United Solar Ovonic LLC, A subsidiary of Energy Conversion Devices, Inc.
3800 Lapeer Road, Auburn Hills, Michigan 48326
Phone: 248-475-0100, Fax: 248-364-0510
info@uni-solar.com
www.uni-solar.com

PVL Training Seminar

UNI-SOLAR®

The PVL Series: 68 Watt and 136 Watt Field Applied PV Laminate Installation Guide for Steel Roof Systems

- ✓ For Top Terminated Laminates (with Quick Connects or J-Boxes)
- ✓ Includes solutions for Mid-Roof connection of Laminates bonded to the same pan
- ✓ Includes PVL Checklist and Final Report for Installers
- ✓ Appendix #1 Wiring PVL Modules with “Quick Connect “ Terminals
- ✓ Appendix #2 Bottom Mounted J-Box Installations
- ✓ Appendix #3 Installation Instructions for Previous Generation PVL Modules
- ✓ Appendix #4 Using a Megger for a High Potential Test (i.e. Hi-Pot)

TABLE OF CONTENTS

Field Applied PV Laminates
PVL-68 and PVL-136

INSTALLATION GUIDE

SECTION #1

1.1. Introduction

United Solar Ovonic LLC ("*UNI-SOLAR*®"), the leader in thin-film amorphous-silicon photovoltaics (PV) offers a revolutionary new line of PV modules. Unlike other photovoltaic technologies that use glass to protect their modules, *UNI-SOLAR*® modules are flexible, lightweight and architecturally attractive. These rooftop solar systems, where *UNI-SOLAR* PVL modules are bonded to conventional steel pans, emulate conventional roofing solutions in design, construction, function and installation.

UNI-SOLAR Field Applied PV laminates (PVL) are designed to provide many years of reliable roofing protection and independent electric power. They will perform at their maximum with the proper power system design, installation, use and maintenance. This manual is designed to assist product owners, roofers, and electricians in the proper use and installation of this product.

The UNI-SOLAR PVL Series modules are lightweight and flexible. These laminates are field applied (i.e. cold bonded) to Zn-Al coated steel pan (Galvalume® and Zincalume® only) pre-painted with Kynar 500® or Hylar 5000® based (70% or more) PVDF coating using a "peel and apply" application process. Certified installers do the application of these laminates to steel pans. *UNI-SOLAR* certifies installers during 1-day seminars that cover *UNI-SOLAR* products, applications and a hands-on demonstration of bonding the laminates to steel pans. Installation of the pans (with laminates) requires only a few, but important, modifications of the conventional installation procedures (location of fasteners, clip modification, Z-closure height). Roofers should be thoroughly familiar with the standard procedures prior to installation. Only qualified, licensed electricians should undertake wiring of the panels to the building's electrical system.

UNI-SOLAR PV laminates are designed for use with other specialized equipment, including DC combiner boxes, charge controllers, DC/AC inverters, and ground fault protection and interruption equipment. System design and component selections must comply with the National Electric Code (NEC) and all state and local codes

DISCLAIMER OF LIABILITY

The information contained in this manual is based on United Solar Ovonic's knowledge and experience, but such information and suggestions do not constitute a warranty expressed or implied. The methods of installation, use and maintenance of steel panels are beyond the control of United Solar Ovonic. United Solar Ovonic assumes no responsibility and expressly disclaims liability for any loss, damage or expense associated with the use, installation or operation of the metal roofing system. Any liability of United Solar Ovonic is strictly limited to the Limited Warranty. United Solar Ovonic reserves the right to make changes to product specifications or to this manual without notice.

1.2. Safety Warnings

- The *UNI-SOLAR* Field Applied PV laminates produce DC electricity when exposed to the sun or other light sources. The power from one individual panel is not considered hazardous. However, if connected in series and/or connected in parallel, the potential shock hazard increases.

CAUTION!!

The *UNI-SOLAR* PV laminates contain live electrical components enclosed and protected within. Do not cut or trim the photovoltaic laminate (bonded to the metal pan) in any way. Do not drive screws into any part of the photovoltaic laminate except at designated areas near the junction box. Doing so can cause electric shock, may result in fire and will void the warranty.

Roofing Contractors Responsibilities:

- Only licensed roofers should install *UNI-SOLAR* PVL products.
- *UNI-SOLAR* PV laminates are slippery, especially when wet. Use extreme caution and proper safety harness when working on or near the panels.
- Do not place equipment on solar laminates.
- Contact appropriate local authorities prior to installation to determine if permits and inspections are required for your particular area.
- Avoid dropping any sharp objects on the solar laminates.

Licensed Electricians Responsibilities:

- Observe safe electrical practices at all times. Use insulated tools when wiring solar PV laminates.
- Cover solar panels with an opaque material before making wiring connections to reduce the risk of electric shock or sparks.
- Observe proper polarity when connecting the solar PV laminates into an electrical circuit (see section on wiring). Reverse connection will damage the PV laminates, may result in fire and will void the warranty.
- Avoid dropping any sharp objects on solar PV laminates.

