the eave. This is the same method used for the top section of the tile level of guttered square obstructions. (See *Guttered Square Obstructions on page 352*)



3. To get the length of the C channel, measure the distance between:
    - the bottom edge of the down-roof vented riser,
    - to the top of the flange of the up-roof vented riser,
    - minus 3 in.



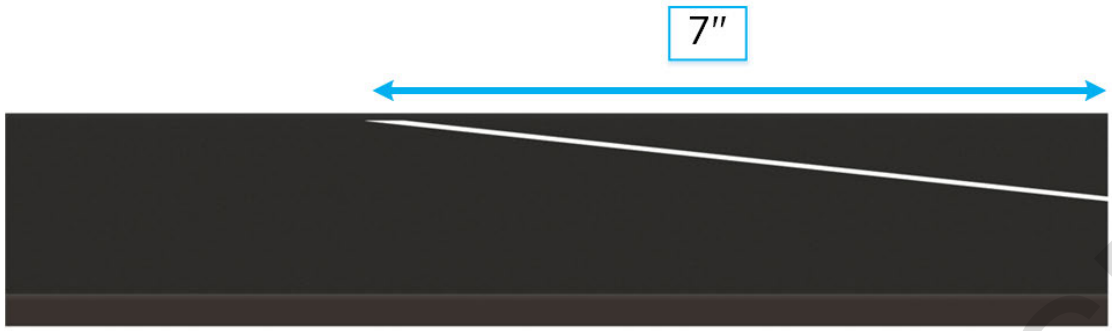


1 - Bottom edge of the vented riser

2 - Top of the flange

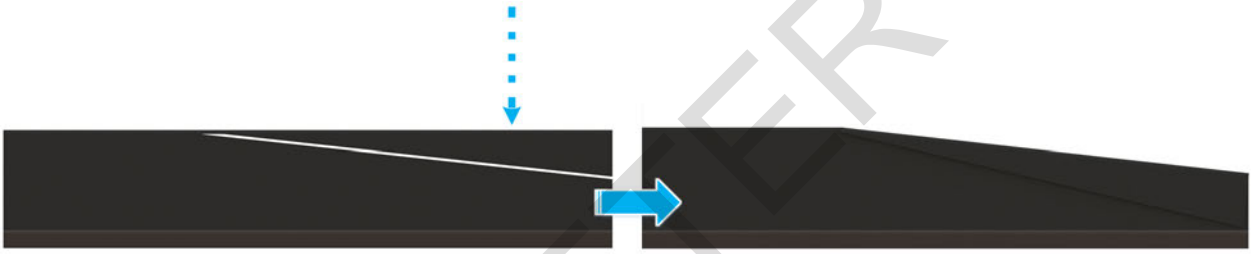
3 - The yellow bar indicating the 3 in no C channel zone

4. Modify the C channel in the same way as modifying it for the top corners of a square obstruction. The C channel has to dive down under the first course of tiles from the down-roof eave that intersects this detail. To do this:
    a. Measure and mark 7 in on the top of the vertical wall/section of the C channel and mark halfway up the vertical section. The vertical wall measures 1 ½ in, so measuring ¾ in would show the halfway point.

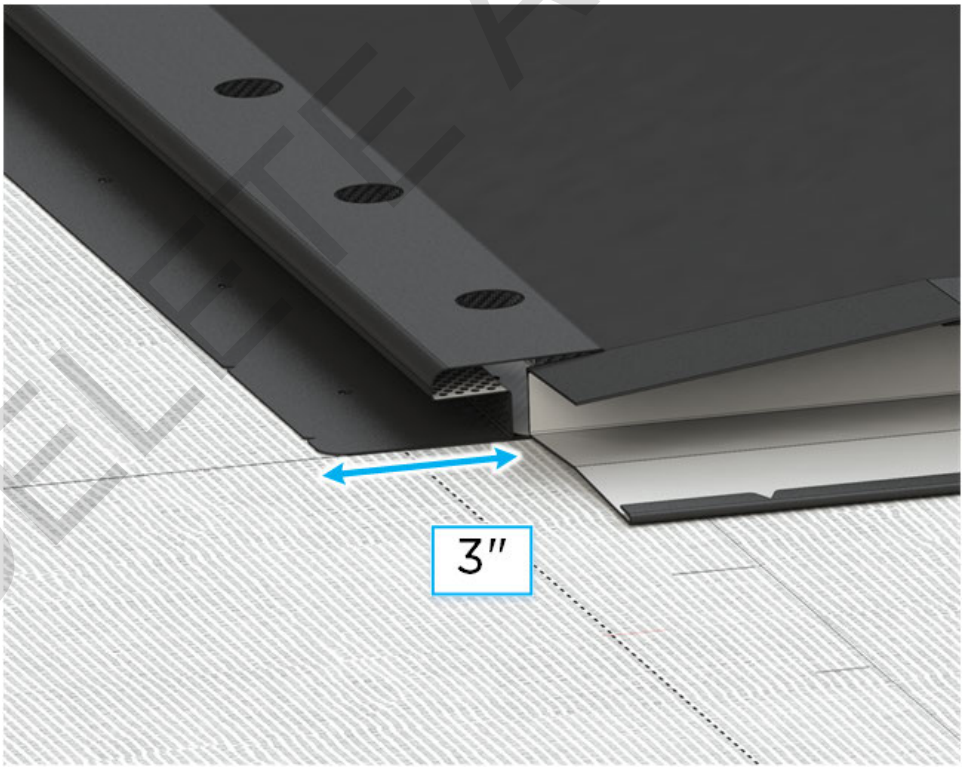


b. Connect these two points with a line using chalk/pencil.

c. This is the cut line. Make sure to use the correct metal snips so that the top section of the vertical wall overlaps with the bottom section when the C channel is pushed down.

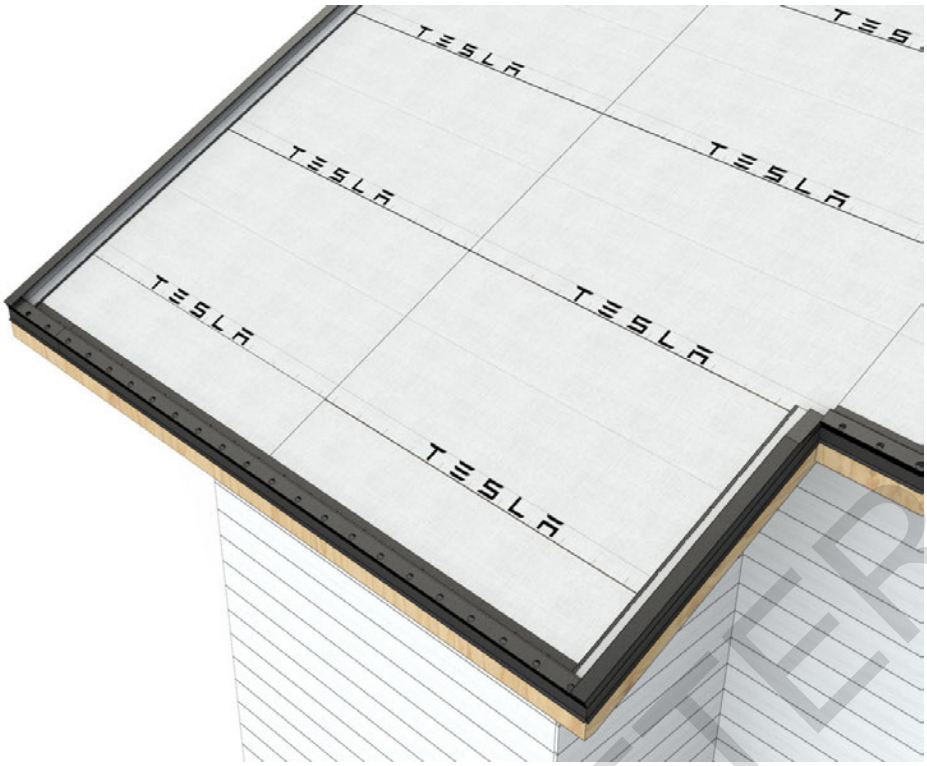


d. Once the cut is made, the C channel can be installed and pushed down to match the height of the vented riser and the tiles above will overlap on top, ensuring proper water shedding.



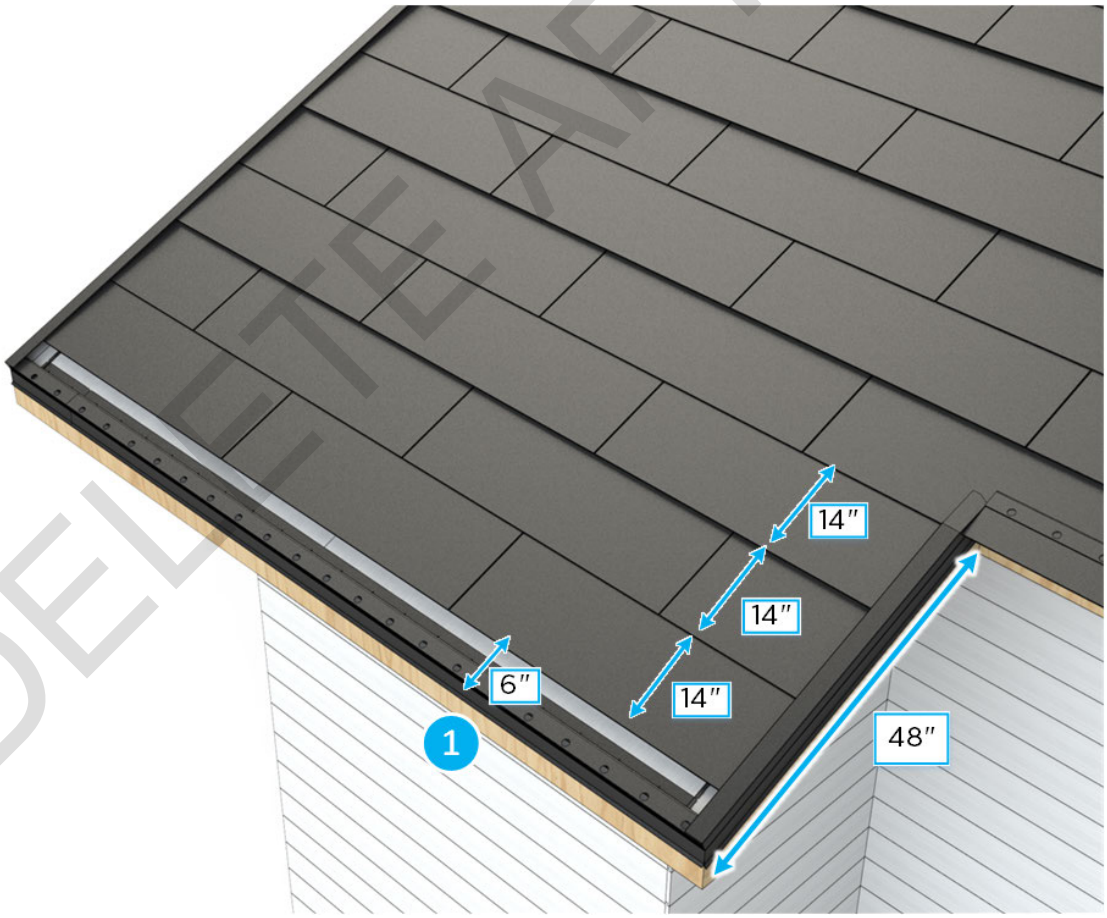
3 in - No C Channel Zone

Result:



5. Now that the perimeter metal is set, double check the distance between the two eaves.
    - If the measurement is a multiple of 14 (14 in, 28 in, 42 in, 56 in, 70 in, etc), it is fine to proceed with tile installation without the need to modify/ “rip” any tile courses.
    - If the measurement from the down-roof riser to the riser up-roof does not land on a number which is a multiple of 14, then measure the difference and "rip" the first course of tiles down to make up the difference. (See example below)
    - Since Tesla tiles **cannot** be cut down to be smaller than 6 inches, if the measured difference is less than 6 inches, it is necessary to "rip" down **two** courses of tiles to make up the difference.

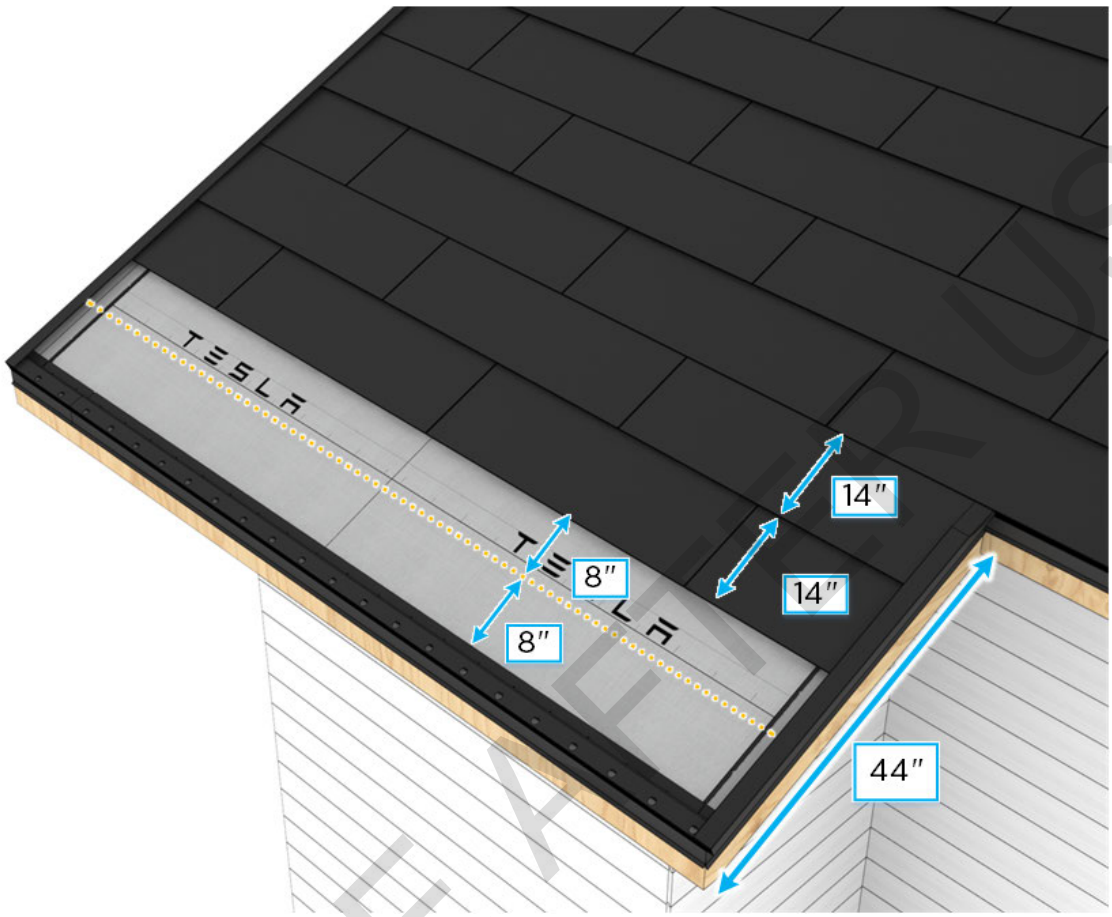
Example of one "ripped course":



1 - Min 6 in "ripped" course

Example of two "ripped courses":

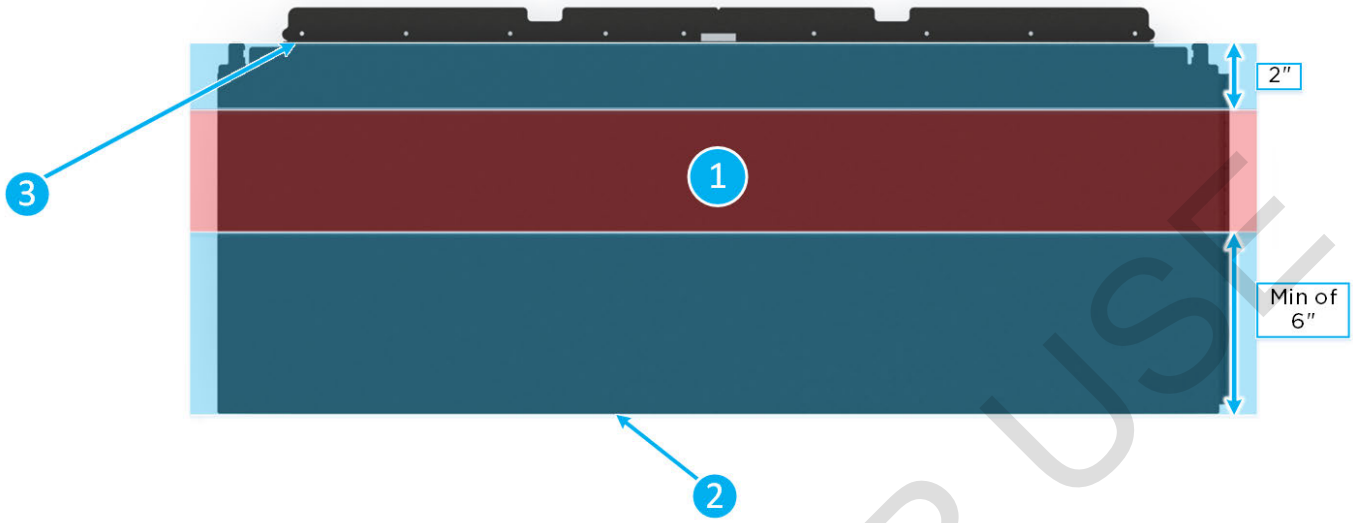
In this example, 44 in leaves the installer 2 in short of nominal tile placement. Since the tile cannot be "ripped" down to 2 in (minimum tile "rip" is 6 in), two "ripped" courses will solve the problem in such situations.



How to "Rip" a Metal Tile

"Ripping" a metal tile refers to the process of cutting the tile lengthwise (horizontally) to minimize/shrink the width of the tile.

1. Cut out a middle section of the tile, separating it into 2 parts; the nailing flange/shoulder section and the bottom edge/engagement hook section.
    - The bottom edge section cannot be less than 6 in. The top flange section will always be 2 in from the top of the shoulder (not the top of the flange).

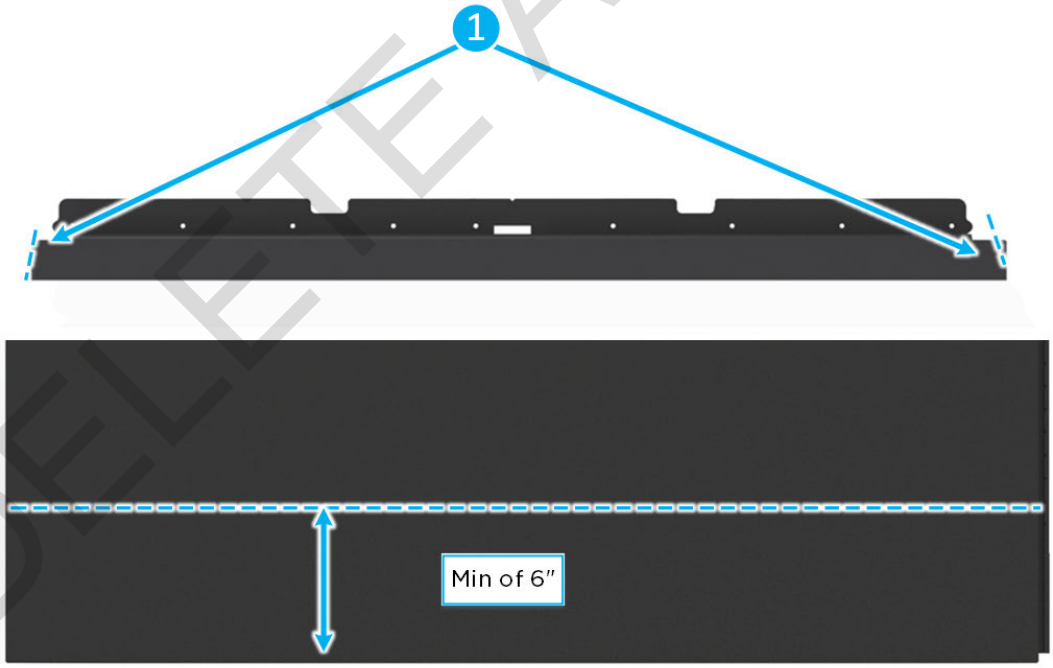


1 - Section that gets removed.

2 - Bottom edge section.

3 - Top of the shoulder of the nailing flange section.

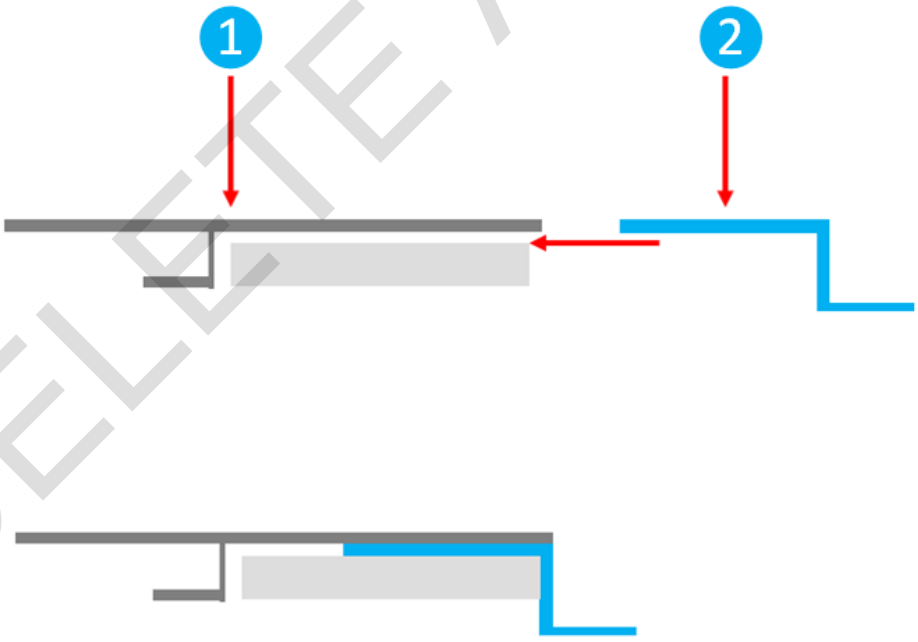
2. Cut the nailing flange section first, since it is a small section and cutting it first will make the process easier.
3. Then, cut away the water channel on either side of the nailing flange section.
4. Mark out the width of the "ripped" tile (minimum of 6 in).



1 - Water Channels

5. Cut the bottom edge section of the tile to the new length. The top nailing flange section will be placed underneath the bottom edge section and fastened together.
    a. If possible, leave the plastic supports and slide the top shoulder in between the plastic and the bottom edge section.

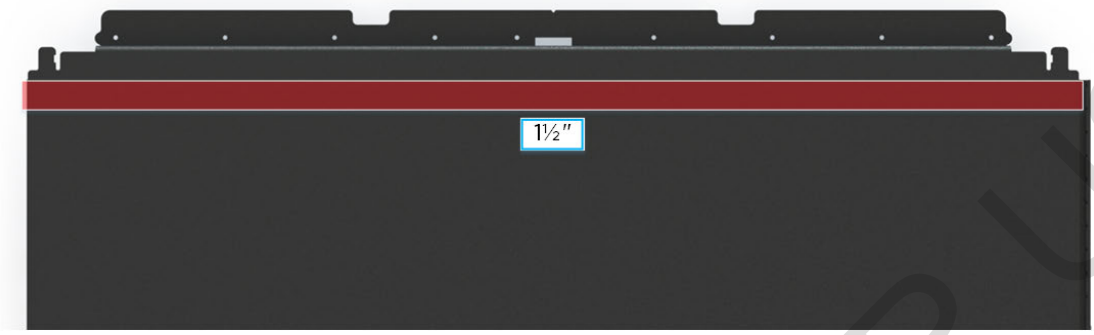
The front and back of the ripped tile



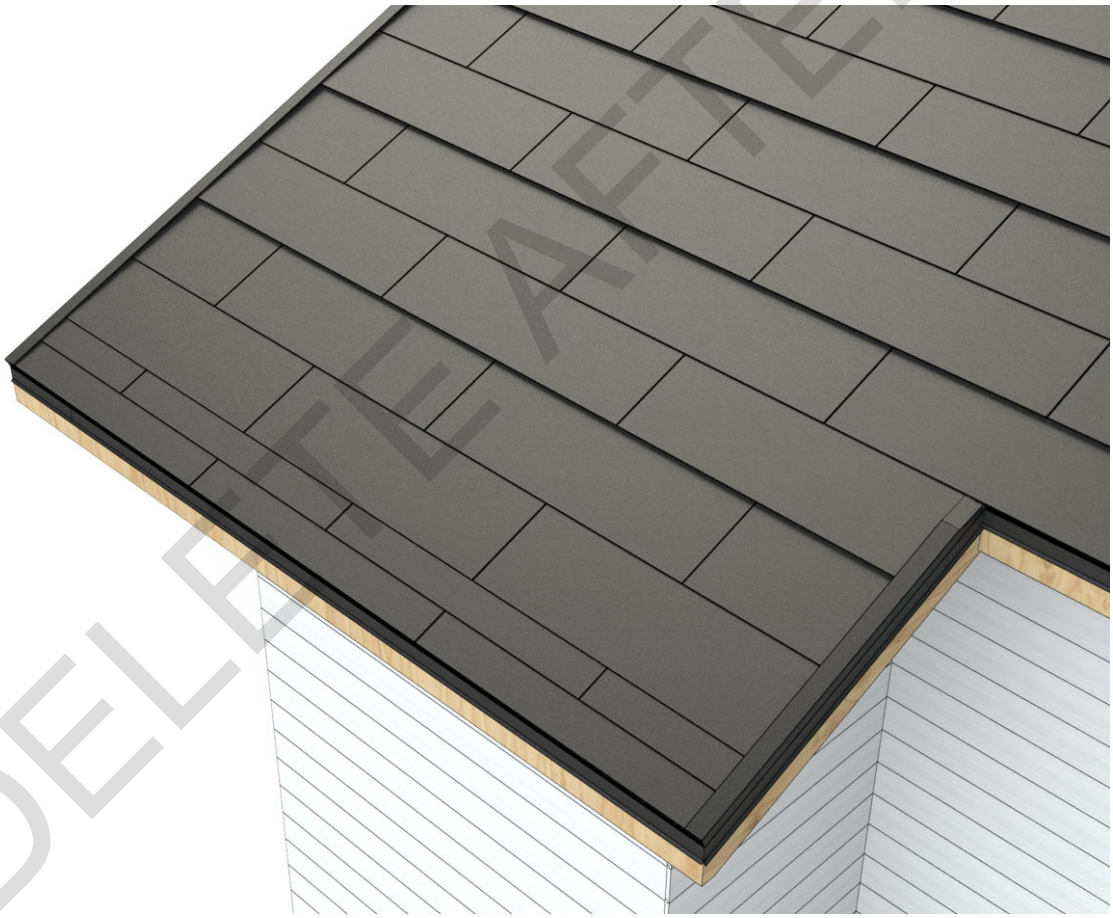
1 - Bottom edge section

2 - Nailing flange section

6. Align the cut edge of the tile to the back of the shoulder and fasten the shoulder to the tile. Use the same number of fasteners required to fasten the tile to the deck.
    a. Fasten a minimum of 1 ½ in below the shoulder, so the self-tappers don't penetrate through the shoulder and obstruct the next tile engagement.
    b. Repeat this process for the number of tiles needed for the course.



1 ½ in - No Fasten Zone



Pitch Transitions and Flat Roof Tie-In

Flat Roof Tie-Ins

Overview

This section covers how to tie in flat roofs into the Tesla Solar Roof System. Here are the main flat roof types that can be tied in:

- **Modified Bitumen**
- **EPDM (Ethylene Propylene Diene Monomer)**
- **TPO (Thermoplastic Polyolefin)**
- **PVC (Polyvinyl Chloride)**
- **Metal Roof**

Tools and Equipment

- Utility Knife
- Impact Driver
- Left & Right Offset Metal Snips
- Laser Level (Recommended) (Other option string line with level)
- Cordless Roofing Nailers
- Caulking gun
- 10 ft Metal Brake

Materials:

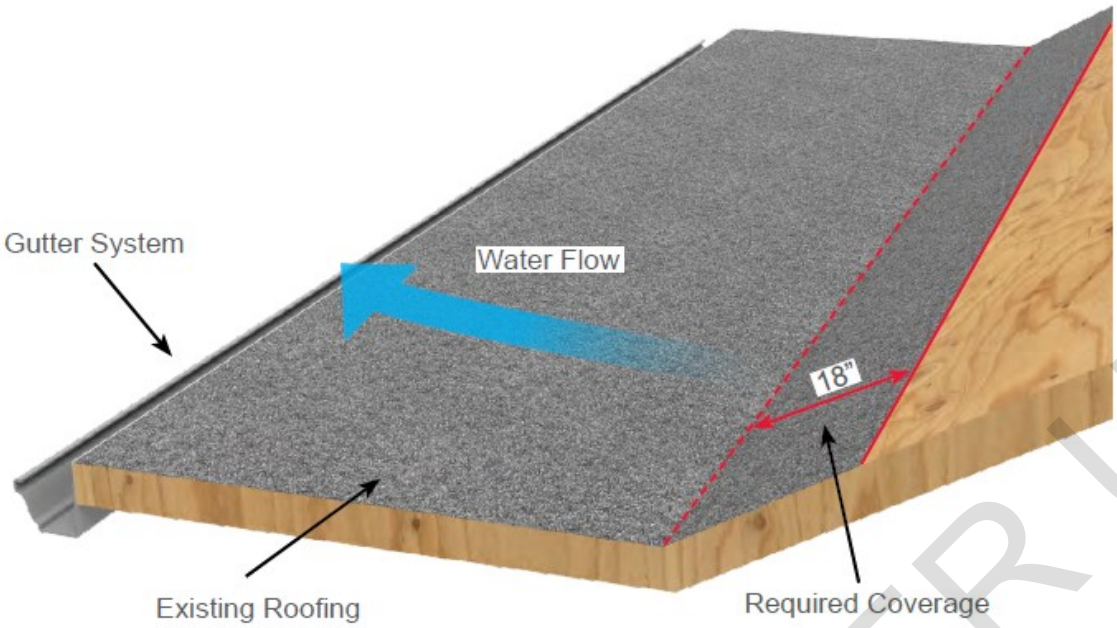
- Transition Flashing
- Cleat Metal
- Vented Riser
- Flat Stock
- Self-Adhered Underlayment Class A
- Tesla Approved Sealant

PPE:

- Safety glasses
- Cut-resistant gloves
- Fall protection

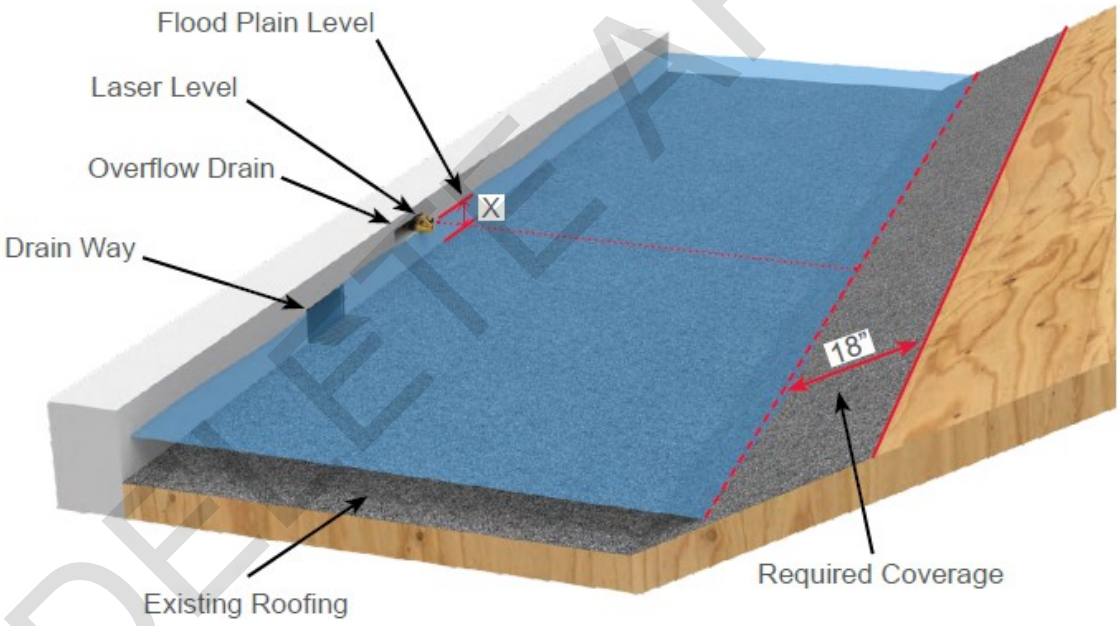
Evaluation

Before you begin: Evaluate whether the existing flat roof meets Tesla's integration specification. In the example below, the water flows down-roof to the gutter systems, so the minimum required coverage of the current flat roof material must extend up-roof 18 in from the roof deck.



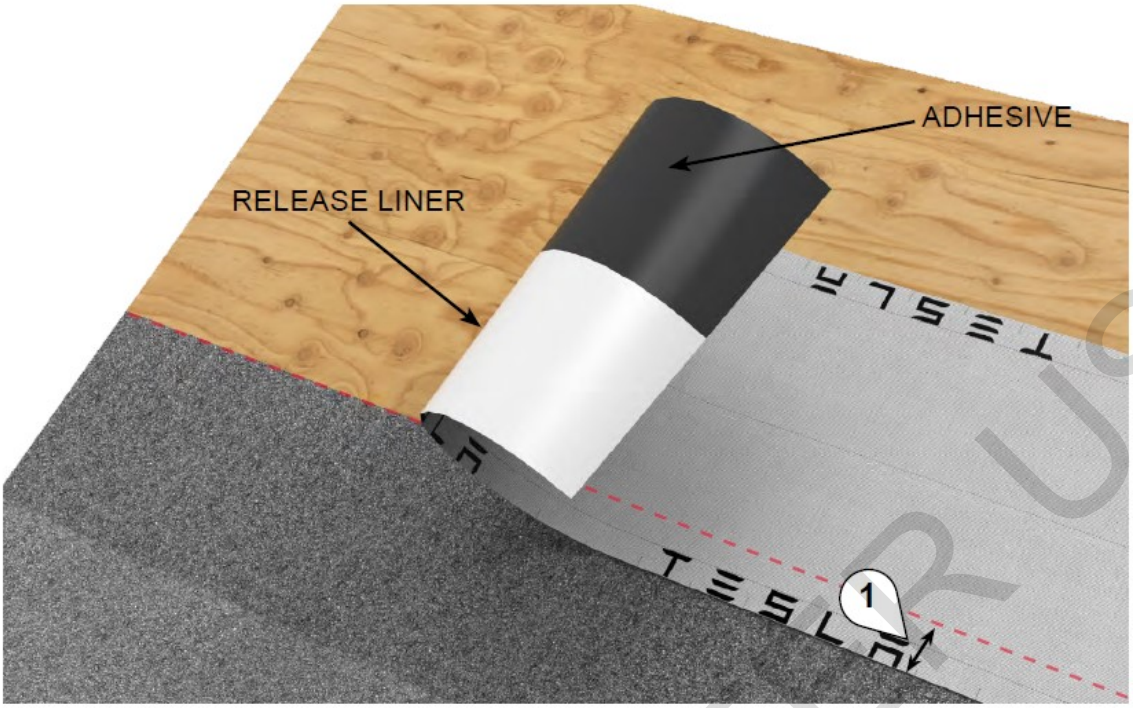
However, in roofing situations with a standing parapet, the flood plain is measured from the overflow drain's height, not the drain way. So, the 18 in of flat roof material is measured from the top of the overflow drain.

It is recommended to use a laser level at this height and project on the sloped area up the roof.



Work Instructions - Flat Roof to Mounting Plane

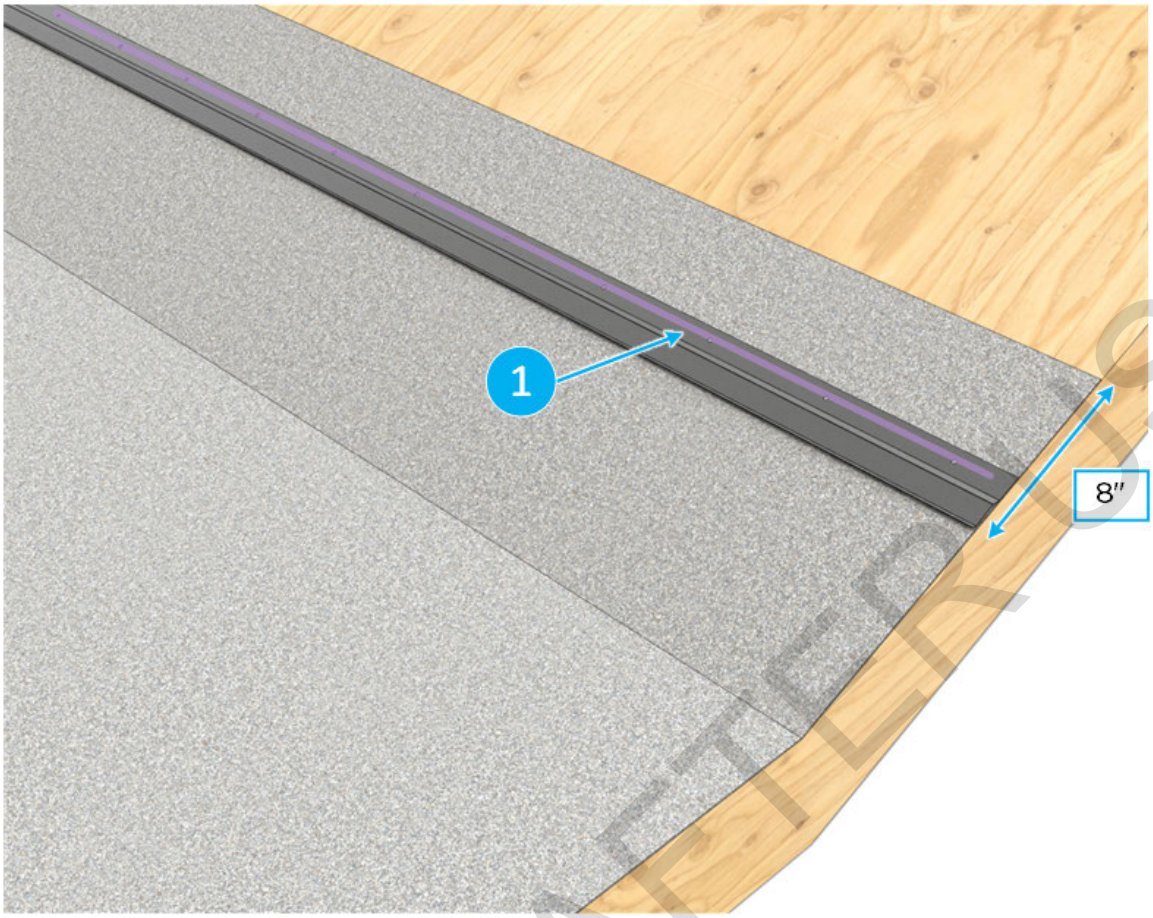
1. The first course of underlayment shall overlap the existing flat roof by 4 in, leaving half of the release liner in place down roof.



2. Since the underlayment is not compatible with the flat roof material, create a 12 in transition flashing from the flat stock to cover the flat roof material and create an adhesive surface for the underlayment. Next, make a ½ in closed hem at the bottom of the flashing going down roof.

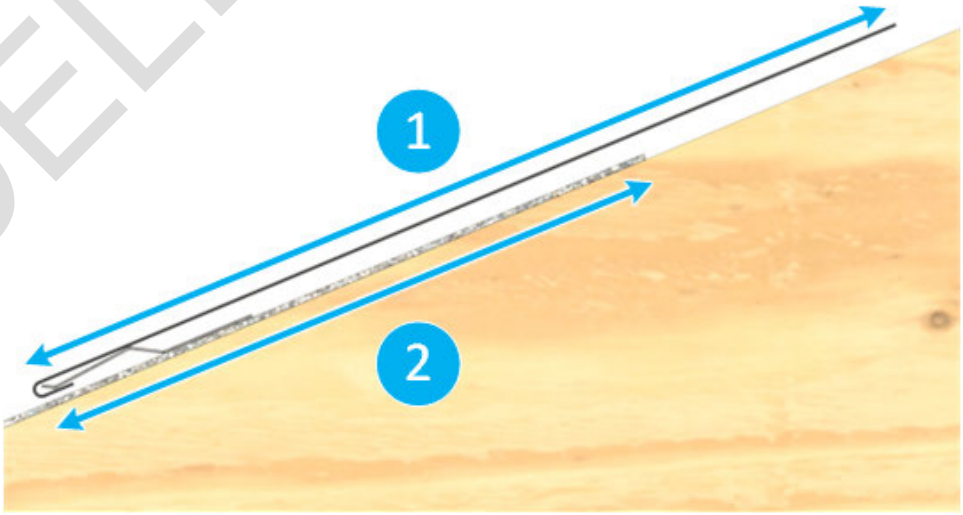
Closeup of 1/2" Hem at Edge.

3. Next, install a cleat to engage with the hem of the flat stock. The cleat should be installed 8 in below the top edge of the flat roof material.
   a. Apply sealant underneath the cleat before fastening. Please reference the *Part Catalog on page 74* for the proper sealant type.
   b. The cleat has pre-made holes every 6 in for fastening it to the roof deck.



1 - Sealant Underneath the Cleat

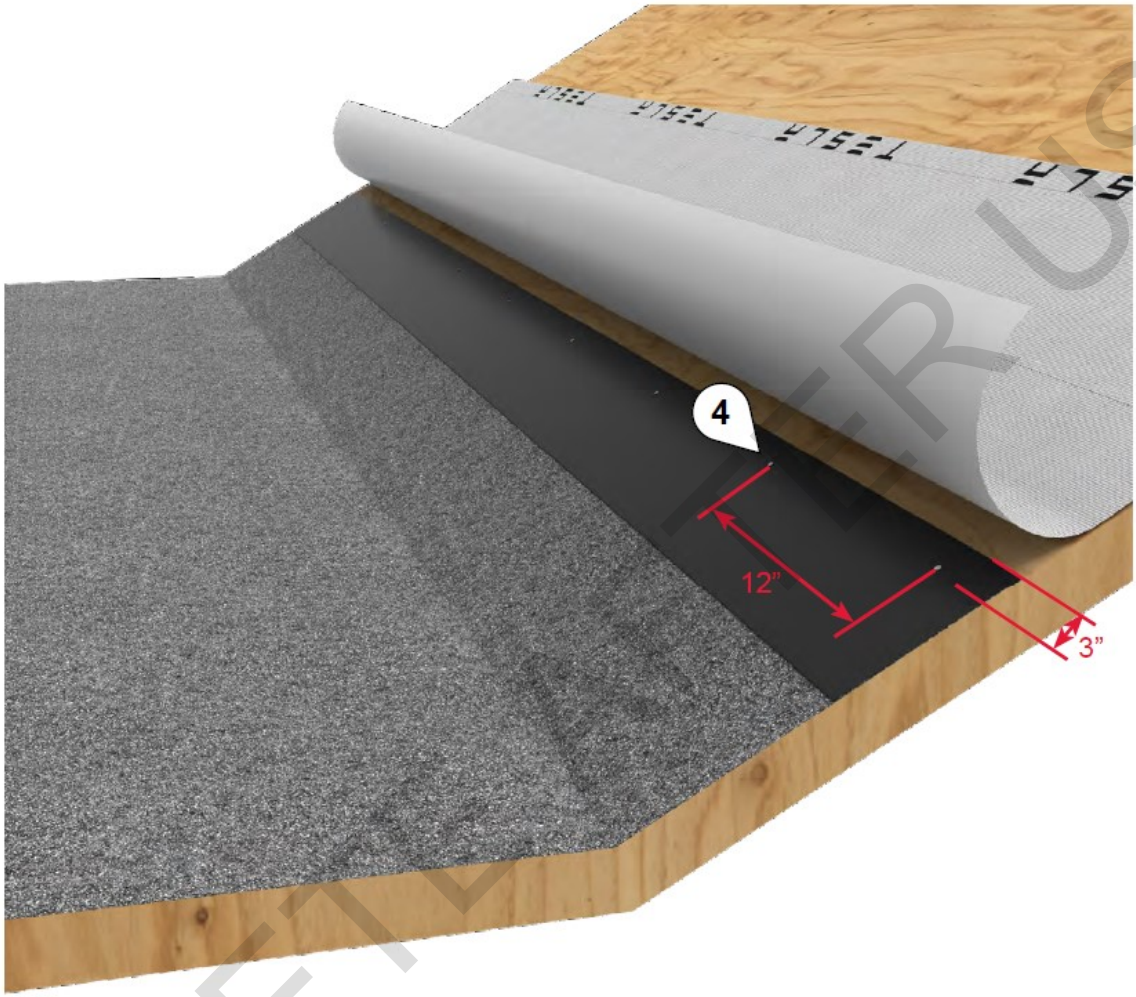
a. Example of flat stock installed and engaged to the cleat:



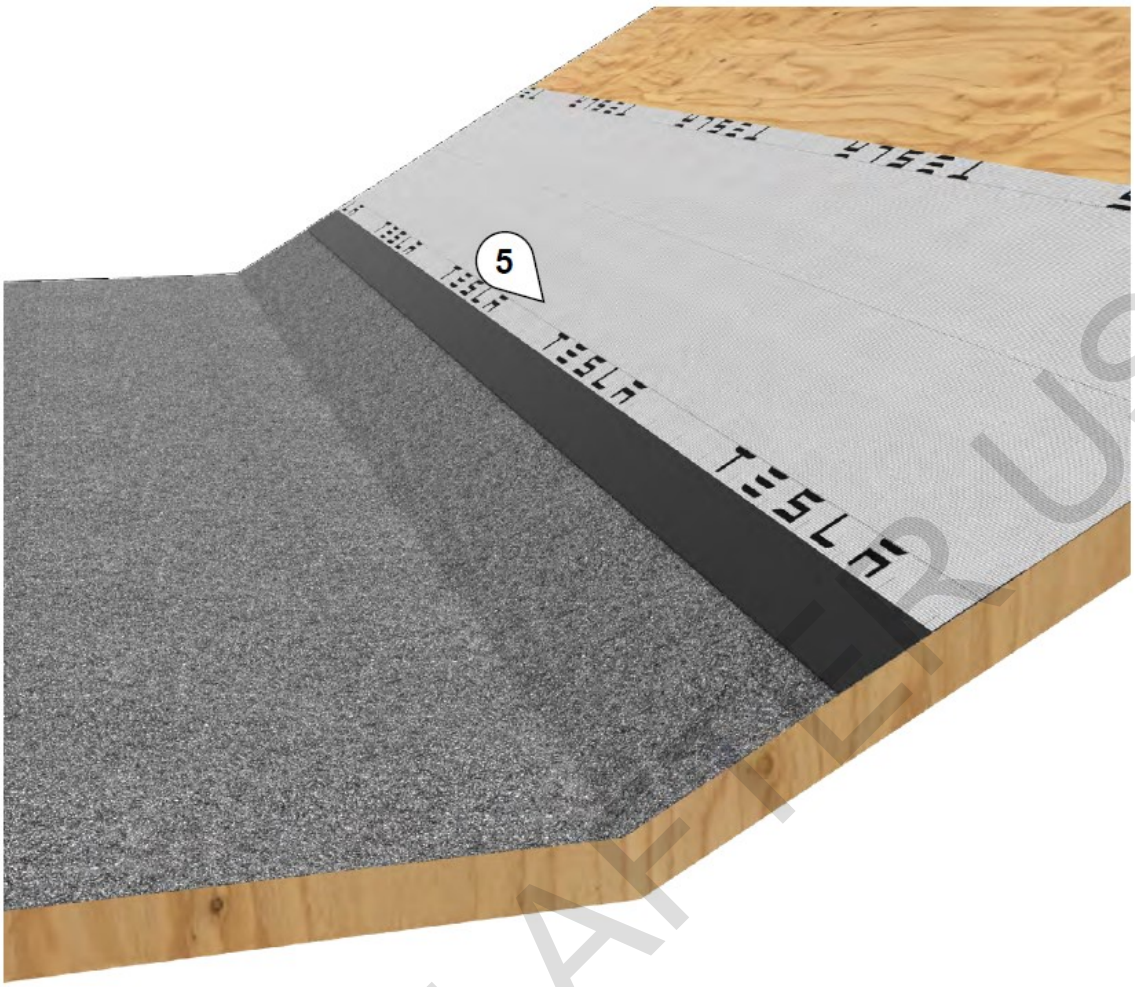
1- Length of the flat stock: 11 ½ in with a ½ in hem

2 - Distance of the leading edge of the cleat to the top edge of the flat roof material: 8 in

4. Make sure the hem is fully engaged into the cleat before fastening. Fasten the flashing in accordance with the *Fastener Schedule on page 703*. Reference the "Transition Flashing" line in the fastener schedule.



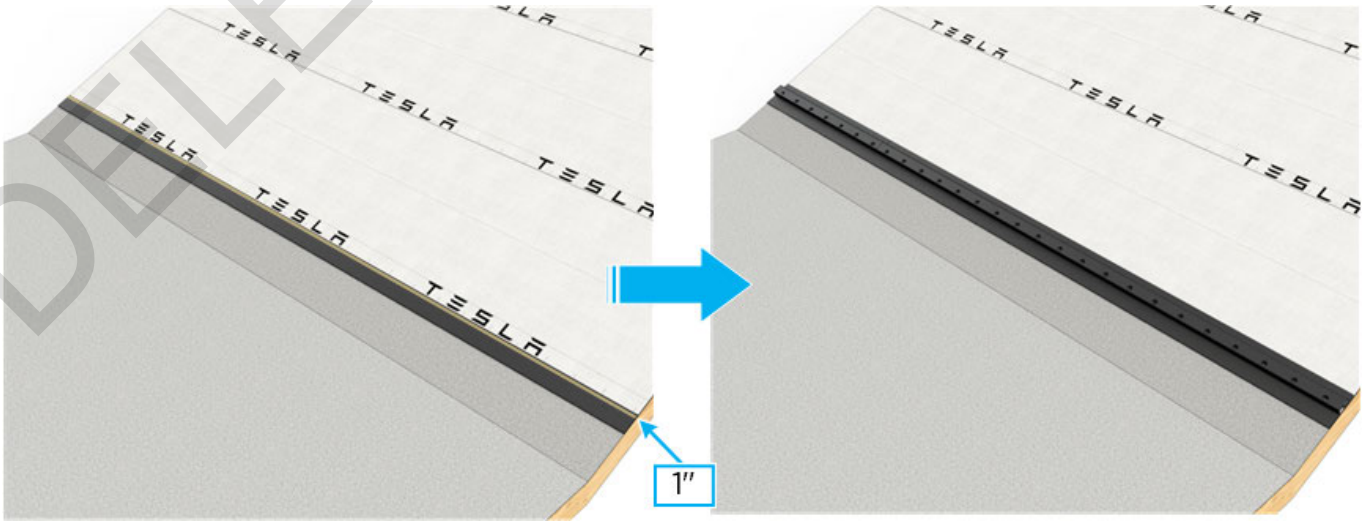
5. Remove the release liner on the back half of the underlayment and adhere it to the transition flashing.



6. After installing the underlayment, the perimeter metals can be installed, starting with the vented riser.

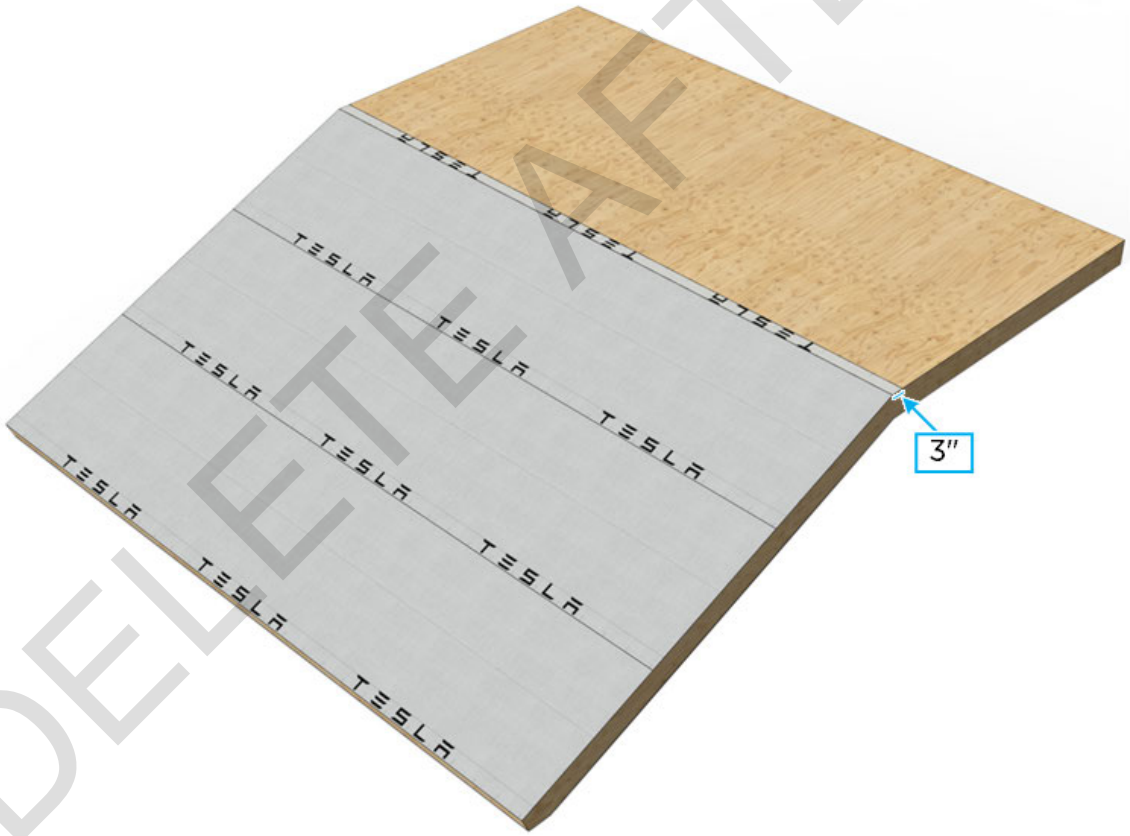
   The vented riser should be installed on top of the underlayment, 1 in below the bottom edge of the first row of underlayment.

   Tile installation can proceed as normal once the perimeter metals are set.

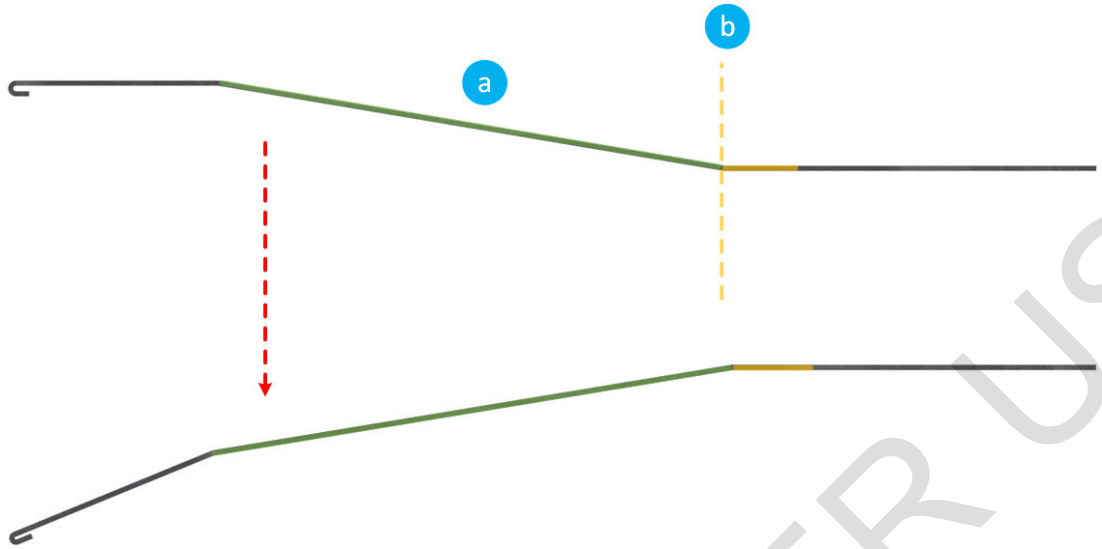


Work Instructions - Mounting Plane to Flat Roof

1. Install the underlayment first. Whenever possible, it is recommended to install it at least 3 in up and on top of the flat roof.



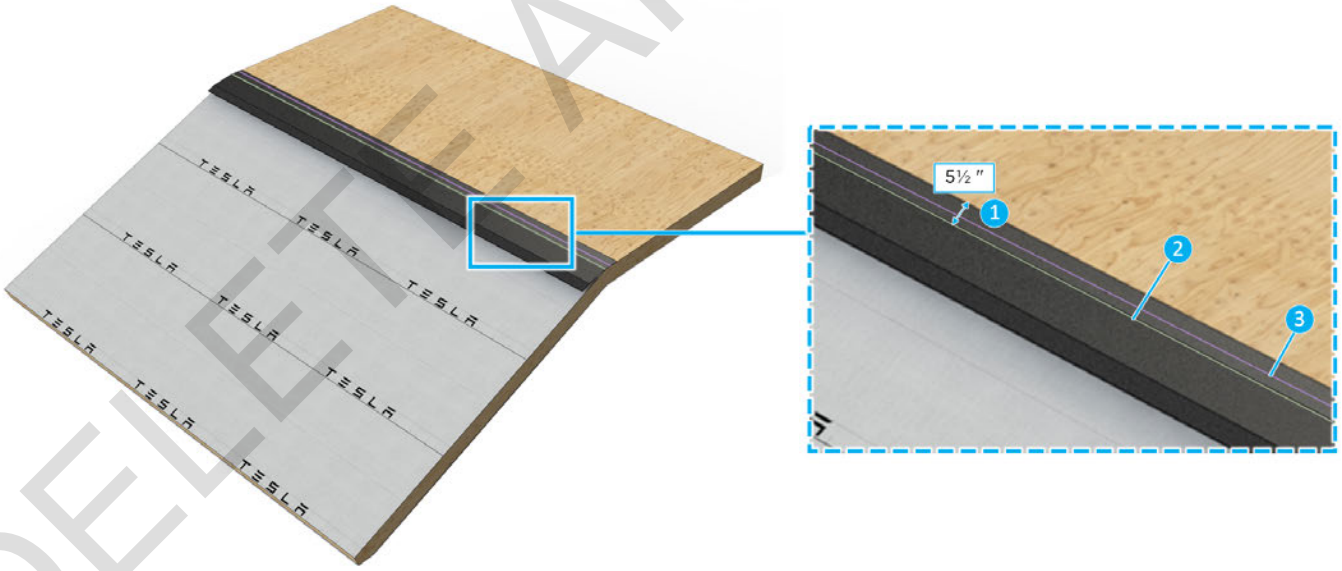
2. Next, install the transition flashing.
   Use a 10 ft brake to bend the transition flashing to the proper pitch at the deck transition line. This will leave 5 ½ in of coverage on top of the flat roof.



a - 7 5/8 in Transition Section

b - Deck transition line, where the pitch is bent.

a. Apply proper sealant along the top edge of the flat roof and underneath the flashing before fastening.



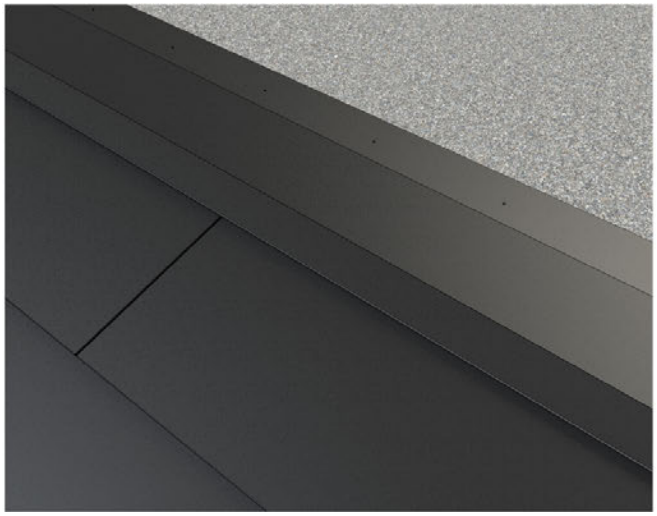
1 - 5 ½ in on top of flat roof

2 - Bend Line

3 - Sealant

3. Fasten the flashing 3 in down from the top edge of the transition flashing. Refer to the *Fastener Schedule on page 703* for spacing.
4. Now that the transition flashing is on the flat roof, the crew can properly counter over the metal transition flashing with the appropriate roof metal.

This can be done after or during the tile installation.

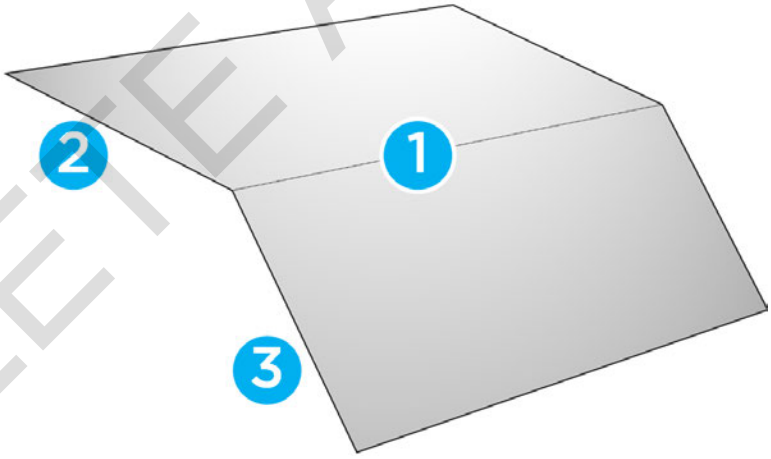


Steep-to-Low Pitch Transitions

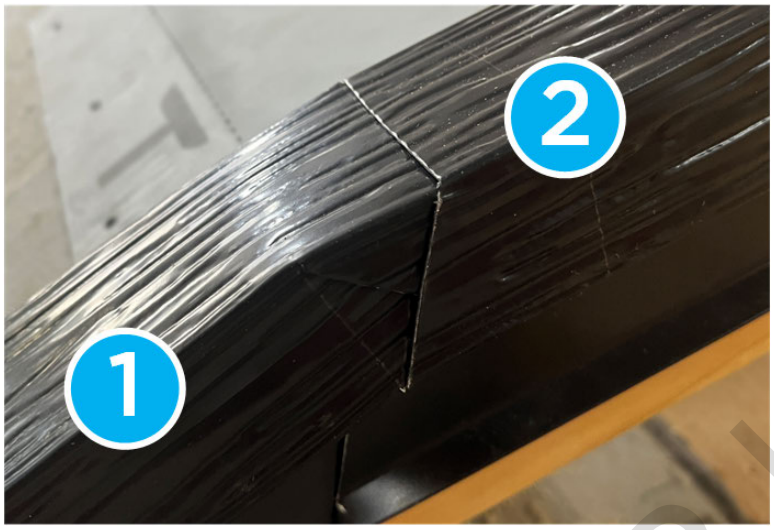
Overview

This section outlines how to splice channel flashing together at a steep to low pitch transition by creating a lower splice and an upper splice.

(1)	Pitch transition
(2)	Low pitch
(3)	Steep pitch



(1)	Lower splice
(2)	Upper splice



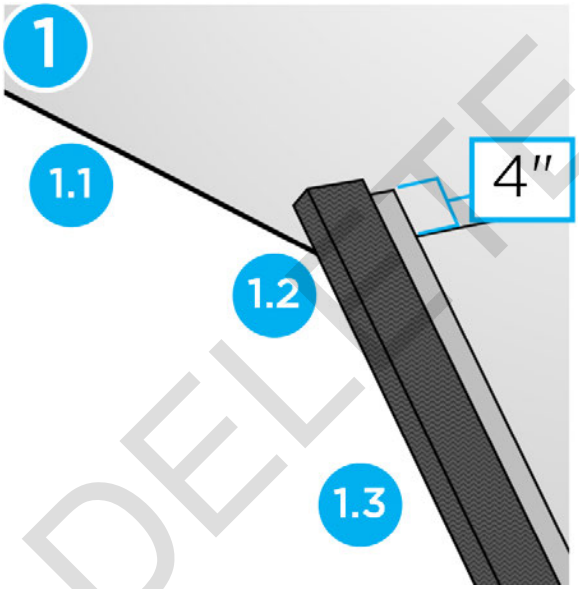
Tools & Equipment

- Channel flashing
- Metal snips
- Speed square

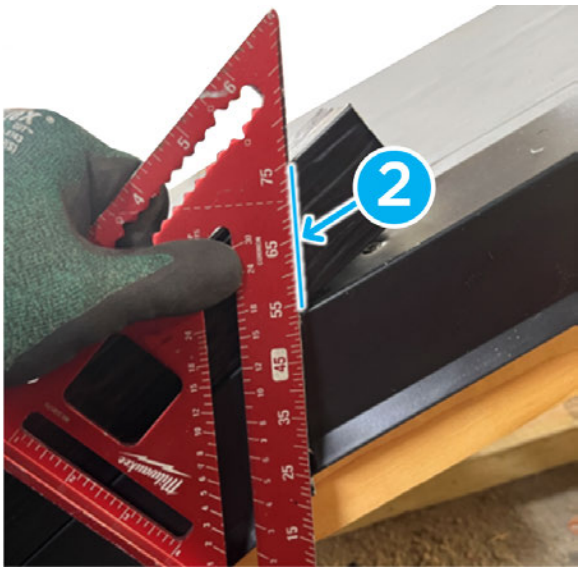
Creating the Lower Splice (Steep Pitch Channel Flashing)

Measure and cut a piece of channel flashing to extend 4 in beyond the pitch transition **(1)**.

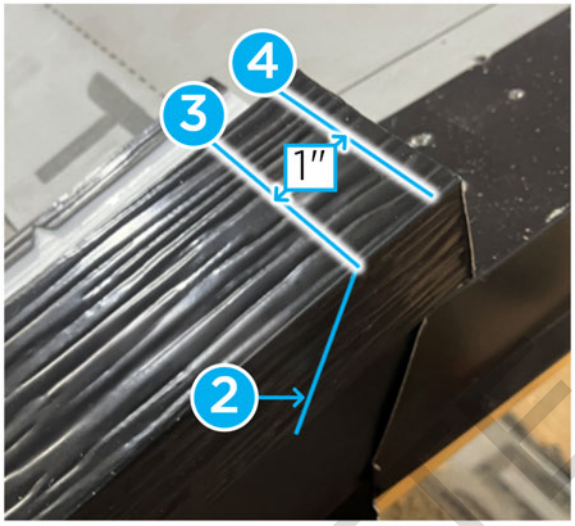
Pictured: Low pitch **(1.1)**, pitch transition **(1.2)**, steep pitch **(1.3)**



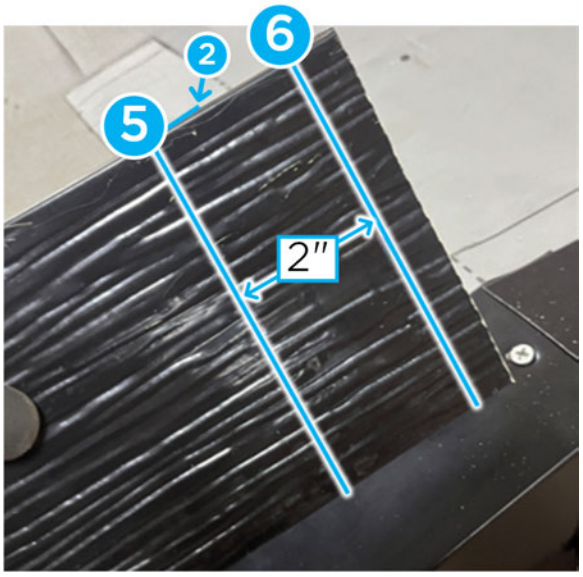
Transfer the angle of the fascia onto the sidewall of the channel flashing **(2)**.



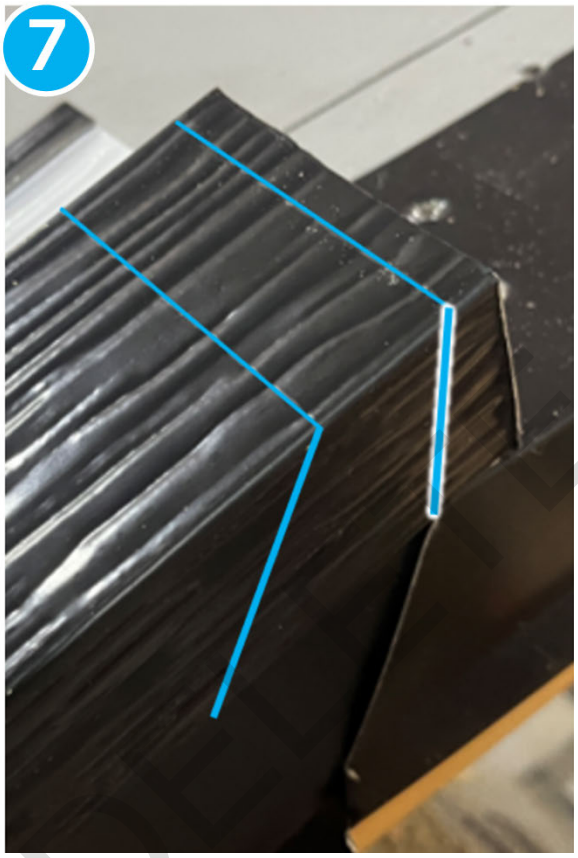
At the upper point of the fascia angle, mark a square line across the top flange **(3)**, then add 1 in and mark another square line **(4)**.



At the lower point of the fascia angle, mark a square line across the lower flange **(5)**, then add 2 in and make another square line **(6)**.

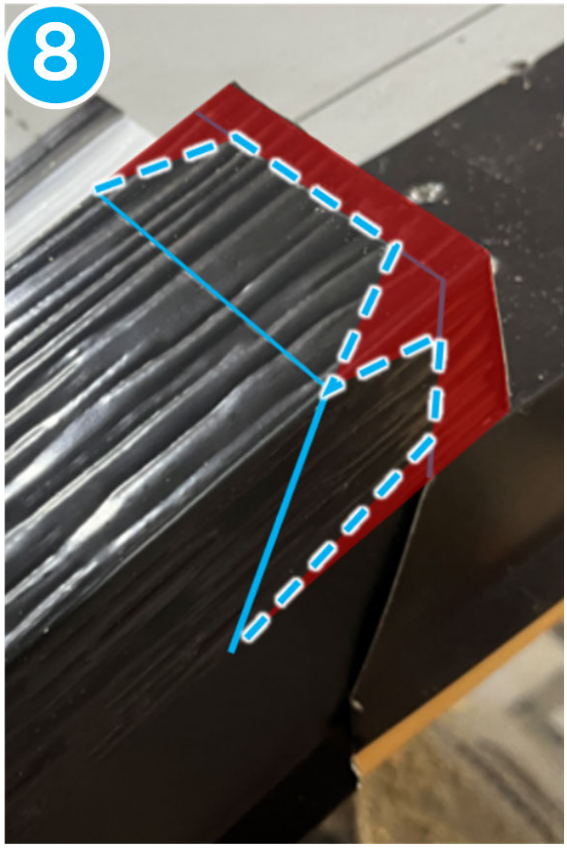


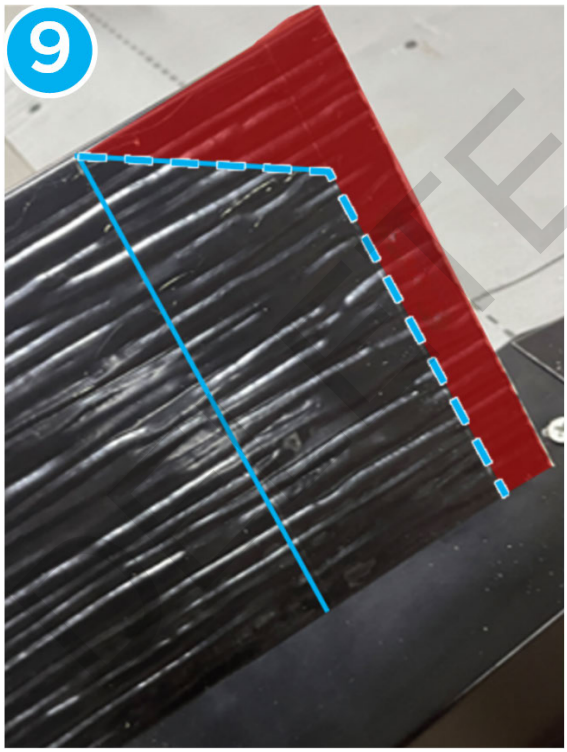
Make a mark along the vertical face of the channel flashing between the top marks on the upper and lower flanges **(7)**.



On the upper flange and vertical face, make angled marks between the two previously marked lines **(8)**. The angled marks need to be wide enough to remove the hem from the upper flange and allow the snips to cut to the corners of the material. On the lower flange, mark a 45° line **(9)**. Remove all material beyond the marks with snips.

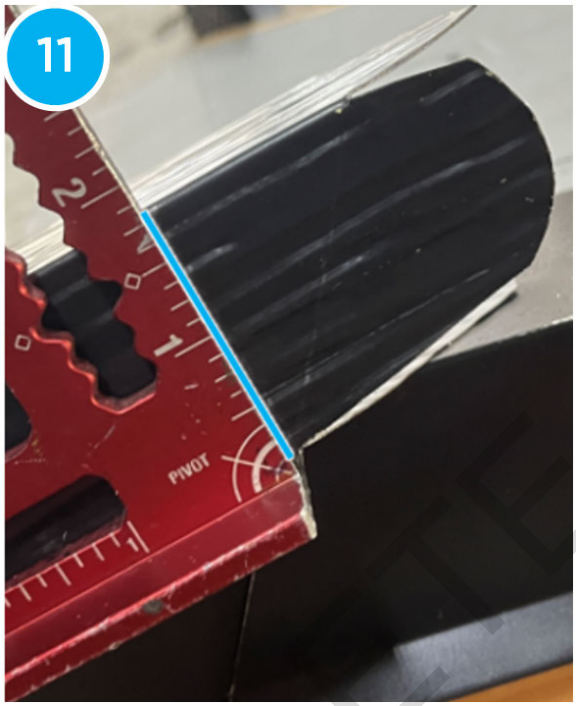
NOTE: The angled cuts serve to separate the upper flange, vertical face and deck flange from each other, so that they can be adjusted individually and splice properly with the upper splice.





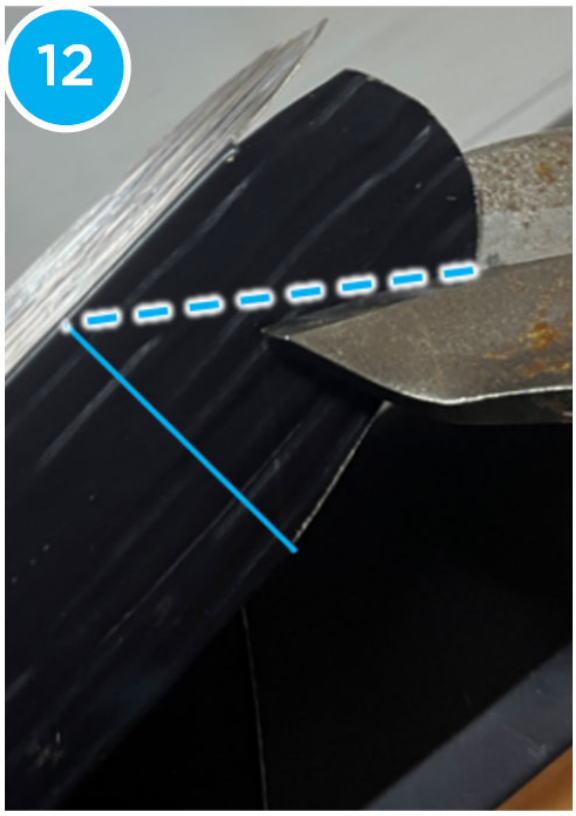
Adjust the 2 in lower flange to conform to the pitch transition **(10).**

Mark a square line from the notch at the pitch the pitch transition **(11)**.



Make a relief cut in the tab of the vertical face to the top of the square line **(12)**.

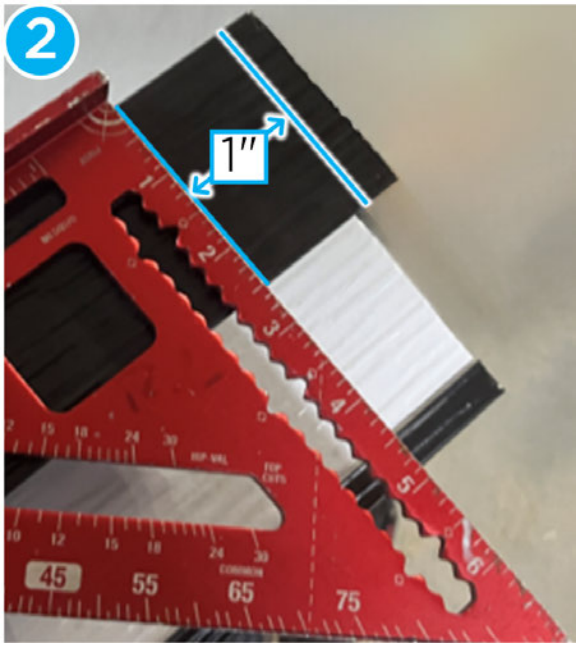
NOTE: This relief cut allows the steep pitch channel flashing to tuck under low pitch channel flashing. Use the correct offset snips to ensure that the material above the relief cut positively laps over the material below the relief cut.



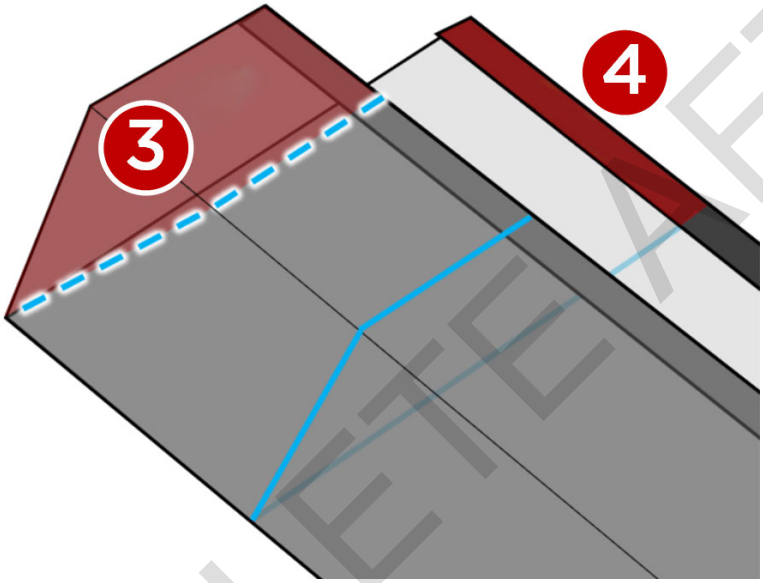
Creating the Upper Splice (Low Pitch Channel Flashing)

Mark a square line on the lower flange 2 in from the end of the channel flashing that will splice with the lower channel flashing and transfer the line across all other faces of the channel flashing **(1)**.

On the upper flange of the channel flashing, mark a square line 1 in up from the 2 in line **(2)**.

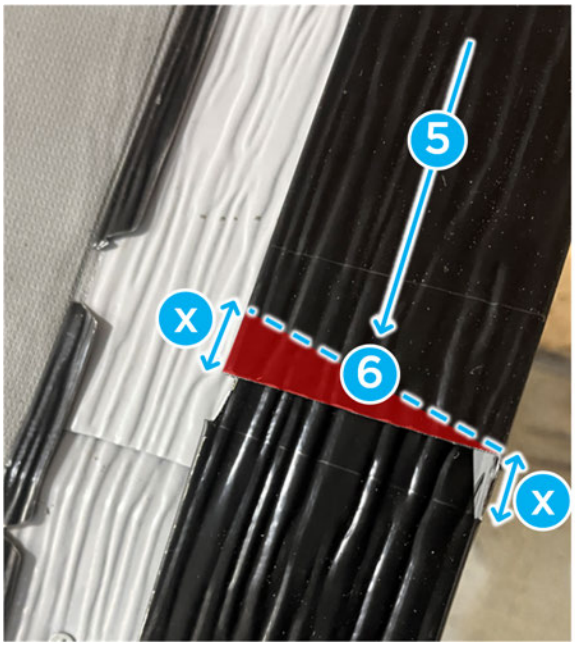


Mark a line on the vertical face from the 1 ¼ in mark to the front edge of the flashing, then cut the material away **(3)**. Remove the hem on the lower flange down to the 2 in mark **(4)**.



Join the upper channel flashing with the lower channel flashing ensuring that the upper channel positively lapped with the lower channel flashing on all sides **(5)**. If gaps are present between the lower and upper channel flashing, create relief cuts in the upper channel flashing's upper flange to allow the two pieces of channel flashing to slide tighter together **(6)**.

NOTE: The tall point of the relief cut is determined by the size of the gap between the two pieces of channel flashing **(x)**.



Tile Installation at Steep to Low Pitch Transition

Overview

This section outlines the procedure for installing tiles at a steep to low pitch transition.

