



SOLAR ROOF

DESIGN AND CONSTRUCTION GUIDE

Tesla Solar Roof is a beautiful and durable roof that generates clean energy. Tesla's power producing photovoltaic (PV) roofing Tiles are visually indistinguishable from the non-power producing metal or glass roofing Tiles, enabling homeowners the ability to harvest solar energy without aesthetic compromise.

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DISCLAIMER

The New Home Design and Construction Guide is published by Tesla for informational purposes. The intended audiences for this guide are targeted towards architects, building designers and construction professionals.

Tesla provides the information in this Guide without any guarantees or warranties of any kind, express or implied. This document is intended to assist in the efforts with building a home that is compatible with the Solar Roof product, but specifically disclaims any representations as to how the guidelines will apply to a particular product. Following these guidelines does not guarantee that Tesla will install Solar Roof at the home. The home's contractor or homebuilder are always solely responsible for compliance with local laws and building codes.

Contact Tesla any time by reaching out to a Tesla representative, or by visiting www.tesla.com/teslaaccount.

Amendments

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 components, their specifications, or this manual without prior notice.

This manual applies to Solar Roof PV Modules, Roofing Tiles, flashing systems, and related deck and/or wall sheathing preparations, and electrical wiring elements manufactured by Tesla. It is explicitly written for qualified professionals ("Installer" or "Installers"), including without limitation licensed electricians and NABCEP-Certified PV Installers.

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EnergyTechPubs@tesla.com

Tesla, Inc
3500 Deer Creek Road
Palo Alto, CA 94304 U.S.A.

Forward

The New Home Design and Construction Guide presents best-practice recommendations for installing Solar Roof on New Home applications. Tesla acknowledges that roofing and building design varies for a specific project, depending on geographical location and micro-climactic conditions. Thus, this Guide does not claim to encompass all practices, designs or applications. The outlined information should not replace professional expertise.

Ongoing technological innovation and product development for the Solar Roof system continues within Tesla. Solar Roof design, materials and installation methods may be updated periodically. Always check partners.tesla.com/home/ for the latest versions of product literature.

Users of this guide should be familiar with all local codes and requirements.

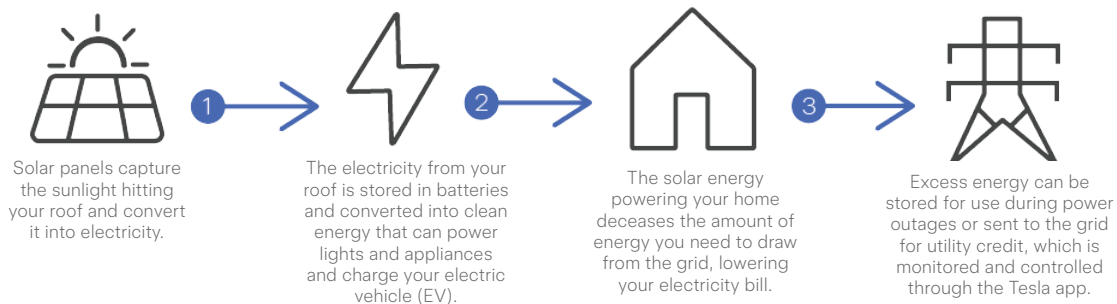
INTRODUCTION

Solar Roof is a building-integrated photovoltaic (BIPV) system that incorporates photovoltaic (PV) tiles as roof coverings to generate on-site electricity for the building.

Solar Roof utilizes visually indistinguishable power producing and non-power producing tiles across the entire roof. Power producing PV Tiles made from glass and fiber-reinforced engineered polymers are installed in areas with direct sunlight. Non-power producing tiles are made from architectural grade, coated galvalume steel or tempered glass and are installed where energy generation is not ideal. Metal roofing Tiles are installed in areas where tiles need to be cut or attachment of obstruction flashing is required.

The New Home Design and Construction Guide is intended to provide a technical overview and industry best practices concerning design, installation and maintenance of the Solar Roof system. This Guide is best used in conjunction with the [Solar Roof Installation Manual](#) and [Solar Roof Installation Basics video](#).

How Does Solar Work?

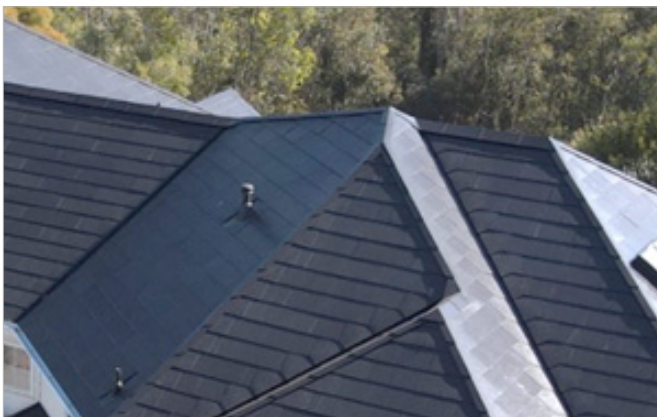


Solar Roof vs Traditional Solar Panels

A Solar Roof functions fundamentally the same way as traditional roof-mounted photovoltaic (PV) systems. PV Tiles convert sunlight into direct current (DC) electricity and groups of PV Tiles form strings that are connected in series or parallel. These strings are connected to an inverter that converts the power to alternating current (AC).

Solar Roof Tiles are a mix of PV and Metal Roofing Tiles that are designed to aesthetically match, enabling homeowners the ability to harvest solar energy without aesthetic compromise. For communities with Homeowner Associations (HOAs) that restrict solar panel installations to preserve community aesthetics, Solar Roof is an excellent alternative. Due to the high efficiency and smaller size of the PV Tiles, Solar Roof can harvest more energy than a traditional solar panel system, especially on complex roof geometries.

Solar Roof



Traditional Solar Panels



Benefits of Solar Roof



Aesthetics

An integrated solar and roofing system that complements the home's natural styling with power producing and non-power producing Tiles blending seamlessly.

Durability

Integrated solar and roofing system made from tempered glass, galvalume steel and engineered polymers designed for extreme toughness and longevity.

Sustainability

Power homes with a renewable energy source. Using solar power reduces the home's carbon footprint being emitted into the environment.

Energy Independence

Homeowners are protected from rising energy costs and grid power outages. Excess power can be stored in the Powerwall and/or exported to the grid for energy credits usable at a later time.

Solar Roof Power Generation

The Solar Roof PV Tile produces 72-watts (W) at standard testing conditions (STC), which is a temperature of 77° F (25° C), irradiance of 1,000-W/m² and an air mass of 1.5. The power output changes as these three factors change.

Solar Roof PV Tiles have a coverage area of 4.39 sqft. This makes the power density 16.4-W/sqft. This is the highest for any integrated PV product and close to traditional modules that have a coverage rate of 21.3 sqft at 400-W or 18.8-W/sqft.

However, due to the smaller size of the PV Tiles, the Solar Roof system can pack more Tiles per roofing plane, allowing for greater system sizes than traditional panels without the aesthetic compromise.

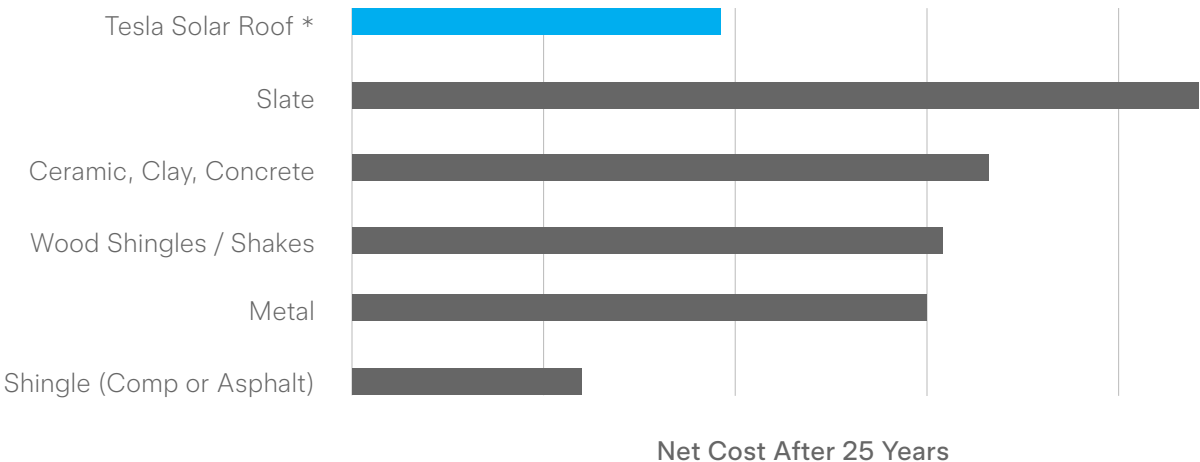
Installed Cost Comparisons

Tesla Solar Roof is an excellent alternative for anyone considering a luxury roof such as clay, slate or metal. Those roofing systems do not provide a return on the upfront investment as they do not offset home energy usage.

After 25 years of energy savings, the cost of Solar Roof is comparable to asphalt compositional shingled roof. Tesla provides a 25 year power performance guarantee and the system is expected to continue to provide clean, sustainable energy for even longer, which can eventually pay for itself completely.

Visit tesla.com/support/incentives for a comprehensive overview of tax and utility incentives for more information.

Roofing Cost Comparison



*After federal and state incentives and the value of 25 years of energy independence.

Insurance Premium

Many factors may affect the price of a home insurance premium. Solar Roof is a Class A fire and Class 4 hail rated roof assembly and may be eligible for a discounted home insurance rate depending on the specifics on an insurance policy. Consult individual insurance companies for information on how Solar Roof can impact your home insurance premium.

SOLAR ROOF DESCRIPTION

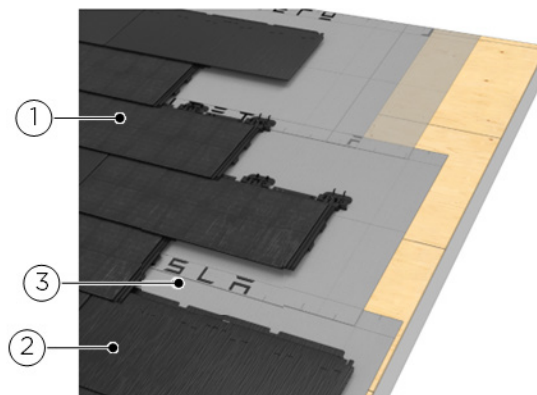
General

Solar Roof is available in a tree bark textured black pattern. The system is comprised of power producing photovoltaic (PV) Tiles and non-power producing Tiles made from metal or glass. The Tiles are installed directly to the roof deck, half-staggered and positively lapped over one another to shed water from rain or snow.

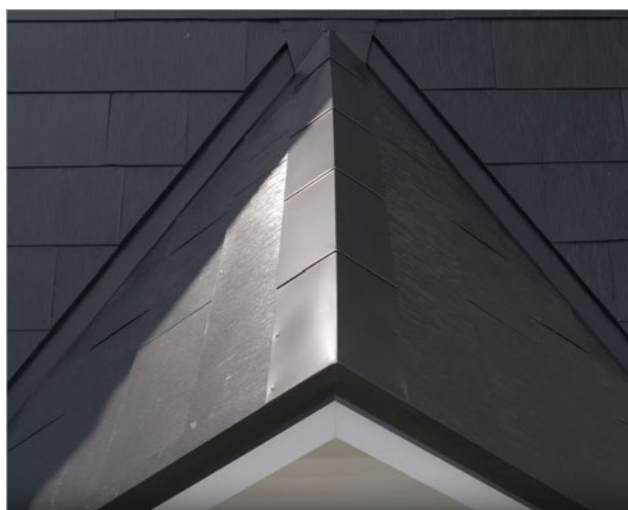
Metal Flashings such as drip edge, eave riser, channel flashing, valley pans, wall flashing and caps are used throughout the system to protect the home from weather infiltration.

A typical Solar Roof system includes the following:

(1) PV Tiles; (2) Metal Tiles; (3) Underlayment.

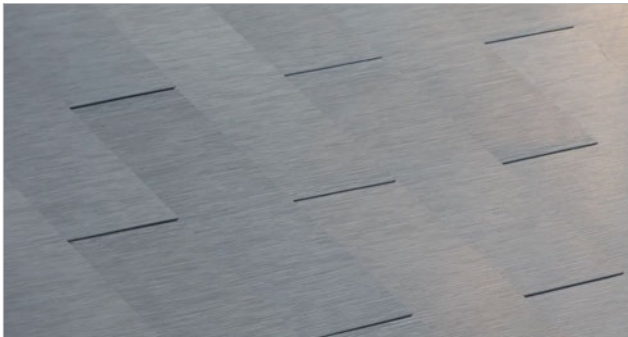


Completed Installation Examples



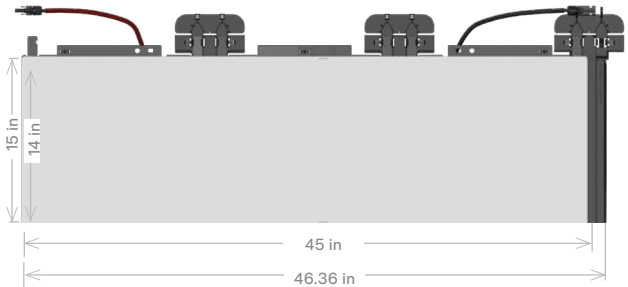
Solar Roof Tiles

PV Tiles

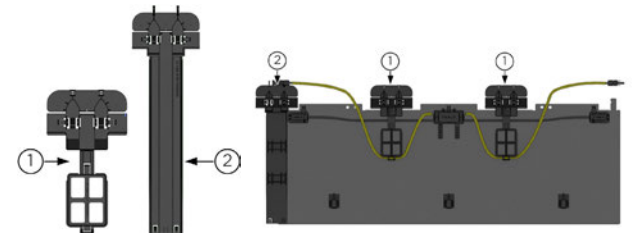


PV Tiles are photovoltaic modules designed to be both a roof covering and a solar panel, seamlessly producing energy from sunlight. Each Tile is made of several high-efficiency solar cells with a maximum total power of 72 W, and manufactured in Tesla's Buffalo, New York Gigafactory. Unlike conventional solar panels, which have solar cells electrically connected with copper ribbons, Tesla utilizes cascaded solar cells to eliminate gaps between cells, increase energy harvesting and improve mechanical performance and reliability. Without the visual circuitry, each Tile has a clean, uniform look.

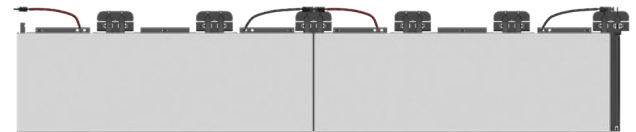
Tile Reveal	Fixed: 14-in
Tile Coverage	4.39-sqft per Tile
Height from Deck	1.375-in
Principal Materials	Glass, Polymers, Fiberglass and Silicon
System Weight	3.31-psf
Operational Temperature	-40 °C up to 85 °C



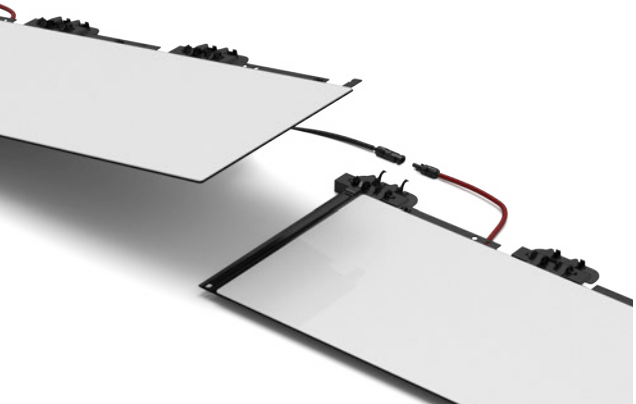
PV Tiles come pre-assembled with two types of mounting hardware: (1) foot and (2) footlap. A footlap is shared between PV Tiles. Therefore, only one side will come with a footlap pre-assembled. The Tile will have an alignment tab that snaps into the mounting hardware to ensure proper placement. The installer will have a visual and audible confirmation that the Tile is properly aligned with the adjacent Tile.



The mounting hardware is designed to raise the Tiles off the deck to provide a gap for wire management and ventilation. The ventilation between the Tiles and roof surface keeps the PV Tiles operating most efficiently and reduces thermal transfer into the home. The mounting hardware allows for removal and replacement of PV Tiles without having to disrupt the fasteners. This reduces the risk of creating leaks on the roof when having to service a PV Tile.



Alignment between two PV Tiles, top view.



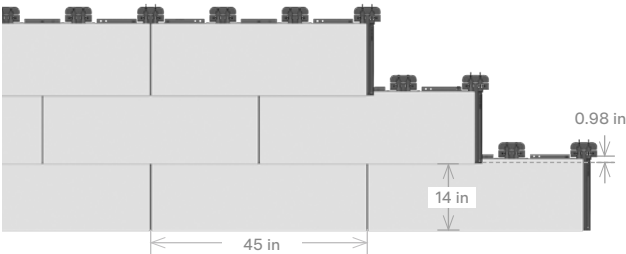
Alignment between two PV Tiles, side view.

PV Tiles are designed with built-in engagement hooks to interlock upper and lower courses together.



Engaged PV Tile hooks, side view.

PV Tiles are installed in a half staggered pattern starting from the roof eave to the ridge.



Metal Tiles

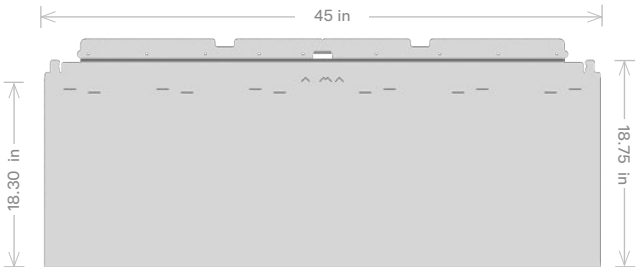


Metal Tiles are used in non-power producing areas of the roof and are made from textured galvalume steel with a black PVDF coated surface to appear identical to the PV Tiles. Metal Tiles can be installed below, above and adjacent to PV Tiles. They can be cut to size and shape to finish edge conditions. Obstruction flashings can be fastened directly to the metal surface using gasketed, color matched metal-to-metal self-tapping screws. Each Tile includes timing marks to indicate proper Tile stagger and overlapping.

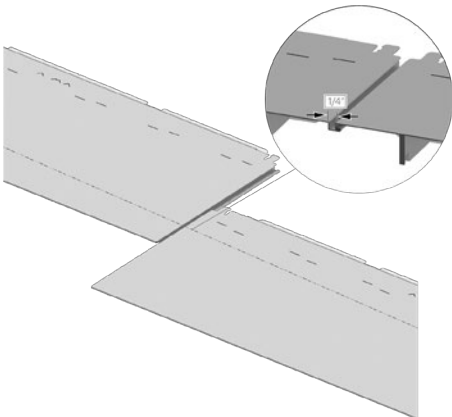
Metal Tiles feature open hems along the water channel that allow adjacent Metal Tiles to lock into each other. This interlocking is important for wind

uplift performance and keeps the Metal Tile surfaces aligned. The gap between Metal Tiles when properly engaged is 1/4-inch.

Tile Reveal	Adjustable: 13.75-in to 14.25-in
Tile Coverage	4.39 sqft per Tile
Height from Deck	1.375-in
Material	PVDF Coated 24 Gauge Galvalume
System Weight	2.15-psf
Finish	
Light Reflectance Value, LRV	0.228
Emissivity	0.82
Solar Reflectance Index SRI	19
60° Gloss	30

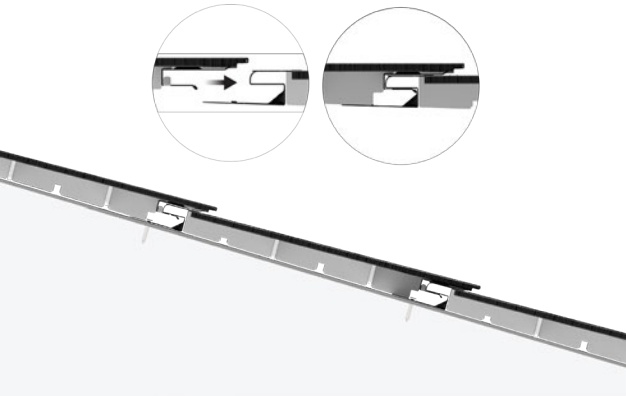


Interlocking between two Metal Tiles, top view.



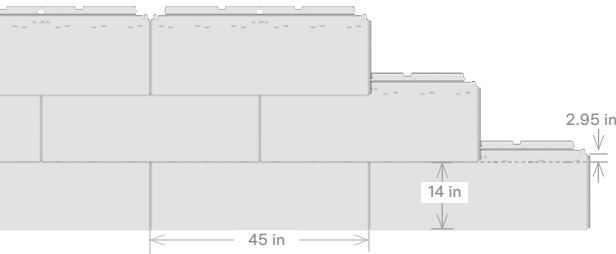
Interlocking between two Metal Tiles, side view.

The top edge of the Metal Tiles are designed with a built-in engagement feature to interlock upper and lower courses together.



Engaged Metal Tile hooks, side view.

Similar to PV Tiles, Metal Tiles are installed in a half staggered pattern, starting from roof eave to ridge.



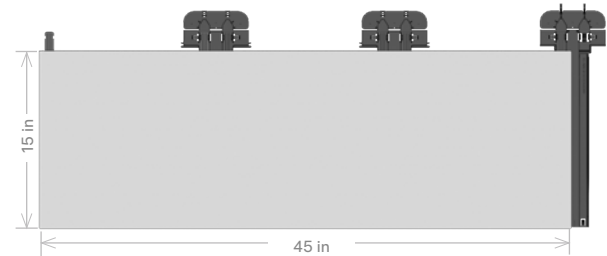
Glass Tiles



Glass Tiles are used in non-power producing areas of the roof typically in High Velocity Hurricane Zone (HVHZ) installations. These Tiles are made from tempered glass with a black silicone backer without any PV cells and textured to appear identical to PV Tiles. Glass Tiles buffer the array at all edge conditions and can be installed in place of,

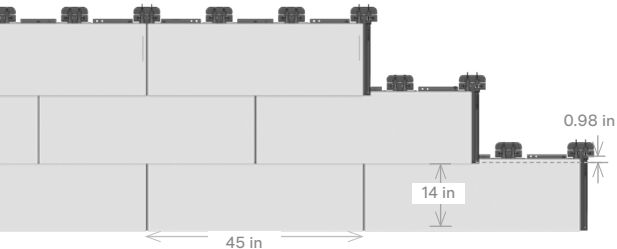
below, adjacent to or over PV Tiles. These Tiles can also be installed against metal trim and flashings.

Tile Reveal	Fixed: 14-in
Tile Coverage	4.39-sqft per Tile
Height from Deck	1.375-in
Material	Glass, Polymers and Silicone
System Weight	3.18-psf
Dimension	15-in x 45-in x 0.25-in



Identical to PV Tiles, Glass Tiles come pre-assembled with foot and footlap and features the same built-in engagement hooks to interlock upper and lower courses. Refer to PV Tiles section for more information.

Glass Tiles are installed in a half staggered pattern starting from roof eave to ridge. See below for a visual example of how Glass Tiles are laid out.



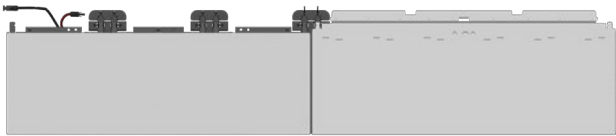
Tile Fastening

Mounting hardware and flashings are fastened directly to the roof sheathing with ring shanked nails or screws. The quality of the fastener's ring shank or thread is critical to uplift resistance. Only Tesla approved fasteners shall be used to fasten tiles or flashings. Fastening schedule for flashing components can be found in the Solar Roof Installation Manual.