1.3. General Metal Roofing Installation Notes

- *UNI-SOLAR* field applied PV material are to be installed on a new roof while the pans are still on the ground. Any existing roof has to be qualified by *UNI-SOLAR* Engineering before the warranty can be validated.

- Laminates are to be bonded to Zinc-Aluminum steel pans (Galvalume® AZ50, AZ55, AZ60 or Zincalume® AZ150) coated with PVDF (mixture containing 70% or more of Kynar 500® or Hylar 5000®). Please see the following chart of approved substrates. Substrates not listed must be approved by United Solar Ovonic or the warranty will be voided.

- *UNI-SOLAR* field applied PV laminates are bonded to steel pans that are at least 16 inches (42 cm) in width and have a flat profile. Laminates cannot be bonded to pans with decorative stippling, pencil beads or stiffening ribs. Striations are allowed.

- *UNI-SOLAR* field applied PV laminates are bonded to steel pans and secured in place the same as traditional metal roofing panels using anchor panel clips and fasteners (available from the metal roofing panel manufacturer).

- The PVL laminates are bonded to the steel pans following procedures detailed in this manual.

- The PVL laminates come in a wide variety of lengths. To fit an individual roof length, the appropriate PVL laminate is bonded to a steel pan that fits the length of the roof.

- Water tightness is a function of the metal erector. For best results, a minimum layer of 30# felt paper or should be applied between a structural steel pan and a deck substructure. Felt paper is unnecessary if the steel pans are mounted on purlins.

- Polyethylene closures or metal top closures shall not be attached unless the proper sealant is placed under or around those closures. Sealant shall be field applied on dry clean surfaces (ex. on the clean laminate surface under a “Z-closure”).

- Roof clips, as required, shall allow for thermal movement and should be installed at each panel joint. **To control thermal expansion in one direction, the panel will be fastened to the substructure below at the top of the panel only. This applies when the module junction box is mounted on top of the pan.**

- Some field cutting and fitting of panels and flashing is to be expected by the erector and minor field corrections are a part of normal erection work.

- Additional help can be found in the steel pans supplier’s installation instructions.

1.4. Field Applied PV Laminate (PVL) Specifications

Physical Specification:

	Laminate Length	Laminate Width	Laminate Thickness	Weight
PVL-68	9 ft. 4⅛ in.	15½ in.	0.12 in.	9 lb.
PVL-136	18 ft.	15½ in.	0.12 in.	17 lb.

Electrical Specification:

	PVL-68*	PVL-136*
Rated Power (Watts)	68	136
Nominal Operating Voltage	12	24
Operating Voltage (Volts)	16.5	33.0
Operating Current (Amps)	4.13	4.13
Open-Circuit Voltage (Volts)	23.1	46.2
Open-Circuit Voltage (Volts) at -10°C and 1250 W/m2	26.3	52.7
Short-Circuit Current (Amps)	5.1	5.1
Short-Circuit Current (Amps) At 75°C and 1250 W/m2	6.7	6.7
Series Fuse Rating (Amps)	8	8
Min. Blocking Diode (Amps)	8	8

NOTES:

- During the first 8-10 weeks of operation, electrical output exceeds specified ratings. Power output may be higher by 15%, operating voltage may be higher by 11% and operating current may be higher by 4%.
- Electrical specifications (±5%) are based on measurements performed at standard test conditions of 1000 W/m^2 irradiance, Air Mass 1.5, and Cell Temperature of 25°C after long-term stabilization. Actual performance may vary up to 10% from rated power due to low temperature operation, spectral and other related effects.
- Maximum system open-circuit voltage not to exceed 600 VDC.
- Specifications subject to change without notice.

* PVL-68 and PVL-136 laminates rated at 64 watts and 128 watts respectively are produced in limited quantities. Please contract your distributor for availability.

Roof Specification

Slope	Roof temperature at the bonding interface between metal substrate and laminate		
	≤70°C	>70°C	>85°C
>60°	Not allowed**	Not allowed**	Not allowed**
≤60°	Screws recommended*	**Screws needed***	Not allowed**
≤20°	Screws recommended*	Screws recommended*	Not allowed**
<3,5°	Not allowed**	Not allowed**	Not allowed**
Barrels min. radius (50ft)	Screws recommended*	Screws recommended*	Not allowed**

* Under this condition, 2 penetration screws are recommended in designated area to hold the laminate.
** Under this condition, the PVL modules cannot be installed.