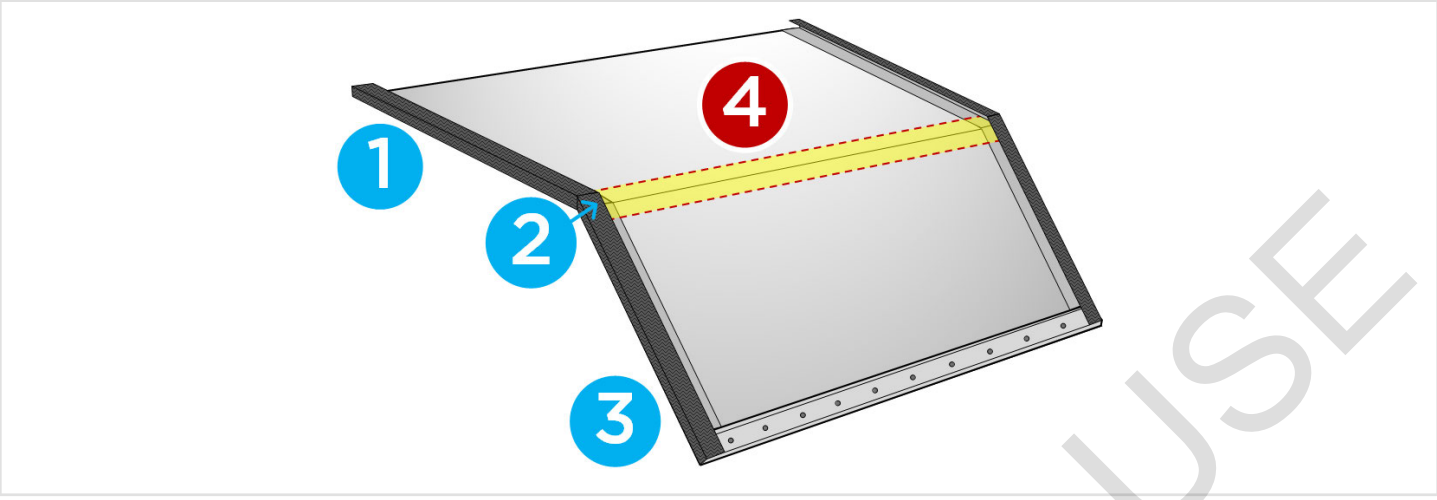
Tools and Equipment

- Metal tiles
- Vented riser
- Transition flashing
- Metal snips

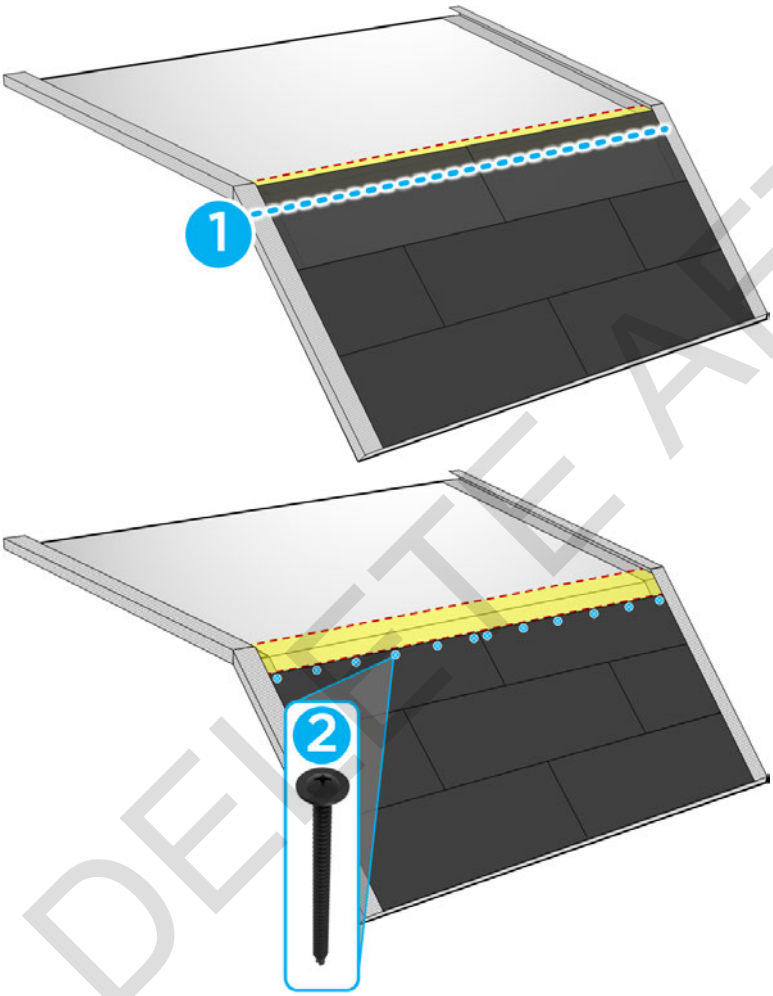
Work Instruction

NOTE: Do not install fasteners within 4 in of the steep to low pitch transition.

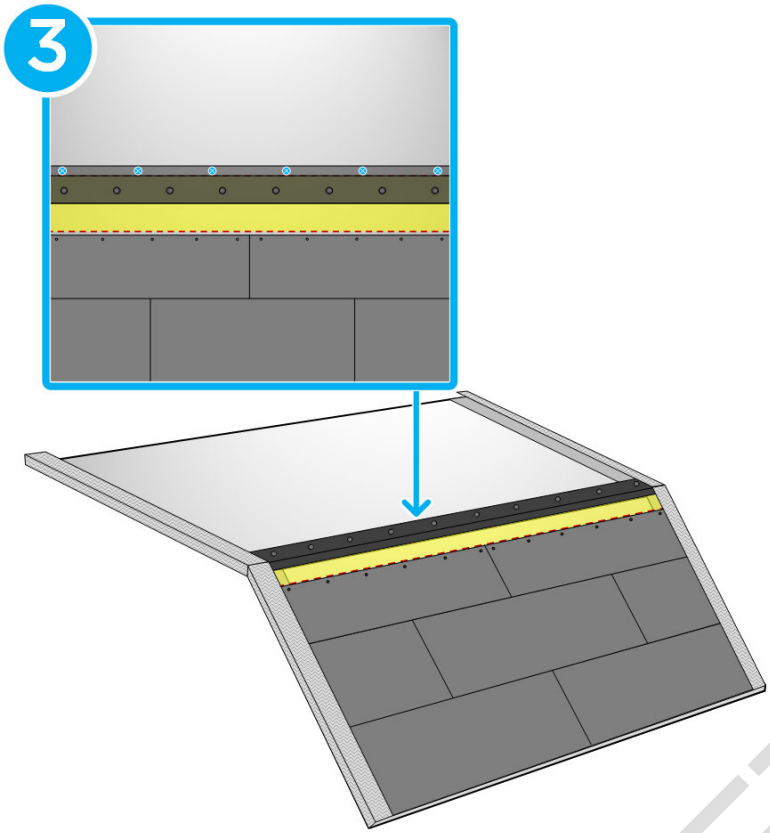
(1)	Low pitch
(2)	Pitch transition
(3)	Steep pitch
(4)	No fasteners within 4 in zone



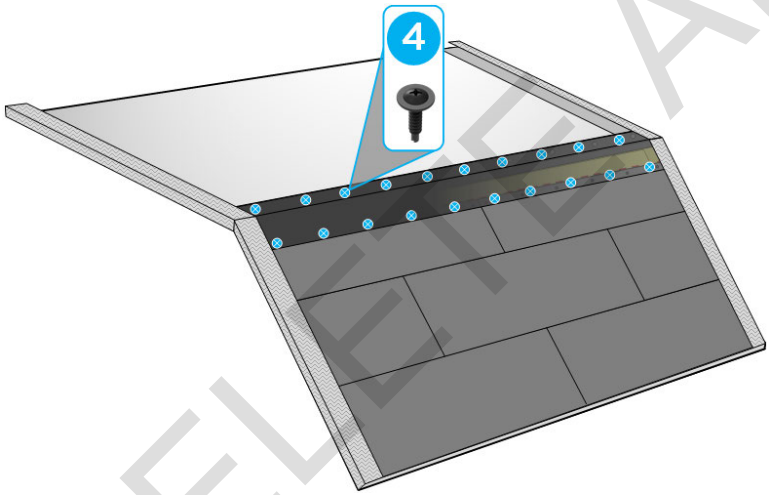
Install tiles up to the pitch transition. If the last row of tiles lands within the 4 in no fastener zone, rip the tiles **(1)** and secure with 2 ½ in self-tapping screws **(2)**.



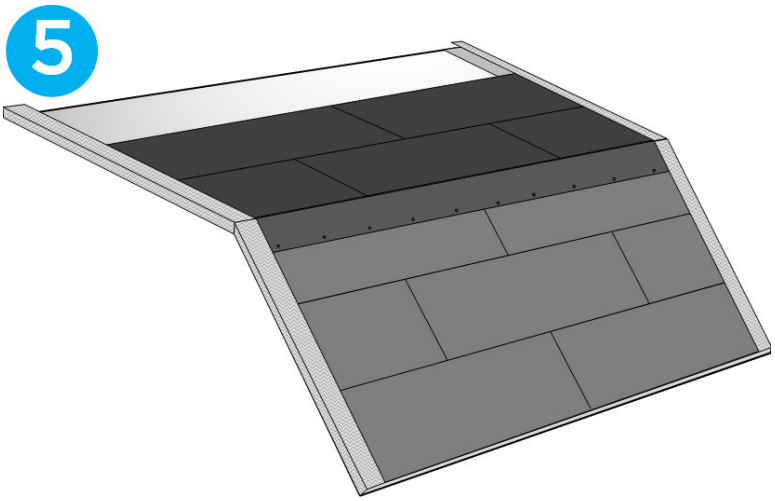
Next, align vented riser with the pitch transition and secure per the applicable wind tier in the *Fastener Schedule on page 703* **(3)**.



Cut and bend transition flashing to span over the vented riser and tiles on the steep pitch. Secure with ¾ in self-tappers per the applicable wind tier in the *Fastener Schedule on page 703***(4)**.



Install tiles on the low pitch section of the roof **(5)**.

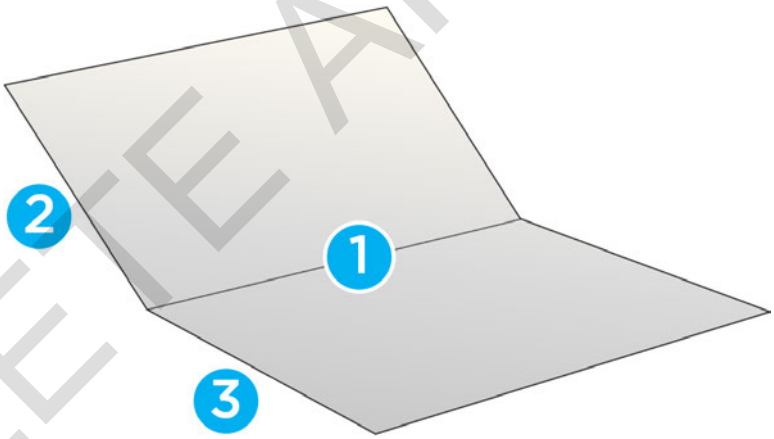


Low-to-Steep Pitch Transitions

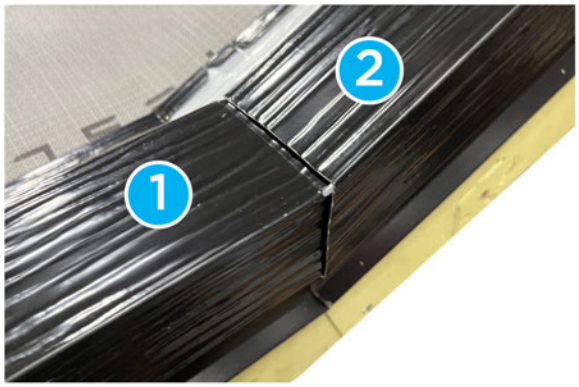
Overview

This section outlines how to splice channel flashing together at a low to steep pitch transition by creating a lower splice and upper splice.

(1)	Pitch transition
(2)	Steep pitch
(3)	Low pitch



(1)	Lower splice
(2)	Upper splice



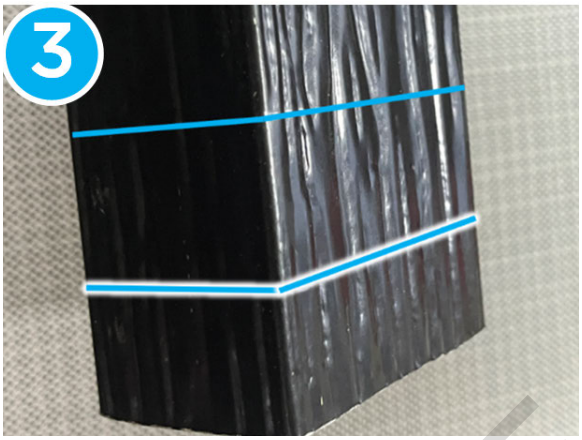
Tools & Equipment

- Channel flashing
- Metal snips
- Speed square

Creating the Lower Splice (Low Pitch Channel Flashing)

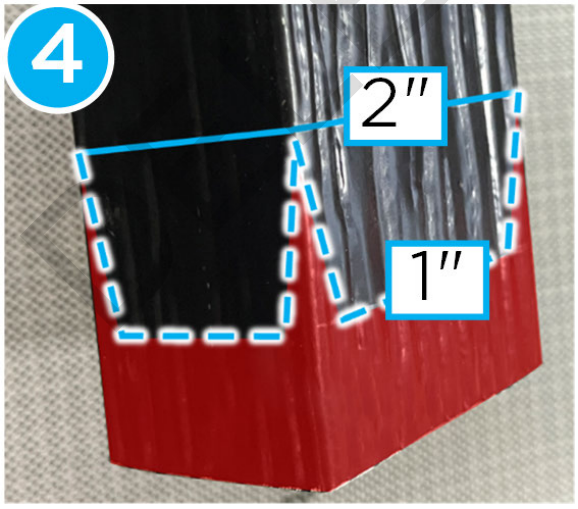
Mark 2 in from the edge the channel flashing **(1)** then carry the mark around on all sides **(2)**.

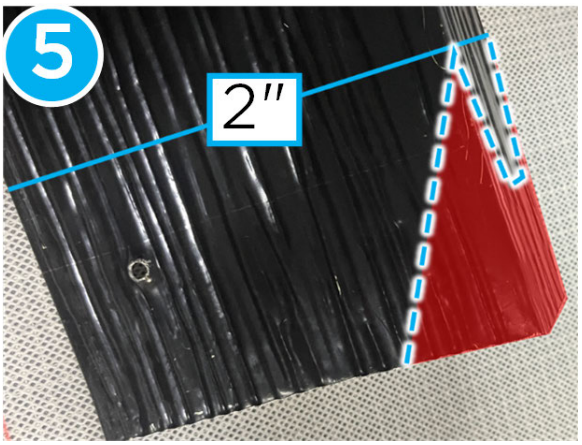
Mark a line 1 in up from the 2 in line on the top flange and vertical face **(3)**.



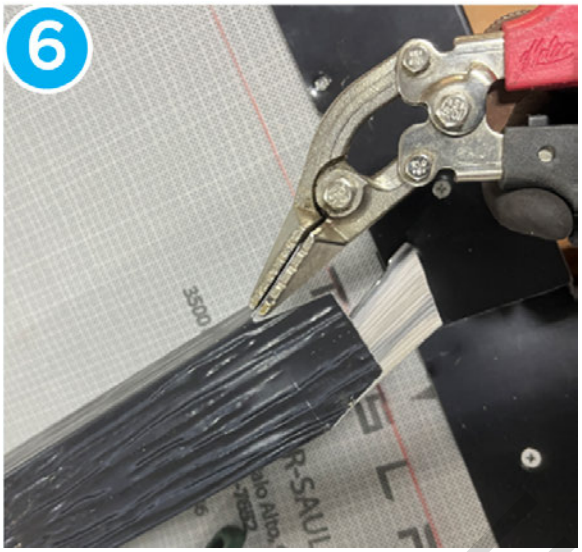
On the upper flange and vertical face, make angled marks between the two previously marked lines. The angled marks need to be wide enough to remove the hem from the upper flange and allow the snips to cut to the corners of the material **(4)**. On the lower flange, mark a 45° line. Remove all material beyond the marks with snips. **(5)**.

NOTE: The angled cuts serve to separate the upper flange, vertical face and deck flange from each other, so that they can be adjusted individually.



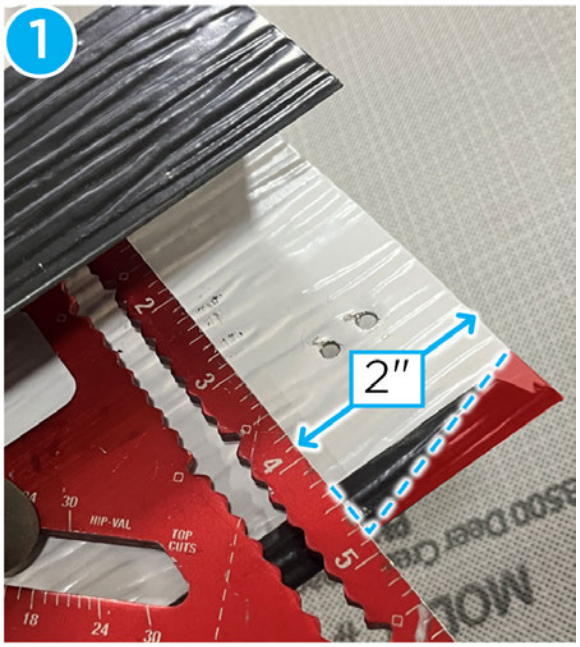


Using hand seamers adjust the deck flange and top flange tabs to match the profile of the pitch transition **(6)**.

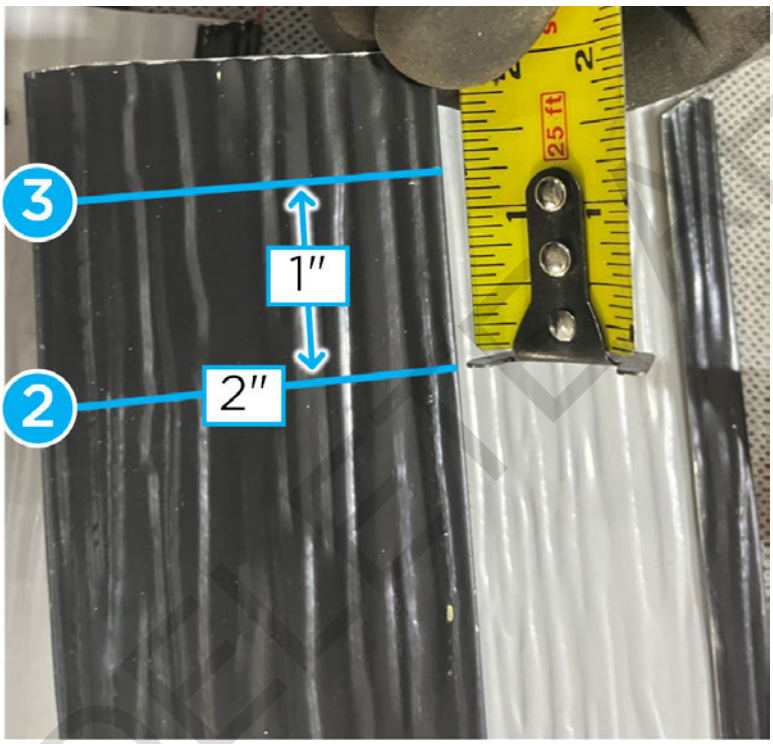


Creating the Upper Splice (Steep Pitch Channel Flashing)

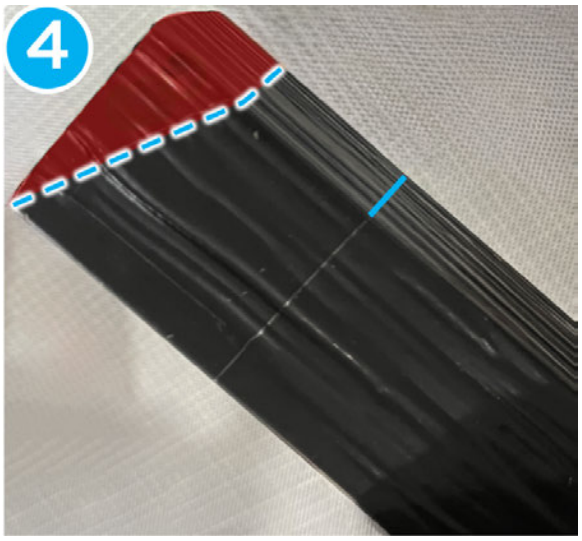
On the deck flange, remove 2 in of the hem and create a slight back cut to allow the upper splice's deck flange to slide into the hem of the lower splice's deck flange **(1)**.



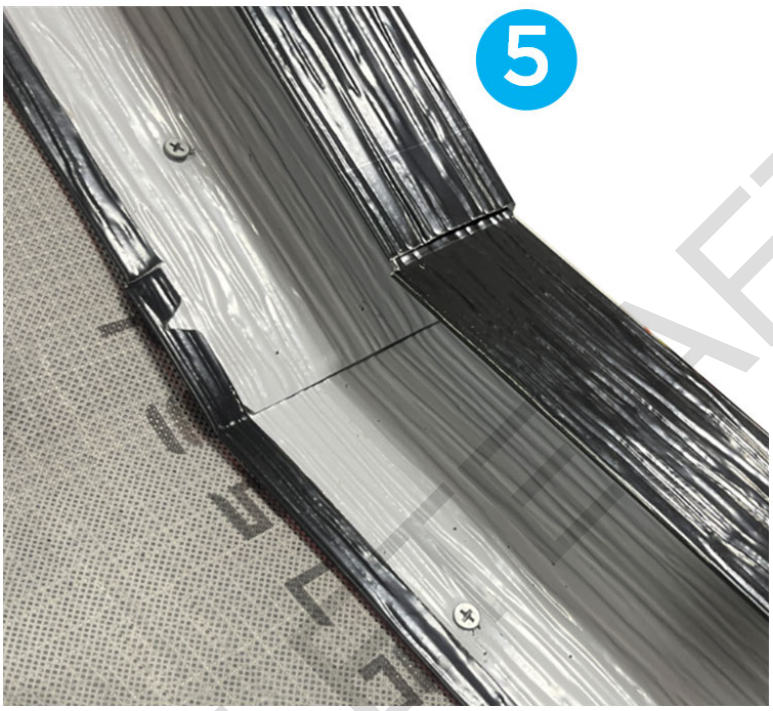
On the upper flange, mark a line 2 in from the edge of the channel flashing **(2)**, then make an additional line 1 in up from the 2 in line **(3)**.



On the vertical face make a line connecting the 1-¼ in line to the front of the channel flashing and remove the material beyond the lines **(4)**.



Splice the lower and upper splices together ensuring that all tabs and flanges are positively lapped **(5)**.



Tile Installation at Low to Steep Pitch Transition

Overview

This section outlines the procedure for installing tiles at a low to steep pitch transition.

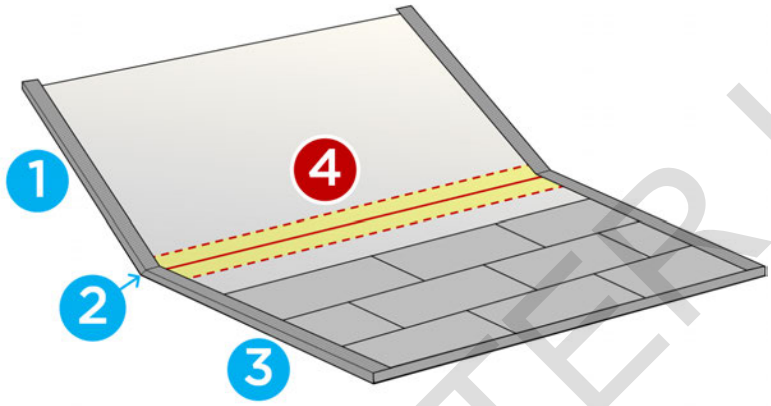
Tools and Equipment

- Metal tiles
- Vented riser
- Transition flashing
- Metal snips

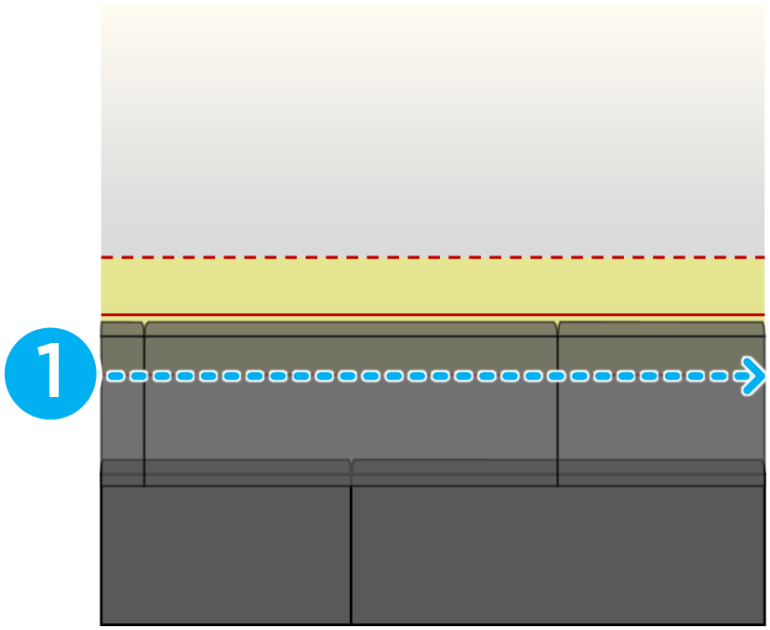
Work Instruction

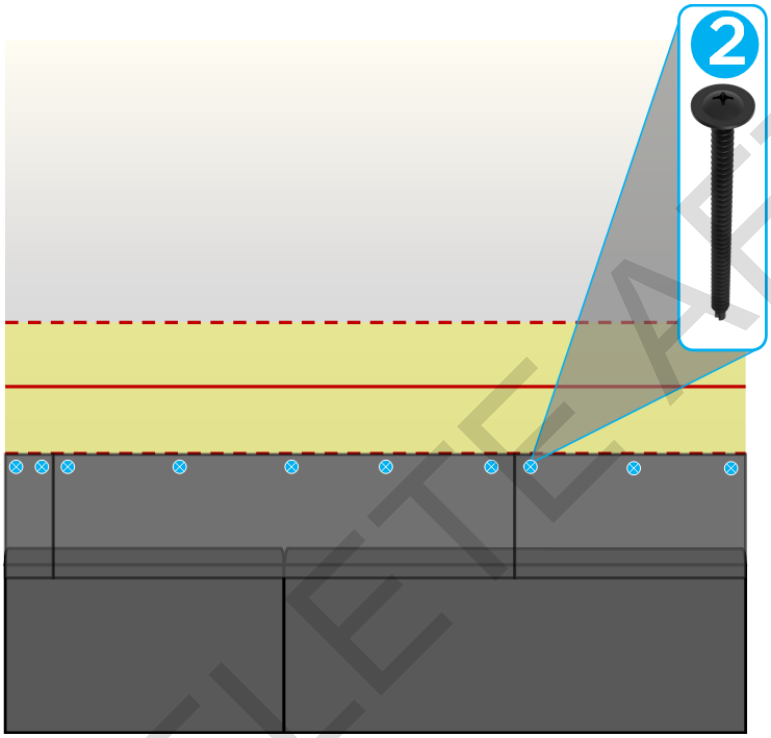
NOTE: Do not install fasteners within 4 in of the pitch transition.

(1)	Steep pitch
(2)	Pitch transition
(3)	Low pitch
(4)	No fasteners within 4 in zone

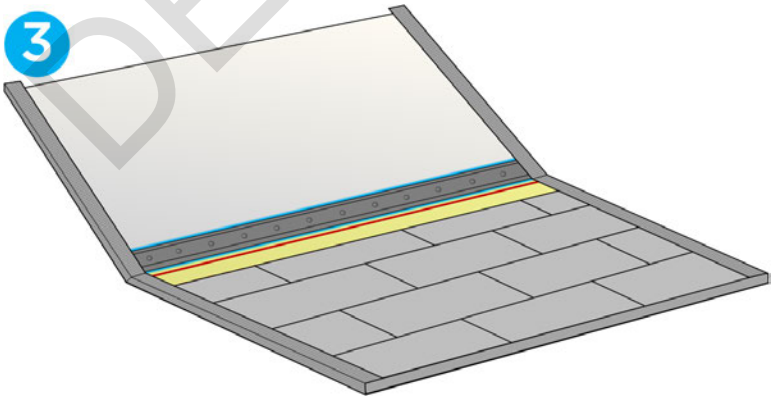


Install metal tiles up to the pitch transition. If the last row of tiles lands within 4 in of the pitch transition, rip the metal tiles **(1)** and secure with 2 ½ in self-tapping screws **(2)**.

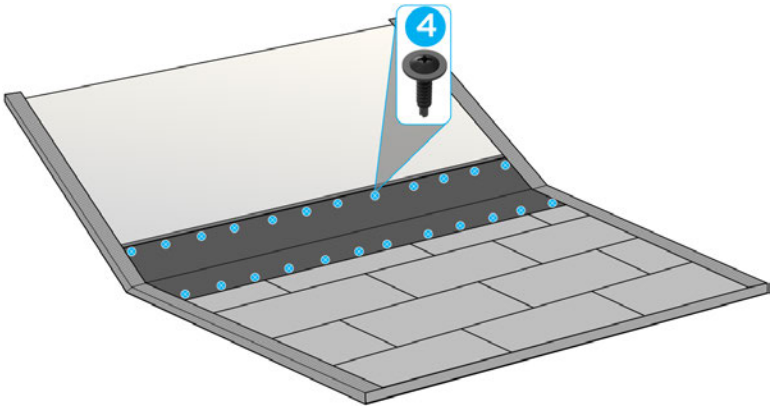




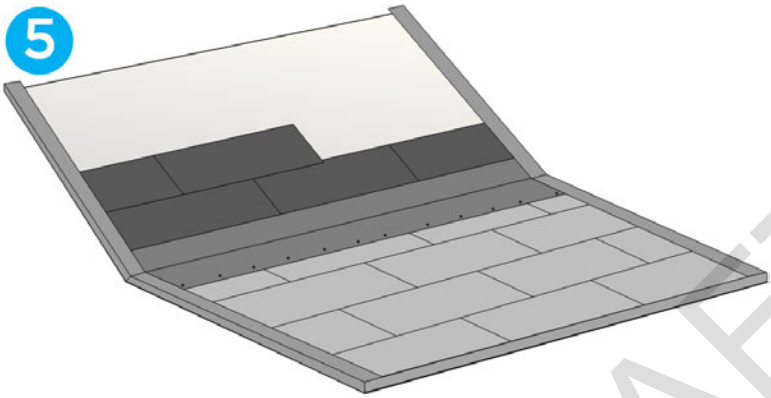
Install vented riser on the steep pitch with the nailing flange placed directly above the 4 in no nail zone **(3)**.



Cut and bend transition flashing to span between the vented riser and the tile course below the pitch transition. Secure the transition flashing to the vented riser and tiles with ¾ in self-tapping screws **(4)**.



Install tiles above the pitch transition **(5)**.



Uncommon Junctions

Rake-Headwall

Overview

This section outlines the following procedures for drying in the rake to headwall junction:

- *Fabricating and Installing Rake Channel Flashing on page 488*
- *Fabricating and Installing Transition Flashing on page 490*

Tools and Equipment

- Channel flashing
- Transition flashing
- Hand seamers
- Metal snips

Finished installation for reference:

Work Instruction

Fabricating and Installing Rake Channel Flashing

Fabricate the channel flashing so that it tapers towards the deck and the bottom flange acts as a washout.

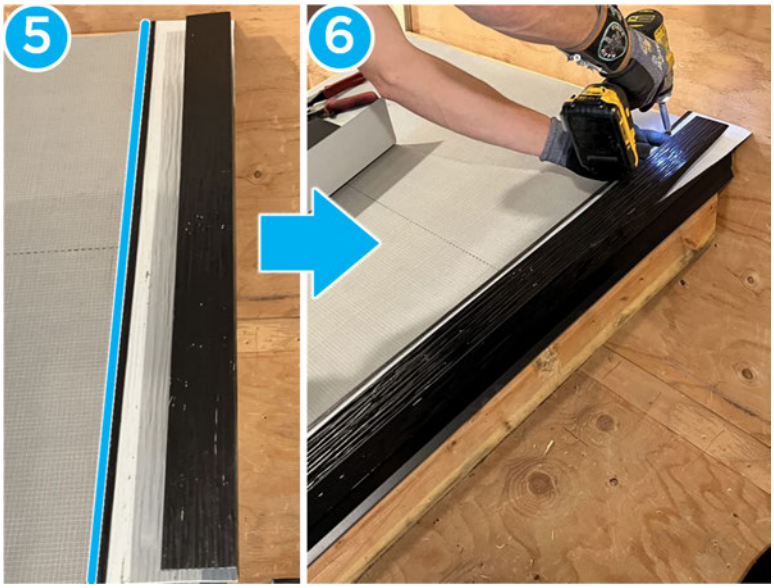
On the wall-facing end of the channel flashing, measure, mark and cut off 1.5 in of metal from the edge on the bottom flange **(1)**. Scribe a diagonal 14 in line that starts at the 1.5 in point and reaches the top flange. Then, cut into this line **(2)**.

Step 1 and 2 result:

Press the top flange down so that it overlaps with the bottom flange. Mark and cut off the excess overlapping metal so that both flanges are aligned **(3)**.

Step 3 Result:

Snap a control line at the rake **(4)** and align the channel flashing bottom flange edge with the line **(5)**. Fasten the channel flashing to the rake in accordance with the applicable wind tier in the *Fastener Schedule* **(6)**.

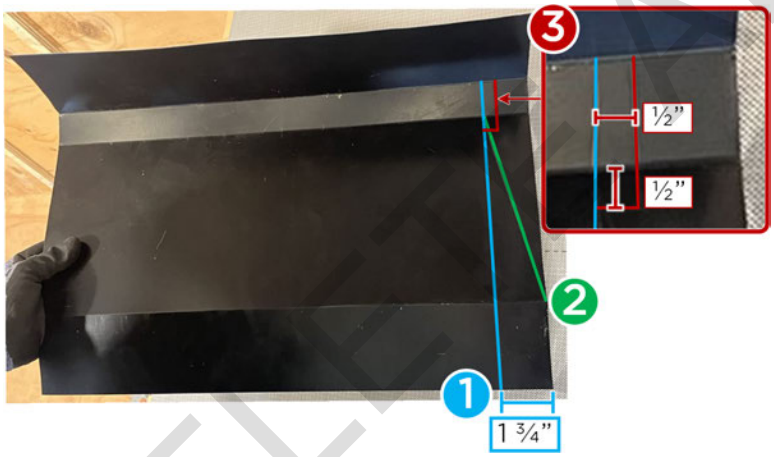


Fabricating and Installing Transition Flashing

Begin by marking the transition flashing with cut and bend guidelines.

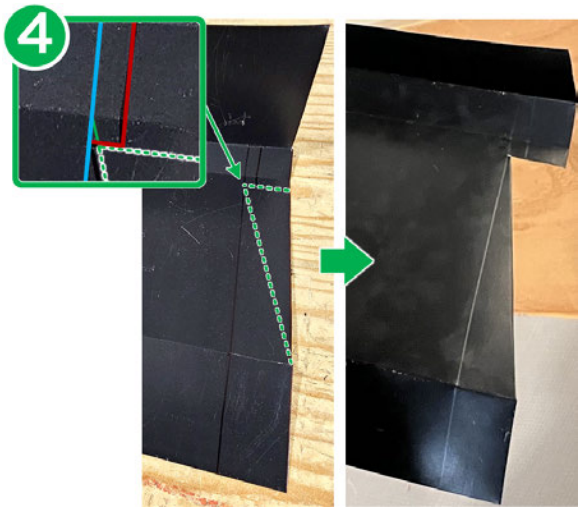
First, scribe a straight line across the transition flashing at 1 ¾ in from the edge **(1)**. Then, scribe a diagonal line starting from the edge of the lowest bend line up to the nearest upper flange bend line **(2)**.

Finally, draw tab guidelines. Draw a vertical line ½ in from the line drawn in step 1 and a horizontal line ½ in below the upper flange bend line **(3).**



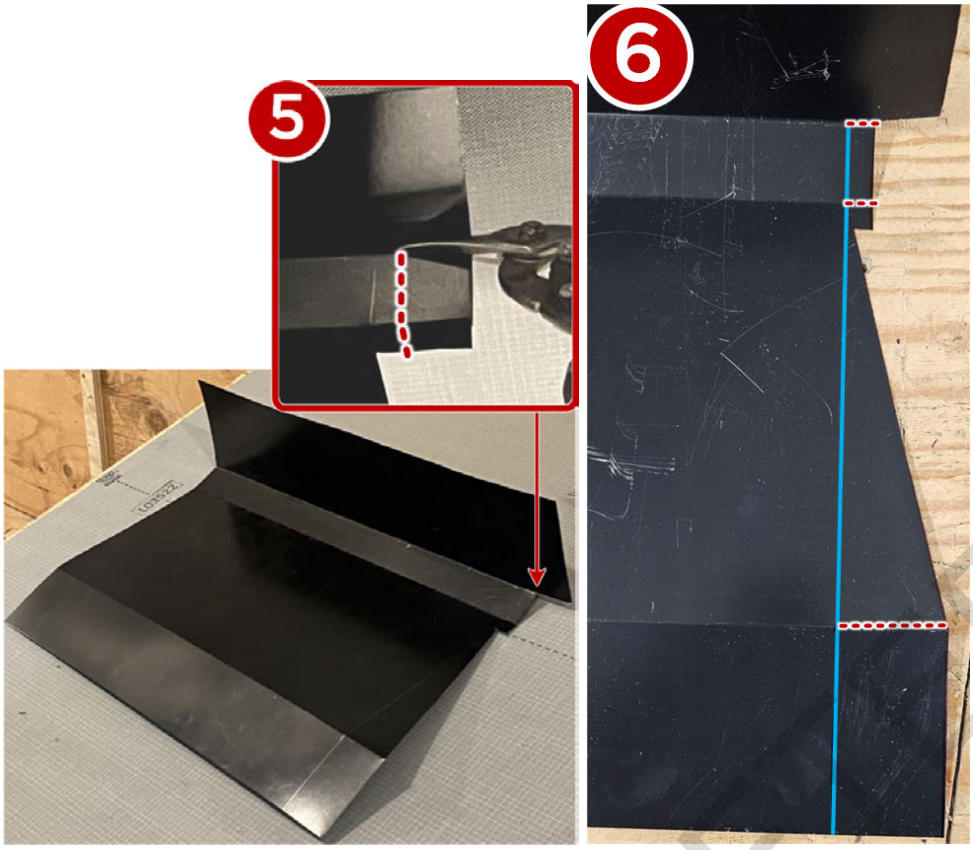
Cut along the diagonal line from step 2 and along the bottom horizontal tab line from step 3 **(4)**.

NOTE: Do **NOT** cut into the tab marks. Although the diagonal line intersects with a tab line, the cut is finished early to keep the tab intact.

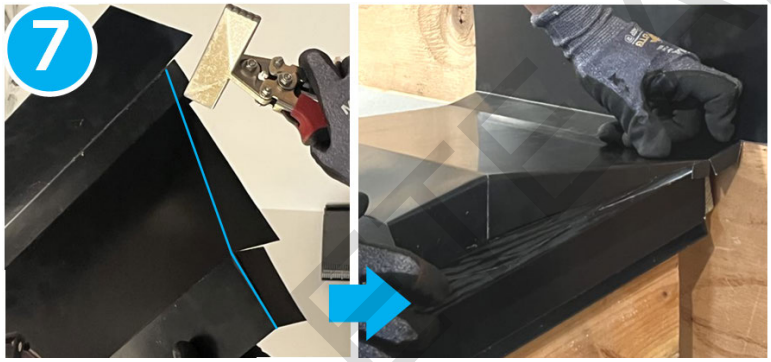


Step 4 result:

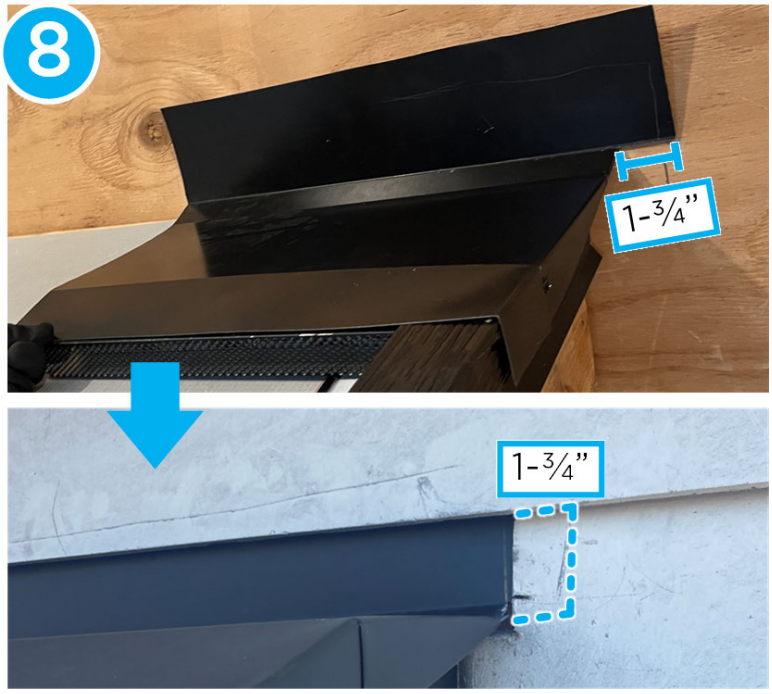
Finish cutting out the tab **(5)**. Then, add relief cuts into the transition flashing to allow for easier bending **(6)**. This will also split the tab into two tabs.



Make a 90° bend along the remaining line drawn in step 1. Then, place the transition flashing over the channel flashing **(7)**.



Ensure that 1¾ in of the transition flashing slides in behind the siding and past the rake **(8)**. If the metal cannot be placed behind the wall, cut it to be flush with the wall and cover the intersection with sealant.



Bend and wrap the tabs tightly around the channel flashing washout to close the gap in between the transition flashing and the channel flashing **(9)**.

PRO TIP: Pinch the tabs with seamers to close the gap as much as possible.

Finally, fasten the transition flashing in accordance with the applicable wind tier in the *Fastener Schedule*. Additionally, fasten through both flanges in the transition flashing bend intersection with a self-tapping screw **(10)**. Do **NOT** fasten through the wall / siding and see step 8 for guidance on securing the top flange.

Proceed to install tiles up to the transition flashing.

OPTIONAL: If tile courses are too small to support the transition flashing, install a vented riser under the transition flashing for support. Fasten through the transition flashing and into the riser **(11)**.

- **PRO TIP:** Even if riser installation is not necessary, risers can be used as a reference for the transition flashing's final position throughout installation.

Ridge-Hip

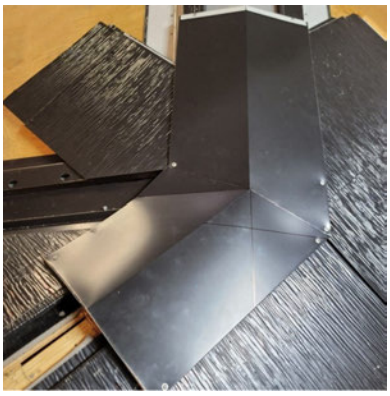
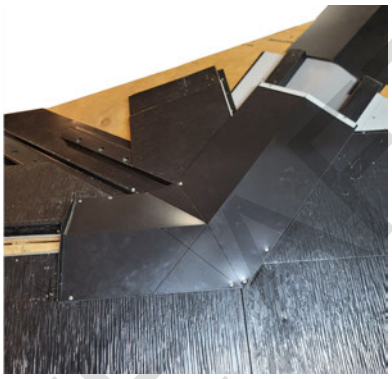
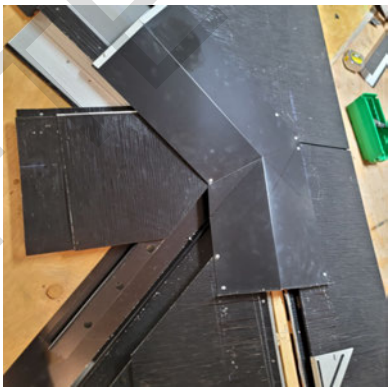
Overview

This document outlines the steps for installing caps at the ridge to hip junction.

Tools & Equipment

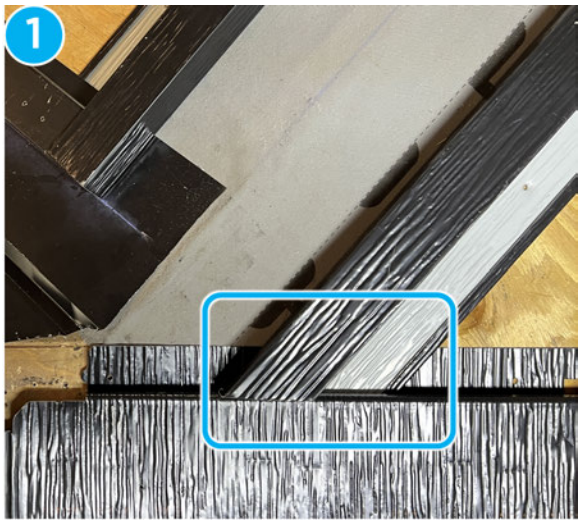
- Ridge caps
- Metal tiles
- Channel flashing
- Metal snips
- Wire mesh
- Robin jig
- Sealant

Finished installation for reference:

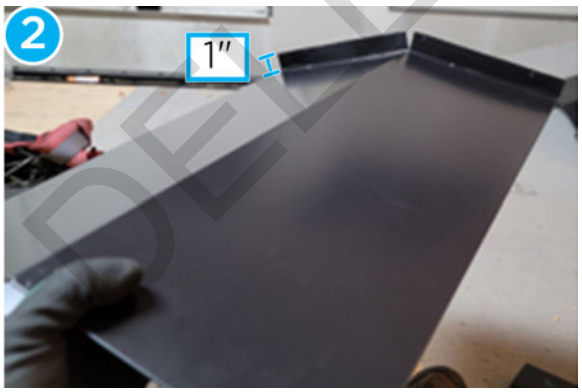





Work Instruction

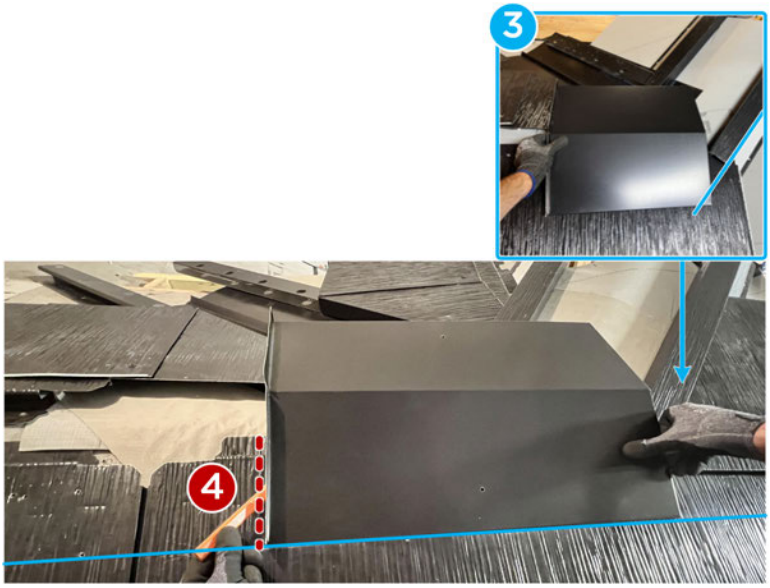
Install metal tiles up to the top of the ridge. Then, make a back cut on the hip channel flashing and install the flashing flush with the top of the tile **(1)**.



Cut off the cleat of a hip cap and fabricate a 1 in turn-up **(2)**.



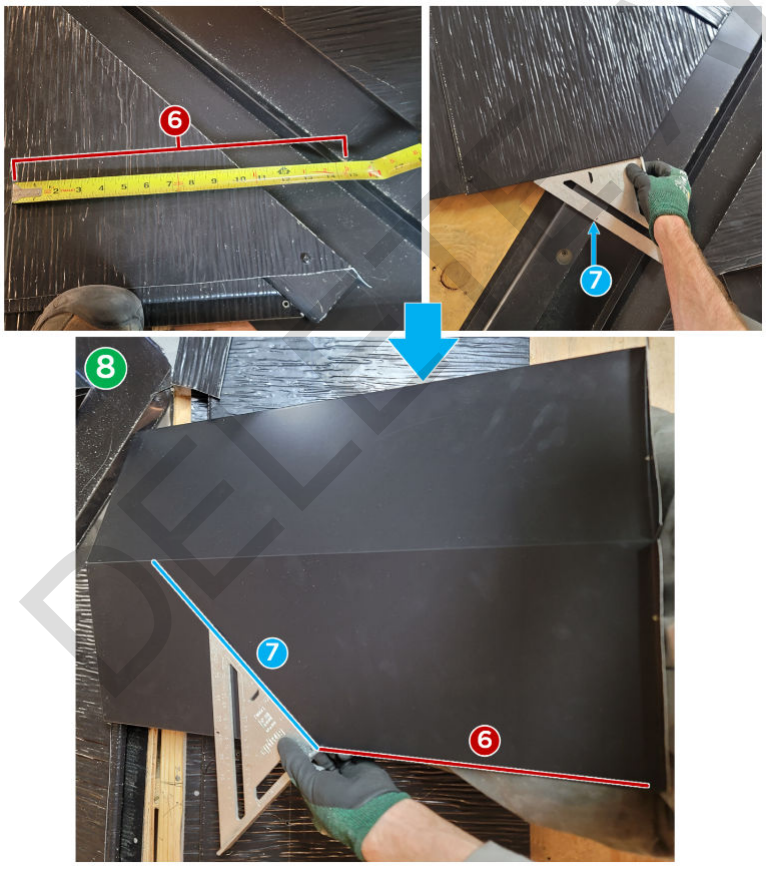
Snap ridge layout lines using the *Robin Jig on page 603*. Ensure the corner of the cap extends past the channel flashing **(3)**. With the cap in this position, make a mark along the turn-up **(4)**.



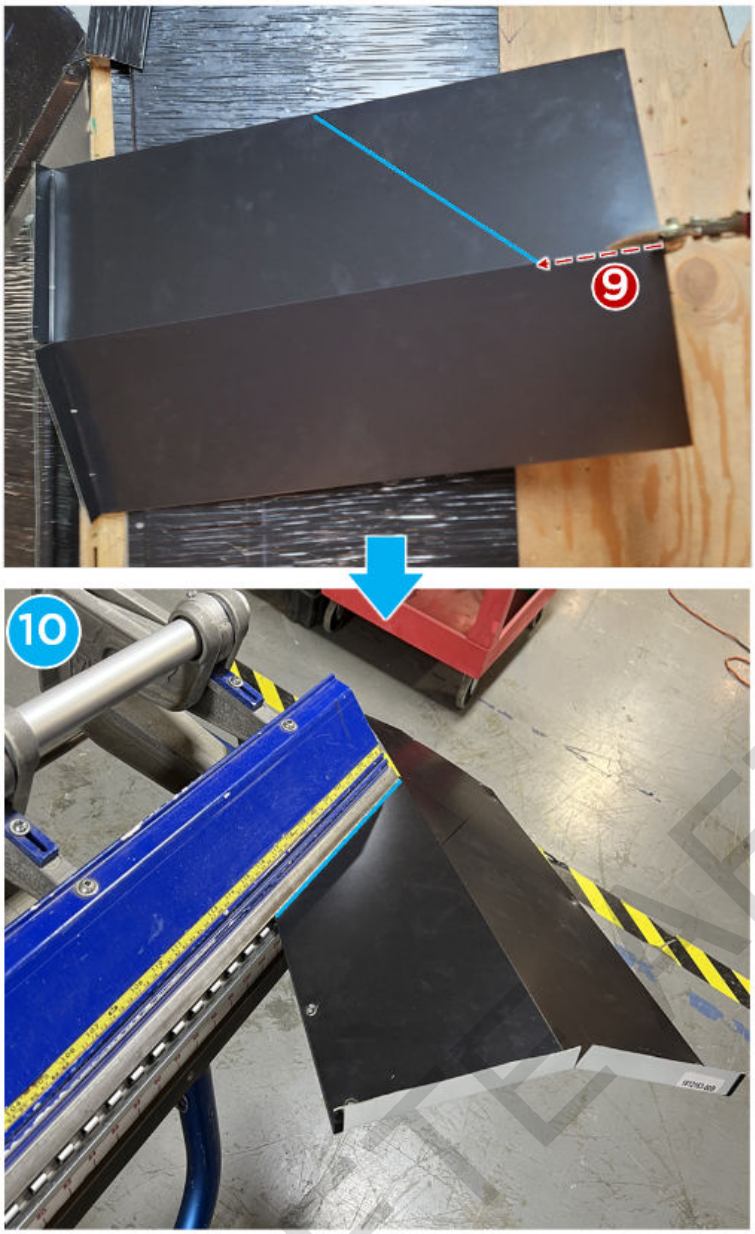
Move the cap away from the hip and align the front edge of the cap with the line scribed in step 3. Then, on the opposite side of the ridge, create a corner mark in line with step 3's line **(5)**.

Measure the distance between the corner mark made in step 4 and the valley center **(6)**. Determine the valley angle using a speed square **(7)**.

Transfer the valley measurement from step 5 onto the cap using the turn-up as a starting point. Then, beginning at the valley measurement and ending at the cap center, transfer the valley angle onto the cap as well **(8)**.



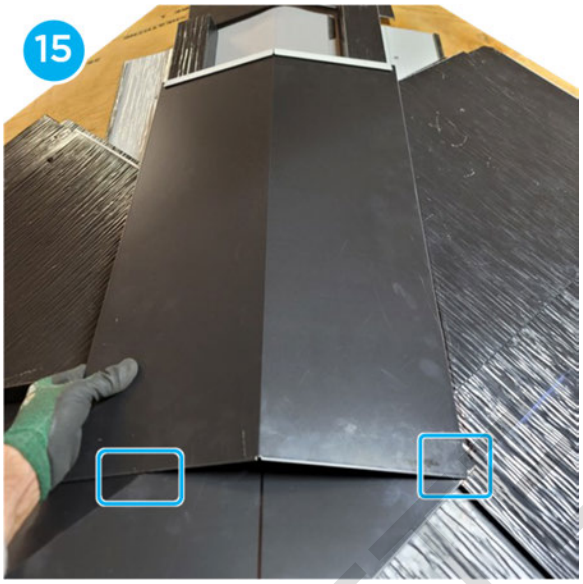
Make a relief cut in the cap center up to the valley angle line **(9)**. Brake the cap on this line to the pitch of the roof **(10)**.

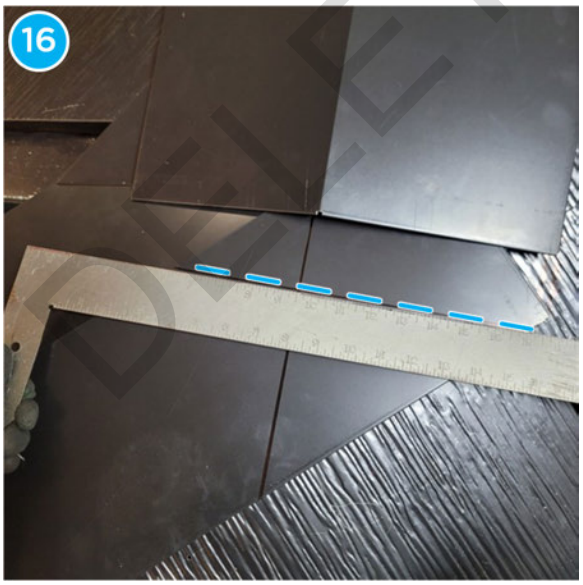


Install wire mesh at the valley opening **(11)**. Then, locate the ridge-hip intersection. **(12)**. Install the cap square over the ridge and centered on the ridge-hip intersection (use the *Robin Jig on page 603* to square the cap). Fasten the cap with exposed fasteners at the locations pictured below **(13)**.

Scribe a hip line onto the installed ridge-hip cap **(14)**. Align another hip cap (which will become the valley cap) with the hip center and the line scribed in step 13.

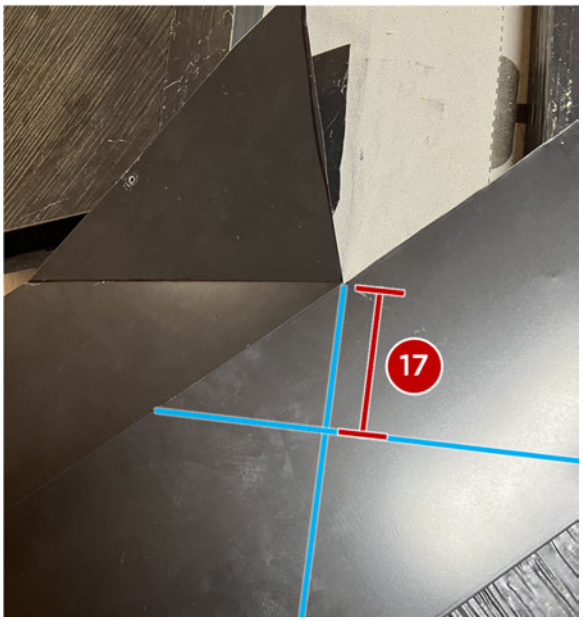
Then, move the valley cap down until it intersects with both the center and the bottom side of the ridge-hip cap. Mark these intersections **(15)**and connect them with a scribed line **(16)**.

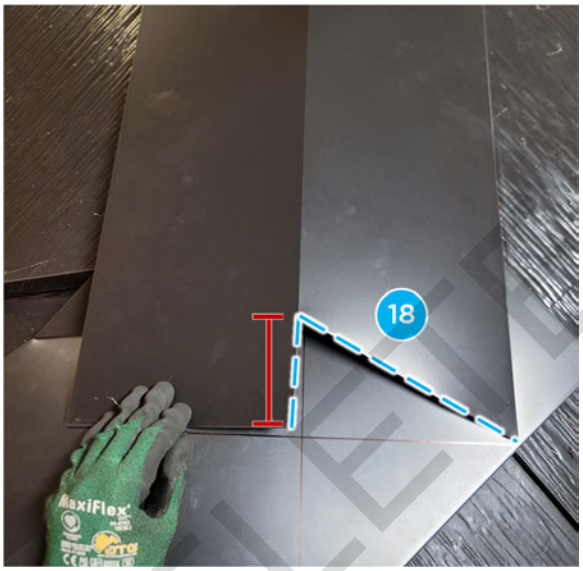


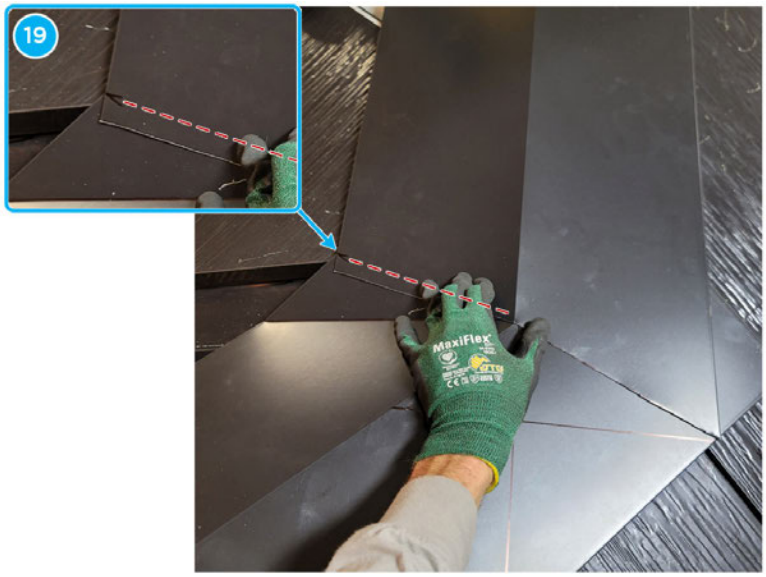


Measure the distance between the line intersection and the relief cut made in step 8 **(17)**. Make an angled cut of the same length on the valley cap **(18)**.

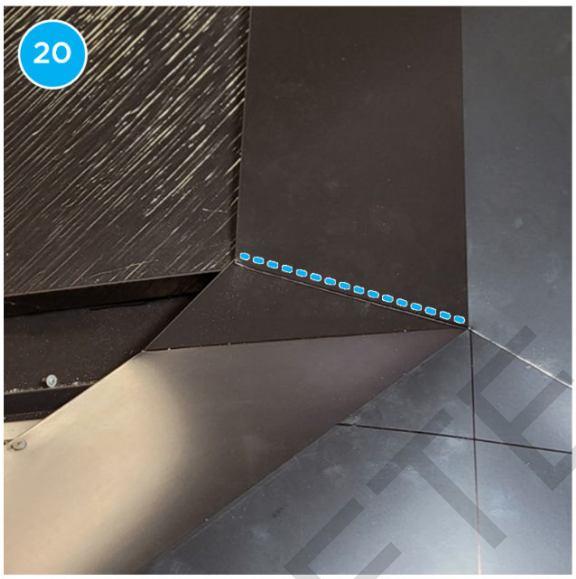
Trim the valley side of this cap until it can lay flat over the ridge-hip cap. Mark the point where both caps intersect and cut off excess metal beneath it **(19)**.

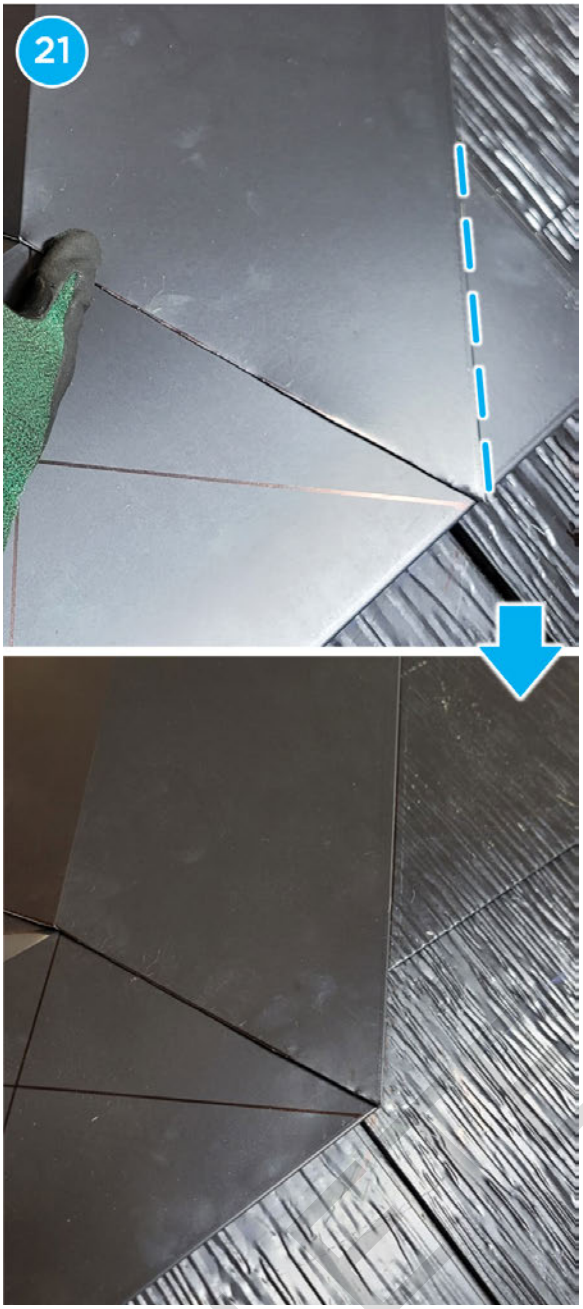




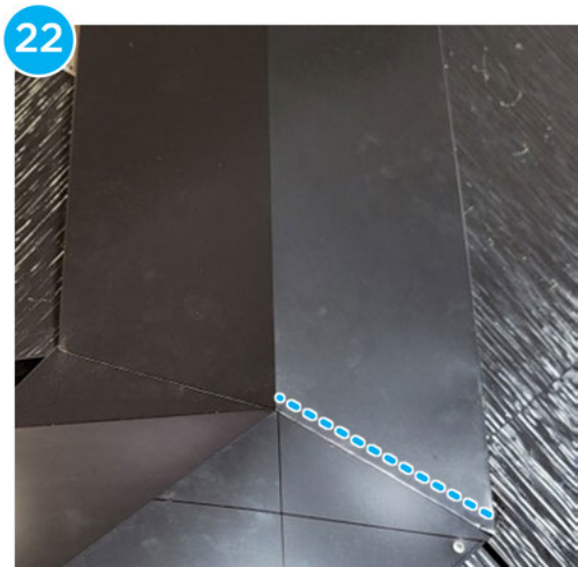


Apply sealant beneath the seam **(20)**. Then, cut away the excess corner metal from the ridge-hip cap underneath the valley cap **(21)**.

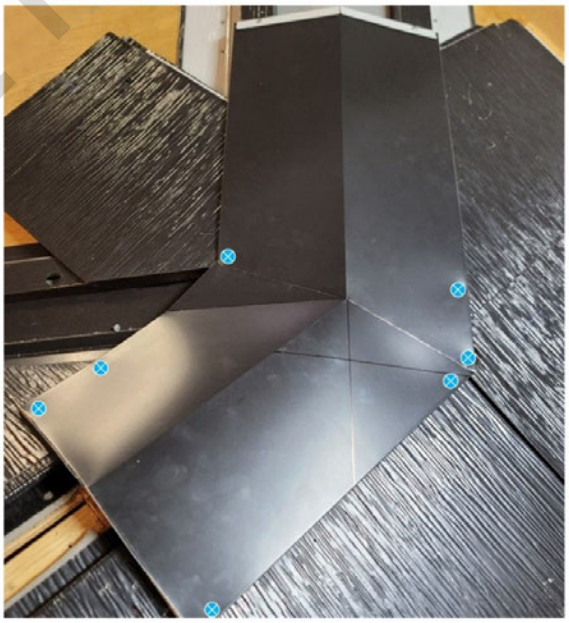




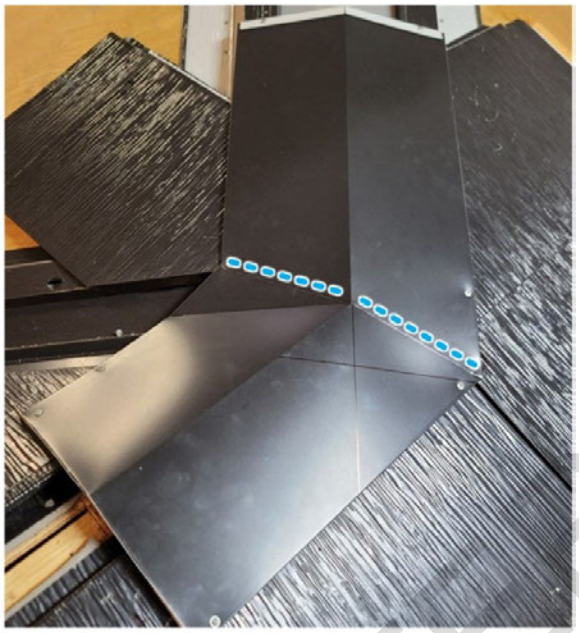
Apply sealant under the opposite seam **(22)**. Fasten the valley cap with exposed fasteners at the locations pictured below **(23)**:



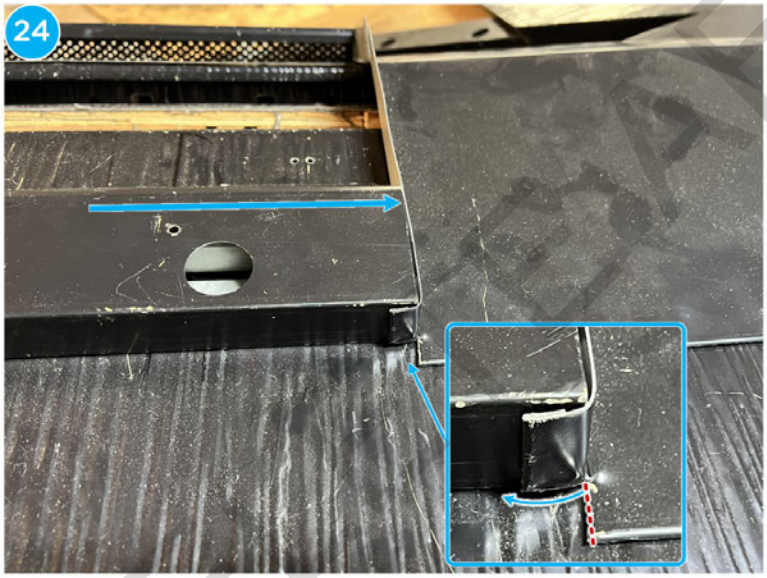
All final valley / ridge cap fastener and sealant locations for reference:

Fastener Locations


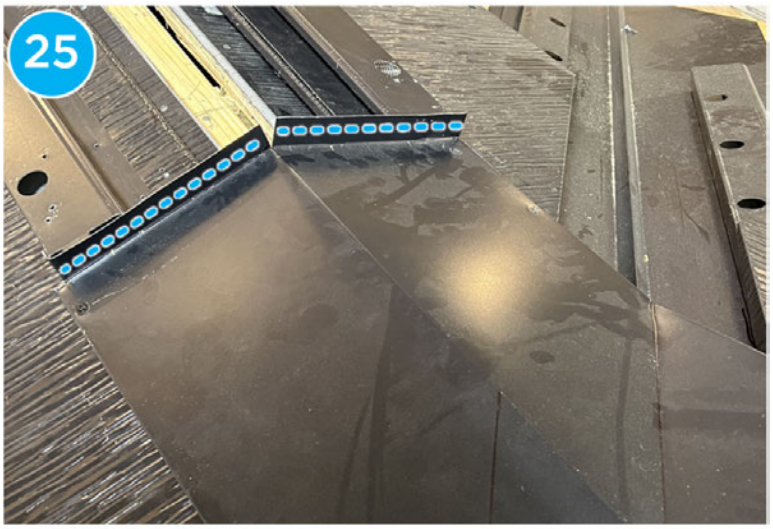
Sealant Locations



Position vented risers tightly against the ridge-hip cap turn-ups. Cut tabs out of the turn-up outer edges and bend tabs to sit flat against the vented risers **(24)**.



Apply sealant to both sides of the turn-up **(25)**.



Create a 1 in turn-down on the following hip cap to lap over the ridge-hip turn-up. Install and fasten this cap with exposed fasteners at the locations pictured below **(26).**

Hip-Rake

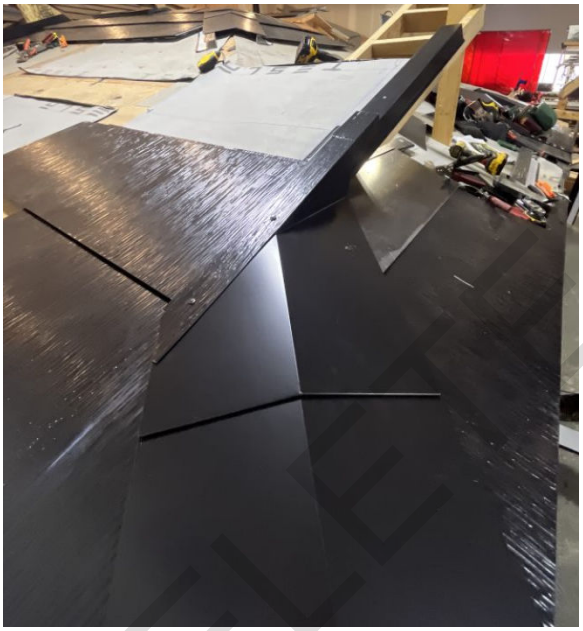
Overview

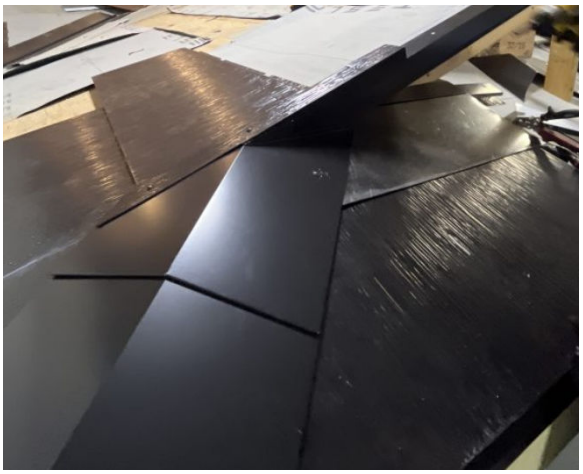
This document provides instructions for installing channel flashing, transition flashing and hip caps at the hip-to-rake junction.

Tools & Equipment:

- Hip caps
- Underlayment
- Channel flashing
- Metal snips
- Transition flashing
- Robin jig
- Drip metal
- Speed square
- Sealant

Finished installation for reference:



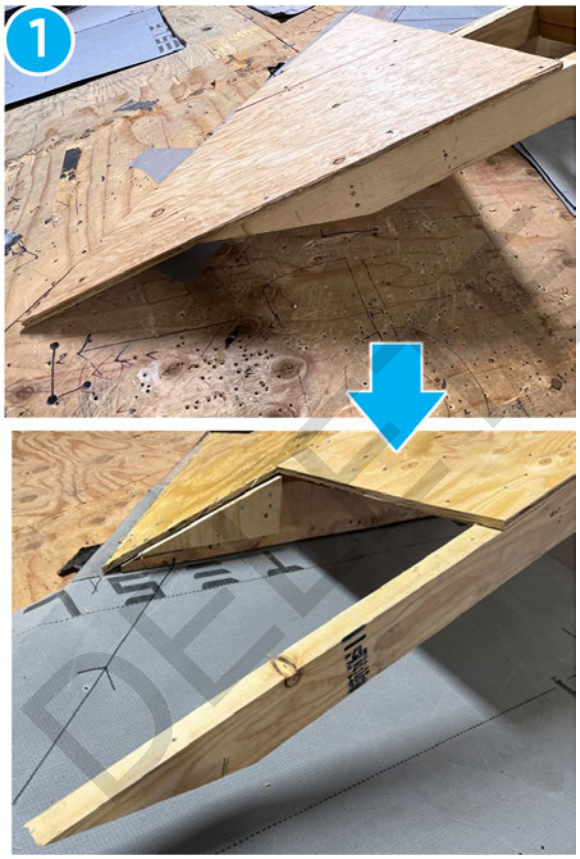


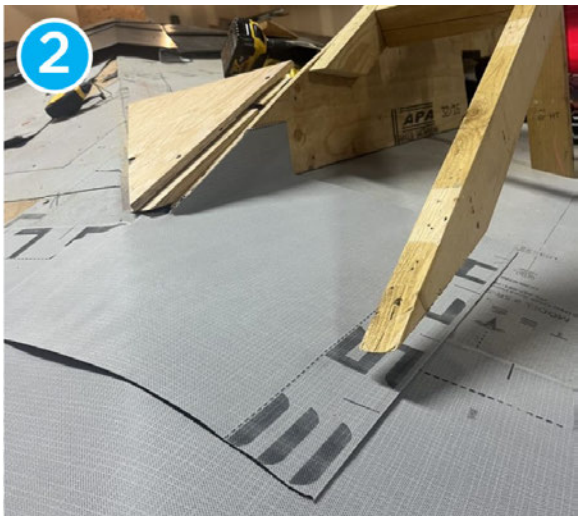
Work Instruction

Undershot Fabrication

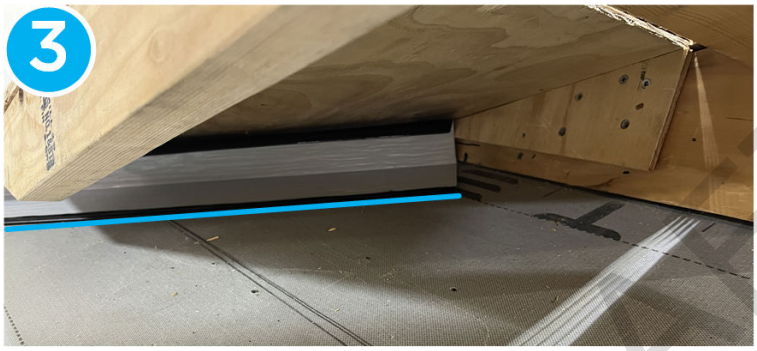
NOTE: Ensure fascia board is cut to the height of channel flashing before beginning.

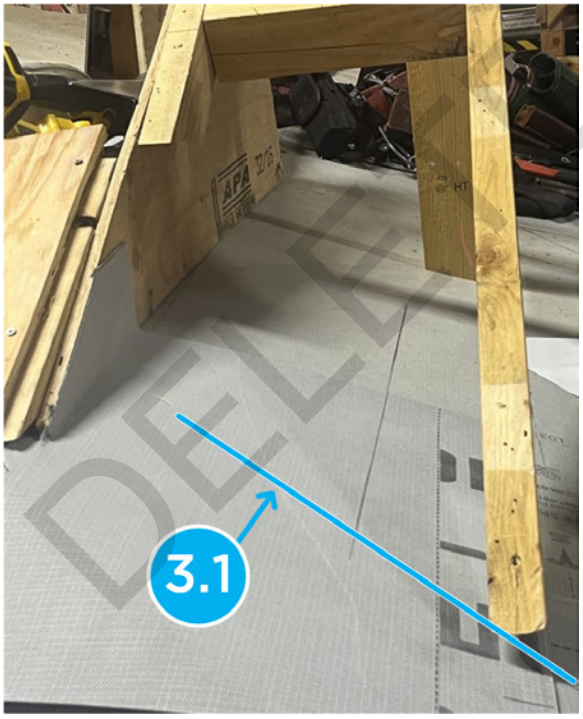
Remove decking from the undershot **(1)** and lap underlayment over the hip **(2)**. If possible, turn underlayment up the undershot headwall.





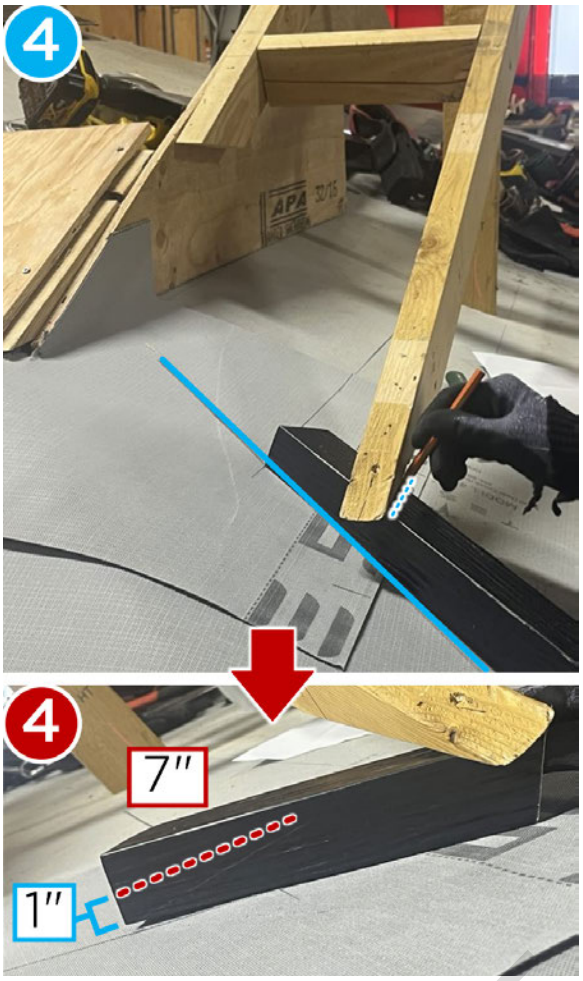
Place the decking back over the undershot and position a piece of channel flashing tight to the undershot back wall **(3)**. Then, mark a control line across the channel flashing edge **(3.1)**.

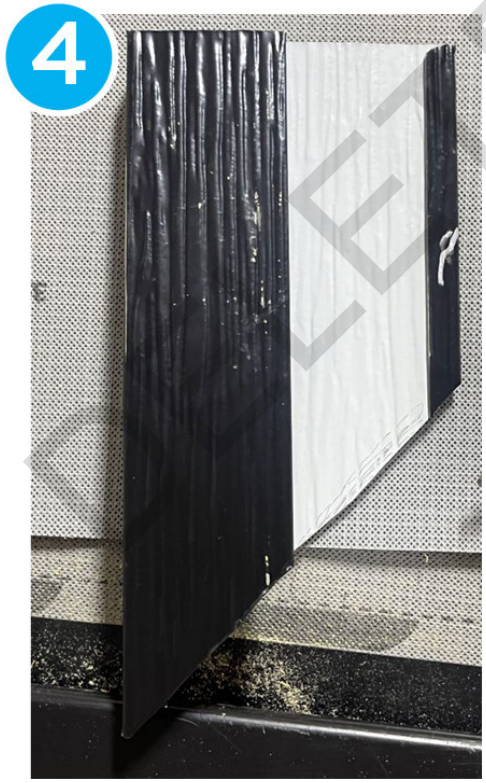


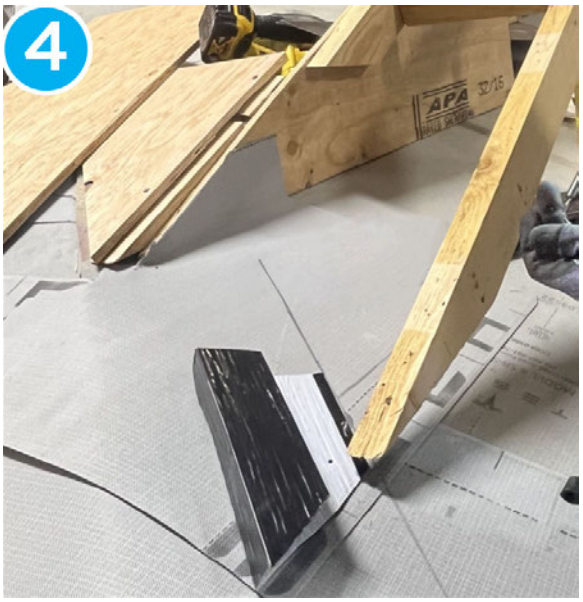


Align the channel flashing back wall with the flashing control line. Mark and cut the channel flashing in line with the fascia board front face. Add a relief cut to the side of the channel flashing beginning 1 inch from the base flange and 7 inches across the flashing (this will allow it to sit flat under the transition flashing).

Finally, install the channel flashing in line with the flashing control line **(4)**.

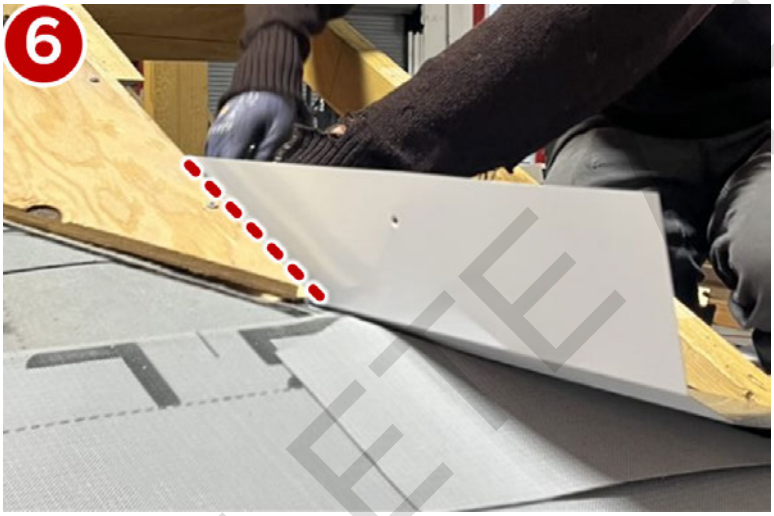




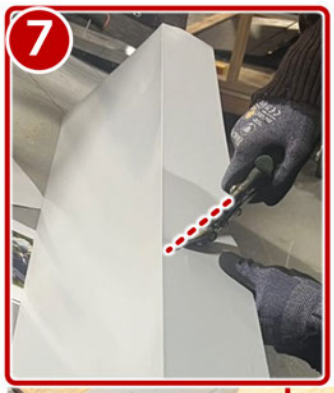


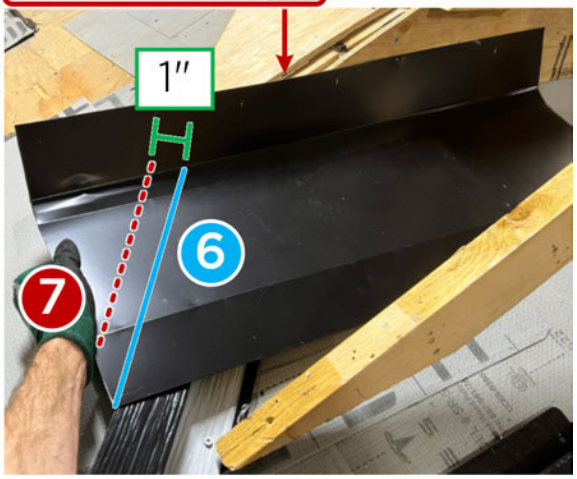
Position transition flashing against and the wall and past the channel flashing **(5)**.