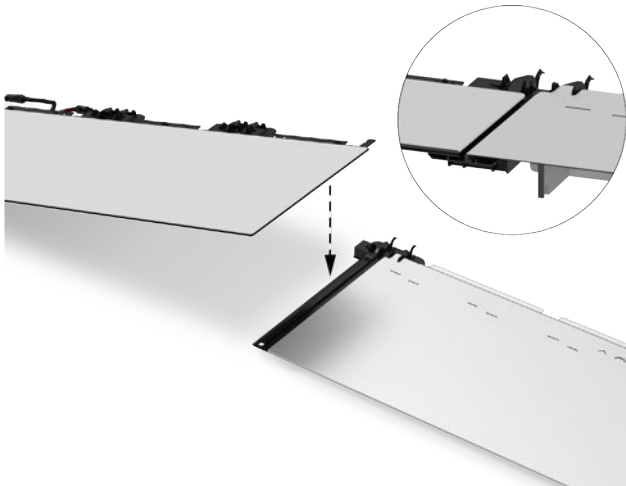
Tile Interchangeability

Solar Roof Tiles are designed with interlocking features that allow for interchangeable side joint connections between all Tile types.

Metal Tiles are locked into PV and Glass Tiles by engaging the Metal Tile engagement tab with the footlap. The distance between a Metal Tile and PV or Glass Tile is 1/4-inch.



Interlocking between a PV Tile and a Metal Tile, top view.



Interlocking between a PV Tile and a Metal Tile, side view.

Underlayment

Tesla Underlayment is a self-adhering, non-asphaltic engineered composite material. It waterproofs the roof surface during dry-in phase, seals around Tile and flashing fasteners and has a proprietary fire barrier core. This fire barrier core is required to obtain Class A fire resistance performance. The Underlayment is certified to resist ice dams and ponding water as defined in ASTM D1970. The entire roof, in all regions, is covered with the Tesla Underlayment. This provides a secondary line of defense against wind-driven rain and snow infiltration. Underlayment can also function as a temporary roof for up to 6 months of exposure.

Tesla Underlayment is a Class 1 vapor retarder, which is a requirement to achieve ASTM D1970 performance. Special attention must be considered when installing the Underlayment over unventilated roof assemblies. Unvented roof assemblies (warm roofs) have been notorious for creating moisture problems and the building code prescribes how these roof assemblies need to be designed to mitigate risk, IRC Section R806.5.

Tesla Underlayment is offered without the fire barrier core. Solar Roof installed without the fire barrier core can only obtain a Class C fire resistance rating. The type of Underlayment allowed to be used on a project is governed by building code and enforced by local authorities having jurisdiction (AHJS).



Tesla offers two types of Underlayment based on fire resistance classifications under ASTM E108, "Standard Test Methods for Fire Tests of Roof Coverings:"

- Class A – Roof coverings that are expected to be effective against severe fire exposure.
- Class C – Roof that are expected to be effective against light fire exposure.

Designers should consult local jurisdictions to ensure compliance with the applicable building code.

	Underlayment Dimensions		
	Class A		Class C
	SAUL - 1	SAUL - 3	SAUL - 2
	1613738-03-A	1947922-00-C	1751844-00-A
Thickness (w/ release film)	51 mils	55-mils	40-mils
Roll Weight (w/release film)	74 lbs	60-lbs	47-lbs
Roll Dimension	38" W x 68' L	35.5" W x 74' L	28" W x 107' L
Roll Coverage (gross)	215.33 sqft/roll	219 sqft/roll	338.83 sqft/roll
Roll Coverage (net-excluding 3-in overlap)	198.33 sqft/roll	200 sqft/roll	312.08 sqft/roll

Detail Roll

Detail Roll is a narrower version of the self-adhering, non-asphaltic composite material, identical to the Class C Tesla Underlayment. These are installed before the Tesla Underlayment along eaves and rakes to provide extra protection from wind-driven rain, ice dams and overflowing gutters that can cause premature failure of the fascia and roof sheathing. Detail Roll is also used to "strip-in" flashings along valley pans and wall flashings for added protection from water infiltration along these critical junctions.

Detail Roll Dimensions	
Thickness (w/ release film)	51-mils
Roll Weight (w/ release film)	23.67-lbs
Roll Dimension	12.67-in (W) x 68 ft (L)
Roll Coverage (gross)	71.78-sqft/roll
Roll Coverage (net - excluding 3-in overlap)	66.11 sqft/roll



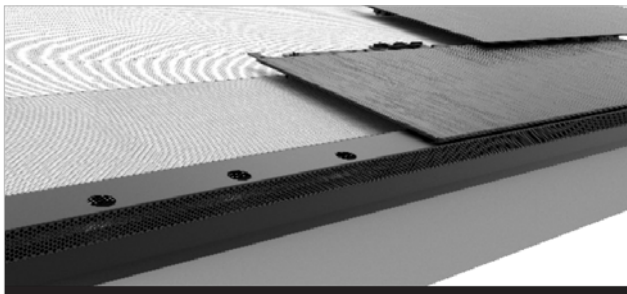
Roof and Flashing System

Eave and Rake

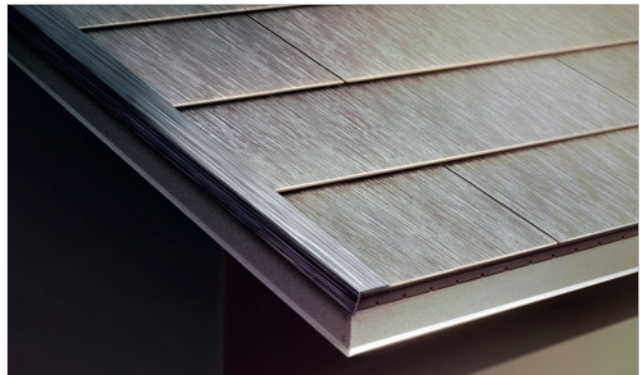
Drip Edge requirements are defined by building code, IRC Section R905.2.8.5. They are installed along eaves and rakes to divert rainwater away from the fascia boards. Before installing Drip Edge, Detail Roll shall be installed along the eaves and rakes and wrap the edge of the roof sheathing a minimum 1". This adds an extra layer of protection and is recommended by Insurance Institute for Business & Home Safety (IBHS) to meet Fortified Roof requirements. Underlayment is installed over the drip edge along the eaves and rakes.

Underlayment over the rake's **Drip Edge** is only acceptable when the Detail Roll is first installed under the rake **Drip Edge**. Check with your local AHJ for what is acceptable in your region.

Vented Risers are installed along eaves to elevate and engage the first row of tiles. They are perforated to ventilate the air space between the Tiles and deck surface. The perforations also allow any wind driven rain or snow melt that may get past the Tiles to drain out.



Channel Flashing is installed along the rakes. They are spliced and positively lapped to ensure any water infiltration will travel down and out through the Vented Riser along the eave. Metal Tiles along the rake are often cut to size and the Channel Flashing conceals those cut edges that tuck into the channel – this is called the cut and tuck method. The Channel Flashing is textured to match the aesthetic of the metal tiles.



Hip

Channel Flashing is installed along hips and provide drainage for any wind driven rain. In this assembly, the Channel Flashing is not exposed. They provide a continuous anchoring zone where the Caps are fastened into. Concealed fasteners secure the Caps to the Channel Flashing and the leading edge of the Caps are hemmed and interlock together to provide wind resistance.



Ridge

Ridge Roll is first installed over the ridge opening. This prevents wind driven rain and snow infiltration from entering the attic. This can serve as a temporary ventilated cap during dry-in to continue to ventilate the attic during installation.

If the Ridge is ventilated: **Vented Riser** is then installed on both sides of the ridge. These elevate the Caps and are perforated to provide the ridge assembly with an exhaust. The Vented Riser also serves as a continuous anchoring zone for the Caps. Concealed fasteners secure the Caps to the Vented Riser and the leading edge of the Caps are hemmed and interlock together to provide wind resistance. The Ridge Vent assembly provides 12.5 sq-inches per linear foot of net free ventilating area.



If the Ridge is not ventilated: No Vented Riser is required, and the caps can be fastened directly to the last row of Metal Tiles.



Valley

Valley Pans protect the convergence of two mounting planes. They include a center rib to divert rainwater down to the eave or washout, but also provide the pan with stiffness. They are fastened with nails and stripped-in with Detail Roll.

Vented Riser is installed alongside the Valley Pans to elevate and provide a fastening zone for the **Adjustable Trim** flashing. These trims are used to conceal the cut edge of the Metal Tiles running along the valley. Adjustable Trim flashings are fastened to the Vented Riser and Metal Tiles. The Adjustable Trim Flashing will satisfy most cases. For extreme angled valley ($>135^\circ$), **Tile Skins** will need to be cut and bent over the Vented Riser.

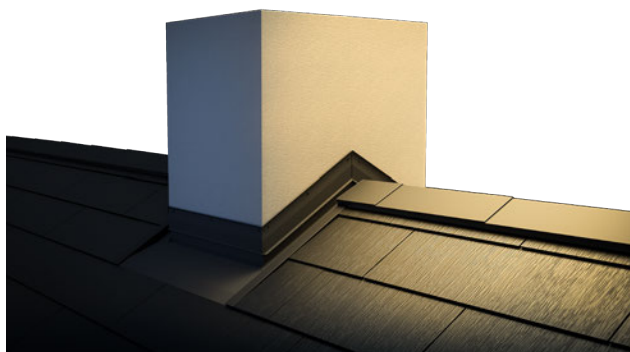


Flashings

Transition Flashing is used at all headwalls and anywhere a flashing detail requires a transition from deck to tile level. The prefabricated Transition Flashing can be used when the roof plane is greater than 3:12 (14°) slope, otherwise a transition will need to be fabricated from sheet metal. The transition from deck level is intended to simplify the integration of the Transition Flashing with existing cut siding or integrated counterflashing that may already exist. Instructions on how to properly splice, support, and fasten the Transition Flashing can be found in the Solar Roof Installation Manual.

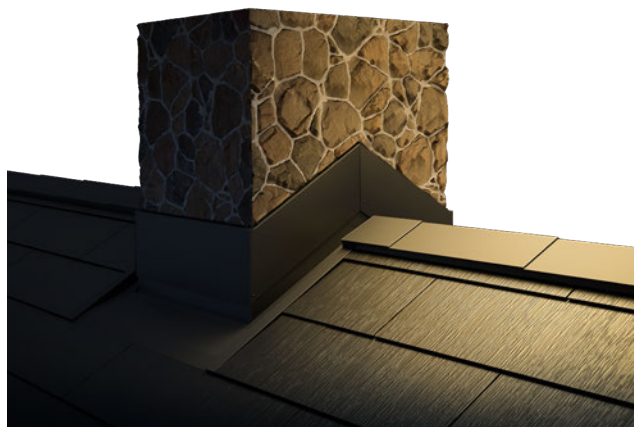
Wall Flashing is installed along sidewalls and endwalls that are less than 30" wide. The Wall Flashing is fastened against the roof with nails and stripped-in with Detail Roll. The flashing is tucked behind the wall cladding's building paper for proper waterproofing continuity. It can also be counterflashed with metal that has been properly integrated, e.g. Z Bar Flashing.

Surface Mount Counter Flashing is installed over Transition and Wall Flashings. It is used most often in retrofit stucco applications that do not have a properly integrated counter flashing or the homeowner does not want to invest in getting a Z-Bar Flashing integrated. To properly tuck the Transition and Wall Flashings, the stucco must be cut and broken to reveal the building paper. The Surface Mount Counter Flashing conceals this integration while also serving as a first line of defense from wind driven rain. Stucco absorbs water. If the Transition and Wall Flashing only butts against the surface of the stucco without a counter flashing, water will get behind the flashings and cause a leak. Fastening of the Surface Mount Counter Flashing is done with Hi-Lo Screws with Gaskets.



Reglet Flashing is used to counterflash Transition and Wall Flashing. It is designed for masonry (brick and stone) or other concrete type wall surfaces. Reglet Flashing is prefabricated with an open hem that is inserted and sealed in kerfs made in the brick or masonry wall. Reglet Flashing is fastened with black masonry Hi-Lo screws that include an EPDM gasket. Sealant is applied into the kerf to resist water from getting behind the Transition and Wall Flashing. It is critical to properly adhere the Tesla Underlayment along the base of the masonry detail before Transition and Wall Flashing are installed. Masonry chimneys are notorious for leaking if not properly maintained, e.g. missing or cracked chimney crowns and cracks in the mortar joints.

It is highly recommended to have chimneys inspected by a mason before installation of Solar Roof.



Flat stock is 26-gauge prefinished galvalume sheet used to create any field fabricated components required, such as cricket flashings or flashing extensions, and bridge between Solar Roof Tiles and perimeter flashings.

Drain Waste Vents (DWV) are flashed at deck and tile level. Both are made from galvalume and include a Santoprene rubber boot and have a pipe size range of 1-1/4" to 4". Only the tile level DWV flashing is textured and colored to match the aesthetic of the tiles. The deck level DWV Pipe Flashing is nailed to the deck and integrated with the Tesla Underlayment. The tile level flashing is fastened to the surrounding metal tile surface with color matched, gasketed self-tapping screws. The redundancy in rubber boots provide an extra level of durability and allows the dry-in phase to be completely waterproof.



Heat Vent detailing is similar to that of drain waste vents, except that the Tile level metal flashing used for heat vents is composed of metal and does not include an elastomeric collar. A Heat Vent Cap is also used to cover the heat vent.



Concentric Vents may be flashed with standard off-the-shelf metal pipe flashings with rain collars to provide weather protection at the penetration-to-roof interface. Flat Stock sheets can be used to integrate these vents with the Solar Roof system as needed.

Roof Vents

Roof vents are installed to provide exhaust and intake for attic ventilation. Solar Roof provides two options to accommodate ventilation needs: Ridge Vents and Tile Vents.

The Tesla **Tile Vent** is a discrete static vent that can be installed as exhaust or intake to assist in ventilation design. Each Tile Vent provides 40-sq-inches of net free ventilating area. The Tile Vent is made of a deck level and Tile level component. The deck level component includes an integral mesh to help mitigate the impact of harsh weather conditions, such as snow from entering the roof assembly. The mesh also prevents birds, insects and other small animals from entering the roof space. The Tile level component conceals the underlying waterproofing detailing and integrates with the rest of the Solar Roof Tile system.



Accessories

The **Assisted Access Point** is installed to allow roof access for any potential future serviceability of the Solar Roof system. The ideal access point placement is within 25-feet of the eave. Installed access points overhang slightly onto the surface of a Solar Roof Tile and blend in with the aesthetic appearance of the system.



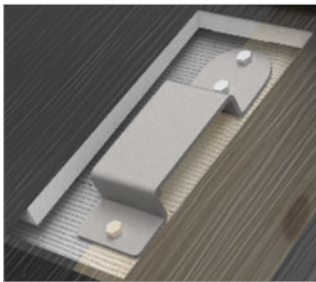
Sealant

The sealant for roof flashing joints and overlaps is a high performance elastomeric, moisture cure sealant specially formulated for optimum performance to accommodate joint movement.

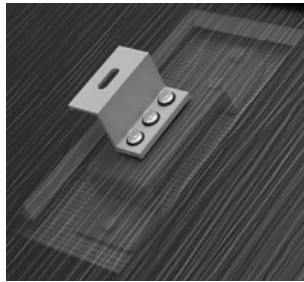
Accessory Brackets

The Tesla **Accessory Bracket Kit** is designed to accommodate installation of snow fences or any other roof-mounted attachment components.

The brackets are installed directly over the Tesla Underlayment at the deck level. Solar Roof Metal Tiles are then installed over the bracket to conceal the bracket. Subsequently, the roof accessory is installed onto the bracket by fastening through the Metal Tile.



Accessory Bracket



*Example Third
Party Part*

PERFORMANCE AND COMPLIANCE

As a building-integrated photovoltaic (BIPV) system, Solar Roof's performance is designed and evaluated as both a roof construction material and as a photovoltaic product.

The Solar Roof system was tested and has demonstrated compliance with all requirements for BIPV roof coverings for use as a component of a steep-slope roof assembly per UL 7103, "Outline for Investigation for Building-Integrated Photovoltaic Roof Coverings." This standard aims to address concerns related to wind resistance, weather protection, fire, impact resistance, durability and electrical.

The operating temperature of the Solar Roof system is within -40 C (-40F) to 85 C (185 F).

Wind Resistance and Roof Wind Load

The wind resistance of the Solar Roof system was tested and classified according to ASTM D3161, "Standard Test Method for Wind Resistance of Steep Slope Roofing Products (Fan-induced Method)." This testing method measures a roof's ability to withstand a fan-induced wind of a specified velocity.



Wind Resistance Classification

Solar Roof system has a Class F wind resistance classification (highest possible).

Tesla has gone above and beyond the requirements of building code and tested the Solar Roof Tiles and Flashings up to 156-mph wind speed (the maximum speed possible at the International Hurricane Research Center). Tesla further instrumented in-house testing and measured the uplift loads. Testing was completed at various angles and along different roof features. The fastening schedule and type required is based on the loads measured plus an applied safety factor.

Wind-Driven Rain Resistance

The Solar Roof system was tested for wind-driven rain resistance as evaluated in accordance with both UL 7103 Section 26, "Outline for Investigation for Building-Integrated Photovoltaic Roof Covering" and TAS 100, "Standard Test Method for Wind and Wind-Driven Rain Resistance of Discontinuous Roof Systems." The assembly had no water infiltration through the deck sheathing under test prescribed protocol.



Wind-Driven Rain Resistance

Solar Roof system complies with TAS 100 Wind-Driven Rain Resistance.

Fire Resistance

Solar Roof fire resistance was tested and classified according to UL 790, "Standard Test Methods for Fire Tests of Roof Coverings (Building Integrated Photovoltaics – BIPV products only)." This standard includes three classes of fire exposure, with Class A being effective against "severe" fire test exposures, Class B being effective against "moderate" fire test exposures, and Class C being effective against "light" fire test exposures.



Fire Resistance Classification

Solar Roof system has a Class A fire resistance classification.

This testing method evaluates a roofing covering's ability to resist: (1) the spreading of flames on the surface, (2) fire penetration from the exterior to the underside of the roof deck and (3) recurring intermittent flame.

Impact Resistance

Solar Roof PV Tile and Metal Tile are tested and classified according to UL 2218, "Impact Resistance of Prepared Roof Coverings". This standard tests the impact resistance of roofing materials by dropping steel balls of varying sizes from predetermined heights.

Solar Roof Glass Tile are tested and classified according to FM 4473, "Specification Test Standard of Impact Resistance of Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls." This standard tests the impact resistance of roofing materials by launching ice ball of varying sizes horizontally from a specific distance.

Both Standards aim to evaluate a roof covering's ability to withstand significant hail events and include similar rating system based on test results. There are four levels of classifications, with Class 1 being the lowest classified level and Class 4 being the highest and most impact resistant.



Impact Resistance Classification

Solar Roof Tiles have a Class 4 Impact Resistance rating under respective testing standards.

Water and Ice Dam Protection

Tesla Underlayment was tested to and meets the water and ice-dam protection classification under ASTM D1970 "Standard for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection" and ICC-ES Acceptance Criteria for Roof Underlayment (AC188).

Since Tesla Underlayment is installed along the roof perimeter at eaves and rakes as well as other vulnerable areas such as valleys, penetrations and transitions, it is compliant with the 2021 International Residential Code Section R905.1.2 as an ice barrier.

Snow Load

Solar Roof is designed to resist the following snow loads:

- Surface normal: Up to 150 psf (7.18 kPa)
- Shear: Up to 103 psf (4.93 kPa)

Other Code Considerations and Compliance

The local Authority Having Jurisdiction (AHJ) can have their own requirements for Solar Roof compliance. Involving AHJs early in the design process is critical to ensure compliance with all local requirements and regulations.

California Energy Code Compliant

California's Title 24, Part 6 2022 Building Energy Efficiency Standards outlines the energy efficiency requirements for new and existing buildings. The intent of the code is to reduce energy costs and wasteful consumption, improve building comfort and reduce environmental impacts of energy use.

The Standard outlines roofing materials to meet cool roof requirements. A cool roof is designed to reflect more solar energy and absorb less heat than a standard roof assembly. The primary characteristics of a cool roof are its high thermal emittance and solar reflectance values. For new construction steep sloped roofs, the Standard prescribes roofing products in Climate Zones 10 - 15 to have a minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum Solar Reflectance Index (SRI) of 16. Solar Roof Metal Tiles utilize a black paint with SRI of 19.

The Standard further outlines that the roof areas covered by BIPV are exempt from cool roof requirements, per Section 150.1 (c) 11 Exemption 1.

- From a functionality perspective, BIPV and cool roof roofing materials have opposite surface properties: BIPV is designed to absorb sunlight for energy production, while cool roofs utilize reflective materials to reduce solar heat gain.
- From a regulatory perspective, the exemption acknowledges the overall energy benefits derived from renewable energy generation and encourages BIPV adoption in sustainable building design.

Solar Roof PV Tiles satisfy the intent of this reference exemption.

Wildlife Urban Interface (WUI) Compliant Roof Assembly

WUI refers to areas where buildings are in proximity to, or interspersed with, vegetative or wildland areas. Buildings in WUI will often require exterior wildfire exposure code provisions.

To qualify, Solar Roof had to satisfy design principles and construction techniques related to:

- Fire resistance of roof covering assembly.
- Vent opening protection and materials.



WUI Compliance

Solar Roof system has been approved by UL Solutions as having met requirements to comply with 2022 California Building Code (CBC), Chapter 7A [SFM] "Materials and Construction Methods for Exterior Wildfire Exposure."

In addition to using non-combustible and corrosion-resistant vent materials, the Ridge Vent openings do not exceed the code prescribed sizing of 1/8-inch. Ventilation openings for enclosed attics are also fully covered with ridge roll to minimize the risk of embers from entering the roof assembly. Wire mesh is also installed at the top adjacent Tiles, at the last course near the ridge to reduce potential ember intrusion risks.



Insurance Institute for Business and Home Safety (IBHS) FORTIFIED Roof Compliant

The IBHS FORTIFIED roof program offers a set of engineering and building standards designed to enhance the durability and resilience of homes against specific severe weather conditions.

Solar Roof incorporates design principles and construction techniques that comply with the IBHS FORTIFIED roof program related to the following:

- Roof deck attachment
- Roof deck sealing ability
- Roof edges securement
- Impact resistance
- Wind and rain resistance of attic vents
- Wind and rain resistance of attic vents



IBHS Compliance

Solar Roof system is compliant with the IBHS FORTIFIED roof program.



Insurance Institute for Business and Home Safety (IBHS) WILDFIRE PREPARED Compliant

The IBHS WILDFIRE PREPARED program empowers homeowners to take science-based, proven steps to meaningfully reduce wildfire risk to their home and property by providing explicit mitigation steps, as well as offering a designation certificate to those who meet the requirements.

Solar Roof incorporates design principles and construction techniques that comply with the IBHS WILDFIRE PREPARED home program related to the Class A fire rating of Tesla's underlayment.



IBHS Compliance

Solar Roof system is compliant with the WILDFIRE PREPARED roof program.



Florida Building Code and High Velocity Hurricane Zone Approved



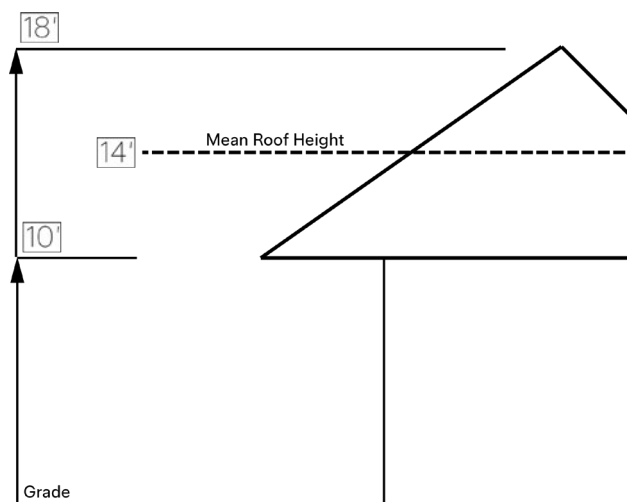
HVHZ Compliance

Solar Roof has been approved by UL Solutions as having met requirements to comply with the 2020 Florida building Code – Building and Florida Building Code – Residential, including High-Velocity Hurricane Zones.