Approved Substrates

Approved substrate	Approved vendors	Comments
Galvalume® Steel with Kynar500® PVDF coating	All vendors complying with the use of Galvalume Steel AZ50, AZ55 or AZ60, combined with Valspar Fluropon®, Fluropon Classic®, Fluropon Classic® II or Fluropon® Premiere coating	
Zincalume® with Kynar500® PVDF coating	BHP Steel	Zincalume Steel AZ150 combined with ColorBond® XPD
AluZink® AZ185 (SSAB) AluZinc® AZ185 (Galvalange)	SSAB, Netherlands Galvalange	TUV protection class II, IEC 61646 available, (ref. Report Nr. 21200062B, March 31st, 2003)
SSAB -> Prelaq Nova 50 finished	SSAB Prelaq, Netherlands	TUV protection class II, IEC 61646 available, (ref. Report Nr. 21200062B, March 31st, 2003)
Haironville -> HairExcel Granite finished	Haironville, Belgium	TUV protection class II, IEC 61646 available, (ref. Report Nr. 21200062B, March 31st, 2003). Min. Slope 5,7° (for corrosion warranty)
Dofasco 8000+ Dofasco 10000	Dofasco Inc. Dofasco USA	8000+ series → Silicon modified polyester 10000 series → PVDF
Stelcolour 8000+ Stelcolour 10000	Stelco Inc.	8000+ series → Silicon modified polyester 10000 series → PVDF
3004 or 3005 Aluminium alloy with Kynar500® PVDF coating	Corus Bausysteme GmbH	Kalzip sheets AF 65/537, 1.0 mm thickness

PVL Models and Part Numbers:

Description	Model	Part Number
68 W, Bottom Termination, Std. J-Box with 4” wires	PVL68B S/S	M535223
68 W, Top termination, Std. J-Box with 4” wires	PVL68T- S/S	M535123
68 W, Top termination, Terminal Housing with Quick Connects	PVL68T QC/S	M535125
136 W, Bottom Termination, Std. J-Box with 4” wires	PVL136B S/S	M538223
136 W, Top termination, Std. J-Box with 4” wires	PVL136T S/S	M538123
136 W, Top termination, Terminal Housing with Quick Connects	PVL136T QC/S	M538125

1.5. Application of Field Applied PV Laminates

Transportation and Handling of PVL Products

- *UNI-SOLAR* field applied PV laminates are shipped coiled in a 4'x4'x17" or 2'x2'x17" transport boxes.

- *UNI-SOLAR* field applied PV laminates are to be stored in a ambient temperature of 15°C to 30°C (50°F to 85°F)

- *UNI-SOLAR* PV laminates must be handled so as to not crease or bend the solar cells. Cells are interconnected with copper bus bars and these bus bars must not be stretched beyond their tolerances by coiling the laminate any tighter than **20 inches** in diameter.

- Avoid standing on the PV laminates whenever possible. If unavoidable, wear clean, soft-soled shoes and walk in the center of the panel. **CAUTION!!** Laminates are very slippery when wet.

Supplied Equipment and Required Tools

- All boxes of PV Laminates contain 1 junction box and/or quick connect terminals, 1 wiring terminal block, 2 jumpers, 2 screws (#12-1, Self Drilling, 5/16th hex washer head with sealing washer), 4 Phillips head J-Box lid screws and 1 junction box lid for each of the contained PVL laminates. The caulk required for bonding the junction boxes to the laminates is also included. A template for indicating proper screw penetration areas is also included (see View 15).

- All shipments of PVL product can be accompanied by a factory supplied lamination roller (Contact *UNI-SOLAR* Sales office). This roller is called a J-roller because of its shape. Other rollers can be used but we recommend that the roller itself be made of a soft rubber material, ergonomically shaped for effective pressing and the handle of the roller attached to only one side of the roller axle. This will allow you to use the roller up against the edge of the standing seam and not scratch the paint.

- Cleaning solutions will need to be acquired for the steel pans. If the pans are new, use Isopropyl Alcohol. The alcohol should be diluted to 90% alcohol / 10% water to improve cleaning. If the steel pans have been stored outside or have been installed on the roof for more than a few weeks, another cleaning solvent made up of Trisodium phosphate, laundry detergent and water can be put through a power washer prior to cleaning with the alcohol solution. The recipe for this cleaning solution is detailed later in this manual.

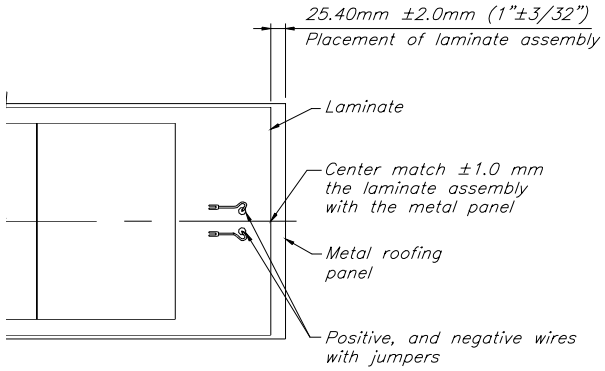
- Other tools required include a ruler, a marker (ex. a Carpenters pencil), cleaning towels and a caulk gun. A flat, rigid working surface will be required for the laminate bonding (rolling) procedure. The laminate should be applied before the steel pan is installed on the roof.