Mark the point where the channel flashing and transition flashing intersect. Then, scribe a line along the decking on the back flange. Draw a line connecting these points **(6)**.

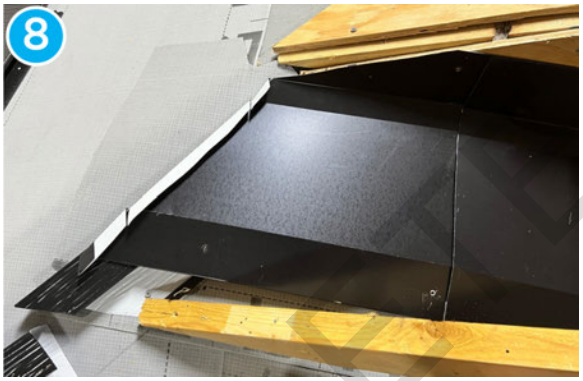


Draw an additional line 1 in away from the line drawn in step 8. Cut excess material off the back flange line and the 1 in line. Finally, create a 1 in open hem along the remaining line **(7)**.





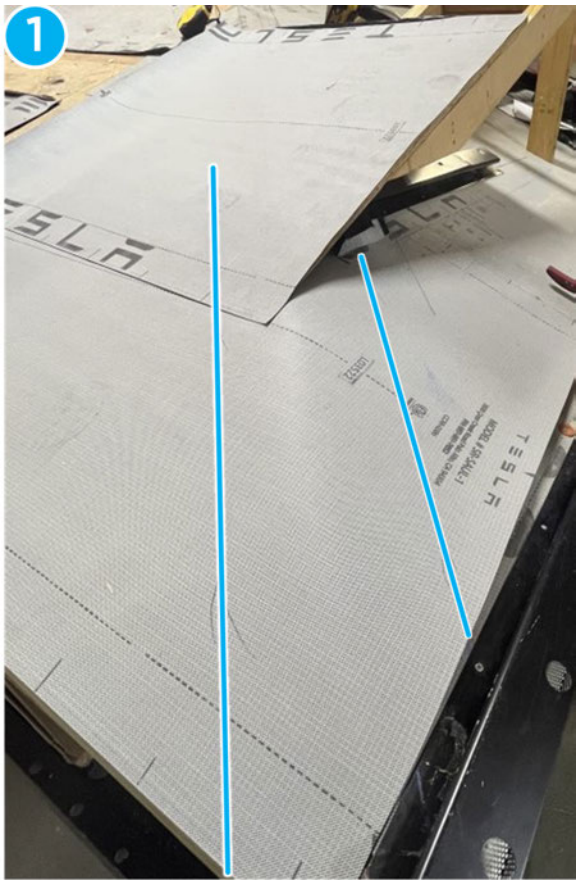
Install the transition flashing over the channel flashing **(8).**



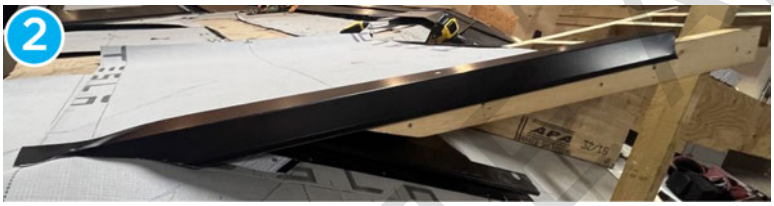
Re-install the decking and apply underlayment on top **(9)**. The transition flashing should sit tight against the decking.

Hip Assembly

Use the *Robin Jig on page 603* to snap control lines over the hip **(1).**



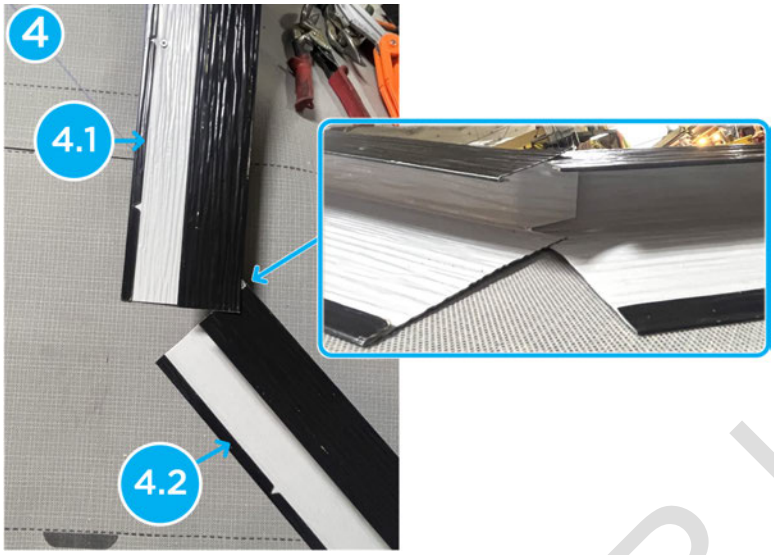
Install drip metal over the rake. To cover the rake edge, cut the drip metal to match the angle of the roof **(2)**.



Cut a tab out of a piece of rake channel flashing. Position and install the flashing so that the tab intersects with the hip control line **(3)**.

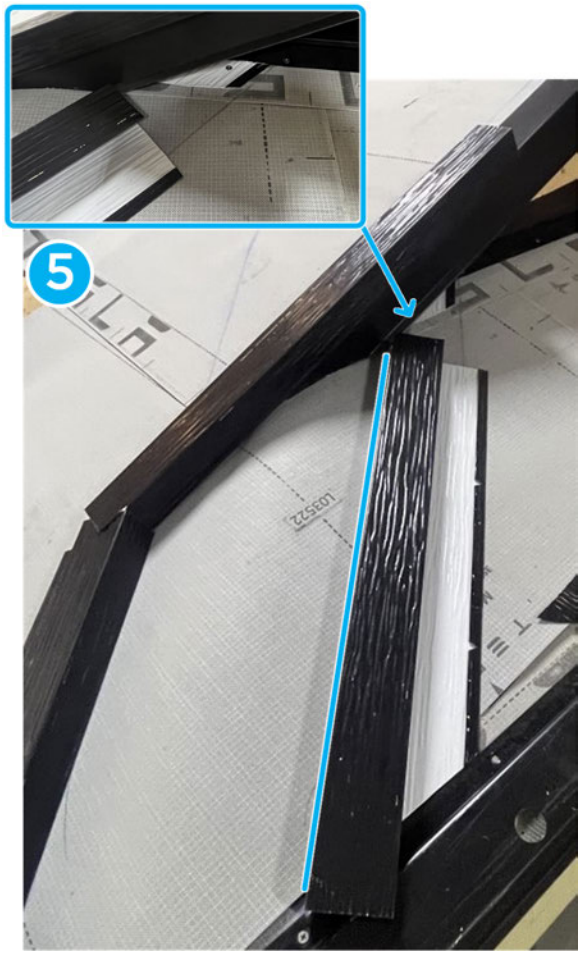
Then, install hip channel flashing along the same control line and properly lapped with the rake channel flashing tab as pictured below **(4)**.

(4.1)	Rake channel flashing
(4.2)	Hip channel flashing

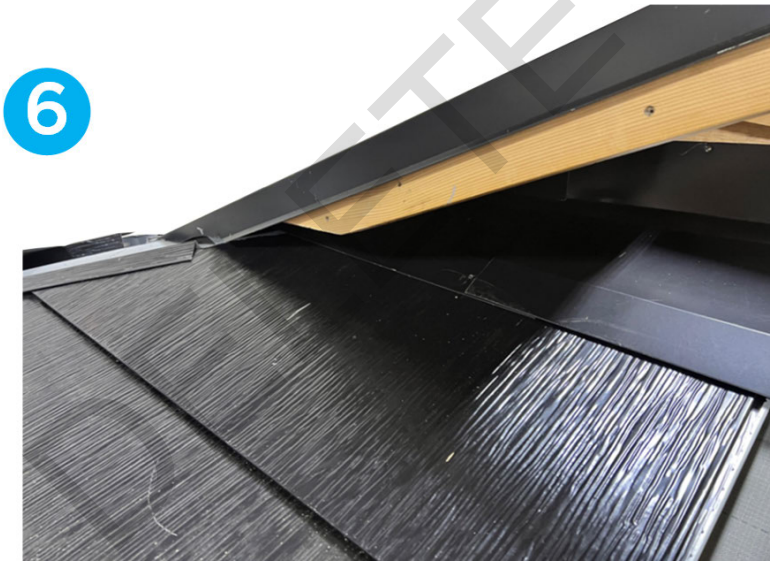


Final view of step 4:

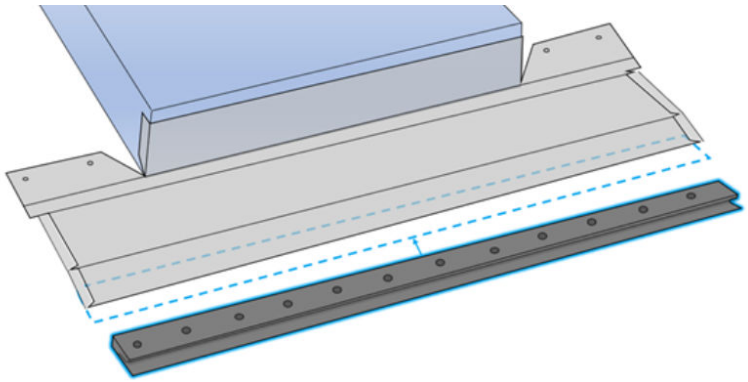
Install another piece of channel flashing over the second control line. Ensure the top of this flashing touches the rake **(5)**.



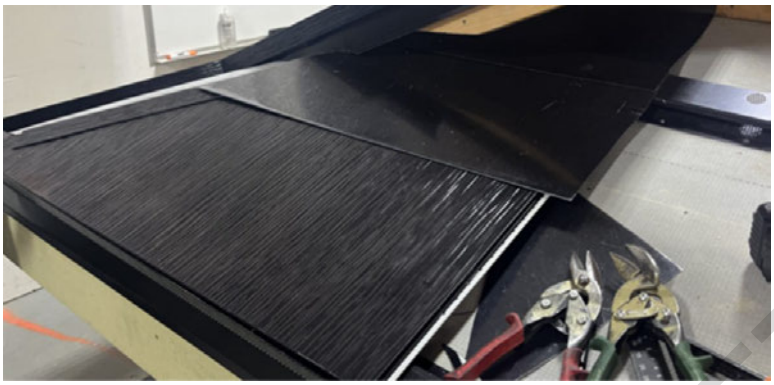
Proceed to *cut and install on page 178* tiles around this junction and up to the transition flashing. Fasten tiles underneath the transition flashing with 3 in deck screws **(6)** Trim drip metal to fit all components as needed.



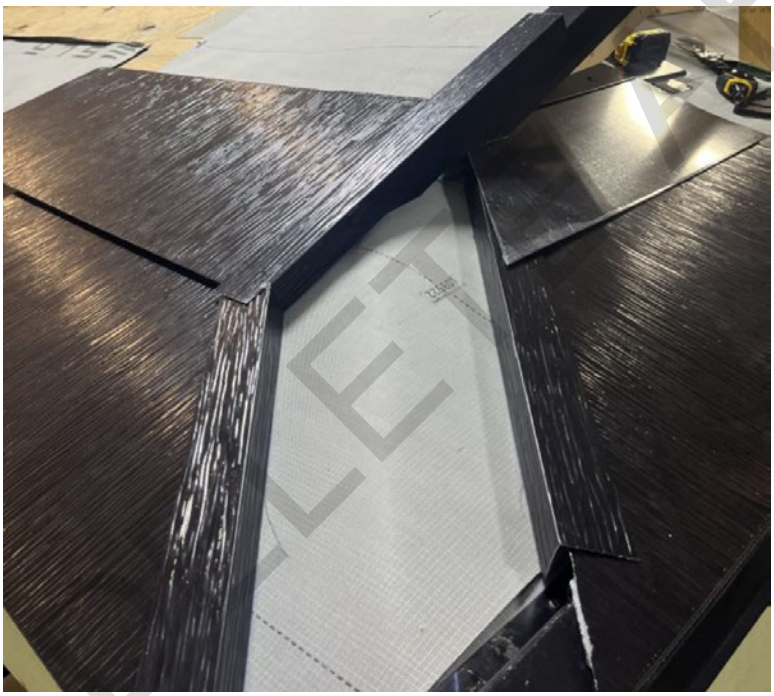
PRO TIP: If the last course of tiles must be cut shorter than the *allowed threshold on page 164* to fit underneath the transition flashing, install a vented riser backwards beneath the down roof flange of the transition flashing for support. Then, install a headwall extension using 90-bit as needed (see *Headwall Deadzone on page 309* for in-depth guidance).



Headwall extension installed at the undershot:

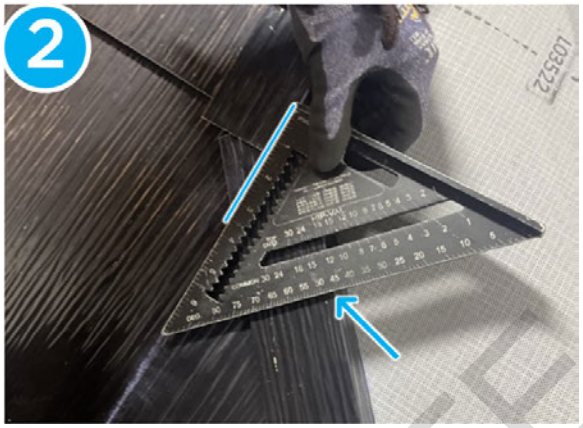


Final view of step 6 (headwall extension pictured):

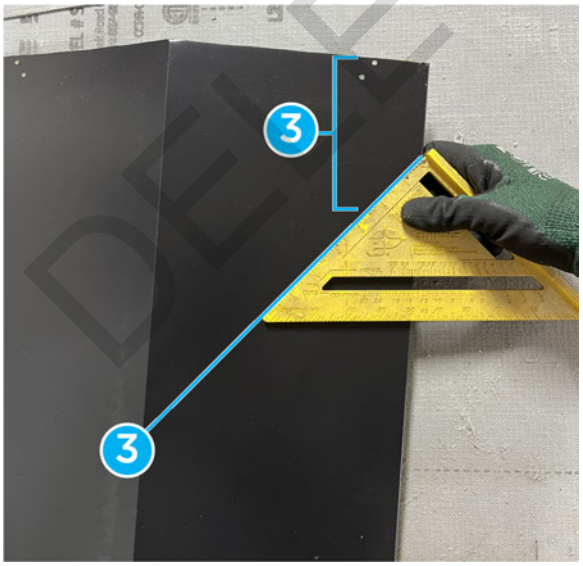


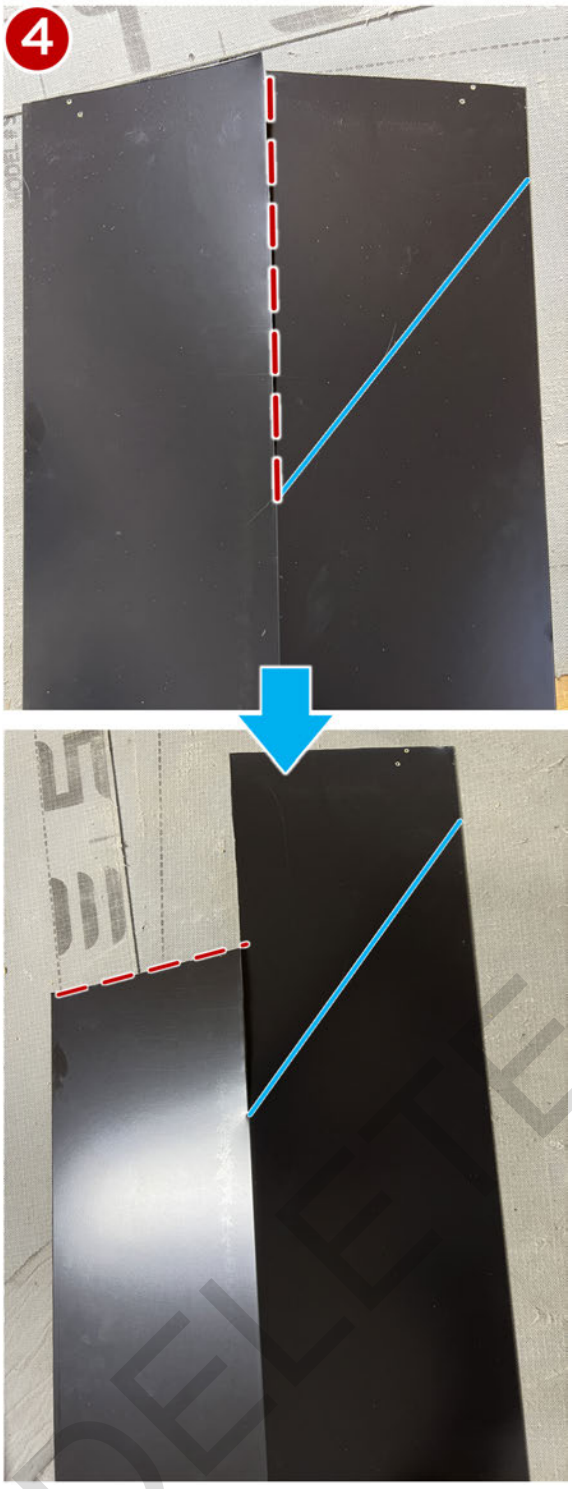
Fabricating and Installing Hip Caps

Install a hip starter cap over the hip channel flashing. Then, snap a line down the rake channel flashing and across the hip channel flashing intersection **(1)**. Determine the hip channel flashing angle using a speed square **(2)**.

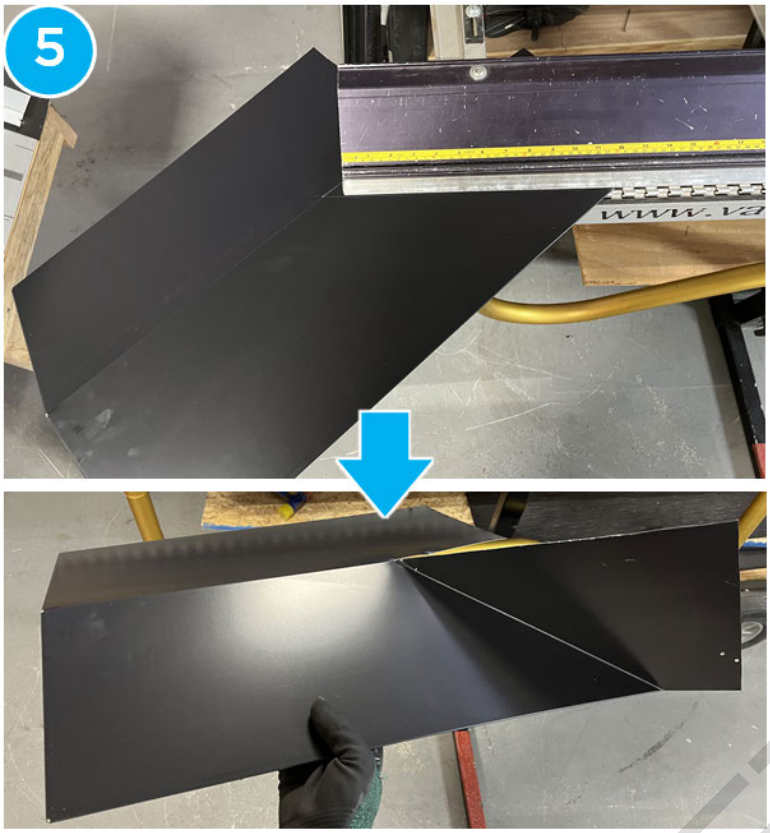


Transfer the hip channel flashing angle onto a standard cap. Ensure **enough material remains to create a turn-up** at the rake edge **(3)**. Cut into the center of the cap until you reach the scribed line. Then, cut off excess metal until there is no brake interference **(4)**.





Brake the cap along the hip channel flashing angle line to 90° **(5)**.

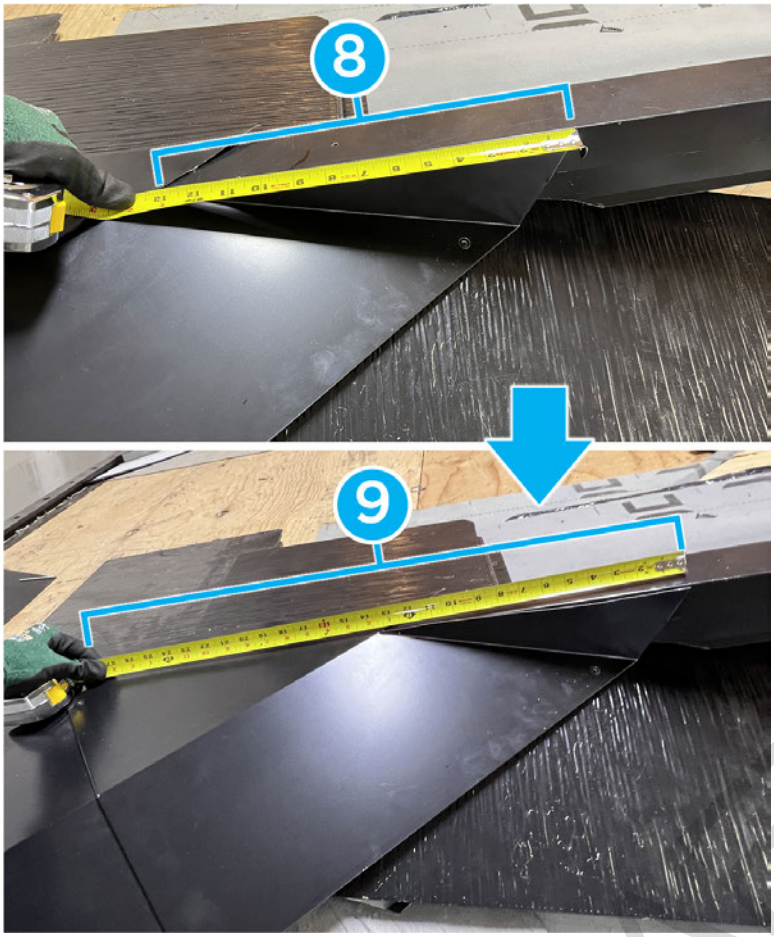


Position the cap along the rake channel flashing and cut off excess metal so that the cap edges are aligned with the rake channel flashing edges **(6)**.

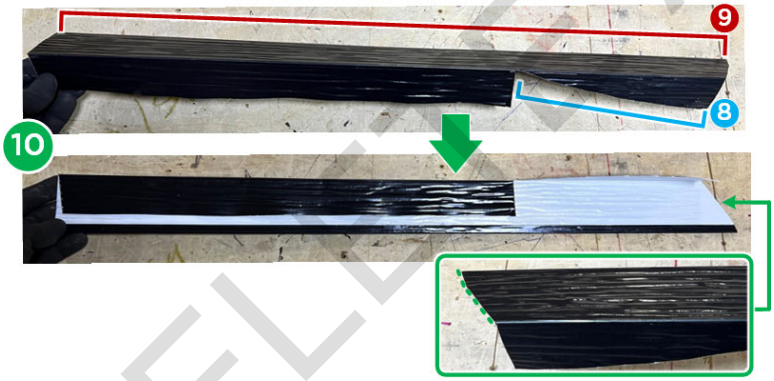
0

Scribe a plumb line onto the turn-up and fabricate a tab that matches the depth of the channel flashing **(7)**.

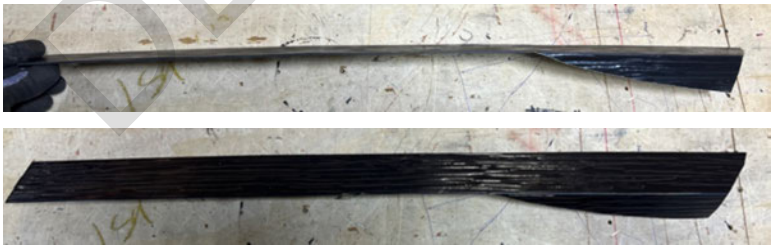
Measure the distance between the hip cap turn-up end / top to the **center of the cap (8)**. Then, measure the distance between the end / top of the hip cap turn-up and the **edge of the cap (9)**.



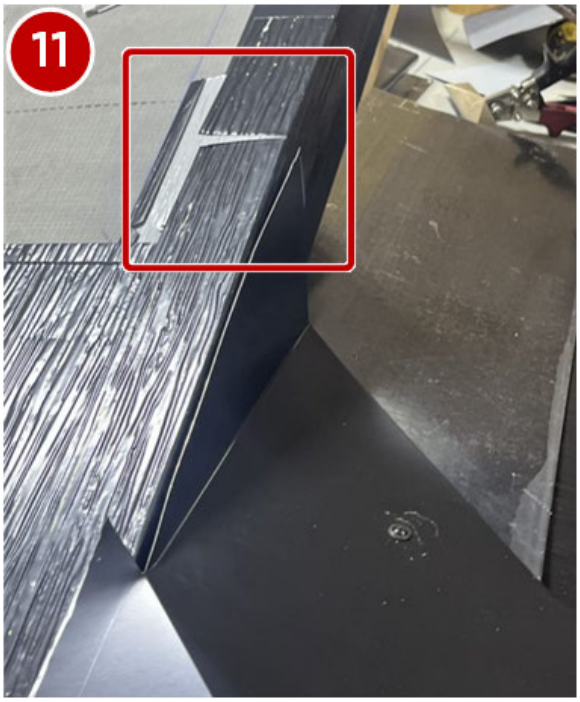
Use these measurements to create a channel flashing cap out of channel flashing. Add an additional 1 in flat section. Finally, hem the channel flashing cap side and make a back cut on the top tab of the cap **(10)**.



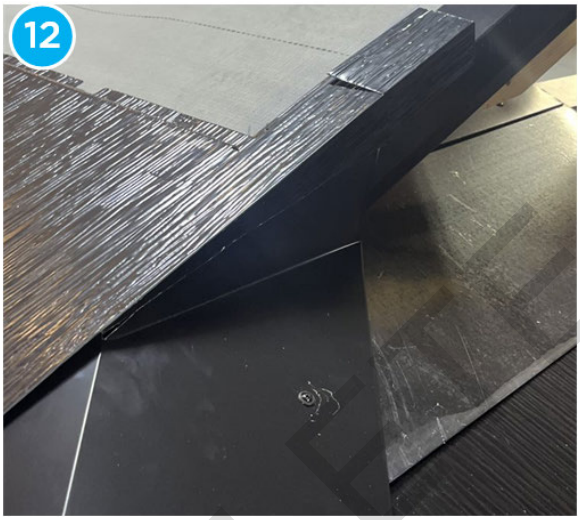
Final channel flashing cap:



Cut a square line on top of the channel flashing and in line with the edge of the hip cap's turn-up **(11)**.



Apply sealant underneath the channel flashing cap top tab and insert the top flat section of the channel flashing cap into the cut channel flashing **(12)**.

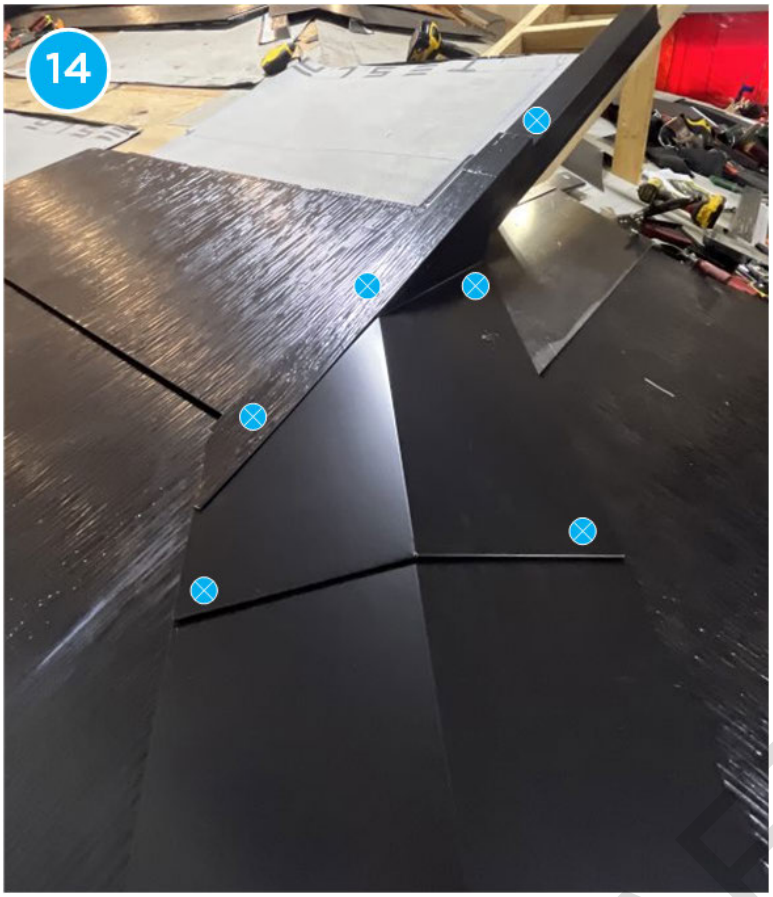


Cut away any excess material so that the channel flashing is aligned with the hip cap and turn-up edges **(13)**.

Finally, fasten the channel flashing cap and hip cap at the locations pictured below with exposed fasteners in accordance with the applicable wind tier in the *Fastener Schedule on page 703* **(14)**.

NOTE: The final cap does not need to engage with a cleat and is instead secured with exposed fasteners as pictured

- Ensure all fasteners in the cap are fastened into the channel flashing
- Ensure all fasteners in the rake channel flashing are fasted ½ in from the other edge so that they aren't fastened into the rake tiles



Sidewall-Headwall on Hip

Overview

This document provides instructions for installing flashing and hip caps at the sidewall-to-headwall junction on hips.

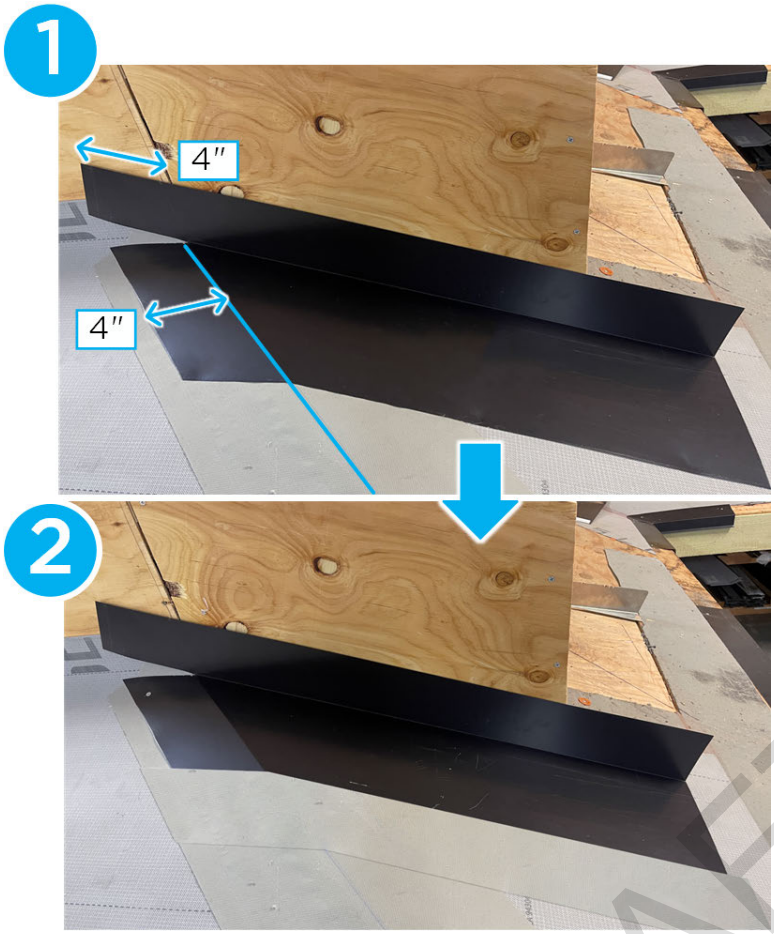
Finished installation for reference:

Work Instruction

Sidewall Flashing Fabrication & Installation

Place sidewall flashing flush against the sidewall with 4 in of metal extending past the hip center. Then, mark and bend the deck portion of the flashing to the angle of the hip **(1)**.

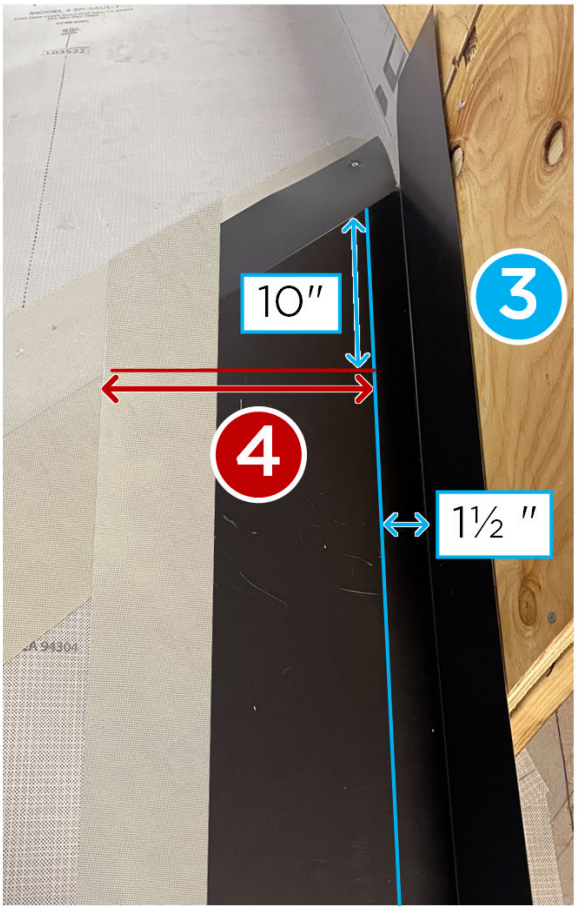
Fasten the sidewall flashing in accordance with the applicable wind tier in the *Fastener Schedule on page 703* and cover fasteners with detail roll **(2)**.



Measure 1 ½ in from the wall and scribe a line across the length of the flashing at this point. Starting at the hip center, measure 10 in along this line with a speed square **(3)**.

Measure the distance between the 10 in point found in step 3 and the hip center. This length depends on the pitch of the hip, meaning it could be different in every installation **(4)**.

NOTE: The measurement from step 4 will be used later in step 2 of the *Transition Flashing Fabrication & Installation on page 531* procedure.



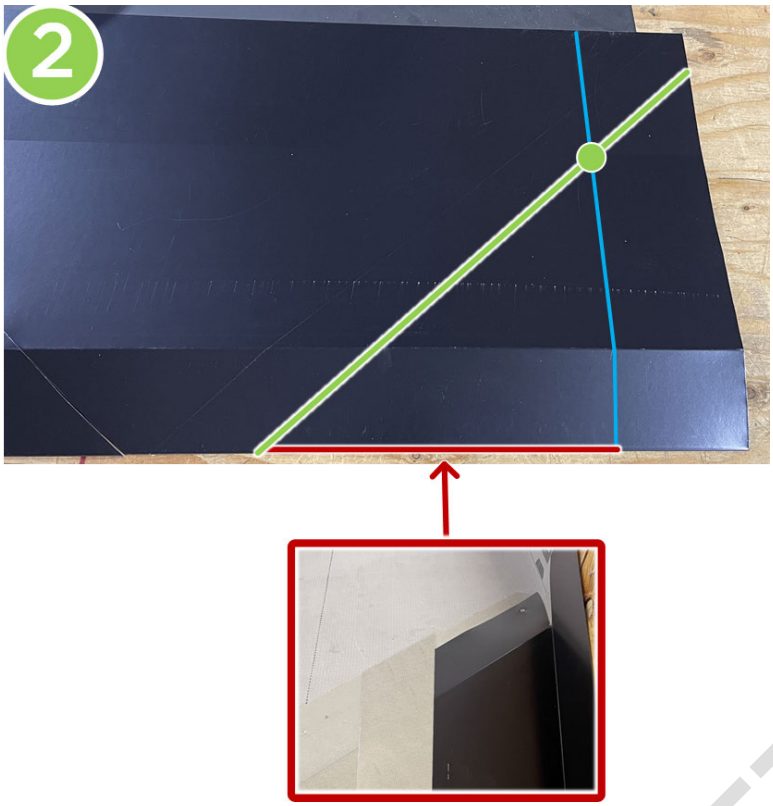
Transition Flashing Fabrication & Installation

Two pieces of transition flashing will be fabricated and installed in this portion of the process:

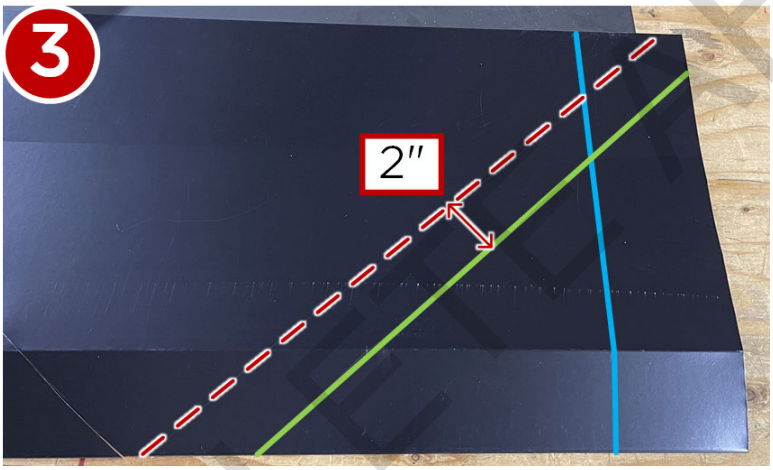
- One piece of headwall transition flashing
- One "triangle" shaped piece to cover the gap between the headwall transition flashing and the sidewall flashing

Measure 4 in from the edge of standard transition flashing and scribe a line across the flashing at this point. Then, measure and mark 10 in on this line starting from the bottom edge **(1)**.

Beginning from the 4 in line, transfer the measurement from step 4 of *Sidewall Flashing Fabrication & Installation on page 529* to the bottom edge of the transition flashing. This will determine the width of the "triangle" gap piece. Starting from the opposite end of this measurement, draw a diagonal line that intersects with the 10 in point **(2)**.

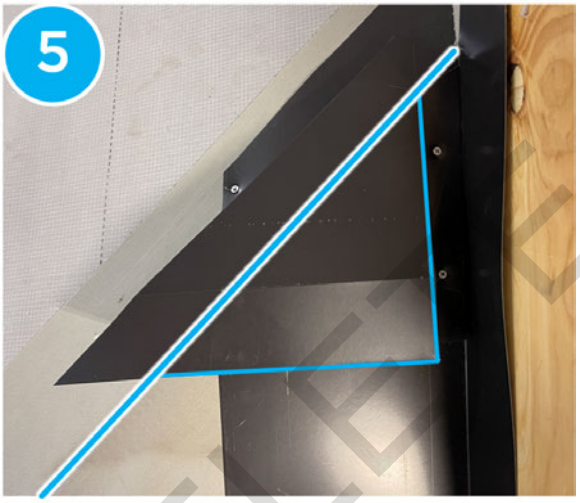


Measure, mark and cut along a second diagonal line 2 in from the line drawn in step 2 **(3)**.

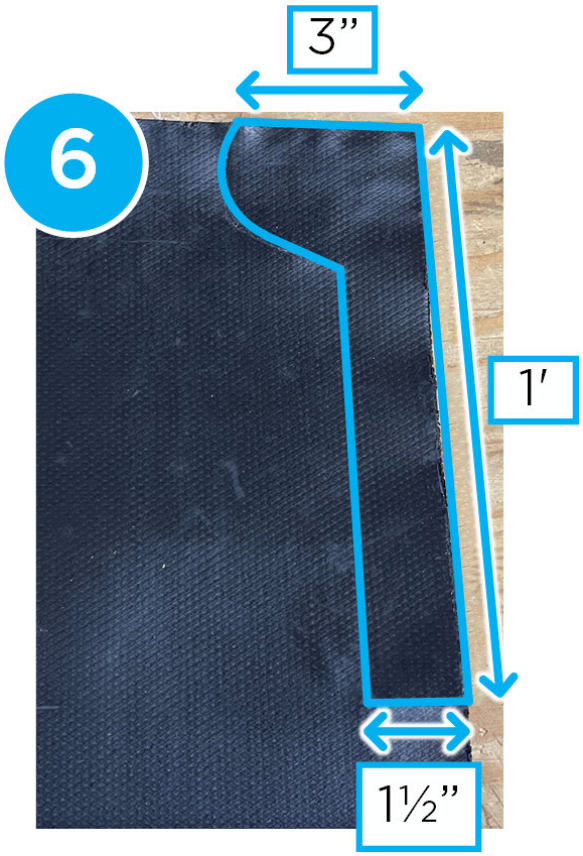


Create a "turn down and out" on page 307 in the new "triangle" piece of transition flashing (ensure the vertical face 1 ¾ in long). Then, make a relief cut at the top corner **(4)**.

Place this piece of transition flashing over the sidewall flashing and align the remaining diagonal line with the hip center **(5)**.



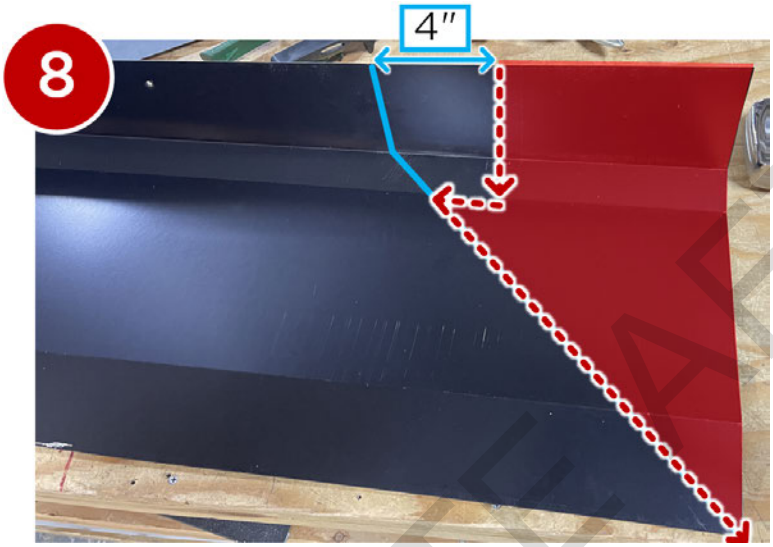
Cut a piece of flexible flashing to be 1 ft long, 1 ½ in wide on one end and extend to 3 in wide on the opposite end. Apply the flexible flashing over the intersection between the transition flashing piece and the sidewall flashing **(6)**.



Step 6 result:

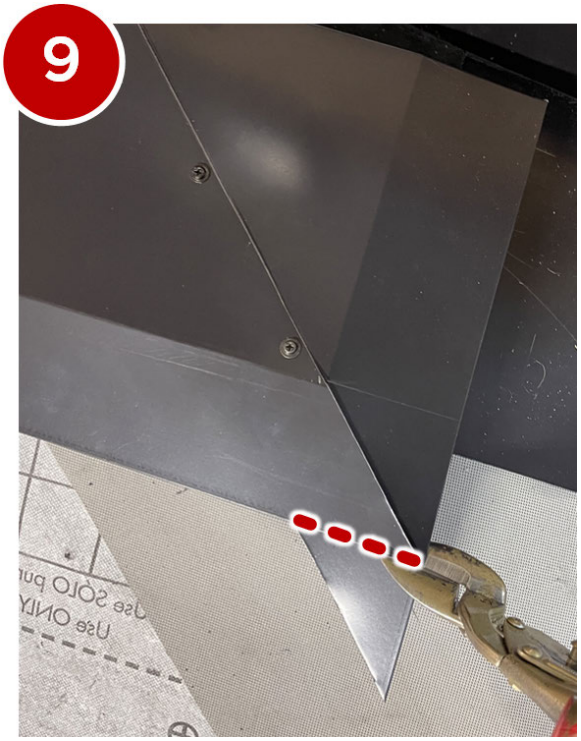
Place a full piece of headwall transition flashing over the sidewall flashing. Ensure the edge of the transition flashing is aligned with the hip center. Then, mark the angle of the hip across this transition flashing using a speed square **(7)**.

Measure 4 in from the line scribed in step 10. Cut into this 4 in point, then cut towards the diagonal line along the lowest bend in the upper flange and finish by cutting along the remainder of the diagonal line **(8)**.

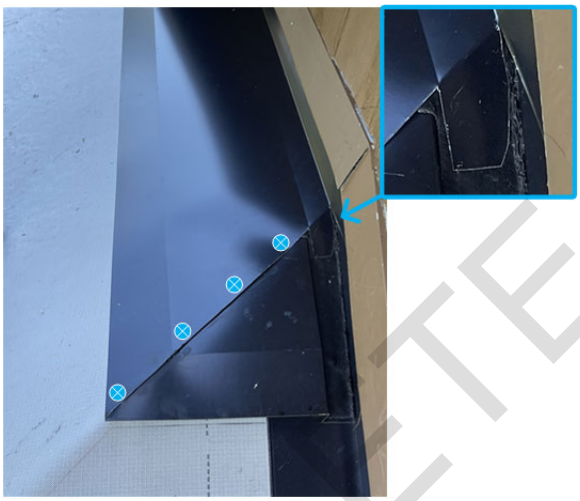


Install the headwall transition flashing and cut off the excess metal **(9).** Fasten in accordance with the applicable wind tier in the *Fastener Schedule on page 703*.

9



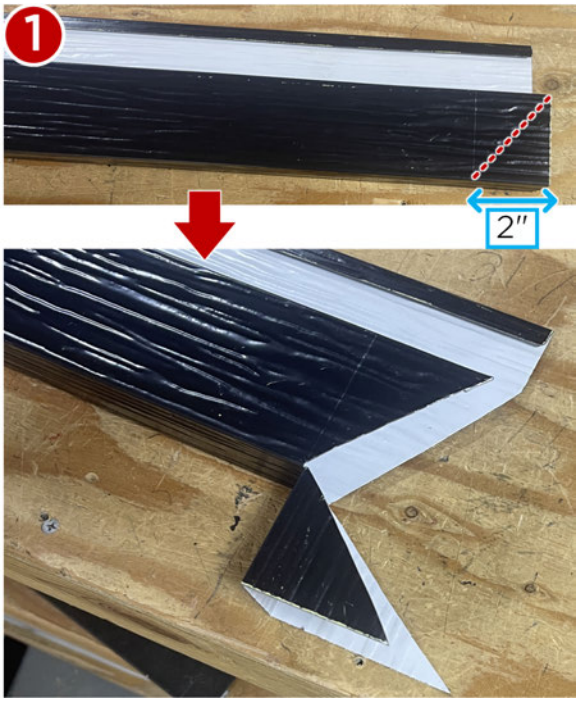
Final view of tab / transition flashing:



PRO TIP: The lowest fastener will need to be removed to properly install the hip cap during *Hip Cap Fabrication & Installation on page 537*.

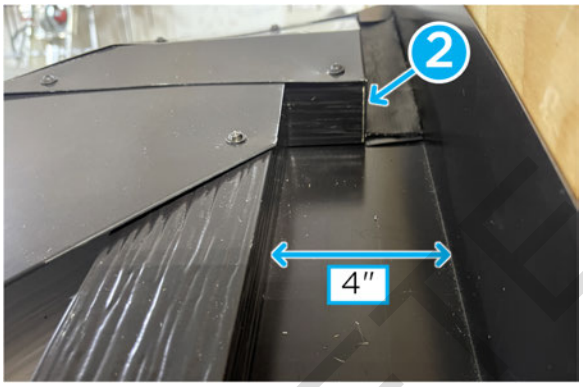
Channel Flashing Fabrication & Installation

On standard channel flashing, measure 2 in from the edge of the top flange. Then, draw a 45° line beginning at the 2 in mark. Cut into the 45° line but do **not** completely remove the metal as this will create a tab to cover the transition flashing gap. Repeat this step on the bottom flange **(1)**.



Install the cut channel flashing underneath the transition flashing, ensuring it effectively closes the gap **(2)**.

PRO TIP: Position the channel flashing so that the gutter remains 4 in wide.



Proceed to install channel flashing at the hip to support hip caps, see Installing Channel Flashing at Hips.

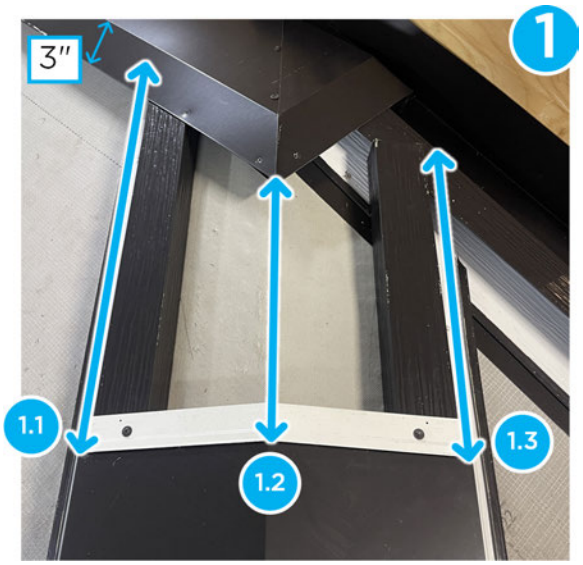
Hip Cap Fabrication & Installation

Begin by fabricating and installing a hip starter cap over the channel flashing. Then, fabricate a hip cap to fit underneath the transition flashing.

Make the following measurements **(1)**:

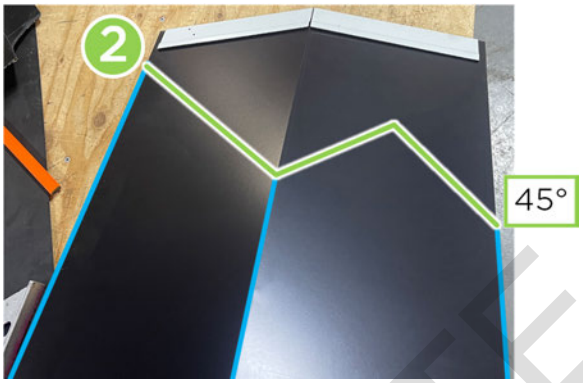
- **(1.1)** This distance between starter cap cleat and the transition flashing side (increase this measurement as needed to ensure that the hip cap will lands within 3 in of the transition flashing)
- **(1.2)** The distance between the starter cap cleat and the diagonal channel flashing
- **(1.3)** The distance between the starter cap cleat and the transition flashing over the hip center

NOTE: These measurements will likely each be different from each other.

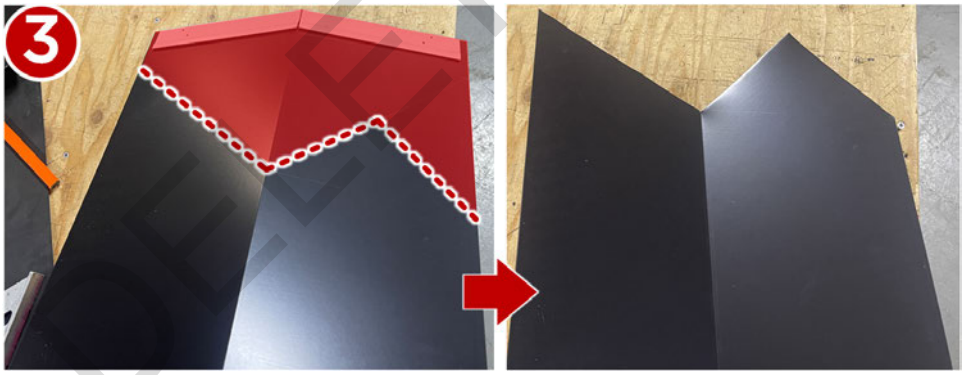


Transfer those measurements onto a standard hip cap and connect the measurements with diagonal lines across the hip cap **(2)**:

- Draw a line between measurements 1.1 and 1.2
- Draw a 45° line starting from measurement 1.3 and finish the connection to 1.2 with another diagonal line



Cut off the excess metal **(3)**.



Install the fabricated hip cap over the channel flashing and engage the cleats. Fasten according to the applicable wind tier in the *Fastener Schedule on page 703* **(5)**.

Angled Wall

Angled Wall - Eave to Angled Wall

Tools & Equipment:

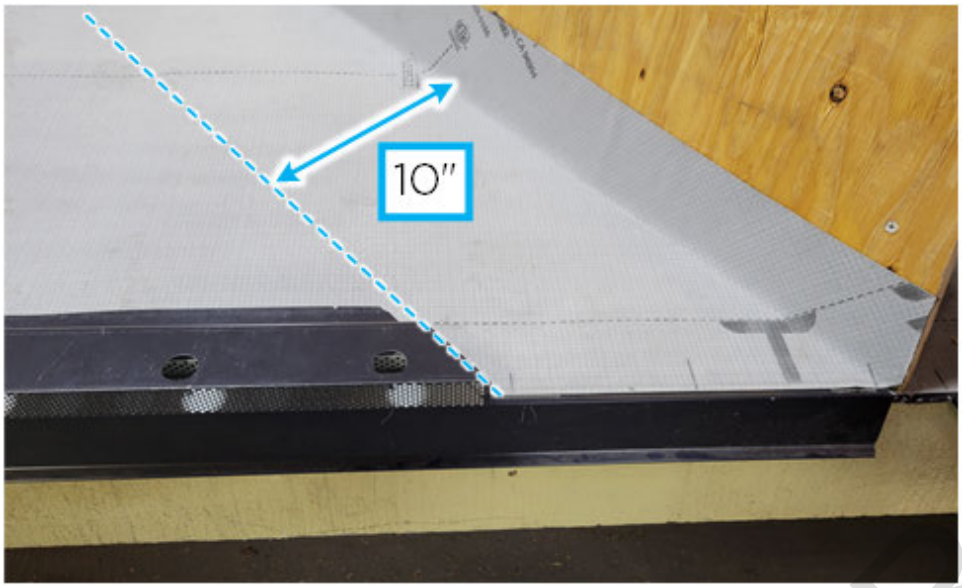
- Transition Flashing
- Riser
- Tile skin
- Self-tapper
- Tile cutter

Finished installation for reference

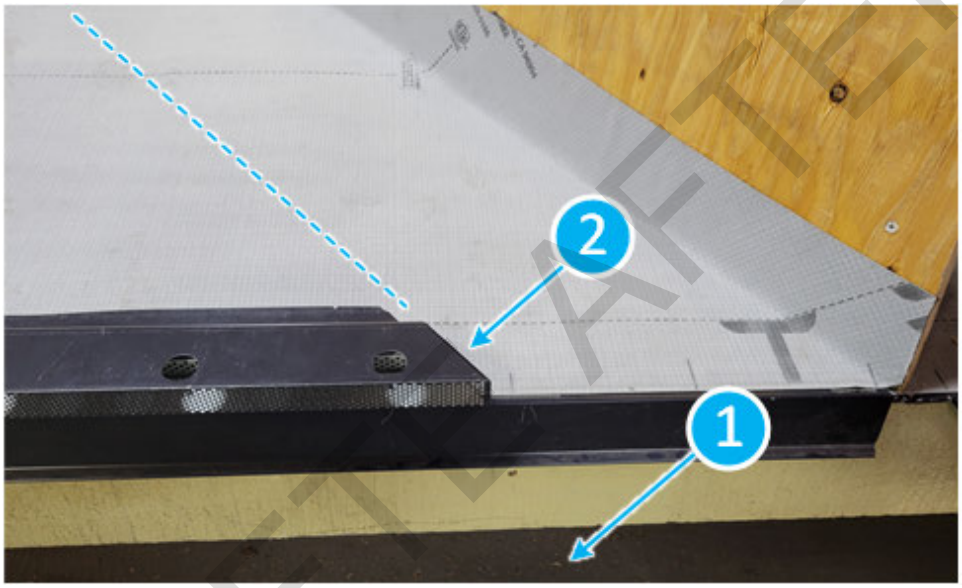
Work Instructions

When working with an angled wall, in most situations you will need to start with the eave interaction.

1. Before installing the riser, measure and mark a line 10 in away from the wall.



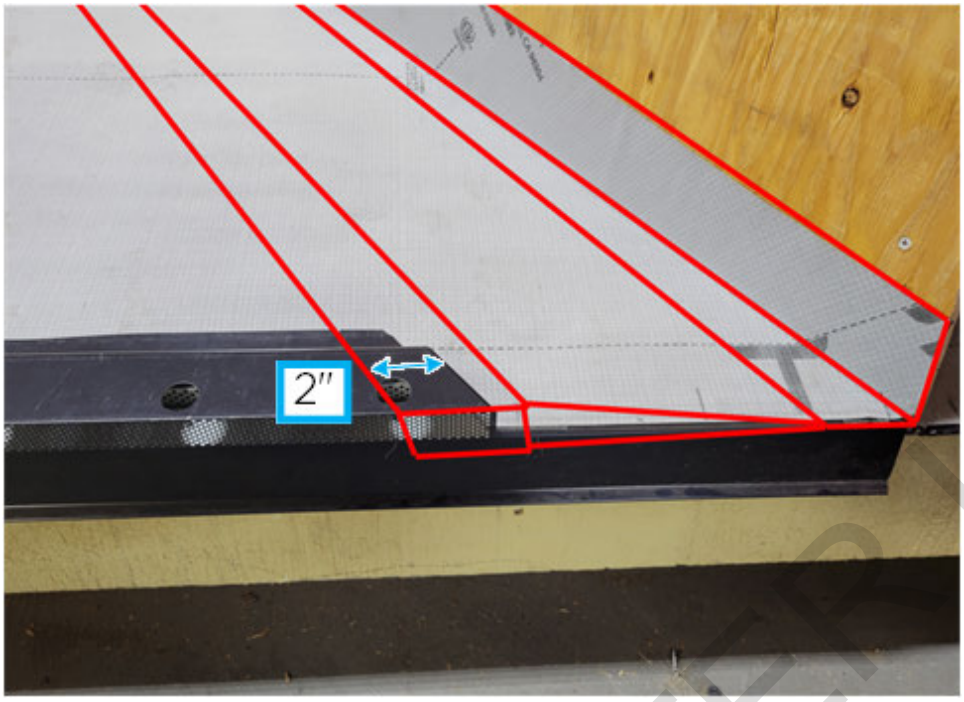
2. Then, cut the riser at the angle of the headwall and install it on the 10 in line.



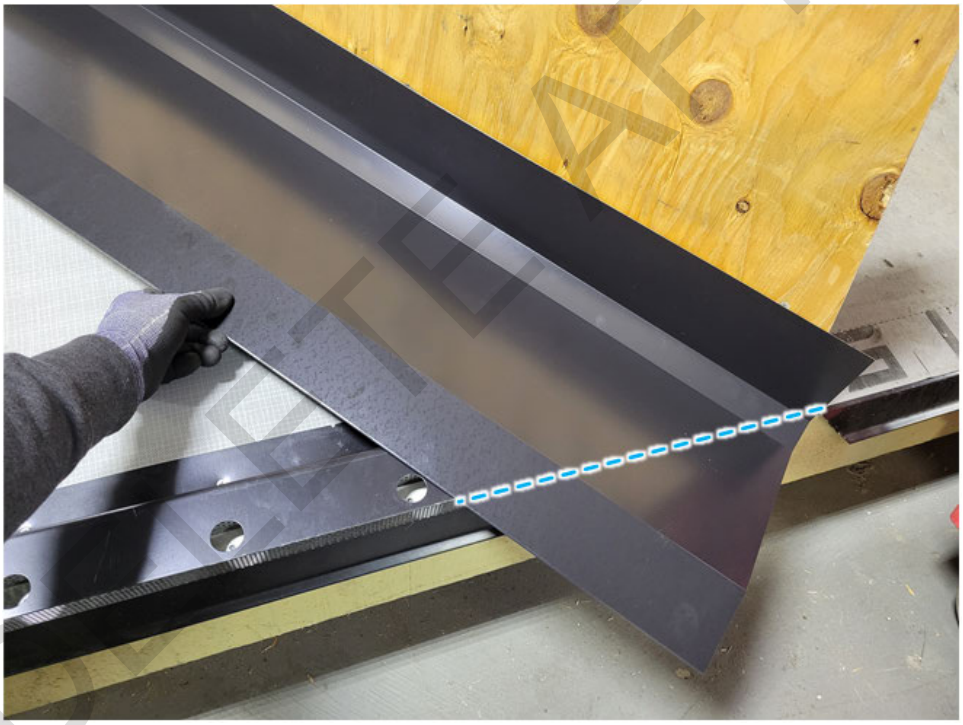
1 - Eave

2 - Angled cut to match the angle of the wall

   a. This will ensure that the riser terminates 2 in underneath the leading edge of the headwall transition flashing, which will be installed next.

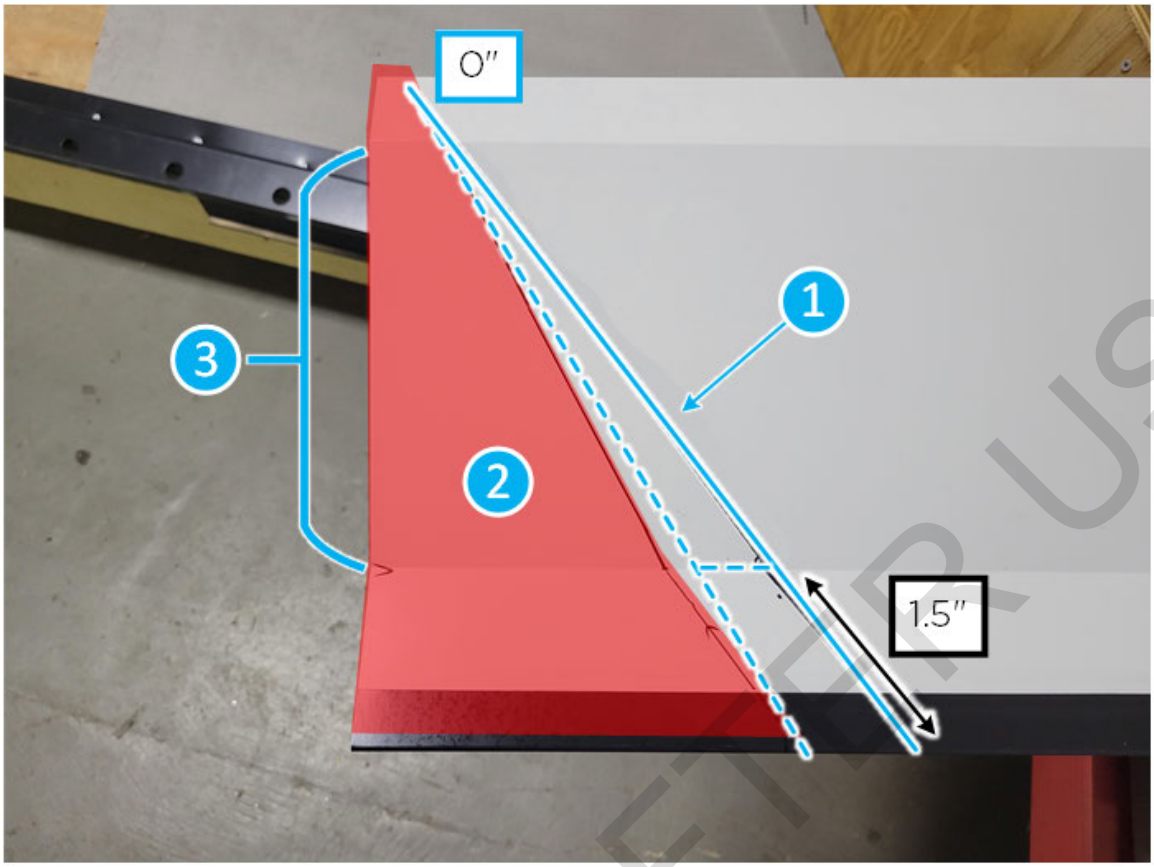


3. Break the transition flashing to pitch and mock it up in place. Scribe the bottom of the flashing where it will break over the riser.



4. Mark a cut line at 1.5 in beyond the previously scribed bend line on the leading edge of the flashing. On the "ramp" of the flashing, the cut line will taper from 1.5 in and end at zero at the scribed bend line. The scribed line will also act as your bend line.
    a. You will bend the 1.5 in - 0 in section down 90°.

> **NOTE:** It is best to bend the section before cutting it.

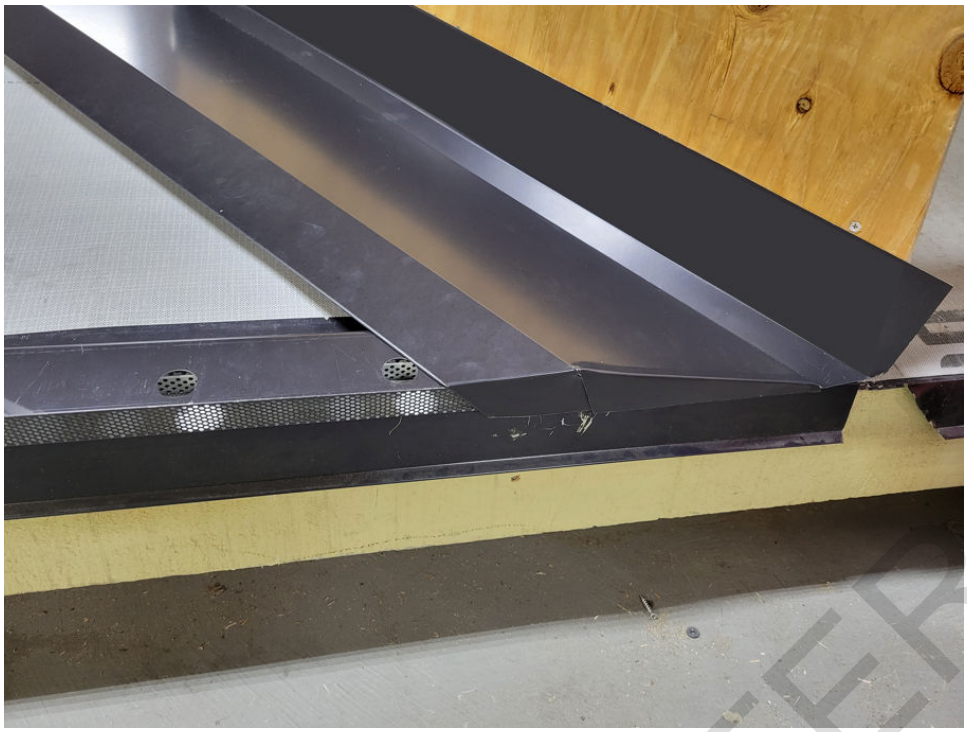


1 - Scribed bend line

2 - Remove

3 - "Ramp" Section

5. The transition flashing should look like below image once you bend the 1.5 - 0 in section down 90°. The flashing should be installed behind the siding and the building paper.



6. Use self tappers to fasten the transition flashing to the riser and to the tucked metal tiles after they are installed.

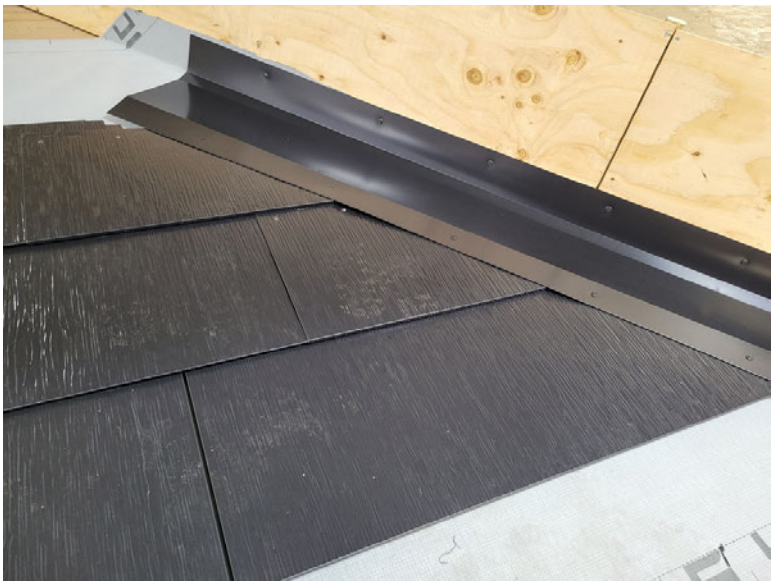
Angled Wall

Continue installation of transition flashing along an angled wall.

NOTE: Note that on an angled wall, the transition flashing will need to be spliced with the up-roof flashing on top of the down roof flashing. Refer to "Splicing Transition Flashing" in *Splicing Perimeter Metals on page 262*.

Tools & Equipment:

- Transition Flashing
- Tile skin
- Self-tapper



Finished installation for reference

Work Instructions:

1. During dry-in, use transition flashing to flash the angled wall. It should be broken to pitch.
    a. The transition flashing should not be fastened to the wall.
    b. The wall portion should be tucked behind the siding and building paper.

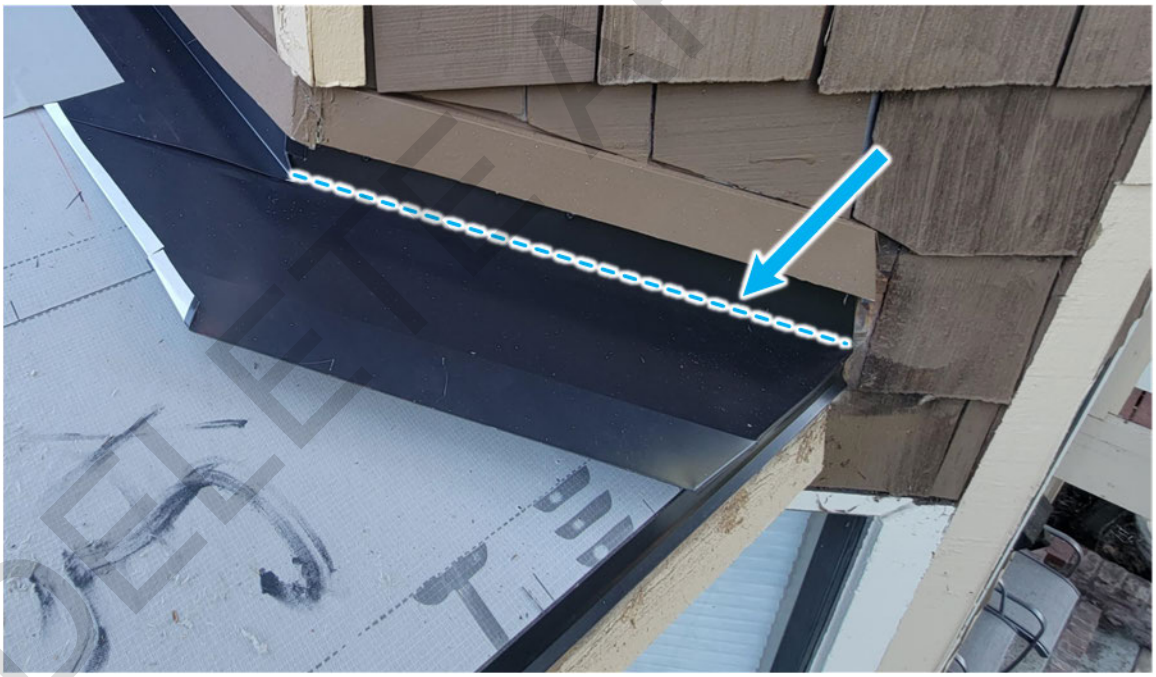
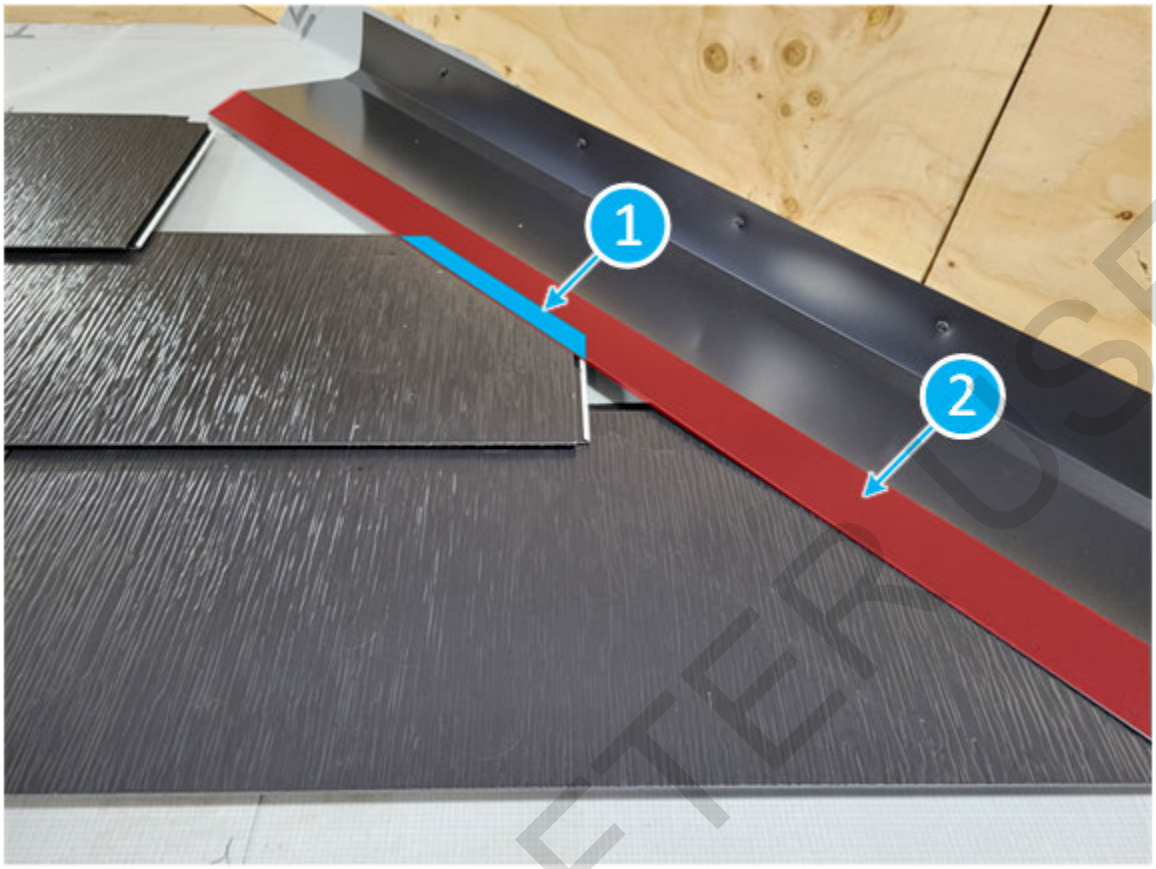


Image showing the bend line

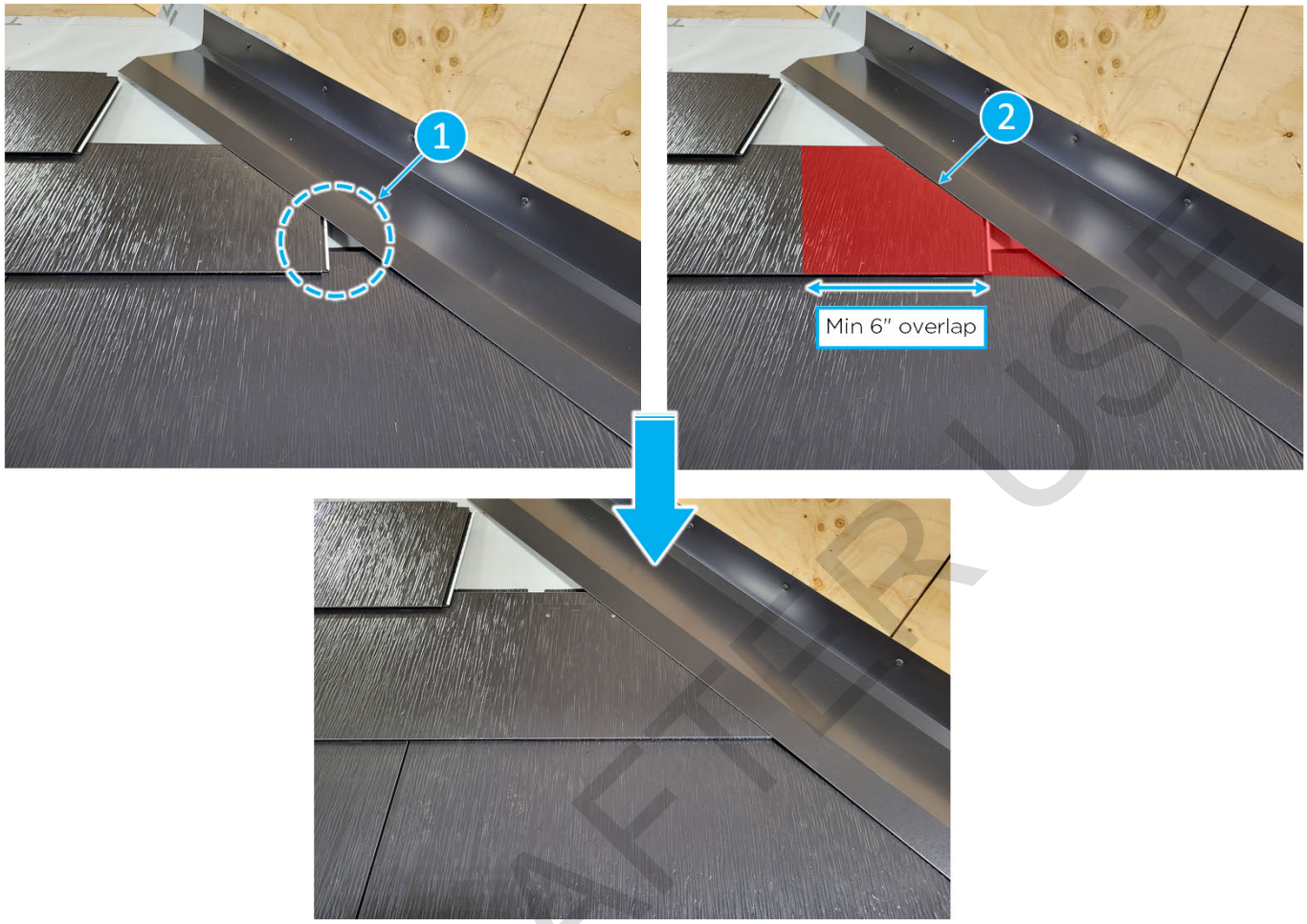
2. Cut the tiles and tuck them under the 3 in leading edge of the transition flashing.
    a. Tiles must be tucked at least 1 in under the transition flashing, and cannot extend past the 3 in leading edge.



1 - Minimum of 1" of coverage

2 - Not extend past the 3 in Leading edge

3. When another tile cannot be installed to finish a course and there is a dead zone present (1), use a tile skin where shown below (2) to fasten to the metal tile and span the dead zone. Cut the tile skin to the correct shape and size and remember that the skin needs at least 6 in of overlap with the metal tile.



4. After installing the tiles, use self tappers to fasten the leading edge of the transition flashing to the metal tiles according to the *Fastener Schedule on page 703*.

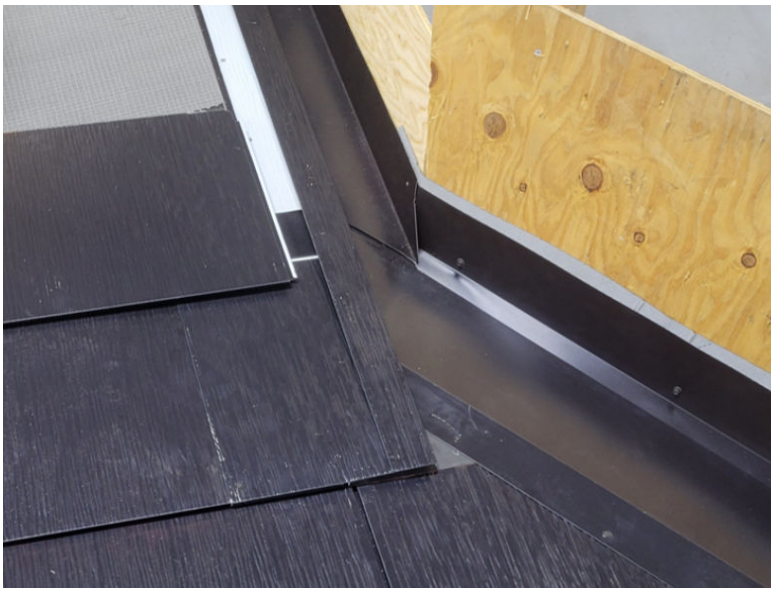
Angled Wall - Angled Wall to Sidewall

Overview:

Many angled walls will have a sidewall junction. This section contains instructions on how to deal with this detail.

Tools & Equipment

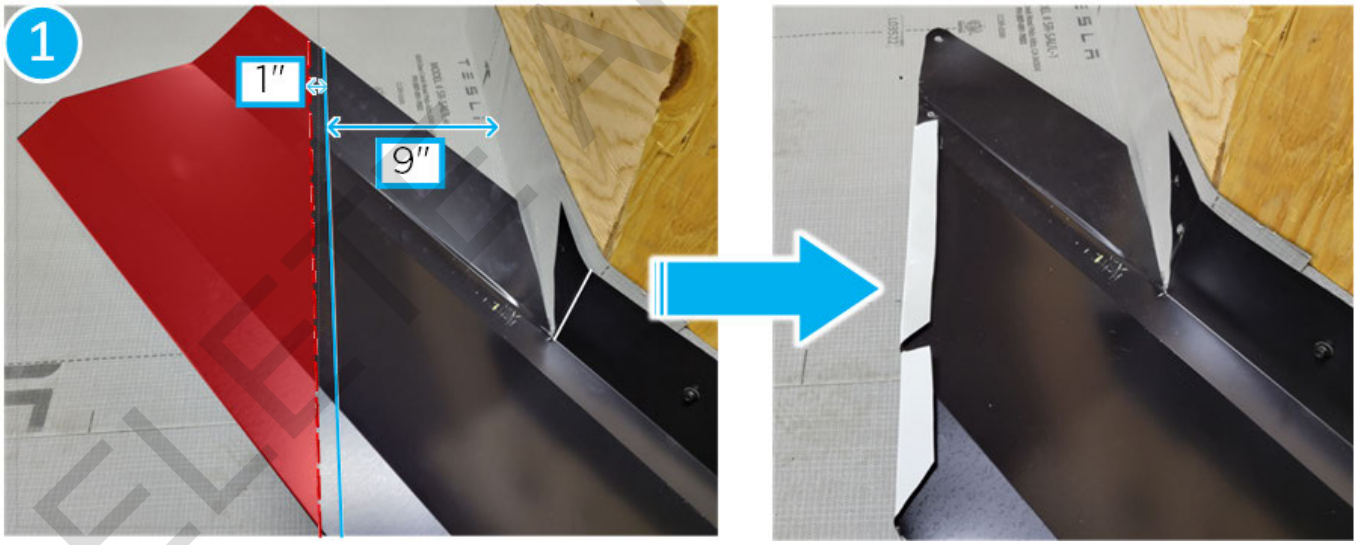
- Tile cutter
- Marker
- Tape measure
- Transition Flashing



Finished installation for reference

Work Instructions

1. Bend a transition flashing to pitch and tab it up the sidewall, terminating it beyond the outside corner at the sidewall junction with a 1 in open hem.
    a. Mark a bend line at 9 in from the sidewall, and a cut line at 10 in and remove the rest (1)

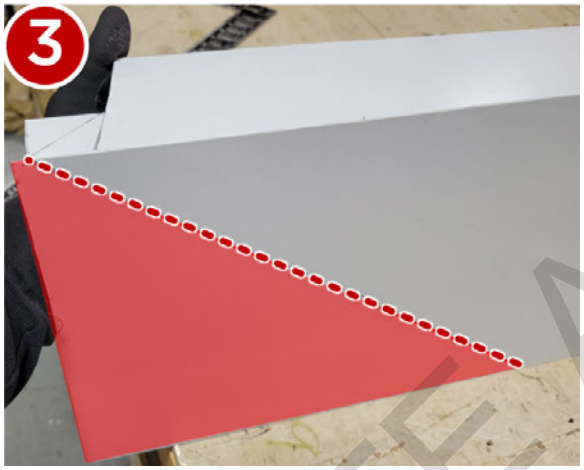


2. Next, the wall flashing will be installed over the transition flashing. Scribe the wall flashing to pitch and fabricate a diverter on the wall flange by removing the material (2) (this angle is pitch dependent, scribe it plumb).