The current Florida State Product Approval Number can be found on the [Florida Building Code Product Approval Search](#).

Note that to comply with the 2020 Florida Building Code, the following conditions should also be satisfied:

- The maximum mean roof height is 33 feet. Additional site specific analysis can be done to approve heights above 33 feet.
- The maximum roof slope is 20:12.



Mean Roof Height Example

SITE DESIGN GUIDELINES

When implementing Solar Roof into new home construction, the building lot / site can impact Solar Roof's overall performance and efficiency. Addressing site planning and orientation factors early in the design phase will ensure optimal sun exposure for Solar Roof that harmonizes the roof design.

- Orientation and Sun Exposure
- Neighboring Obstructions and Shading
- Climate and Weather Conditions
- Geographic Considerations

Orientation and Sun Exposure

Certain site layouts will optimize the building's sun exposure, thus maximizing Solar Roof's energy production.

The sun's position changes constantly throughout the day and across seasons. In the northern hemisphere, the sun is higher in the sky in summer and lower in winter. To maximize sunlight exposure throughout the day, the roof area should ideally face south.

Roof areas facing southeast and southwest will also have good sunlight exposure.

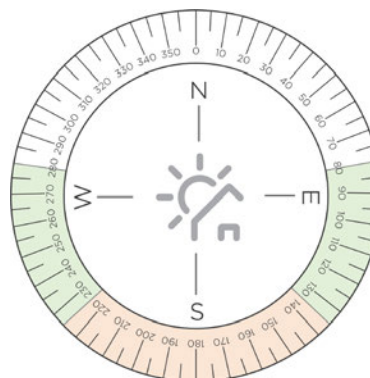


Optimal Solar Roof PV Tile Orientation

In azimuth terms, the ideal positioning of Solar Roof is south-facing roof areas between 135° to 225°.

Legend

- Ideal positioning
- Acceptable positioning



East-facing (between 80° to 135°) and west-facing (between 225° to 280°) roof planes will experience optimal sunlight at different times of the day. East-facing roof planes have higher power production during the morning since the sun rises in that direction, while west-facing roof planes are more productive in the late afternoon, coinciding with sunset direction.

North-facing roof planes experience higher sunlight exposure during certain times of the day as well, but less than east, west and south-facing planes even at these optimal times.

Thus, the pitch of a north-facing roof plane is a more critical factor for maximizing power production efficiency. Typically, high pitch north-facing roof planes (above 30°) are less efficient than low pitch north-facing roof planes (under 30°), but these values vary by location. In general, the power production efficiency of north-facing roof planes increases with closer proximity to the equator as the sun's path becomes more directly overhead throughout the year.

Neighboring Obstructions and Shading Impact

Minimizing the amount of shading on the roof will contribute to Solar Roof's solar access and energy production. Solar access is expressed as a percentage, where 100% is no shading at all and 0% is entirely shaded with no sunlight exposure.



Solar Access

Solar Roof PV Tiles should be installed in areas with more than 20% solar access.

To prevent excess shading, designers should consider positioning or orienting the home away from hard shades and soft shade. Hard shade refers to neighboring buildings and solid structures that allow no light to pass through. Soft shade refers to adjacent trees that allow some light to pass through gaps, creating a diffuse shading effect. Where feasible, trim or remove trees that create soft shade.

Climate and Weather Conditions

Local climate factors such as wind speed, rainfall, snow loads, etc., are important considerations in designing and installing Solar Roof. The system is designed to withstand specific environmental loadings, which are further discussed in the [Performance and Compliance section](#).

Geographic Considerations

High Altitude



Altitude Warning

Solar Roof, specifically PV Tiles, should not be installed above 13,120-feet (4,000-meters) altitude above sea level.

Coastal Regions

Solar Roof metal tiles and flashings use weather-resistant aluminum-zinc-coated steel and PVDF paint, enabling them to be installed in all climate types. Tesla does not guarantee corrosion resistance within 1,500 feet of salt water, salt spray, or salt fog.

Wildland Urban Interface (WUI)

Buildings in WUI areas should be designed to enhance fire resistance and protection from ignition due to airborne embers and direct flame contact. This includes but is not limited to:

- Adhering to local building codes for site positioning and clearances.
- Utilizing simple roof designs with fewer valleys and protrusions to reduce the chances of ember accumulation & ignition.
- Utilizing a Class A roof covering.
- Constructing eaves and soffits with ignition-resistant materials approved by local fire code officials.
- Incorporating non-combustible gutter design and detailing.

Refer to [Wildlife Urban Interface \(WUI\) Compliant Roof Assembly](#) for specific information on how Solar Roof complies with WUI requirements.

ROOF DESIGN GUIDELINES

Solar Roof systems can be designed and installed for a variety of applications where incorporating renewable energy, achieving sustainable design and architectural acceptance, enhancing durability and watertightness are of prime importance.

Roof Configuration

Solar Roof can accommodate a variety of complex configurations and architectural styles. However, the higher the roof complexity, the more challenges there will be in regard to construction and overall material and labor cost.

Rectangular

A simple roof design with minimal but large rectangular mounting planes is ideal for Solar Roof, as it maximizes solar potential and the use of prefabricated Solar Roof Tiles and components.



Optimal Roof Area

Generally, roof areas less than 50-sq/ft cannot accommodate PV Tile installation.

Multiple Planes

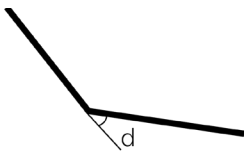
A roof design involving multiple slopes, angles and intersecting planes complements various architectural styles. However, this type of design will require field cutting and fitting to achieve the desired design intent. It can also create shading effects which reduce the overall energy production of Solar Roof.

Arched or Curved

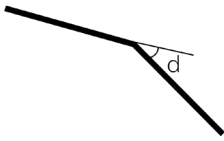
Due to the Solar Roof Tile rigidity, Solar Roof is not recommended for applications on highly curved

eaves, rounded roof surfaces and other non-linear head walls / end walls/ side walls. Alternative roofing material will be required for these planes or features. Solar Roof Tiles can be installed on concave and convex roofs, accommodating minor curvatures or pitch changes. Refer to the summary table below.

	Concave Roof	Convex Roof
Metal Tile	• Max angle delta 27 deg • Equivalent to L/8.5 • Example: Transition from 3:12 to 7:12 allowed	• Max angle delta 8 deg • Equivalent to L/28 • Example: Transition from 4:12 to 6:12 allowed
PV Tile	• Max angle delta 8 deg • Equivalent to L/28 • Example: Transition from 4:12 to 6:12 allowed	



Concave Roof



Convex Roof

Roof Pitch

Impact on Energy Production

The roof pitch is one of the most critical factors impacting Solar Roof's energy production. To optimize sunlight exposure, the ideal slope for Solar Roof is often close to or equal to the latitude of the location. This angle is typically between 30-degrees and 45-degrees. Thus, power producing tiles should be installed in areas with roof slopes between 6:12 and 12:12 when possible. However, the steeper the pitch, the more it can create shaded areas and influence the amount of sunlight the roof receives.

Impact on Water Drainage

One of Solar Roof's primary functions is to maintain efficient water drainage and weathertightness. The steeper the roof pitch, the faster water can run off, reducing the risk of water pooling or potential leakage.

A very low / shallow slope hinders water shedding from the roof surface, increasing the risk of water pooling. In regions that experience intense rainfall or are prone to heavy snow accumulations, the risk of water infiltration and ice dam formation increases with low-slope roof systems utilizing water-shedding strategies. Industry best practice recommends avoiding roof slopes lower than 4:12 in these regions.

Pitch Range for Solar Roof



Minimum Allowable Pitch

The minimum allowable roof pitch for Solar Roof is 2:12.

Some special considerations or alternate installation practices for specific features may be required when the Solar Roof pitch is above 12:12 or under 3:12.

Note that Solar Roof is designed as a roofing product, and extremely steep or vertical applications will need specific building envelope design considerations and detailing to ensure proper control of heat, air and moisture as these impact the durability of the envelope.

These applications should be evaluated on a case-by-case basis. For more information and guidance, consult your local Tesla Representative.

Roof Deck

Roof decks provide the structural base for Solar Roof materials. Solar Roof Tiles, along with relevant mounting hardware, are directly attached to the roof deck.

Wood Panels

Wood panel roof decks are typically subdivided into two general types: (1) Plywood and (2) Oriented Strand Board (OSB).

All wood-based panels used to support Solar Roof should be rated for structural use as roof sheathing, conforming to the code adopted and enforced by the local jurisdiction. This typically means complying with the following Declarations of Conformity (DOC) performance standards with Exposure 1 or Exterior Grade ratings:

- U.S. Product Standards (PS) PS-1, "Construction and Industrial Plywood," for all-veneer plywood.
- PS-2, "Performance Standard for Wood-Based Structural-Use Panels."

Wood Boards

Wood board roof decks are composed of solid-sawn dimensional lumber. Common board dimensions have widths between 4-inches and 12-inches, and thickness less than 2-inches.

Solar Roof cannot be installed over widely spaced wood board decks (sometimes referred as "skip sheathing") or in areas where gaps are greater than 1/4-inch.

The proper thickness, type and species of roof deck wood required for the Solar Roof system should be determined by the anticipated design loads, including the distance (span) supporting members and wind uplift. The table below outlines the minimum deck thickness based on fire classifications (Class A and Class B) and wind resistance.

	Material	Recommended Minimum Deck Thickness
Wood Panels	Plywood	15/32-inch
	OSB	7/16-inch
Wood Boards	Board	3/4-inch

These recommended minimum thicknesses are intended to provide adequate support and pull-out resistance for the fasteners used to attach Solar Roof to the decking. Depending on anticipated design loads and span between supporting members, thicker panels may be necessary. Structural professionals should be consulted for the applicable deck thickness recommendations.



Other Deck Types

While uncommon for residential applications, other types of structural decks (such as metal, concrete, gypsum, cementitious wood fiber or other non-wood / fabricated wood materials) can sometimes be used for steep-sloped roof systems. Solar Roof should not be installed directly to these structural deck types.

Underlayment

A single layer of Tesla Underlayment is installed over the entire roof prior to Solar Roof Tile installation.



System Warranty

To achieve system warranty, Tesla Underlayment should not be substituted by other commercially available underlayment products. Tesla Underlayment should be installed with Solar Roof.

Underlayment Application Over Low-Slope Membrane Roof Systems

In instances where the Solar Roof system intersects with and drains onto an adjacent low-slope membrane roof system, the Tesla Underlayment should positively lap over the upslope membrane extension. The overlap should be a minimum of 6-inches.



Low-Slope Roofing Membrane Compatibility

Tesla Underlayment is chemically compatible with Ethylene Propylene Diene Monomer (EPDM) and Thermoplastic Polyolefin (TPO) low-slope roofing membranes.

There are a variety of commercially available EPDM and TPO membrane products. Adhesion between products should be verified via field adhesion testing to minimize potential separation between the Underlayment and low slope roofing membrane.

Architectural Features

Shading Impact

The direction and path of sun throughout the day and seasons can impact the energy production of a Solar Roof. Dependent on their positioning, roof vents, chimneys, dormers, mechanical equipment and other obstructions or protrusions are roof features that could cast shadows and block PV Tiles from sunlight.



To maximize energy production, Tesla recommends utilizing an unobstructed roof layout by minimizing the amount of rooftop equipment and penetrations across the roof area in south and southwest elevations. Plumbing and mechanical design / trades should be consulted to group penetrations and locate equipment and vents on north elevations.

Having multiple roof levels on a new home can also impact sun access. A second story can cast shadows on the roof below, reducing the amount of sunlight that reaches the first story roof areas. This self-shading can be more pronounced during certain times of the day, especially when the second story is located on top of the first story at south and southwest elevations.

Energy Production Impact

Roof features will have an impact on power producing Tile placement. During the planning phase, determining the best location for the roof features will help maximize energy generation of the Solar Roof.

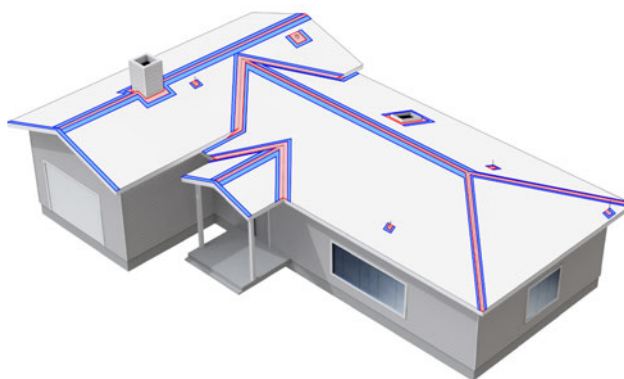
Tesla specifies two types of clearance requirements around roof features: (1) No Tile Zone; (2) No PV Zone. These requirements are established to assist in waterproofing detailing, improve installation efficiency and create aesthetic consistency.

- No Tile Zones are areas around the roof feature where installation of the Solar Roof Tiles is avoided to comply with Solar Roof installation practices. In these areas, metal flashings are used to protect the roof assembly instead.
- No PV Zones are areas around the roof feature where PV Tiles cannot be installed to avoid covering PV Tiles with metal flashings.

The clearance requirements are roof feature specific. The figure below shows an example of a hip roof overlaid with clearance requirements.

Legend

-  No Tile Zone
-  No PV Zone



Note that local fire and building codes typically include spatial implications for rooftop solar energy systems to allow for emergency access and ventilation. These requirements should be considered and incorporated when designing for Solar Roof system. Where there exists a conflict between clearance setbacks, the more stringent requirements prevail.

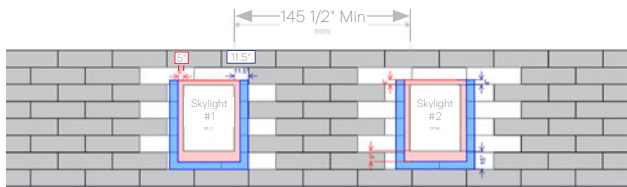
Roof Features and Installation Clearance

From an installation perspective, the maximum amount of space possible should be provided between roof features, inclusive of walls and curbs.

While in-house Tesla designers will collaborate through any design challenges, below are two examples that offer insights on how Solar Roof Tiles are integrated into roof feature designs.

Example 1: Skylights

Legend



The placement, size and frequency of skylights on roof assemblies can influence overall Solar Roof energy production.

Two 42-inch by 55-inch skylights are used in this example. Solar Roof Tiles are installed from the roof eave, working their way up. Using the half staggering Tile installation rule, to maximize energy production Tile placement and to satisfy clearance setback requirements, the skylights should be positioned at least 145 1/2-inches apart from each other so that two PV Tiles can fit between skylights. Note that the distance between the two skylights varies dependent on the skylight size.

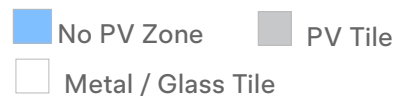
Per industry best practice, there should be a minimum of 24-inches between roof features, walls and skylight openings.

Example 2: Pipe Penetrations

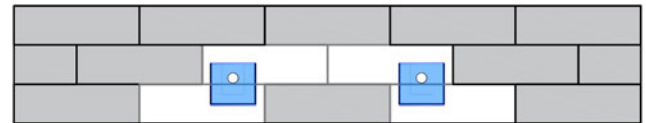
Similar to skylights, the placement, pipe diameter and quantity of circular pipe penetrations within the field of the roof can impact the total amount of PV Tiles designed and installed.

Two drain waste vents (DWVs) with a 3 1/2-inch pipe diameter are used in this example. These DWVs are positioned in three different scenarios. Scenario 1 places the DWVs 22 1/2-inches apart, while Scenarios 2 and 3 place the DWVs approximately 68-inches and 84-inches apart, respectively, measuring from center of pipe.

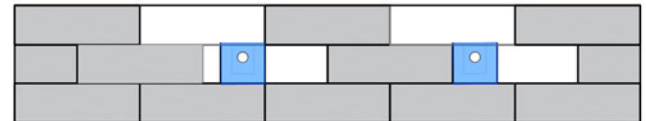
Legend



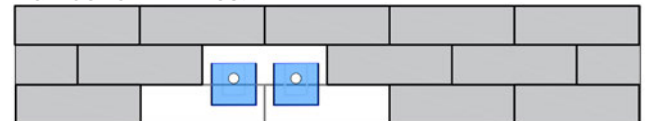
Number of PV Tiles: 11



Number of PV Tiles: 11



Number of PV Tiles: 12



By having pipe penetrations closer together, an additional PV Tile can be utilized to increase Solar Roof energy production.

From an ease of installation perspective, pipe penetrations should be placed at least 12-inches apart horizontally.

Furthermore, penetrations should not be located in valley areas. Per industry best practice, a penetration should be at least 18-inches away from the valley center.

Roof Penetrations

Proper flashing and integration of roof penetrations with Solar Roof system is critical to the roof's watertightness performance.

As mentioned in Solar Roof Assembly and Design, Solar Roof has relevant pipe flashing accessories to detail penetrations for small pipes and ducts above the roof deck.

Interior flashing, insulation and/or sealant should be installed around roof penetrations at the interior to provide continuous heat, air and moisture control layers across the roof assembly. These are not provided by Tesla and are the designer's and / or building professional's responsibility to properly design and incorporate.

Curbs

For larger penetrations, a roof curb (which is an elevated platform) may be designed and installed close to the perimeter of the opening to support the penetration or rooftop equipment.

A critical function of a roof curb is that it is elevated from the roof's drainage plane, reducing the risk of water intrusion at the penetration. Furthermore, a curb facilitates proper installation and integration of flashing around the penetration.



Minimum Curb Height

Tesla recommends the top of curbs to be at least 4-inches above the Solar Roof surface.

Curb construction should utilize wood framing or be made from stainless steel, galvanized steel or aluminum / zinc alloy-coated steel to ensure compatibility with Solar Roof.



Wood-framed curb around skylight penetration.

Irregularly Shaped Penetrations

Irregularly shaped penetrations (e.g. bracing penetrations to rafters / sheathing, lighting protection systems) may be integrated with the Solar Roof system. Depending on their attachment method, a "guttering" process (which utilizes Wall Flashing and Transition Flashing) may generally be applicable. Tesla recommends evaluating irregularly shaped penetration on a case-by-case basis to ensure proper waterproofing detailing. For more information and guidance, consult your local Tesla Representative.

Other Miscellaneous Penetration Items

Tesla does not recommend the following items be attached to the Solar Roof assembly due to their potential to cause damage, compromise the roof's integrity and create safety hazards or aesthetic distractions:

- Satellite dishes
- Television or radio antenna
- Sign supports

Designers should consider attaching and detailing these on wall assemblies.

Roof-to-Wall Intersections

Roof systems can be interrupted by adjacent walls, adjoining roof sections or other types of rectangular penetrations. All of these can create potential paths for water intrusion, requiring additional provisions for weather protection.

The 2021 International Residential Code (IRC) provides specific requirements for flashing as part of weather protection of a roof covering system. Section R903.2 states that “flashing shall be installed at wall and roof intersections, where there is a change in roof slope or direction and around roof openings.” Similar requirements are also found in the 2021 International Building Code (IBC), Section 1503.2.

As mentioned in Solar Roof Assembly and Design, Solar Roof utilizes four types of metal flashings at wall to roof intersections.



Underlayment Upturn Height

Prior to flashing application, Underlayment extends from the deck and turns up the vertical wall a minimum of 8-inches from the intersection point.

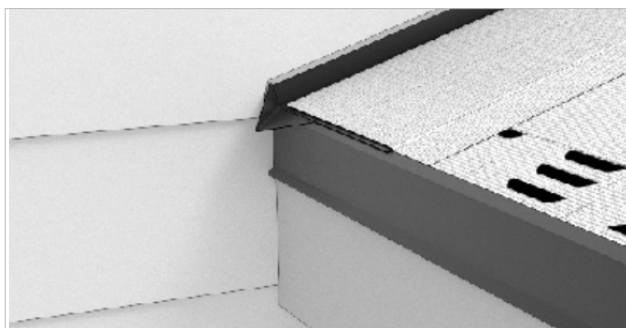
8-inches will allow for 2-inches of membrane overlap between the wall weather resistive barrier (WRB) and the Underlayment upturn to preserve air and water continuity, especially when the wall assembly encloses conditioned spaces. It also allows for positive lapping of the WRB onto the upper leg of metal flashing.

Eave to Sidewall Intersection

The 2021 International Residential Code (Section R903.2 Flashing) requires flashing “be installed to divert the water away from where the eave of a sloped roof intersects a vertical sidewall.”

When a sloped roof abuts a vertical wall, there is the possibility of water infiltration (especially where the roof eave meets the wall).

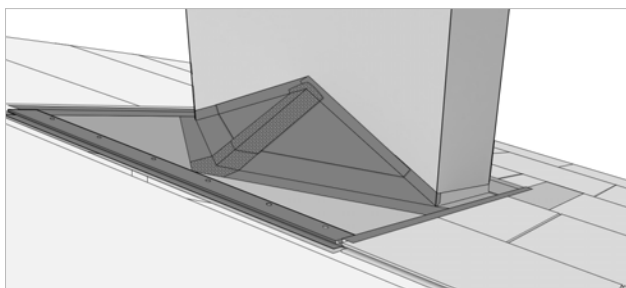
Tesla recommends a kickout flashing (also known as diverter flashing) formed from Wall Flashing be integrated at the base of the wall with the weather resistive barrier system to direct water out and away from a building and minimize water ingress to the wall assembly.



Cricket at End Walls

A cricket is a ridge-shaped structure installed on the upslope side of walls (also known as end walls), chimneys, or other vertical projections on the roof. The primary purpose of a cricket is to divert water around these obstacles and prevent water accumulation at the base of the wall.

The 2021 International Building Code (Section 1503.5) requires that a cricket be installed “on the ridge side of a chimney or penetration greater than 30-inches wide as measured perpendicular to the slope.” Tesla recommends installing a cricket on the upslope side of walls or penetrations as prescribed per code.



Field-fabricated cricket flashings using Flat Stock sheet metal are then incorporated into the Solar Roof system to provide weather protection.

Roof Transitions and Changes in Slope

There are three main types of slope transitions that Solar Roof may encounter in multi-slope roof designs:

- Low-to-steep slope transitions
- Steep-to-low slope transitions
- Steep-to-steep slope transitions

Low-to-Steep Slope Transitions

Occasionally, the Solar Roof system can terminate and drain onto adjacent low-slope roof membrane systems. Tesla recommends placing Solar Roof tiles above the flood plane to avoid potentially submerging Solar Roof components. Flat Stock sheet metal flashing is used at the bottom of the Tiles to conceal underlying membrane overlaps and to ease the transition.



Steep-to-Low Slope Transitions

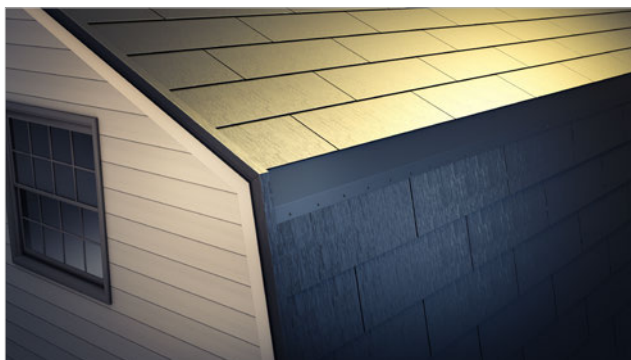
This type of transition occurs when the uppermost roof system is a low-slope roof membrane system that terminates onto the top of the Solar Roof system. The top flange of the edge metal should meet requirements from the low-slope roof membrane manufacturer's installation instructions.