SECTION #2

2.1. Detailed PVL Application Instructions – With Top Mounted Junction Box

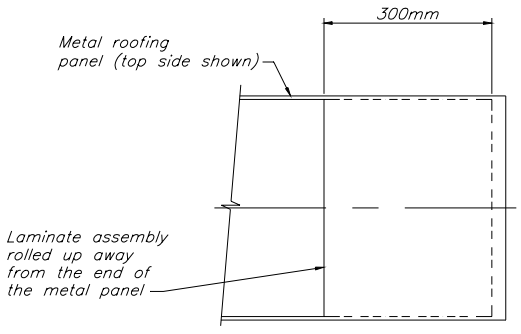
Laminate Installation

1. Remove any protective film from the face of the steel pan. Clean the steel pan with ISOPROPYL ALCOHOL (90% Alcohol - 10% Water) where the double stick and the laminate will be placed. If the pan is very dirty (material has been stored outside), the pan should be washed using a low-pressure water spray (i.e. garden hose) or power washer (ex. 1600 PSI) and a cleaning solution [¼ Cup Trisodium Phosphate, ½ cup liquid detergent (optional) and 5 gallons water] and then rinsed before cleaning with alcohol solution.
2. PVL should be bonded while still on the ground on a flat and rigid surface with temperature between 10º and 40º (50ºF and 100ºF). Unroll and align the laminate and double stick assembly in the center of the steel pan. The laminate assembly should be positioned ~25mm (1 inch) from the end of the steel panel (see View #1)



View 1

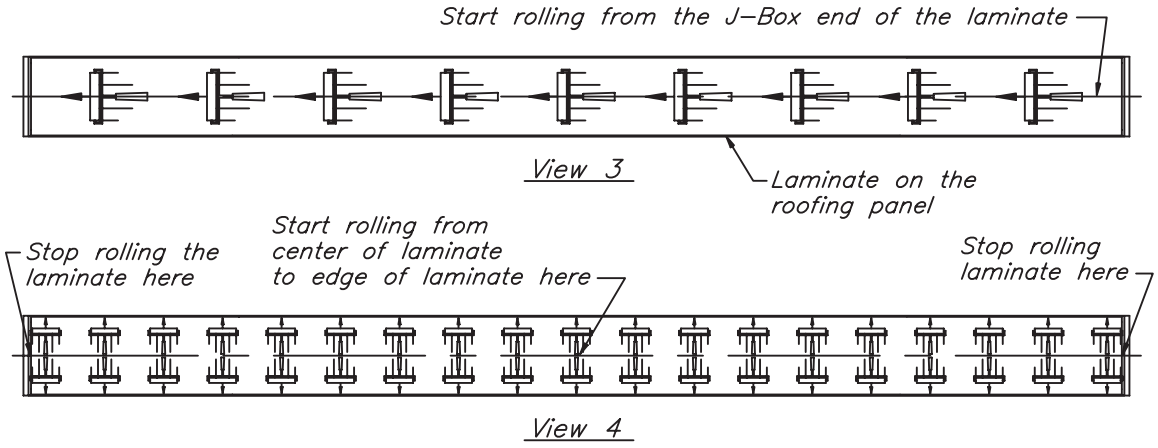
3. Lift up the laminate and double stick assembly about 300 mm (12") off of the steel pan, peel the release paper off of the double stick material approximately 150 mm (6") off the metal and fold it under. Ensure that the laminate is centered on the metal panel, and that the laminate assembly does not move on the metal panel during the process (see View 2). This is critical, as **the laminate's position will be fixed after the first six inches is bonded to the steel pan.**
4. Stick the peeled end of the laminate assembly onto the steel pan. Roll up the rest of the laminate assembly up to the stuck portion of the laminate. After the



View 2

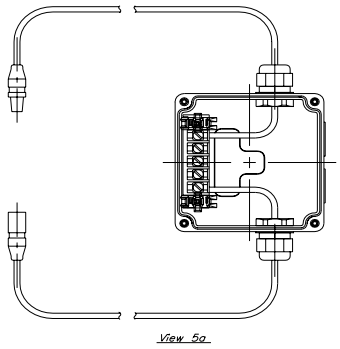
laminate assembly is rolled up on the steel pan, one person should peel the release paper from the bottom of the laminate assembly as another person unrolls the laminate onto the steel pan. Stick the remaining laminate against the pan, making sure the laminate is aligned properly on the steel pan.

5. After the laminate has been applied completely to the steel pan, use a roller to press the center of the laminate against the steel pan (See View 3). Then use a roller to press the laminate onto the steel pan, starting from the center of the laminate, and rolling out to the edges of the laminate (See View 4).