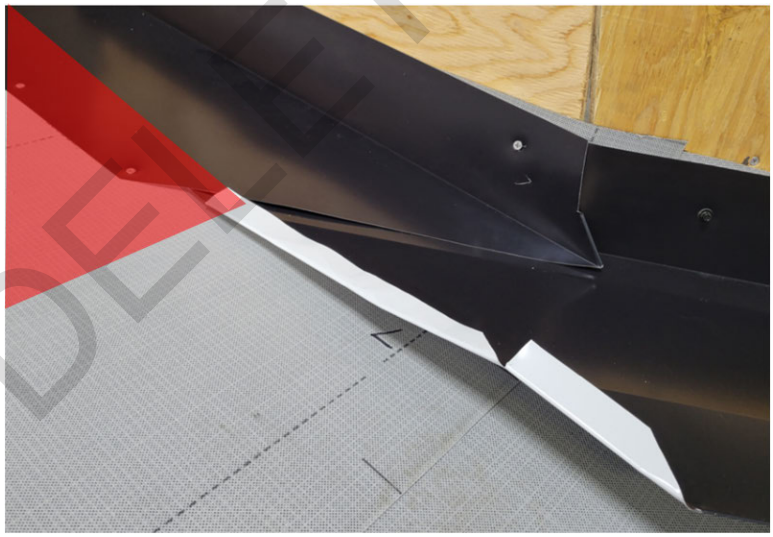
The diverter will be bent along the diagonal line, so it is black on both sides.

Image showing the back of the wall flashing

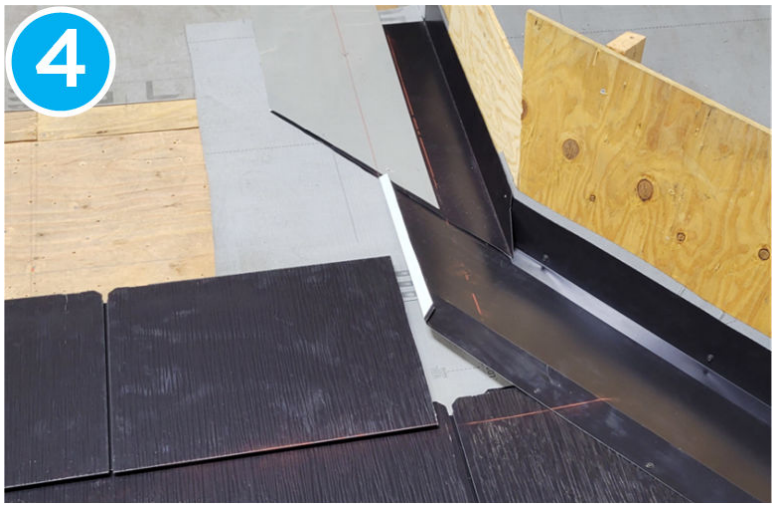
3. Scribe the headwall angle onto the deck flange of the wall flashing and remove the excess material (3).



   a. Apply a detail roll of underlayment to the wall flashing 5 in away from the wall.



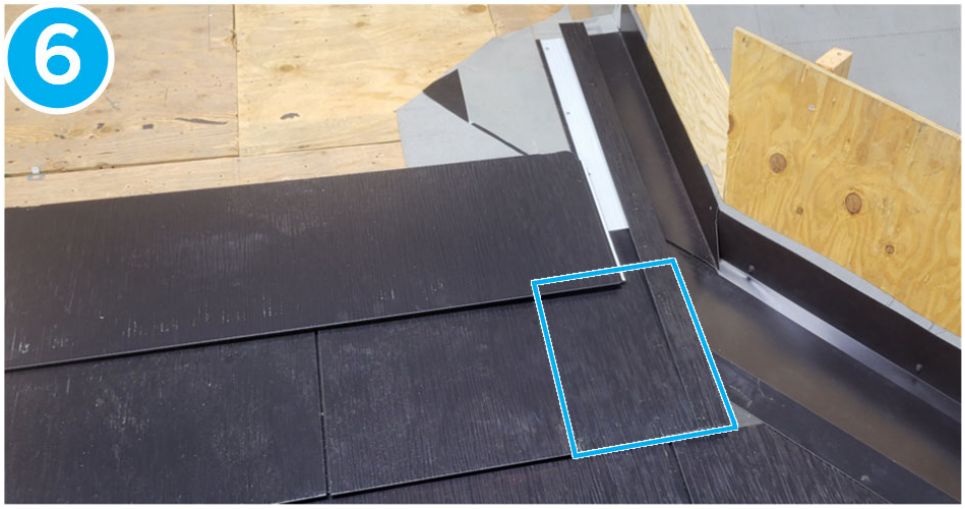
4. Tuck the tiles underneath the leading edge of the transition flashing. A lower extension will need to be added to wash out to the final course of tiles at the dead zone (4).



5. Fabricate a lower extension out of flat stock and include a 1 in open hem to ensure that all water is funneled down and over the tiles from the above gutter.
    a. Use self tappers to fasten the lower extension to the tile underneath and ensure that it matches the tile reveal (5).

6. Install the channel flashing along the sidewall and span the dead zone with a tile skin (6).

> **NOTE:** Because the transition flashing is angled, the robin jig cannot be used to trim the channel flashing. Use a tape measure to get lengths and trim the channel flashing accordingly.



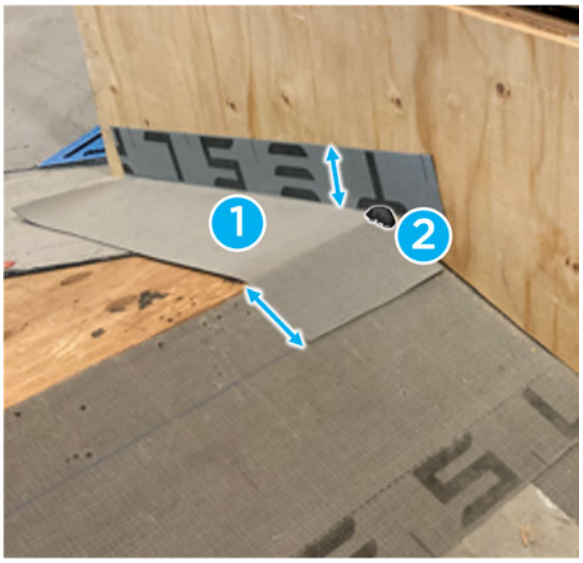
Sidewall-Sidewall-Ridge

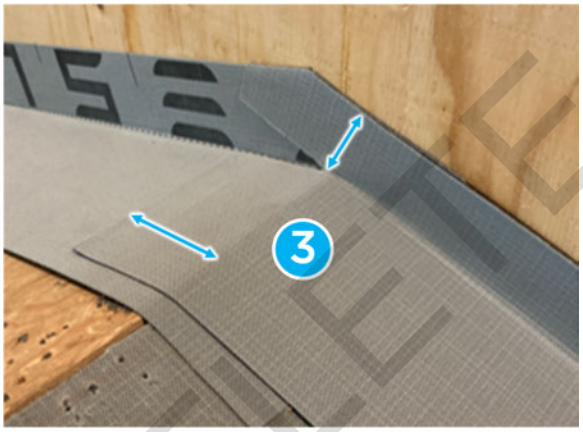
Overview

This section provides instructions for installing underlayment and wall flashing at a sidewall-sidewall-ridge junction.

Work Instruction

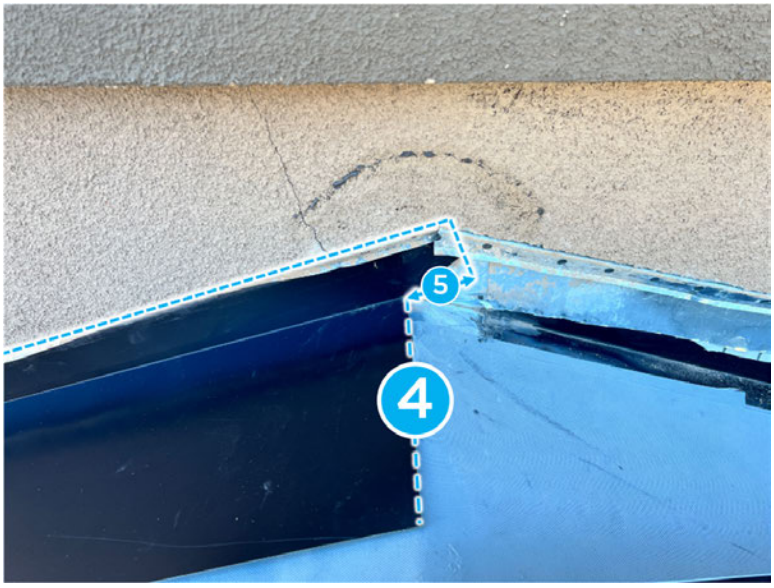
Lap underlayment a minimum of 3 in up the sidewall and over the ridge **(1)**. Add a dollop of sealant at the ridge to wall apex **(2)** and then install underlayment on the opposite side of the ridge **(3)**.





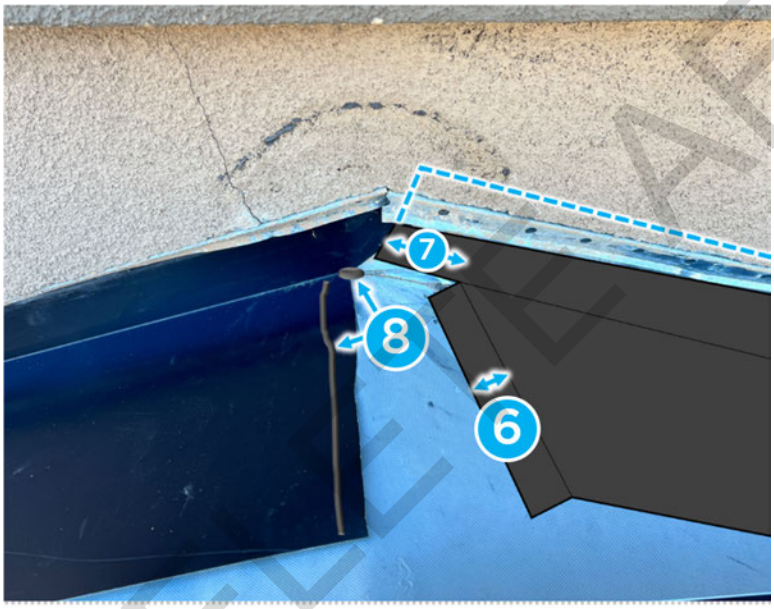
Next, install wall flashing on one side of the ridge. Terminate the deck flange at the ridge **(4)**. Terminate the wall flange 3 in beyond the ridge **(5)**.

NOTE: Wall flashing must be tucked behind building paper and siding or counterflashing.



On the opposite side of the ridge, install wall flashing with a minimum 1 ½ in deck flange tab over the ridge **(6)**. The wall flange must extend 3 in beyond the ridge **(7)**. Apply a dollop of sealant at the ridge apex and a bead of sealant under the deck flange tab **(8)**.

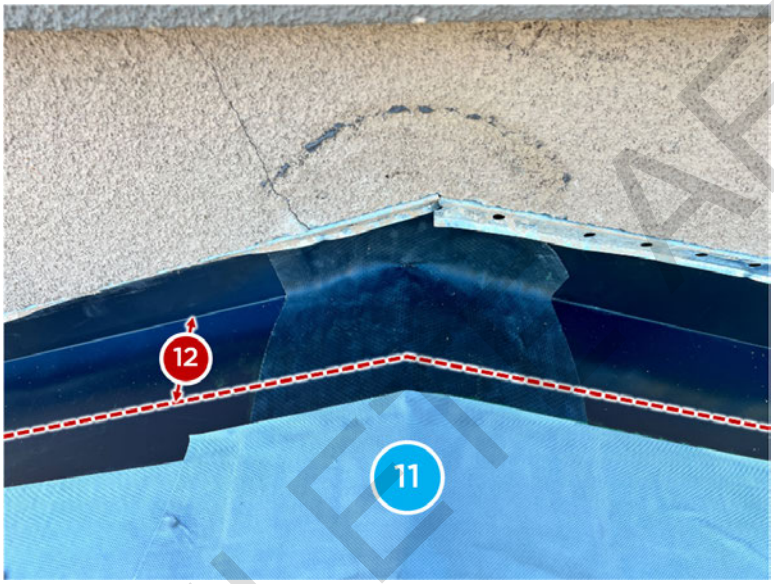
NOTE: Wall flashing must be tucked behind building paper and siding or counterflashed.



Install flexible flashing over the wall flashing at the ridge apex **(9)** extending a minimum 1 in up the sidewalls **(10)**.

Strip in the wall flashing with a detail roll **(11)**.

NOTE: Do NOT place underlayment within 5 in of the sidewall **(12)** to avoid exposed underlayment within sidewall gutter.



Ridge-Rake Washout

Ridge-Rake Washout (Dry In)

Overview:

This section provides instructions for drying in the ridge-to-rake junction.

Tools & Equipment

- Metal snips
- Underlayment
- Wall flashing
- Detail roll

- Speed square
- Transition flashing
- Flexible flashing

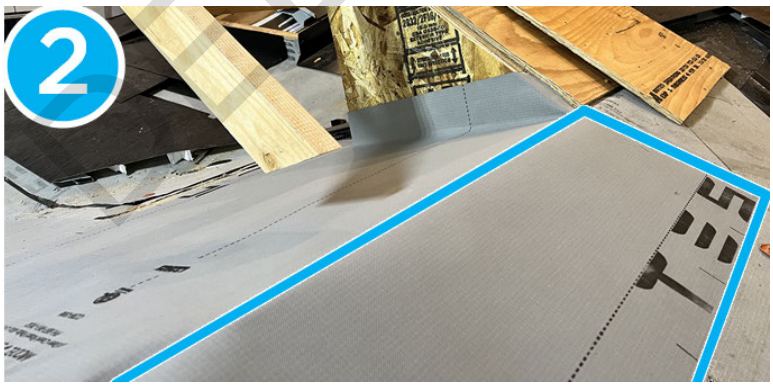
Finished installation for reference:

Work Instruction

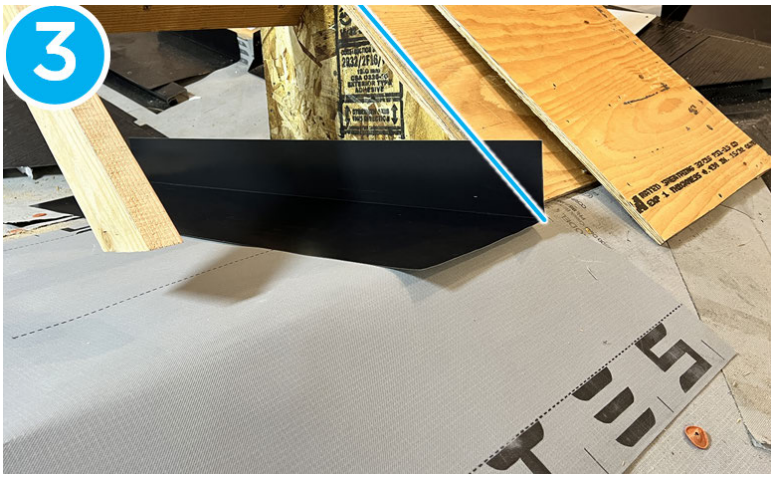
Remove the decking to expose the undershot **(1)**.

PRO TIP: Ensure the saw is set to the depth of the plywood and cut vertically along the wall rafter.

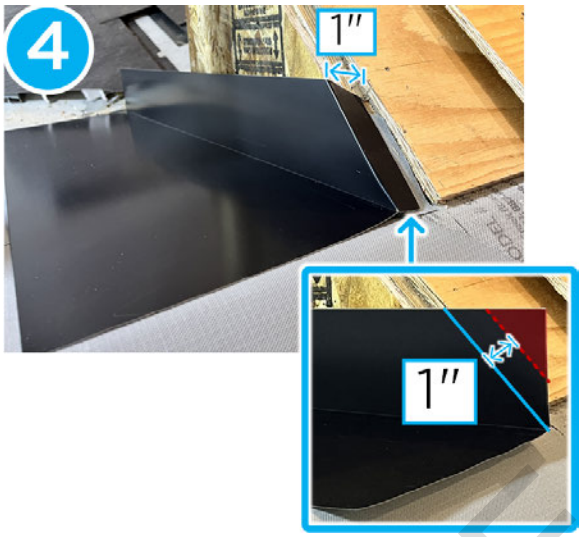
Lap underlayment over the ridge and on top of the opposite mounting plane's underlayment **(2)**.



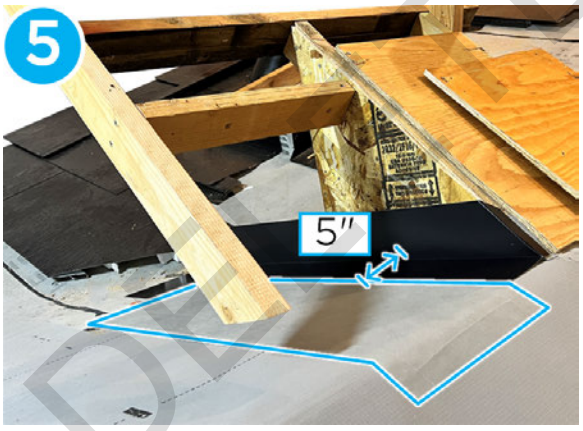
Position wall flashing against the wall and up to the top of the ridge. Mark the edge of the wall onto the vertical flange **(3)**.



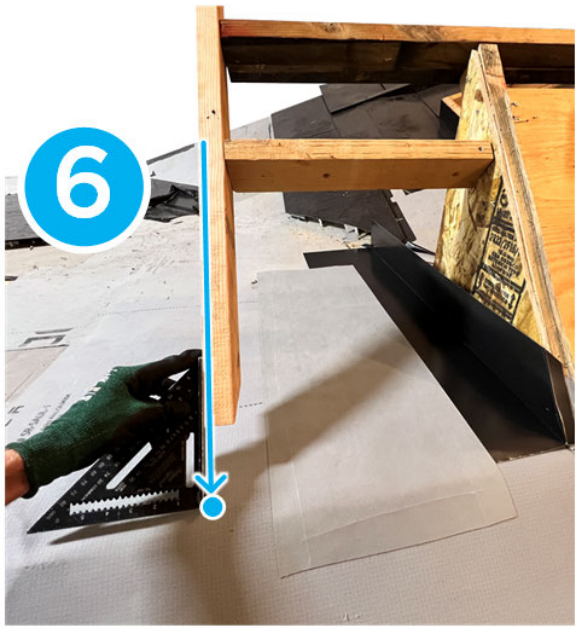
Fabricate a 1 in tab into the vertical flange past this wall edge point (remove any excess material) **(4)**.



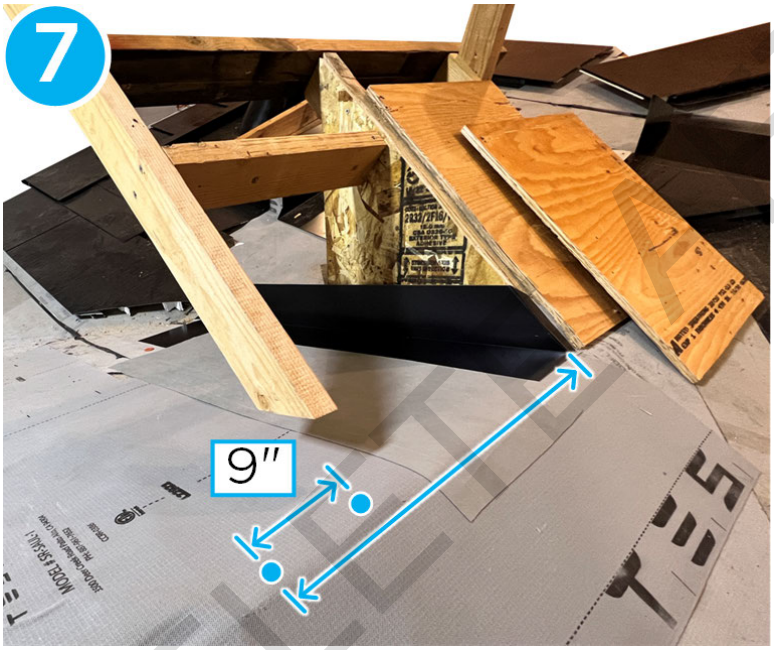
Strip in the wall flashing with a detail roll. Ensure the detail roll does not come within 5 in of the wall **(5)**.



Place a speed square against the fascia to determine where the rake edge intersects with the mounting plane. Mark this intersection point **(6)**.

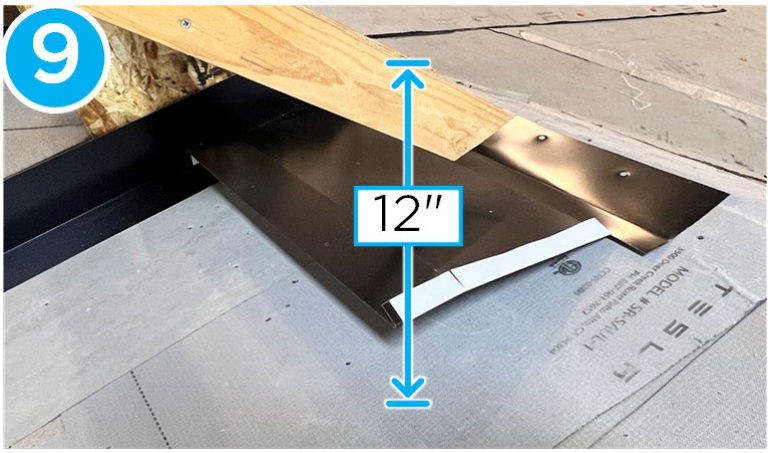


Make an additional mark at 9 in past the rake intersection marking. Then, measure the distance between the wall and the 9 in-past-the-rake-intersection-mark. This total measurement will be used to fabricate the transition flashing **(7)**.

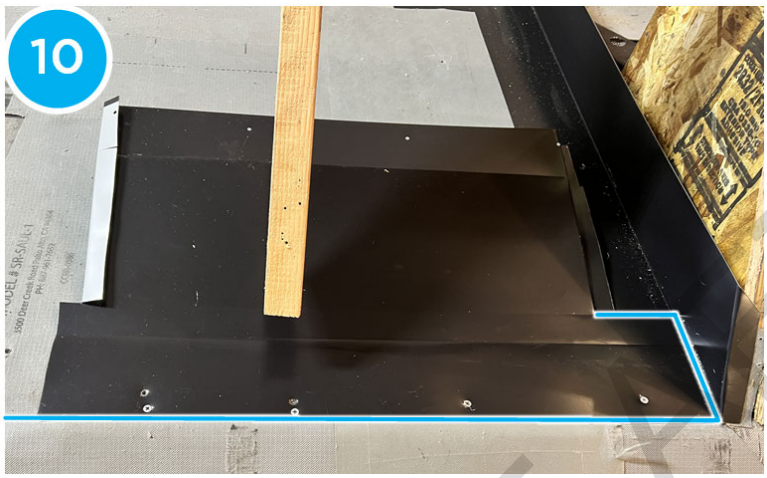


Cut a transition flashing to the length determined in step 7 plus one extra inch (this extra inch will be used to create an open hem). Proceed to *craft a turn down and out on page 307* into the transition flashing **(8)**.

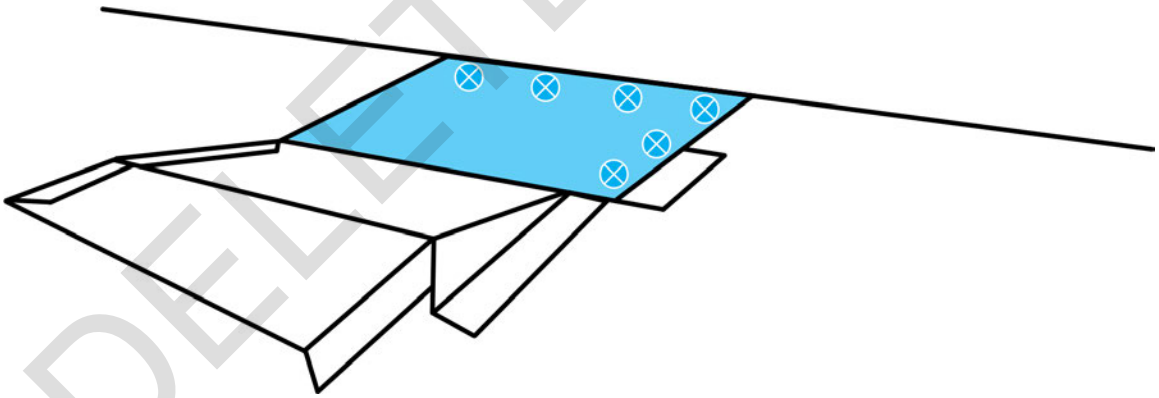
Measure 12 in from the top of the fascia to the deck. The transition flashing will be installed at this point **(9)**.



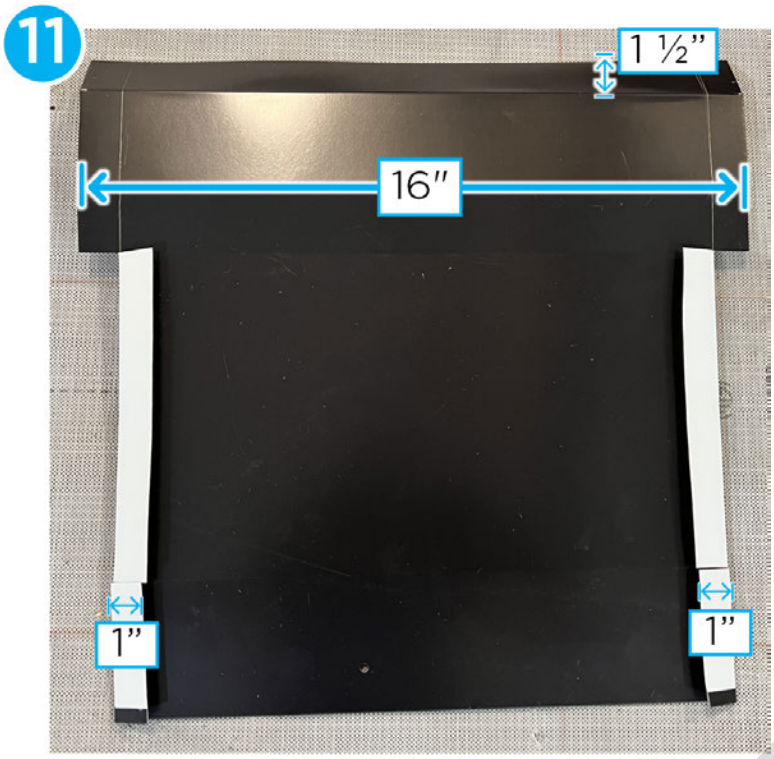
Place the transition flashing at this 12 in point. Ensure the transition flashing extends to the apex of the ridge and is installed against the wall **(10)**.



If the transition flashing does not reach the ridge, fabricate and install an extension pan. Determine the extension width by subtracting 2 in from the width of the transition flashing (this will ensure the extension will fit against the wall flashing).

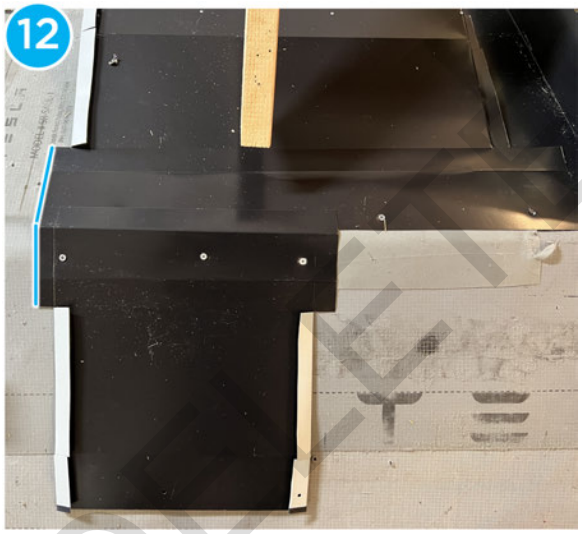


Fabricate a second 16 in-wide transition flashing for the opposite side of the ridge (this width does not vary). Fabricate this transition flashing to have 1 in open hems on both sides and a 1 ½ in bend at the upper flange top edge that will lap over the ridge **(11).**

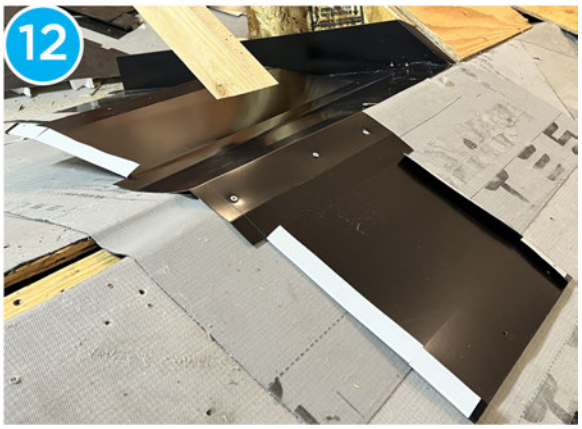


Install the second transition flashing **(12)**. Ensure the edges of both transition flashings are aligned; this will ensure all open hems are aligned with each other as well.

Step 12 result top view:



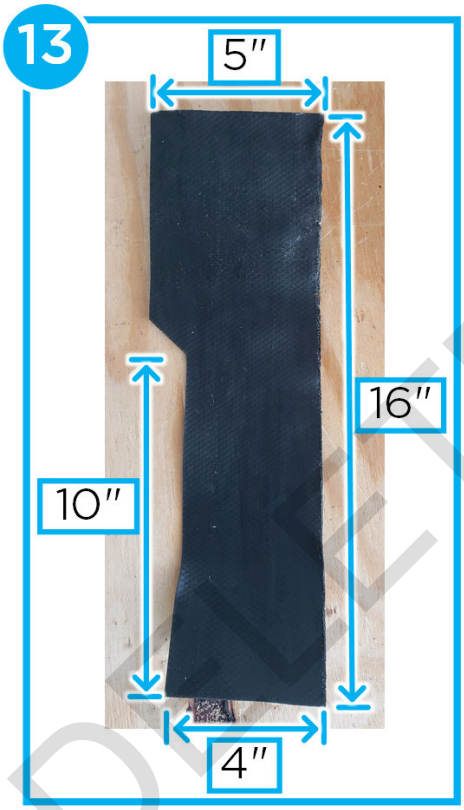
Step 12 result side view:



Cut a piece of flexible flashing to lap over the base flange of the first transition flashing **(13)**.

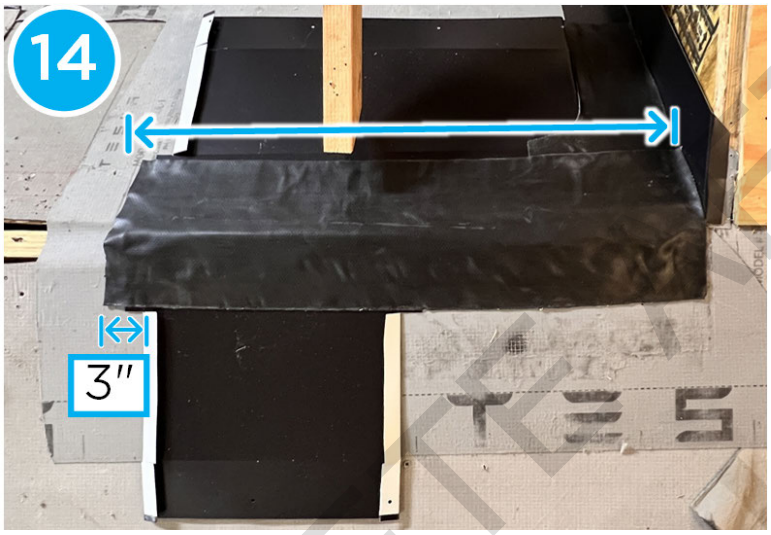
Pictured: Flashing tape dimensions:

- Flashing tape is a total of 16 in long
- 4 in wide at the bottom
- At 10 in, the tape must widen to 5 in

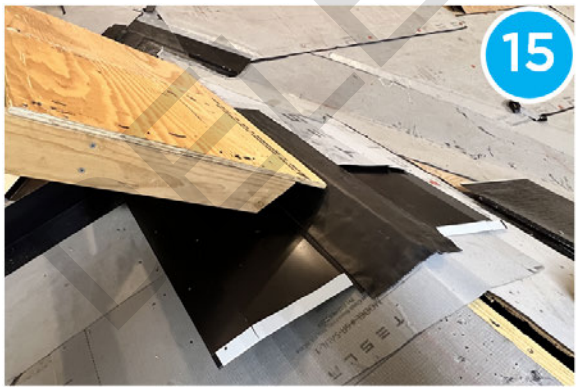


OPTIONAL: If an extension pan was installed, use the same dimensions from step 13 for the flexible flashing. However, alter the total length to match the distance between the transition flashing and the ridge.

Cut additional flexible flashing to span between the wall and 3 in past the transition flashings. Ensure the flexible flashing laps over the ridge and extends to the open hems on both transition flashings **(14)**.



Finally, reinstall the decking and continue drying in the upper mounting plane **(15)**.



Ridge-Rake Washout (SRI)

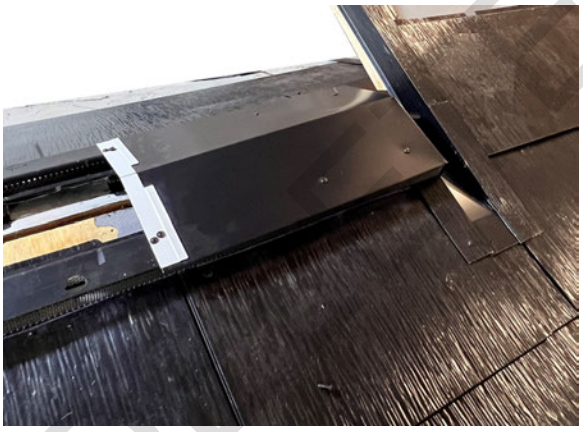
Overview

This section provides instructions for installing perimeter metals and tiles at a ridge-to-rake washout. This procedure occurs *after this junction has been dried in. on page 555*

Tools & Equipment

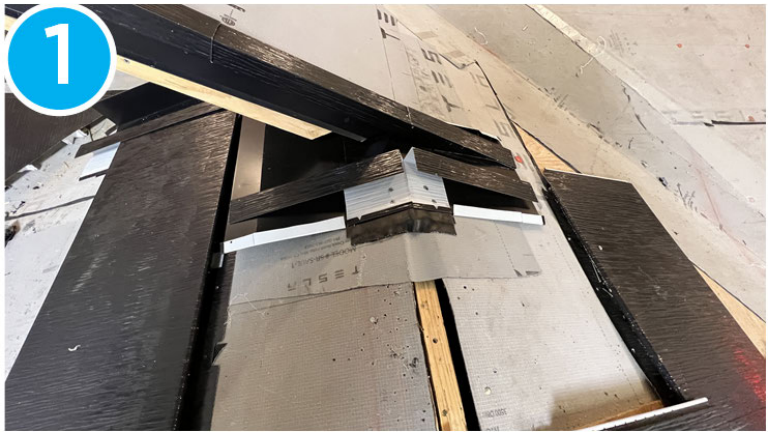
- Robin jig
- Metal tiles
- Tile skin
- Channel flashing
- Vented riser
- Ridge cap

Finished installation for reference:

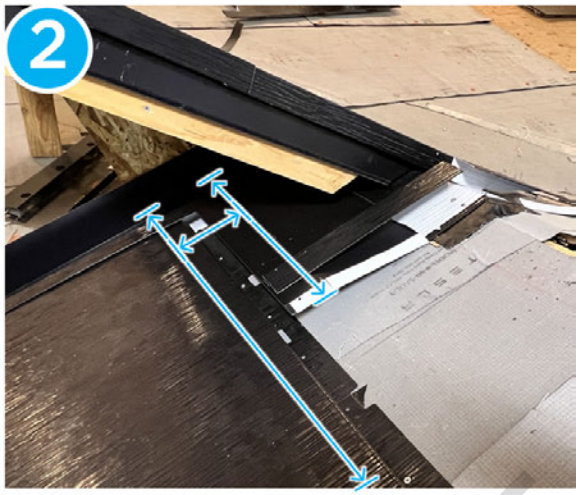


Work Instruction

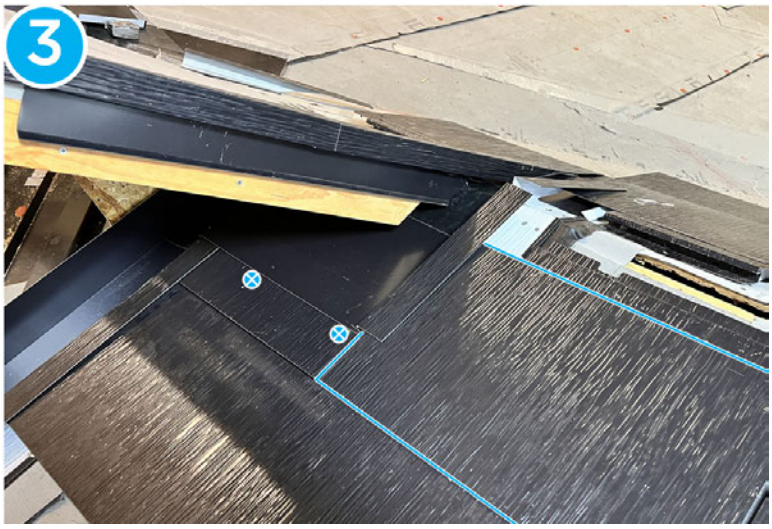
Use the *robin jig on page 603* to scribe the transition profile of the ridge onto channel flashing. Cut the channel flashing accordingly and install it down the rake and on both sides of the transition **(1)**.



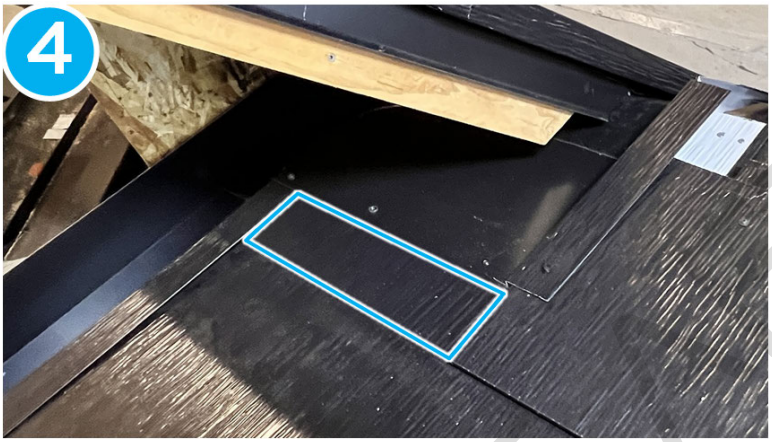
Determine the tile cutting measurements to allow a portion of a metal tile to sit beneath the undershot. Cut a metal tile accordingly and install **(2)**.



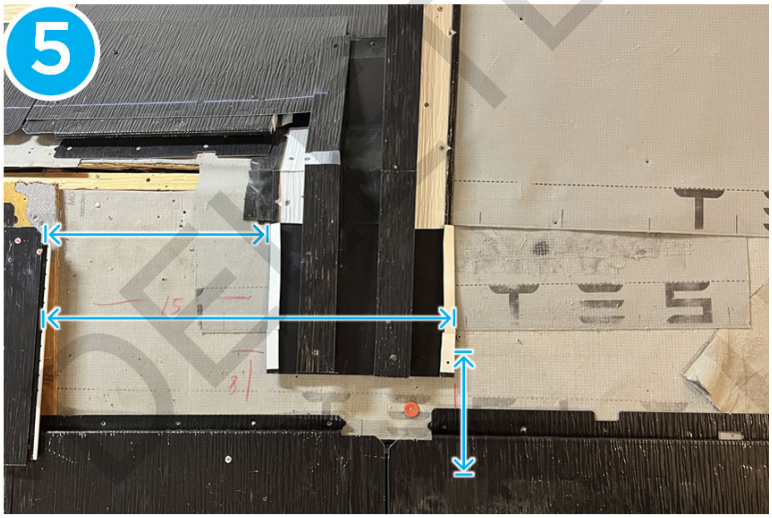
Fasten the cut tile section that sits under the undershot with 2 ½ in screws. Then, install a tile skin into the channel flashing that also laps over the transition flashing **(3)**.

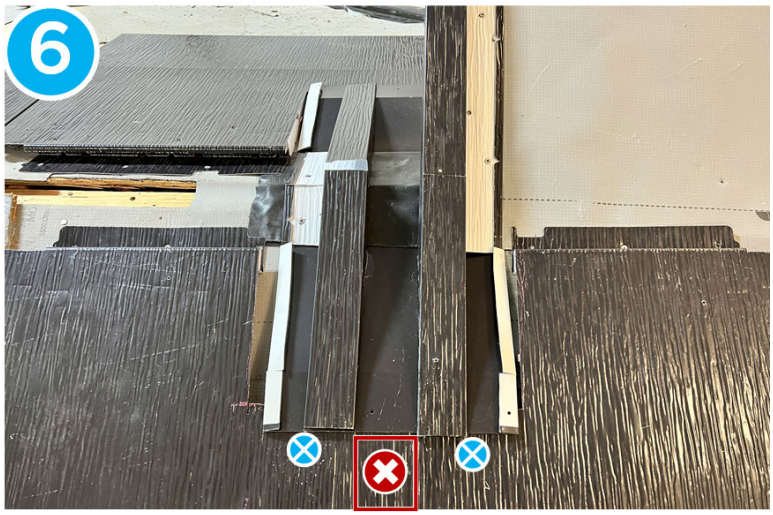


Cut and install an additional tile skin to cover the 2 ½ in screws **(4)**.

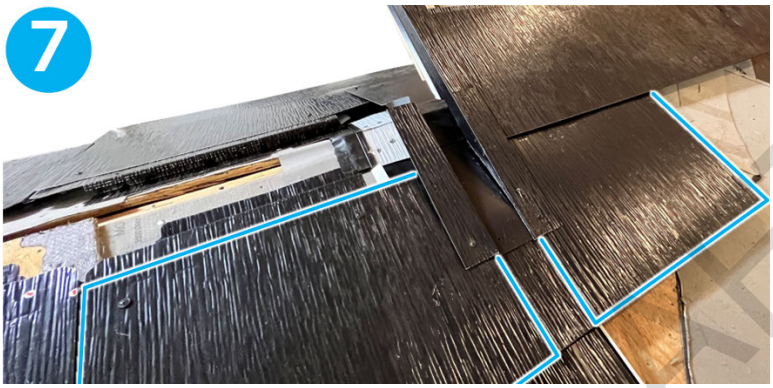


Determine the tile cutting measurements on the opposite side of the ridge **(5)**. Install and fasten the cut tile with 2 ½ in screws under the cut section **(6)**. Do **not** fasten under the gutter.

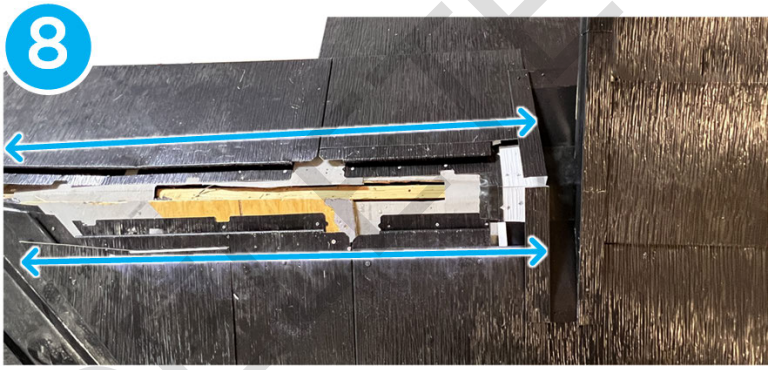




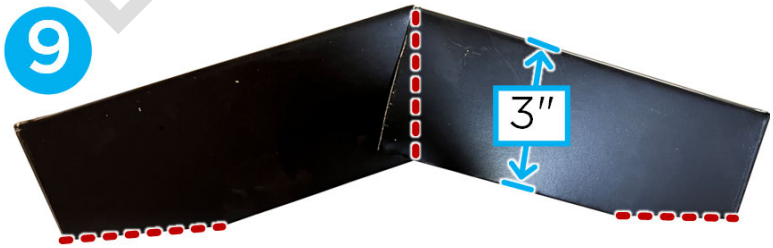
Install two sections of tile skin: one on each side of the channel flashing to lap over the transition and cover the 2 ½ in screws **(7)**.



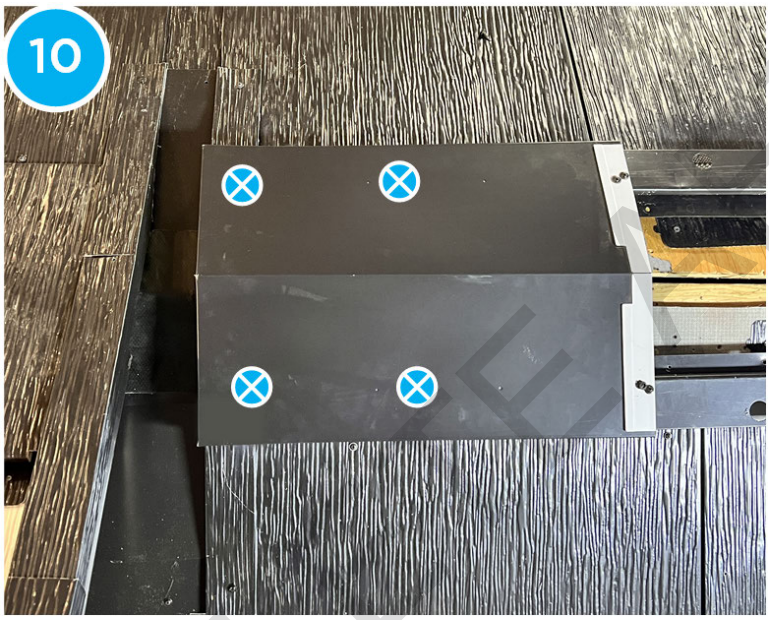
Snap vented riser layout lines over the ridge with the robin jig. Then, install vented risers that reach the edge of the channel flashing (see *Installing Vented Risers Over the Ridge on page 249*) **(8)**.



Fabricate a ridge end cap with a 3 in downturn (see the standard Ridge to Rake procedure). To ensure this cap will sit flat to the vented riser, trim the cap corners to match the slope of the transition flashing. Additionally, cut a plumb line into the center of the cap **(9)**.



Install the cap (see the standard Ridge to Rake procedure) and fasten according to the applicable wind tier in the *Fastener Schedule on page 703* and proceed with installing additional ridge caps (see Ridge Cap Installation) and tiles along the ridge **(10).**



Valley-Headwall-Sidewall

Overview

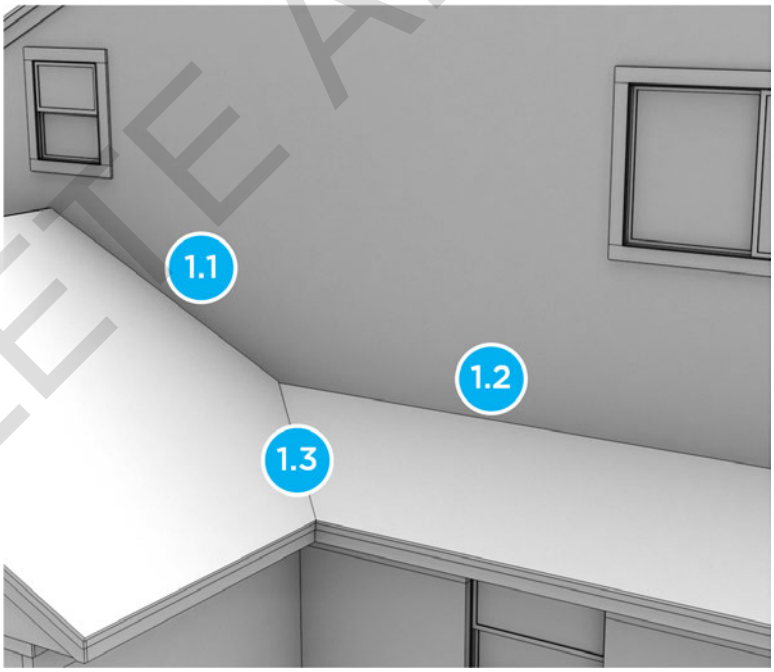
This section provides instructions for installing valley pans, vented risers, transition flashing and wall flashing at valley to headwall-sidewall junctions during the dry-in process.

Tools & Equipment

- Wall flashing
- Transition flashing
- Valley pan
- Vented riser
- Detail roll
- Flexible flashing
- Wire mesh
- Sealant

Refer to the labels below to understand which parts of the roof are being worked on throughout this work instruction.

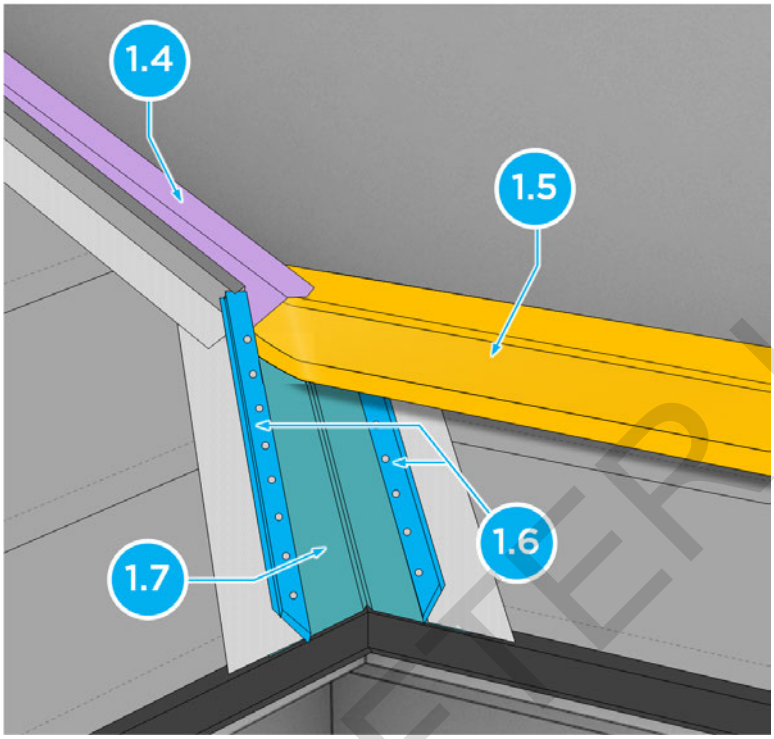
1.1	Sidewall
1.2	Headwall
1.3	Valley



Refer to the labels below for an overview of where different components are installed throughout this work instruction.

1.4	Wall flashing
1.5	Transition flashing

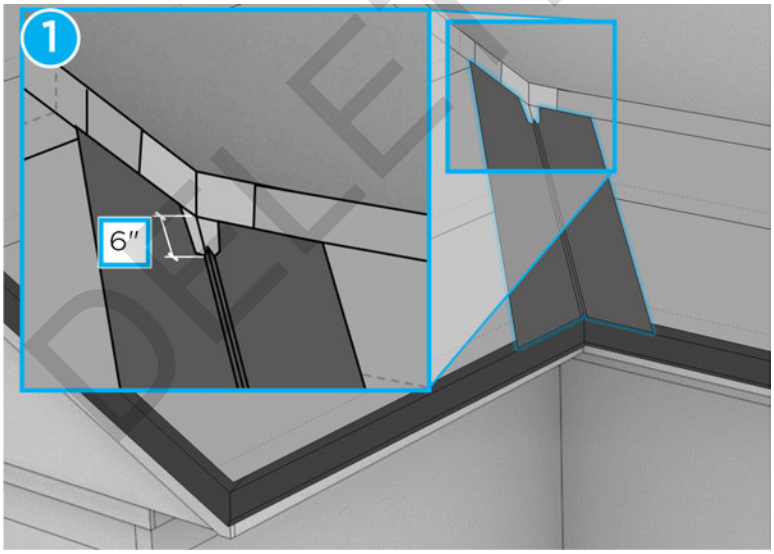
1.6	Vented riser
1.7	Valley pan



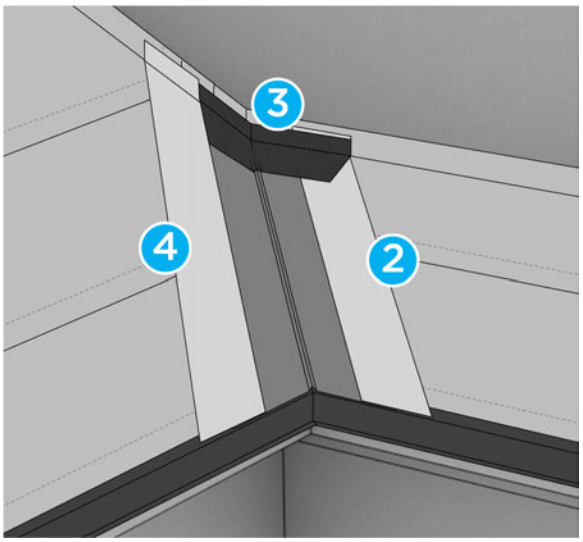
Work Instruction

Where the valley pan reaches the headwall-sidewall junction, remove 6 in of the valley pan's spine and install it tight to the wall.

NOTE: Removing this material from the valley pan allows the transition flashing to float over the valley center in step 3.

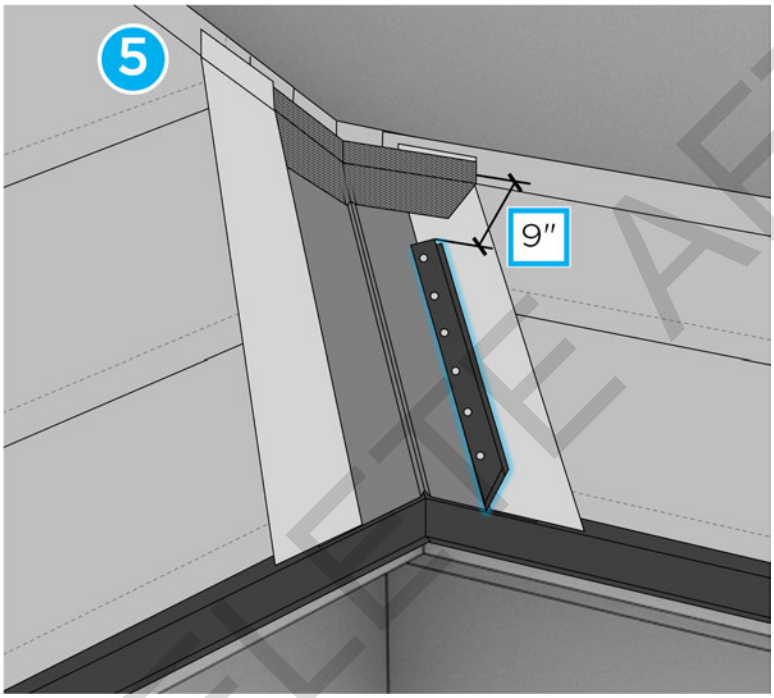


Strip in the headwall side of the valley pan with a detail roll **(2)**. Then, apply flexible flashing lapping up the wall and over the valley pan. The flexible flashing needs to cover the intact portion of valley pans spine by a minimum of 2 in **(3).**Next, strip in the other side of the valley pan with the detail roll **(4)**



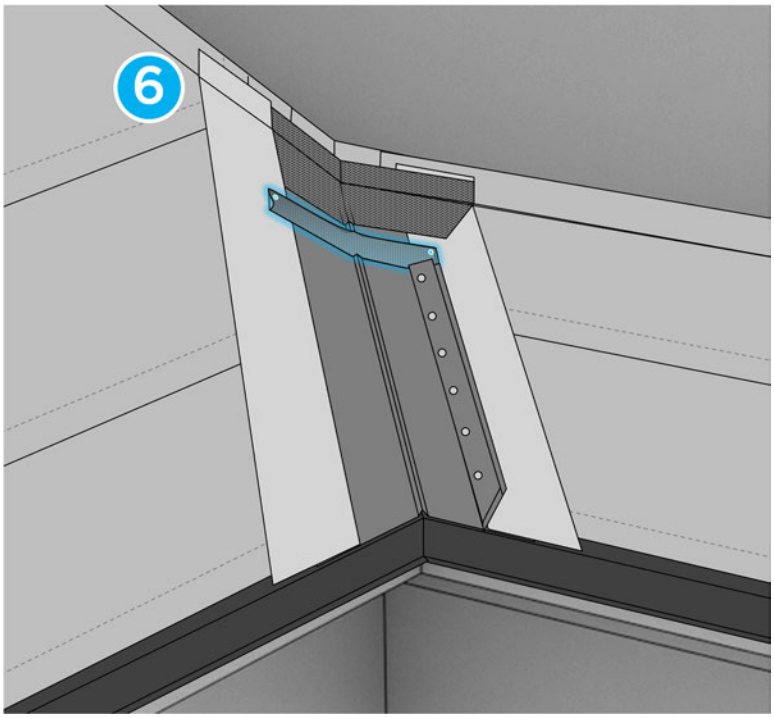
Install vented riser along the headwall side of the valley pan and terminate it 9 in away from the wall **(5)**.

NOTE: Terminating the vented riser 9 in from the headwall allows the transition flashing installed at the headwall to float over the vented riser.

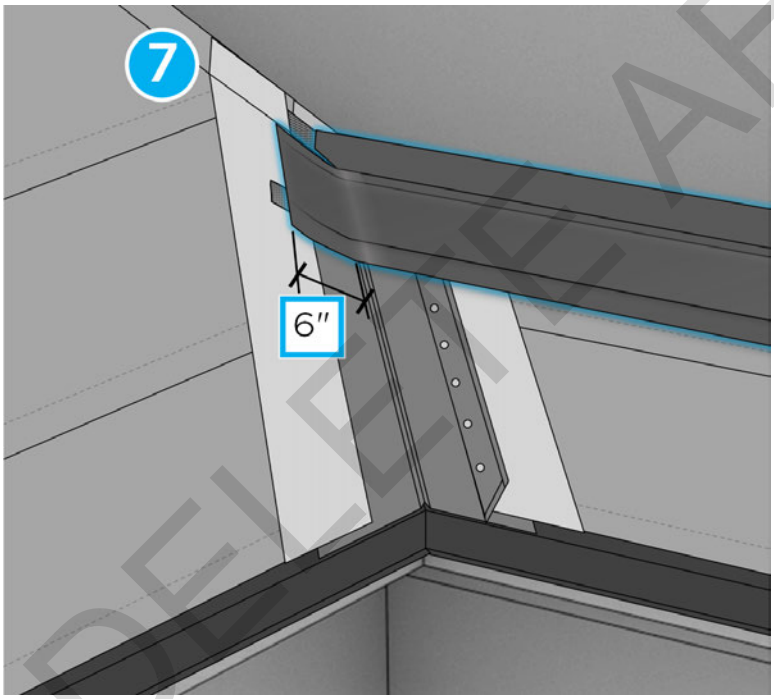


Create a pest and debris block by installing wire mesh molded into a "C" shape, wide enough to span beyond the valley's gutter on either side **(6)**.

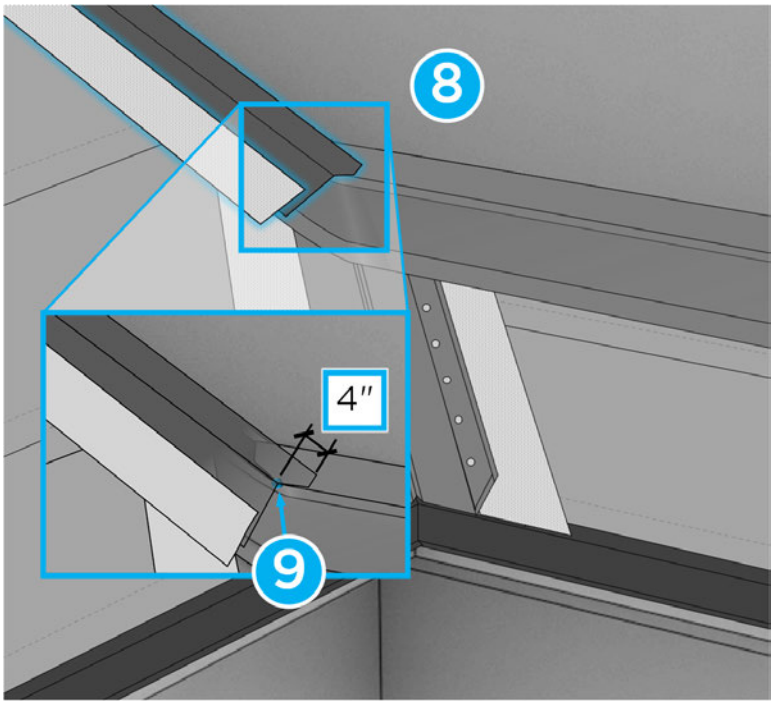
NOTE: Do not install fasteners through portions of the valley pan that are not stripped in.



Install transition flashing at the headwall. Cut a notch into the transition flashing where it meets the adjacent mounting plane and sidewall to allow the transition flashing to flex onto the adjacent mounting plane. The transition flashing must lap a minimum of 6 in onto the adjacent mounting plane **(7)**.

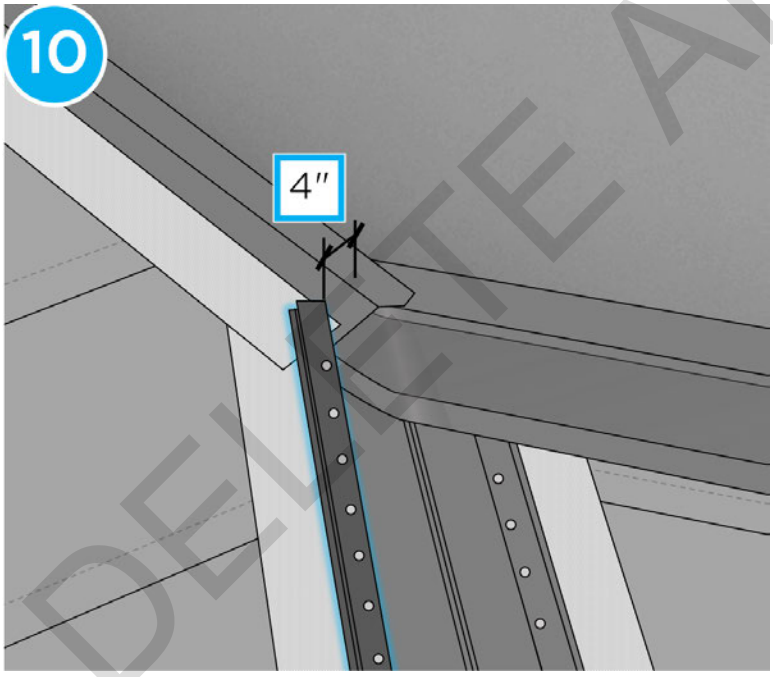


Notch wall flashing to create a 4 in tab that will lap onto the headwall **(8)**. Before installing the wall flashing, apply a dollop of sealant on top of the transition flashing at the headwall-sidewall junction **(9)**. Strip-in the wall flashing with the detail roll.



Install vented riser terminating 4 in from the sidewall to align with channel flashing installed up roof along the sidewall **(10)**.

NOTE: Once secured, the vented riser should compress the wire mesh, transition flashing and wall flashing together to create a tight assembly.



Accessories

Assisted Access Point

Overview

This section provides guidance for installing and using the assisted access point to make the roof accessible for future serviceability.

Pictured: Finished installation for reference.

Tools and Equipment:

- Assisted access point
- Metal tile
- Drill
- Anchor Lags
- Sealant

Key Installation Practices

Below is a list of key practices that must be performed / adhered to during assisted access point installation. These practices ensure that the tool remains accessible without impacting the roof's integrity or solar production.

- Install one assisted access point on each story of the home.
- The assisted access point should be installed on an ideal mounting plane for service access (within 20 ft of the eave). However, if possible, areas that are highly visible should be avoided. The aesthetic implications are not a priority but should be considered.
- Ensure the assisted access point is installed directly above a ladder access.

> **NOTE:** The assisted access point is NOT rated for side loads.

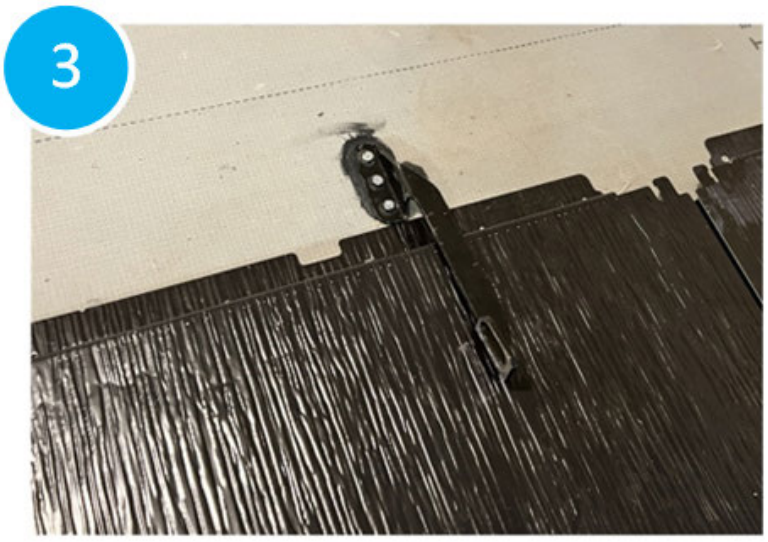
- **Do not** install assisted access points under the ridge assembly - this will prevent the lags from going through the top of the ridge rafters which may cause splitting.
- **Do not** install assisted access points over PV tiles - this will block the solar cells and prevent tile serviceability.
- **Do not** install assisted access points at tile seams – this will prevent PV engagement.
- **Do not** install assisted access points above a service drop or within 10 ft of either side of the service drop.

Work Instructions

1. Begin by locating the rafter on which the assisted access point will be installed. Position the assisted access point with the fastening plate pressed against the metal tile nailing flange. Drill pilot holes through the three holes on the fastening base plate **(1)**.

2. Remove the assisted access point and fill the pilot holes with sealant. Apply a vertical bead of sealant across the holes **(2)**.

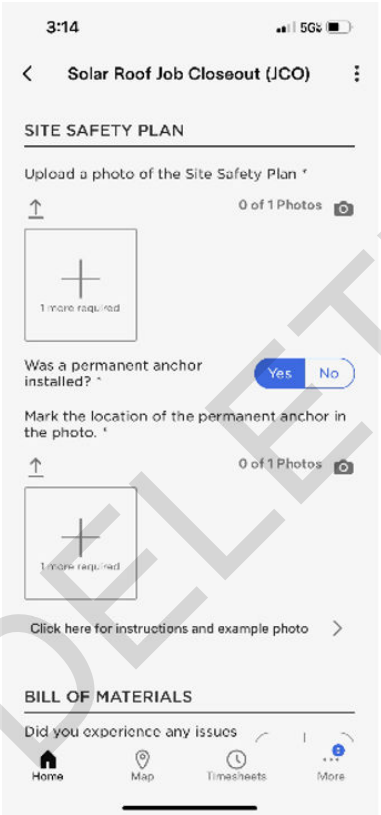
3. Reposition the assisted access point with the fastening base plate placed on top of the sealant and pressed against the metal tile nailing flange. Select an anchor lag that is 5/16 in diameter and sufficient length to ensure 2.5 in threaded embedment in the framing member. Install an anchor lag into each of the base plate holes (for a total of three). Apply another bead of sealant around the top of the installed assisted access point **(3)**.



4. Before installing the upper course of tiles, mark the location of the assisted access point on a metal tile. Cut a notch out of the metal tile hook at this mark to contain the assisted access point **(4)**.

5. Install the cut metal tile with the notch covering the assisted access point **(5)**.

6. Record the location of the assisted access point in the job closeout form in Tesla One.



Assisted Access Point - Access and Egress

Tools and Equipment:

- Extension Pole: 6 to 24 ft, lightweight construction (*Amazon link: DocaZoo 30ft Telescoping Pole*)

- Carabiner Holder: Clip holds carabiner in place, but allows easy removal. Threads onto standard extension pole. (*Backcountry link: Metolius Superclip Rescue*)

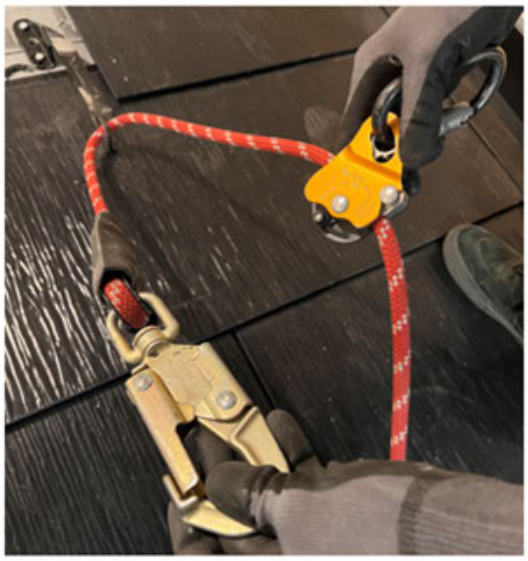
- Quick Draw Sling: Allows Safety Carabiner to be connected to the safety rope snap hook. (*Amazon link: 22kN Quick Draw Sling 11cm*)

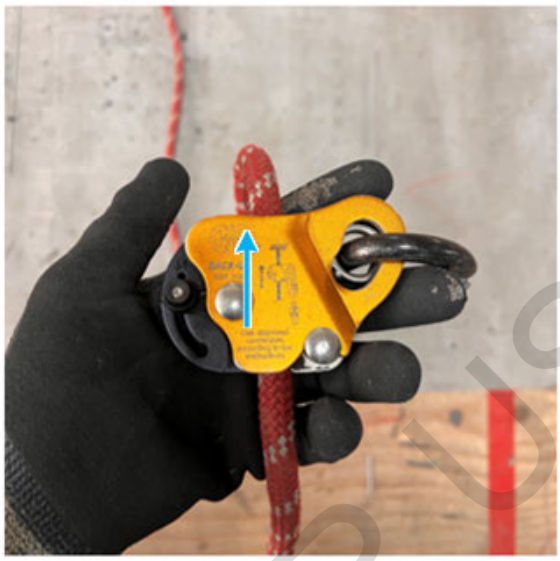
- 50ft Rope
- Fall Protection Carabiner
- Underlayment Patch
- Anchor
- Anchor Lags
- Drill
- Impact Driver

Last Person Down:

1. While still connected to the last anchor, take a second rope and remove the Kong. Run the working end of the rope through the assisted access point.
    - The assisted access point should be installed no more then 20 ft from the eave and a 50 ft rope can be used to rappel down roof at this distance.

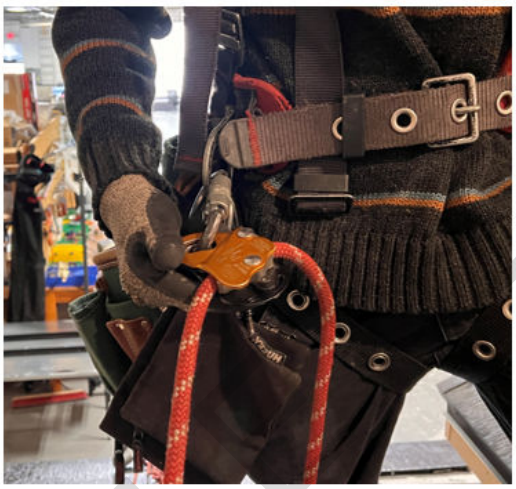
2. Reattach the Kong to the rope, ensuring it is attached in the correct direction, with the arrow facing up-roof.

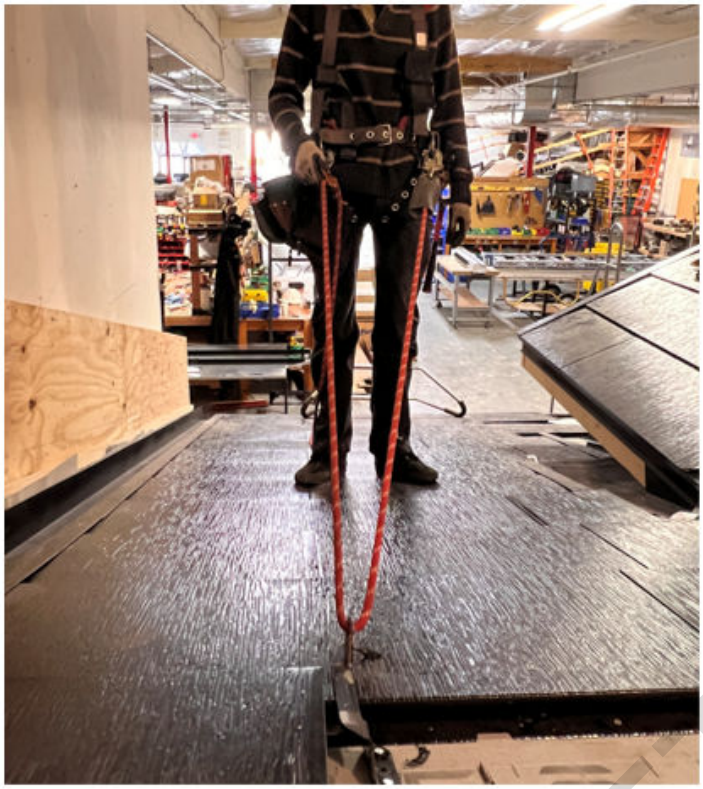




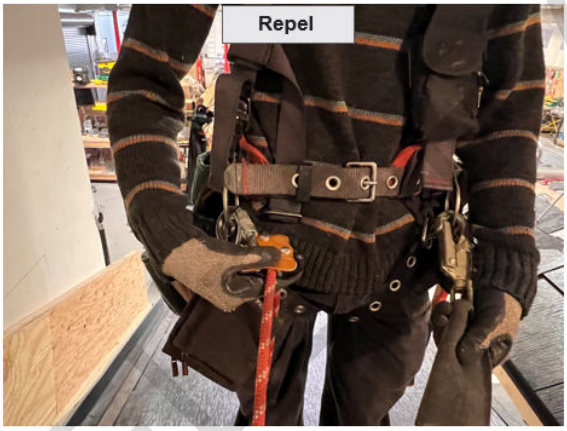
3. Attach the Kong to a D ring and the rope's double action snap hook to the opposite D ring.
    - Ensure a figure eight is tied properly on the end of your rope.

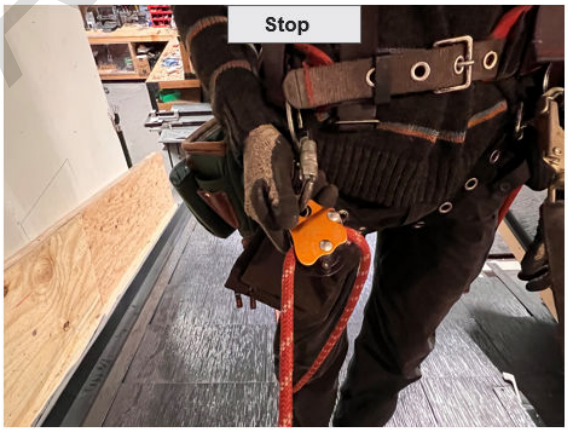
When secure, uninstall and patch the last anchor.





4. When the roof is all closed up, rappel down by tilting the Kong downward. Turn the Kong sideways to stop.

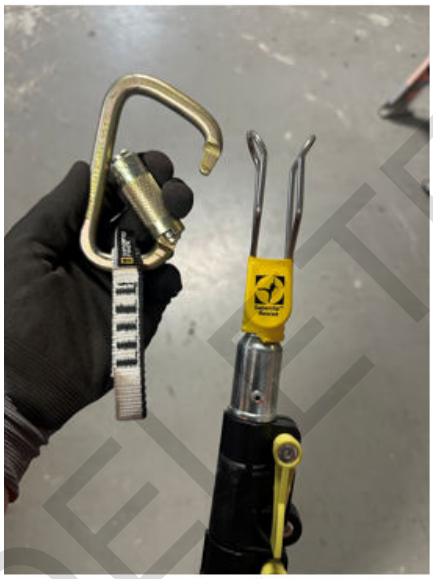




5. While safely on the ladder, remove the Kong from the rope, untie the figure eight knot and pull the rope through the assisted access point.

First Person Up Solar Roof Servicing:

1. Clip the Fall Protection Carabiner to the Super Clip Rescue, so the clip locks the gate open.

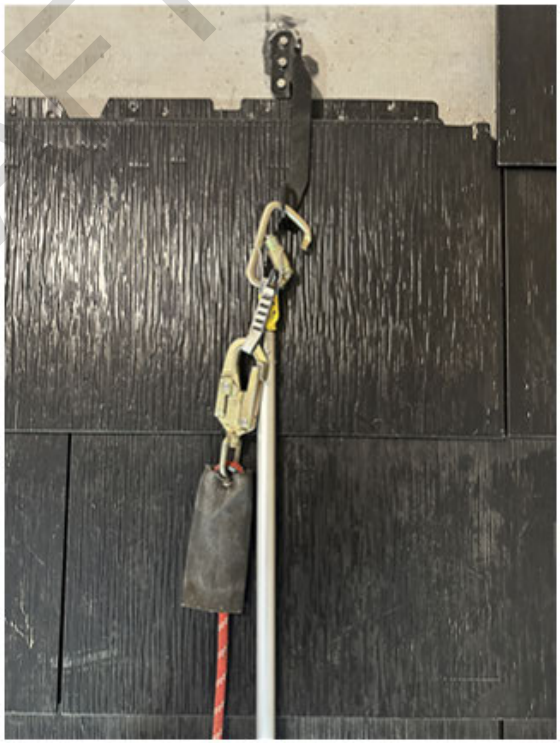


2. Attach the fall protection rope snap hook to the open end of the fabric sling.

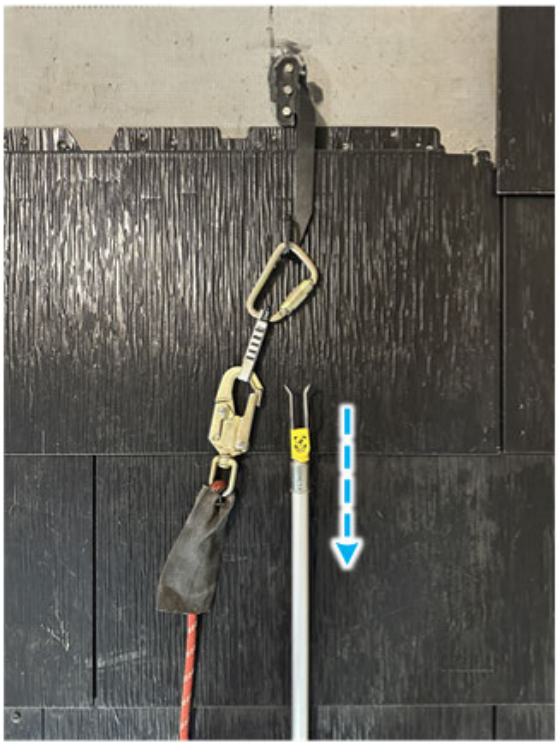


CAUTION: Be mindful of overhead power lines and service drops when using the Extension Pole. Follow all Service drop safety procedures.

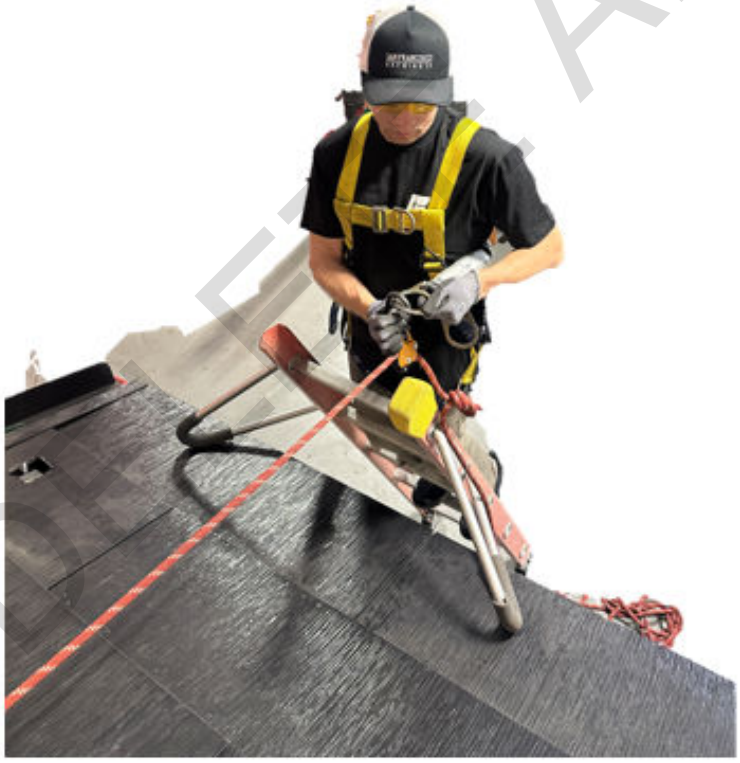
3. Locate the assisted access point within the JCO. Extend the pole to clip the Carabiner onto the assisted access point.