The bottom flange of the edge metal should extend past Channel Flashing, overlapping a minimum of 2-inches over the uppermost course Solar Roof Tiles.

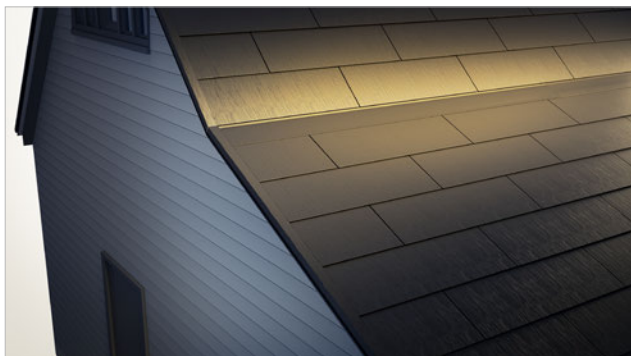
Note that the edge metal flashing is not provided by Tesla and must be procured from a low-slope roofing membrane manufacturer for proper integration with their membrane roof system.

Steep-to-Steep Slope Transitions

Multi-pitched roof configurations typically involve steep-slope transitions. The transition can be formed from a higher pitch to a lower pitch configuration, or vice versa. For example, a gambrel style roof will have an uppermost roof with a lower pitch than the adjacent lower roof, whereas a bonnet style roof's uppermost roof will have a higher pitch than the adjacent lower roof.



Gambrel Roof



Bonnet Roof

In both of these scenarios, Tesla Transition Flashing is integrated with the Solar Roof system at the Tile level to provide weatherproofing and to conceal the underlying Tesla Underlayment.

Other Compatible Roofing Types

Solar Roof can be installed in conjunction with other roof types in multi-roof designs in different sections of the building. Compatible roof types include: asphalt shingle, clay and concrete tile, wood shingle, slate and standing seam metal panel roofing system. Special attention should be given to the type of metal material. Copper metal roofs must not be incorporated upstream of Solar Roof to minimize corrosion risks from dissimilar metals. Copper metal roofs should not be installed downstream of Solar Roof to minimize corrosion risks of the copper roofing.

Roof Ventilation

Attic Ventilation

Solar Roof is typically installed over attic-ceiling roof assembly types. Attic ventilation is an important element in residential roof constructions as it prevents moisture from entering the attic space. Adequate attic ventilation also limits the potential for moisture-induced deterioration. It is the designer's and / or building professional's responsibility to account for adequate roof ventilation.

In general, the building code provides minimum requirements for attic ventilation. Both the 2021 International Residential Code (IRC), Section R806 – Roof Ventilation, and the 2021 International Building Code (IBC), Section 1202.2 – Roof Ventilation, specify a minimum ventilation ratio of 1:150, or 1 sqft of Net Free Vent Area (NFVA) for each 150 sqft of attic floor space or roof area.

The amount of ventilation can be reduced to 1:300, in effect 50% less, if both of the following conditions are met:

1. A 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. Refer to [Appendix A: Glossary](#) for vapor retarder definitions.
2. Using a balanced ventilation system. See [Balanced Attic Ventilation Systems for further information.](#)
3. Buildings located in Climate Zones 6 through 8.

NOTE: State and local jurisdictions may amend the roof ventilation requirements outlined by the IBC or IRC. Therefore, it is important for designers to always consult, verify and follow local building codes and requirements.

Balanced Attic Ventilation Systems

Balanced Vent Recommendation

Tesla recommends designing a balanced attic ventilation system.

Splitting the total ventilation evenly between exhaust and intake helps prevent negative pressure (meaning the interior pressure is lower than the exterior pressure) from forming within the attic space.

Since air moves from high to low pressure areas, a negative pressure promotes air to move from the exterior to the interior. Furthermore, this could draw conditioned air within the house into the attic space, thus increasing the strain on the residential HVAC systems.

If the total ventilation cannot be split evenly, always provide more ventilation at intake than at exhaust. If exhaust ventilation exceeds the amount of intake ventilation, a reverse airflow could occur,

where intake air is pulled from the building interior through openings (e.g. ceiling lights, attic access doors) rather than being pulled from the building exterior.

Ventilation Location

The following should be considered when determining the locations of ventilation openings.

Exhaust Ventilation: 40% to 50% of the total ventilation should be located in the upper portion of the attic or rafter space, typically at the top one-third of the attic. The IRC and IBC further specify that exhaust vents "be at or within 3-feet vertically of the highest point of each roof section. Where the location of wall or roof framing members conflicts with the installation of exhaust vents, installation more than 3-feet below the ridge, or highest point of the space shall be permitted."

Intake Ventilation: The remaining percentage of the total ventilation, 60% to 50%, should be located in the bottom one-third of the attic space, typically located in the soffit or near the eaves of the roof. Intake ventilation should be continuous along the roof perimeter.

Cross Ventilation: Vents should be well distributed. Installing vents uniformly on opposite sides of the roof space will facilitate greater air movement.

Heat, Air and Vapor Control at Ceiling Level

While Solar Roof design and installation extent starts at deck sheathing and above, heat, air and vapor control at the ceiling level must be carefully considered by designers and building professionals. For attic ventilation systems to work efficiently, the ceiling plane must be airtight.

Air barriers at the ceiling should be continuous with no air leakage.

This means penetrations through the ceiling should be sealed to minimize air leakage. Moisture can enter the attic either by air leakage and/or vapor diffusion. Therefore, it is important to incorporate proper air barriers and insulation to separate a conditioned living space from the unconditioned attic. The IRC and IBC specify the minimum R-value of insulation materials.

Hip Roof and Ventilation

Hip roofs are a type of roof where all four sides of the roof slope downwards from the peak. Due to its geometry, hip roofs form a large volumetric attic space, yet the ridge is often too short to accommodate adequate exhaust ventilation.

In this application, third-party mechanical vents designed and installed near the ridge could be a good alternative. Adequate intake vents should be provided to ensure continued airflow along the underside of the roof sheathing to achieve a balanced ventilation system.

Cathedral Ceiling Ventilation

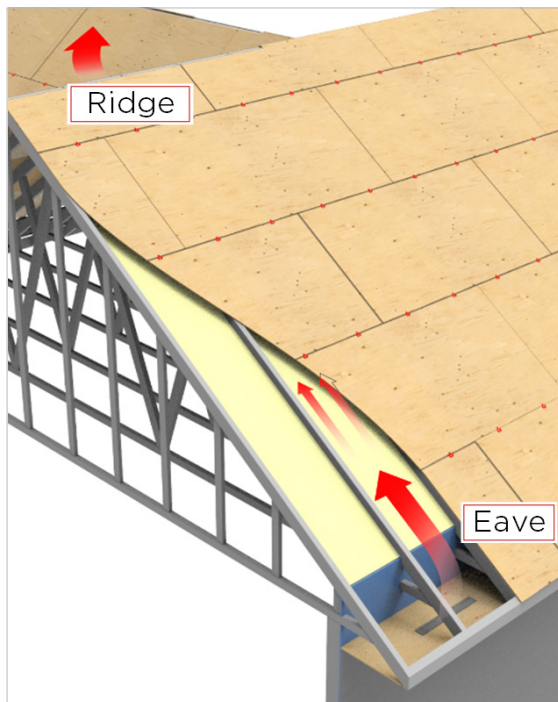
Solar Roof can be installed on cathedral ceiling type roof assemblies. Unlike attic-ceiling roof assemblies where roof insulation is located along the air-tight ceiling plane, cathedral ceilings have roof insulation installed along the roof deck plane, between rafters, and are enclosed by deck sheathing. Due to its insulation location, the hydrothermal behavior of the cathedral ceiling changes from that of the attic ceiling. Special attention in regards to insulation type and thickness, as well as air and vapor controls needs to be paid when designing cathedral ceiling ventilation to minimize moisture-related issues.

The same building code minimal ventilation requirements (with ventilation ratio of 1:150 or 1:300) used for attic-ceiling type roof assemblies are applicable to cathedral ceiling type roof assemblies.

Furthermore, the 2021 International Residential Code (IRC), Section R806.3, and 2021 International Building Code (IBC), Section 1202.2.1, specify “an airspace of not less than 1-inch shall be provided between the insulation and the roof sheathing.” This air space is typically created using cross strapping, with the intent to promote lateral air movement between rafter bays. It is the designer’s responsibility to specify an adequate airspace to accommodate required ventilation.

i Cathedral Ceiling Ventilation

In general, Tesla recommends pairing continuous exhaust vents along the ridge and continuous intake vents along the eave for cathedral ceiling ventilation. Designers should consult, verify and follow local building codes and requirements.



Unvented Attics and Unvented Enclosed Rafter Assemblies

Unvented roof assemblies, such as conditioned attics and unvented cathedral ceilings, eliminate ventilation openings and shift the building envelope control layers (heat, air, moisture) to the roof deck plane. These assemblies typically utilize spray foam insulation at the underside of the roof deck sheathing.

It is the designer’s responsibility to ensure venting is designed correctly. Designers should consult, verify and follow local building codes and requirements when opting to install Solar Roof on unvented roof assemblies.

The 2021 International Residential Code described three classes of water vapor retarders in subsection R702.7 Vapor Retarder:

- Class I vapor retarders (0.1 perms or less).
- Class II vapor retarders (greater than 0.1 perms and less than or equal to 1.0 perms).
- Class III vapor retarders (greater than 1.0 perms and less than or equal to 10 perms).



Vapor Retarders Class

Tesla Underlayment is a Class 1 vapor retarder with a maximum moisture vapor permeance of 0.07 perm.

Other Roof Design Elements

Skylights

Skylights are often added to a building to provide natural light. Proper flashing around a skylight is crucial for preventing water infiltration and ensuring the integrity of the Solar Roof. Solar Roof utilizes Tesla Underlayment and sheet metal flashings to provide weathertightness at skylights.

Curb-Mounted vs. Deck-Mounted Skylights

- i** When incorporating skylights with Solar Roof, Tesla's preference is to utilize curb-mounted skylights instead of deck-mounted skylights.

Curb-mounted skylights are raised above the level of the roof deck, providing better protection against water pooling and leakage. The elevated nature also allows for more effective and reliable flashing integration with the Solar Roof system.



Commercially available curb-mounted skylights typically include an integral counterflashing that is part of the skylight's frame. The upper leg of Solar Roof metal flashings should be installed behind the counterflashing to minimize water infiltration.

Solar Tubes

Solar tubes are small roof-mounted domes or collectors that capture sunlight. Solar tubes can be integrated into the Solar Roof system. Commercially available solar tubes typically include an integral flashing that is part of the solar tube's frame. The flashing flange is integrated with Tesla Underlayment. Flat Stock sheet metal is also used at the upslope side and flanking side with Solar Roof Tiles to conceal any exposed Underlayment detailing and fastening.

Windows Near Roof-to-Wall Transitions

Homes with multiple levels typically have windows designed within the upper floor wall assembly.

i Window Positioning

Where wall assemblies intersect with Solar Roof, Tesla recommends positioning windows a minimum of 8-inches above the roof deck surface.

8-inches allows the weather resistive membranes used to detail rough window openings to establish a 2-inch positive overlap onto the Tesla Underlayment upturn. It also allows for the water control of base-of-wall metal flashing, by positively lapping onto the upper leg of metal flashing.

Snow Fence

In areas where snow and ice occur frequently, Tesla recommends snow fence installation to prevent snow slides.

The inclined nature of a steep-slope roof system along with the smooth surfaces of the Solar Roof system can contribute to snow accumulation, and accumulated snow on the roof can release suddenly. A properly designed and installed snow fence can break up the snow mass as it slides down, preventing large, uncontrolled snow slides. This reduces the risk of injury to individuals and property damage in the areas below the roof. Snow fences also help distribute the snow load evenly, reducing the concentrated load on specific areas of the roof.

In cold-weather regions with frequent freeze-thaw cycles, snow accumulation can contribute to the formation of ice dams. Ice dams occur when melting snow refreezes at the eaves, creating a localized ridge of ice that prevents melting snow from draining the roof system.

Snow fences can help manage snow distribution, thus reducing the likelihood of ice dam formation and potential associated water damage.



The design, placement and specifications of snow fences are not Tesla's responsibility. The snow fence manufacturer's installation guidelines should be followed.

Note that snow build up on the roof will add more weight to the Solar Roof system and structure. Snow fence design should comply with applicable safety and building regulations. Third party snow fences should be installed at the time of Solar Roof installation.

Snow Fence Installation & Energy Production

Installing snow fences will impact energy production as one or more courses of PV Tiles near the roof eave will be eliminated and Metal Tiles will be utilized instead.

Roof Gutters and Drainage System

When gutters and downspouts are installed, they play a critical role in managing rainwater and melted snow runoffs from Solar Roof. Gutter and downspout materials, design and installation are beyond the scope of this Guide and the Tesla Solar Roof system does not include a dedicated gutters and drainage system.

Gutters and downspouts should be designed and constructed in accordance with the applicable Codes, Standards and best practices.

Gutters and downspouts systems can be easily integrated with Solar Roof's flashing system.

Gutter Size

Tesla recommends a minimum 6-inch gutter size for homes with heavy rainfall.

Gutters are installed at the exterior of the fascia board at eaves. Since Solar Roof utilizes drip edge metal flashing at eaves, the vertical flange of the drip edge should extend over the fascia, positively lapping over the back edge of the gutter. This overlap helps direct water into the gutter, rather than allowing it to run behind the gutter, which could lead to water damage to the fascia or soffit especially in an overflow scenario.

Dissimilar Metal Corrosion Warning

Note that Solar Roof uses galvalume metal for flashings. When designing gutters and downspouts system, Tesla does not recommend using copper to minimize corrosion risks from dissimilar metals.

MAINTENANCE, REPAIRS AND REPLACEMENT

Solar Roof's surface protects the building's interior and structural components from weather elements such as precipitation, high winds and debris.

Routine Solar Roof maintenance contributes to the overall efficiency and longevity of the system while enhancing the building's lifespan and maintaining the roof's aesthetic.

IMPORTANT: Servicing Solar Roof requires specialized skills and knowledge, only trained professionals should be walking on the roof or performing any kind of roof work. Solar Roof is slippery when wet and is a fall hazard. Excessive or careless roof traffic can cause damage.

Recommended Practices

Solar Roof Inspections

Inspections Frequency: Tesla recommends visually inspecting the roof for damage, debris and any conditions that may obstruct energy production at least twice a year or during routine gutter cleanings.

The roof should also be inspected following severe weather or unusual occurrences such as heavy rains, unusually high winds, hail, nearby fires, etc. Snow or ice that may accumulate during snowstorms can slide off the roof, resulting in property damage or bodily harm. When there is attic access, check for signs of leaks such as water stains, mold or mildew growth, wet insulation, peeling paint, etc.

Homeowners should contact [Energy Customer Support](#) for guidance on safely addressing weather-related issues.

Conditions to Inspect: Listed below are conditions that may require maintenance to prevent hindering energy production:

- Trees or other tall plants that shade Solar Roof from the sun.
- Blocked gutters and downspouts creating leakage.
- Significant buildup of dust and debris.
- Any source of water infiltration into a building that is not exclusive to the Solar Roof system and its associated flashing.

Cleaning

Tesla recommends a professional perform any required cleaning service. Take appropriate safety precautions when working on or around Solar Roof.

It is acceptable to hose down the roof with water at standard garden hose pressures. Direct the spray or flow in the same direction that water typically flows on the roof (down) while ensuring that the spray nozzle is not too close to the roof. Avoid directly spraying the front edges of Tiles or in between Tiles. Where dust and debris have built up, or for problematic areas, it is acceptable to use a telescoping soft brush to gently wipe the roof surface.

[Contact Energy Customer Support for cleaning guidance.](#)



Cleaning Practices to Avoid

Do not use detergents, abrasives, solvents or any other types of cleaning products. Do not use snow blowers, heaters or other power equipment. Do not power wash Solar Roof.

Repair and Replacement



Damaged PV Tiles

Note that damaged PV Tiles cannot be used and must be replaced.

Homeowners should always contact [Energy Customer Support](#) if any component in the Solar Roof system requires repair or replacement.

Appendices

APPENDIX A: GLOSSARY

The section provides a glossary of terms used in the context of the Solar Roof system. Some terms / definitions may have different interpretations when used in a different context.

Roofing Terminologies

Term	Definition
Building-Integrated Photovoltaic (BIPV)	Building materials that also generate electricity via solar energy.
Counterflashing	The portion of the flashing attached to a vertical surface to help prevent water from migrating behind the base flashing.
Course	A row of Solar Roof Tiles running parallel to the roof eave.
Cricket	A triangular structure or saddle installed around the upslope side of a large penetration (e.g. a chimney, skylight) or other roof protrusion to help divert water towards a drainage location.
Deck	The surface installed over the supporting roof framing members to which the roofing materials are applied.
Drip Edge	Metal flashing used along the roof perimeter to allow water run-off to drip clear from fascia boards and underlying materials.
Eave	The horizontal, lowest edge of a sloped roof that extends beyond the exterior wall.
End Wall	The upslope portion of a roof-to-wall intersection.
Fasteners	Nails, screws, etc. used to secure roofing materials to the deck.
Fascia Boards	A decorative board that runs along the lower edge of the roof, attached to the ends of the rafters or trusses.
Flange	A projecting flat rim or collar used to assist attachment and detailing with another roofing element.
Flashing System	Components that prevent water from entering a building around any intersection or penetration in a roof.
Head Wall	The horizontal intersection of a wall and a pitched roof at the downslope portion.
Kickout Flashing	Flashing that specifically diverts water into gutters.
Mean Roof Height	Per ASCE 7, the Mean Roof Height (h) is defined as the average of the roof eave height and the height to the highest point on the roof surface, except that, for roof angles of less than or equal to 10°, the mean roof height is permitted to be taken as the roof eave height.
Mounting Plane	The sloping surface of a roof that the Solar Roof tiles are attached to.
Metal Tile/Glass Tile	Non-power producing Solar Roof Tiles.
Obstructions	Any component that interrupts the roof plane is considered an obstruction.
PV Tile	Power producing Solar Roof Tiles.
Rake	The exposed portion on the sides of a gable roof that extends upwards toward the ridge.
Ridge	The uppermost horizontal line where two sloping planes meet on a roof.
Roof Pitch	The steepness of a roof, typically expressed as a ratio of rise to run in feet (e.g. 4:12)
Side Wall	A junction between a wall and a sloped portion of a roof.
Surface Mount Counter Flashing	A type of counterflashing that is applied on the surface of the wall to protect the roof-to-wall intersection.

Vapor Retardant	A material used in building construction to control the rate of water vapor from entering the building envelope assemblies. The ability of a material to retard the diffusion of water vapor is measured in units known as "perms" or permeability.
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Solar Terminologies

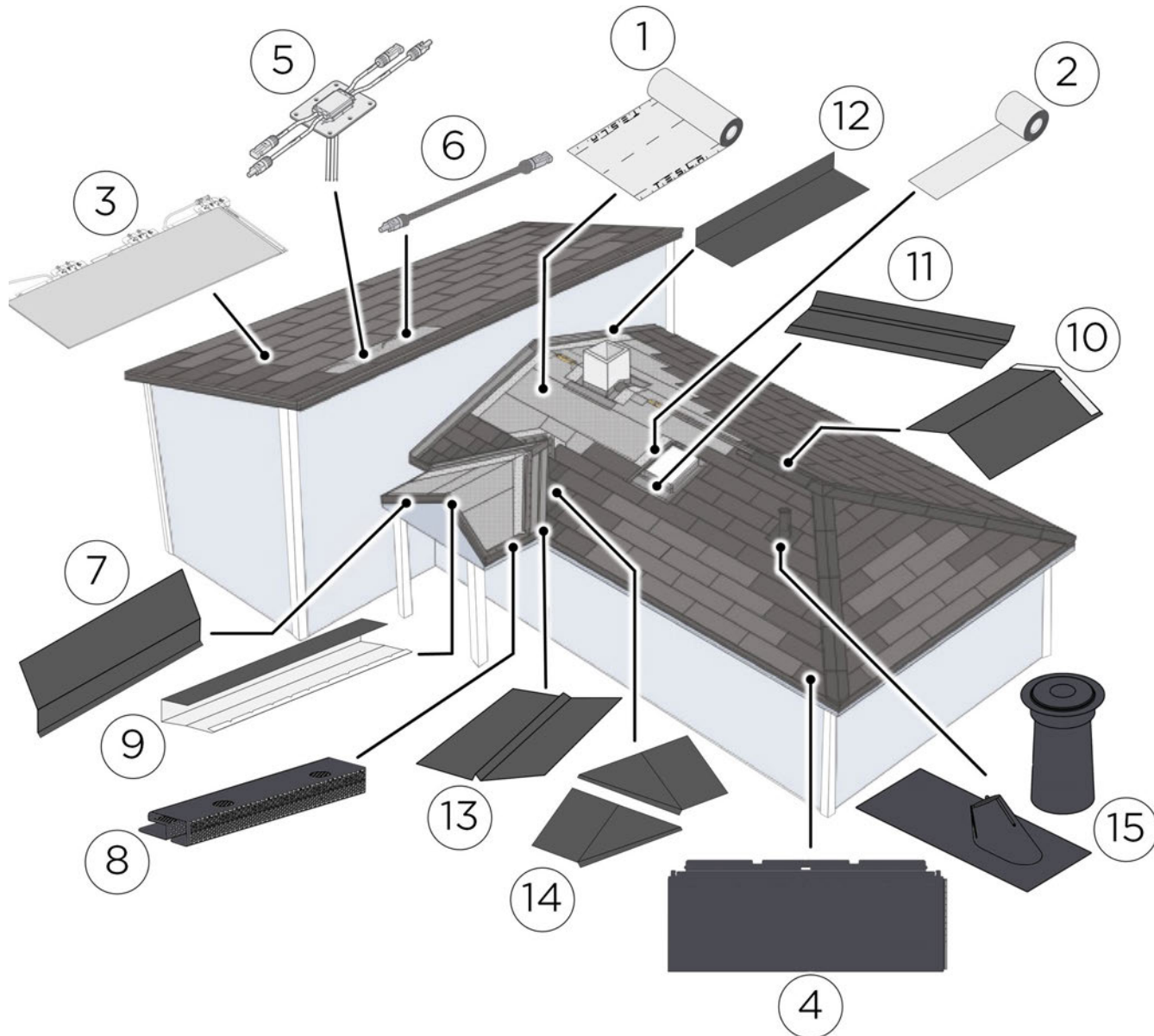
Term	Definition
Azimuth	The direction a roof plane points on the compass rose. Azimuth is measured in degrees on a circle where north is 0° and south is 180°.
Efficiency	The fraction of incident sunlight converted to useful power, as a % of 1 standard sun of illumination.
(Electrical) Grid	A network of power lines and associated infrastructure used to generate and distribute electricity from power plants to consumers. This includes electrical power-generating stations, transmission lines and distribution lines that provide electricity to homes, businesses, etc.
Hard Shade	Shade from a solid building or structure that allows no light to pass through.
Inverter	Converts solar-generated power from Direct Current (DC) voltage to Alternating Current (AC) voltage to power homes.
kWh	kWh are the units in which electrical energy usage is primarily measured.
Light Reflectance Value (LRV)	Often referred to as glare and used to quantify the amount of visible light that a surface reflects. LRV is typically expressed as a percentage, ranging from 0% (absolute black, absorbing all light) to 100% (absolute white, reflecting all light).
Power Density	The amount of power generated, measured in watts, per meter squared.
Solar Reflectance (SR)	The ability of a material to reflect solar energy to the atmosphere. It is typically expressed as a number between 0 and 1. The higher the value, the better the material reflects solar energy,
Solar Reflectance Index (SRI)	An indicator of the roof surface's ability to return solar energy to the atmosphere. It is calculated using the roof surface's Solar Reflectance (SR) and Thermal Emittance (TE). Material with a higher SRI will be cooler than that with a lower SRI under the same solar energy exposure.
Soft Shade	Shade from trees that allow some light to pass through gaps and thin leaves.
Thermal Emittance (TE)	The relative ability of a material to radiate heat after the material has absorbed some portions of solar energy. It is typically expressed as a number between 0 and 1. The higher the value, more the material radiates the absorbed heat.