PVL Modules supplied with Factory "Quick Connect" Wires and Terminals

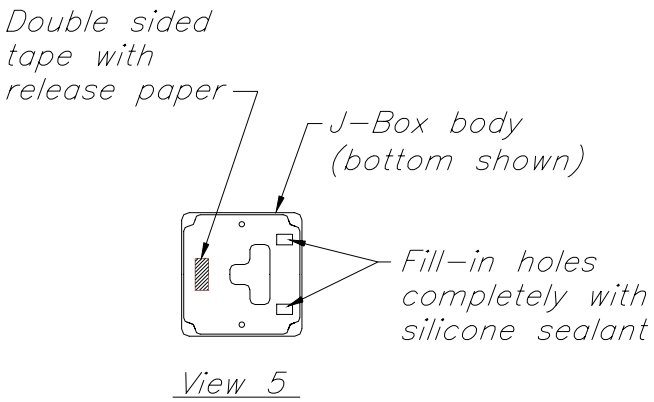
6. The PVL Modules can also be supplied with J-Boxes with factory-installed Quick Connect wires and terminals. The J-Box is bonded to the laminate/steel pan assembly using the Top Mounted J-Box Instructions found in this manual. After the J-Box is mounted to the laminate / steel pan assembly, the modules are wired together using the Quick Connect wires and terminals. (See View 5a). See Addendum #1: wiring *UNI-SOLAR* PVL Modules with Quick Connect Terminals



NOTE: The Quick connect terminals are meant to be used as interconnection devices only. They are not to be used as a means of disconnecting the solar array.

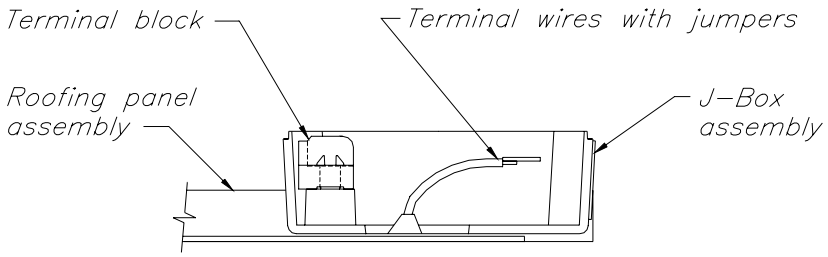
Top Mounted Junction Box Installation

7. Make sure there is a piece of double-sided tape on the bottom of the J-Box (See View 5). If you have ordered the J-Box with Quick Connects, your J-Box will look like View 5a.



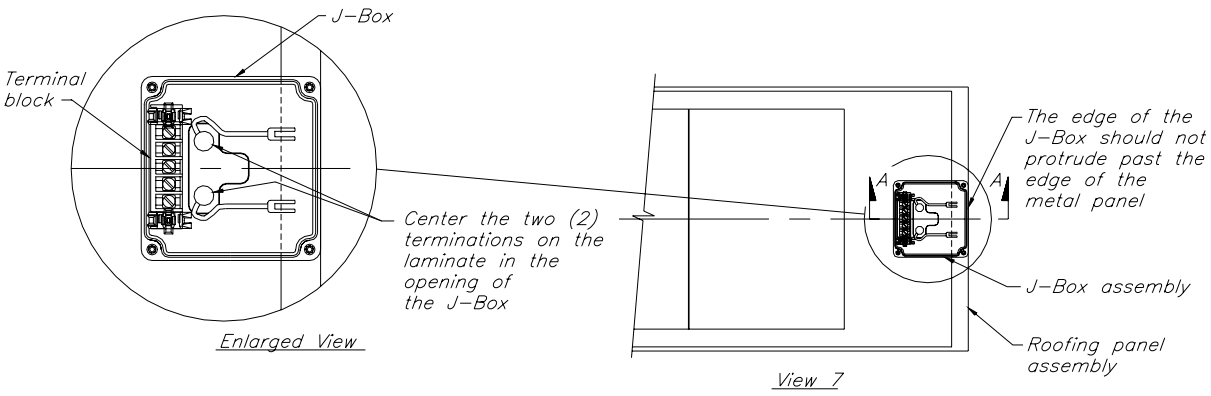
View 5

8. Place the J-Box on the laminate with the two (2) wires protruding through the opening on the bottom of the J-Box (see View 6)