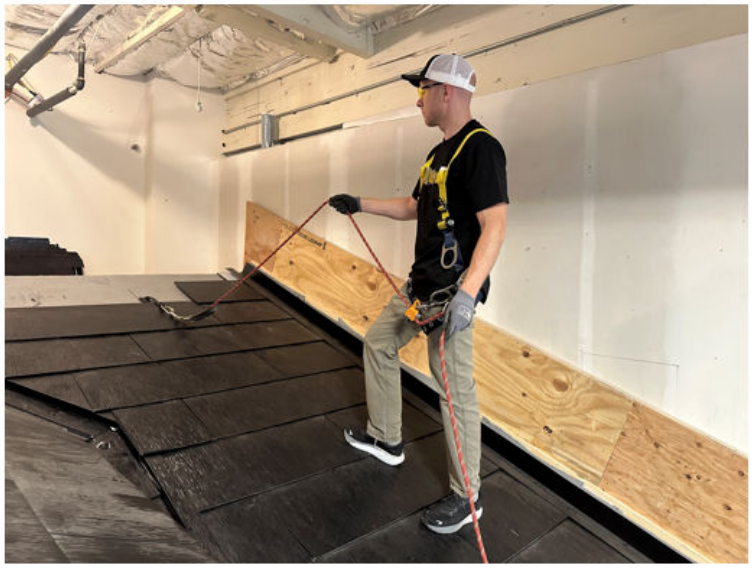
4. Pull back sharply on the extension pole to release the super clip and latch the carabiner on the assisted access point.
   Whip and tug on the rope to ensure the carabiner is properly clipped onto the assisted access point.



5. Attach the Rope Grab to your shock pack D ring and access the roof.



6. Pull slack through the Kong while ascending the roof to prevent sliding down roof in the event of a fall.



7. Install a safety anchor by removing a PV tile or tile skin and locating a rafter.

   NOTE: A safety anchor must be installed; the assisted access point is only to be used for accessing the roof.

8. Attach a second rope to the newly installed anchor and to your D ring.
9. Detach the assisted access point rope from your D ring and proceed with servicing/installation needs.
10. When servicing/installation is complete, proceed with the last person down guidance.

Shingle Flashing Installation

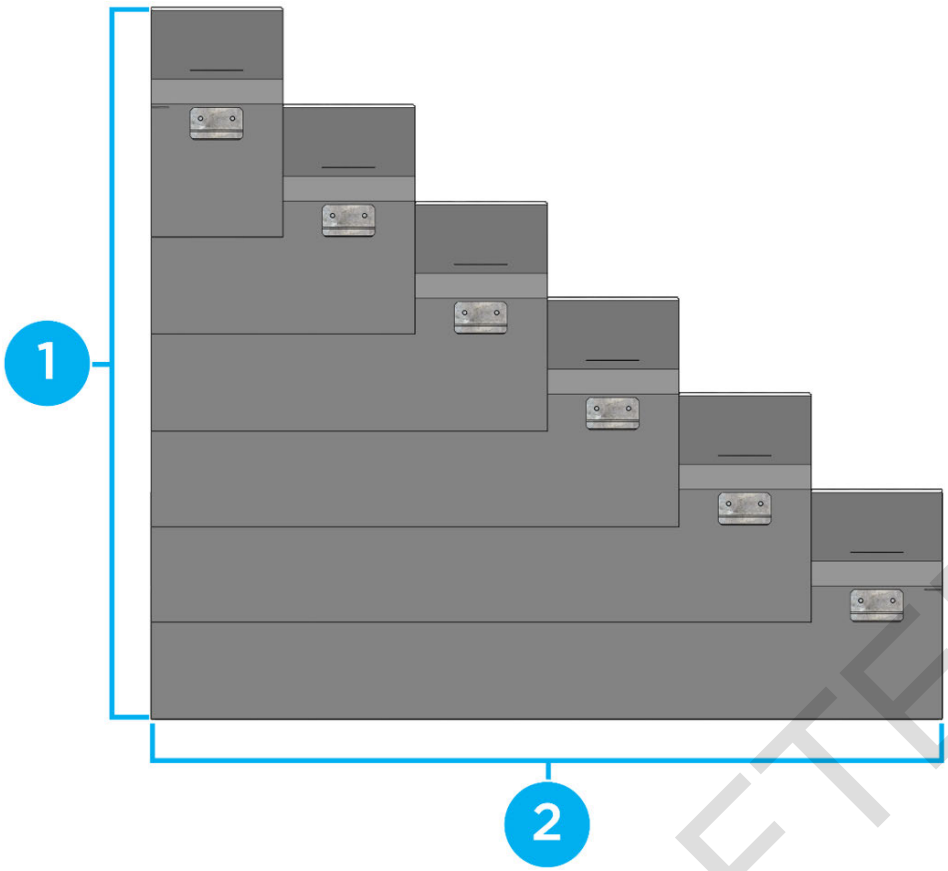
Overview

This section outlines the procedure for installing shingle flashing over mounting planes without obstructions. Shingle flashing replaces metal tiles in small areas of the roof without the need to build up to standard tile level.

See Shingle Flashing under *Part Inscription Identifier on page 709* for an overview of shingle flashing features used throughout installation.

Shingle Flashing is installed similarly to traditional composition shingles by installing courses of shingle flashing as "books."

A book **(1)** is created by first installing a full piece of shingle flashing **(2)**. All shingle flashing pieces that follow in the book are cut and arranged to form a diagonal up roof line, ensuring proper stagger. All shingle flashing courses that follow use this same installation method and engage with the previous course.



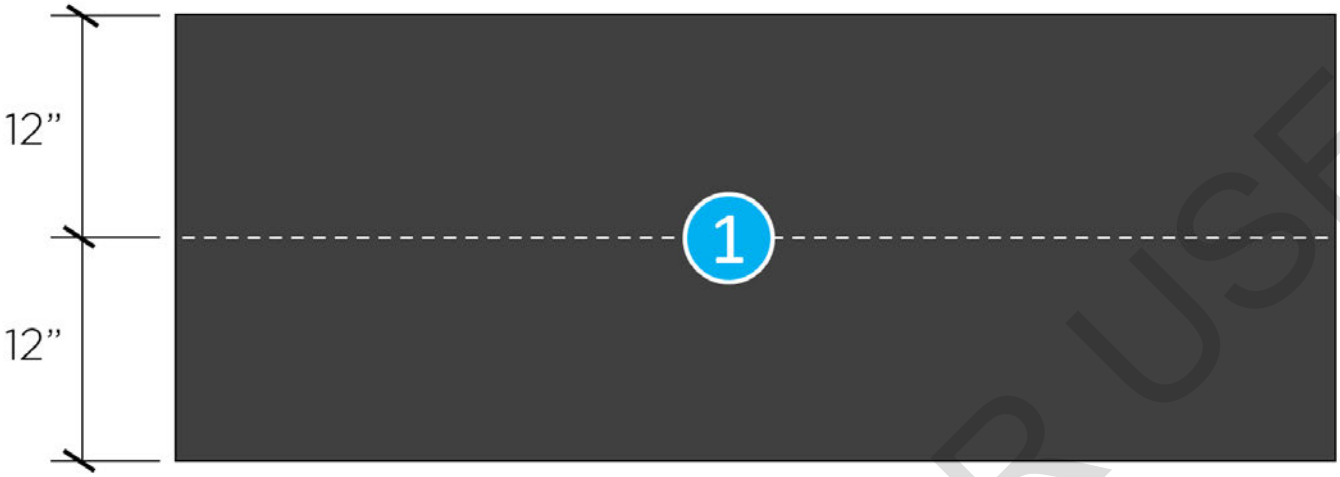
NOTE: If the mounting plane is smaller than a full piece of shingle flashing, the booking installation method is not required. Instead, each piece of shingle flashing in a course can be installed on top of each other. This would be common practice for features such as bay windows.

Refer to the table below to determine areas of the roof where shingle flashing installation is appropriate.

Shingle Flashing Installation Parameters	
Zipper Hips	✗
Raised roofing mounting planes that would require additional parts	✗
Areas where existing flashing needs replacement	✗
Areas with living spaces located beneath the mounting plane	✗
Mounting planes that exclusively lead into walls (without obstructions)	✓
Bay windows	✓

Work Instruction

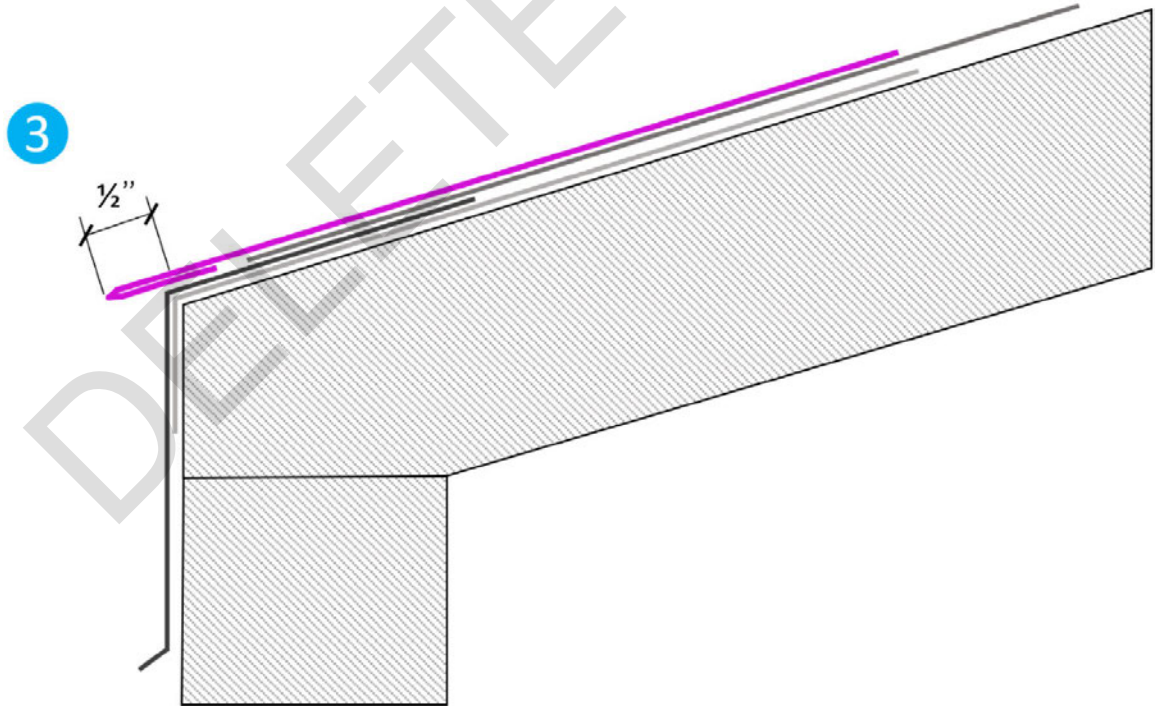
Create a shingle flashing starter course out of flat stock. Cut the flat stock horizontally through the center so that two 12 in wide pieces remain **(1).**



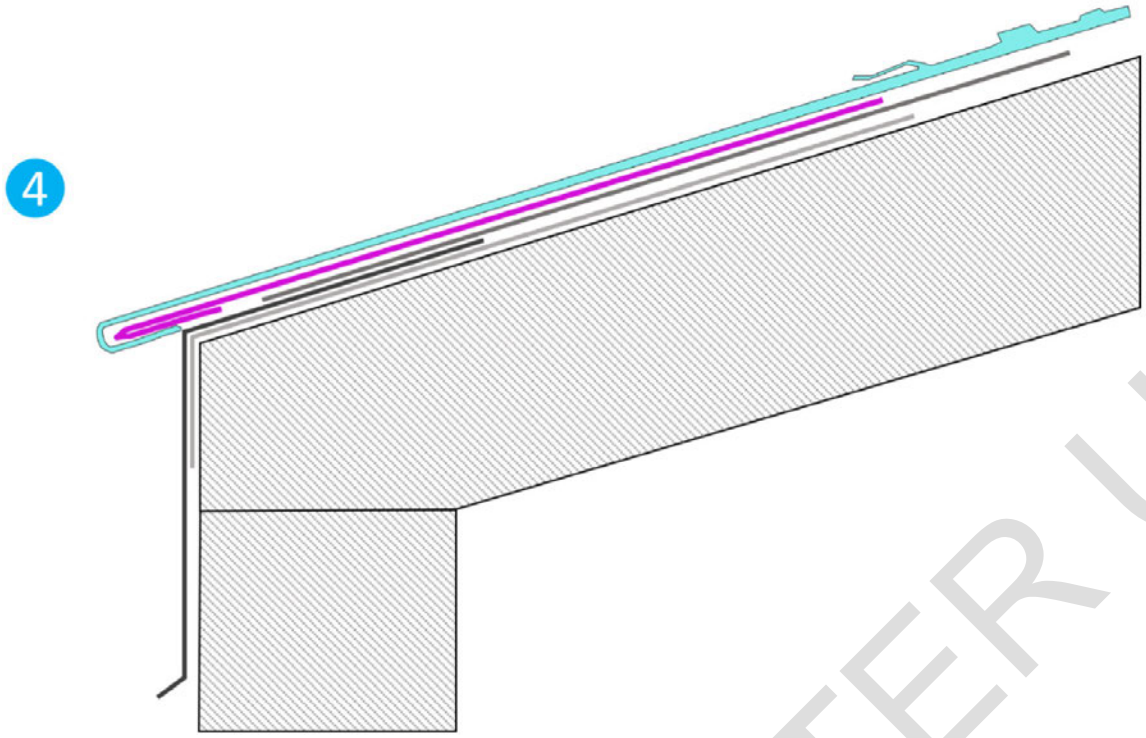
Create a 1 in closed hem along one edge of the flat stock **(2).**

Install the flat stock with the closed-hem overhanging ½ in over the eave **(3)**.

NOTE: Before fastening, ensure fasteners will be driven through both the deck and eave metal. Otherwise, the flat stock will not be properly secured.



Install the first row of shingle flashing over the flat stock course, ensuring that the shingle flashing cleats engage with the flat stock closed hems **(4).**



Continue installing the next courses of shingle flashing, maintaining proper stagger. Fasten shingle flashing above the cleat and in line with the center of the nailing lines in accordance with the applicable wind tier in the *Fastener Schedule. on page 703* Engage overlapping shingle flashing courses with the cleats of the courses below **(5)**.

NOTE: Most fasteners will be covered by the overlapping shingle flashing throughout installation. Cover fasteners that remain exposed in the top course with a dollop of sealant.

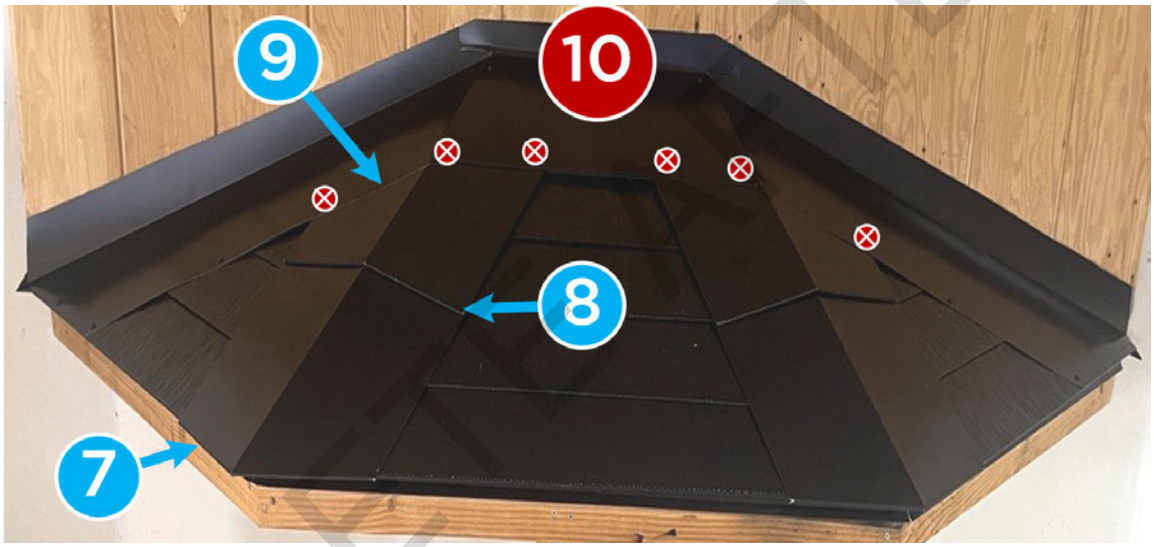
Integrate the final course of shingle flashing with the wall flashing, ensuring that the final course is tucked underneath the wall flashing **(6).**

If the mounting plane contains hips, install hip caps. Additional risers or channel flashing are not needed to support hip caps. Instead, hip caps are installed directly over shingle flashing.

The down roof edge of the starter cap engages with the overhanging first course of flat stock **(7).**

- For instructions on fabricating a starter cap, see Starter Cap Fabrication under Hip Starter Cap.

The following caps engage with the starter cap cleats **(8)**, are tucked into the wall flashing **(9)** and fastened through the wall flashing **(10)**.



Bracket Fastening

Overview

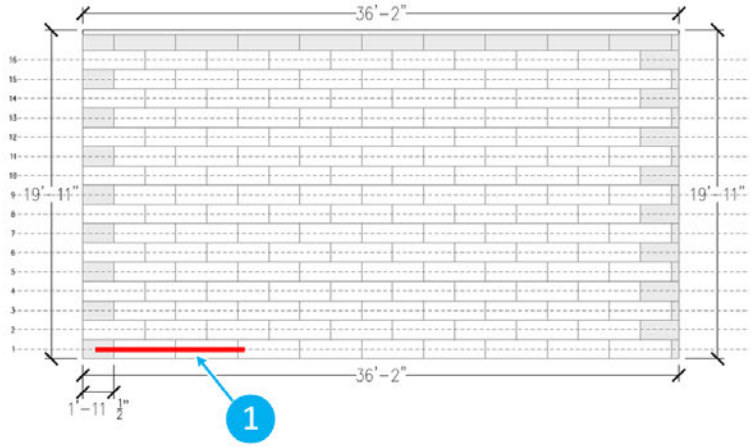
This procedure covers how to install the accessory bracket for securing roof fixtures (for example: a snow fence or chimney supports) to the Solar Roof. The bracket does not support satellite dish or lightning rod applications.

Tools and Equipment:

- Accessory Bracket Kit
- Measuring Tape
- Metal Snips
- ½ in Socket Bit
- 3/16 in Drill Bit
- Hammer
- Impact Driver
- Caulk Gun and Sealant

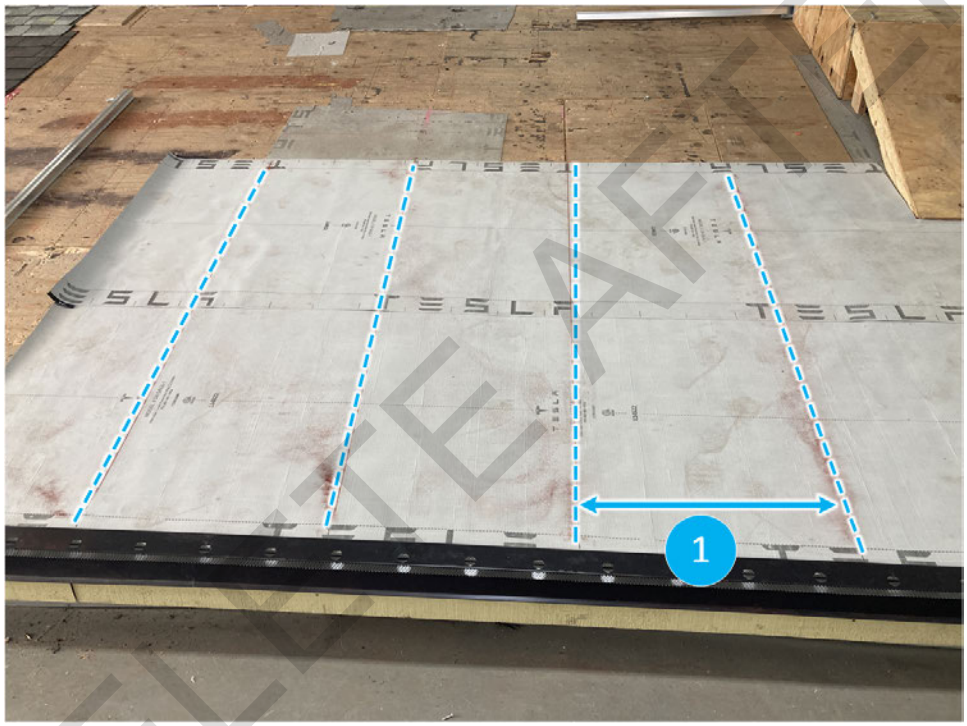
Work Instructions:

1. Identify the tile course where the accessory bracket(s) will be installed. When installing a snow fence, refer to the manufacturer's installation instructions or job plan set for allowable spans, mounting schedules, and cantilever dimensions to determine the exact location and quantity of accessory anchors to be installed.



1 - Snow Fence

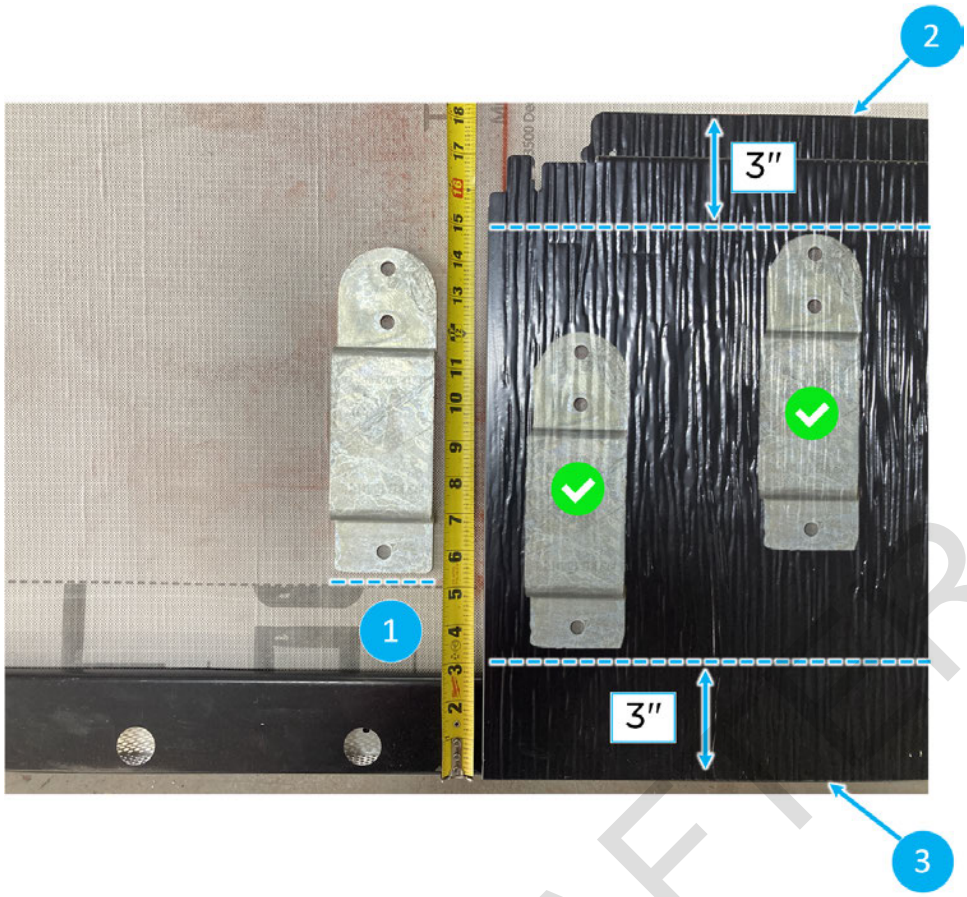
2. First, determine the locations of rafters used to anchor the brackets. The below example shows bracket installation for mounting a snow fence.



1 - Rafter spacing can vary; always double check with a hammer and if necessary, chalk a line to have a reference of where the rafter location may be.

3. Next is determining the location of the bracket on the metal tile. The bracket must be positioned vertically with the rounded edge up roof.

   The bracket can land between 3 in above the leading edge of the tile, or 3 in below the top edge of the tile. This will ensure that the bracket does not interfere with the engagement shoulder/hook of the metal tile.



1 - Bottom leading edge of the bracket

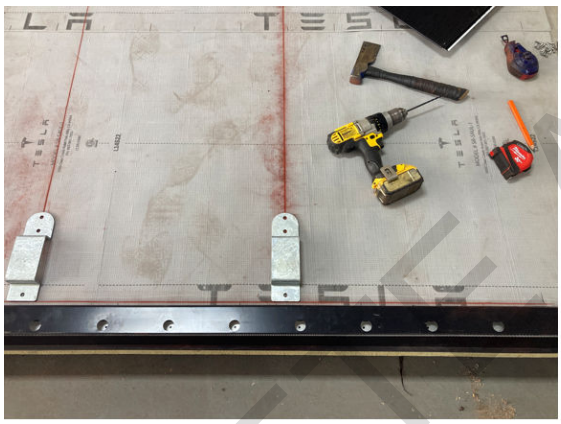
2 - Top edge of the tile

3 - Leading edge of the tile

CAUTION: Avoid installing the bracket under the water channels of the tiles. It is best practice to either shift the array or in cases of chimney supports, move them to the tile course above when possible.

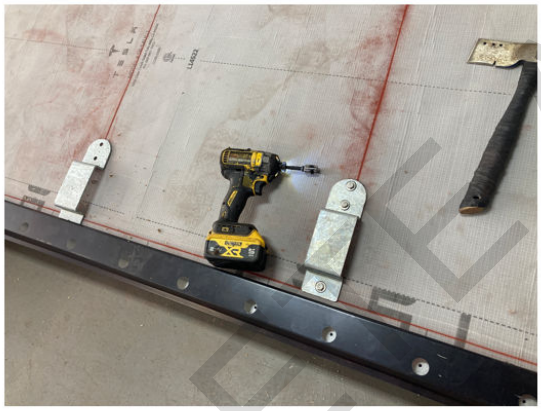
4. As with installing a snow fence, make sure that the brackets are in line with each other. This can be done by measuring or chalking a line.

5. Once the location of the bracket has been determined, place the accessory bracket over the rafter location and make pilot holes for the lag screws.
   Clean debris away from the pilot holes.

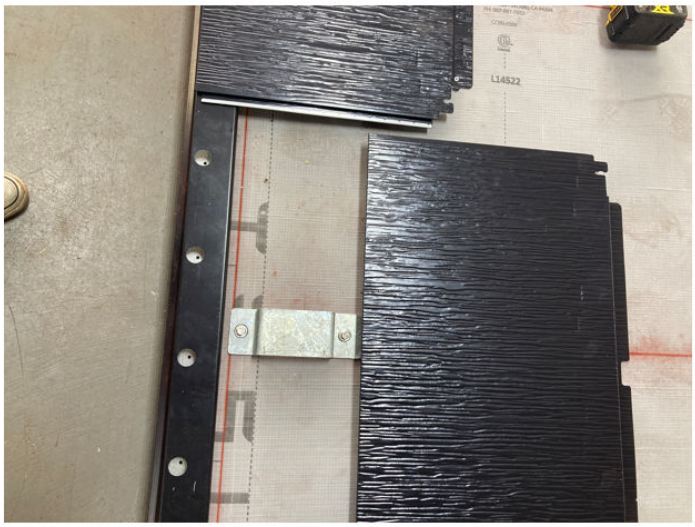


6. Add sealant to the bracket and pilot holes, then secure the bracket with three lag screws and bonded washers (provided with the accessory bracket kit.)

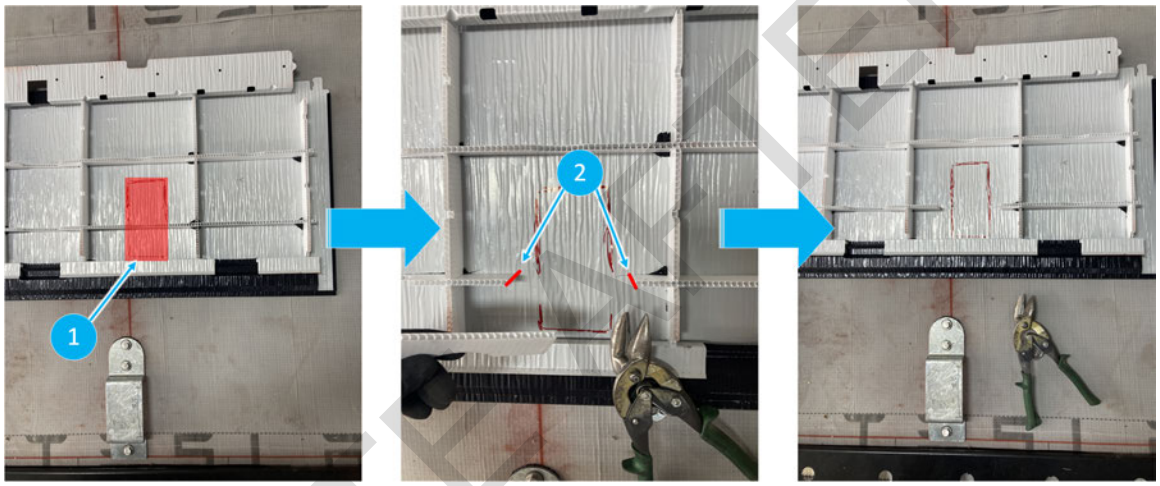
7. Once the brackets are installed, begin the tile installation.



   a. When installing metal tiles over a bracket, it is recommended to measure where the bracket is going to sit underneath the tile and mark it on the back of the tile.



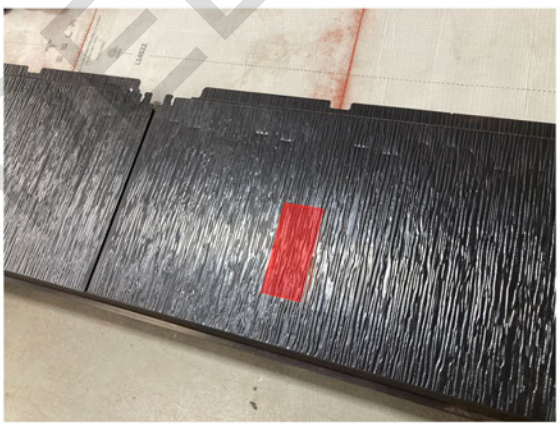
8. At this point, you may need to snip away any supports that are interfering with the bracket.



1 - Location of the bracket once it is installed

2 - Snip

9. Fixtures can now be attached to the accessory bracket. Ensure that all the screws are installed through the accessory bracket. If screws miss the accessory bracket, the fixture will not be secure.



NOTE: Pro Tip: Use a string/chalk line to ensure that the snow fence is installed in a straight line.

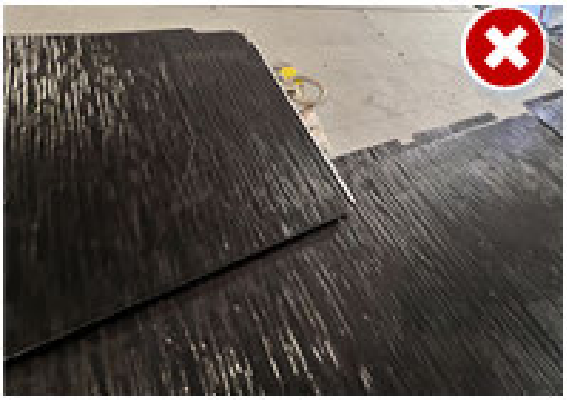
10. Follow the manufacturer's instructions for the assembly and installation of snow fences.
    - *ColorGard Installation Instructions*

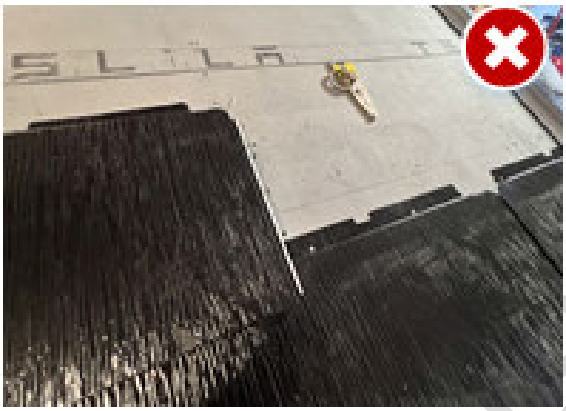
Anchor Relocation

Overview:

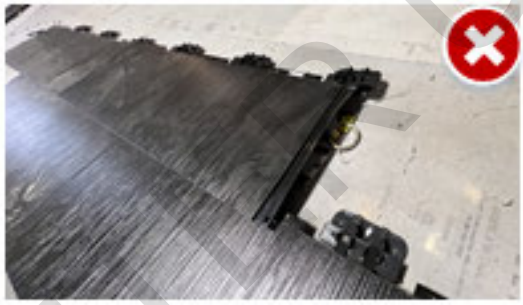
This section provides instructions for relocating anchors that interfere with tiles during installation. To ensure anchors are accessible and to achieve proper waterproofing, an anchor must be relocated if the current location causes any of the following:

- The anchor interferes with a metal tile's water channel or nailing flange.

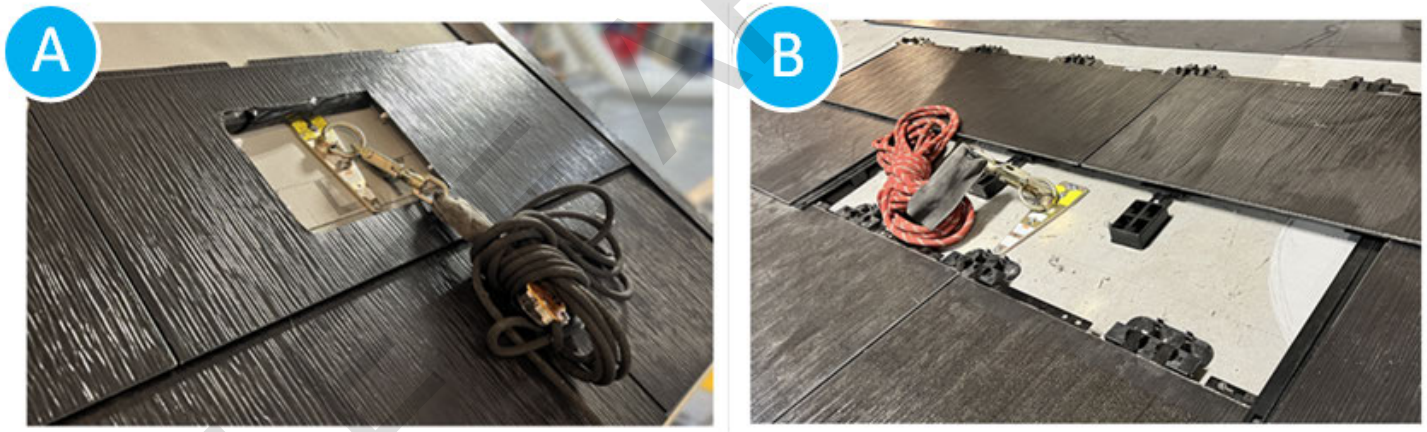




- The anchor interferes with the top of a PV tile, foot, or footlap.



Pictured: Finished installation at metal tile courses **(A)** and PV tile courses **(B)**.

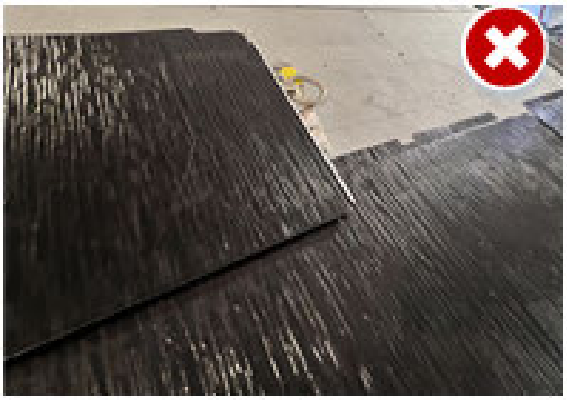


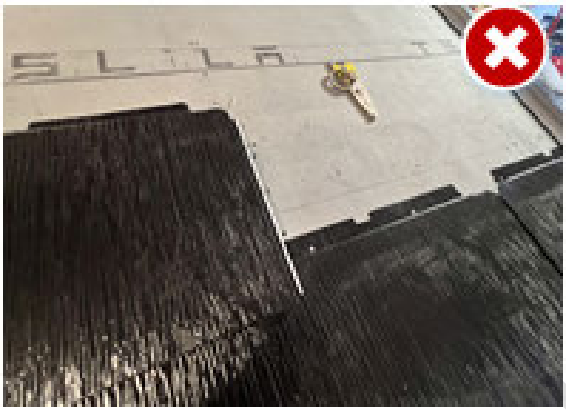
Tools and Equipment:

- Metal Snips
- Anchors
- Sealant
- Underlayment (patches)

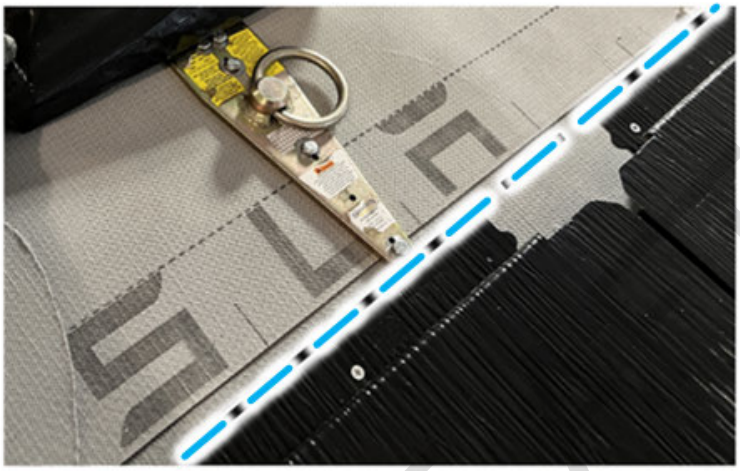
Relocating Anchors Interfering with Metal Tiles

If an anchor interferes with a metal tile's water channel or nailing flange, uninstall the anchor and patch the holes left over with sealant and underlayment (see step 3).





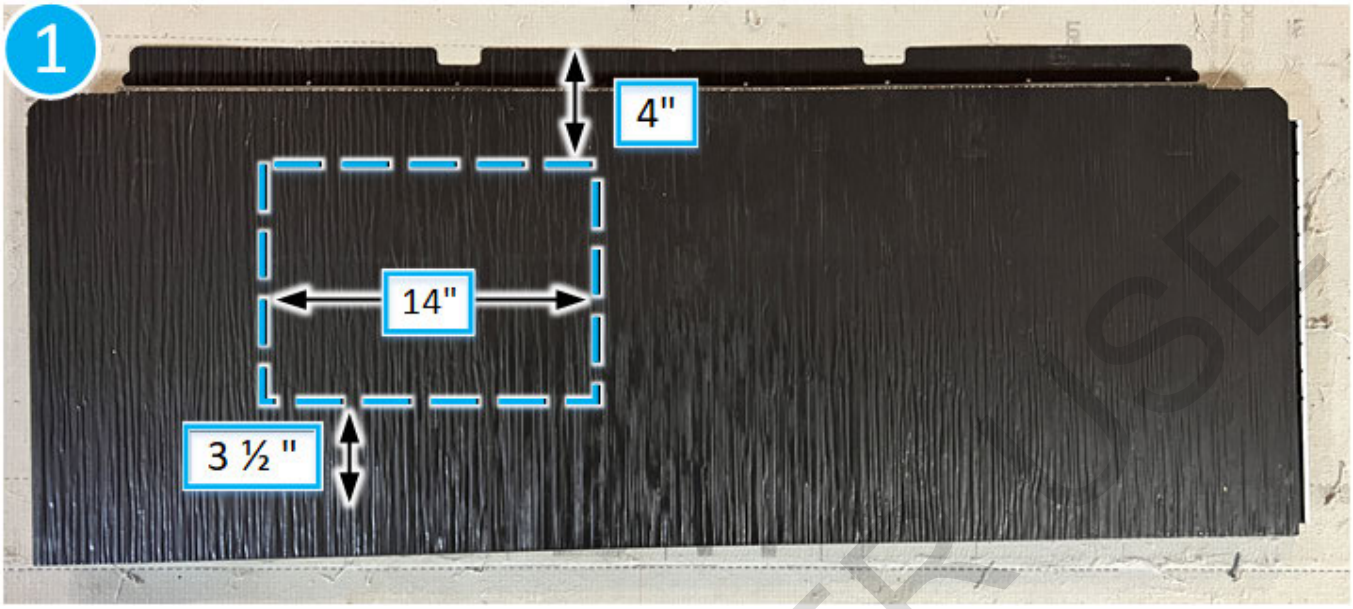
1. Identify a new location for the anchor. Locate a rafter that does not interfere with any metal tile water channel and is ideally near the center of a tile. Install the anchor and ensure the bottom of the anchor is in line with the top of the lower course metal tile nailing flange.



2. Cut a hole into a metal tile with the following parameters **(1)**:

> **NOTE:** These dimensions ensure the tile hook remains intact and the metal tile can support a tile skin.

   - 4 in from the nailing flange
   - 3 ½ in from the bottom edge
   - 14 in wide



3. Cut an anchor patch out of underlayment. Unpeel a small portion of the patch's lining (leave 6 in of liner intact) and stick it above the anchor **(2)**.

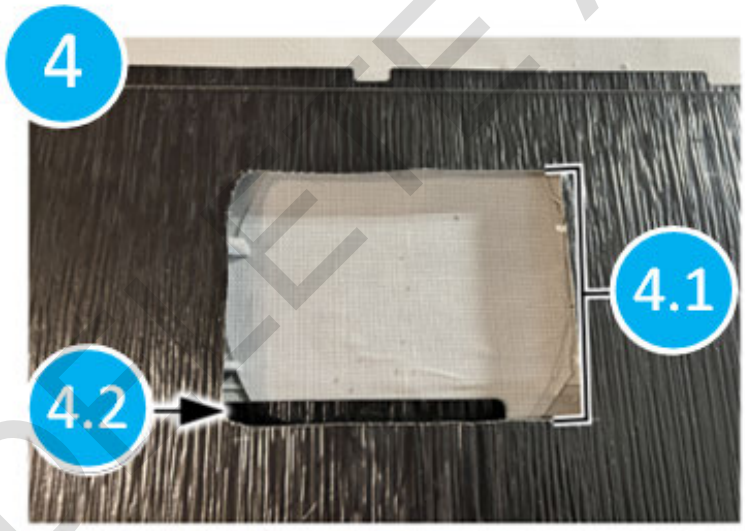
4. Roll up the remaining patch material and install the cut metal tile over the anchor. Tuck the patch above the anchor and underneath the tile. At this point, the anchor is no longer interfering with a metal tile – attach ropes to the anchor and continue installation **(3)**.

5. Once SRI is completed or the anchor is no longer needed, uninstall the anchor. This will leave holes in the deck that must be filled with sealant and covered by the anchor patch.

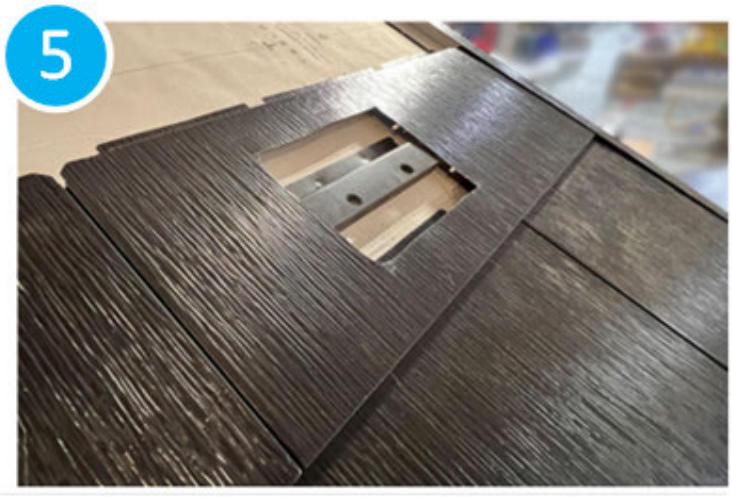
> **NOTE: PRO TIP:** Before applying sealant, slightly reduce the anchor patch's adhesion by peeling off the liner and briefly sticking the patch to the deck and removing it. This will prevent the patch from sticking to the deck before it can be tucked under the nailing flange in step 4.

6. Fill in the remaining holes with sealant and remove the fasteners from the lower course metal tile beneath the cut metal tile. Unfurl the anchor patch and slide it underneath the same nailing flange and re-fasten the nailing flange **(4)**.

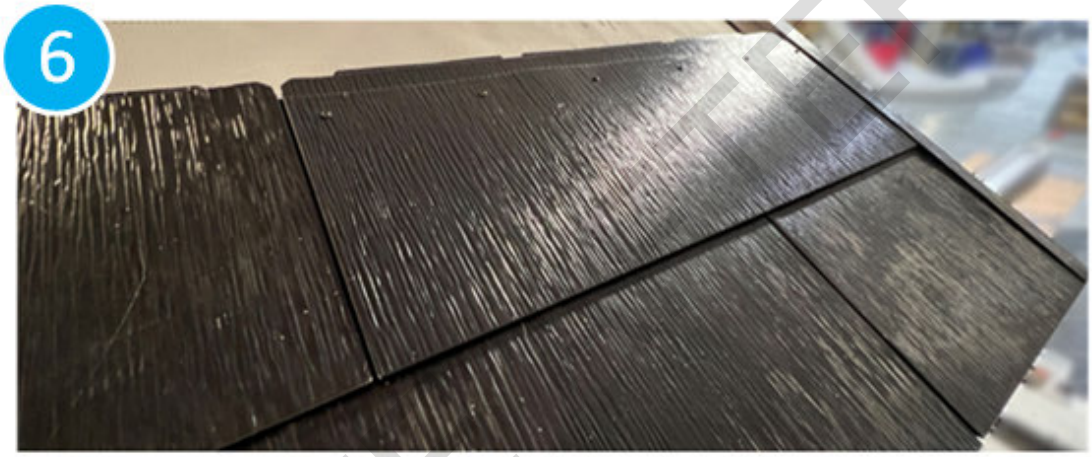
   Pictured: Anchor patch **(4.1)** tucked into lower course metal tile nailing flange **(4.2)**.



7. Install a piece of vented riser cut to 14 in (the width of the metal tile hole) **(5)**.

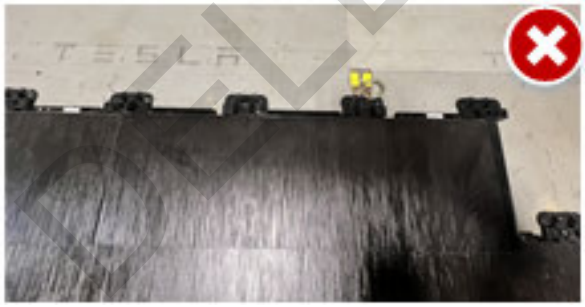


8. Install a tile skin to conceal the hole. **(6)**.



Relocating Anchors Interfering with PV Tiles

If an anchor interferes with the top of a PV tile, foot, or footlap, uninstall the anchor and patch the holes left over with sealant and underlayment (see step 3).



1. Remove a PV tile with the feet and footlap remaining in place. Locate a rafter that does not interfere with the feet and install the anchor aligned with the top of the lower PV tile course foot **(1)**

.

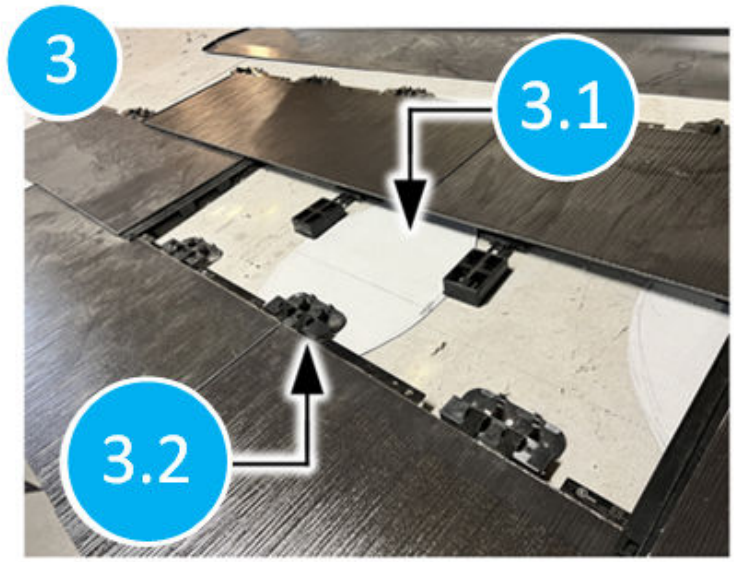
2. At this point, the anchor is no longer interfering with a PV tile – attach ropes to the anchor and continue installation **(2)**.

3. Once installation is completed, uninstall the anchor. This will leave holes in the deck that must be filled with sealant and covered by the anchor patch.

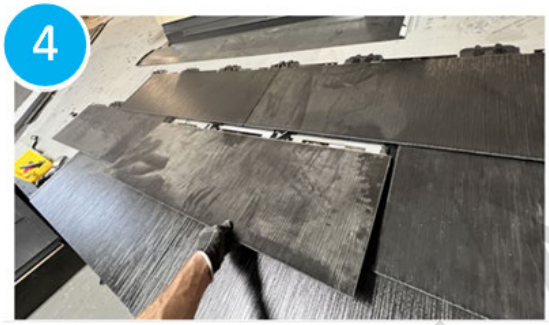
> **NOTE: PRO TIP:** Before applying sealant, slightly reduce the anchor patch's adhesion by peeling off the liner and briefly sticking the patch to the deck and removing it. This will prevent the patch from sticking to the deck before it can be tucked under the nailing flange in step 3.

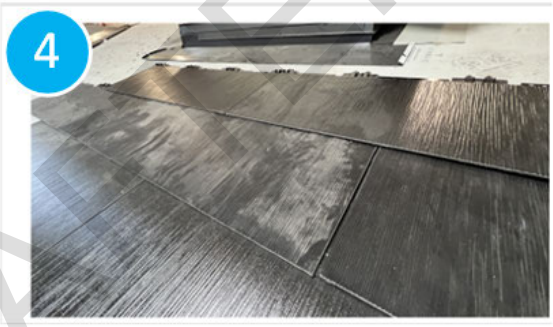
Fill in the remaining holes with sealant and remove the fasteners from the lower course PV tile foot. Unfurl the anchor patch and slide it underneath the same foot and re-fasten the foot **(3)**.

Pictured: Anchor patch **(3.1)** tucked into lower course metal tile nailing flange **(3.2).**



4. Re-attach the missing PV tile and reconnect the leads **(4)**.





Tesla Tools and Jigs

Robin Jig

Overview

This section provides an overview of the Robin Jig tool. For in-depth instructions on using the tool, watch the *Robin Jig Use Cases video on page 606*.

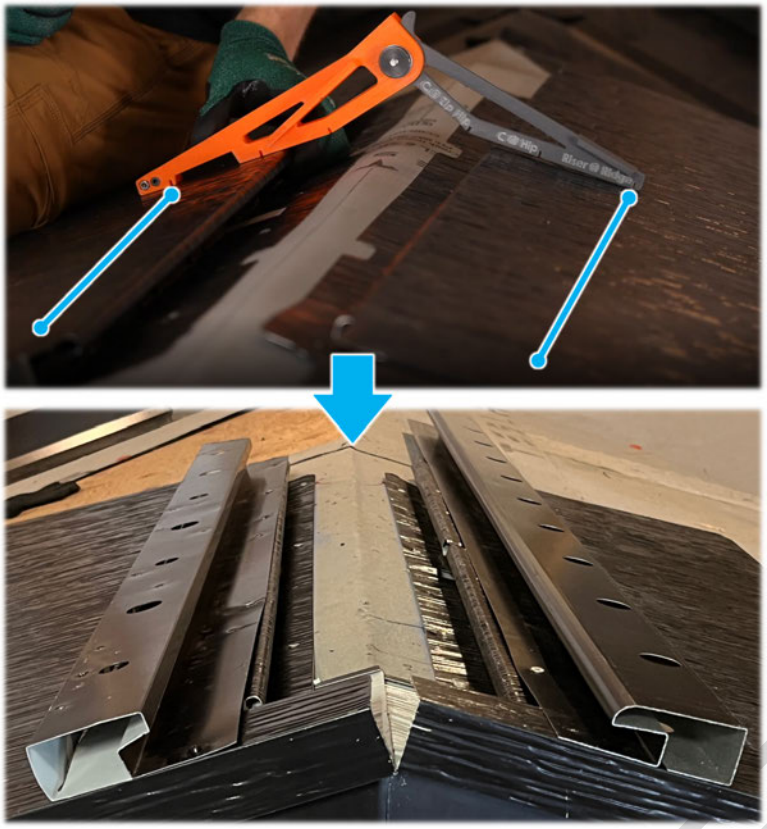
The Robin Jig is used to determine the locations of channel flashing and riser flashing on a Ridge or Hip. These flashing locations vary with roof pitch and the Jig helps provide standard methods for identifying them.

NOTE: To lock the Jig into one position / angle during any of the use cases outlined below, twist the thumb screw.

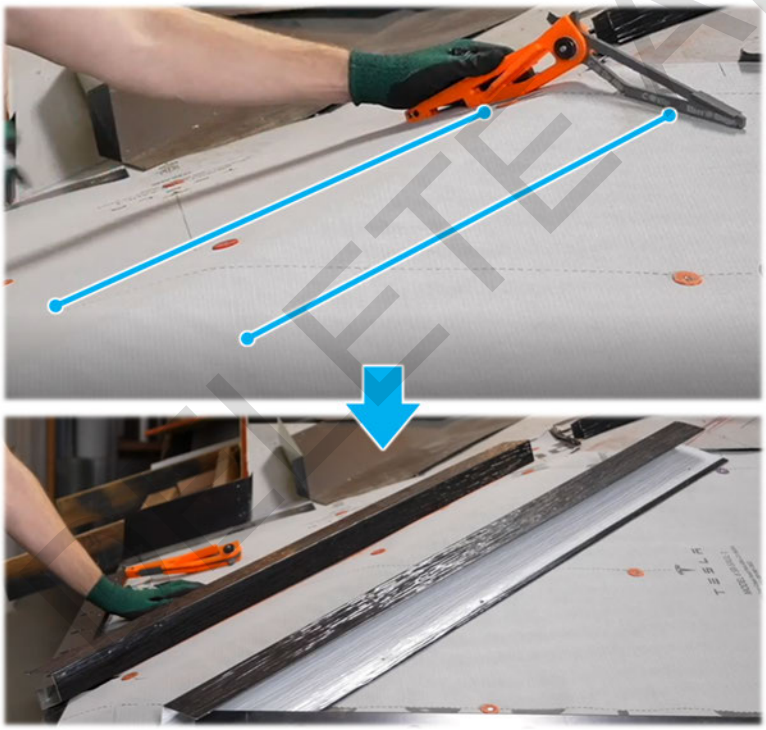
The Robin Jig features three sets of marks to indicate important flashing measurements on the roof as well as shoulders on both sides to help set channel washout and ridge cap starter alignment.

Robin Jig Features Guide	
1	Riser at Ridge marks
2	Channel at Hip marks
3	Channel at Zip Hip marks
4	Shoulder

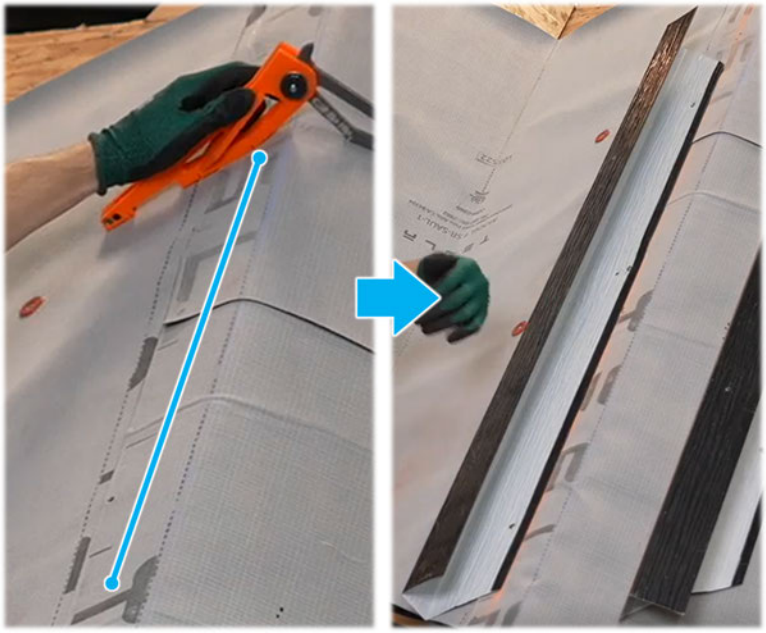
1 - Riser at Ridge: Used to set the location of vented risers at the ridge by marking the "Riser @ Ridge" points at the front and back of the ridge.



2 - Channel at Hip: Used to set the location of channel flashing at hips by marking the "C @ Hip" points at the front and back of the hip.

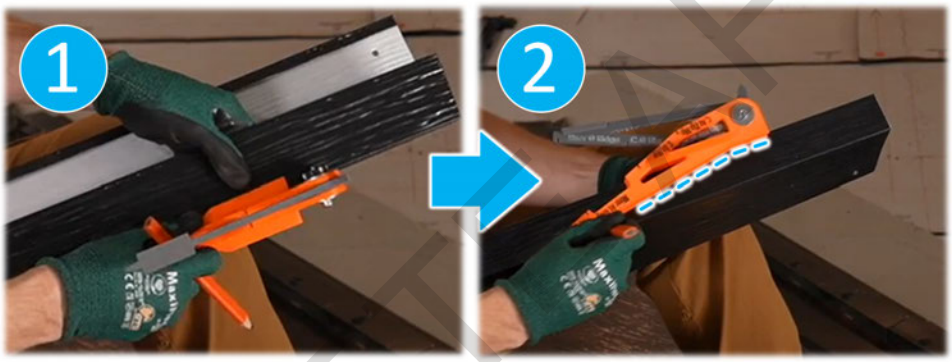


3 - Channel at Zip Hip: Used to set the location of flat stock at zipper hips that will have direct to deck tiles installed over them by marking the "C @ Zip Hip" points at the front and back of the zipper hip.

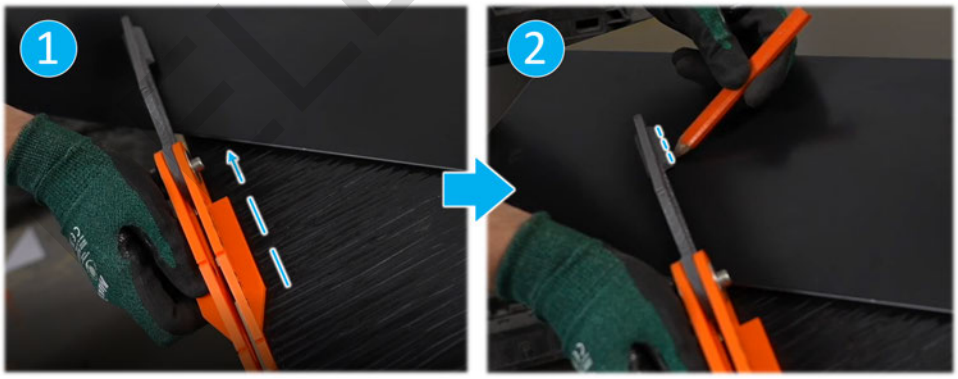


Other Use Cases

The Robin Jig can help create a **channel washout** by determining where to cut the flashing so that it will align with a washout pan. One Jig shoulder is placed against the upper side of the channel flashing **(1)** and the cut line is scribed across the Jig's bottom edge **(2)**.



The Robin Jig can also be used to help fabricate a **hip cap starter**. Robin Jig shoulder is aligned with the Tile closest to the hip and placed as close to the cap as possible **(1)**. Mark the shoulder location on the cap **(2)**.



Use Cases

Up and Over Jig

Overview

This section provides guidance for using the up and over jig to install PV tiles at an "up and over" feature (where two valleys converge at a ridge).

Solar Roof is intended to be installed upwards from eave to ridge. When a dormer, perpendicular ridge line, or large obstruction intersects the middle of a roof plane, it can be difficult to build up from both eaves and match the X and Y position of tiles at the intersection. Rather than building up from both eaves, it is best to build up one side, over the intersection, and down the other side of the roof plane in what is commonly called an 'up and over'. To accomplish this, the Up and Over Jig is used to set the X and Y position of footlaps when building down. Once the eave is reached, tiles can be installed back up to the intersection with confidence that the tiles will meet accurately.

Tools and Equipment:

- Up and over Jig
- Chalk line
- Nail gun
- Measuring tape

Pictured: Finished installation for reference.

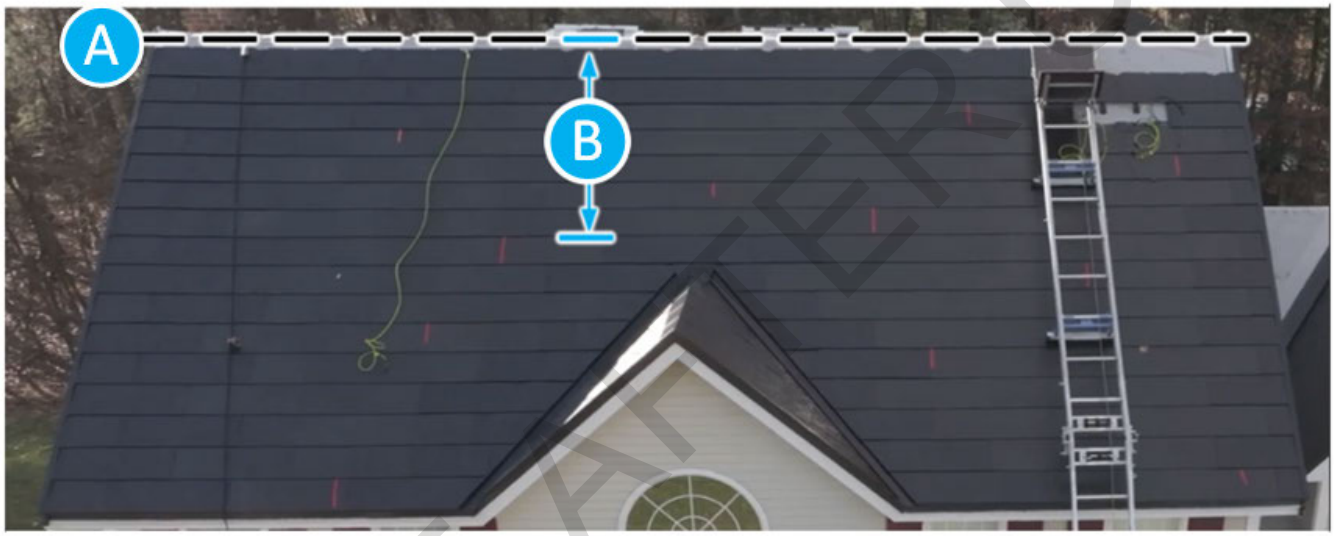
Work Instructions

NOTE: These instructions picture all steps performed to the right of the up and over feature. The same process applies for the left side if the building is in the opposite direction.

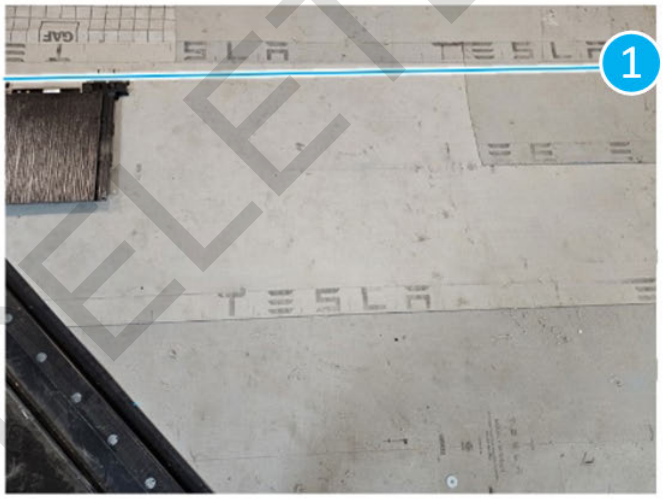
Install PV tiles up roof per standard installation practices until a PV tile is installed above the ridge of the up and over feature. From this point, mark the mounting plane (MP) with reveal lines that will determine footlap placement throughout these instructions.

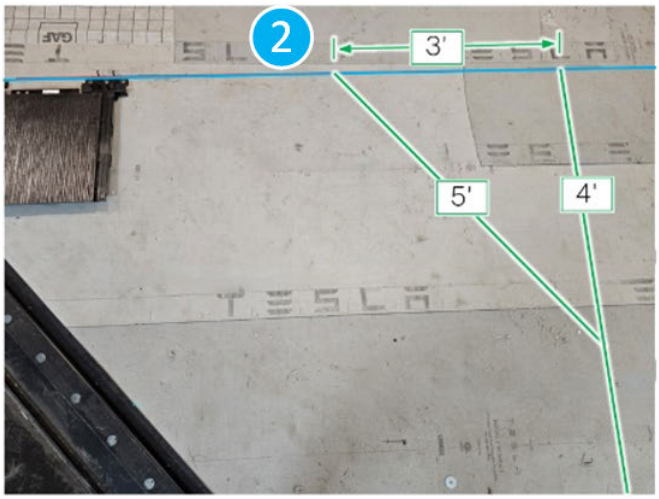
1. Measure the distance between the MP ridge and the top of the installed PV tile foot. Note that this measurement will be taken from the MP ridge, not from the "up and over" feature ridge.

   Pictured:MP ridge **(A)**, measurement to be taken **(B).**



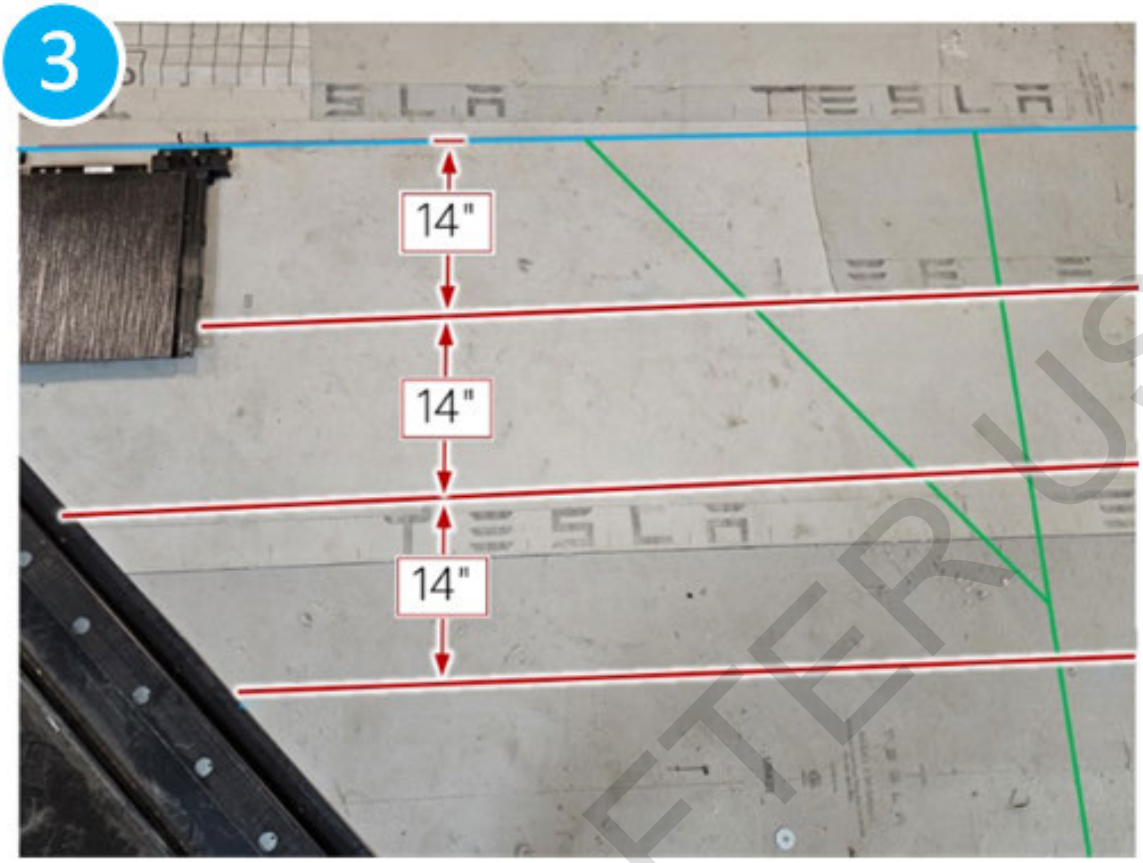
2. Snap a chalk line across the MP at this measurement - this will ensure that the chalk line is level **(1)**. Then, create a vertical bond line that intersects the eave using a 3-4-5 square **(2)**.





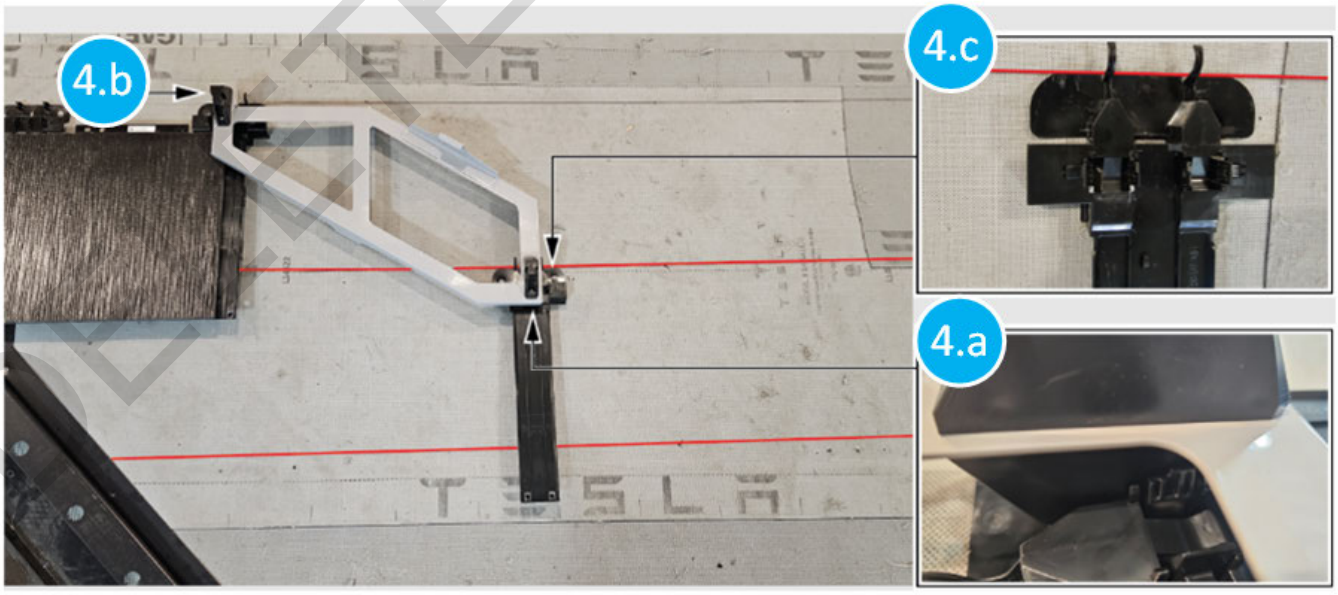
3. Snap horizontal chalk lines at 14 in increments from each other starting from the line snapped in step 1 **(3).**

   Make marks at 14 in increments down the bond line from the control line snapped in step 1. Repeat this with a secondary bond line, then snap chalk lines between these marks to create reveal lines.

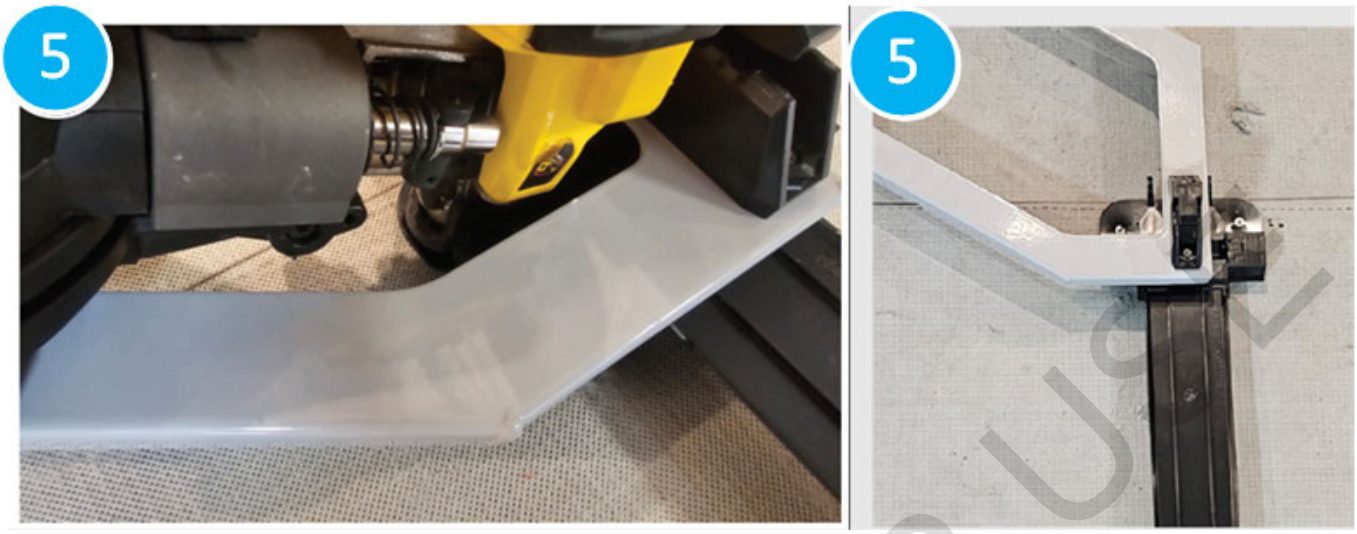


4. Attach a loose footlap to the bottom of the up and over jig **(4a)** and the installed PV tile's footlap to the top of the jig **(4b)**. Ensure the top edge of the loose footlap's nailing flange is aligned with the first reveal line **(4c)**.

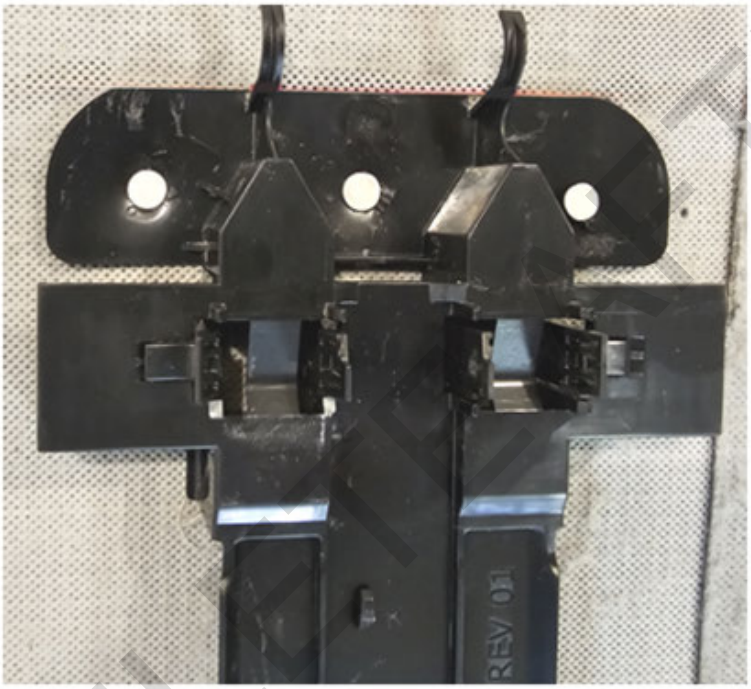
> **NOTE:** Proper jig-to-tile engagement will be indicated with a click sound.



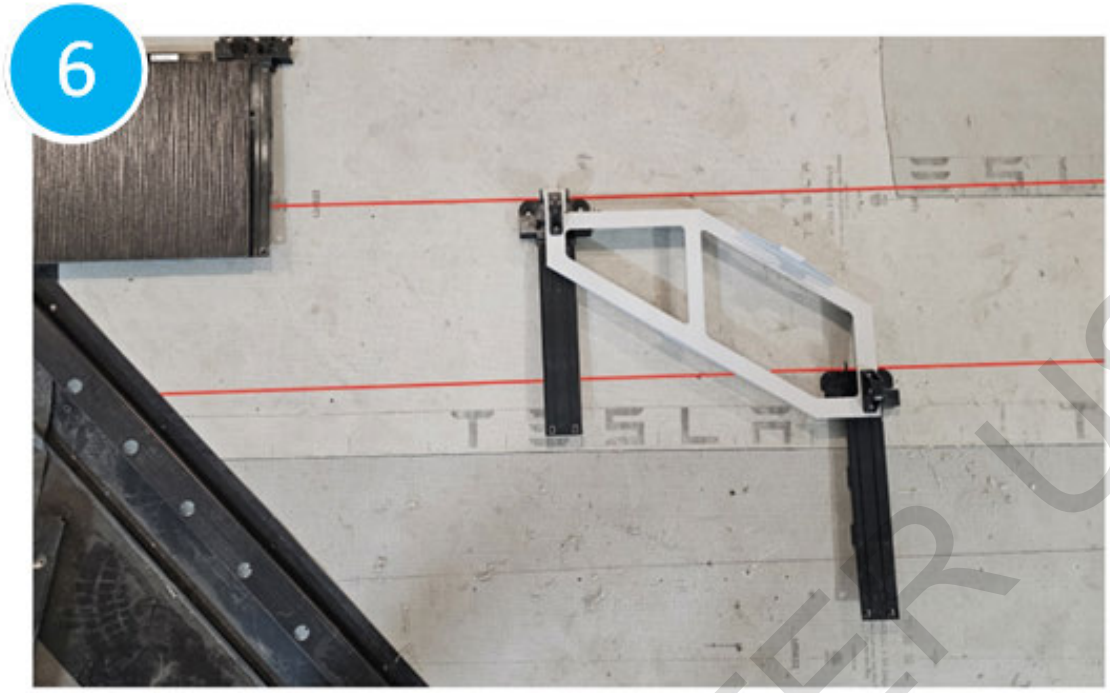
5. Fasten the loose footlap through the nailing flange (the nail gun may need to be rotated 90° to achieve this) **(5)**. Remove the jig and set a nail in the center section of the footlap.



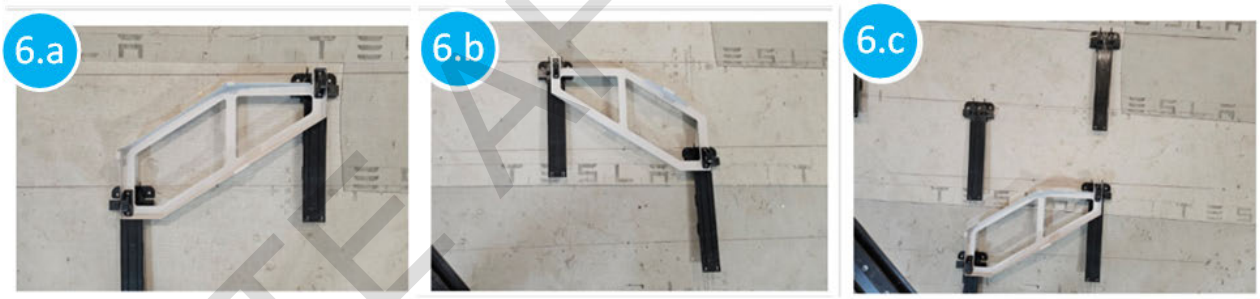
Pictured: Fastened footlap without an up and over jig showing all three fasteners in place for reference.



6. Repeat steps 4 and 5 for all footlaps as you move down the MP using the up and over jig and reveal lines to guide footlap placements **(6)**.



a. The up and over jig is reversible and can be used to attach footlaps down roof to the left **(6a)**, down roof to the right **(6b)** or flipped back and forth to build directly down **(6c)**.



7. Proceed to build PV tiles up the MP starting from the eave. Align each tile with the pre-installed footlaps. These PV tile courses will have proper alignment and stagger if footlaps are installed correctly **(7).** Cut and install metal tiles and adjustable trim covers along the valleys where PV tiles cannot be installed.

Tile Trimmer Maintenance Guide

Overview

Maintenance guide for user-serviceable parts of the Solar Roof Tile Trimmer.

Prerequisites

N/A

Hazards

Figure 1. Cut Hazard

Figure 2. Pinching Hazard

Safety and PPE

- Cut-resistant gloves (ANSI Cut Level 3 or EN 388 Level C)
- Safety glasses (ANSI Z87.1 or EN 166)

General Equipment

- Hex key, 4 mm
- Hex key, 5 mm
- Socket, 10 mm
- Ratchet
- Pliers
- Loctite 272 Red Threadlocker
- Loctite 242 Blue Threadlocker
- Microfiber cloth
- Lightweight oil (3-in-1, Waylube, or similar)

Required Parts and Tools

Tools listed are in addition to *Tesla Standard Tool Kit on page* .Refer to *Solar Roof Part Catalog*

- Tile Trimmer 2.0 (1947389-00-X)
- Saw plate subassembly (2220454-00-X)
- Saw plate mounting fasteners, M8 (*McMaster-Carr ordering link*)

- Gas spring, 40 lbs (*McMaster-Carr ordering link*)
- Vinyl plastic round grips 7/8 in OD (*McMaster-Carr ordering link*)
- Rubber strip (1948342-02-X)
- Rubber strip mounting fasteners, M6 (*McMaster-Carr ordering link*)
- Link subassembly (2221492-00-X)

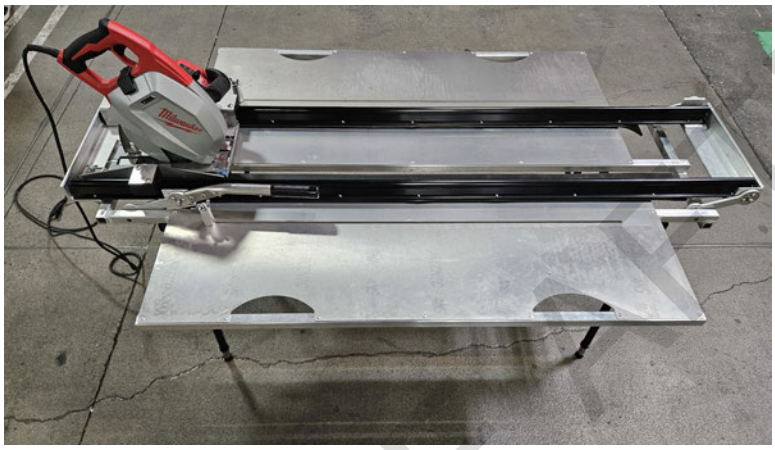
Saw Plate Replacement

It is recommended to replace the saw plate when replacing the saw. The saw plate is match-cut for the saw and is part of the alignment system for the Tile Trimmer.