Code-Related Acronyms

Term	Definition
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
FBC	Florida Building Code
HVHZ	High Velocity Hurricane Zone as defined with in FBC.
IBC	International Building Code
IBHS	Insurance Institute for Business and Home Safety
IRC	International Residential Code
WUI	Wildlife Urban Interface

APPENDIX B: KEY PARTS OVERVIEW

This section lists the key Solar Roof parts.



1. Underlayment

2. Detail Roll

3. PV Tile

4. Metal Tile

5. Pass Through Box

6. Jumper Cable

7. Drip Edge

8. Vented Riser

9. Channel Flashing

10. Cap

11. Transition Flashing

12. Wall Flashing

13. Valley Pan

14. Adjustable Trim (left, right)

15. Heat Vent Flashing and Cap

APPENDIX C: DESIGN CLEARANCE REQUIREMENTS

Tesla Designers will work with designers, building professionals and homeowners to determine the optimal Solar Roof power producing and non-power producing Tiles layout to meet the building's anticipated energy demand. The illustrations and Tables in this section summarize the "No Tile" and "No PV" clearance requirements around common roof features, penetrations and obstructions.

Note that local fire and building codes clearance requirements are not included in the Tables. Tesla designers will also consider and incorporate these requirements during the design and permitting process.

Table 1 - Linear Feature Set Back Table

Common Roof Feature	No Tile Zone (inches)	No PV Zone (inches)
Eave	0-in	0-in
Valley	8-in	14-in
Hip	5-in	9.5-in
Ridge	3.5-in	13-in
Rake	0-in	6.5-in
Peak Wall	0-in	7-in
Head Wall	9-in	16-in
Side Wall	5-in	11.5-in
End Wall	4-in	4-in
Other	1-in	1-in

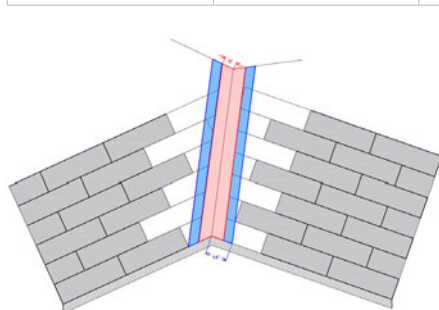
Legend

 PV Tile

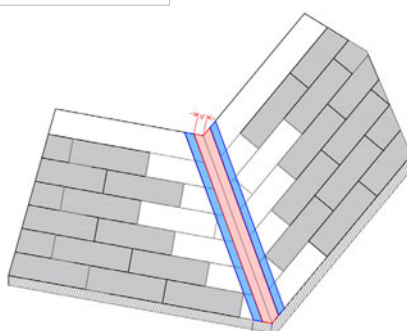
 Metal / Glass Tile

 No Tile Zone - Areas around the roof feature where cutting of the Metal Tiles should be avoided to comply with Solar Roof installation practices.

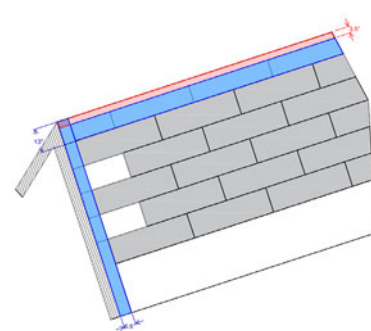
 No PV Zone - Areas around the roof feature where PV Tiles cannot be installed to avoid installation complications.



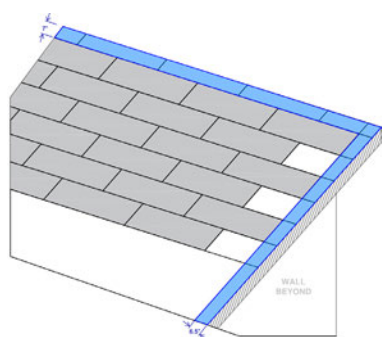
Eave and Valley



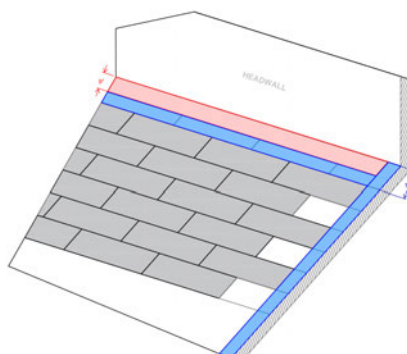
Hip



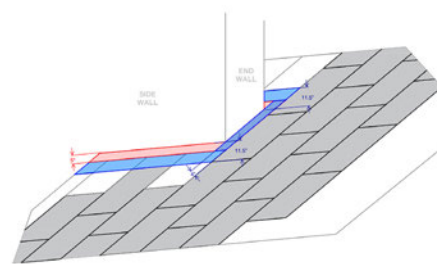
Ridge



Peak Wall



Head Wall



Side Wall and
End Wall

Table 2 - Common Roof Penetrations and Obstructions Clearance Requirements

Penetration or Obstruction	Junction	No Cut Zone (inches)	No PV Zone (inches)	Note
Skylight and Chimney	Down roof (head wall)	9-in	15-in	Measured from obstruction edges.
	Left / right side (side wall)	5-in	11.5-in	
	Up roof (end wall)	4-in	4-in	
Drain Waste Vent	Down roof (head wall)	6-in	9.5-in	Measured from obstruction center.
	Left / right side (side wall)	4-in	8-in	
	Up roof (end wall)	5-in	5-in	
Heat Vent (4-in or less)	Down roof (head wall)	9-in	12-in	Measured from obstruction center.
	Left / right side (side wall)	5-in	8.5-in	
	Up roof (end wall)	5-in	6-in	
Heat Vent (5-in to 8-in in size)	Down roof (head wall)	9-in	15.5-in	Measured from obstruction center.
	Left / right side (side wall)	5-in	10.5-in	
	Up roof (end wall)	5-in	8-in	
All Other Obstructions	Down roof (head wall)	9-in	15-in	Measured from obstruction edges.
	Left / right side (side wall)	5-in	11.5-in	
	Up roof (end wall)	4-in	4-in	

APPENDIX D: ARCHITECTURAL DETAILS

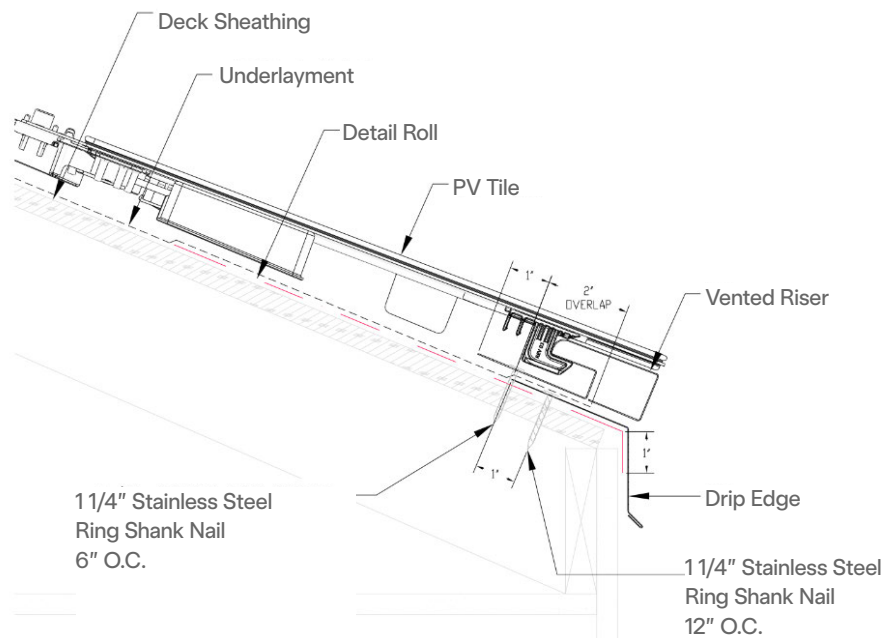
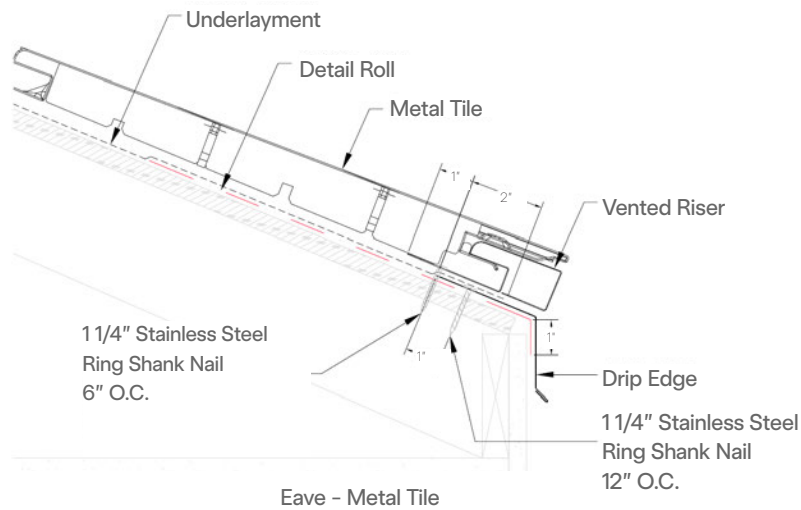
The section provides architectural drawings of common roof features.

Architectural Details Table of Contents

1. Eave
2. Eave with Gutter
3. Rake
4. Hip
5. Ridge - Vented
6. Ridge - Unvented
7. Valley
8. Head Wall Flashing
9. Side Wall Flashing
10. End Wall Flashing
11. Drain Waste Vent (DWV)
12. Tile Vent
13. Chimney
14. Chimney with Cricket at End Wall
15. Curb-Mounted Skylight
16. Peak Wall
17. Peak Wall with Overhang
18. Roof Windows at Head Wall
19. Roof Windows at Side Wall
20. Low Slope (Single-Ply Membrane) to Steep Slope Roof Transition
21. Steep-to-Steep Slope Transitions: Gambrel Roof
22. Steep-to-Steep Slope Transitions: Bonnet Roof

Eave

Scale: None

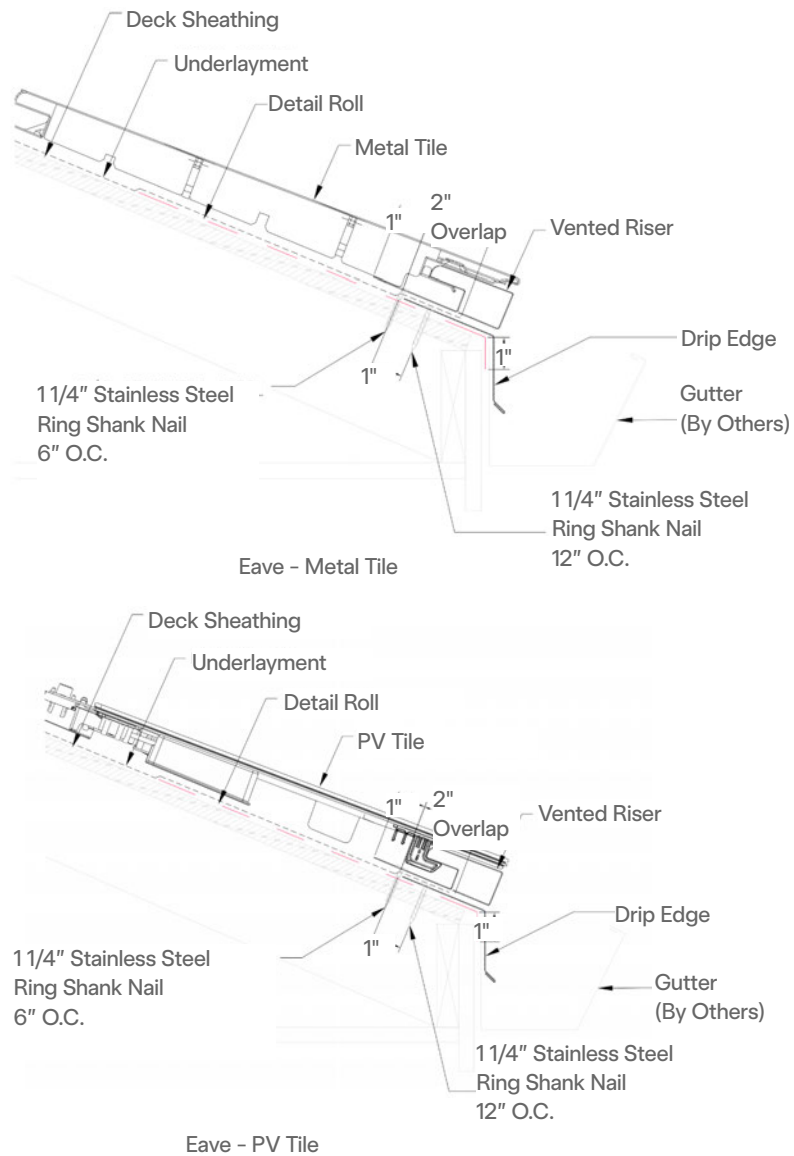


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. DETAIL ROLL EXTENDS 1-INCH DOWN THE FACE OF THE FASCIA.
3. FIELD UNDERLAYMENT OVERLAPS ONTO DRIP EDGE. ALIGN UNDERLAYMENT ONTO THE NOTCH INDICATED ON THE DRIP EDGE, WHICH IS 1-INCH FROM THE EDGE.
4. FASTENING REQUIREMENTS FOR HIGH WIND ENVIRONMENT WITH WIND SPEED BETWEEN 121-180 MPH ARE DIFFERENT THAN STANDARD APPLICATION, REFER TO [SOLAR ROOF INSTALLATION MANUAL: FASTENING SCHEDULE](#).

Eave with Gutter

Scale: None

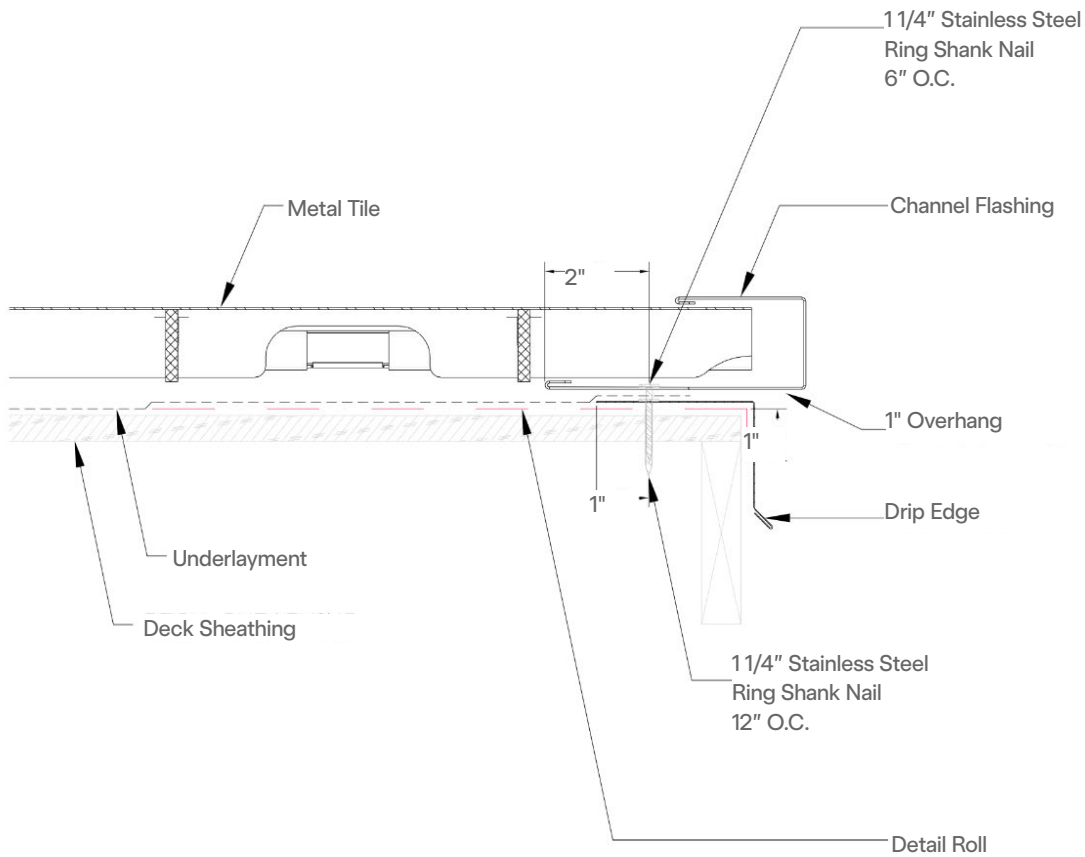


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. DETAIL ROLL EXTENDS 1-INCH DOWN THE FACE OF THE FASCIA.
3. GUTTER STYLE AND PLACEMENT ARE BEYOND THE SCOPE OF DESIGN FOR SOLAR ROOF. GUTTER SYSTEM AND ITS DRAINAGE CAPACITY IS ROOF PITCH DEPENDENT. RECOMMEND EXTENDING DRIP EDGE 2-INCH MIN INTO GUTTER.

Rake

Scale: None

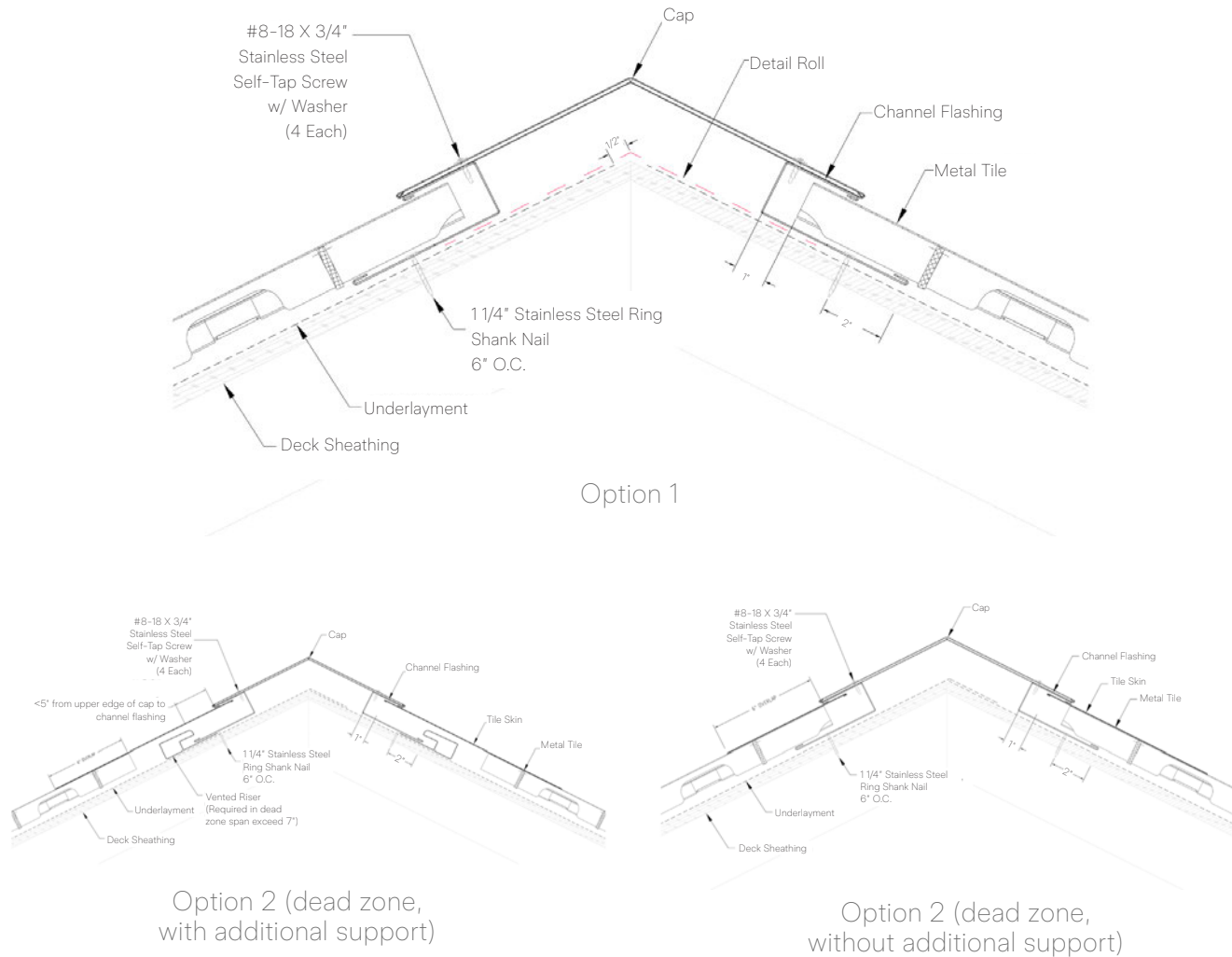


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. DETAIL ROLL EXTENDS 1-INCH DOWN THE FACE OF THE FACIA.