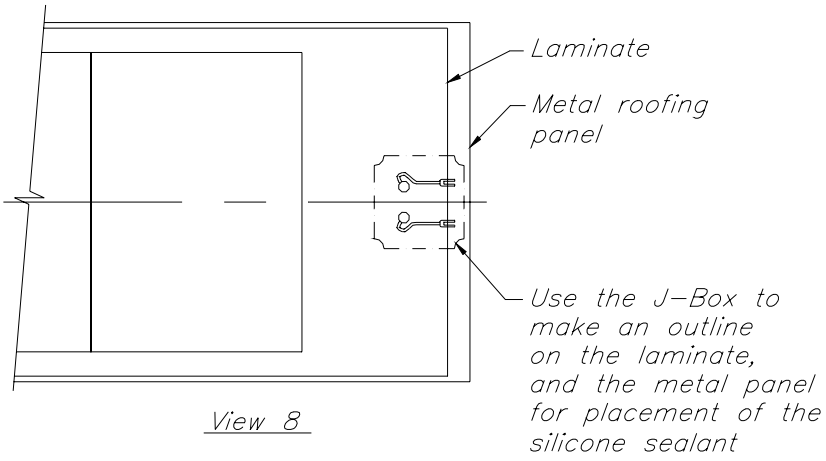
View 6

9. Center the two (2) termination wires on the laminate in the center of the opening on the bottom of the J-Box (See Enlarged View and View 7).



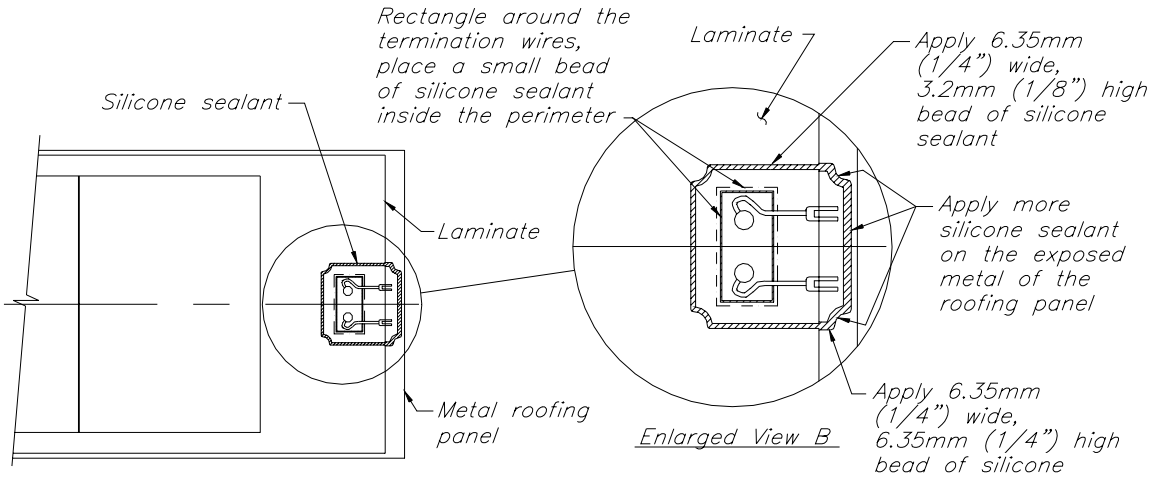
View 7

10. Make an outline of the box with a felt tip marker. After you have made the outline of the J-Box, set the J-Box aside (See View 8).



View 8

11. Fill in the two openings on the bottom of the J-Box with silicone sealant (see View 5)
12. Apply the silicone sealant caulking just inside the marked position on the laminate and steel pan as shown in View 9 and the Enlarged View B. Apply a generous bead (1/4" x 1/4") of silicone sealant. Apply a small bead (1/4" x 1/8") of silicone sealant on the inside perimeter of the rectangular marking around the two (2) terminal wires (See Enlarged View B).

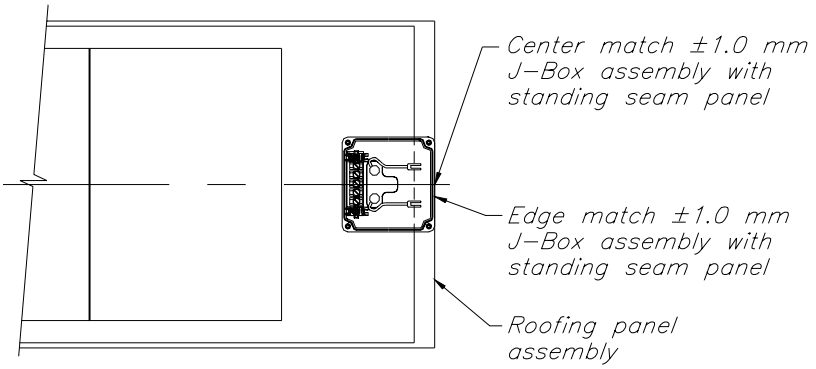


View 9

Enlarged View B

13. Make sure the sealant bead is continuous and uniform.
14. Remove the release paper from the double-sided tape on the bottom of the J-Box.
15. Align the J-Box case on the silicone sealant on the laminate and steel pan. Make sure the edges of the bottom of the J-Box are aligned properly with the silicone sealant on the steel pan.