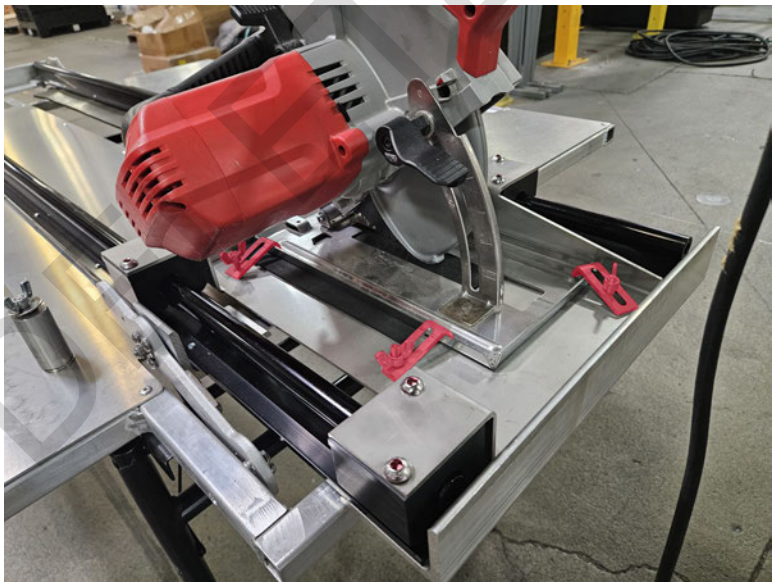
WARNING: Cutting the saw plate multiple times will reduce accuracy and increase risk for the user.

NOTE: It is recommended to replace the rubber strip to the right of the saw when replacing the saw plate.

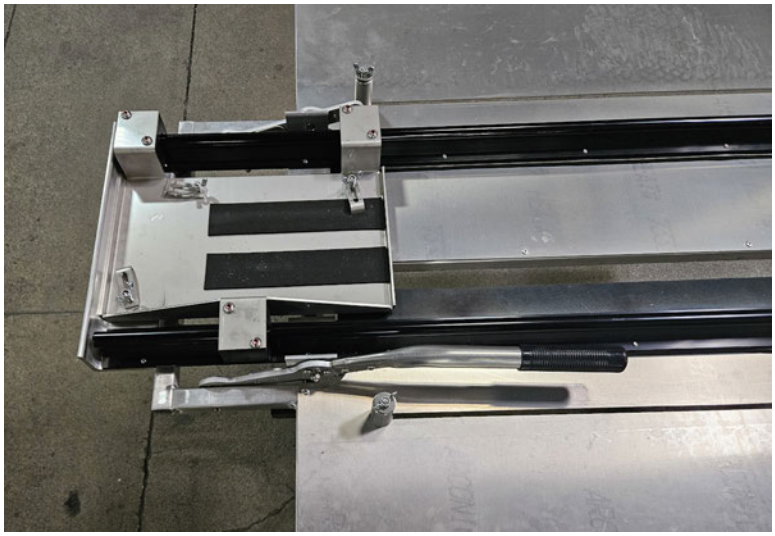
1. Disconnect the saw from power and raise the blade to sit above the saw plate.



2. Loosen the wing nuts securing the saw hold-downs in place and rotate the hold-downs away from the saw.



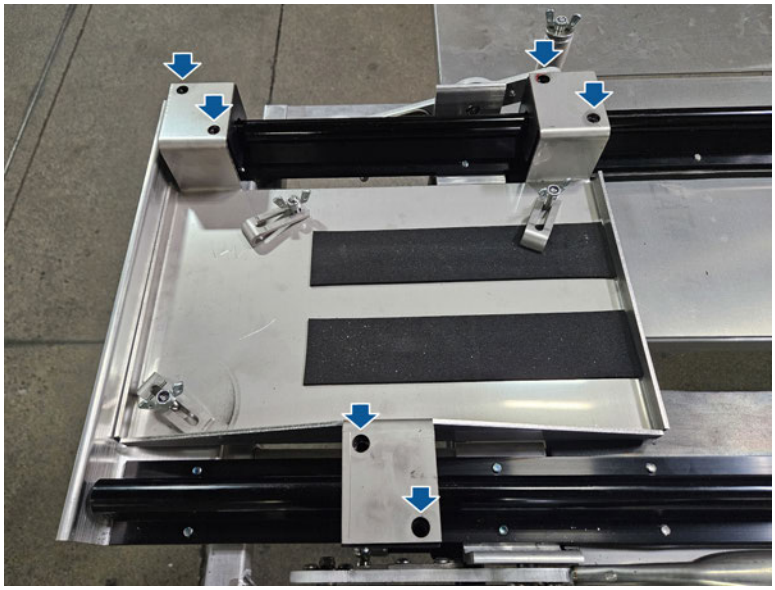
3. Remove the saw from the saw plate.



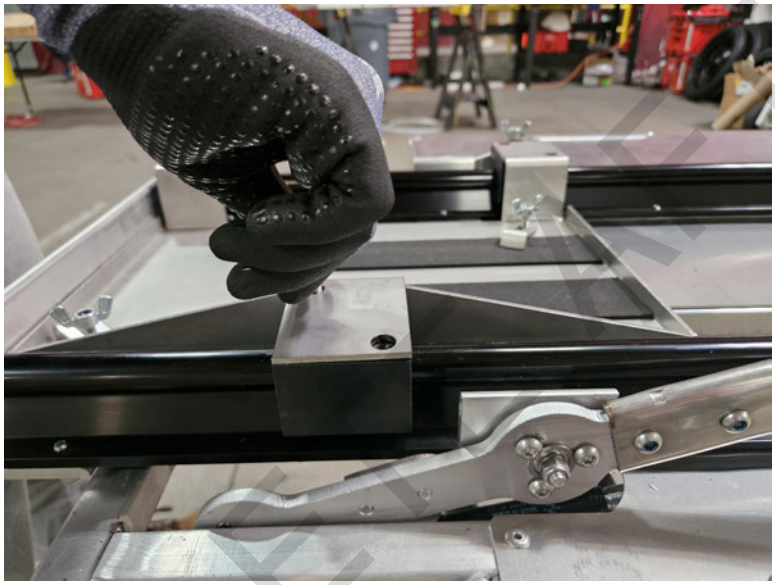
4. Use a 5 mm hex key to remove six M8 x 1.25 mm fasteners securing the saw plate to the linear bearings.

5. With the Tile Trimmer rails in the raised position, replace the rubber strip. (*Rubber Strip Replacement on page 618*)

6. Place the new saw plate on the linear bearings and align the six holes.

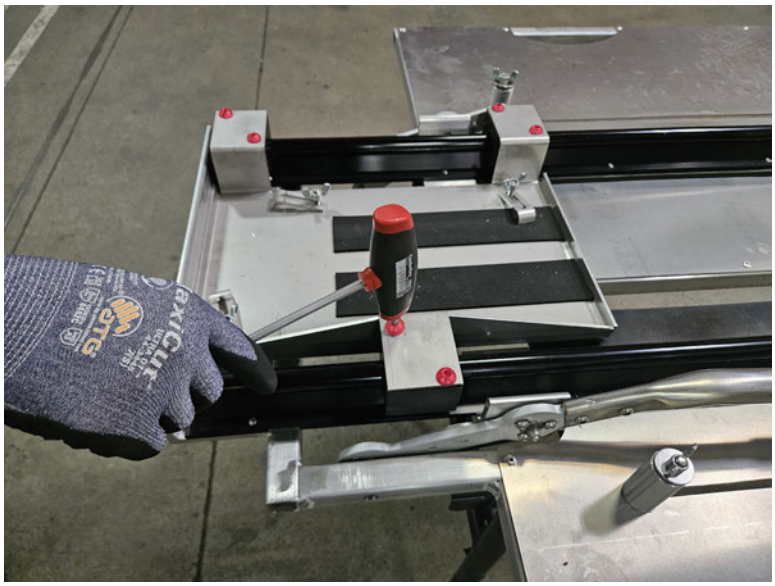


7. Add one drop of Loctite 272 to the threads of each fastener and hand-start all six.

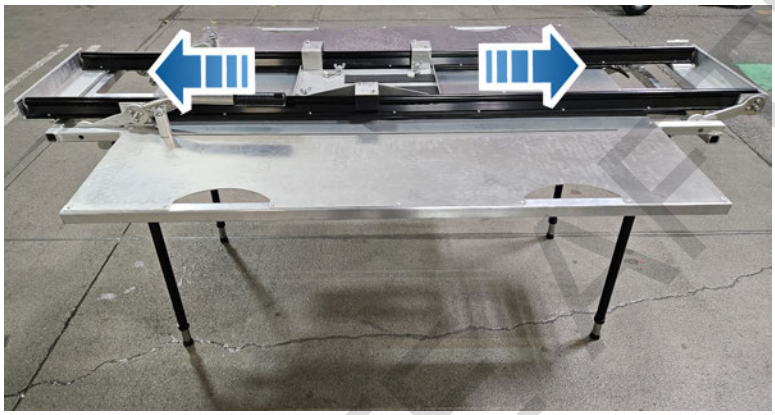


8. Use a 5 mm hex key to lightly seat the six fasteners and lock them into place with an additional ¼ turn.

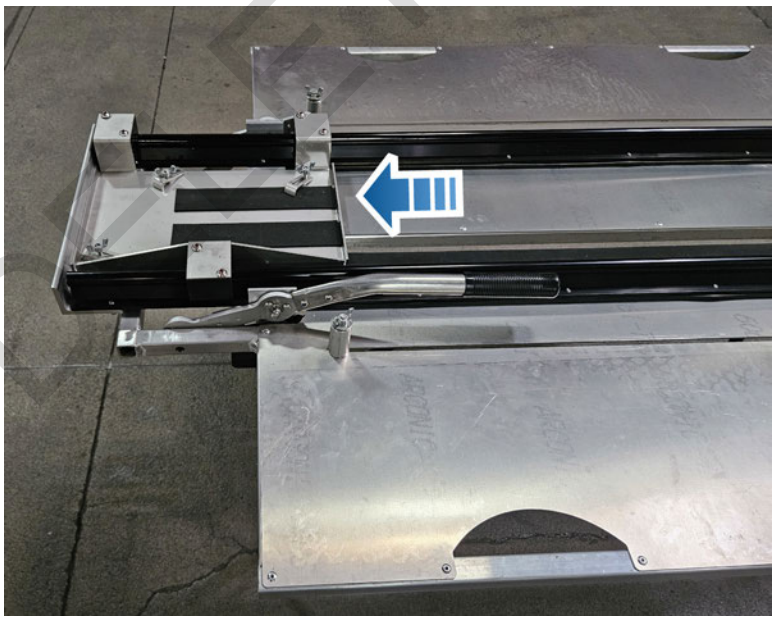
> **CAUTION:** Overtightening the fasteners can cause the saw plate to bind and prevent it from sliding along the rails.



9. Slide the saw plate along the rails to check for ease of movement. If significant friction is present, loosen the fasteners and repeat Step *8 on page 615*.



10. With the Tile Trimmer rails in the lowered position, slide the saw plate all the way to the end of the rail on the side with the handle.

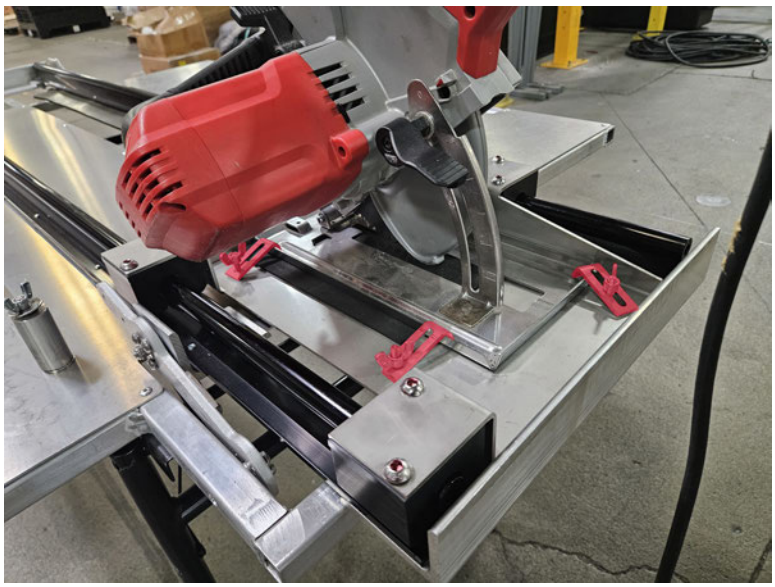


11. Adjust the angle lock of the saw to secure the blade in the most retracted position.

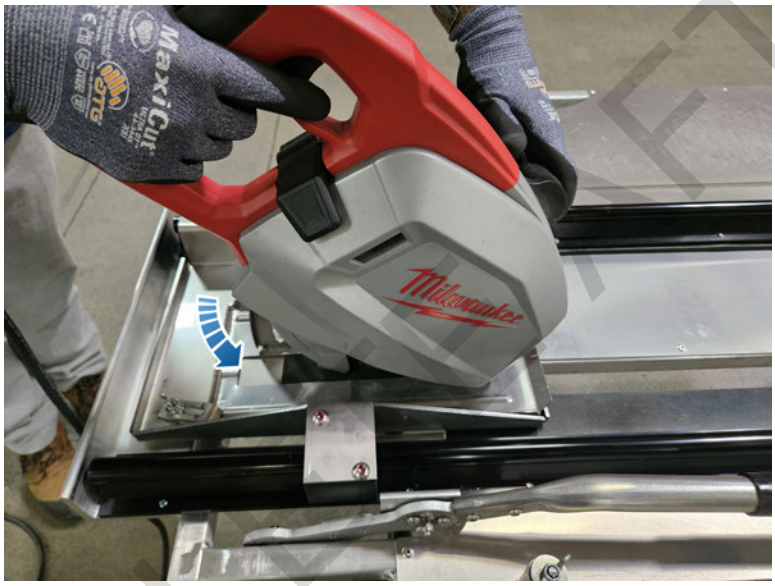
12. Align the base plate of the saw with the front right side of the new saw plate.

> **NOTE:** The front of the saw must be facing the center of the Tile Trimmer, with the single linear bearing rail on the right (1).

13. Rotate the three saw hold-downs over the saw base plate and tighten the wing nuts by hand to secure the saw.



14. Plug in the saw and secure the power cord out of the path of the blade.
15. Unlock the saw blade and perform a plunge cut into the new saw plate.

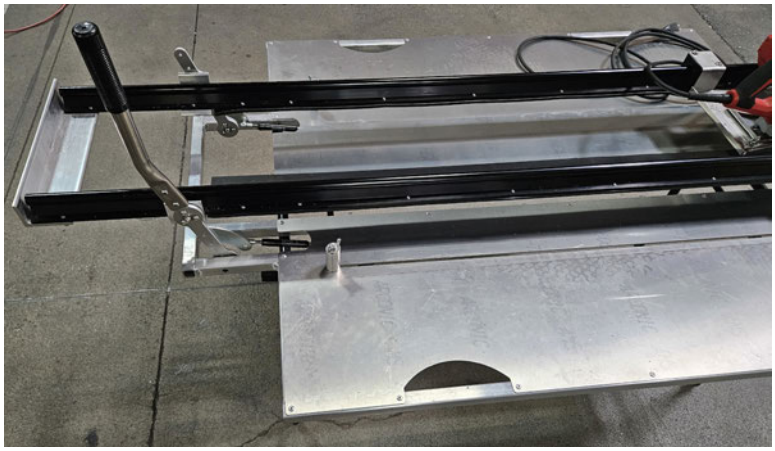


16. Perform a single cut along the entire length of the Tile Trimmer to cut the sightline into the rubber strip.

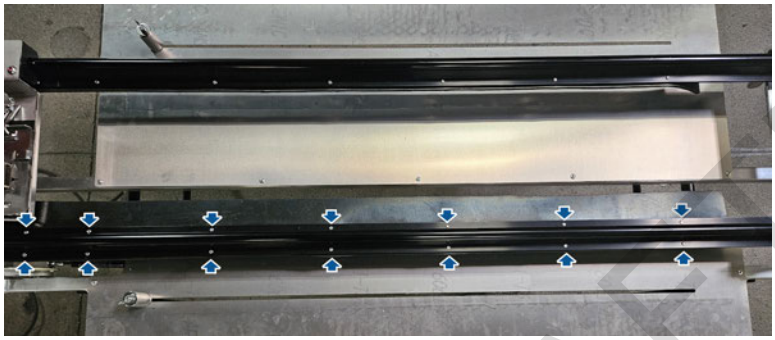
Rubber Strip Replacement

The rubber strip acts as a visual guide for tile cuts and should be replaced at the same time as the saw plate.

1. Use the Tile Trimmer handle to raise the 4-bar linkage and secure the saw blade in the most retracted position.

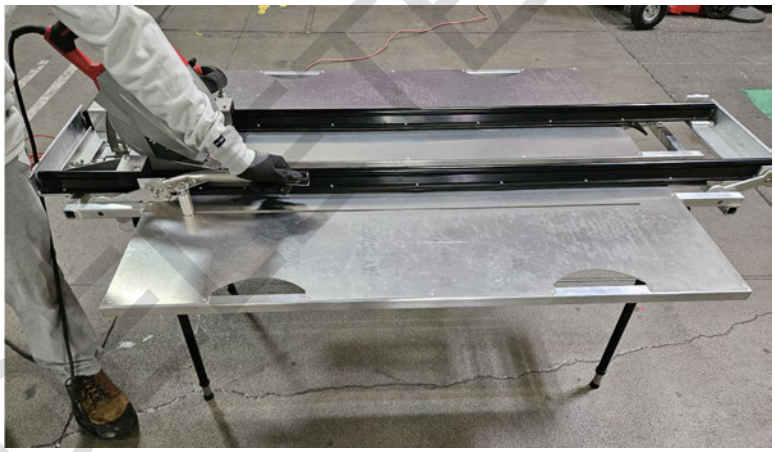


2. Use a 4 mm hex key to remove 14 M6 fasteners securing the rubber strip to the rail.

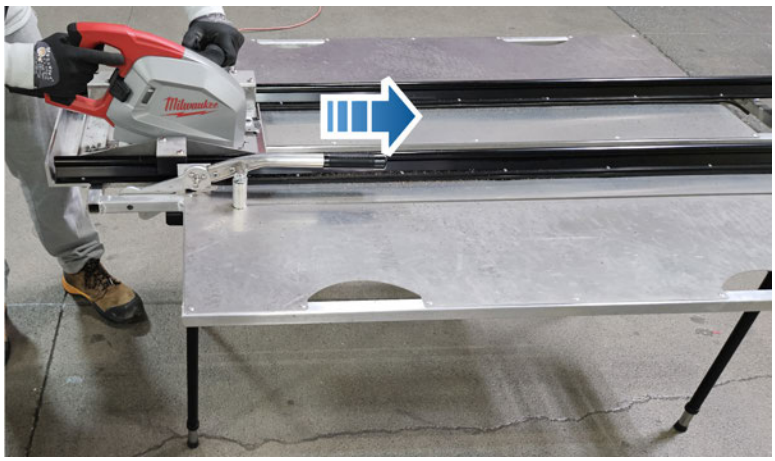


3. Install the new rubber strip on the underside of the rail and use a 4 mm hex key to tighten the 14 M6 fasteners until the heads are flush with the rubber strip.

4. Use the handle to lower the 4-bar linkage and lock the saw blade at its maximum depth.



5. Complete one dry cut along the rubber strip to create a sightline.



Cleaning and Lubricating Rails

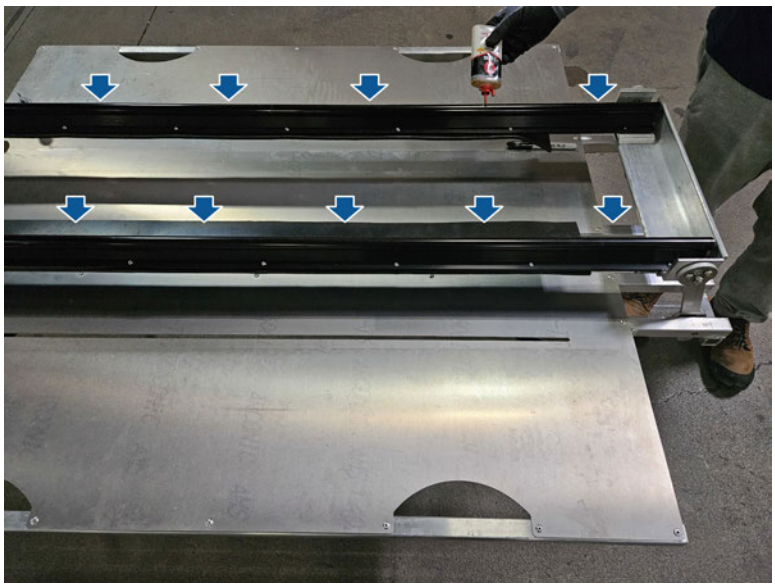
To be performed every three months and when there is visible debris build-up on the rails.

1. Use the Tile Trimmer handle to raise the 4-bar linkage and slide the saw plate all the way to one end of the rails.

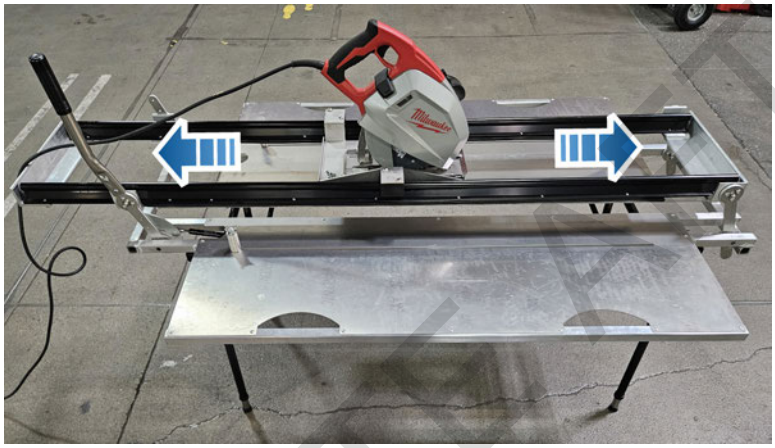
2. Use a clean rag to wipe the rail surface and remove any debris.

3. Slide the saw plate to the other end of the rails and wipe the rails down again. Repeat 2 - 3 times to remove debris.

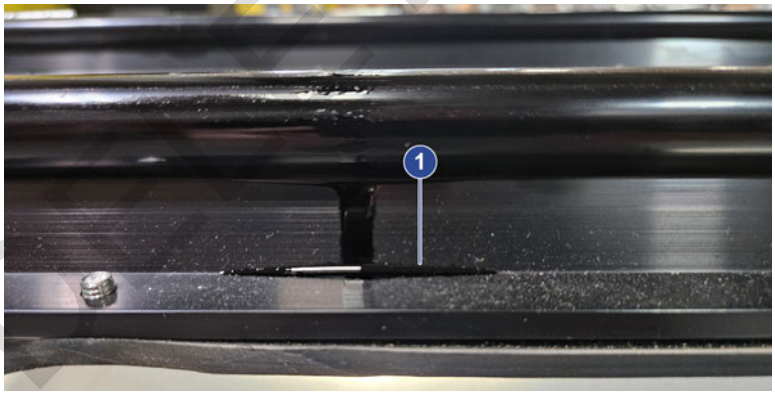
4. Place a drop of an approved lubricant every 6 in on each rail.



5. Slide the saw plate along the rails 10 - 15 times to distribute the lubricant.



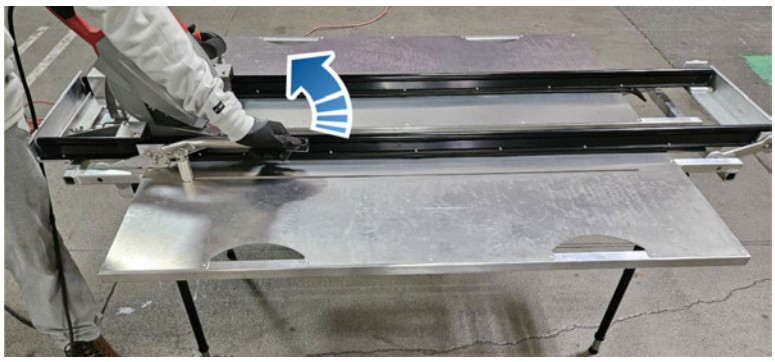
6. Use a clean cloth to wipe away excess lubricant that is pooling or running down the rails (1).



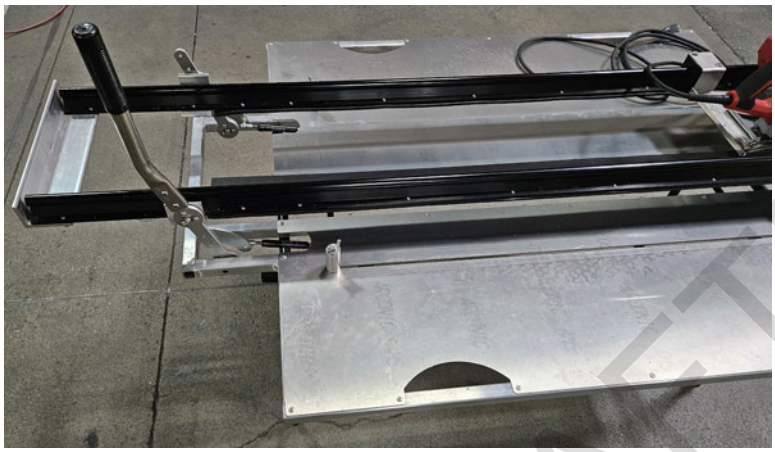
Gas Spring Replacement

Gas springs should be replaced if visibly damaged or if the effort to raise the 4-bar linkage is significantly increased.

1. Use the Tile Trimmer handle to raise the 4-bar linkage and disconnect the saw.

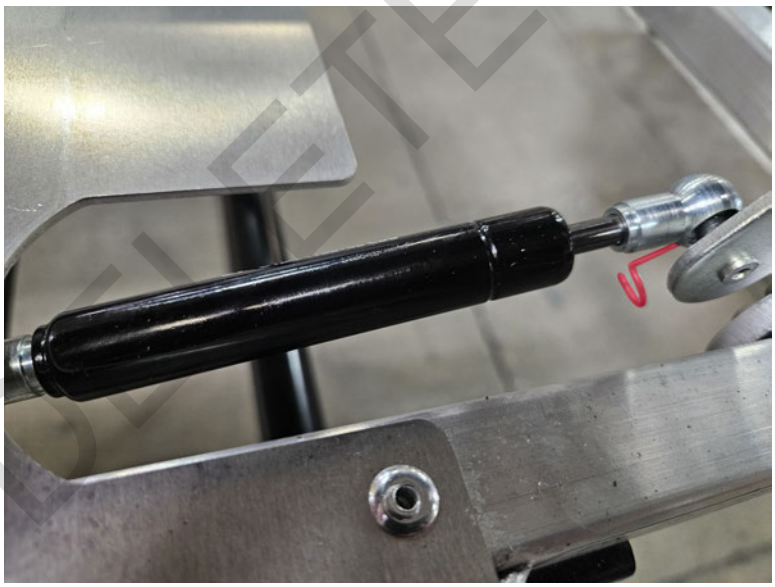


2. Slide the saw plate to the end of the rails opposite where the replacement is being performed.



3. Rotate and remove the locking pin from the end of the gas spring connected to the 4-bar linkage.

> **NOTE:** The locking pin can be removed by hand but may require pliers.



4. Use a slotted screwdriver to gently pry the gas spring off of the ball stud on the linkage bracket.

5. Rotate and remove the locking pin from the other end of the gas spring.

6. Rotate the body of the gas spring until it disconnects from the ball stud.

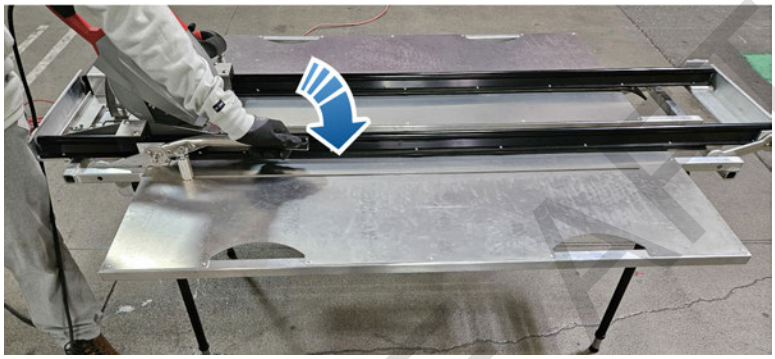
7. Remove the locking pins from both ends of the replacement gas spring.

8. Remove the ball studs from the receiving sockets on both ends of the replacement gas spring.

9. Place the ball stud receiver of the fixed end of the gas spring onto the ball stud on the Tile Trimmer frame and apply pressure until it snaps into place.

10. Insert the locking pin into the holes on the ball stud receiver and rotate the pin into place.

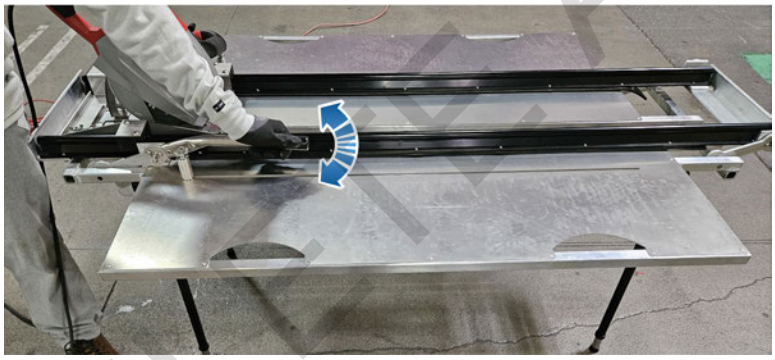
11. Use the handle to lower the 4-bar linkage.



12. Compress the gas spring by hand and snap the ball stud receiver onto the ball stud on the linkage bracket.

13. Insert the locking pin into the holes on the ball stud receiver and rotate the pin into place.

14. Use the handle to raise and lower the 4-bar linkage several times to ensure that it is working properly.



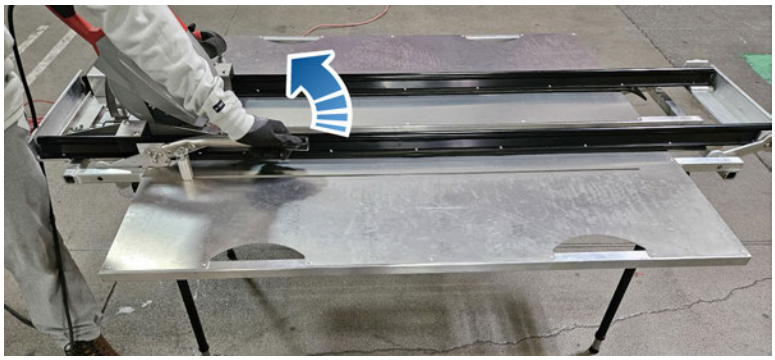
Link Replacement

Links should be replaced if broken or damaged.

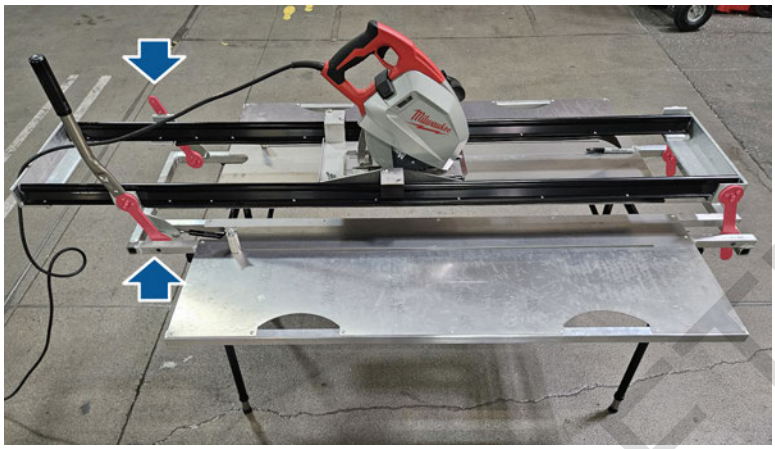
NOTE: The same part is used for all four link positions but the orientation is inverted on the end of the rails opposite the handle.

1. Disconnect the saw from power and slide the saw plate to the end of the rails opposite where the replacement is being performed.
2. Use the handle to raise the 4-bar linkage.

WARNING: Place a 2x4 or similar-sized spacer between the linkage and the table to prevent accidental closure while replacing parts.



3. Follow these steps to replace a link on the side of the Tile Trimmer where the handle is located:



   a. Use a 4 mm hex key to remove 2x M6 fasteners securing the handle to the link.

      NOTE: Save the handle and M6 fasteners for re-installation on the new link.

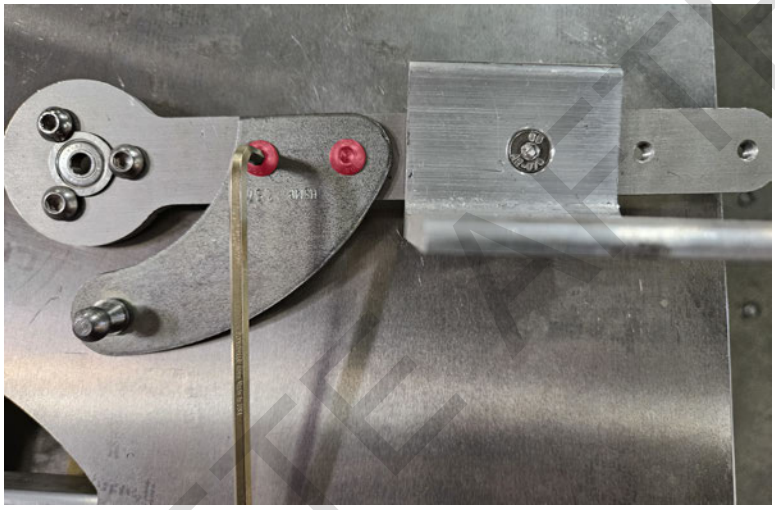
   b. Use a 4 mm hex key to remove 2x M6 fasteners securing the L bracket to the linear rail.

   c. Use a 5 mm hex key and 10 mm socket to remove the M6 fastener securing the link to the Tile Trimmer frame.

      NOTE: Save the washer, spacer, and fastener for re-installation.

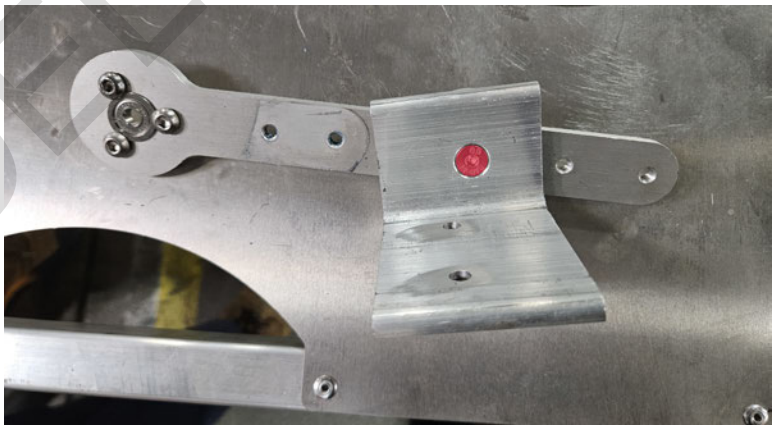
d. Use a 4 mm hex key to remove 2x M6 fasteners securing the ball stud bracket to the link.

NOTE: Save the fasteners for re-installation.



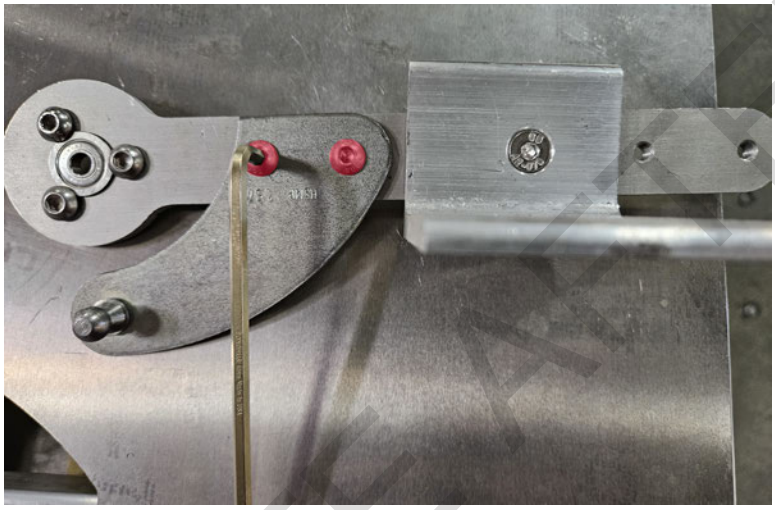
e. Use a 4 mm hex key and 10 mm socket to remove the fastener securing the L bracket to the link.

NOTE: Save the washer, spacer, and fastener for re-installation.

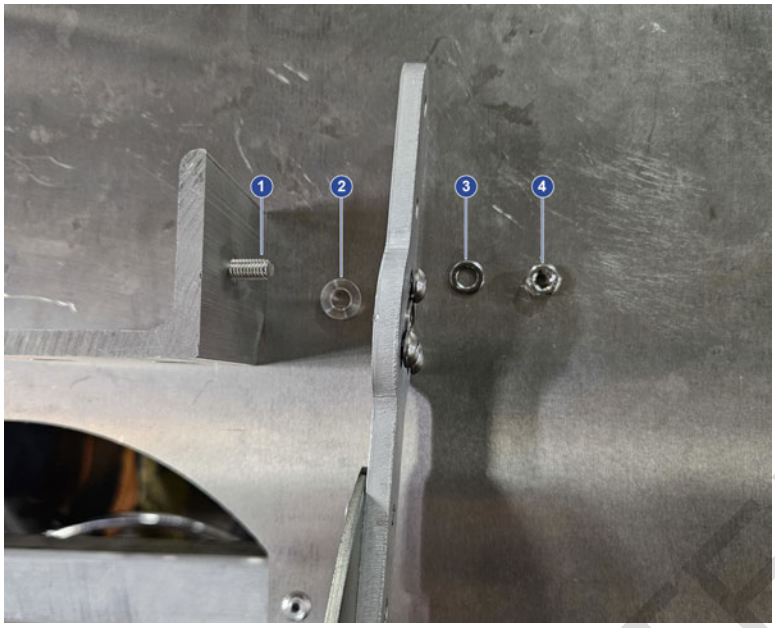


f. Position the link with the handle interface pointing up, the L bracket bearing fasteners (1) on the outer side of the rail, and the ball stud bracket (2) on the inner side of the rail.

g. Add Loctite 242 to each of the M6 fasteners and secure them with a 4 mm hex key. Torque to 4 Nm.

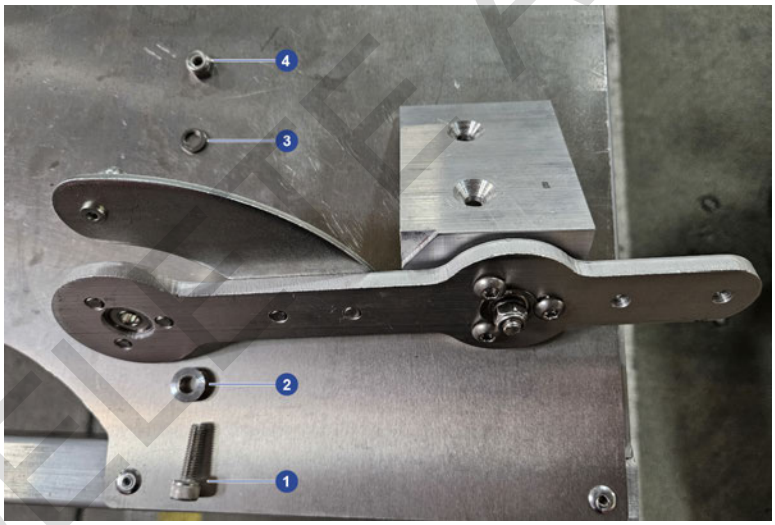


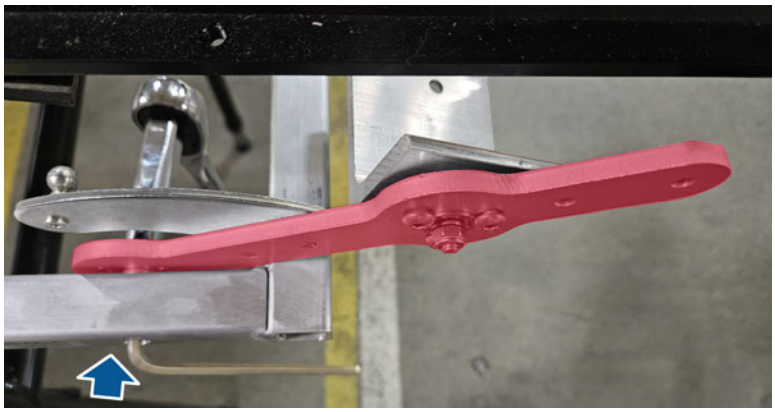
h. Use a 4 mm hex key and 10 mm socket to secure the L bracket to the link with an M6 fastener (1). Insert the unthreaded spacer (2) between the link and L bracket, and insert the washer (3) between the link and M6 nut (4). Torque to 4 Nm.



i. Use a 4 mm hex key and 10 mm socket to secure the link between the Tile Trimmer frame and the rail with an M6 fastener (1). Insert the unthreaded spacer (2) between the frame and link, and insert the washer (3) between the link and M6 nut (4). Torque to 4 Nm.

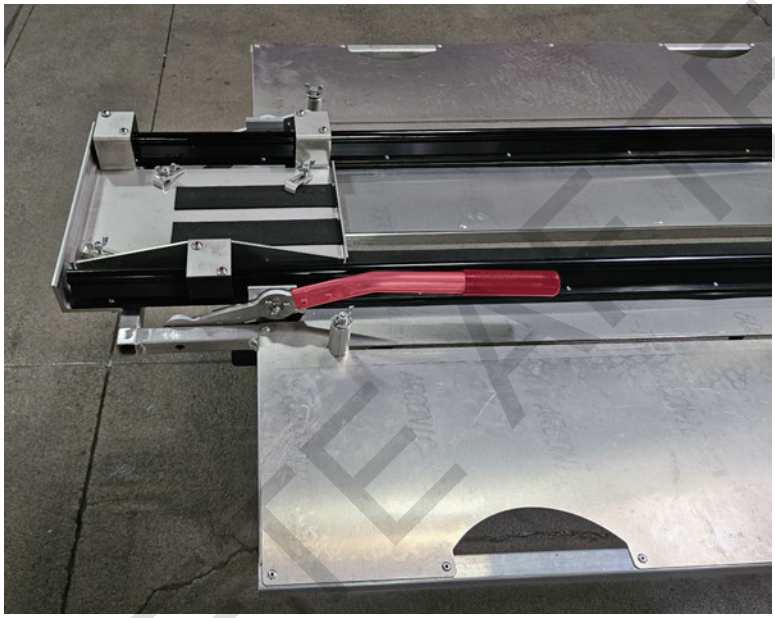
> ⚠ **CAUTION:** Avoid dropping the spacer inside the frame when inserting the fastener.





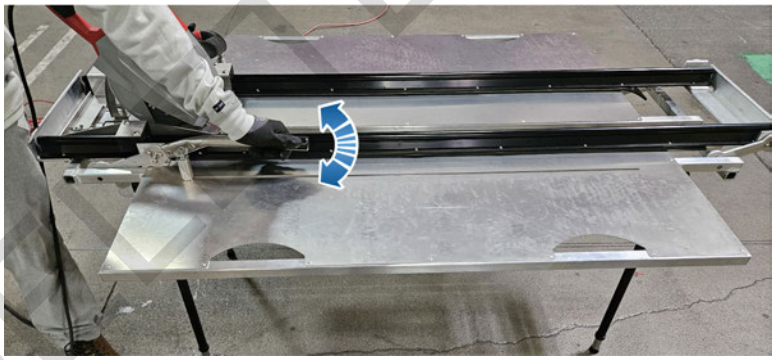
NOTE: The L bracket supports the rail from the outside and should face the center line of the Tile Trimmer.

j. If replacing the handle, install the handle onto the new link so that the handle bends toward the table surface. Add a drop of Loctite 242 and use a 4 mm hex key to secure 2 M6 fasteners. Torque to 4 Nm.



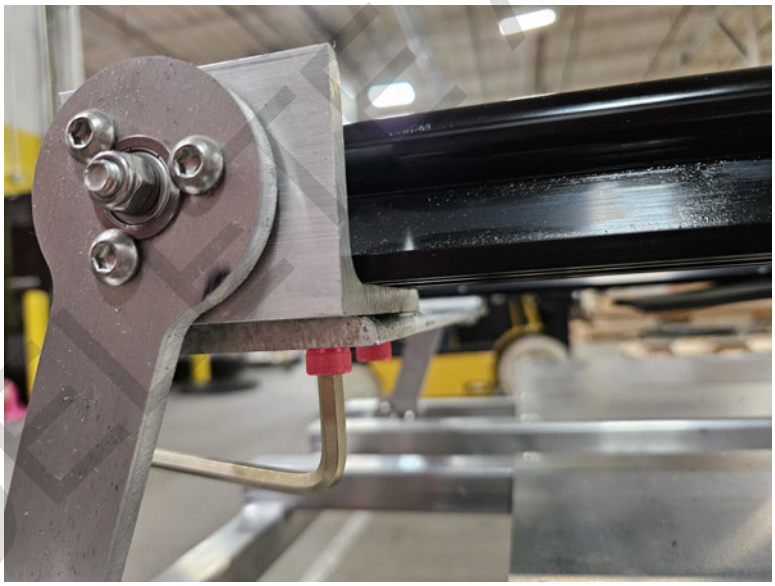
k. Use the handle to lower the 4-bar linkage, install the gas spring onto the ball stud bracket as in Steps *12 on page 626* and *13 on page 627* of *Gas Spring Replacement on page 622*.

l. Use the handle to raise and lower the 4-bar linkage several times to ensure that it is working properly.



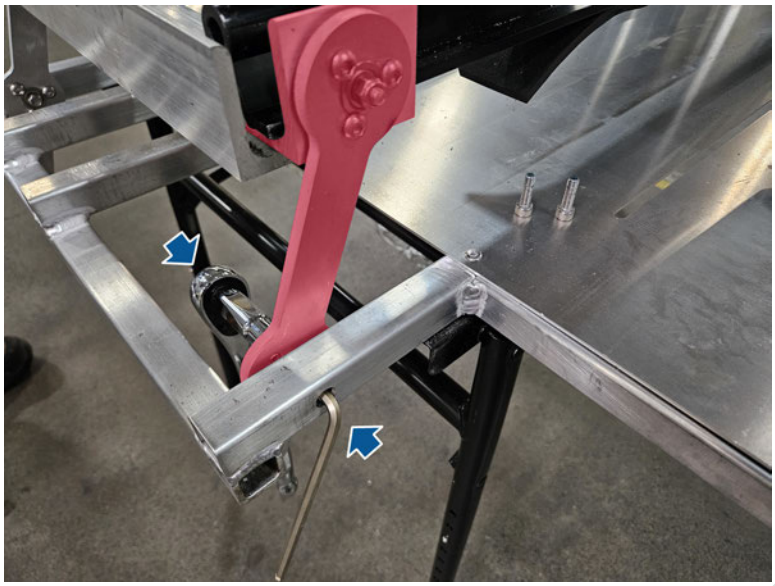
4. Follow these steps to install a link on the side of the Tile Trimmer opposite the handle.

   a. Use a 5 mm hex key to remove 2x M6 fasteners securing the L bracket and L channel to the linear rail.

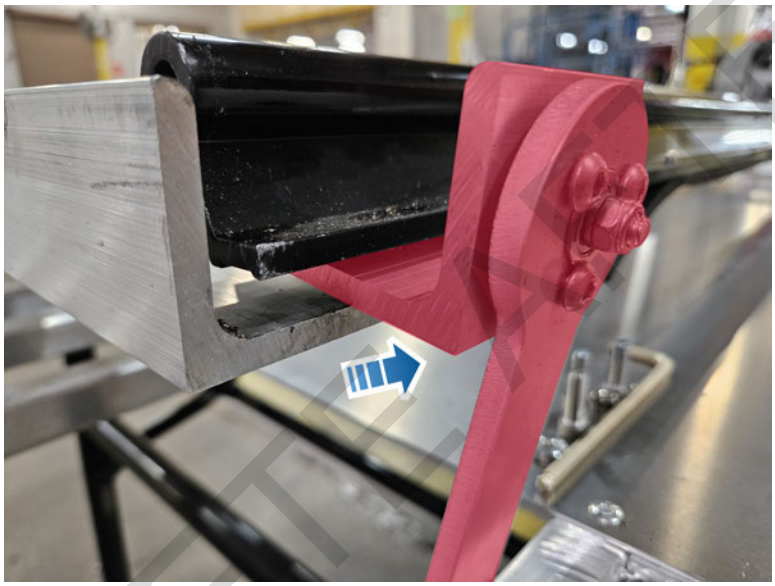


   b. Use a 5 mm hex key and 10 mm socket to remove the M6 fastener securing the link to the Tile Trimmer frame.

> **NOTE:** Save the washer, spacer, and fastener for re-installation.

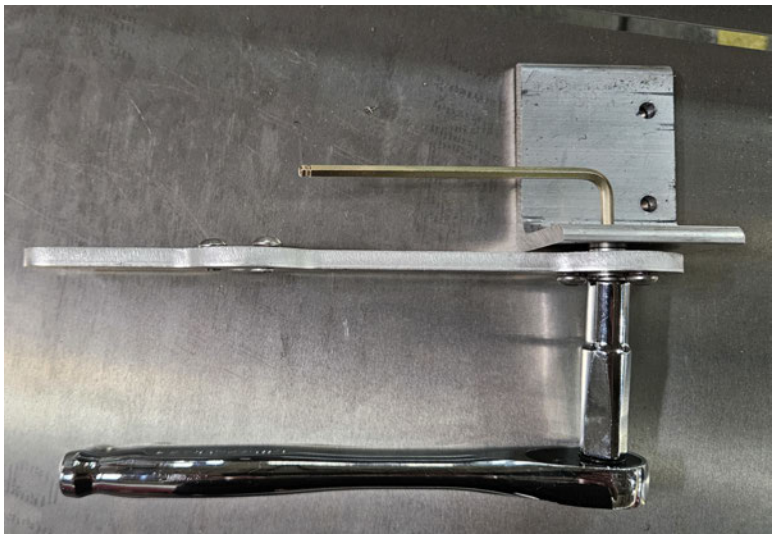


c. Slide the link out from between the linear rail and L channel.



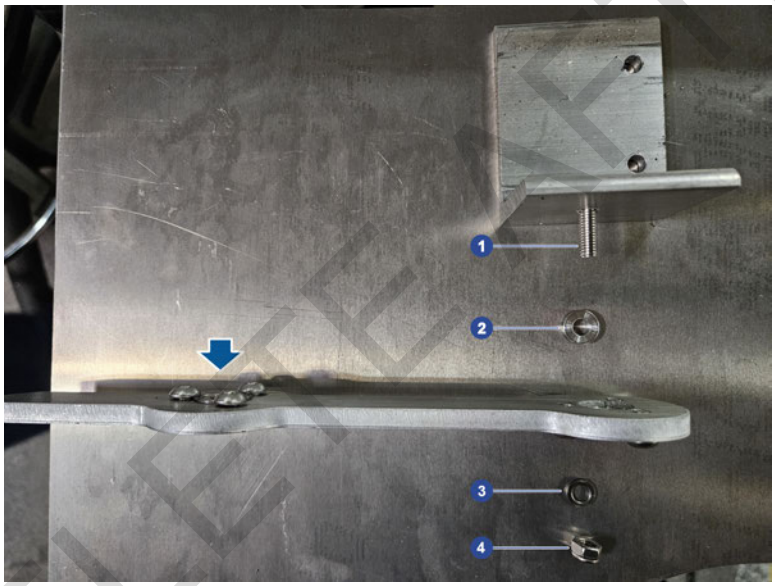
d. Use a 4 mm hex key and 10 mm socket to remove the fastener securing the L bracket to the link.

NOTE: Save the washer, spacer, and fastener for re-installation.

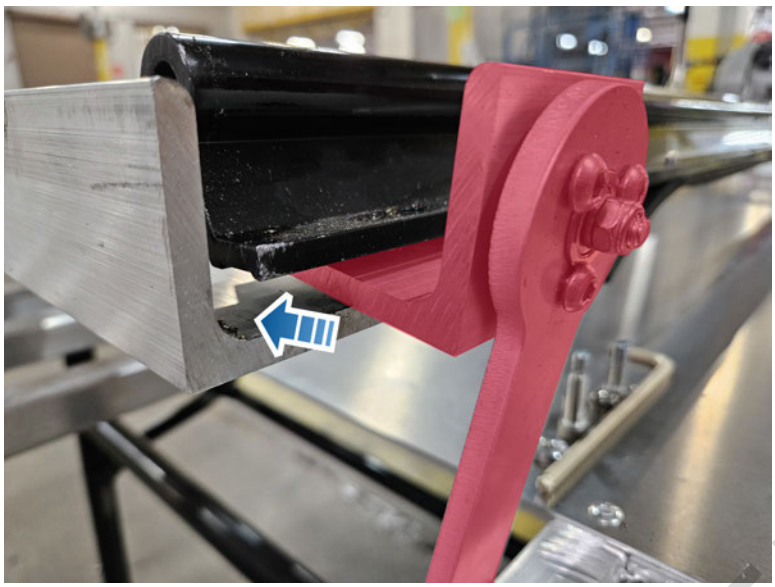


e. Use a 4 mm hex key and 10 mm socket to secure the L bracket to the new link with an M6 fastener. Insert the unthreaded spacer between the link and L bracket, and insert the washer between the link and M6 nut. Torque to 4 Nm.

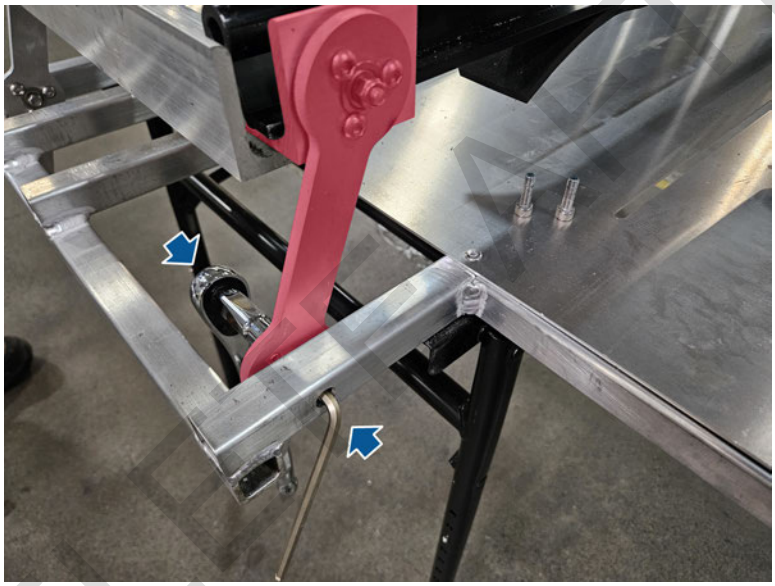
NOTE: The L bracket must be installed on the same side of the link as the fasteners on the opposite end as seen below.



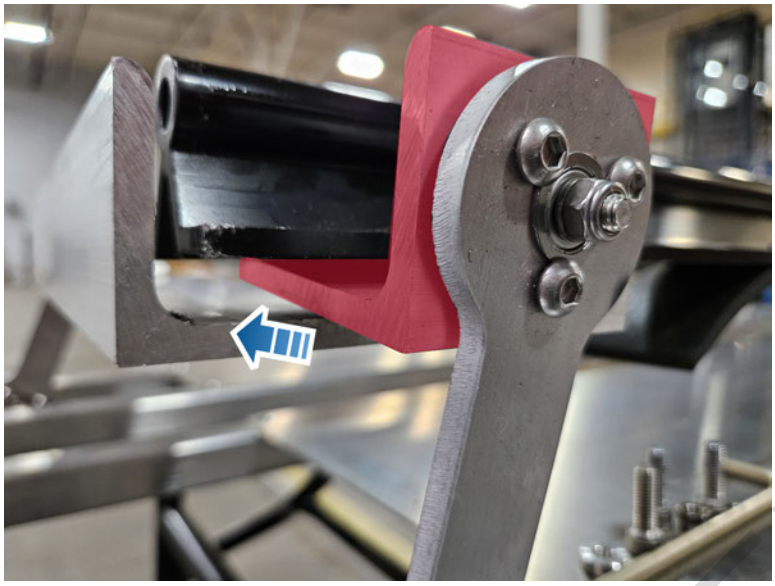
f. Rotate the link until the attached L bracket is positioned between the linear rail and L channel.

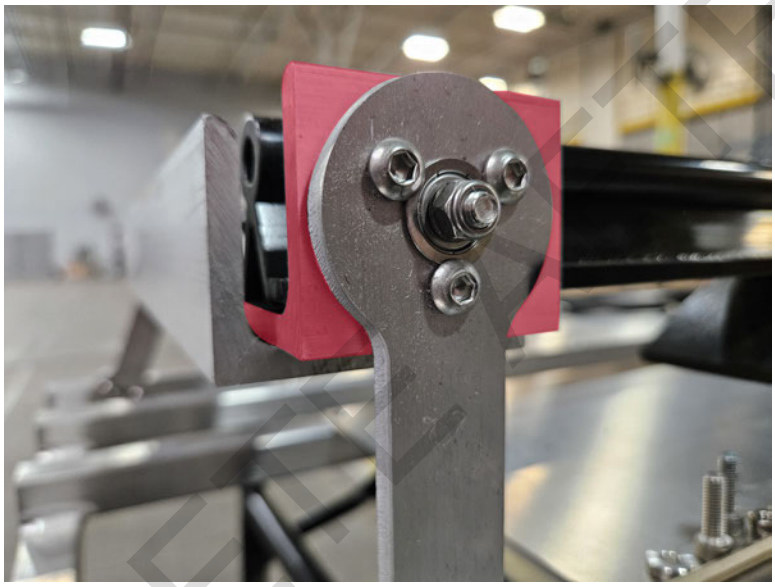


g. Use a 4 mm hex key and 10 mm socket to install the link between the Tile Trimmer frame and the rail. Insert the unthreaded spacer between the frame and link, and insert the washer between the link and M6 nut. Torque to 4 Nm.

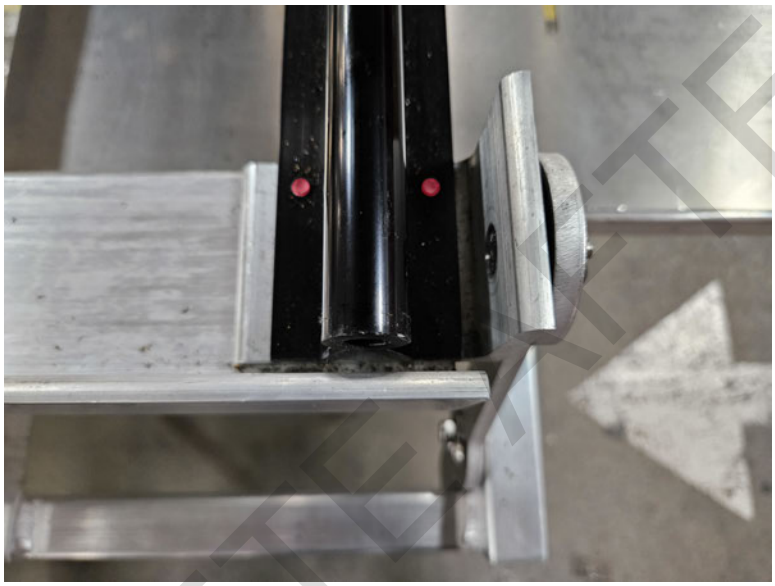


h. Slide the L bracket between the linear rail and the L channel and align it with the threaded holes in the rail.

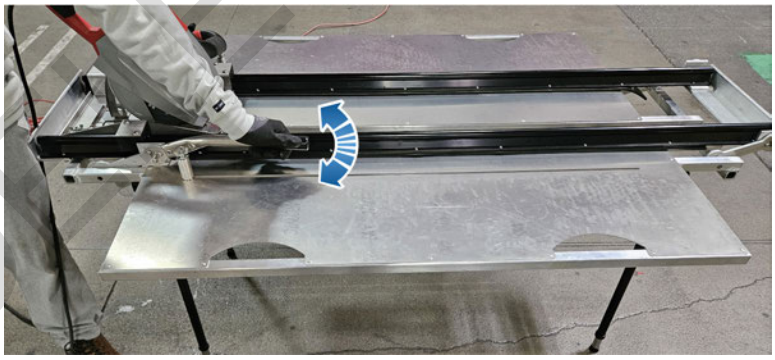




i. Apply a drop of Loctite 242 and use a 5 mm hex key to secure the L channel, L bracket, and linear rail with two M6 fasteners. Torque to 4 Nm.



j. Use the handle to raise and lower the 4-bar linkage several times to ensure that it is working properly.



Roof Rack 2.0 Installation

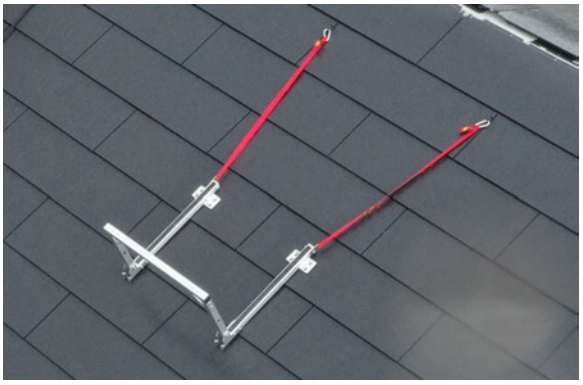
Overview

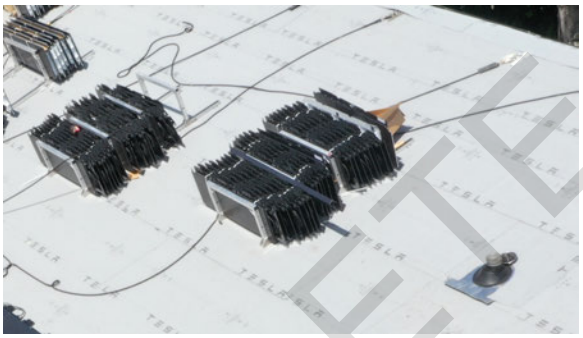
This section provides instructions for installing the roof rack 2.0 over rafters, PV tiles and metal tiles. The roof rack can securely hold 12 bundles of metal tiles and 14 bundles of PV tiles on the roof for easy access during installation.

Tools and Equipment

- Roof rack 2.0
- Roof rack straps
- Carabiners
- Hammerhead hooks
- Glass hooks

Pictured: Finished Installations

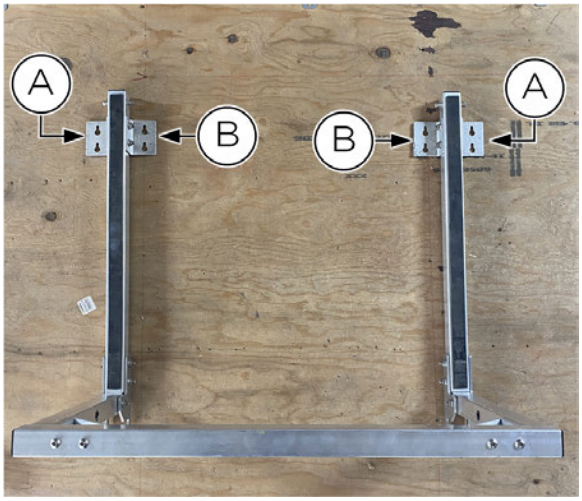




Installing Roof Racks Over Rafters

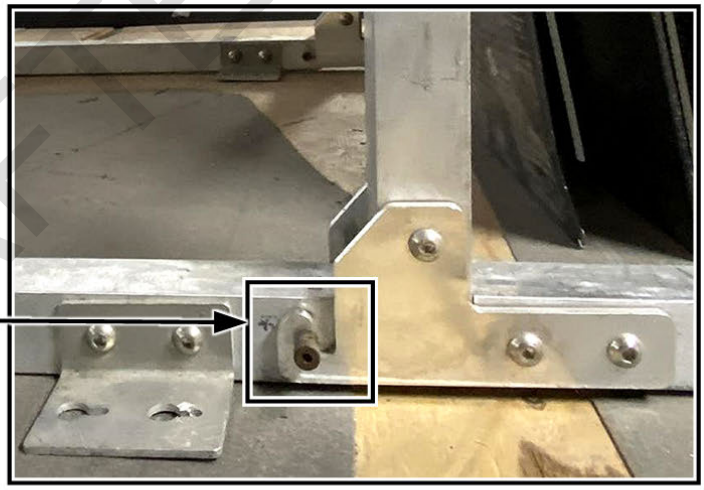
When not installed over metal or PV tiles, roof racks can be secured into rafters using four 16 D nails. Racks can be secured through either 16 in O.C. rafters or 24 in O.C. rafters.

- For 16 in O.C. rafters, fasten the roof rack through the outer plates **(A)**.
- For 24 in O.C. rafters, fasten the roof rack through the inner plates **(B)**.



OPTIONAL: Up to four roof racks can be daisy chained together to hold more tile bundles in one location. After one roof rack has been secured, latch the hook plate of the next roof rack to the "Frankenstein bolt" of the first rack to chain them together.

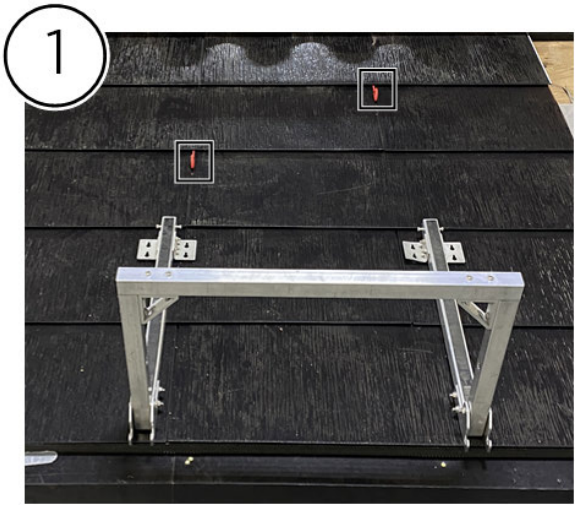
IMPORTANT: Only racks installed **directly on rafters** can be daisy chained together.



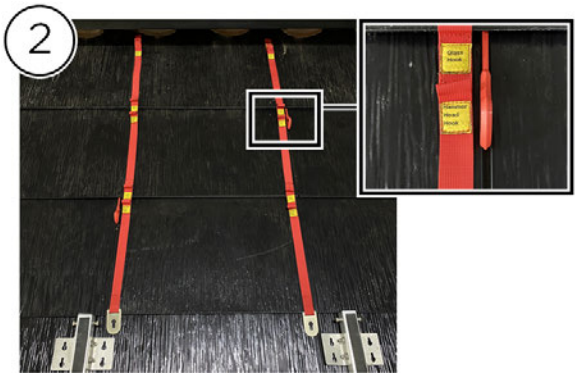
Installing Roof Racks Over Metal Tiles

IMPORTANT: Roof rack straps are used to install roof racks over metal tiles. Racks installed with straps **cannot** be daisy-chained.

Begin by determining the roof rack location over courses of metal tiles. Then, install hammerhead hooks staggered between the water channels of metal tile courses above the rack (see *Installing and Removing Hammerhead Hooks on page 645*) **(1)**.

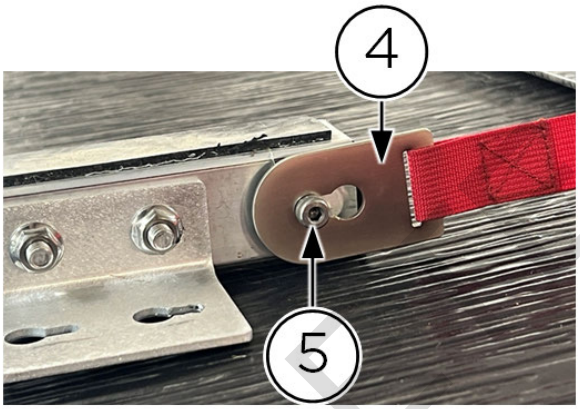


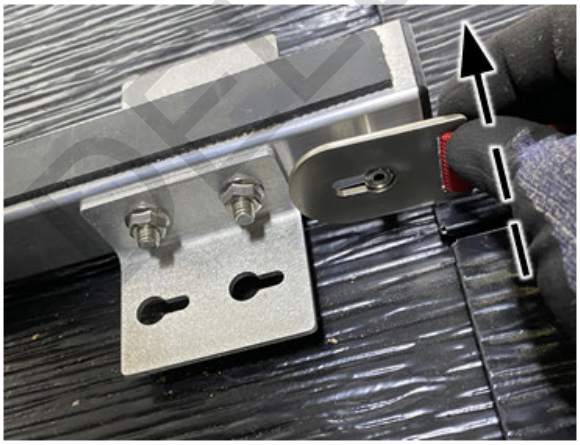
Lay two roof rack straps over the mounting plane and locate the loops labeled “Hammerhead Hook” **(2)**.

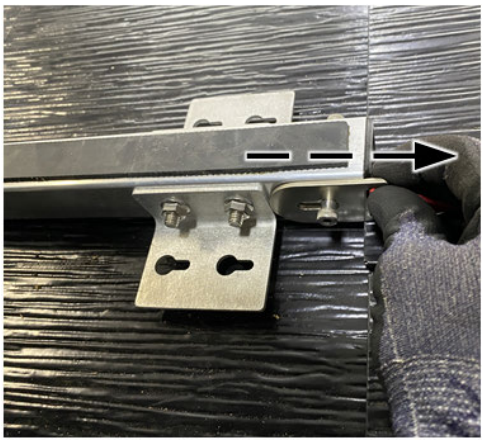


Attach this loop on both roof rack straps to each hammerhead hook using carabiners **(3)**.

Once the straps are attached to the hammerhead hooks, attach each strap's hook plate **(4)** to the "Frankenstein bolt" located next to the rack's inner plates **(5)**. Insert the bolt through the hook plate's larger hole and pull the hook plate up roof to secure the bolt in the smaller hole. This completes the roof rack installation.







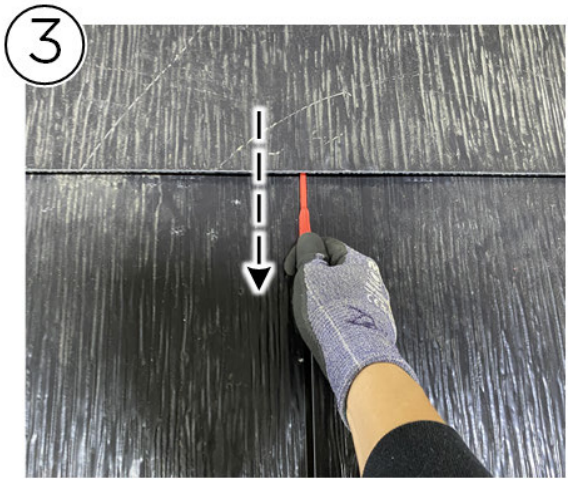
Installing and Removing Hammerhead Hooks

This section provides instructions for using hammerhead hooks to secure roof racks to metal tiles. They can also be used to securely hold items such as parachute bags and tools with lanyards for easy access during installation.

Installing Hammerhead Hooks

Choose a metal tile to hold the hammerhead hook. Position the hook such that the handle sits within the water channel of the metal tile course beneath the selected tile **(1)**.

In this position, push the hammerhead hook forward until it clears the lower metal tile shoulder and engages with the upper metal tile support **(2)**. Finally, pull the hook back to test whether the hook is properly engaged and secure **(3)**.

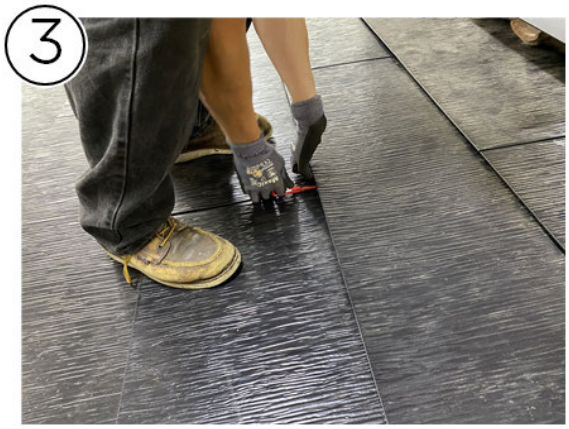


Removing Hammerhead Hooks

To remove the hammerhead hook, position the *robin jig on page 603* close to the hook and wedge it underneath the metal tile to slightly lift the tile **(1)**.

While the tile is lifted, grab the hammerhead hook loop, apply slight upward pressure and pull the hook back to remove it **(2)**.

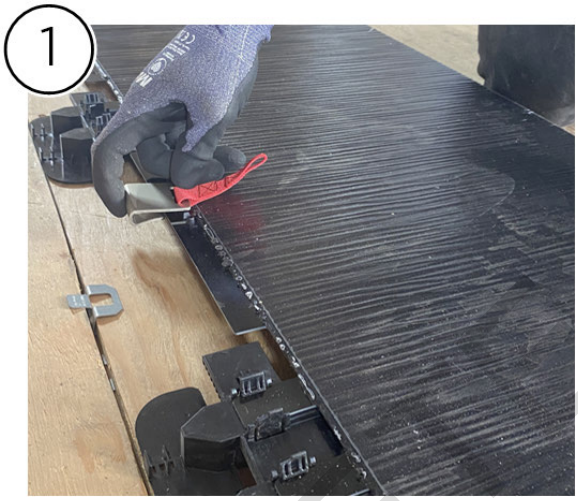
Alternatively, lift the tile by hand and push the hammerhead hook forward to disengage it from the metal tile, then apply slight upward pressure and pull the hook back to remove it **(3)**.

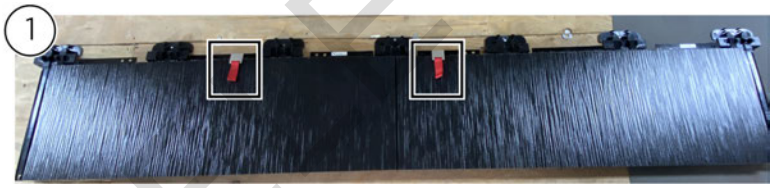


Installing Roof Racks Over PV Tiles

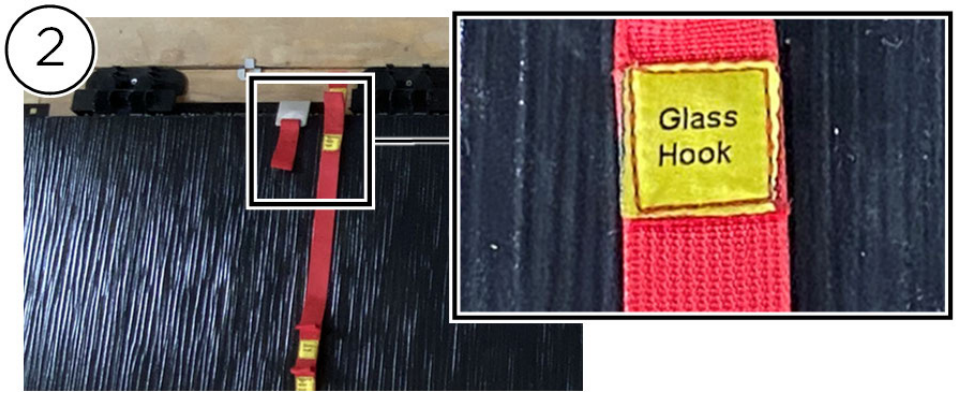
IMPORTANT: Roof rack straps are used to install roof racks over PV tiles. Racks installed with straps **cannot** be daisy-chained.

Attach one glass hook to the shoulder of two adjacent PV tiles (unlike hammerhead hooks, glass hooks can be placed anywhere on the tile shoulder) **(1)**.



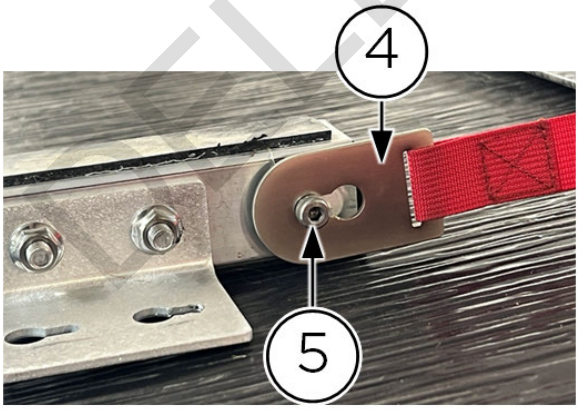


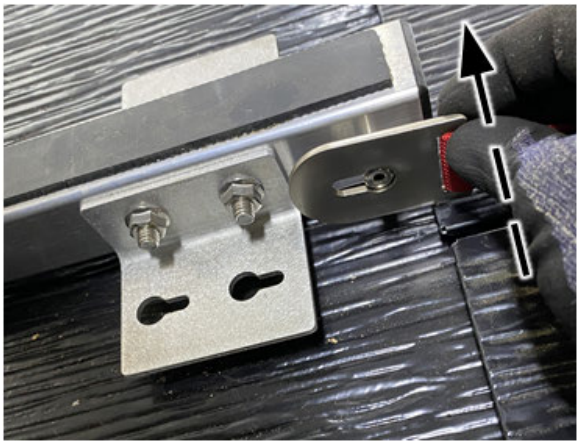
Place a pair of roof rack straps next to the glass hooks and locate the loops labeled “Glass Hook” **(2)**.

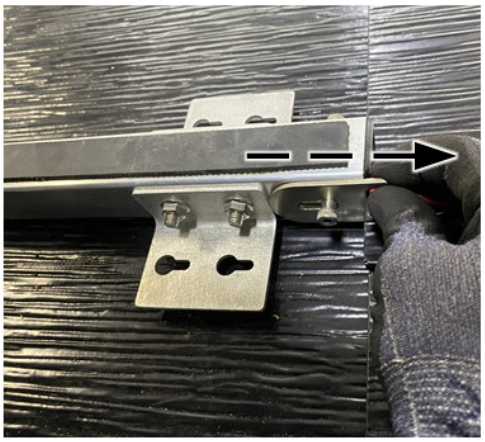


Attach this loop on both roof rack straps to both glass hooks using carabiners **(3)**.

Once the straps are attached to the glass hooks, attach each strap's hook plate **(4)** to the "Frankenstein bolt" located next to the rack's inner plates **(5)**. Insert the bolt through the hook plate's larger hole and pull the hook plate up roof to secure the bolt in the smaller hole. This completes the roof rack installation.







Installing Roof Racks Over Both Metal and PV Tiles

If a roof rack is located in between metal and PV tile courses, one glass hook is used to secure the rack to the PV side and one hammerhead hook is used to secure the rack to the metal side. Follow the same procedures outlined in Installing Roof Racks Over Metal Tiles and Installing Roof Racks Over PV Tiles.

Traction Mats

Basic Setup for Ingress and Egress Paths

Overview

This section provides instructions for setting up ingress and egress paths for the traction mat on the roof.

WARNING: The Traction Mat is strictly designed as a supplemental safety tool that improves traction on slippery surfaces, and does not replace conventional fall protection methods. Effectiveness is applied only when used properly. The use of this mat is supplemental to Tesla and a required piece of fall protection equipment. Although effective this should not be trusted to protect your life. Use only one mat per person.

Pictured: Final installation.

Maximum Number of Mat Chains Per Pitch	
Pitch	**Max Chain Length**
9 - 12:12	4 mats
6 - 8:12	6 mats
0 - 5:12	8 mats

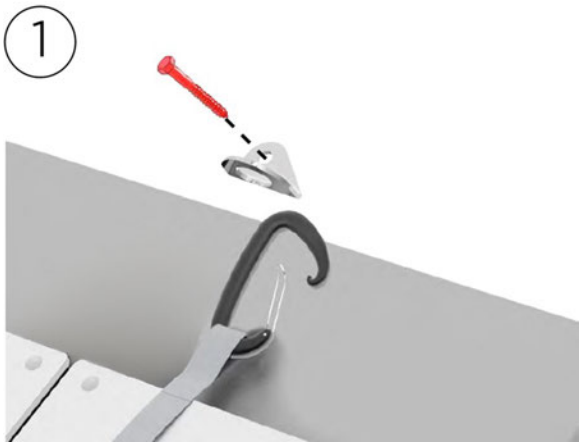
Tools & Equipment

- Metal hammer
- Cordless impact driver drill
- Carpenter's pencil/black marker
- Utility knife
- Climbing anchor
- Wire Gate Carabiner
- Traction Mat Personal Kit
- Safety glasses
- Cut-resistant gloves
- Fall protection

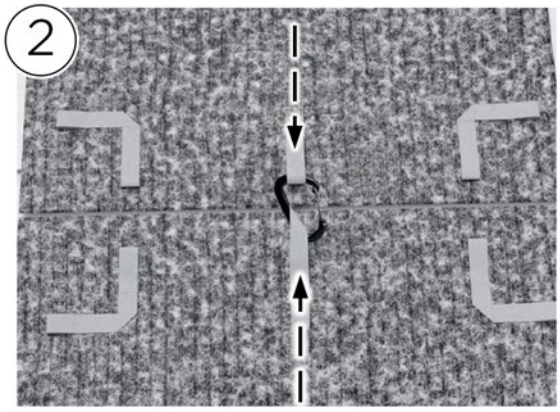
Work Instruction

The ingress/egress pathway is created by connecting up to three traction mats. Connect the top mat with a climbing anchor and fasten it to the ridge **(1)**.

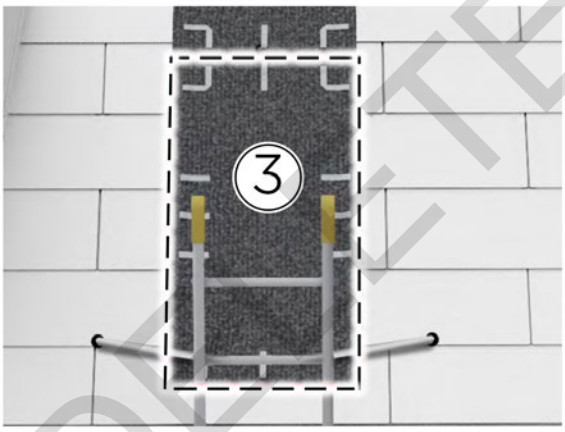
NOTE: All Tesla employees are required to use traction mats at ingress and egress areas where recommended to use traction mats in these cases.



Next, connect the following mats with carabiners **(2)**. If the conditions of the roof are dry and the slope is low, one carabiner can be used per chain. For wetter and steeper slope conditions, use two to three carabiners.



The last mat chain should be placed near the eave or ladder without interfering with the ladder connection to the roof **(3)**.



Setting Up Traction Mats on Glass Tiles

Overview

This section provides instructions for installing traction mats over glass tiles.

WARNING: The Traction Mat is strictly designed as a supplemental safety tool that improves traction on slippery surfaces, and does not replace conventional fall protection methods. Effectiveness is applied only when used properly. The use of this mat is supplemental to Tesla and a required piece of fall protection equipment. Although effective this should not be trusted to protect your life. **Use only one mat per person.**

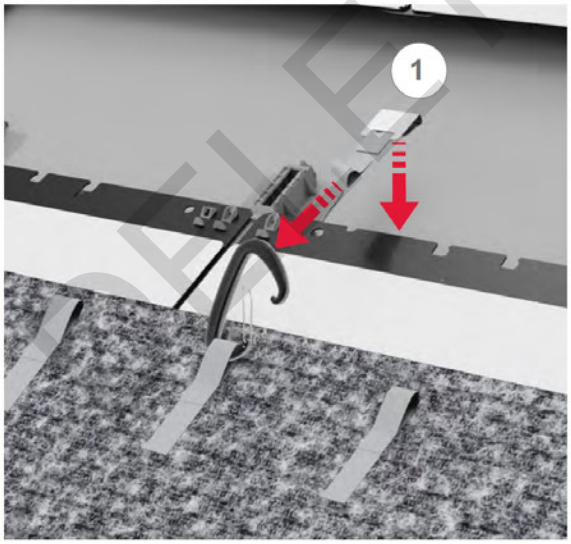
Pictured: Finished installation.