Hip

Scale: None

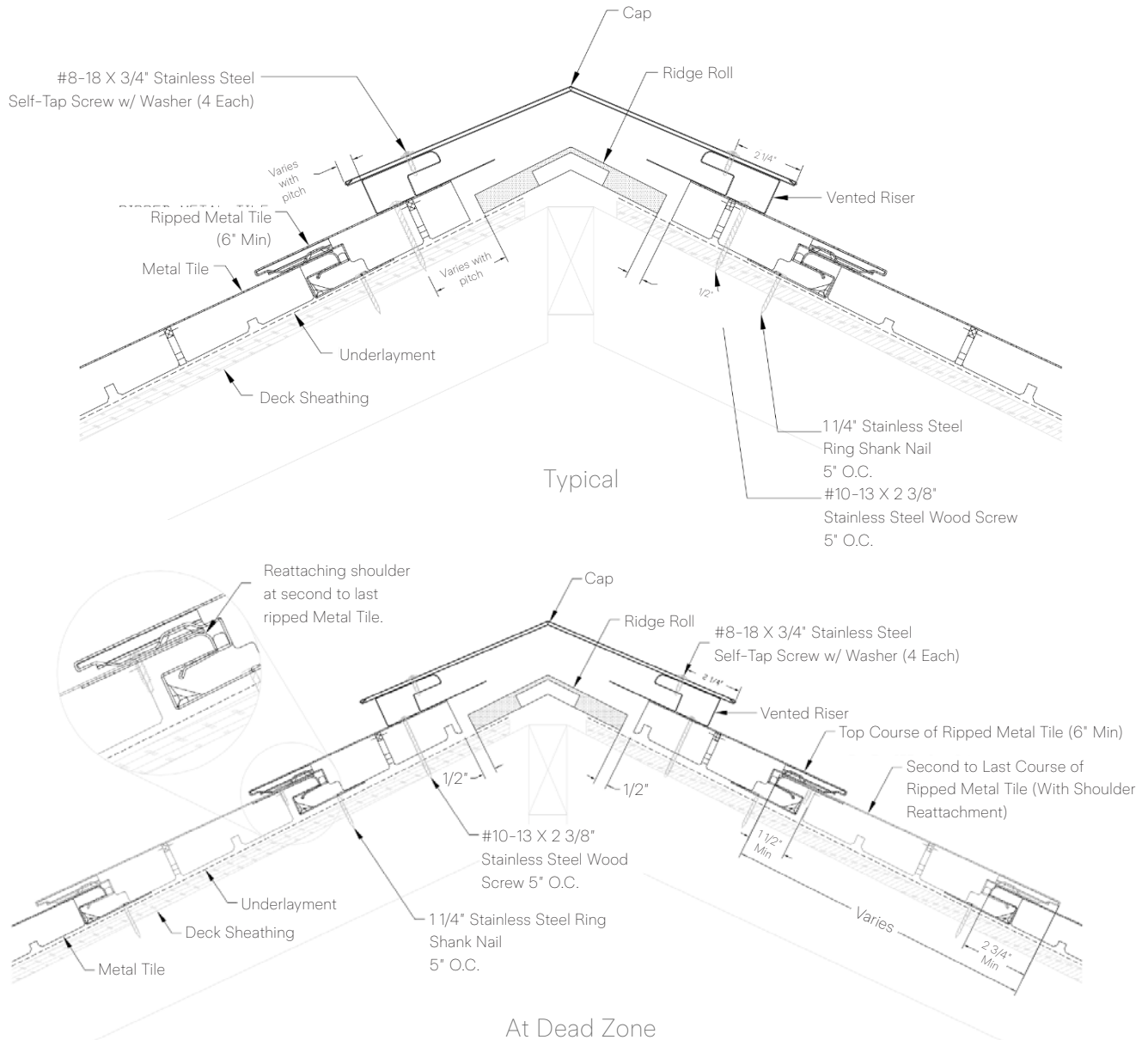


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. A ROOF PITCH OF 6:12 IS ILLUSTRATED.
3. THERE ARE TWO OPTIONS TO ACHIEVE DRY-IN AT HIP. OPTION 1: UTILIZING DETAIL ROLL ABOVE UNDERLAYMENT. OPTION 2: OVERLAPPING OF UNDERLAYMENT.
4. DEAD ZONE AT HIP IS AN AREA IN WHICH A FULL SIZED METAL TILE CANNOT BE INSTALLED NEAR THE CHANNEL FLASHING, REQUIRING THE USE OF TILE SKIN TO BRIDGE THE GAP BETWEEN THE FULL SIZED METAL TILE AND THE CHANNEL FLASHING.
5. TILE SKIN SHOULD LAP OVER TILE FOR 6-INCHES.
6. DEPENDING ON THE SIZE OF THE DEAD ZONE, ADDITIONAL SUPPORT MAY BE REQUIRED. MAXIMUM SPAN ON A DEAD ZONE IS 7-INCHES. IF ANY PORTION OF DEAD ZONE EXCEEDS 7-INCHES, VENTED RISER SHOULD BE INSTALLED BELOW THE TILE SKIN TO PROVIDE ADEQUATE SUPPORT.

Ridge - Vented

Scale: None

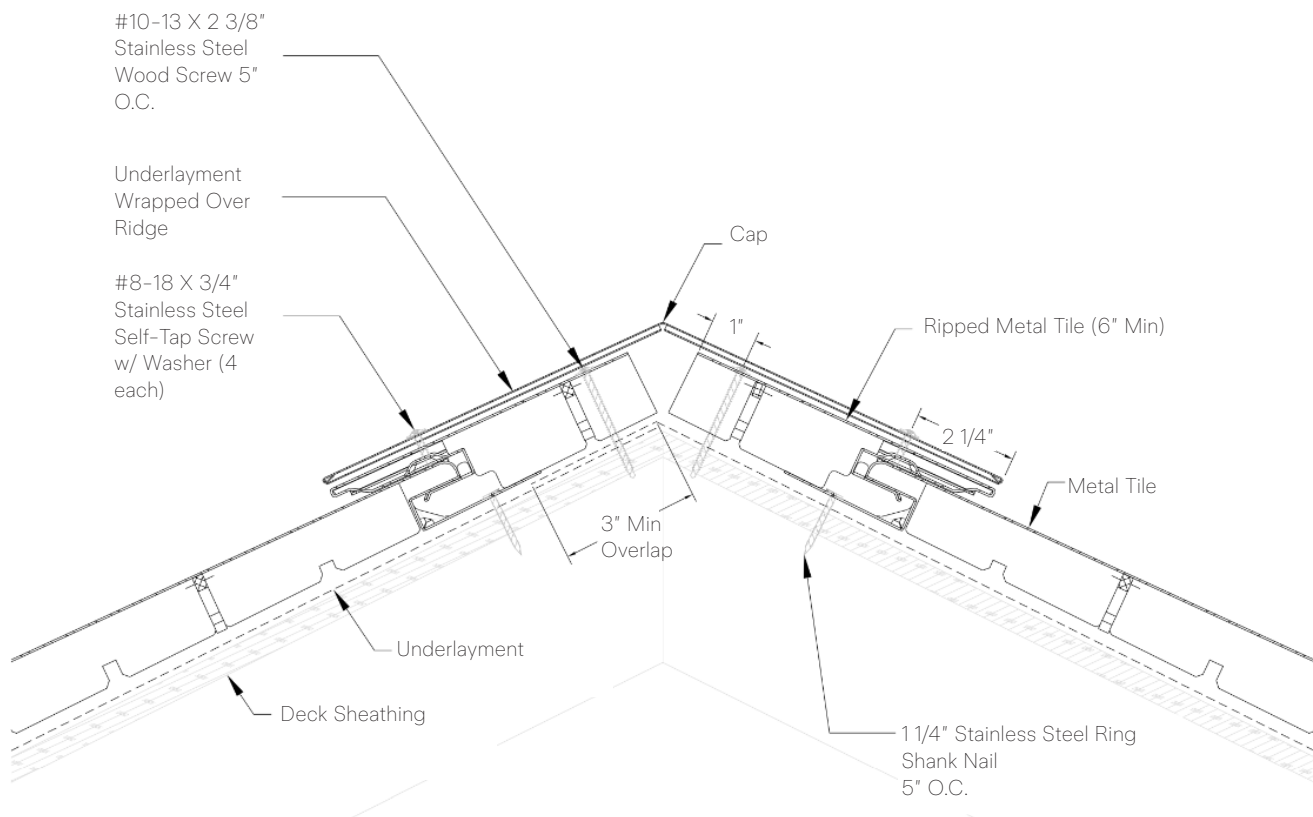


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. A ROOF PITCH OF 5:12 IS ILLUSTRATED.
3. MINIMUM WIDTH OF RIPPED METAL TILE IS 6-INCHES. RIPPED METAL AT RIDGE DOES NOT REQUIRE SHOULDER REATTACHMENT.
4. VENT OPENING AT DECK SHOULD BE 1/2-INCH MINIMUM, BUT SHOULD NOT EXCEED 3/4-INCH.
5. THE NET FREE VENTILATION AREA (NFVA) IS 12.5-INCHES PER LINEAR FOOT OF RIDGE LENGTH.

Ridge - Unvented

Scale: None

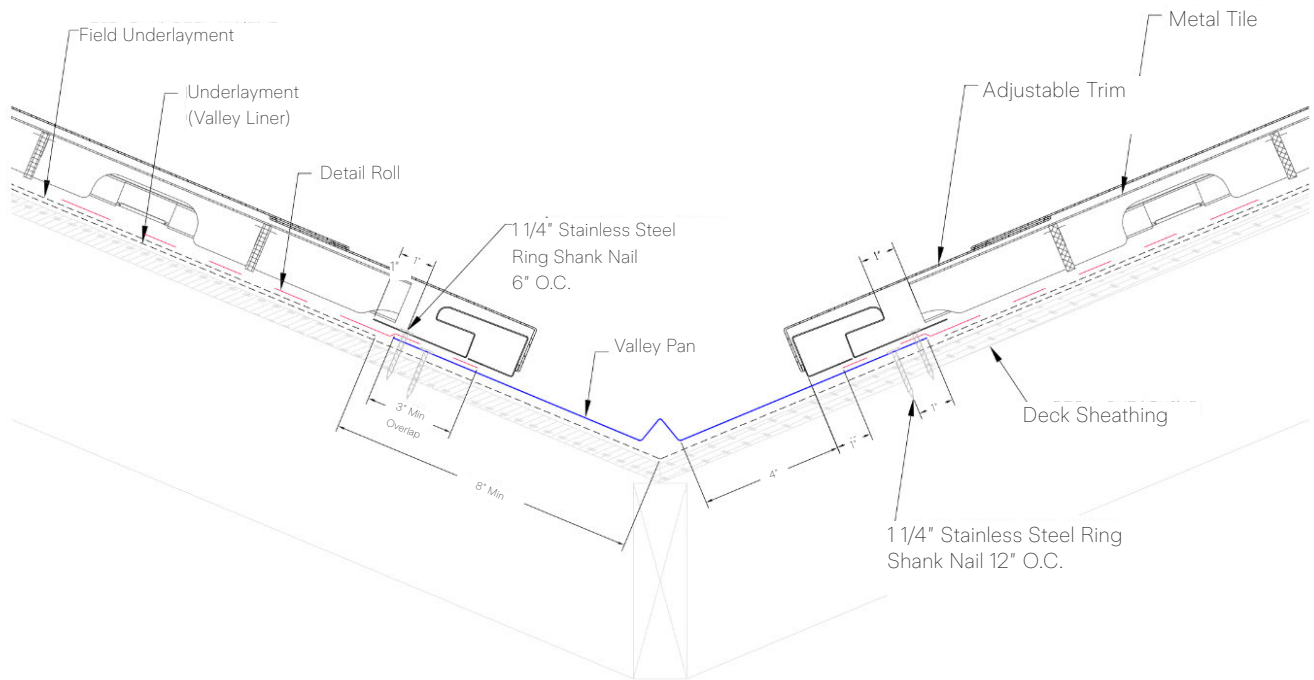


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. A ROOF PITCH OF 6:12 IS ILLUSTRATED.
3. MINIMUM WIDTH OF RIPPED METAL TILE IS 6-INCHES. RIPPED METAL AT RIDGE DOES NOT REQUIRE SHOULDER REATTACHMENT.

Valley

Scale: None

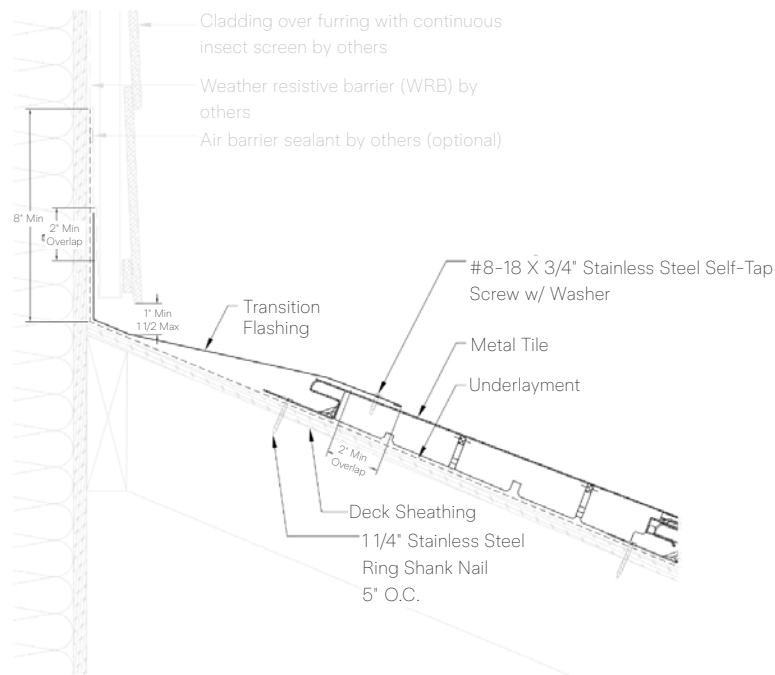


NOTES

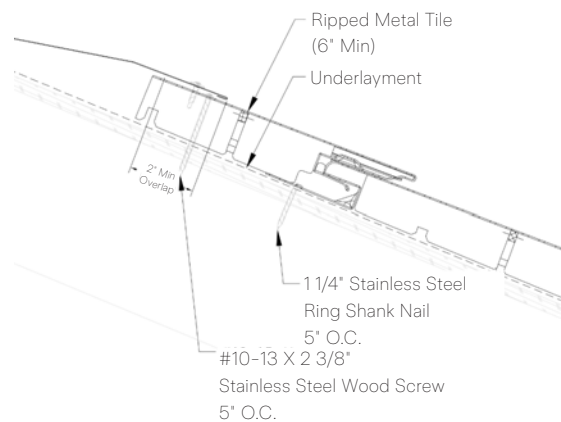
1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.

Head Wall Flashing

Scale: None



Typical



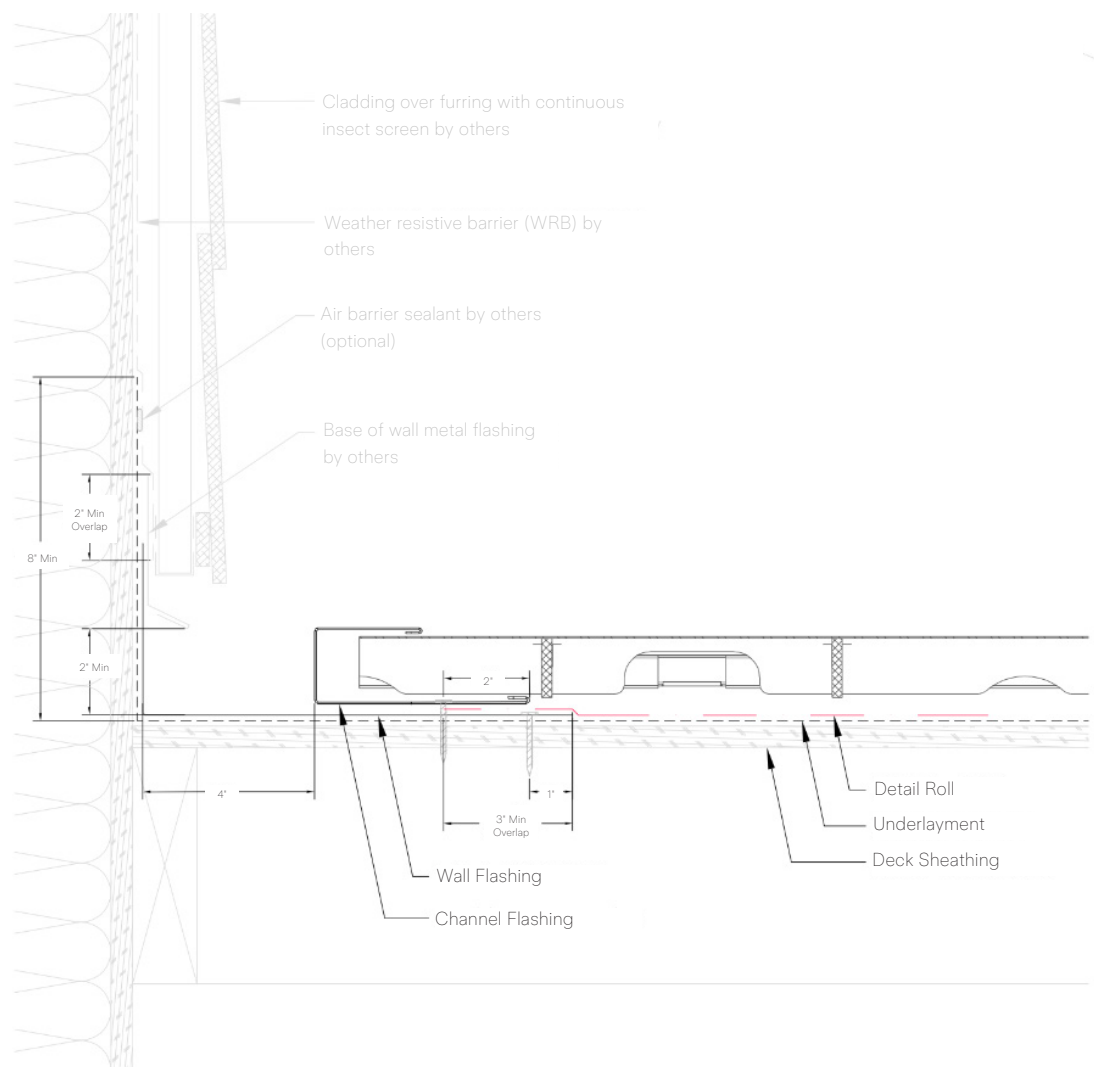
Alternate Detailing: When top course of Metal Tile requires ripping.

NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.

Side Wall Flashing

Scale: None

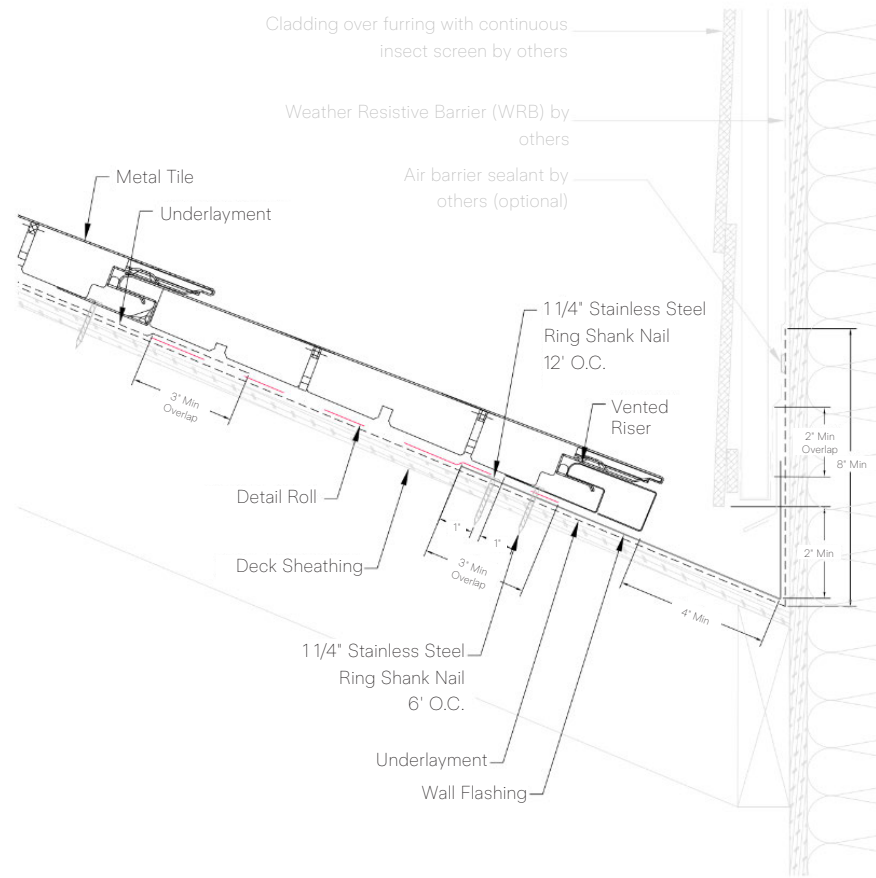


NOTES

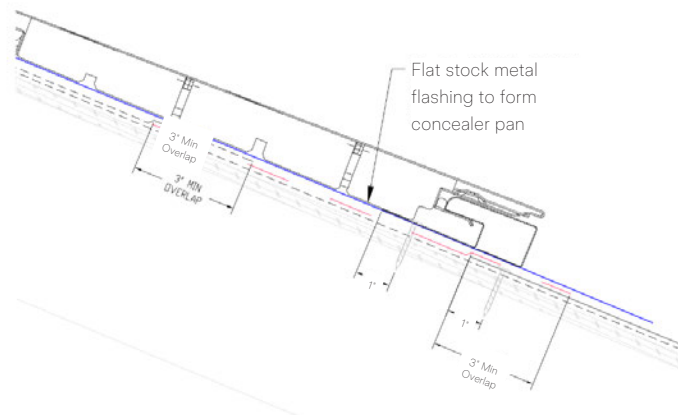
1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.

End Wall Flashing

Scale: None



Typical



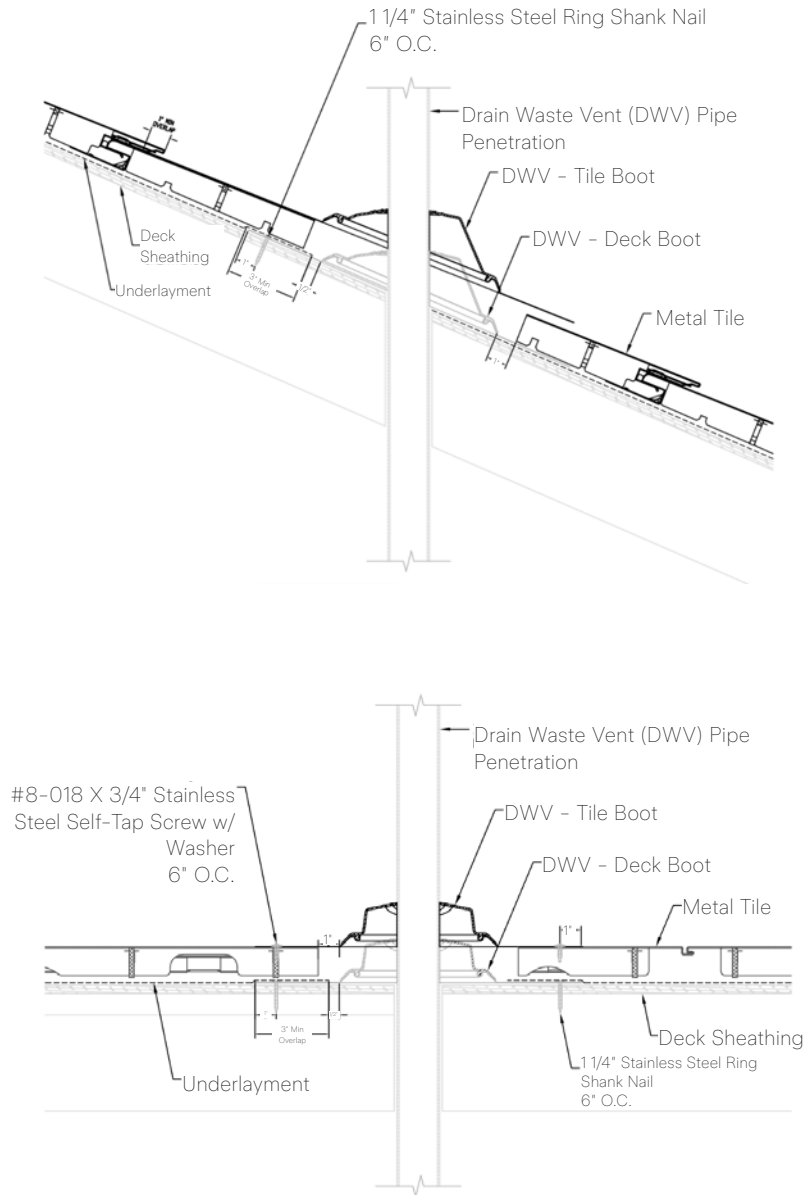
Alternative detailing: When Metal Tile does not align with 4-inch Wall Flashing

NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.