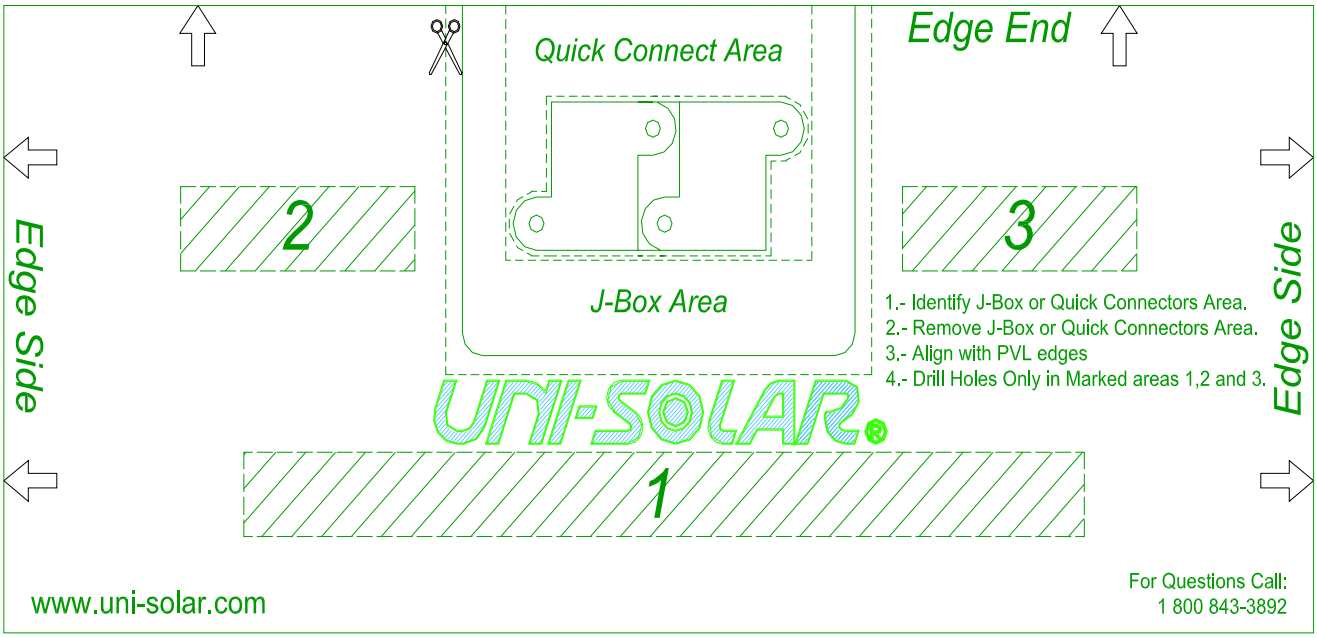
16. Make sure that the two terminal wires are properly aligned with the opening on the bottom of the J-Box. **The J-Box should be center matched, and edge matched with the steel pan** (See View 10).



View 10

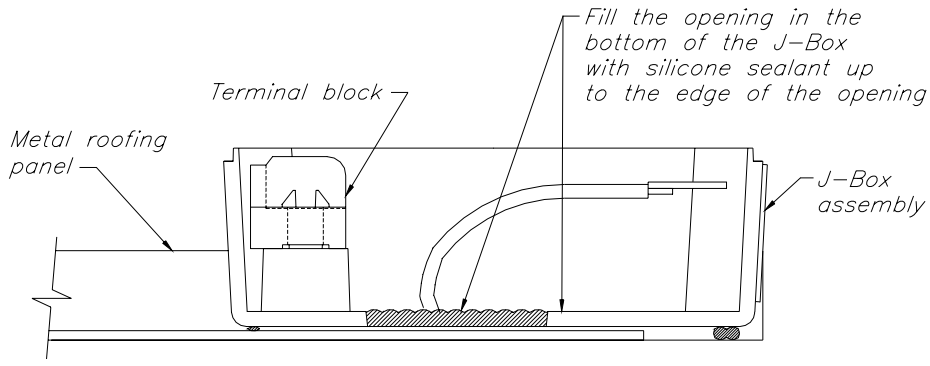
17. Check to make sure that the two terminal wires are not trapped or pinched between the J-Box case and the laminate.
18. Press the J-Box against the steel pan so that the double-sided tape on the bottom of the J-Box sticks to the PV laminate (the double-sided tape will hold the J-Box in place until the silicone sealant has fully cured).

NOTE: If you are required to use screws with the laminate (ex. high slope roofs in very hot climates), installers can use the screw penetration template included with their PVL shipment. A picture of the template is shown below as View 11.