Tools & Equipment

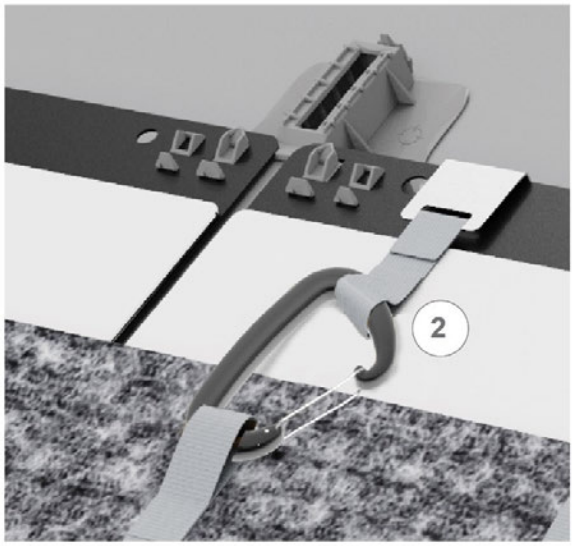
- Climbing anchor
- Glass hook
- Wire gate carabiner
- Traction mat personal kit
- Safety glasses
- Cut-resistant gloves
- Fall protection

Work Instruction

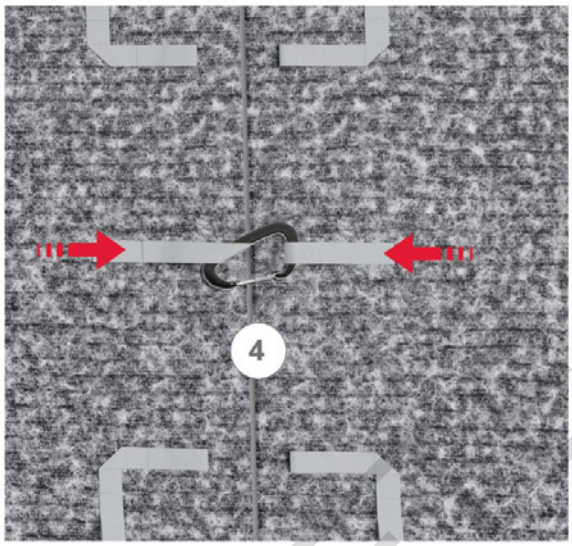
Before the second tile course is laid up-roof, attach a glass hook to the tile shoulder **(1)**. Then, attach the a carabiner to the loops facing the horizontal side of the mat **(2)**. Once the transition mat is in place, you can fully install the tile.



It is recommended that you install three glass clips per tile to ensure stability **(3)**.



Chain each traction mat together in the middle with carabiners **(4)**. **Keep in mind that glass clips cannot be used as anchors**, and are only rated for single static person weight. **Be sure to inspect all traction mats, glass clips, branched webbing, and carabiners for damage before installing.**



Setting Up Traction Mats on Metal Tiles

This section covers the process of using the traction mat with ROR tiles.

Overview

This section provides guidance for key practices when using traction mats over metal tiles.

WARNING: The Traction Mat is strictly designed as a supplemental safety tool that improves traction on slippery surfaces, and does not replace conventional fall protection methods. Effectiveness is applied only when used properly. The use of this mat is supplemental to Tesla and a required piece of fall protection equipment. Although effective this should not be trusted to protect your life. **Use only one mat per person.**

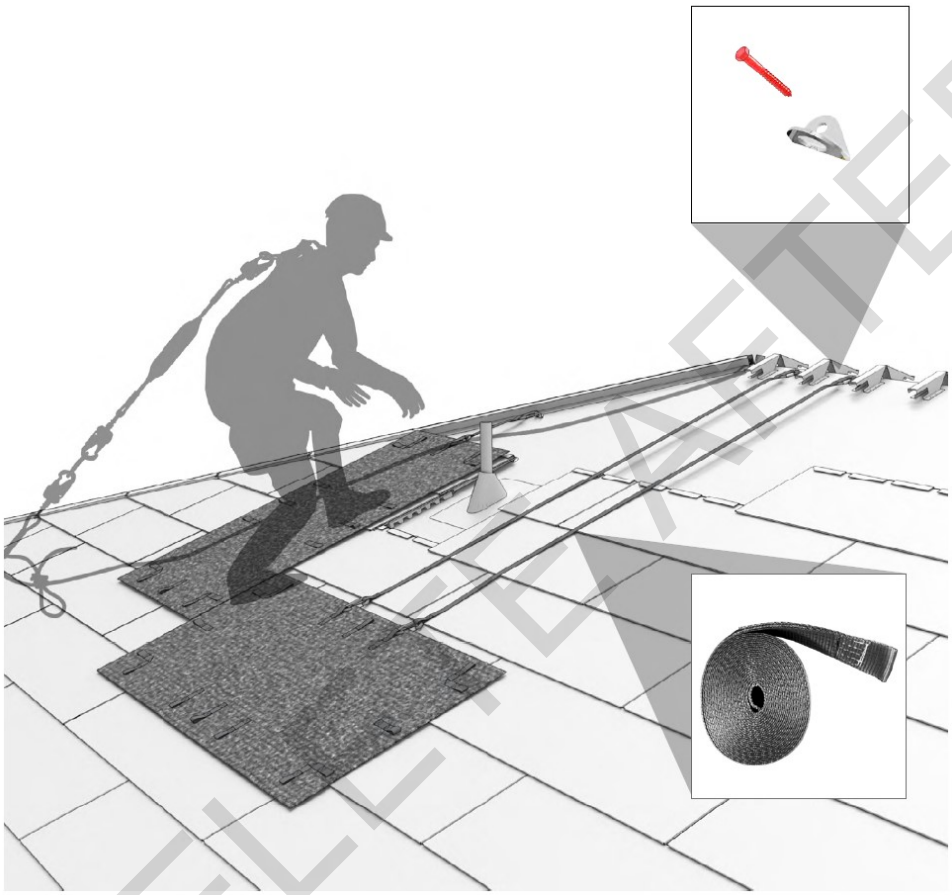
Tools & Equipment

- Metal hammer
- Cordless impact driver drill
- Carpenter's pencil/black marker

- Utility knife
- Climbing anchor
- Wire Gate Carabiner
- Traction Mat Personal Kit
- Safety glasses
- Cut-resistant gloves
- Fall protection

Work Instruction

Traction mats should be used and anchored to a climbing anchor when working with prefabricated obstruction areas during wet conditions and on slopes 6:12 or higher on metal tile mounting planes.



Setting Up Traction Mats at Obstruction Areas

Overview

This section provides guidance for installing traction mats at obstruction areas.

NOTE: All Tesla employees are required to use Traction Mat at obstruction areas. Non-Tesla employees are recommended to use Traction Mats in these cases.

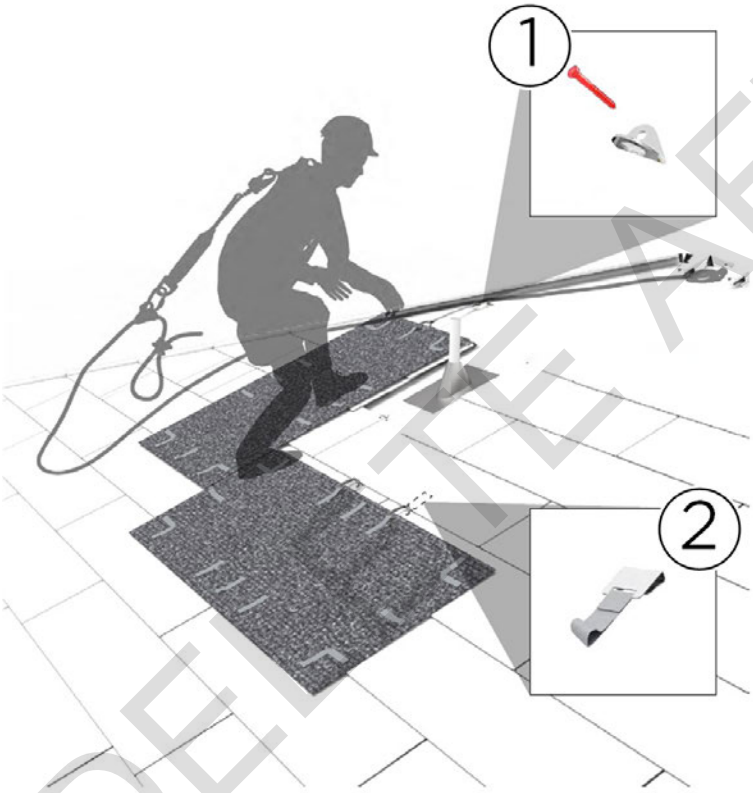
Tools & Equipment

- Metal hammer

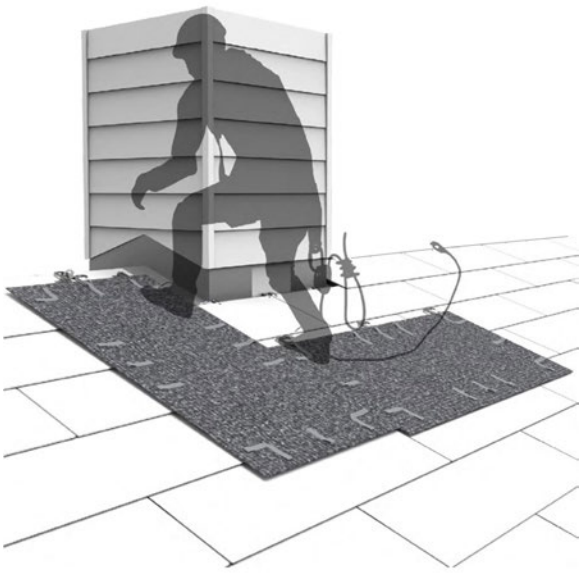
- Cordless impact driver drill
- Carpenter's pencil/black marker
- Utility knife
- Climbing anchor
- Wire Gate Carabiner
- Traction Mat Personal Kit
- Safety glasses
- Cut-resistant gloves
- Fall protection

Work Instruction

Traction mats should be used and anchored when working with prefabricated obstruction areas when working in wet conditions and at slopes 6:12 or higher. Secure the vertically placed mat with an anchor at the ridge **(1)** and the horizontally placed mat with glass hooks **(2)**. If working at dry conditions at slopes 5:12 or less, traction mats can be placed directly on a debris-free surface.



Traction mats should not be placed inside the obstruction working area. Place glass hooks on the next tile course below if tile-level flashing will interact or overlap with the clips.



Pictured: Example of traction mats used at low slope at a ridge obstruction.

Setting Up Traction Mats in Unique Situations

Overview

This section outlines best practices when using traction mats in unique situations.

WARNING: The Traction Mat is strictly designed as a supplemental safety tool that improves traction on slippery surfaces, and does not replace conventional fall protection methods. Effectiveness is applied only when used properly. The use of this mat is supplemental to Tesla and a required piece of fall protection equipment. Although effective this should not be trusted to protect your life. **Use only one mat per person.**

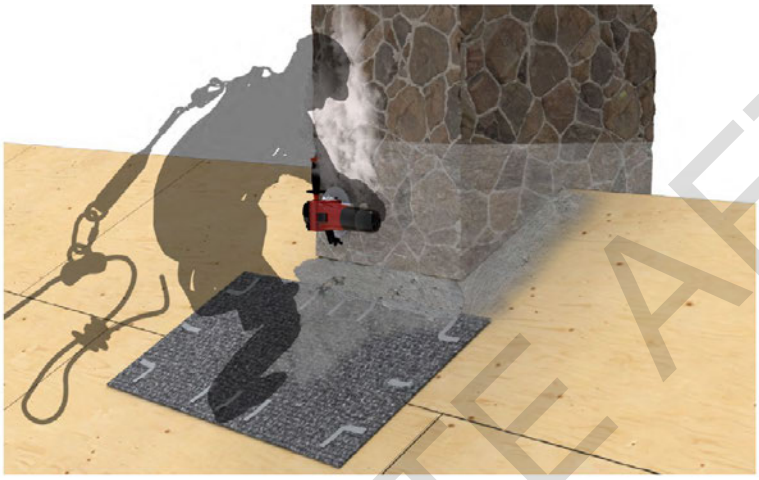
NOTE: All Tesla employees are required to use Traction Mat at areas where a significant amount of dust or small debris is produced, step offs and transition changes. Non-Tesla employees are recommended to use Traction Mats in these cases.

Tools & Equipment

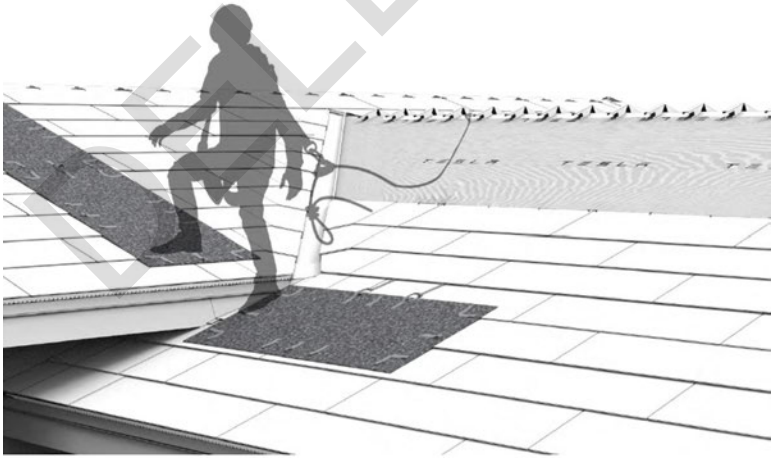
- Metal hammer
- Cordless impact driver drill
- Carpenter's pencil/black marker
- Utility knife
- Climbing anchor
- Wire Gate Carabiner
- Traction Mat Personal Kit
- Safety glasses
- Cut-resistant gloves
- Fall protection

Work Instruction

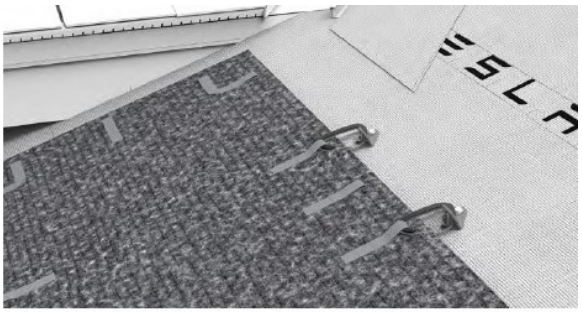
When working on a surface with dust buildup due to grinding or cutting, it is recommended to use a traction mat anchored into the deck.



At step-offs of 18 in or less, it is recommended to place a traction mat at the areas of height difference. Place the traction mat at one side of egress and anchor it to both the ridge and opposing side with glass hooks attached to the tile shoulder. If the adjacent mounting plan is underlayment, anchors must be used. The underlayment will also have to be patched after use.



Pictured: Example of anchors at underlayment.



At slope changes and other areas where the slope increases or decreases, it is recommended to use a traction mat placed at the location in which the transition occurs.

Maintenance for Traction Mats

This section covers the maintenance processes for extending the life on traction mats.

Overview

This section outlines maintenance process for extending the life on traction mats.

Table of Contents

- Cleaning Dirty Mats
- Correcting Pilling or Mat Separation

Tools & Equipment

- Cordless heat gun
- Access to water or water hose
- Wire gate carabiner
- Safety glasses
- Cut-resistant gloves
- N-95 face mask

Cleaning Dirty Mats

If the traction mat is dirty, it will not function as well. Wash down the mat with water and air dry before use. Use a towel or rag and wipe down the mat to speed up the process.

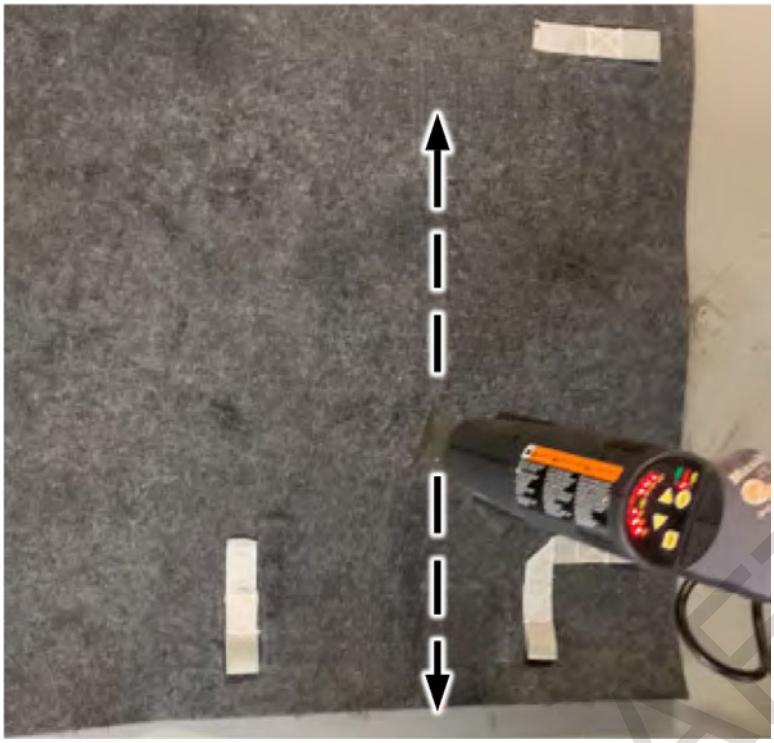
Correcting Pilling or Mat Separation

If the traction mat sees the fibers pulled out in strands due to overuse will create slip hazards.

Pictured: Close up of mat separation.

Use a heat gun set to 1,000° F and warm it up to operating temperature. Slowly heat the traction mat while keeping the gun 1 - 3 in away from the mat. Ensure to keep a slow, even movement while not holding the gun pointed at a specific spot for more than 10 seconds (this will cause the heat to melt through the mat).

WARNING: Perform this process outside in a highly ventilated area. This process produces fumes that should not be breathed in.



Once the mat has been heated, the top surface will have nearly as good traction as a new mat. This will also help prevent further pilling/ separating, though it will not stop altogether. This process can be done multiple times due to the mat's thickness.

NOTE: If you notice the mat begins to bald and the top material is wearing thin, replace the mat.

PRO TIP: It is good practice to perform this process once a quarter to optimize traction mat performance.

Roof Jack Adapter

Overview

This document covers the basics of using roof jack adapters and roof jacks to provide a stable work platform at steep pitch roofs and in inclement weather. Roof jacks are recommended when working below complex details or obstructions where the roof will require a significant amount of work in one place.

Safety Notice

These tools should never be used as the primary fall protection method. Standard harnesses, ropes, and anchoring techniques are always required when working on a roof. Roof jacks should be installed by the fall competent person on site. Their setup and use should be inspected at the beginning of each work day.

Tools and Equipment

- Roof Jack Adapters, 1738051-00-A
- Roof Jack, Werner ARB10-10
- Measuring Tape
- Metal Hammer
- Carpenter's Pencil/Black Marker
- Cordless Impact Driver Drill
- Module Removal Tool

Relevant Flashings and/or Components

- 2″ H x 8″ W 8ft L or 2″ H x 8″ W x 10ft L, wood plank, clear straight grained lumber free of knots or defects (sourced from local hardware retailer)

Required Components

- 16d Nails (3x per adapter), #9 x 3 ¼ in (sourced from local hardware retailer)
- Wood Screws (1x per adapter, #8 ¾ in, 1 in or 1 ½ in), 1460512-00-A, 1470351-00-A or 1716850-00-A

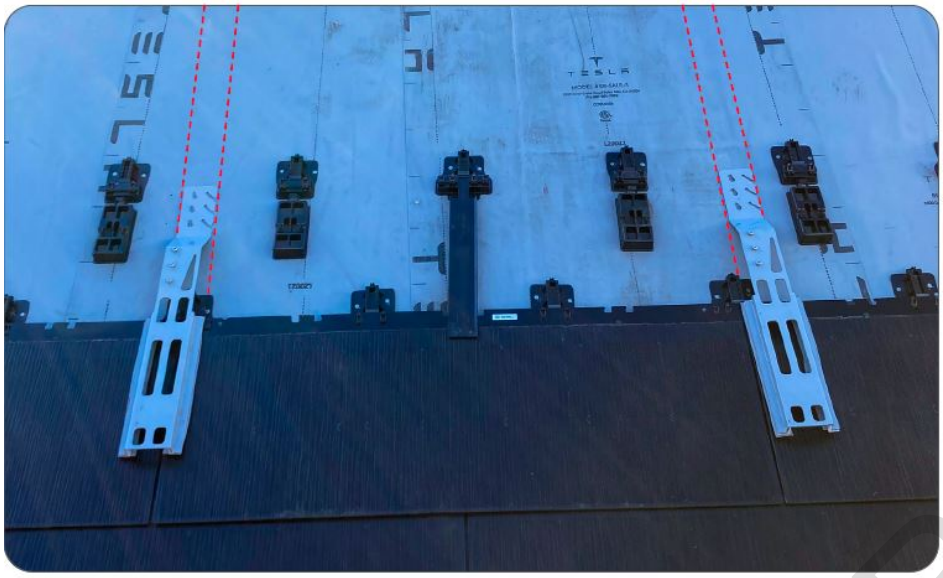
Installing Roof Jacks and Adapter

1. Start by installing the tiles up to the location where the platform needs to be.

2. Remove the tiles where the adapter will be placed.

> **NOTE:** This step is performed to accurately locate where the tile ft should sit.

3. Position the roof jack adapter so that the eyeholes align with the rafter and the support pads sit on top of the tile below.

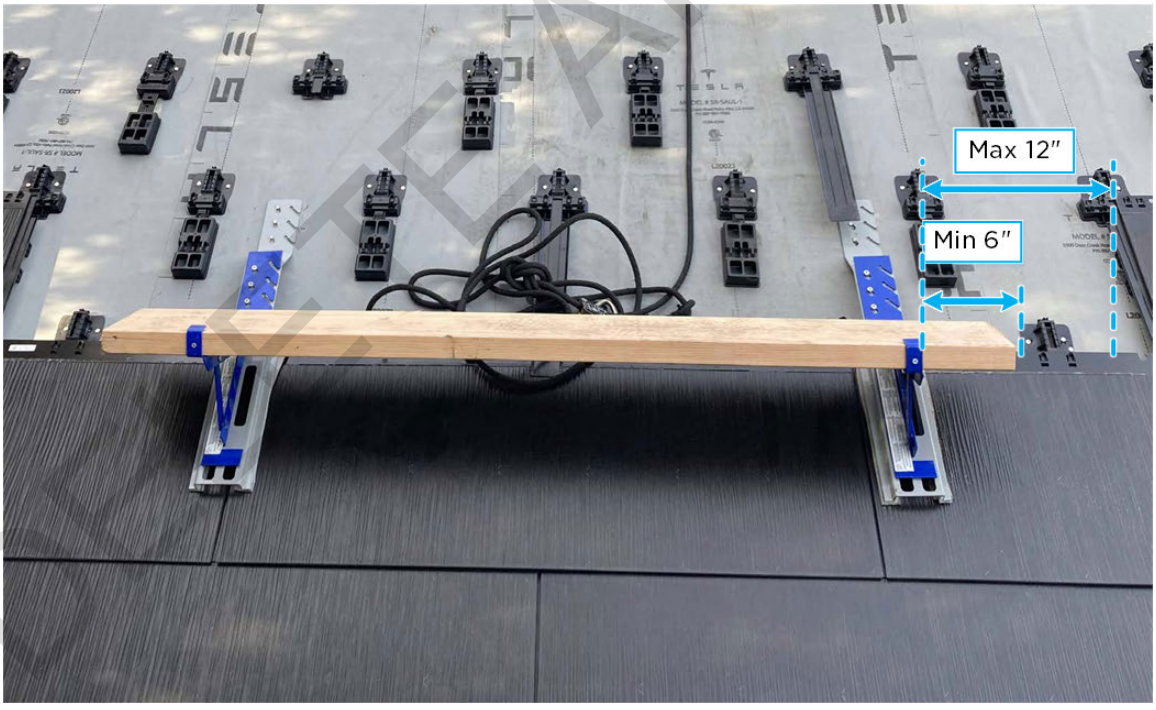


4. Use a hammer to drive 3x 16d nails through the eyelets and into the rafters. Anchor lags can also be used but will require patching once removed.
   Deck screws or wood screws should never be used as they have insufficient strength.

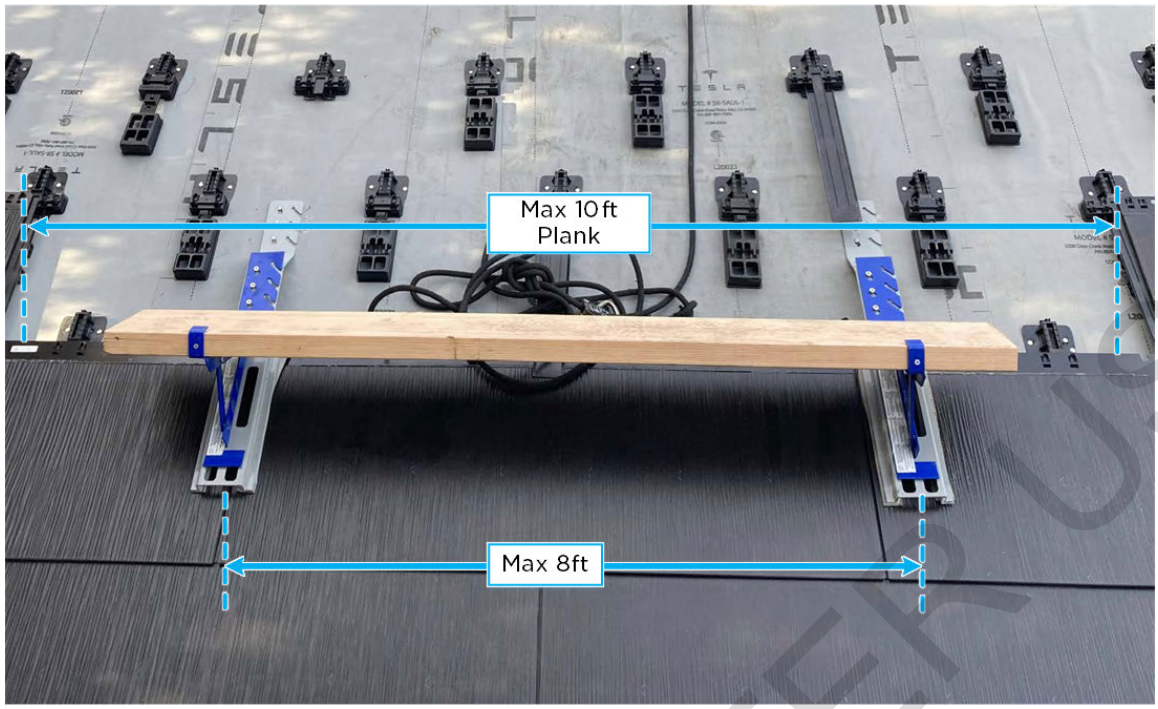
5. Attach the roof jack by slotting it into the shoulder bolts of the adapter. Repeat for the other side.

6. Place a 2 x 8 (8 ft long) wood plank between the roof jacks and inspect it to ensure the wood plank extends beyond the roof jack by 6 in and no more than 12 in.

> **NOTE:** The wood plank may be cut to meet safety regulation of minimum of 6 in and maximum of 12 in beyond the roof jack ends.

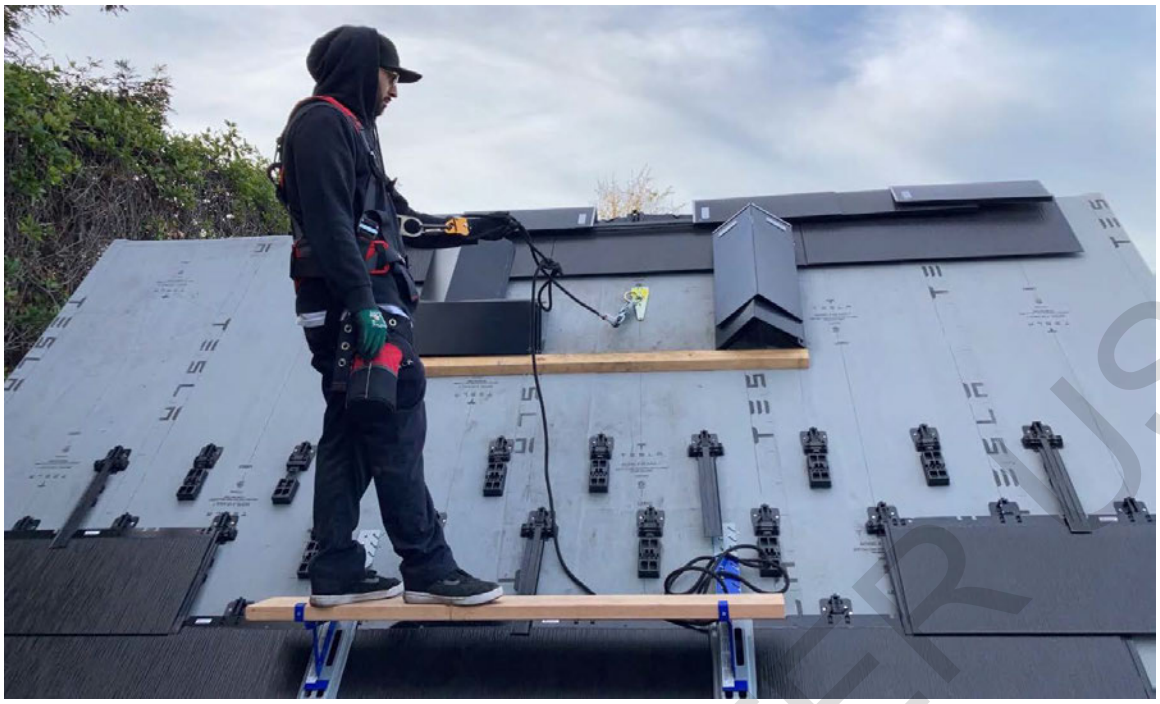


7. Check the spacing between the brackets to make sure it does not exceed 8 ft. Also ensure that the plank is not longer than 10 ft. If the length of a working platform is greater than 10 ft, multiple sets of roof jack adapters and planks are needed.



8. Drive a nail or screw through the hole on the back of roof jack with a hammer or drill to secure the plank.

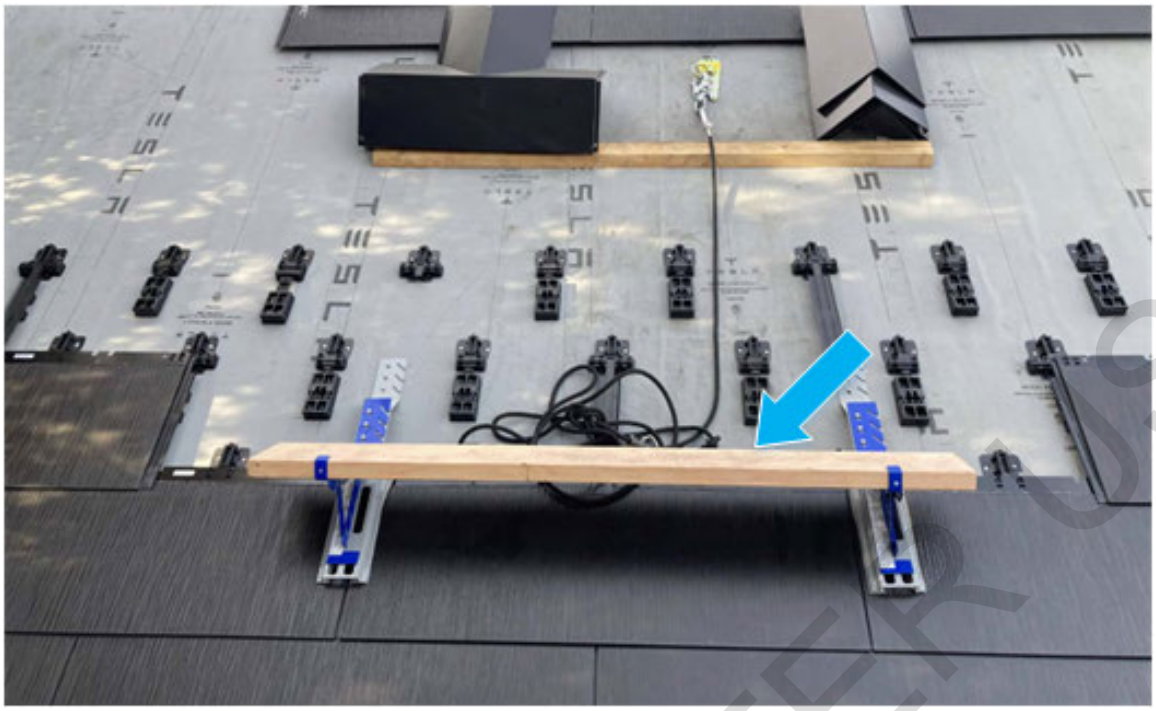
9. The platform can be used and stood on with a harness, rope, and anchor attached.



Removing the Roof Jack and Adapter

1. Start by removing the screws or nails in the wood plank.

2. Remove the wood plank from the jack.



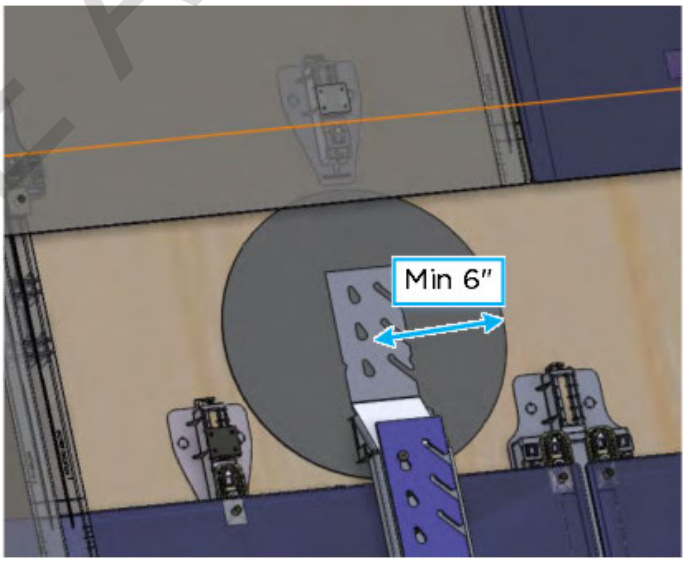
3. Use a hammer to tap the adapter up and slide the nail heads through the holes.

4. Drive the nails into the deck with a hammer.

> **NOTE:** When the nails are driven flush to the deck, they do not require an underlayment patch.

Anchor Lags

If anchor lags were used, remove the anchor lags from the deck. Install a patch that is as large as possible and that fits between the ft. Ideally the patch should cover 6 inches in any direction from the hole.



5. Re-install the tile.

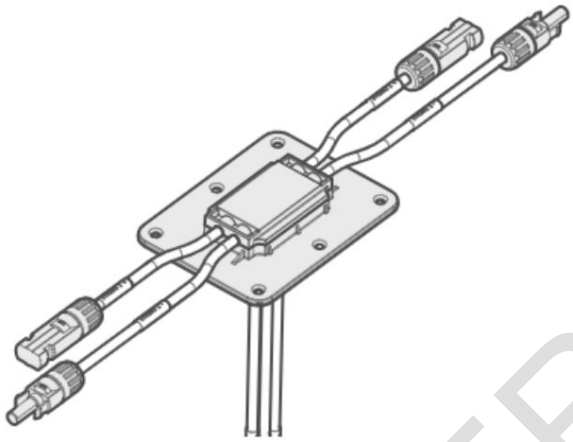
ELECTRICAL OVERVIEW

Electrical Components

Title		Model Number	Certifications	Image
Jumper		#SR-BJ2X, #SR-BJ3X, #SR-BJ4X and #SR-BJMini	UL 9703	
Jumper Description	**Jumper Length**			
1x	59.8 in			
3x	150 in			
5x	240.1 in			
Y-Connector (Socket)		#PV-AZB4	UL 6703	
Y-Connector (Plug)		#PV-AZS4	UL 6703	

Pass Through Box (PTB) Specifications

Model Number	SRPTB-4



Certifications
UL 1741, File #E318357 Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

Mechanical Parameters	
Cable Type	10 AWG PV Wire (ZKLA)
Connector	Staubli MC4 type PV-KST4/6II-UR or type PV-KST4-EVO2 (male) and Staubli MC4 type PV-KBT4/6II-UR or type PV-KBT4-EVO2 (female)
Housing	Plastic

Environmental Specifications	
Max System Voltage	DC 600 V

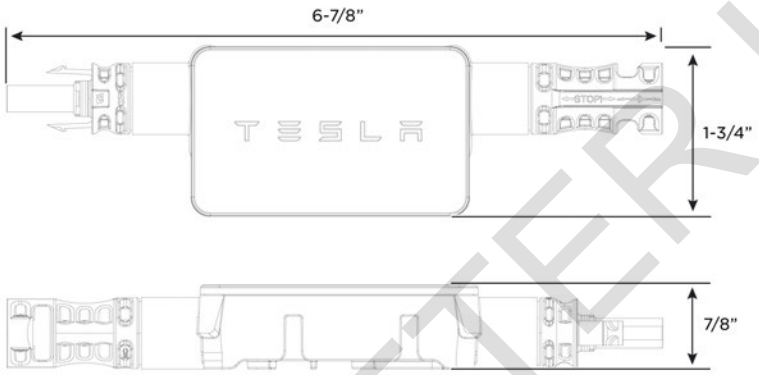
Fastening Specifications
Verify transition location on plan set. Install Pass Through Box using wiring methods and materials that comply with Article 690 and Chapter 3 of the NEC and local regulations. Fasten the Pass Through Box to the deck using six Buglehead Screws. Use Tesla approved fasteners only. Use of unapproved fasteners may invalidate warranty.

Mid-Circuit Interrupter (MCI) Specifications

Certifications (MCI-1 and MCI-2)
UL 1741 PVRSE
UL 3741

MCI-2

Model Number	MCI-2, #1879359



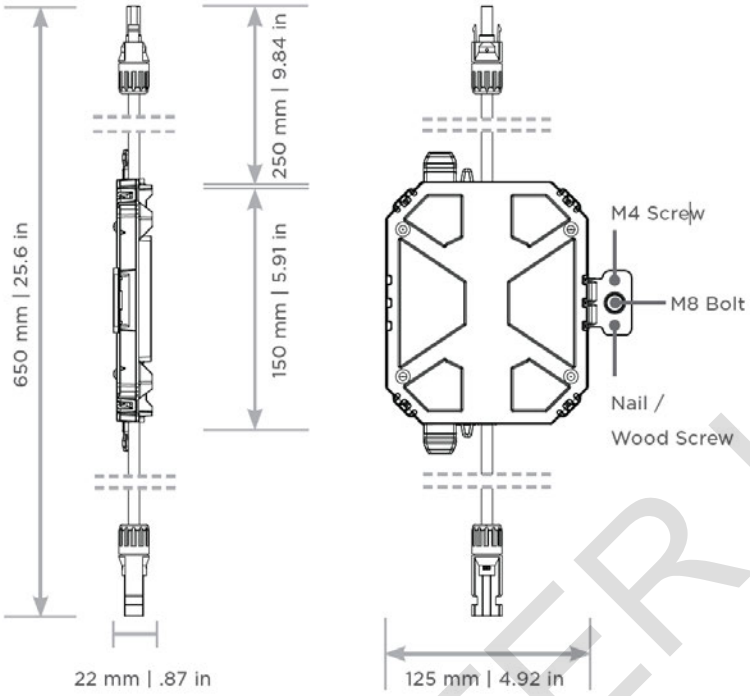
Electrical Characteristics	
Enclosure Rating	NEMA 4 /IP65
Max Input Short Circuit Current, I_{SC} (A)	17 A
Nominal Input Current, I_{MP} (A)	13 A

Mechanical Parameters	
Connector	Staubli MC4 type PV-KST4/6II-UR or type PV-KST4-EVO2 (male) and Staubli MC4 type PV-KBT4/6II-UR or type PV-KBT4-EVO2 (female)
Housing	Plastic
Weight	120 g | 0.26 lb
Dimension	173 mm x 43 mm x 22 mm 6.88 in x 1.75 in x .88 in

Environmental Specifications	
Ambient Temperature	-40 °F up to 158 °F | -40°C to 70°C
Max System Voltage	DC 1000 V

MCI-1

Model Number	MCI-1, #1550379



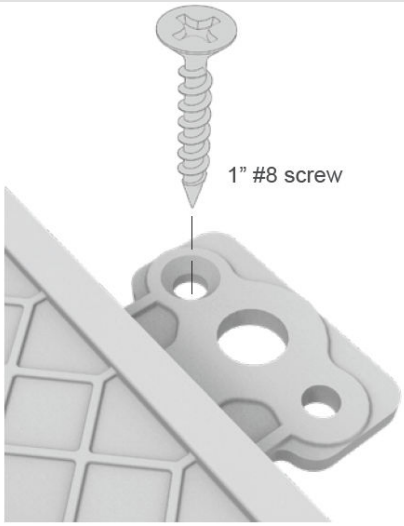
Electrical Characteristics	
Enclosure Rating	NEMA 4 /IP65
Max Input Short Circuit Current, I_{SC} (A)	19 A
Nominal Input Current, I_{MP} (A)	12 A

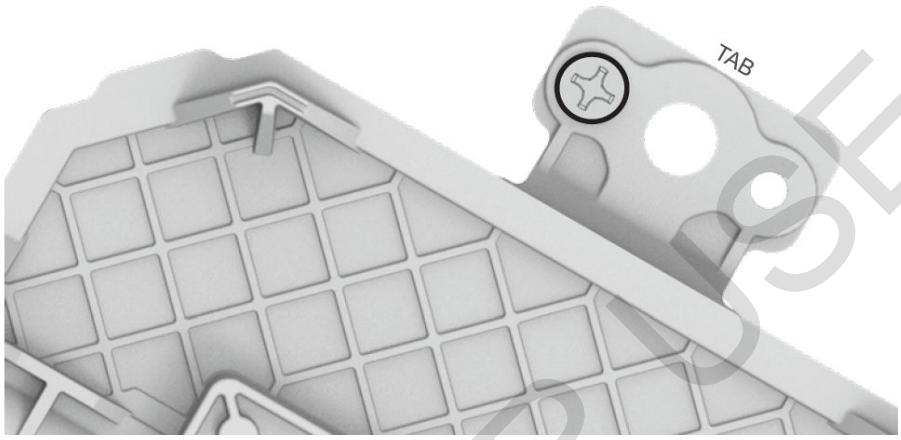
Mechanical Parameters	
Cable	Length 250 mm | 9.84 in
Connector	Staubli MC4 type PV-KST4/6II-UR or type PV-KST4-EVO2 (male) and Staubli MC4 type PV-KBT4/6II-UR or type PV-KBT4-EVO2 (female)
Housing	Plastic
Weight	350 g | 0.77 lb
Dimension	125 mm x 150 mm x 22 mm 5 in x 6 in x 1 in

Environmental Specifications	
Ambient Temperature	-40 °F up to 158 °F | -40°C to 70°C
Max System Voltage	DC 600 V

Fastening Specifications
Use a 1 in #8 deck screw to secure the MCI-1 to the roof surface using the three-hole tab. Install the screw through the beveled hole so that the screw's head sits flush.

Fastening Specifications



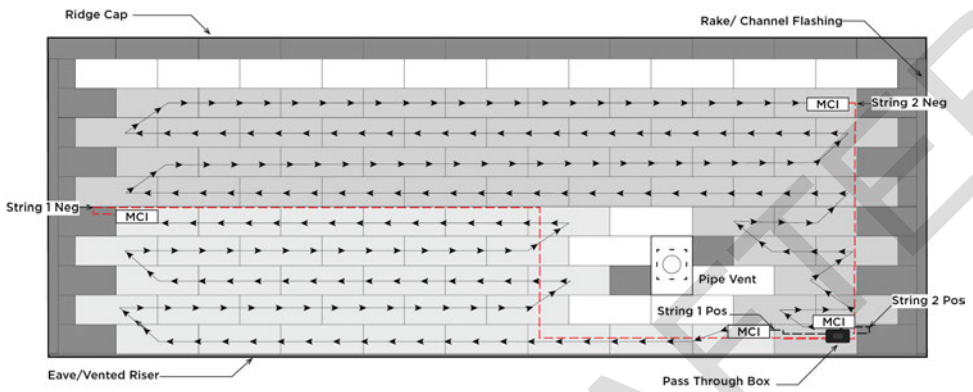


Ground Fault Path

Ground fault paths for Solar Roof systems exist only for the DC circuit conductors as they exit the roof surface into the attic or under an eave or soffit via pass-through assemblies, as shown in the figures below. The PV tiles have no conductive external parts. Circuits exit the pass-through assemblies into conventional junction boxes or conduit couplings, where equipment ground conductors and conduit ground bushings are employed to ensure a continuous EGC path to the solar inverter ground bus in accordance with the National Electrical Code (NEC), ANSI/NFPA 70.

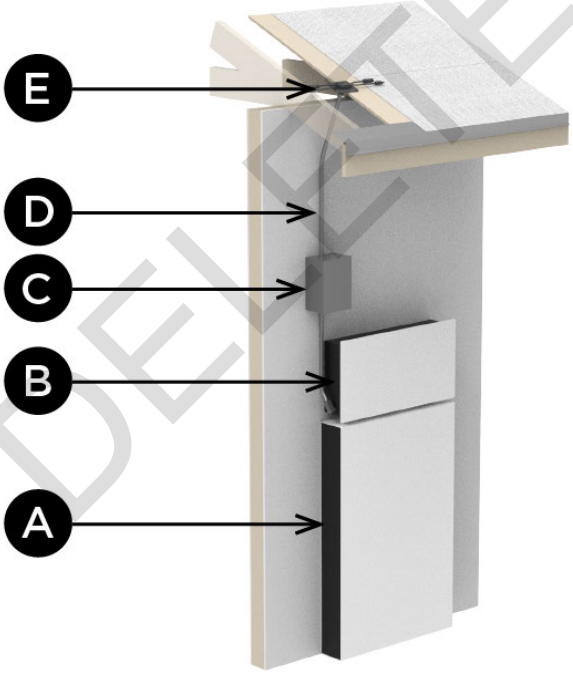
See *On Roof Electrical Wiring Overview on page 196* for descriptions of Solar Roof electrical components installation and layout.

Figure 1: Ground Fault Path



Legend	
MCI	Mid-Circuit Interrupter
	Pass Through Box
	Metal Tile
	PV Tile, String 1
	PV Tile, String 2
	Trim / Flashing

Figure 2: Electrical Ecosystem



(A): Powerwall+

(B): Inverter

(C): Junction/Pull Boxes

(D): Metallic Flex, Non-Metallic Flex and/or EMT Raceway

(E): Pass Through Assembly

Solar Roof PV Hazard Control System

UL 3741 PVHCS

PV RAPID SHUTDOWN ARRAY

WARNING: To reduce the risk of injury, read all instructions.

PV Hazard Control System (PVHCS) Equipment and Components Certification Standards | BIPV				
Function	**Manufacturer**	**Model No.**	**Firmware Versions and Checksums**	**Certification Standard**
PV Module	Tesla	SR72T3R , SR73T3R	N/A	UL 61730 / UL 7103
PVRSE Mid Circuit Interrupter (MCI)	Tesla	MCI-1, MCI-2	N/A	UL 1741 PVRSE
Inverter, Powerwall+, or Powerwall 3	Tesla	7.6 kW: 1538000[1] 3.8 kW: 1534000[1] 7.6 kW: 1850000[1] 11.5kW: 1707000[1]	V4, 6558D2BD V4, FF7BE4E1 V4, 6558D2BD V1, 0x3282A18C	UL 1741, 1998 PVRSS/PVRSE
PVHCS Initiator (PV Inverter)	Dedicated PV system AC circuit breaker or AC disconnect switch, labeled per NEC 690.12 requirements.			N/A
PVHCS Initiator (Powerwall+, Powerwall 3)	Emergency stop device (NISD)- Listed "Emergency Stop Button" or "Emergency Stop Device" or "Emergency Stop Unit"			UL 508 or UL 60947 Parts 1, 5-1 and 5-5
PVHCS Initiator (Powerwall 3)	On/Off Enable switch located on Powerwall 3, when labelled as Rapid Shutdown initiator per NEC 690.12 requirements			UL 1741

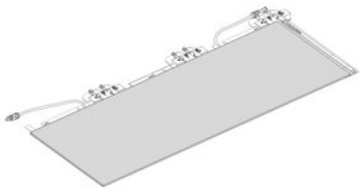
[1] Applies to variations of this part number with suffix of two numbers and one letter.

NOTE: PVHCS installation requirements may reduce the effective equipment and component ratings below the individual equipment and component PVRSE ratings in order to achieve PVHCS shock hazard reduction requirements.

PVHCS Installation Requirements	
Max System Voltage	600 V_{DC}
PVHCS Maximum Circuit Voltage (Array Internal Voltage After MCI Rapid Shutdown Initiation)	600 V_{DC} (cold weather open circuit)

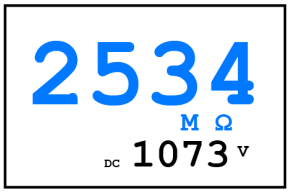
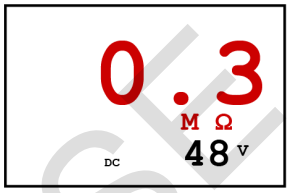
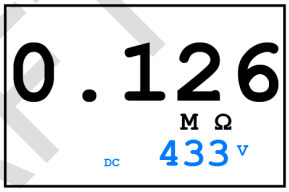
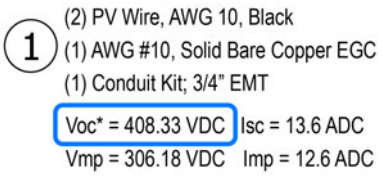
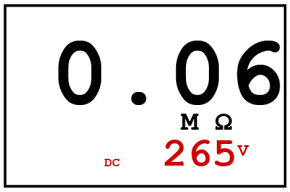
Other Installation Requirements
1. MCIs must be connected at both the positive and negative ends of each series-connected string to satisfy NEC 690.12 requirements for circuits exiting the array to the inverter or Powerwall. MCI-2s have additional installation requirements, as described in this manual.
2. Where a single series-connected string spans across two mounting planes, an additional MCI shall be connected at one end of the connection between mounting planes.
3. Verification that MCIs are installed at the ends of each string and (if applicable) in between mounting planes shall be documented for inspection, via photographs and/or as-built string layout diagrams.
4. For Powerwall+ or Powerwall 3: The PVHCS emergency stop initiator shall have the following minimum ratings: Outdoor (Type 3R or higher), 12V, 1A, and shall be installed in accordance with NEC requirements. The specific part shall be identified on the as-built system drawings. Refer to the Powerwall installation manual for further details.

PVHCS Components

Title	Model Number	Certifications	Image
PV Tile	Model #SR72T3R	UL 61730 UL 3741 UL 7103 UL 790 Class A ASTM D3161 Class F TAS100	
Mid-Circuit Interrupter (MCI)	Model #MCI-1, 600 V, 13 A Model #MCI-2, 1000V, 13A	UL 1741 PVRSE	
Inverter	7.6 kW: #1538000 3.8 kW: #1534000	UL 1741 PVRSS/PVRSE, 1998	
Powerwall+, Powerwall 3	PVRSS/PVRSE	UL 1741, 1998	

Troubleshooting MCI and PV String Issues

Table 3. Overview of Common MCI and PV String Troubleshooting Tests

Test	When to Perform	Required Tools	Pass	Fail
Insulation Resistance (Megger) Test	• Isolation Self-Test Failure	**Klein ET600 Tester** in 1000 V mode 	 Impedance reading (top value) ≥ 1 MΩ	 Impedance reading < 1 MΩ
String True VOC	• Tesla Solar Inverter Displaying 0 A for connected string • Tesla Solar Inverter is under producing • Arc Fault lockout	**Klein ET600 Tester** in 1000V mode 	  String voltage (bottom value) matches expected voltage on planset	Figure 3. Lower Voltage than Expected (Likely Wiring Error)  Figure 4. Higher Voltage than Expected (Likely Open Circuit) 
String Continuity	• Tesla Solar Inverter displaying negative voltage for connected string	Insulation Resistance Tester in DC test mode Examples: • Klein CL800 • Klein ET600 Tester	Single strings: voltage between 10 - 30 V Combined strings: voltage between 31 - 60V	Voltage < 10 V (includes decimal or negative values)

Test	When to Perform	Required Tools	Pass	Fail
MCI Diode Test	• Tesla Solar Inverter displaying 0 A for connected string • Tesla Solar Inverter is under producing • MCI Self-Test failure • Isolation Self-Test Failure • Arc Fault Lockout	Insulation Resistance Tester in Diode test mode Examples: • Klein CL800 • Klein ET600 Tester	0.25 V ≤ Reading ≤ 0.5 V	Reading < 0.25 V or > 0.5 V
MCI Resistance Test		Insulation Resistance Tester in Resistance test mode Examples: • Klein CL800 • Klein ET600 Tester	Reading of "OL" or > 1 MΩ	Reading < 1 MΩ

REGION SPECIFIC INSTALLATIONS

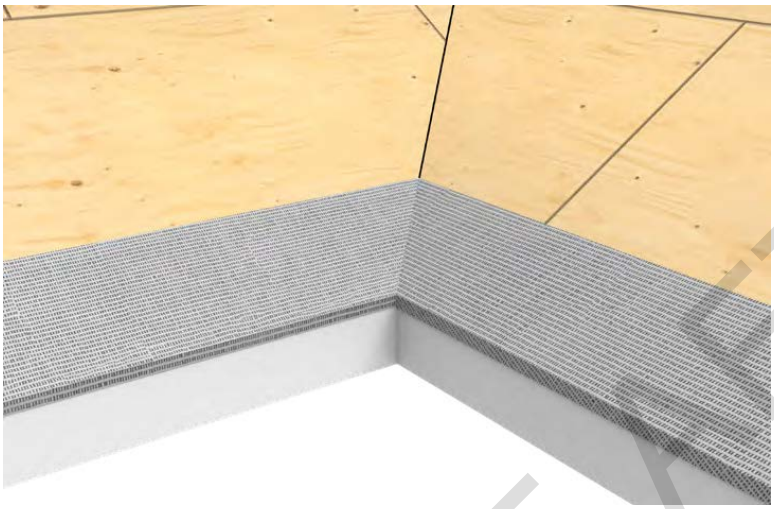
Ice Damming Regions

Overview

This section outlines installation considerations specific to ice damming regions.

Work Instruction

In areas that see ice dams in their gutters, install a detail roll along the eave extending down onto the fascia board 1 in before installing the drip edge along the eave.



High Snow Load Regions

Snow Intrusion Mesh at the Ridge

Overview

This section provides guidance for installing snow intrusion mesh at the ridge. Wind-driven snow can blow below the ridge caps and fall into the attic through the ridge vent in some regions. Cobra Exhaust Vent roll is installed to prevent snow from entering the ridge cavity and falling into the ridge vent.

Tools & Equipment

- Measuring tape
- Utility knife
- Impact driver drill
- Electric roofing nail gun
- GAF Cobra Exhaust Vent roll 10 ½ in x 20 ft, 1799214-00-X (sourced from local roofing supply retailer)
- Safety glasses
- Cut-resistant gloves
- Fall protection

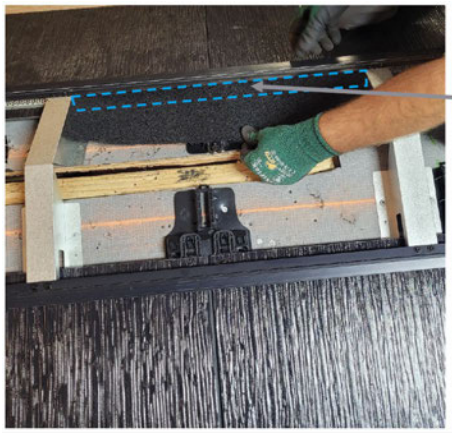
Work Instruction

1. Remove the ridge cap pieces using the impact driver. Set these pieces aside to be reinstalled at the end.

2. At either end, measure the distance between the two ridge brackets and cut a strip of GAF Cobra Exhaust Vent (20 ft x 10 ½ in) to length.

3. Cut this strip in half along its length, resulting in two 5 ¼ in wide strips of material.

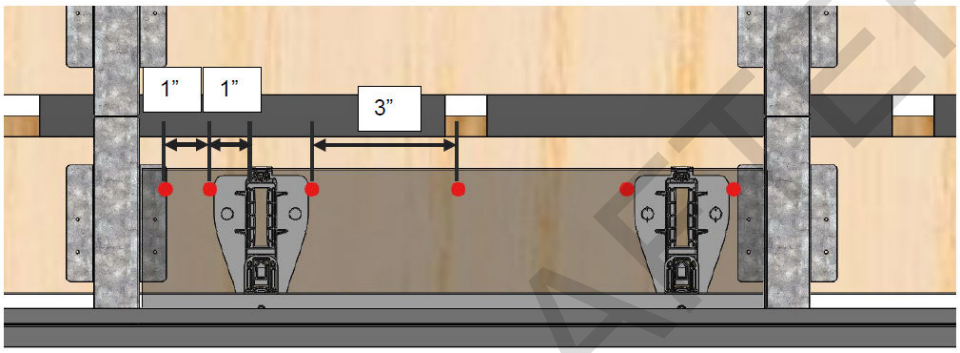
4. Firmly seat the long end of the strip into the vented ridge cleat along the entire length.



Close Up Showing Gap at Ridge Vent

5. While seated, fasten the opposite side of the vent strip with ring shank nails spaced 3 in apart, 1 in back from the ridge-side edge. Ensure fasteners are within 1 in of ridge brackets and both sides of any module feet.

> **NOTE:** A stubby foot replacement may be necessary if the vent strip does not cover the module feet.



6. Repeat on the opposite side of the ridge.

> **NOTE:** The ridge vent remains open, but the vent strip blocks snow and moisture blowing up the roof.

7. Continue this install procedure for the entire ridge.
8. Re-install all ridge cap pieces.

Valley Trim Installation in High Snow Regions

Overview

This instruction applies to tile-level valley trim installations in High Snow Load regions. It affects fastening guidance for all valley trim at all pitch variables. Use these details where the shear component of the roof snow load exceeds 27 lbs/ ft^2 (1290 N/m^2) (typically, where the ground snow load, pg exceeds 55 psf), or as directed by Tesla Engineering, a building official, or by a registered design professional such as a licensed engineer or architect. Refer to the *Fastener Schedule on page 703* for related information.

See *System Specifications on page 62* for roof snow load specifications.

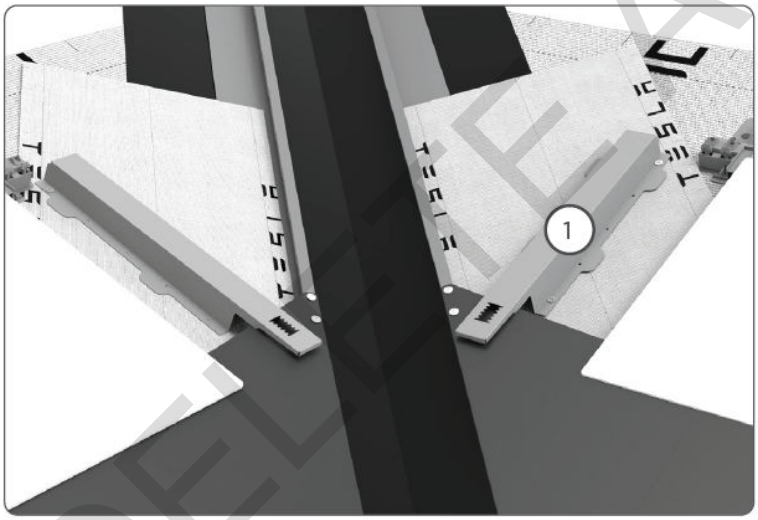
NOTE: Hand and trim tools for trim installation. Refer to the Tool Catalog for part numbers. Refer to *Important Safety Instructions on page 6* and follow safety guidelines for PPE.

Tools & Equipment

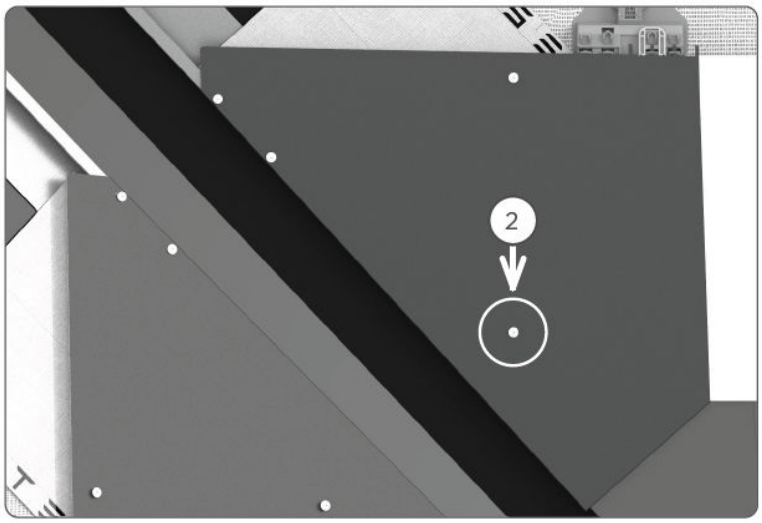
- Electric drill/driver
- Adjustable valley trim
- Safety glasses
- Cut-resistant gloves
- Fall protection

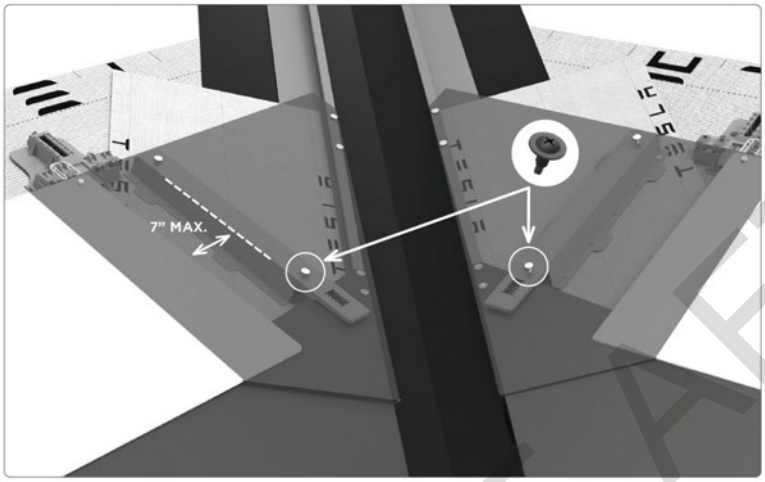
High Strength Valley Work Instruction

At all Valley Trims, install an additional black Self-tapping Screw through the flashing surface and into the Support Bracket Flashing **(1)** that is closest to the tile edge, as shown below.



Install this additional fastener regardless of side (left/right), slope, and whether the trim is adjustable or not. Ensure that the screw does not land in the hollow punch-out region of the Support Bracket Flashing. Take care to ensure the screw is installed at the same location **(2)** on every tile for visual conformity.





Heat Tape Application in High Snow Regions

Overview

The guidance below applies to high snow regions as a solution for melting snow off of the Tesla Solar Roof V3R. This is an optional process.

Work Instructions

- In areas with high snow, heating cable can be installed on top of Tesla Solar Roof in order to melt snow if desired.

  It can be installed along the sides of the valley and fastened to the valley trims. Plan the excess length to be the length of the valley and lay that down in the valley itself.

- Heating cable can also be run underneath the array and be attached to snow guards, or along the ridge and attached to the ridge caps.

Snow melt cable is a preventative measure to keep the snow from accumulating.

High Velocity Hurricane Zones (HVHZ)

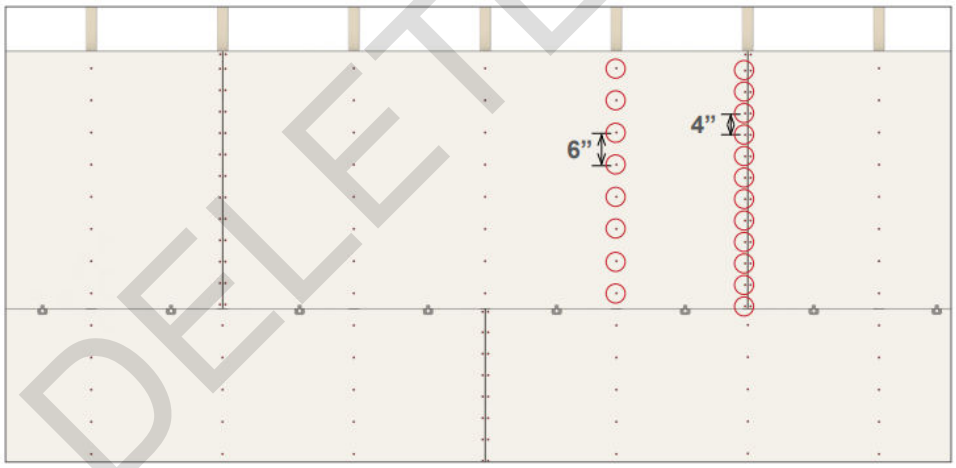
Overview

This section outlines installation considerations in HVHZ zones. Refer to the *Fastener Schedule on page 703* for further guidance.

High Wind Sheathing Fastener Schedule

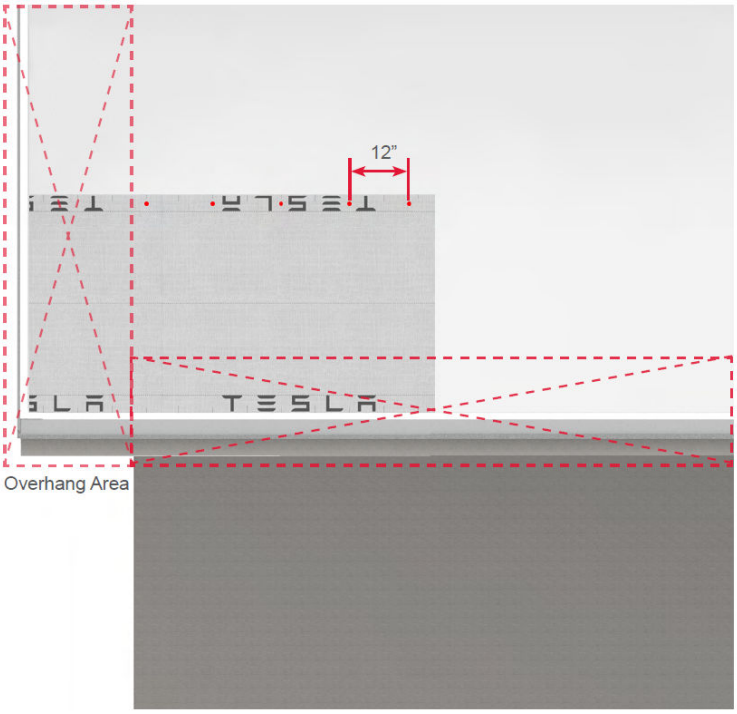
In high wind zones fasten sheathing to rafters 4 in O.C. on seams, and 6 in O.C. in the field using 8d sheathing nails or decking screws. Ref. Code: IRC–12/13 Table R602.3 (1).

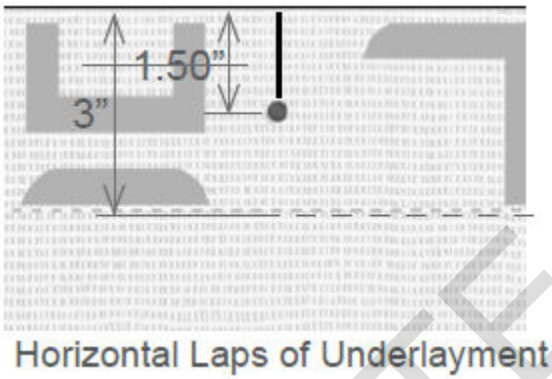
WARNING: When sheathing removal and remediation is required follow recommended safety procedures. Ensure fall protection equipment is managed to prevent a fall through the opening in the walking or working surface.



Blind Nailing Underlayment for Extreme Conditions

Fasten every 12 in on the end of the markers (each marker is spaced 6 in apart) indicated on the top. Ensure to fasten into rafters when exposed soffits are present.



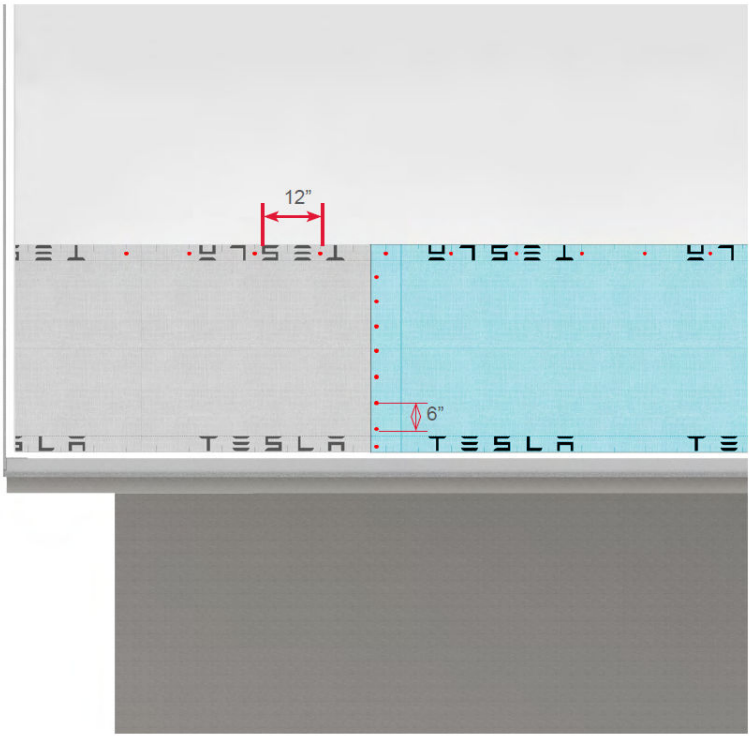


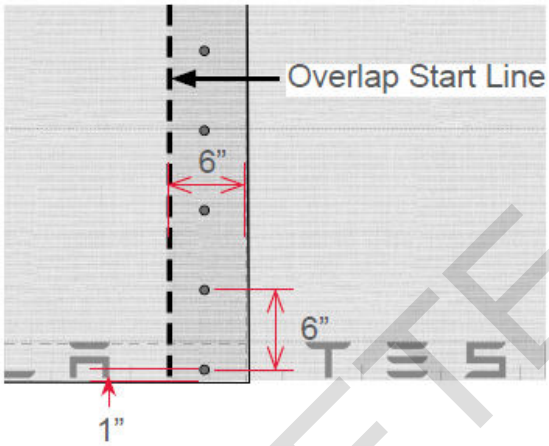
Horizontal Laps of Underlayment

A.Overlap the next section of the underlayment 6 in on top of the last section.

B.Fasten the side-lap with the first nail 1 in away from each edge, and every 6 in after that.

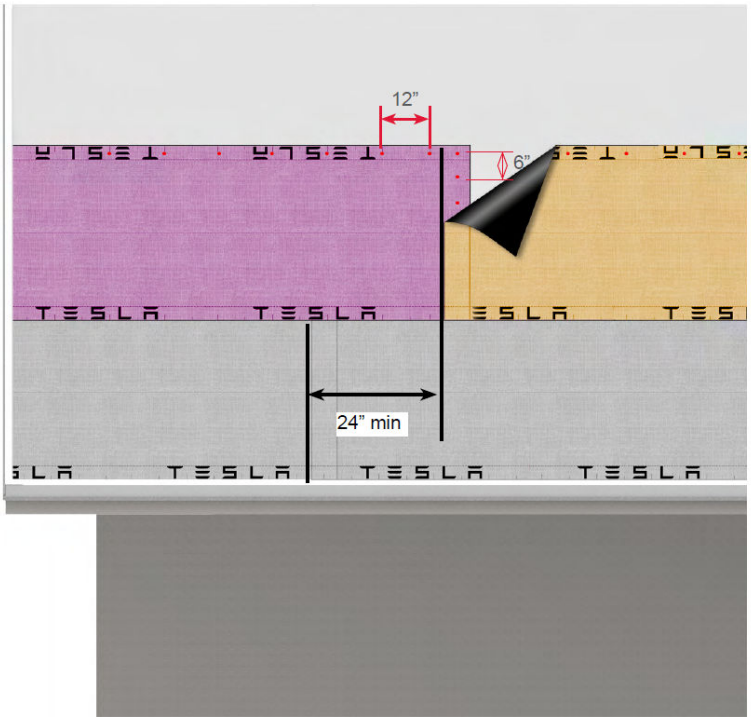
NOTE: Do not fasten in exposed overhang areas. Continue nailing the top-lap every 12 in on the ends of the markers.



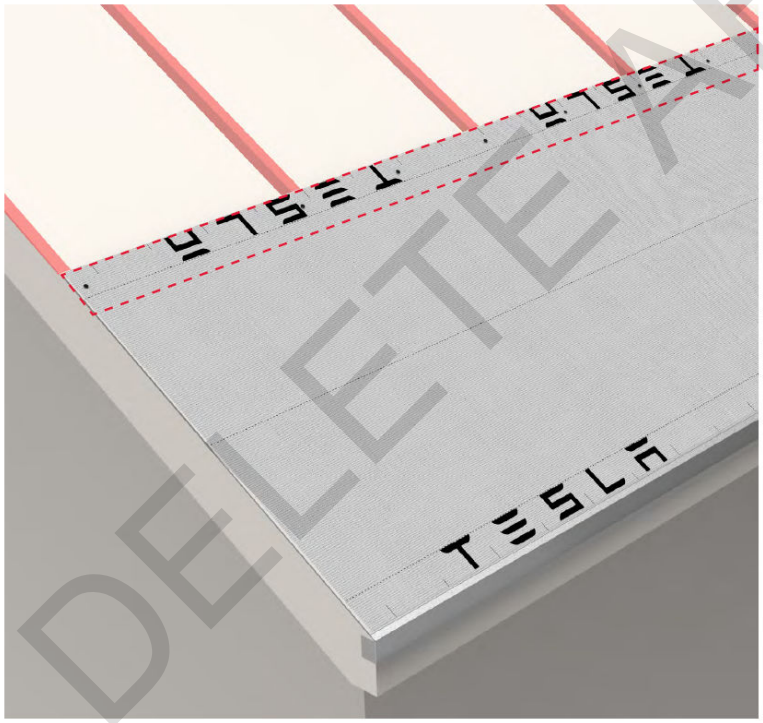


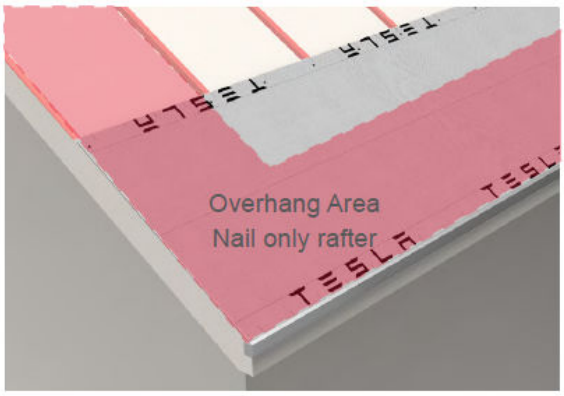
Closeup of End Laps of Underlayment

The next underlayment course will overlap the horizontal laps 3 in. This will cover the nails and the upside-down Tesla logo. Ensure the second course is staggered a minimum of 24 in from the bottom end lap. Continue the same nailing pattern for the next sections and underlayment courses. Use a roller along the entire face of the underlayment to ensure an adequate seal.



When installing underlayment at rake area in extreme conditions fasten the horizontal lap using nails every 12 in on the bottom of the markers. At the eave drip edge, the underlayment will be fastened during the Starter Trim installation. On exposed overhangs, nail only on rafters unless the soffit is enclosed.





Closeup of Nailing with Overhangs

California

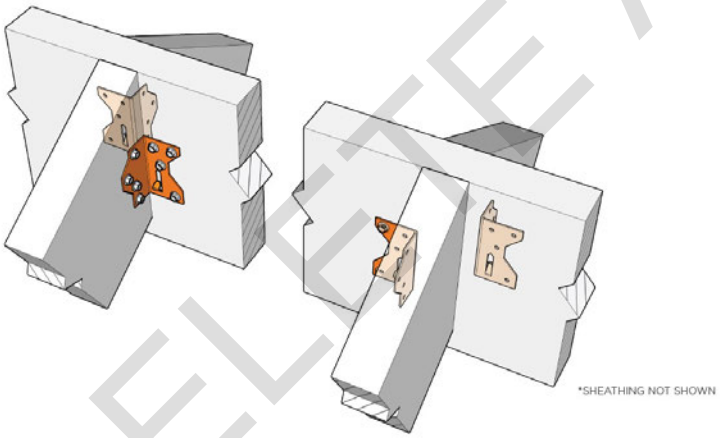
Los Angeles County

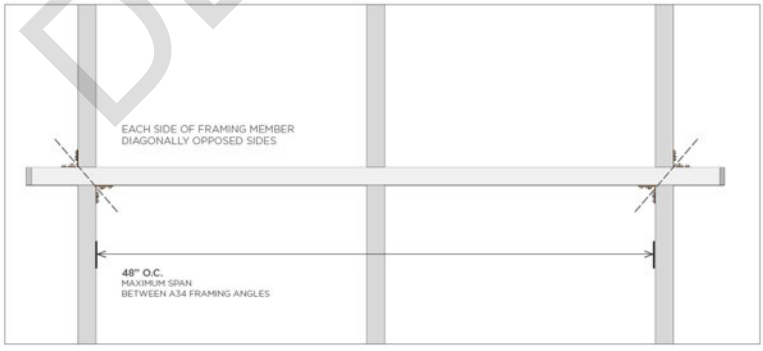
Overview

This section outlines procedures and considerations specific to installations in Los Angeles County.

A34 Framing Angle Installation

Where required by the Authority Having Jurisdiction (AHJ), install the Simpson Strong-Tie A34 framing angle according to the pattern shown. From inside the attic space, install A34 Framing Angle along new ridge vents according to provided details (48 in O.C., each side of roof framing members; diagonally opposed sides of ridge board). Fasten each A34 Framing Angle using eight #9 1 ½ in Strong-Tie SD Connector Screws.



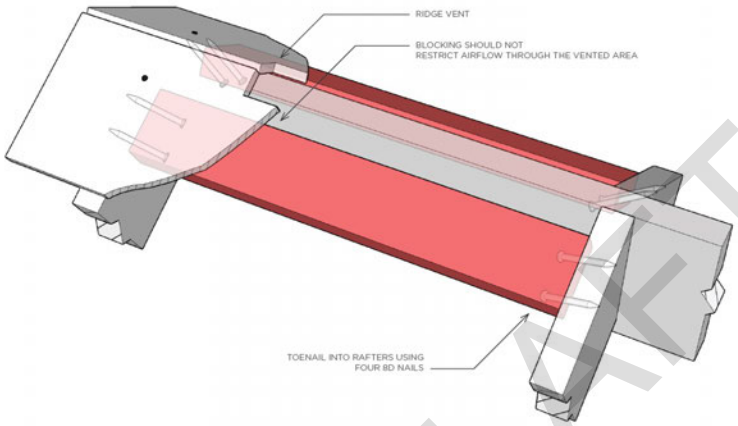


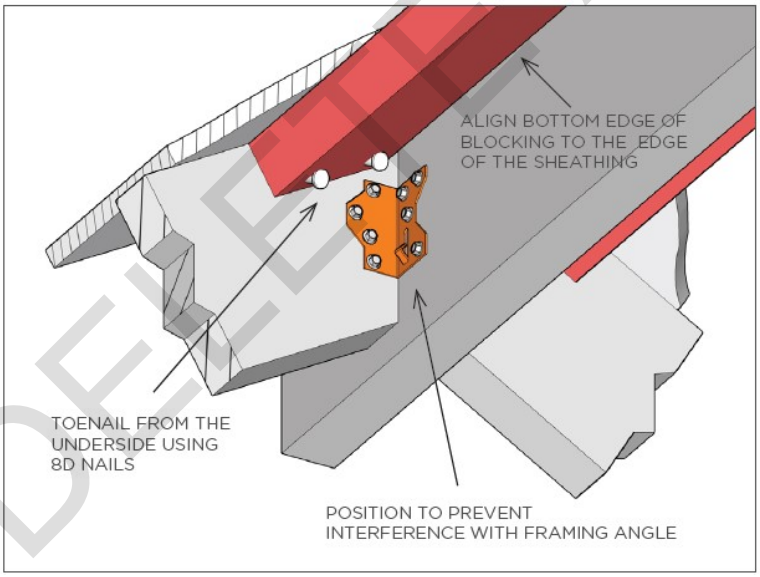
Diaphragm Installation

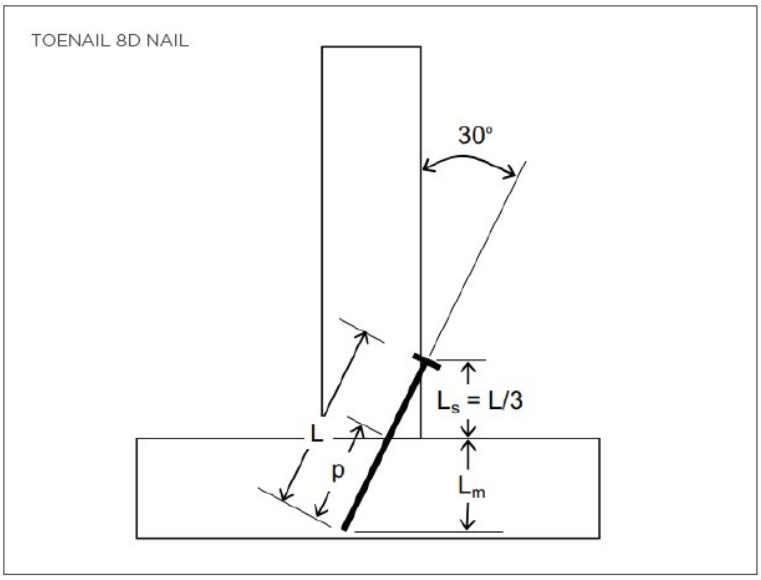
Roof diaphragms are comprised of roof sheathing, framing, and connections which collect and transmit lateral forces to the vertical resisting elements of the building. Some jurisdictions may require additional roof diaphragm reinforcement at new roof ventilation openings. Where required by the Authority Having Jurisdiction (AHJ), details for approved roof diaphragm reinforcement are automatically included in the permitted installation plans. This Work Instruction provides further information on materials and process required to comply with these required details.

NOTE: Prior to construction, verify that the existing roof sheathing is not a "blocked diaphragm" as detailed in Tear Off and Deck Prep. Contact Tesla Installation Hotline for further review if ridge ventilation is specified for a blocked diaphragm.