Drain Waste Vent (DWV)

Scale: None

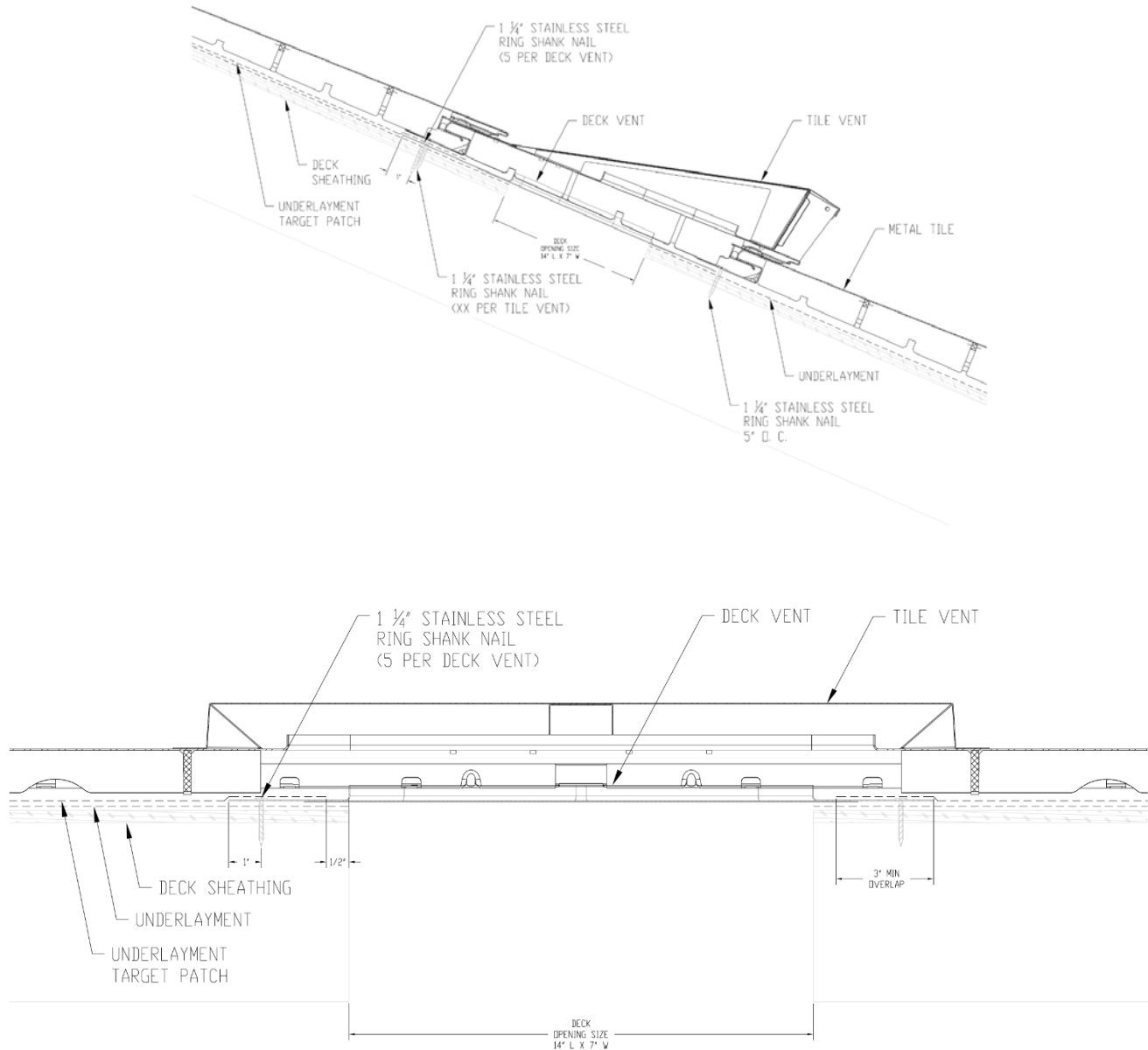


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. FASTENING OF DWV - DECK BOOT OCCURS ON THE FLANGE, ALONG TOP AND SIDES. DECK BOOT IS FASTENED EVERY 6-INCHES. DO NOT FASTEN AT THE BOTTOM SECTION OF FLASHING.
3. FASTENING OF DWV - TILE BOOT OCCURS ON THE FLANGE, ALONG TOP AND SIDES. TILE BOOT IS FASTENED EVERY 6-INCHES. DO NOT FASTEN AT THE BOTTOM SECTION OF FLASHING.
4. THE UPPER FLANGE OF THE TILE BOOT IS TYPICALLY TUCKED BELOW THE NEXT TILE COURSE UP ROOF AND IS FIELD CUT TO SIZE. ENSURE 1-INCH MIN OVERLAP BETWEEN SOLAR ROOF TILE AND UPPER FLANGE.

Tile Vent

Scale: None

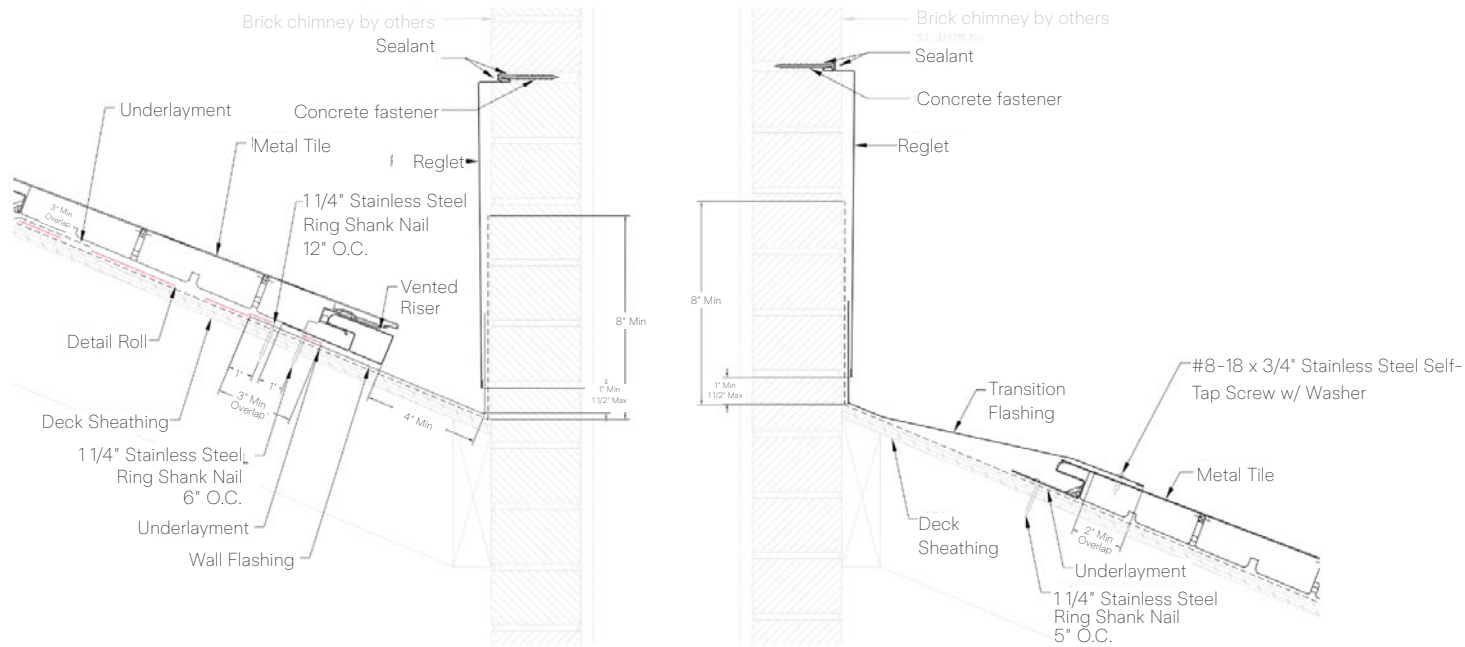


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. DECK OPENING SIZE SHOULD BE THE SAME AS THE MESH PORTION OF THE DECK VENT.
3. DECK VENT SHOULD ALIGN DIRECTLY OVER DECK OPENING.
4. FASTENING OF DECK VENT OCCURS ON THE VENT FLANGE, BELOW WIRE MESH.
5. THE NET FREE VENTILATION AREA (NFVA) IS 40-SQ-INCHES PER TILE VENT.

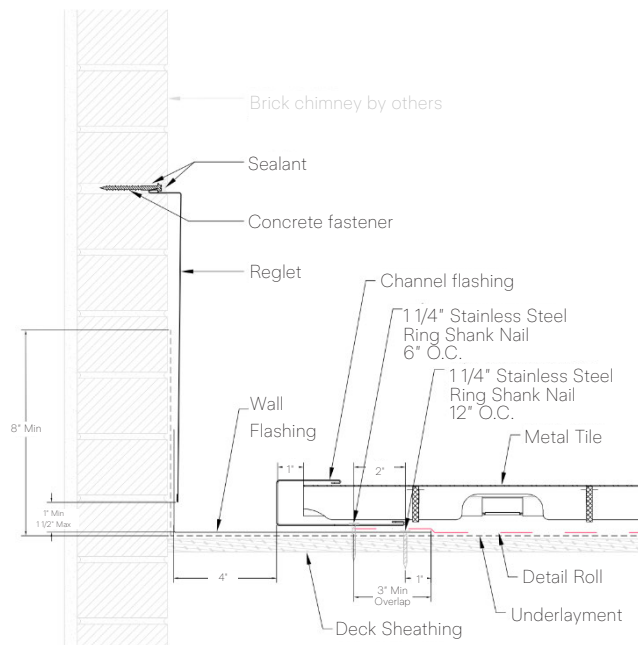
Chimney

Scale: None



End Wall

Head Wall



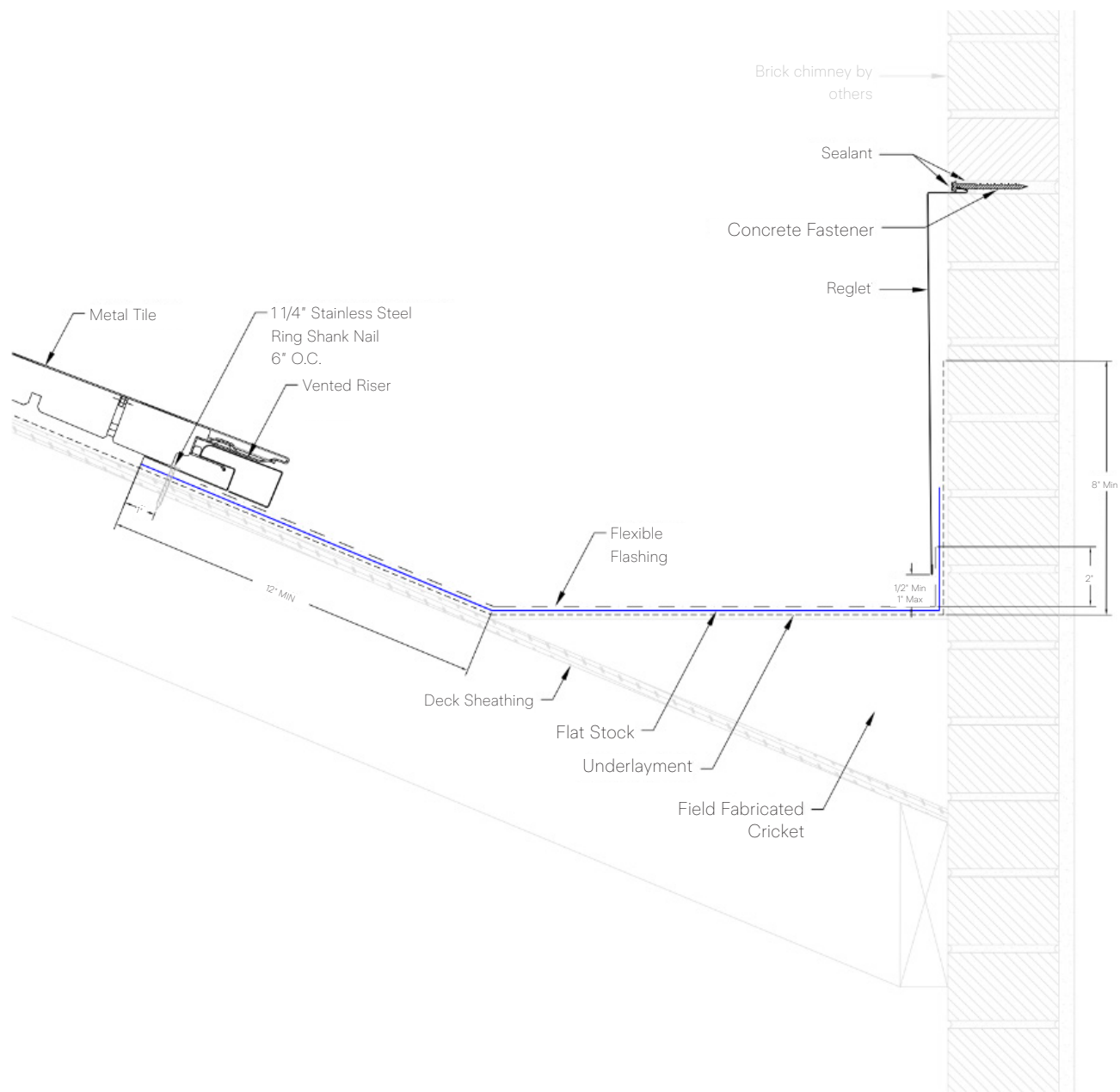
Side Wall

NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. THIS DETAIL IS APPLICABLE WHEN CHIMNEY WIDTH PARALLEL TO THE RIDGELINE IS LESS THAN 30-INCHES.

Chimney with Cricket at End Wall

Scale: None

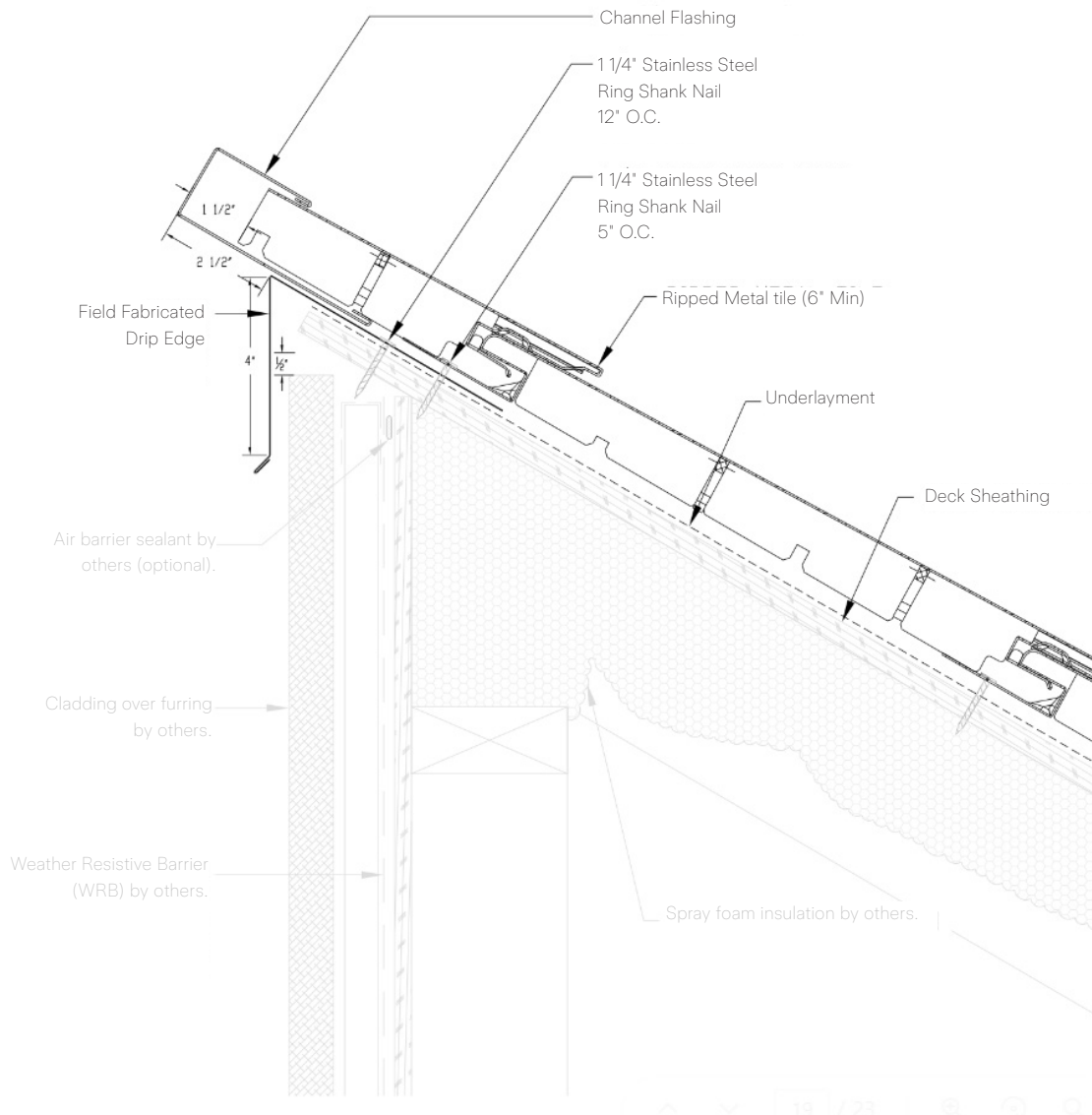


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. THIS DETAIL IS APPLICABLE WHEN CHIMNEY WIDTH PARALLEL TO THE RIDGELINE IS GREATER THAN 30-INCHES AND A CRICKET IS REQUIRED.
3. CRICKETS SHALL BE CONSTRUCTED IN COMPLIANCE WITH APPLICABLE BUILDING CODES AND REGULATION.

Peak Wall

Scale: None

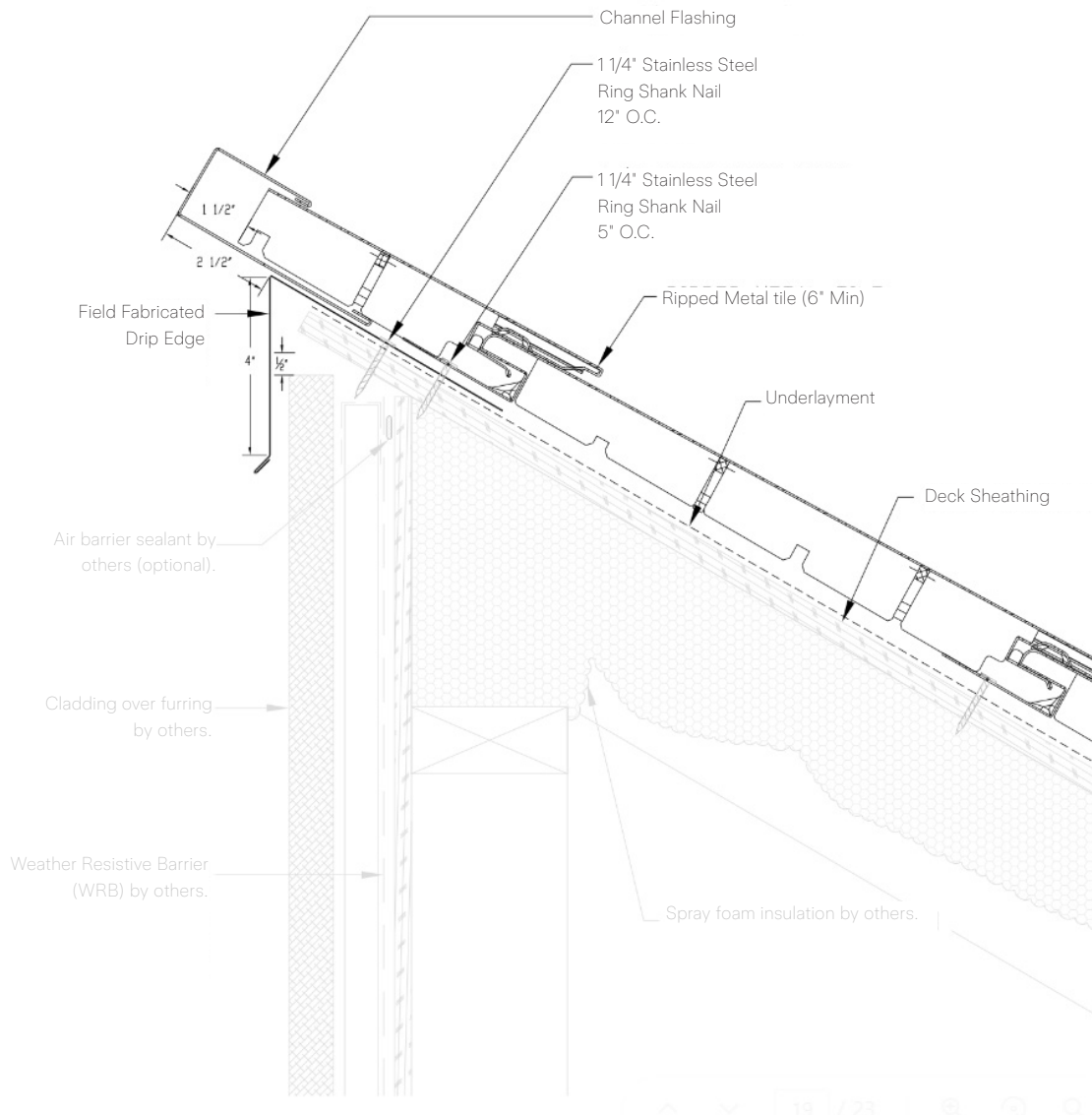


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. THIS DETAIL IS APPLICABLE TO UNVENTED ROOF ASSEMBLIES, WHERE SPRAY FOAM INSULATION IS INSTALLED AT THE UNDERSIDE OF THE DECK SHEATHING. LOCAL BUILDING CODE OUTLINES MINIMUM R-VALUE REQUIREMENTS AND TYPES BY CLIMATE ZONE. CONSULT YOUR JURISDICTION TO ASSURE COMPLIANCE WITH LOCAL BUILDING CODE.

Peak Wall with Overhang

Scale: None

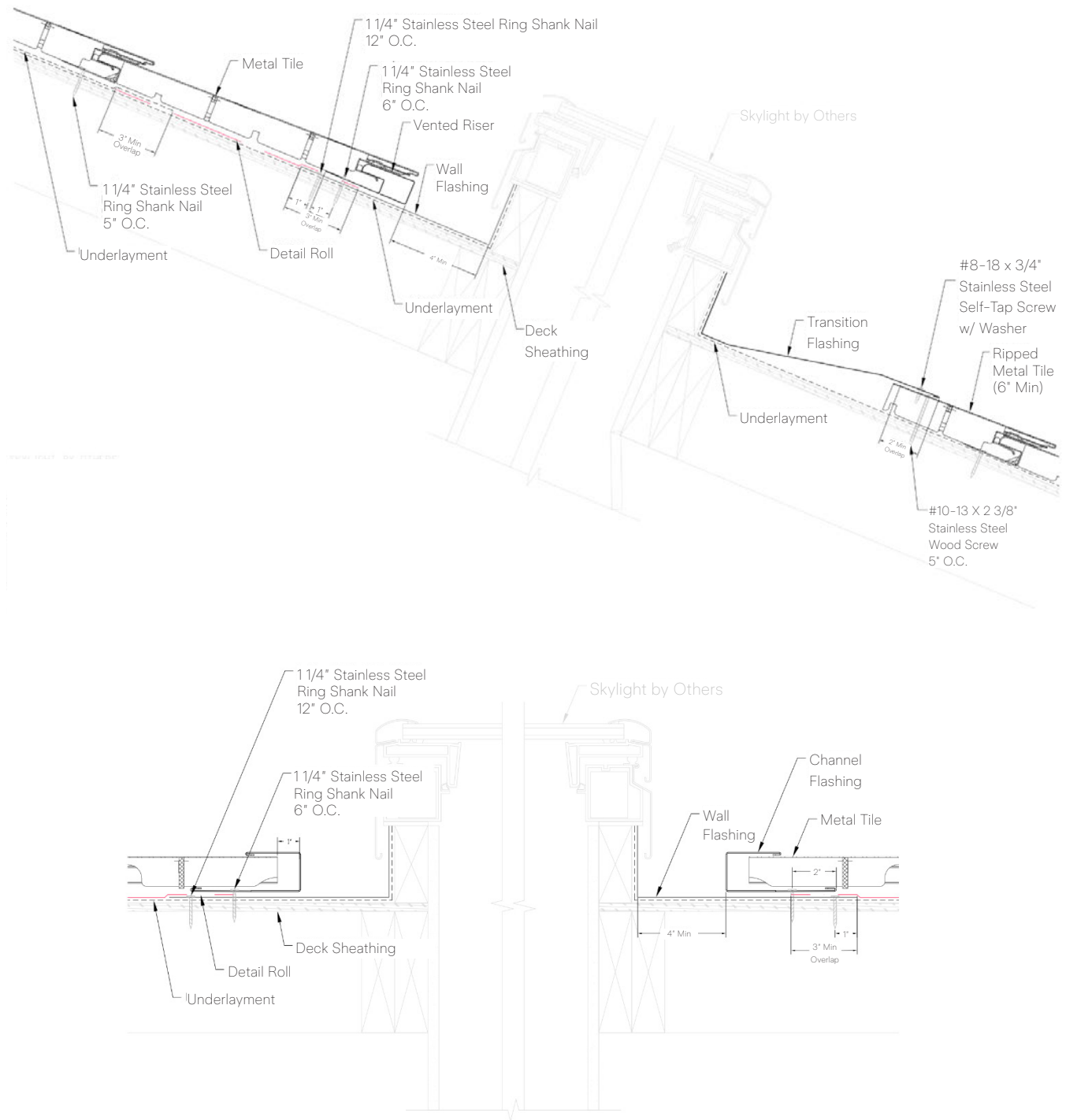


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. THIS DETAIL IS APPLICABLE TO VENTED ROOF ASSEMBLIES. LOCATION AND SIZING OF SOFFIT VENTS ARE BEYOND SCOPE OF DESIGN AND INSTALLATION FOR SOLAR ROOF.
3. DETAIL ROLL EXTENDS 1-INCH DOWN THE FACE OF THE FASCIA.
4. FASTENING REQUIREMENTS FOR HIGH WIND ENVIRONMENT WITH WIND SPEED BETWEEN 121-180 MPH ARE DIFFERENT THAN STANDARD APPLICATION. REFER TO [SOLAR ROOF INSTALLATION MANUAL - FASTENER SCHEDULE](#).