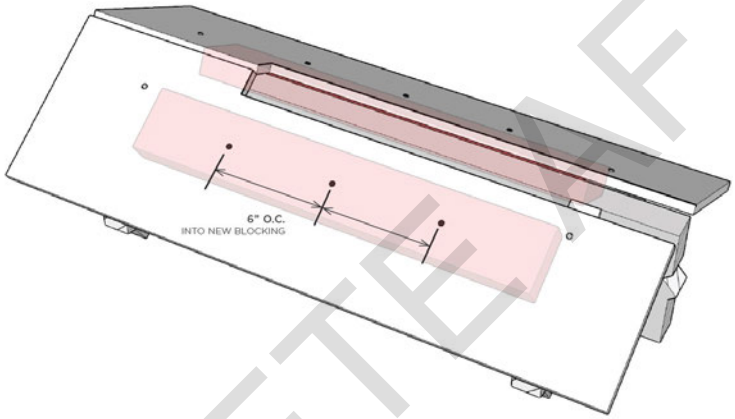
1. From inside the attic space, install 2x4 blocking between every rafter or truss bay. Blocking should be cut for a tight fit between bays, filling as many bays as are affected by the ridge vent cut. Edge of blocking should align to a vertical plumb line from the edge of the sheathing panel. Blocking should not touch the ridge board or existing ridge blocking, nor should it restrict airflow through the vented area. Toenail into rafters using four 8d nails.







2. Fasten 8d nails 6 in O.C. into new blocking.
3. Where required, allow building inspector to evaluate conformance to approved details.
4. Resume Solar Roof dry-in activities as normal.



Installing a Cap Sheet Under the Valley Pans for Fire Protection

Valley Cap Sheets provide extra fire protection and a code requirement for LA County. The installation begins after the underlayment has been applied in the valley area. A Cap Sheet is then placed over the underlayment and fastened down with roofing nails.

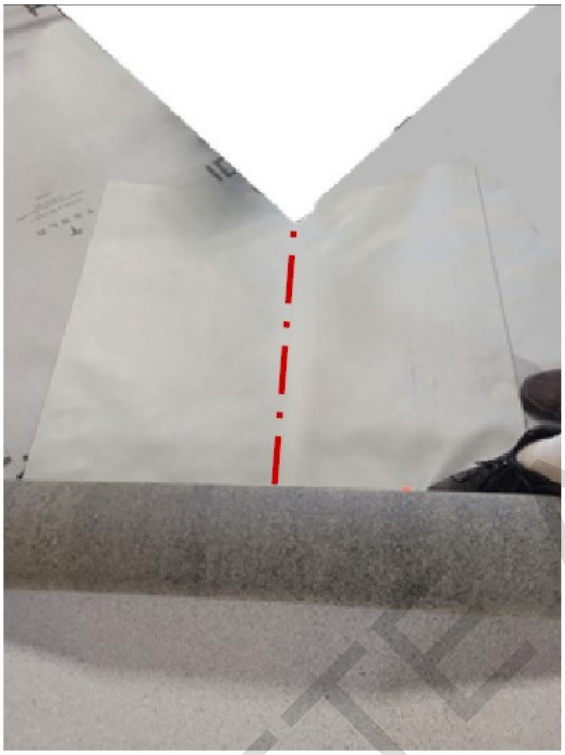
Tools & Equipment

- Carpenter's pencil
- Measuring tape
- Utility knife
- Metal hammer
- Left and right metal snips
- Chalk line
- Cap Sheet

- Underlayment
- Detail roll
- Safety glasses
- Cut-resistant gloves
- Fall protection

1. Start by finding the valley's center, then place the center of the cap sheet at this point. Next, roll the cap sheet down the dried in valley.

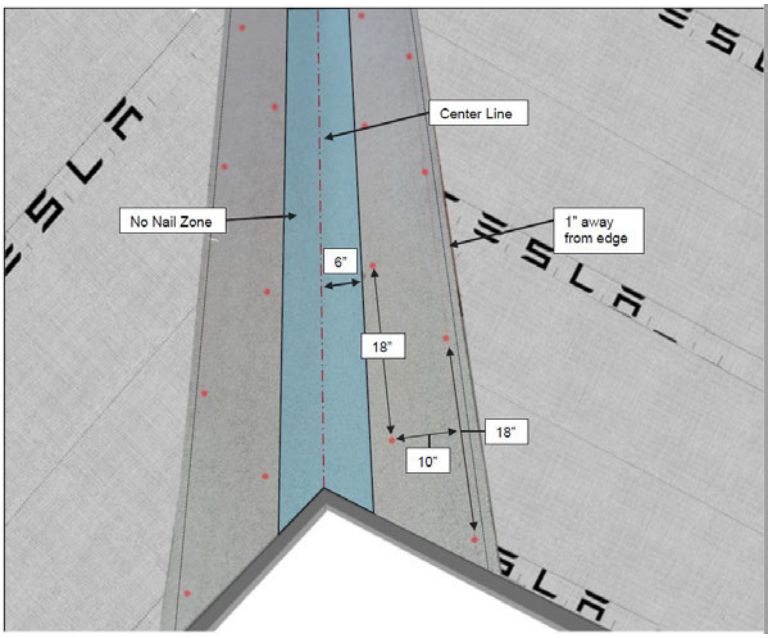
   NOTE: This work begins after the installation of underlayment and before the installation of the Valley Flashing.



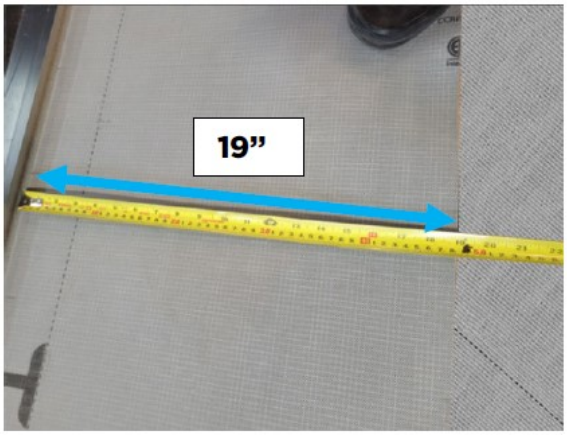
2. The cap sheet will need to be fastened down with 1 ¼ in Ring Shank Roofing Nails.

   NOTE: On steep pitch roofs, cap nails can be used if needed for additional attachment.

3. Fasten the cap sheet with two rows of nails 18 in O.C., staggered, 10 in between rows 1 in away along the edges of the cap sheet. Ensure no nail land within the 6 in no nail zone. This nailing pattern supports up to 5:12. Any slope above 6:12 uses a 12 in on center with a 10 in stagger.



4. Once the cap sheet is secure, install the valley flashing. The only change that will differ from the work instruction is using a wider underlayment roll to cover the sheet cap. This can be accomplished by cutting a full roll of underlayment to size.



Adding Mesh at Ridge Before Riser

See *Adding Mesh at Ridge Before Riser on page 696* for information and guidance.

Wildlife Urban Interface

Adding Mesh at Ridge Before Riser

Overview

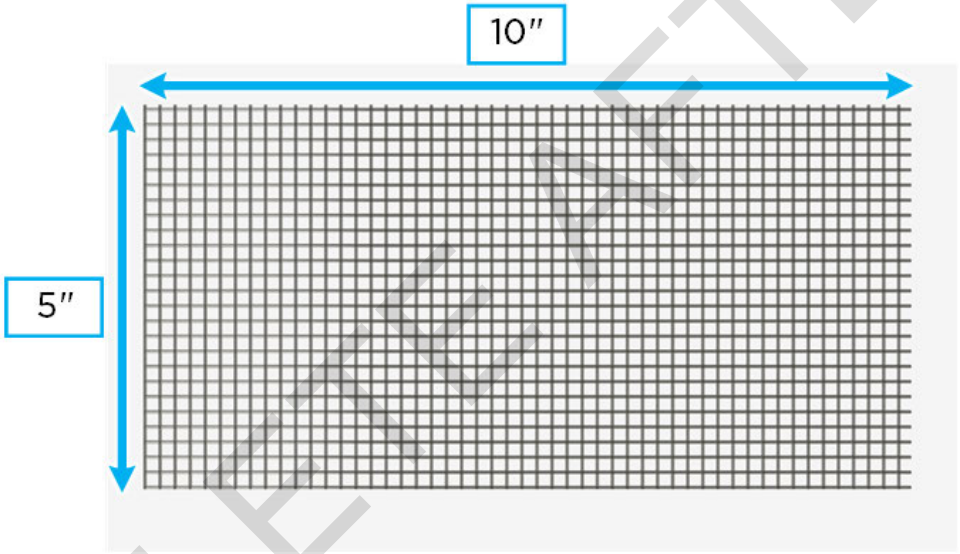
This section provides guidance for installing deck-level wire mesh at the ridge to ensure that embers cannot enter the building in the event of a wildland fire. This is only required for WUI (Wildland Urban Interface) projects under the purview of the Los Angeles County Fire Code.

Tools and Equipment:

- Metal Snips
- Impact
- Mesh
- Deck Screws

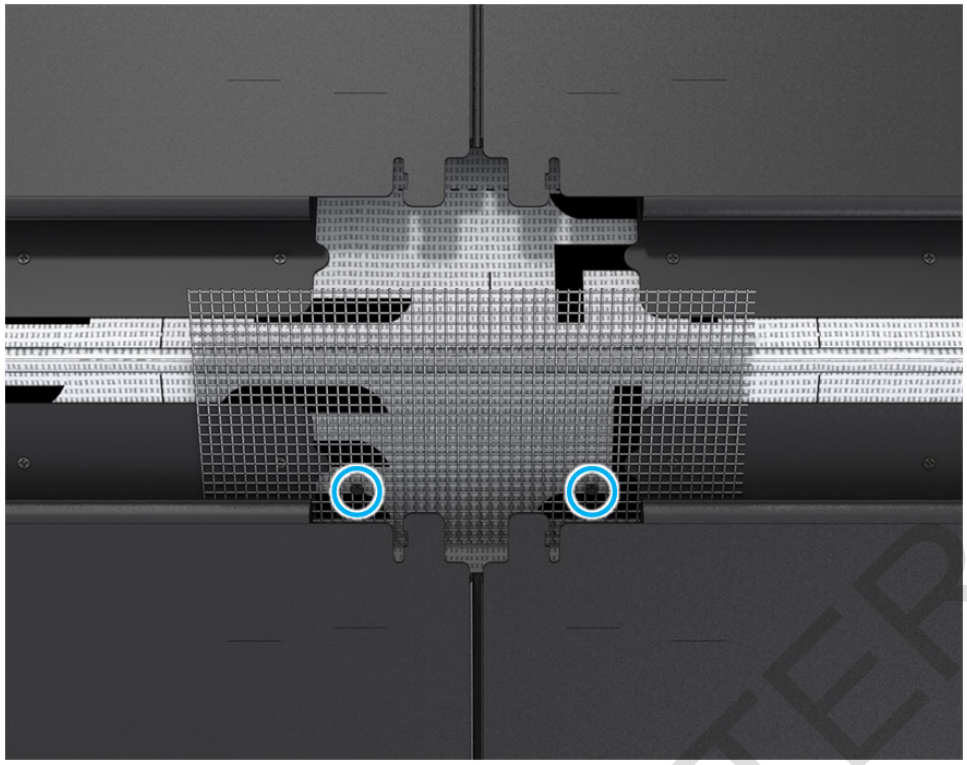
Work Instructions:

1. Cut a piece of mesh to 10 inches by 5 inches.



2. Place the mesh beneath the top of the tiles at the water channel.

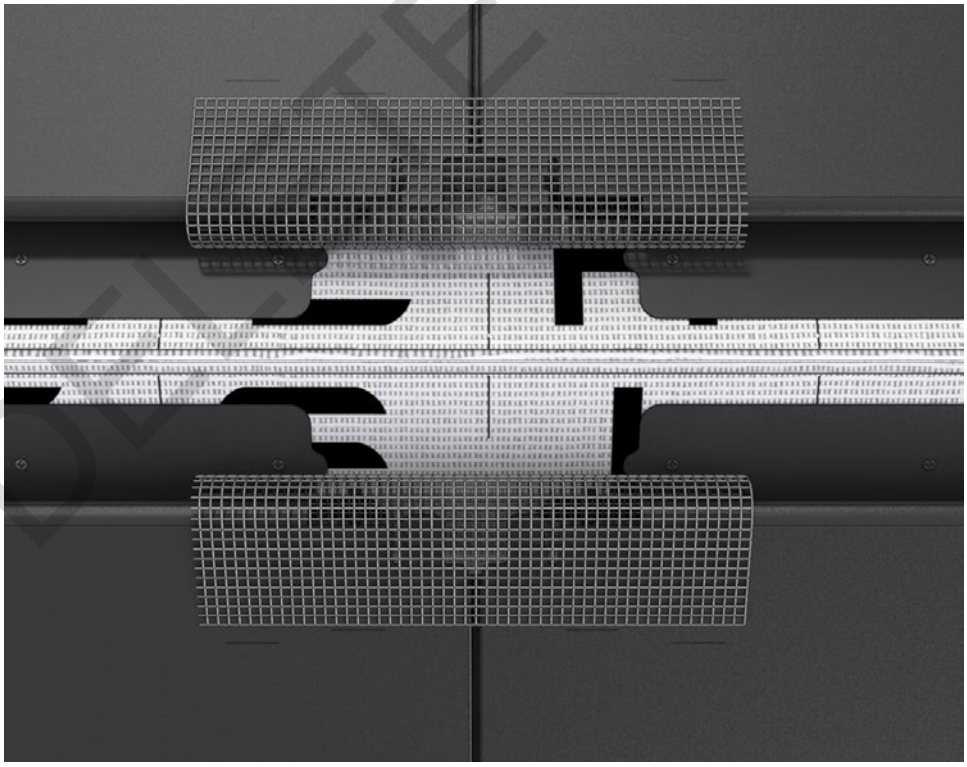
   Attach it to the deck with 2 screws.



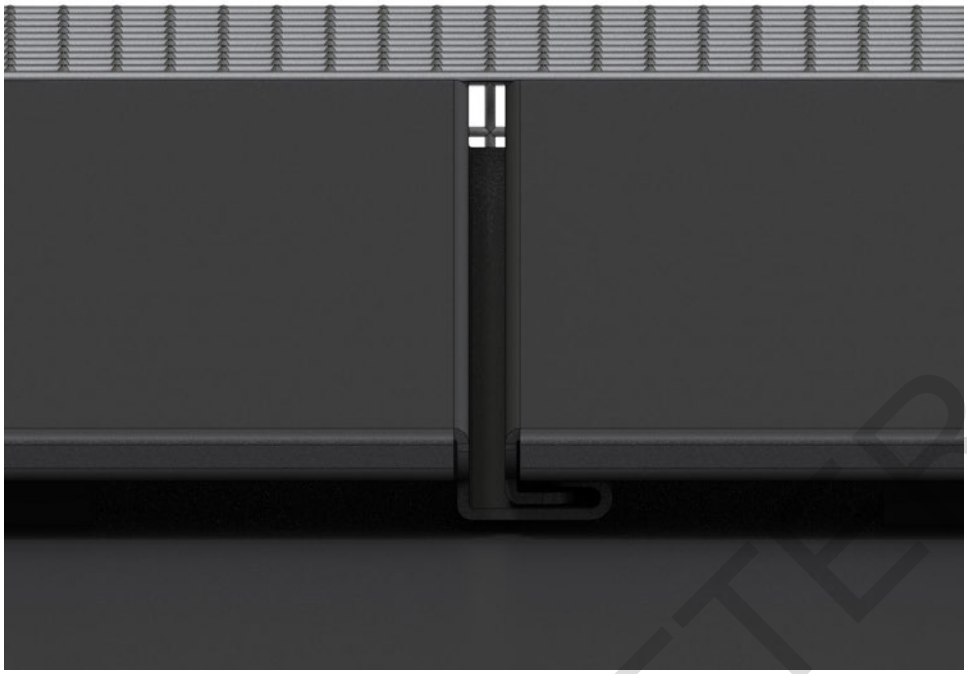
3. Fold the mesh over the tiles and ensure that it is properly covering the water channel.

> **NOTE:** The mesh should not pass the riser line in order to avoid exposure.

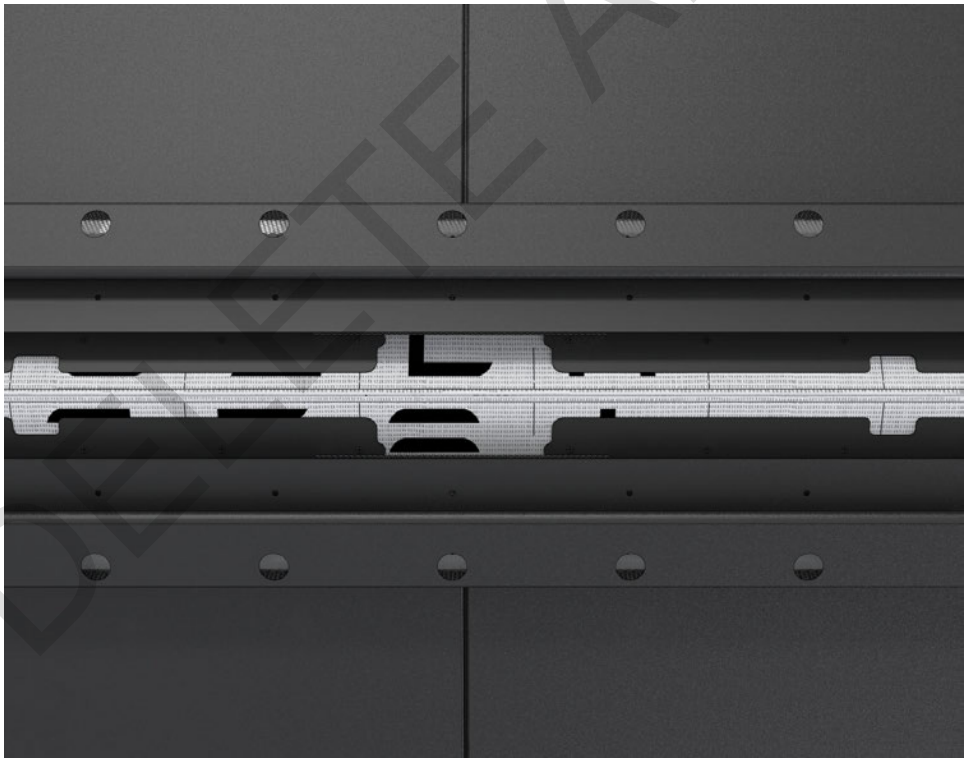
Folded piece of mesh over tiles:



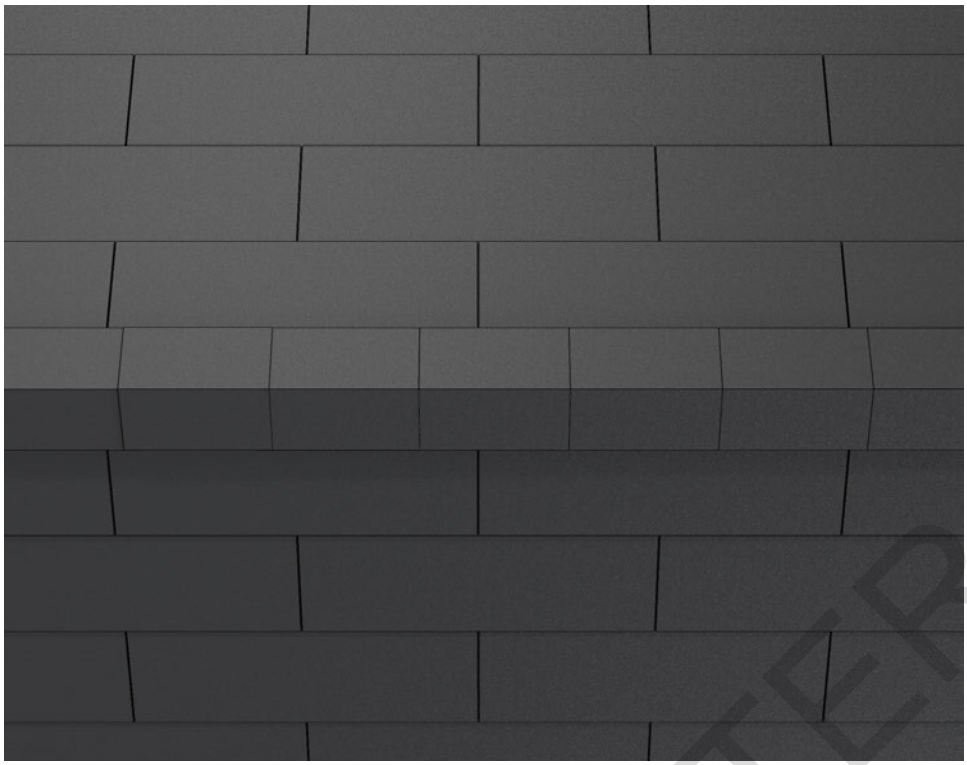
Folded piece of mesh over tiles - water channel angle:



4. Install the vented riser over the tiles and make sure that it sits on the mesh, holding it in place.



5. Install the cap.



San Diego County

Overview

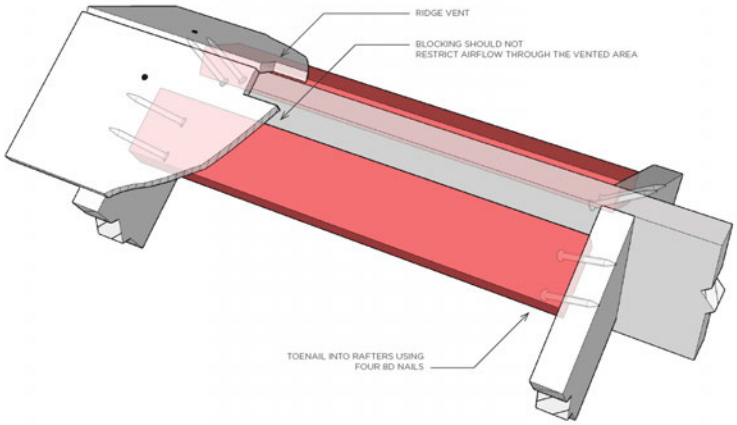
This section outlines procedures and considerations specific to installations in San Diego County.

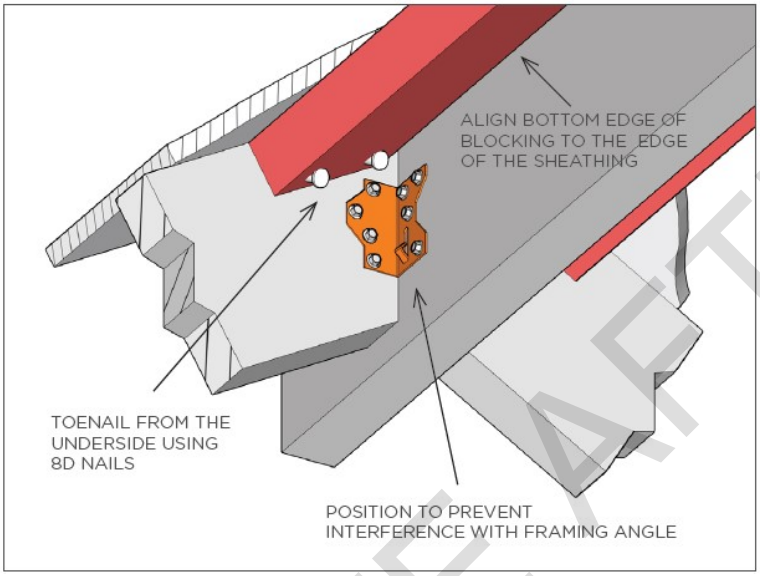
Diaphragm Installation

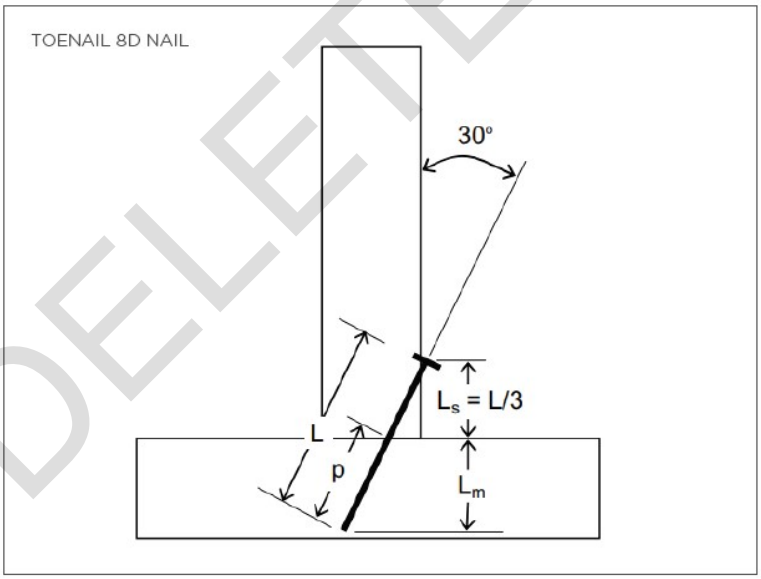
Roof diaphragms are comprised of roof sheathing, framing, and connections which collect and transmit lateral forces to the vertical resisting elements of the building. Some jurisdictions may require additional roof diaphragm reinforcement at new roof ventilation openings. Where required by the Authority Having Jurisdiction (AHJ), details for approved roof diaphragm reinforcement are automatically included in the permitted installation plans. This Work Instruction provides further information on materials and process required to comply with these required details.

NOTE: Prior to construction, verify that the existing roof sheathing is not a "blocked diaphragm" as detailed in Tear Off and Deck Prep. Contact Tesla Installation Hotline for further review if ridge ventilation is specified for a blocked diaphragm.

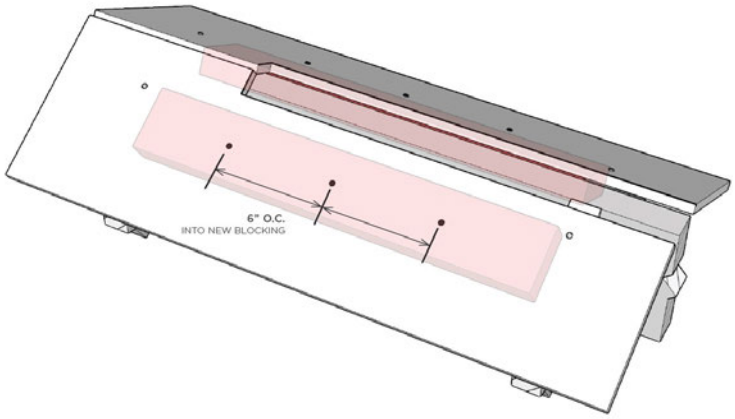
1. From inside the attic space, install 2x4 blocking between every rafter or truss bay. Blocking should be cut for a tight fit between bays, filling as many bays as are affected by the ridge vent cut. Edge of blocking should align to a vertical plumb line from the edge of the sheathing panel. Blocking should not touch the ridge board or existing ridge blocking, nor should it restrict airflow through the vented area. Toenail into rafters using four 8d nails.







2. Fasten 8d nails 6 in O.C. into new blocking.
3. Where required, allow building inspector to evaluate conformance to approved details.
4. Resume Solar Roof dry-in activities as normal.



REFERENCES

Fastener Schedule

NOTE: See *Fasteners in the Part Catalog on page 79* for fastener part numbers.

Installation Phase	Component	Base 0 - 120 MPH		Fortified 121 - 180 MPH	
		Fastener	Pattern	Fastener	Pattern
Dry In	Drip Edge	Roofing nail	12 in O.C.	Roofing nail	4 in O.C. staggered
	Wall Flashing	Roofing nail	12 in O.C.	Roofing nail	12 in O.C.
	Valley Pan	Roofing nail	12 in O.C.	Deck screw	12 in O.C.
Tile Install	Riser at Eave	Roofing nail	6 in O.C.	Deck screw	6 in O.C.
	Riser at Valley	Roofing nail	6 in O.C.	Deck screw	6 in O.C.
	Riser at Ridge	Wood screw (2.375 in)	12 in O.C.	Wood screw (2.375 in)	6 in O.C.
	Channel at Rake, Sidewall, Hip and Peakwall	Roofing nail	6 in O.C.	Deck screw	6 in O.C.
	Channel to Metal Tile at Peakwall	Self-tap screw (0.75 in)	6 in O.C.	Self-tap screw (0.75 in)	6 in O.C.
	PV and Glass Tile	Roofing nail	9 EA. (3 per foot)	Deck screw	9 EA. (3 per foot)
	Metal Tile	Roofing nail	9 EA. (5 in O.C.)	Deck screw	9 EA. (5 in O.C.)
	Metal Tile, with vertical cut	Roofing nail	5 in O.C.	Deck screw	5 in O.C.
	Ripped Metal Tile (when nailing flange removed)	Wood screw (2.375 in)	9 EA. (5 in O.C.)	Wood screw (2.375 in)	9 EA. (5 in O.C.)
	Tile Skins	Self-tap screw (0.75 in)	6 EA. (8 in O.C.)	Self-tap screw (0.75 in)	11 EA. (4 in O.C.)
	Adjustable Trim Covers	Self-tap screw (0.75 in)	3 EA.	Self-tap screw (0.75 in)	4 EA.
	Caps	Self-tap screw (0.75 in)	4 EA. (into cleat pilot holes)	Self-tap screw (0.75 in)	6 EA. (4 into cleat pilot holes, 2 into body dimples)
	Transition Flashing	Deck screw	8 in O.C.	Deck screw	4 in O.C.
	Shingle Flashing	Roofing nail	6 EA. (1 per cleat)	Deck screw	6 EA. (1 per cleat)

Metal Overlap

Component	Overlap	Pattern	Splice	Sealant
Drip Edge	3 in	2 per lap	✓	X
Valley Pan	12 in	2 per lap	X	✓
Wall Flashing	6 in	12 in O.C.	X	✓
Transition Flashing	6 in	**Base:** 8 in O.C. **Fortified:** 4 in O.C.	✓	✓

Special Install Cases

See the table below for additional fastening / installation guidance in special cases.

Florida HVHZ	IBHS Fortified

• Follows the same Fastener Schedule as **Fortified**
• Glass roofing tiles (see *Glass Tile Overview on page 73*)
• Special drip edge installation (see *Underlayment Overview on page 64*)
  ◦ 4 in overlap
  ◦ Sealant on overlap
	• No reuse of existing flashings
	• Use stainless screws for roofs within 3000 ft of saltwater
	• Additional decking and documentation requirements
	• See the *IBHS Fortified Roof program site*

Flashing Bend Angles

Overview

This section provides flashing bend angles based on roof pitches.

Click on the roof pitches below to see their respective flashing bend angles:

Roof Pitch: 2:12

Roof Angle	9.5°
Drip at Eave	81°
Transition Flashing	81°
Wall Flashing at Endwall	100°
Wall Flashing at Cricket	13°
Hip Cap	13°
Ridge Cap	12°

Roof Pitch: 3:12

Roof Angle	14°
Drip at Eave	76°
Transition Flashing	76°
Wall Flashing at Endwall	104°
Wall Flashing at Cricket	20°
Hip Cap	20°
Ridge Cap	21°

Roof Pitch: 4:12

Roof Angle	18.4°

Drip at Eave	72°
Transition Flashing	72°
Wall Flashing at Endwall	108°
Wall Flashing at Cricket	26°
Hip Cap	26°
Ridge Cap	30°

Roof Pitch: 5:12

Roof Angle	22.6°
Drip at Eave	67°
Transition Flashing	67°
Wall Flashing at Endwall	113°
Wall Flashing at Cricket	32°
Hip Cap	32°
Ridge Cap	38°

Roof Pitch: 6:12

Roof Angle	26.6°
Drip at Eave	63°
Transition Flashing	63°
Wall Flashing at Endwall	117°
Wall Flashing at Cricket	37°
Hip Cap	37°
Ridge Cap	46°

Roof Pitch: 7:12

Roof Angle	30.3°
Drip at Eave	60°
Transition Flashing	60°
Wall Flashing at Endwall	120°
Wall Flashing at Cricket	42°
Hip Cap	42°
Ridge Cap	53°

Roof Pitch: 8:12

Roof Angle	33.7°

Drip at Eave	56°
Transition Flashing	56°
Wall Flashing at Endwall	124°
Wall Flashing at Cricket	46°
Hip Cap	46°
Ridge Cap	61°

Roof Pitch: 9:12

Roof Angle	36.9°
Drip at Eave	53°
Transition Flashing	53°
Wall Flashing at Endwall	127°
Wall Flashing at Cricket	50°
Hip Cap	50°
Ridge Cap	67°

Roof Pitch: 10:12

Roof Angle	39.8°
Drip at Eave	50°
Transition Flashing	50°
Wall Flashing at Endwall	130°
Wall Flashing at Cricket	54°
Hip Cap	54°
Ridge Cap	73°

Roof Pitch: 11:12

Roof Angle	42.5°
Drip at Eave	48°
Transition Flashing	48°
Wall Flashing at Endwall	133°
Wall Flashing at Cricket	57°
Hip Cap	57°
Ridge Cap	78°

Roof Pitch: 12:12

Roof Angle	45°

Drip at Eave	45°
Transition Flashing	45°
Wall Flashing at Endwall	135°
Wall Flashing at Cricket	60°
Hip Cap	60°
Ridge Cap	83°

Part Inscription Identifier

Overview

This section explains the installation use cases of various part features. Refer to the *Part Catalog on page 74* for part numbers.

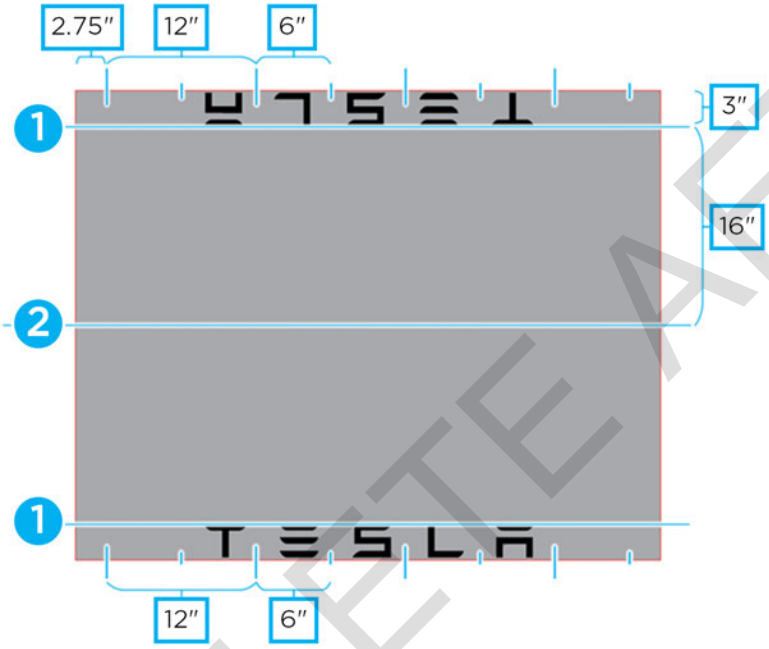
Underlayment

Underlayment is used to create a waterproof barrier on the deck of a roof.

Features:

1. Indicates overlap zone.
2. Exact middle point, used to guide cuts.

NOTE: The increments shown are used to guide cuts, and are consistent across the entire length of the underlayment. The longer lines are to indicate the 12 in increment.

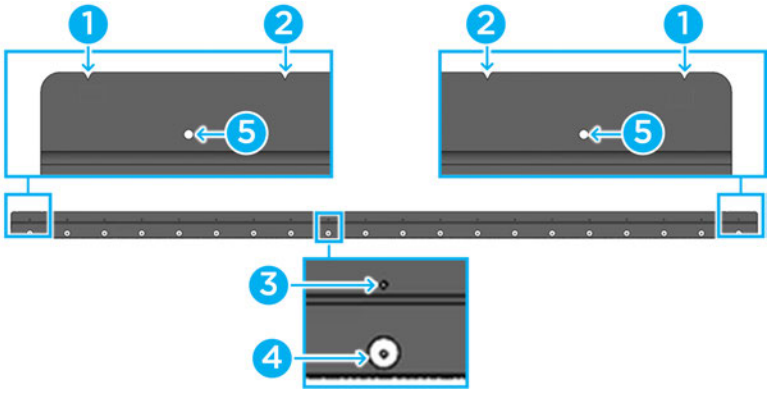


Vented Riser

Vented risers are used to start a row of metal, glass, or PV tiles either at the eave or above obstructions. The riser is also used along the valley and ridge to attach adjustable trim covers and caps when attic ventilation is required. Additionally, the riser is used to support transition flashing and can be used as support between tile level and deck level parts.

Features:

1. Align with rake drip edge to give 1 in offset over rake edge at eave-to-rake junction.
2. 4 in chalk line for channel flashing at rake. Start point of eave-to-valley miter cut.
3. Rear hole; for eave.
4. Front hole; for ridge.
5. Fastener hole.

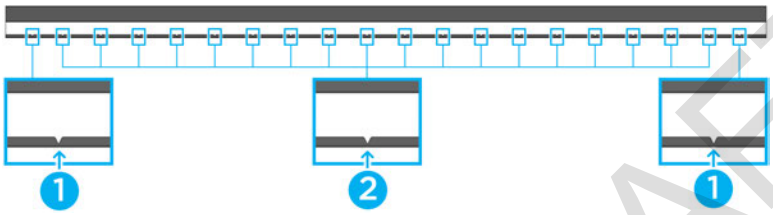


Channel Flashing

Channel flashing is used at rakes, hips, guttered sidewalls and along peak walls. Metal tiles are cut and tucked into channel flashing. Caps along the hip are secured to the channel flashing.

Features:

1. Aligns with 4 in offset chalk line, or rear edge of vented riser.
2. Used for Fastener Schedule.

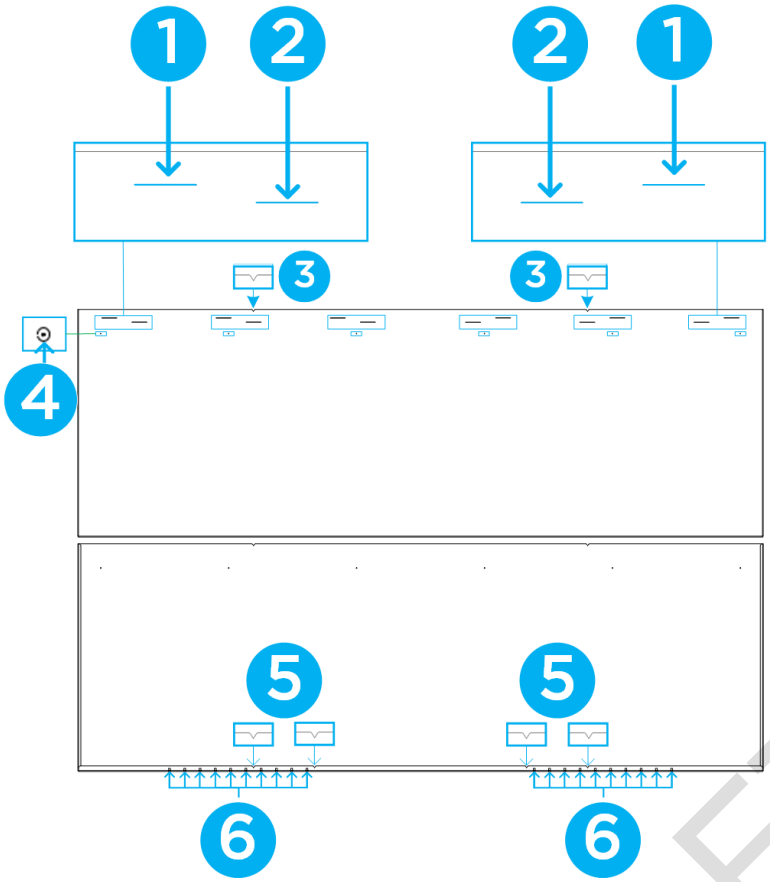


Tile Skin

Tile skins are used to fill in dead zones along hip, rake, and sidewall and to cover cut metal tiles that hide features such as anchors and accessory brackets. This part can also be used as valley trim or rake trims in extreme cases, i.e. when out of the range for adjustable trim covers.

Features:

1. Nominal reveal; next course goes up to this mark.
2. Maximum reveal; leading edge of next tile course goes up to this mark.
3. Guttered obstruction cut guiding carets.
4. Divots for guiding self-tap screw fastening.
5. For extreme angle valleys (anything greater than 135°), adjustable trim will not fit. These notches are used as reference points to create a trim that fits out of the tile skin.
6. Weep holes.

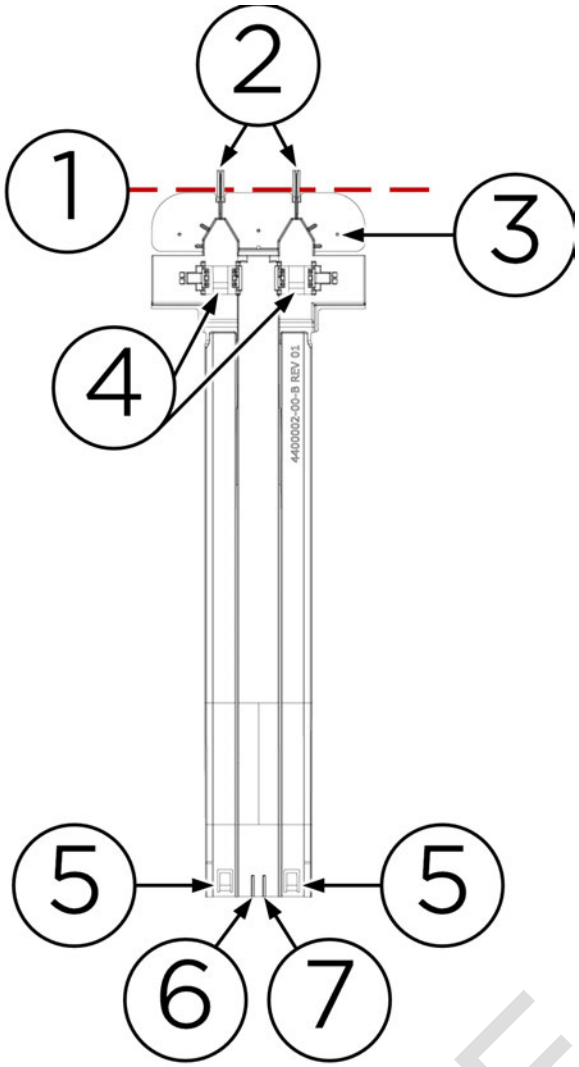


Footlap

Footlaps are used to join PV-to-PV and PV-to-metal tiles and divert water onto tiles below.

Features:

1. The footlap top edge aligns with the top edge of metal tiles (along dotted line).
2. Two slots used for wire connector management.
3. Fastener target.
4. Engagement clips that hold tile tabs.
5. Two tabs that prevent bottom of foot lap from interfering with back edge of glass when re-installing PV tile Prevents back edge of glass from ramming into the foot lap.
6. Aligns with the bottom-left edge of a PV tile to ensure that the footlap is straight.
7. Aligns with the bottom-right edge of a PV tile to ensure that the footlap is straight.

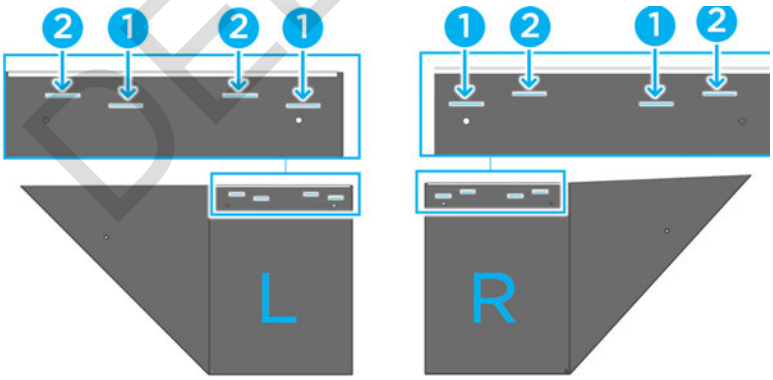


Adjustable Trim Covers, Left and Right

Adjustable trim covers are used at valleys and angled eaves.

Features:

1. Nominal reveal; next course goes up to this mark.
2. Maximum reveal; leading edge of next tile course goes up to this mark.

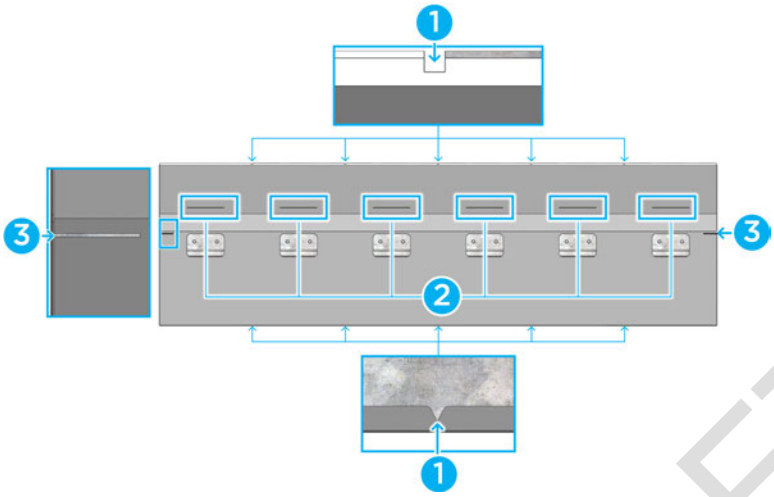


Shingle Flashing

Shingle flashing is used in small areas to function as metal tiles without raising the roof.

Features:

1. Cut-outs that split the full-width tile into 6 parts. This serves two functions: Cut marks to enable 1/6 tile stagger and provides visual confirmation of 1/6 offset alignment.
2. Nailing guide; aligned with cleat and shows acceptable nailing locations. Nails should be as close to the center of the line as possible.
3. Aligns with lower edge of hem of the previous course; confirms full engagement in the cleats.

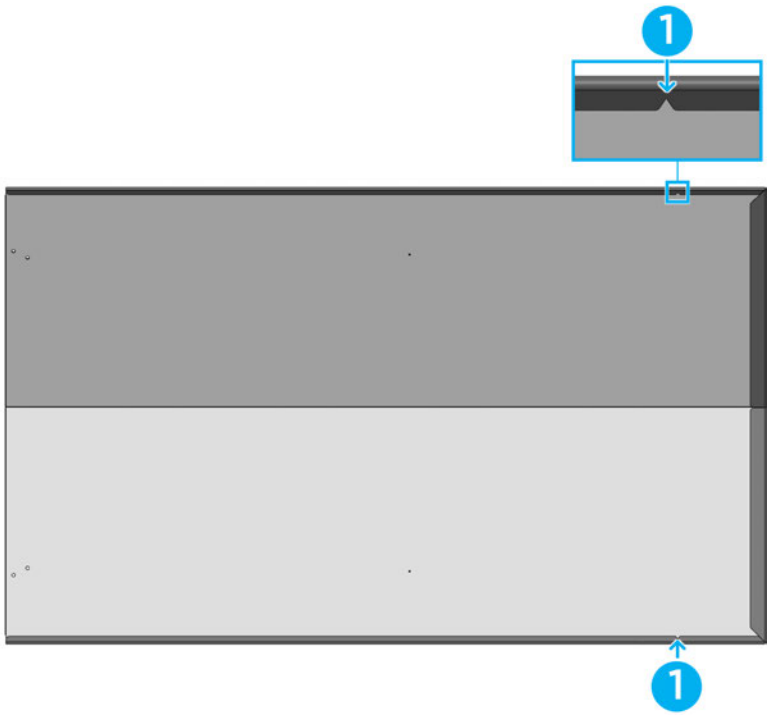


Cap

Caps are used to cover hips and hip-related junctions.

Features:

1. Two carets on the cap underside hem that mark a 3 in offset from the cap front hook (this helps guide ridge end cap fabrication).

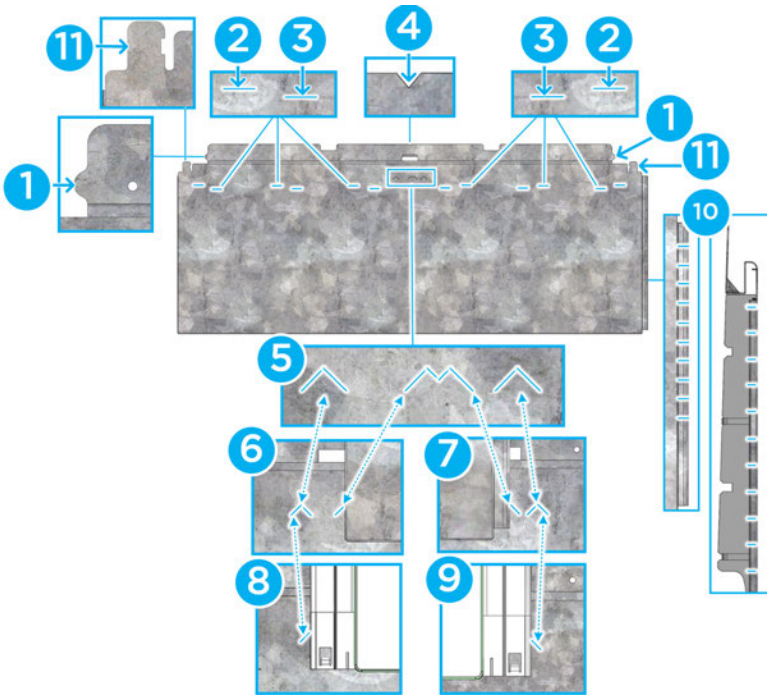


Metal Tile

Metal tiles are used to fill in the areas of the roof where PV tiles are not used.

Features:

1. Half-circle is tangent to the sidelap when installed next to PV or floating feet: the plastic edge should barely touch the metal edge.
2. Nominal reveal; next course goes up to this mark.
3. Maximum reveal; leading edge of next tile course goes up to this mark.
4. Marks exact center of the tile. Mostly useful for setting water channel vertical alignment in up-and-overs.
5. Caret marks to assist with tile alignment; see examples below. The footlap will cover half of the furthest footlap alignment carets and the water channel will cover the center of the metal tile water channel alignment caret.
6. Example of metal tile installation and alignment; left view. When metal tiles are in the correct position next to each other, one-and-a-half carets should be visible.
7. Example of metal tile installation and alignment; right view. When metal tiles are in the correct position next to each other, one-and-a-half carets should be visible.
8. Example of PV tile installation and alignment; left view. Only the left-most line should be visible.
9. Example of PV tile installation and alignment; right view. Only the right-most line should be visible.
10. Marks at 1 in increments. Used when *horizontal cuts and ripped tile courses are required on page 167*.
11. Alignment tabs that clip into the footlap engagement clips.



Cutting Standards

Overview

This section provides general guidance for cutting metal tiles.

Tools & Equipment

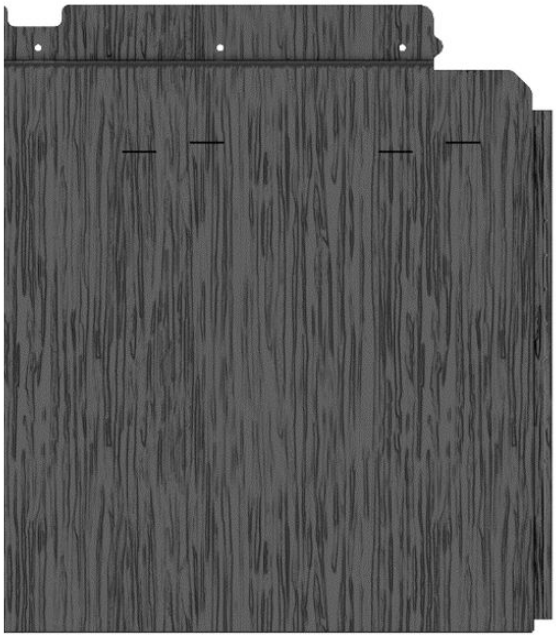
- Digital angle finder
- Measuring tape
- Cut station
- Channel flashing
- Bolt Cut Calculator
- Metal tiles
- PV tiles

Work Instruction

Understanding Left and Right

Factory Left: Keep the left side of the tile, cut away the right side. The right side will be hidden under the channel flashing.

Factory Right: Keep the right side of the tile, cut away the left side. The left side will be hidden under the channel flashing.



Measuring The Roof

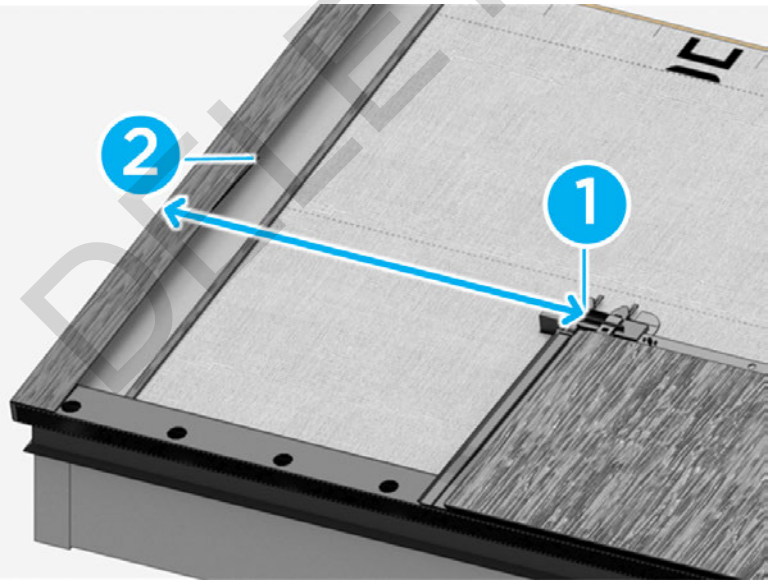
Attention: **Always measure the short edge of the cut tile.**

- The installer should be able to identify and measure the needed length and angle of each cut from the roof. An example of this call out would be **"Factory left or right + (Measurement in inches) + (MP Number) + (course number)"**
- The installer should know how to find the angles of the hip and valleys using the digital angle finder.

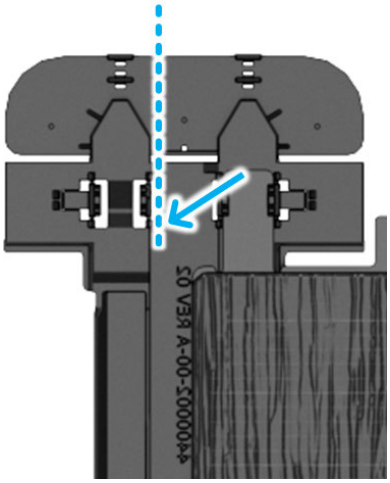
Measuring for Rake, Sidewall, or Other Channel Flashings

Measure from the top of the water channel **(1)** to the inside of the channel flashing **(2)** minus 1 in.

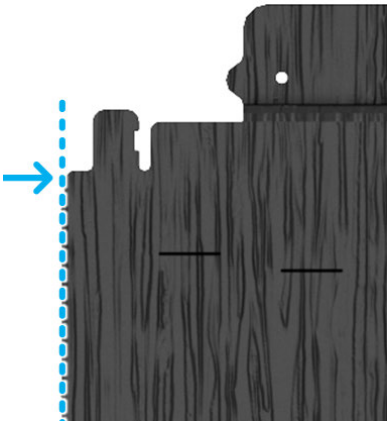
NOTE: Do NOT subtract an inch on the first course. Not subtracting the inch will close the gap between the top edge of the Riser and the Channel Flashing.



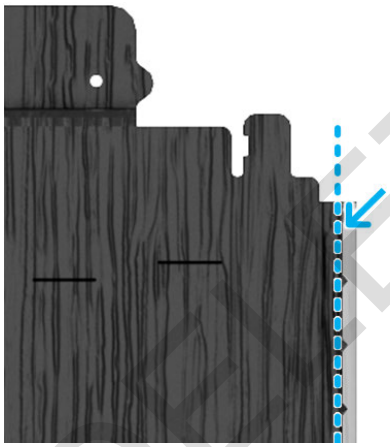
Measuring Point for PV



Measuring Point for Metal Left

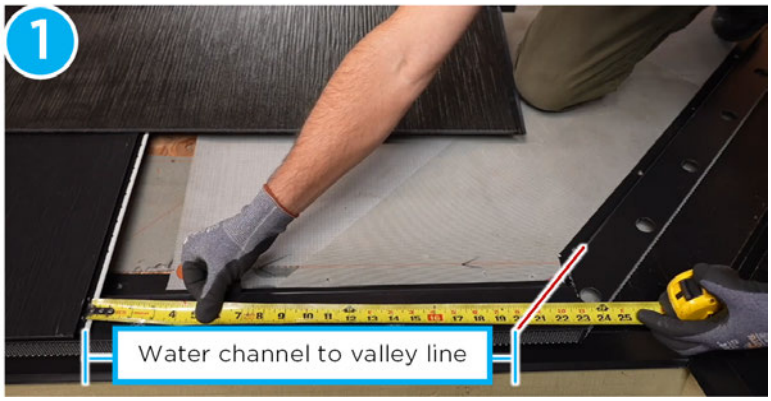


Measuring Point for Metal Right



Measuring for Valleys

Measure from the bottom water channel to the angle of the valley line and subtract 1 in from that measurement **(1)**.

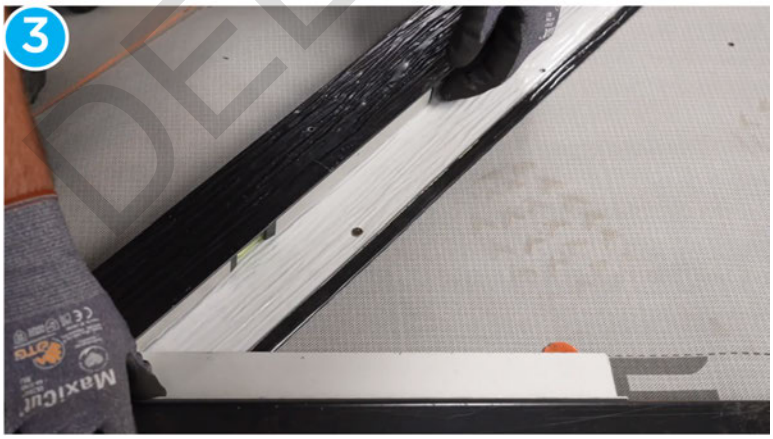


The angle is found by putting the digital angle finder in between the channel flashing and the vented riser.

Measuring for Hips

Measure from the top water channel **(1)** to the angle of the hip line **(2)** and subtract one inch from that measurement.

The angle is found by putting the digital angle finder in between the inside of the channel flashing and the vented riser **(3)**.



Measuring for Cuts for Anchors

When cutting around an anchor, measure a full tile length from the last tile, then determine where the anchor lands between this measurement. The measurement will be called down to the cut station as a factory left and right partial, leaving a void where the anchor will be placed.

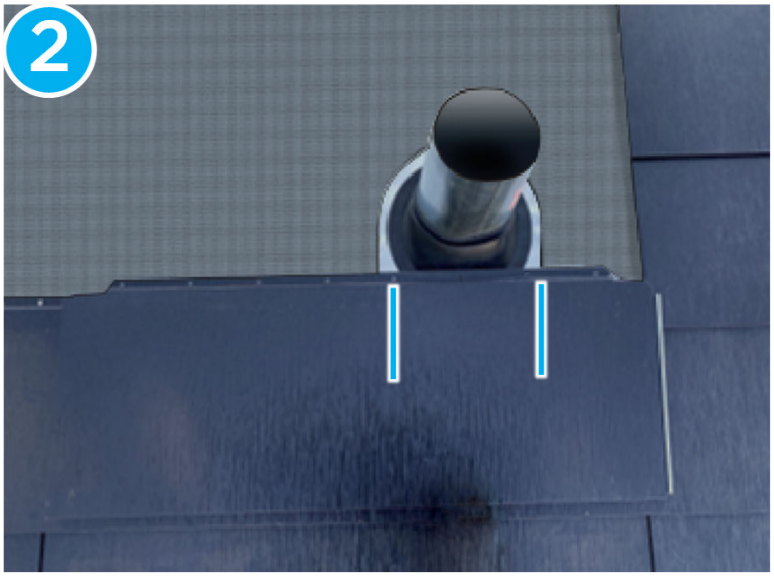
The two partials will then be sent to the roof where it's installed around the anchor and when finished a tile skin over the cuts and anchor with fasteners at the top.

Pictured: Tile skin

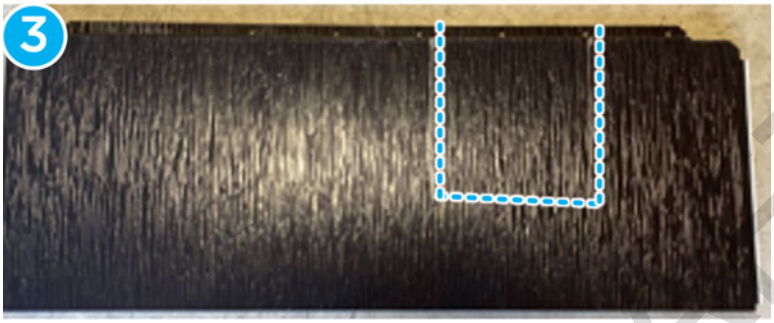
Measuring for Cuts at Round Obstructions

When cutting around round obstructions take a full metal tile and drop it onto the tile course below. Align the tile with the stagger marks then mark on both sides of the round obstruction **(1)**.

Determine how deep the cuts need to be and transfer the depth onto the tile where previously marked and connect the two lines **(2)**.



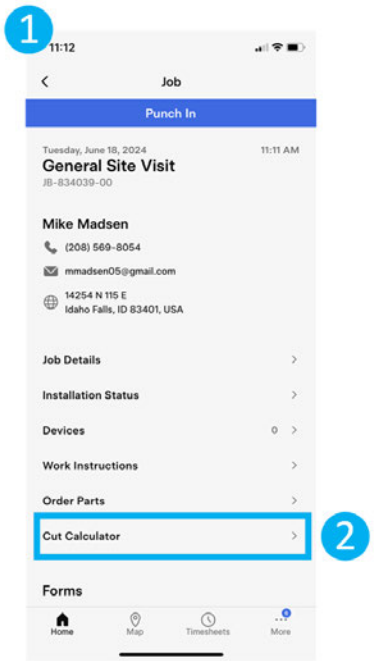
The tile can then be sent down to the cut station where it will be notched out and sent back up to the installer **(3)**.



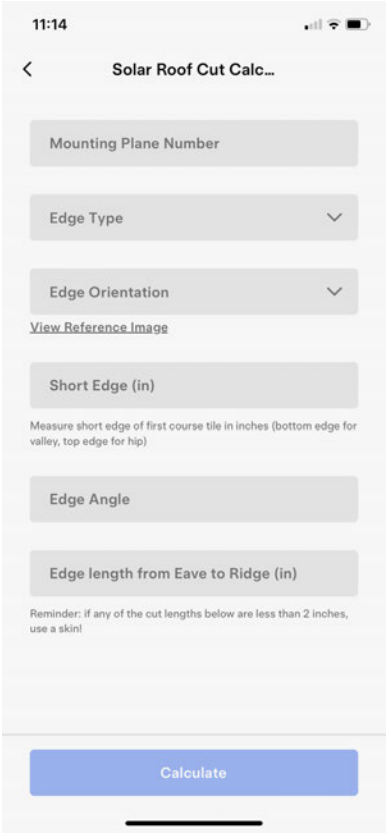
Using the Cut Calculator in Tesla One

The Tesla One cut calculator provides the cut lengths for an entire edge so that the installer on the roof does not need to measure each course.

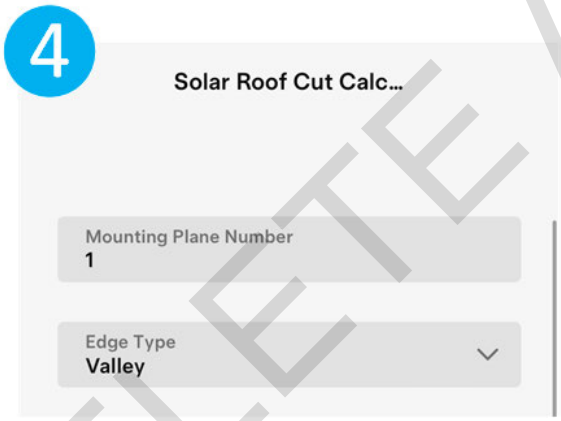
1. The cut calculator can be found in the forms section of the Tesla One app **(1)**. Select "Cut Calculator" **(2)** at the bottom of the page.



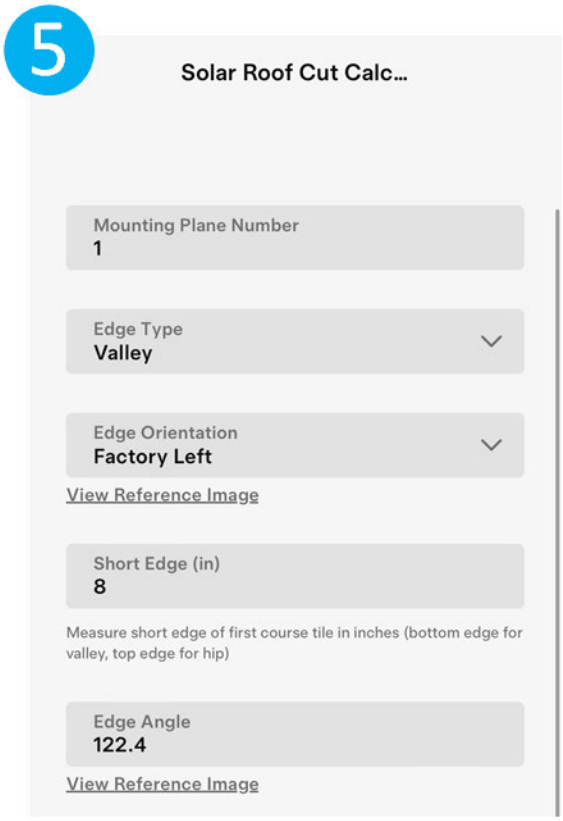
2. On the next screen, select "Solar Roof Calculators" **(3)**.



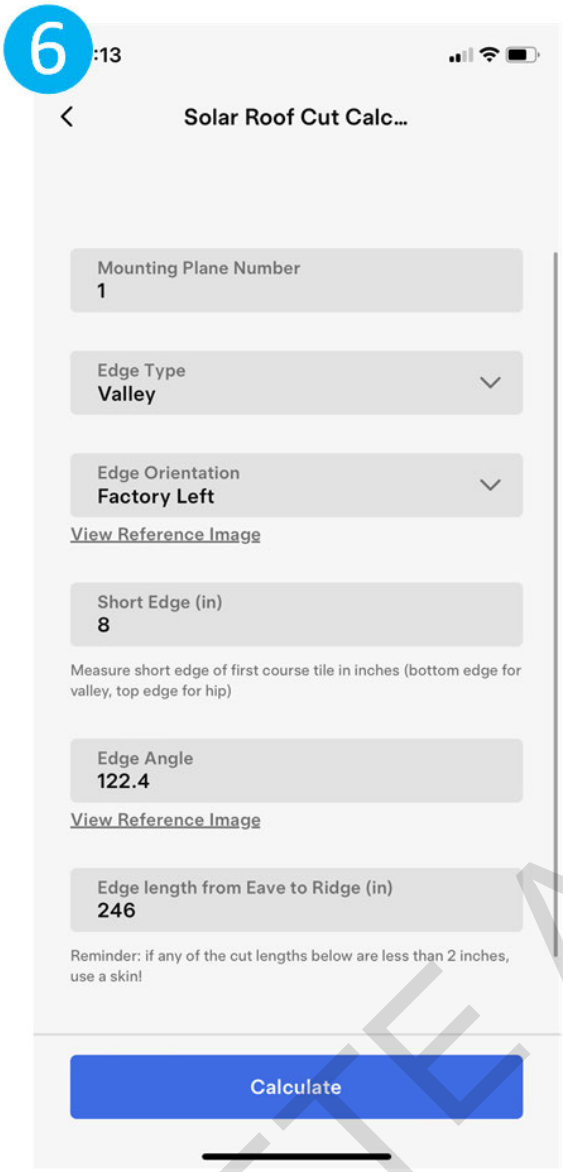
3. Once the form is accessed, start by inputting the feature you are working on **(4)**.



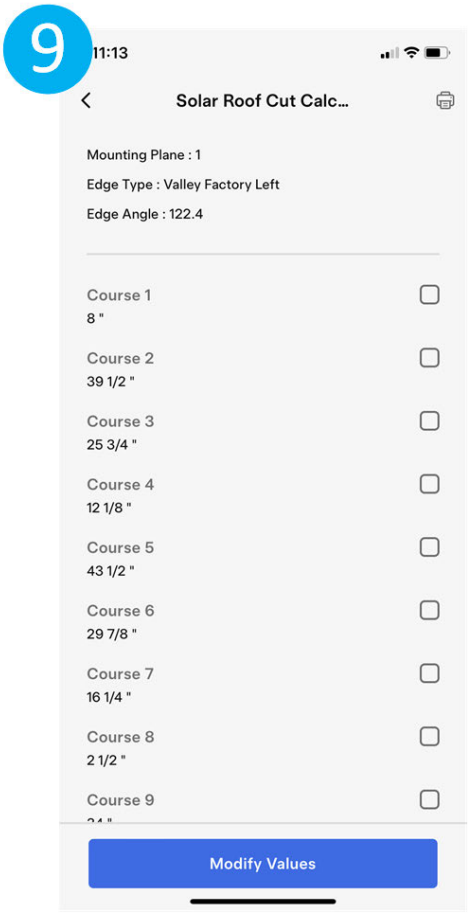
4. Input the edge angle, this will be the angle taken from the angle finder **(5)**.

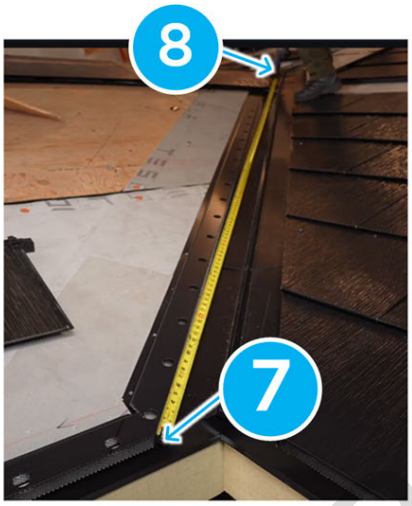


5. Enter the length of the edge, in this case, the bottom edge since it is a valley **(6)**.



6. Next, you will measure the length of the feature. In this case the bottom **(7)** of the valley to the top **(8)** of the valley termination. The cut information will be present on the next page **(9)**.

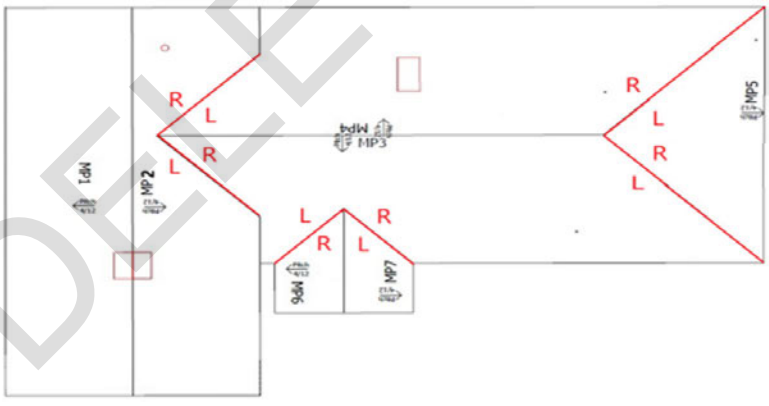




The Cutting Station

- The cutter should have a plan set where they will write down all the angles for each feature. This will allow them to accurately determine how many courses each cut will need.

> **NOTE:** L and R represent factory left and factory right.



- The cutting station will also manage the larger scrap pieces in case they might be used for another feature such as a hip or valley.
- Sort the cut pieces into factory left or factory right to make selection easier.
- The cutting station will write the callout on the top of the tile before sending it to the roof.
    - Cut Callouts:

- MP # Course #

Field-Made MC4 Quick Guide

Overview

This section outlines best practices for creating MC4 connections in the field when needed. *Click here to access the full training module for this procedure*.

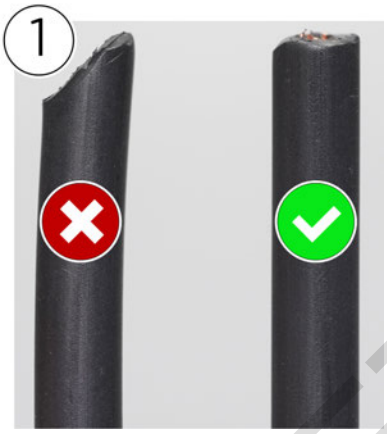
Tools & Equipment

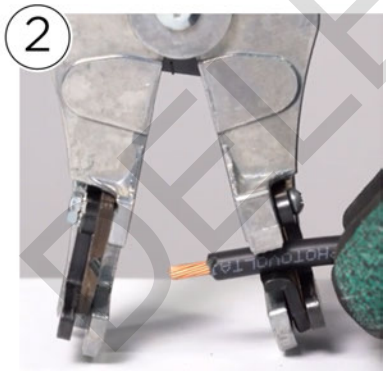
- MC4 connector tool
- Crimping tool
- Torque tool
- Cut-resistant gloves

Pictured:

Work Instruction

Cut wires at a perpendicular angle **(1)**. Strip wires within the manufacturer's provided tolerance **(2)**.





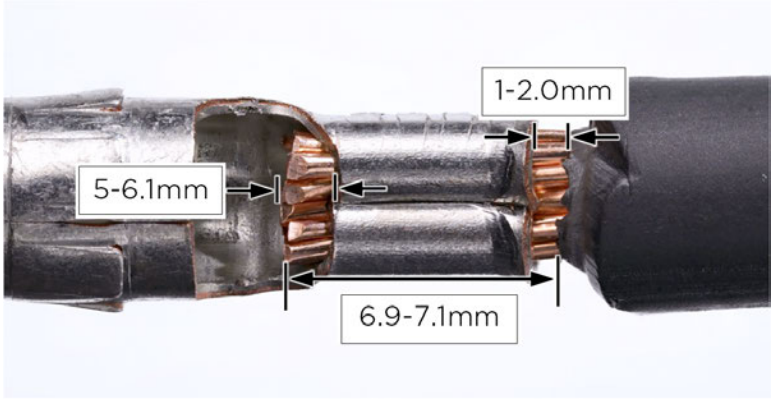
Use the MC4 connector tool to check a wire's strip length **(3)**.

Crimp the correct pin or socket in accordance with the crimping tool manufacturer's instructions **(4)**.

Pictured: Female Housing **(4a)**, Male Housing **(4b)**, Female Socket Terminal **(4c)**, Male Pin Terminal **(4d)**.

Pictured: Example of a correct crimp. Dimensions are in accordance with example manufacturer guidelines:

- Brush: 5-1.5 mm
- Gap: 1 - 2.0 mm
- Strip length: 6.9 - 7.1 mm



Insert the correct pin or socket into the housing **(5)**.

Tighten the backing nut with a torque tool **(6).**

- If the ambient temperature is **below** 75° F, set the torque tool to 3.5 Nm.
- If the ambient temperature is **above** 75° F, set the torque tool to 3.25 Nm.

- Twist using the torque tool, not the MC4 tool **(6a)**.

- Always verify that the backing nut is not cross-threaded or bottomed out **(6b)**.

Suggested Tape Measure Markings

1. In **BLACK**, mark every 14 in for the reveal.
2. In **SILVER**, mark every 22 9/16 in for half tiles plus water channel.
3. In **GOLD**, mark every 45 1/8 in for a full tile plus water channel.

By Color

In BLACK	In SILVER	In GOLD
14 in	22 ½ in	45 1/8 in
28 in	67 5/8 in	90 ¼ in
42 in	112 3/8 in	135 3/8 in
56 in	158 7/8 in	180 ½ in
70 in	203	225 5/8 in
84 in	248 1/8 in	270 ¾ in
98 in	293 ¼ in	
112 in		
126 in		
140 in		
154 in		
168 in		
182 in		
196 in		
210 in		
224 in		
238 in		
252 in		
266 in		
280 in		
294 in		

By Order

Order	Color
14 in	BLACK
22 9/16 in	SILVER
28 in	BLACK
42 in	BLACK
45 1/8 in	GOLD
56 in	BLACK
67 5/8 in	SILVER
70 in	BLACK
84 in	BLACK
90 ¼ in	GOLD
98 in	BLACK
112 in	BLACK
112 3/8 in	SILVER
126 in	BLACK
135 3/8 in	GOLD
140 in	BLACK
154 in	BLACK
158 7/8 in	SILVER
168 in	BLACK
180 ½ in	GOLD
182 in	BLACK
196 in	BLACK
203	SILVER
210 in	BLACK
224 in	BLACK
225 5/8 in	GOLD
238 in	BLACK
248 1/8 in	SILVER
252 in	BLACK
266 in	BLACK
270 ¾ in	GOLD
280 in	BLACK
293 ¼ in	SILVER
294 in	BLACK

Video Library

Cut Station Setup

Cut Station Safety

Cut Station Operation

Robin Jig Use Cases

How to Use the Cut Calculator

How to Pull Measurements for Cut Tiles

Valley Pan Install

Valley-Valley-Ridge

Tool Catalog

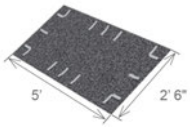
Required Tools

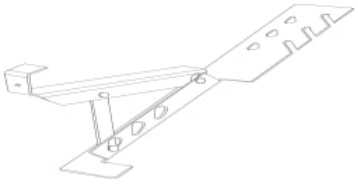
Purchased from Tesla or Tesla Distributor - SRS
Robin Jig **Part number:** 1900190-00-X   

Off the Shelf Tools		
Impact driver with square and Phillips bits Recommend Milwaukee 48-32-4472 square bits for best performance with Solar Roof fasteners  	**7 ¼ in circular saw with steel and wood saw blades** Recommend Diablo D0770F or D0748F blades for best performance on Tesla steel tiles.  	**10 ft brake with slide cutter and angle guides**   
3 in seamer	**Left- and right-handed metal snips**	**Caulking gun**

Off the Shelf Tools		
		
Chalk line 	**Battery or pneumatic roofing nailer** 	**Klein ET600 multimeter and insulation resistance tester** 
MC4 EVO-2 unlocking tool Recommend Staubli tool 32.6066: PV-MS-MC4-EVO 	**PPE for fall protection and cut protection**     	

Recommended Tools

Purchased from Tesla or Tesla Distributor - SRS		
Tile Trimmer **Part number:** 1947389-00-X 	**Roof Staging Racks and Straps** **Part number for Racks:** 1555870-00-E **Part number for Straps:** 1874559-01-X  	**Hammerhead Hooks** **Part number:** 1874380-00-X 
Traction Mats with Webbing **Part number for Mats:** 1606891-00-X **Part number for Webbing:** 1607148-00-X  	**Glass Adapter Hook for Traction Mats** **Part number:** 1606892-00-X 	**Anchors and Carabiners for Traction Mats** **Carabiner Part number:** 1606894-00-X  **Anchor Part number:** 1607147-00-X 
Roof Bracket/Jack Adapter **Part number:** 1738051-00-X		

Purchased from Tesla or Tesla Distributor - SRS	
	

Off the Shelf Tools		
Hammer drill with 1 3/8 in paddle bit  	**Angle grinder with tuck point and stone blades**   	**2 in hand roller** 
Powered handheld metal shears 	**Oscillating multitool** 	**Leaf blower** 
Digital angle finder 		

DOCUMENT REVISION HISTORY

NOTE: The table below does not include the latest changes. See the second page of this document for the latest changes.

Date	Changes
05/28/2025	Updated part number in *Part Catalog on page 74*.

12/12/2024	• Added new tool work instructions: *Roof Jack Adapter on page 661*.
	• Updated the following PNs from 00 to 01 in *Part Catalog on page 74*:
	  ◦ Left Adjustable Trim Cover: 1880185-01-X
	  ◦ Metal Tile: 1833222-01-X
	  ◦ Right Adjustable Trim Cover: 1879857-01-X
	  ◦ Tile Skin: 1847636-01-X

11/22/2024	• Moved *Wildlife Urban Interface on page 696* under section: *Los Angeles County on page 690* and added new work instructions under it: *Adding Mesh at Ridge Before Riser on page 696*. • Updated the *Part Catalog on page 74* by changing all the parts' pedigree (last letter) to letter X. Updated MCI-2 PN from 1879359-00-X to 1879359-15-X.
11/15/2024	• Added 2 new work instructions: *Prepping the Siding for Solar Roof on page 105* and *Skillion Roof on page 428*. • Removed Measuring Planarity. • Updated *Part Catalog on page 74* by removing dimensions/weights and updating the PN for 1x Jumper, Pre-Sleeved from 1705337-41-A to 1705337-41-B. (The same for 3x Jumper and 5x Jumper)
11/7/2024	• Updated *Tool Catalog on page 734* the with a new recommended tool: Roof Bracket Adapter (PN: 1738051-00-A) • Added new section: *Heat Tape Application in High Snow Regions on page 684*.
10/31/2024	• Published new work instructions: *Flat Roof Tie-Ins on page 458*. • Updated the *Part Catalog on page 74* with new tile level flashing (PN: 1856360-11-E). • Added new section: *Troubleshooting MCI and PV String Issues on page 678*.
10/28/2024	Published new work instructions: Measuring Planarity.
9/5/2024	• Published 2 new work instructions: *Circular Vents on page 289* and *Stepped Eave on page 446*. • Updated the *Part Catalog on page 74* with new flashing part: Black Coil Flashing. • Updated the *Tool Catalog on page 734* by moving 4 recommended tools from JTC to the Tesla distributor: Traction Mats with Webbing, Glass Adapter Hook for Traction Mats and Carabiner and Anchor for Traction Mats.
8/21/2024	Updated *Ridges on page 242* with new section: "Ridge Splice".

DOCUMENT REVISION HISTORY

Date	Changes
8/7/2024	Added new work instructions: *Eave-Sidewall with Diverter on page 324*.
7/31/2024	Updated *Assisted Access Point on page 573* by adding instructions for using the Assisted Access Point.
7/24/2024	Updated *Part Catalog on page 74* by adding weight and dimensions to the parts.
7/9/2024	Added new procedure: *Rake to Endwall on page 373*.
7/2/2024	• Updated *Mid-Circuit Interrupter (MCI) Specifications on page 672* with MCI-2 specifications. • Updated *On Roof Electrical Wiring on page 196*: Wiring Summary with MCI-1 and MCI-2 suggested location tables. • Added new section: *Skinning Metal Tiles on page 169*. • Updated *Bracket Fastening on page 589* with new instructions and images. • Updated *Angled Wall on page 540* with instructions for Angled Wall, Angled Wall - Eave to Angled Wall, and Angled Wall - Angled Wall to Sidewall.
6/26/2024	Updated and renamed *Non-Ridge Vents on page 383*.
6/20/2024	• Added new topic: *Site Survey on page 83*. • Updated the *Tool Catalog on page 734* with new images and general format. • Updated the *Ventilation on page 95* and the *Drain Waste Vent (DWV) on page 271* sections with complete information. • Updated *Cutting Standards on page 716* by replacing Bolt screenshots with Tesla One screenshots.
6/14/2024	Initial Release.