Curb-Mounted Skylight

Scale: None

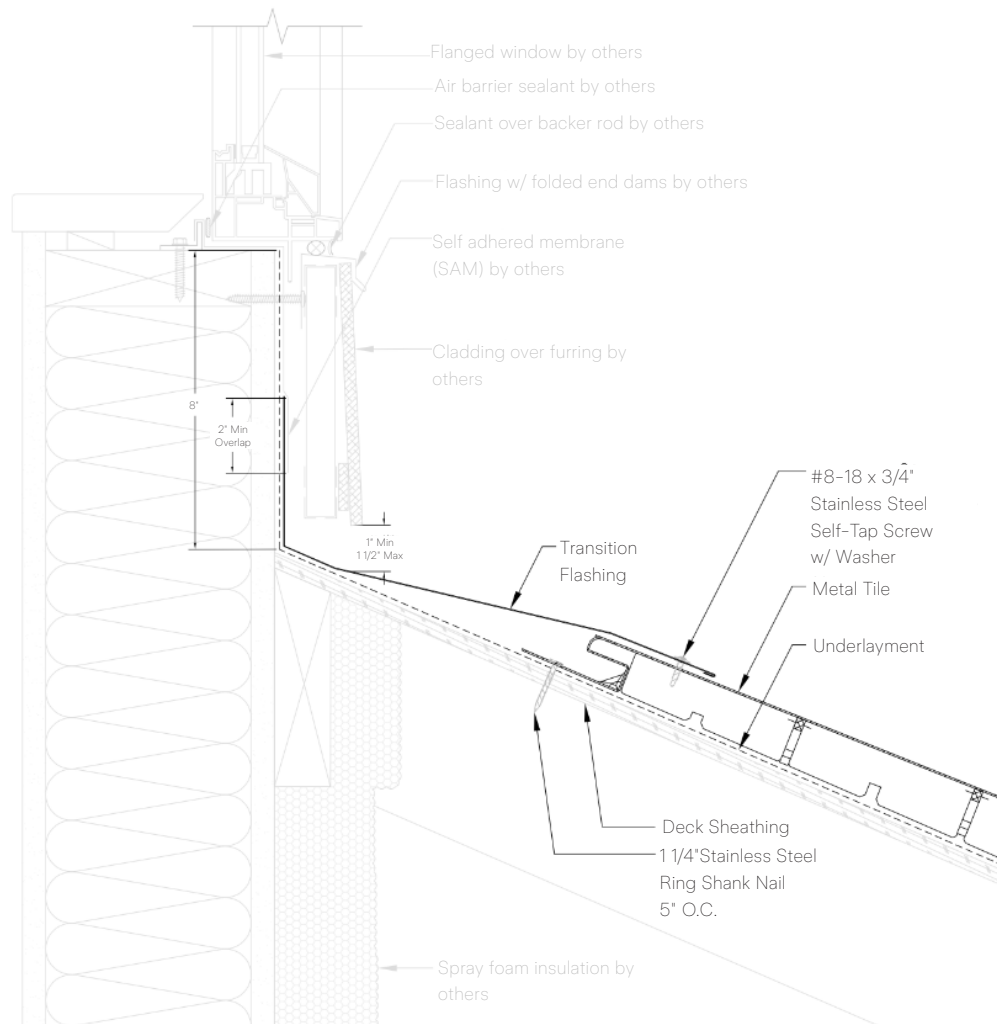


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. LAP TRANSITION FLASHING MINIMUM 2-INCHES OVER UNDERLAYING RIPPED METAL TILE.

Roof to Window Sill at Head Wall

Scale: None

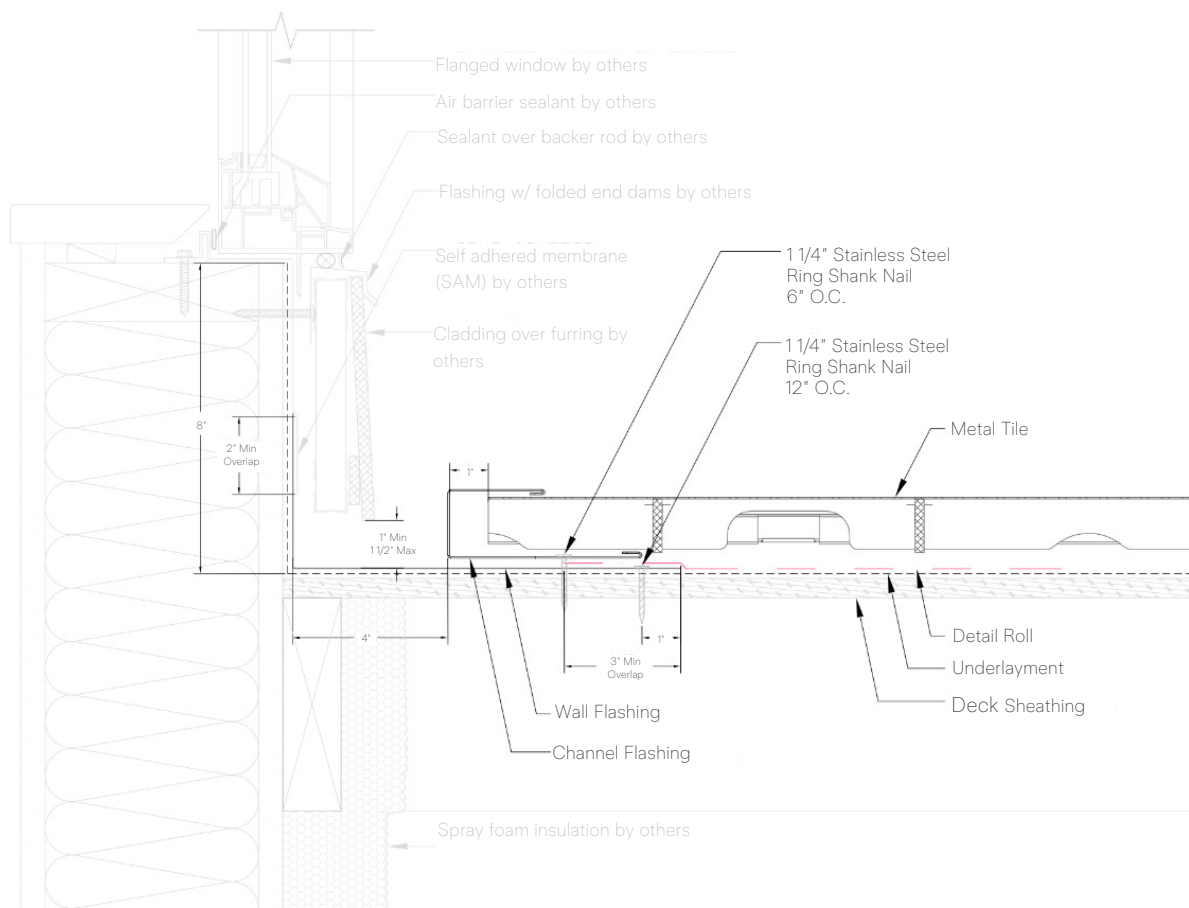


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. THIS DETAIL IS APPLICABLE TO ROOFS WITH ATTIC SPACE BUTTING INTO WALL WITH WINDOW ROUGH OPENING LOCATING WITHIN 8-INCHES FROM THE WALL TO ROOF TRANSITION.
3. SELF ADHERED MEMBRANE (SAM) AT WINDOW SILL SHOULD POSITIVELY LAP OVER THE UPPER LEG OF THE TRANSITION FLASHING TO PROVIDE AIR AND WATER CONTROL.

Roof to Window Sill at Side Wall

Scale: None

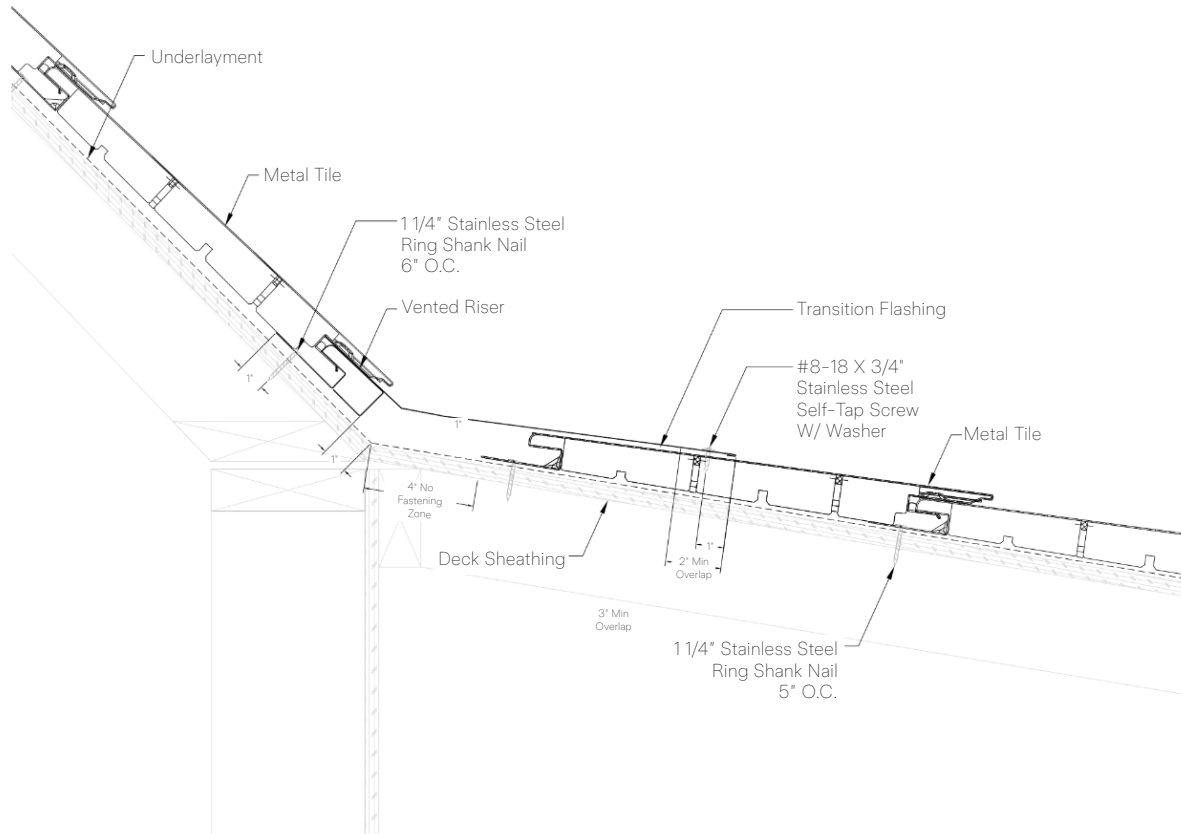


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. THIS DETAIL IS APPLICABLE TO ROOFS WITH ATTIC SPACE BUTTING INTO WALL WITH WINDOW ROUGH OPENING LOCATING WITHIN 8-INCHES FROM THE WALL TO ROOF TRANSITION.
3. SELF ADHERED MEMBRANE (SAM) AT WINDOW SILL SHOULD POSITIVELY LAP OVER THE UPPER LEG OF THE TRANSITION FLASHING TO PROVIDE AIR AND WATER CONTROL.

Steep-to-Steep Slope Transitions: Bonnet Roof

Scale: None

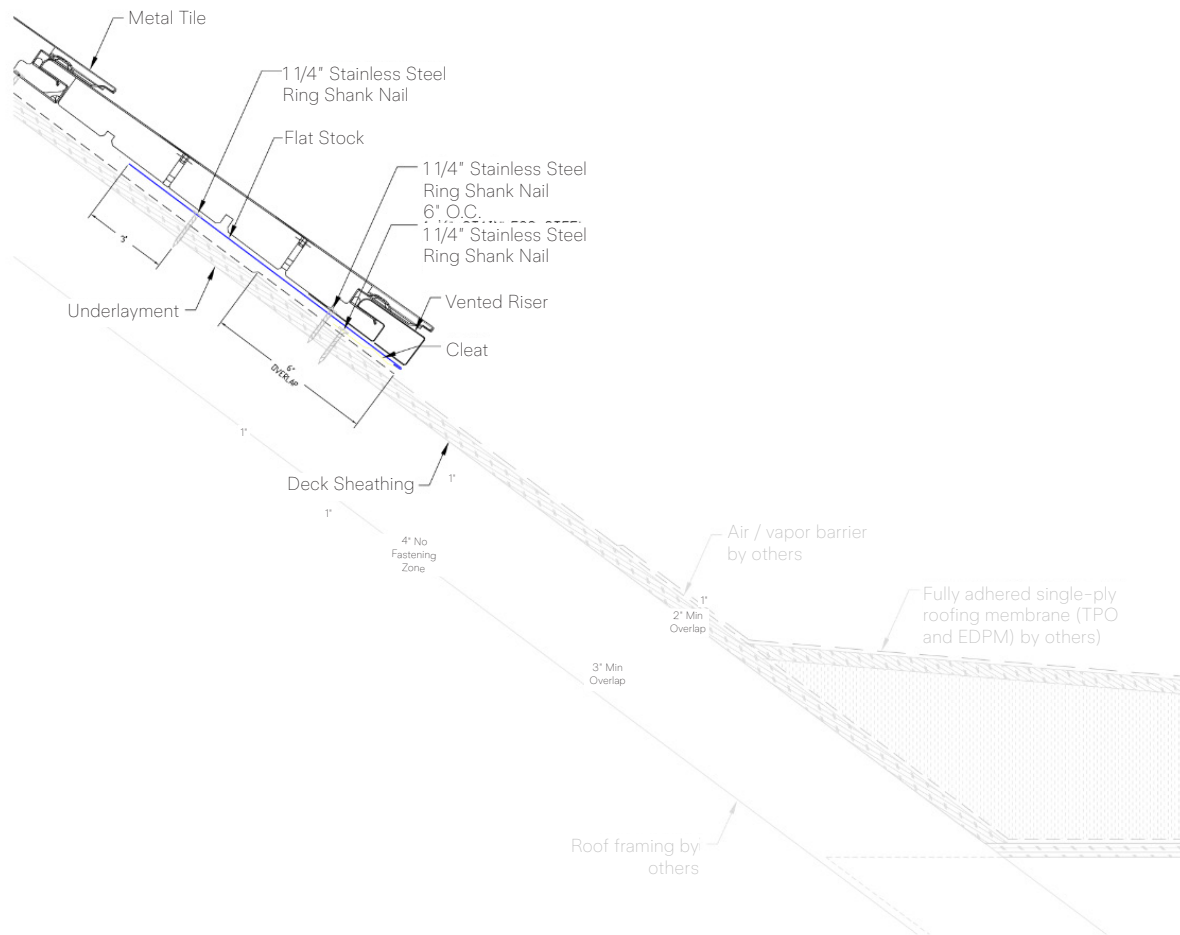


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. A ROOF PITCH OF 2:12 IS ILLUSTRATED FOR THE LOW-SLOPE ROOF ASSEMBLY.
3. A ROOF PITCH OF 11:12 IS ILLUSTRATED FOR THE STEEP-SLOPE ROOF ASSEMBLY.

Low Slope (Single-Ply Membrane) To Steep-Slope Roof Transition

Scale: None

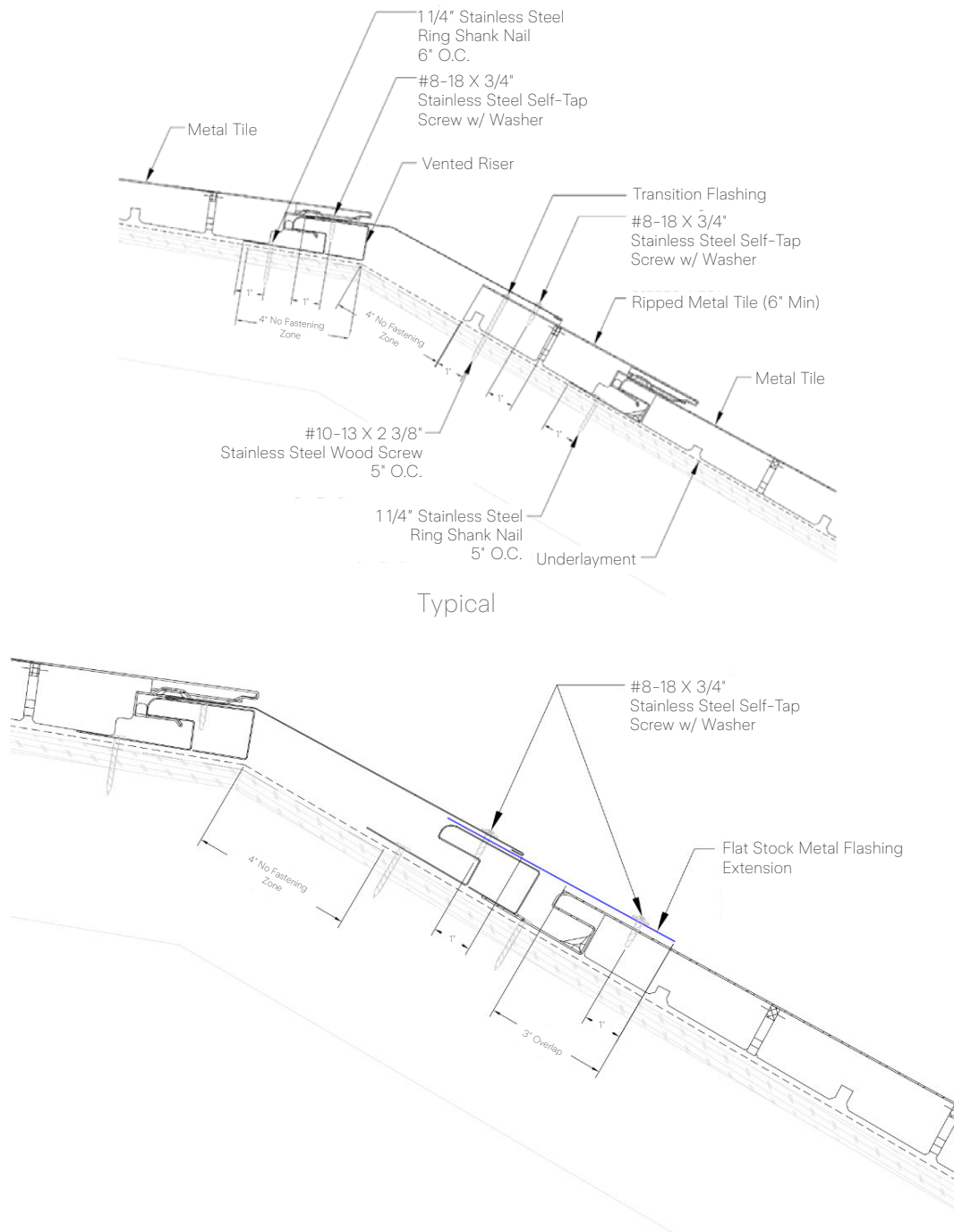


NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. A ROOF PITCH OF 1:12 IS ILLUSTRATED FOR THE LOW-SLOPE ROOF ASSEMBLY.
3. A ROOF PITCH OF 9:12 IS ILLUSTRATED FOR THE STEEP-SLOPE ROOF ASSEMBLY.
4. TESLA UNDERLAYMENT IS COMPATIBLE WITH EPDM AND TPO SINGLE-PLY ROOFING MEMBRANE TYPES. THE UNDERLAYMENT SHOULD OVERLAP A MINIMUM OF 6-INCHES ONTO THESE SINGLE-PLY ROOFING MEMBRANES.
5. THE SINGLE-PLY ROOFING MEMBRANE SHOULD TURN UP BEYOND THE FLOOD PLANE AND/OR ICE DAM ZONE, TYPICALLY 18 TO 24-INCHES FROM THE LOWER ROOF. DEFER TO LOCAL BUILDING CODE AND STANDARD SINGLE-PLY MEMBRANE MANUFACTURER'S INSTALLATION INSTRUCTIONS.

Steep-to-Steep Slope Transitions Gambrel Roof

Scale: None



Alternative Detailing: When top course at sloped roof transition is too short for a ripped Metal Tile.

NOTES

1. DETAIL TO BE USED IN CONJUNCTION WITH TESLA GENERAL REQUIREMENTS, APPLICATION METHODS AND APPROVED DETAILS.
2. STEEP SLOPE ROOF PITCH IS OF 7:12, LOW SLOPE ROOF PITCH IS OF 2:12.

APPENDIX E: WARRANTIES, DESIGN & INSTALLATION SUPPORT RESOURCES

Warranties

Tesla stands behind its products by providing a 25-year warranty on installation and weatherization of Solar Roof. [The limited warranty should be referenced for complete details and any limitations or exclusions.](#)

List of Documents for Solar Roof Designers

Incorporating Solar Roof into a new home construction is a collaborative effort between architects, building designers and construction professionals. Tesla's in-house designers also provide specialized support to these professionals.

To ensure successful design and installation of Solar Roof, submit the following information to Tesla:

- Architectural drawings, specifically:
 - Site plan, indicating location and orientation of building on the site, as well as landscaping features, parking areas and access points.
 - Roof plan, showing detailed representation of the roof structure, geometry and features.
 - Section cut, showing attic locations and extents, where applicable.
 - Obstruction locations or obstruction exclusion zones.

All plans should include scale reference.

Design Support Resources

The following resources can support designers during project qualification.

- For pre-installation or design questions, please email CIDesignInquiry@tesla.com
- Please refer to the [Channel Partners Contacts page](#) to contact Tesla by region.
- To contact local Tesla Certified Installers, see the [Find a Certified Installer page](#).
- See the [Energy Product Support page](#) for helpful resources and support contact information.

Installation Support Resources

Solar Roof can only be installed by Tesla-training technicians and Certified Installers. The resources below can support Tesla Certified Installers during Solar Roof installation.

- Find and contact Tesla Certified Installers at <https://www.tesla.com/support/certified-installers>
- For time-sensitive questions, please call the Tesla Channel Support Hotline: (650-953-5655)
- For non-time-sensitive questions or RMA questions, please email certifiedinstaller@tesla.com.