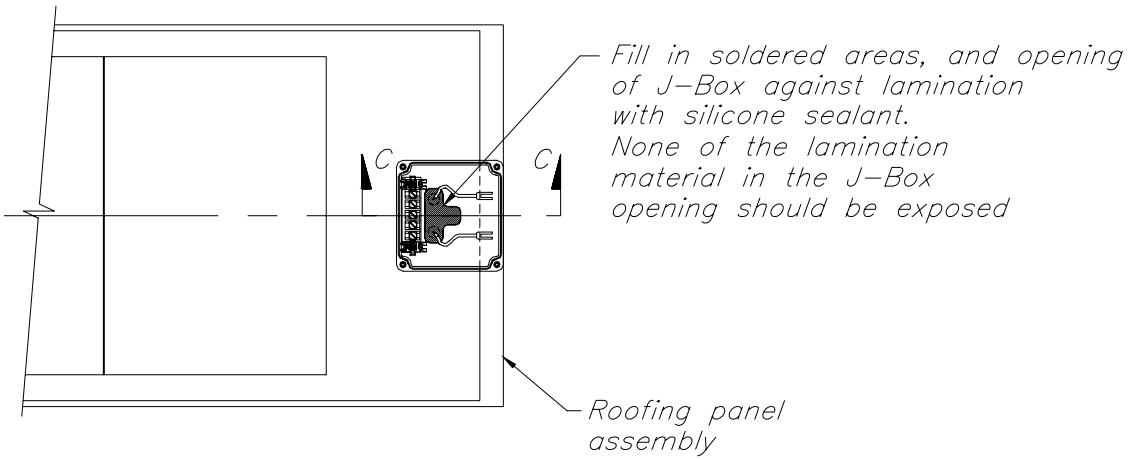


View 11

19. Fill in the opening in the bottom of the J-Box completely with the silicone sealant up to the inside edge of the opening. None of the laminate should be exposed in the J-Box opening. Do not over-fill the opening with sealant (see View 12 and 13). The sealant should come up and over the edge slightly.

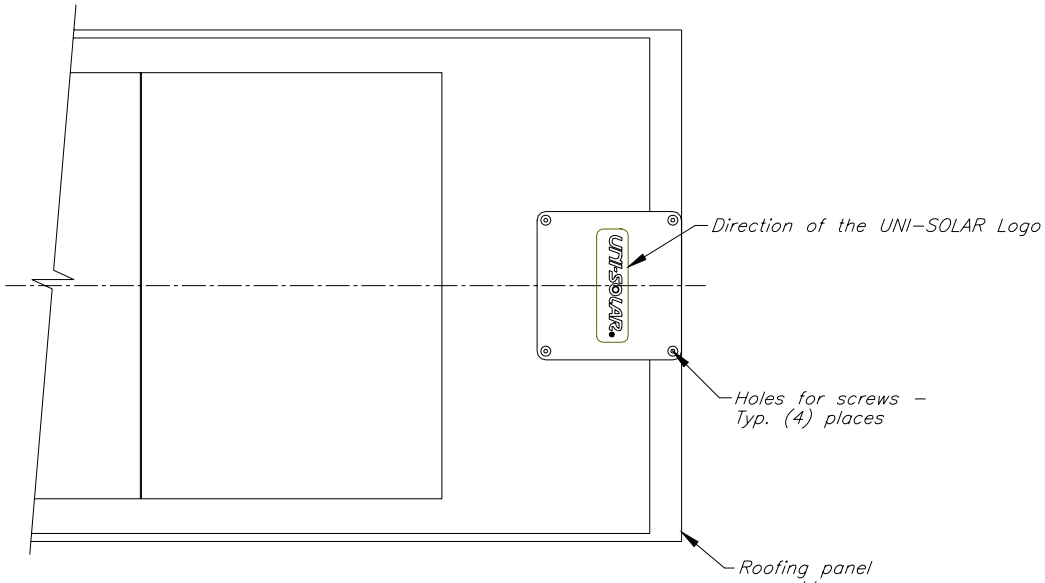


View 12



View 13

20. Place the J-Box lid on the top of the J-Box after allowing the silicone sealant to set up ("cure"). This will take approximately 8 hours.
21. Make sure the direction of the *UNI-SOLAR* logo on the J-Box lid is properly placed with respect to the steel pan (See View 14).
22. Screw down the four screws at the four corners of the J-Box lid. The recommended torque range for the J-Box cover screws is 14 ± 1 in-lb.



View 14

SECTION #3

3.1 PVL with Quick Connects

23. Most PVL modules can supplied with factory-installed module interconnect wires with MC Quick Connect terminals. These terminals are marked "+" and "-" and will only fit into each other one way (See Addendum 1: Wiring *UNI-SOLAR* PVL Modules with Quick Connect Terminals).
24. In order to provide additional strain relief for the wires, a mounting pad with cable tie is supplied with the laminates. The mounting pad comes with an adhesive that is used to bond the mounting pad to the steel pan just above the laminate. The plastic cable tie is then tightened around the wire to help to secure the connection from being pulled loose (See Drawing on Page 17).

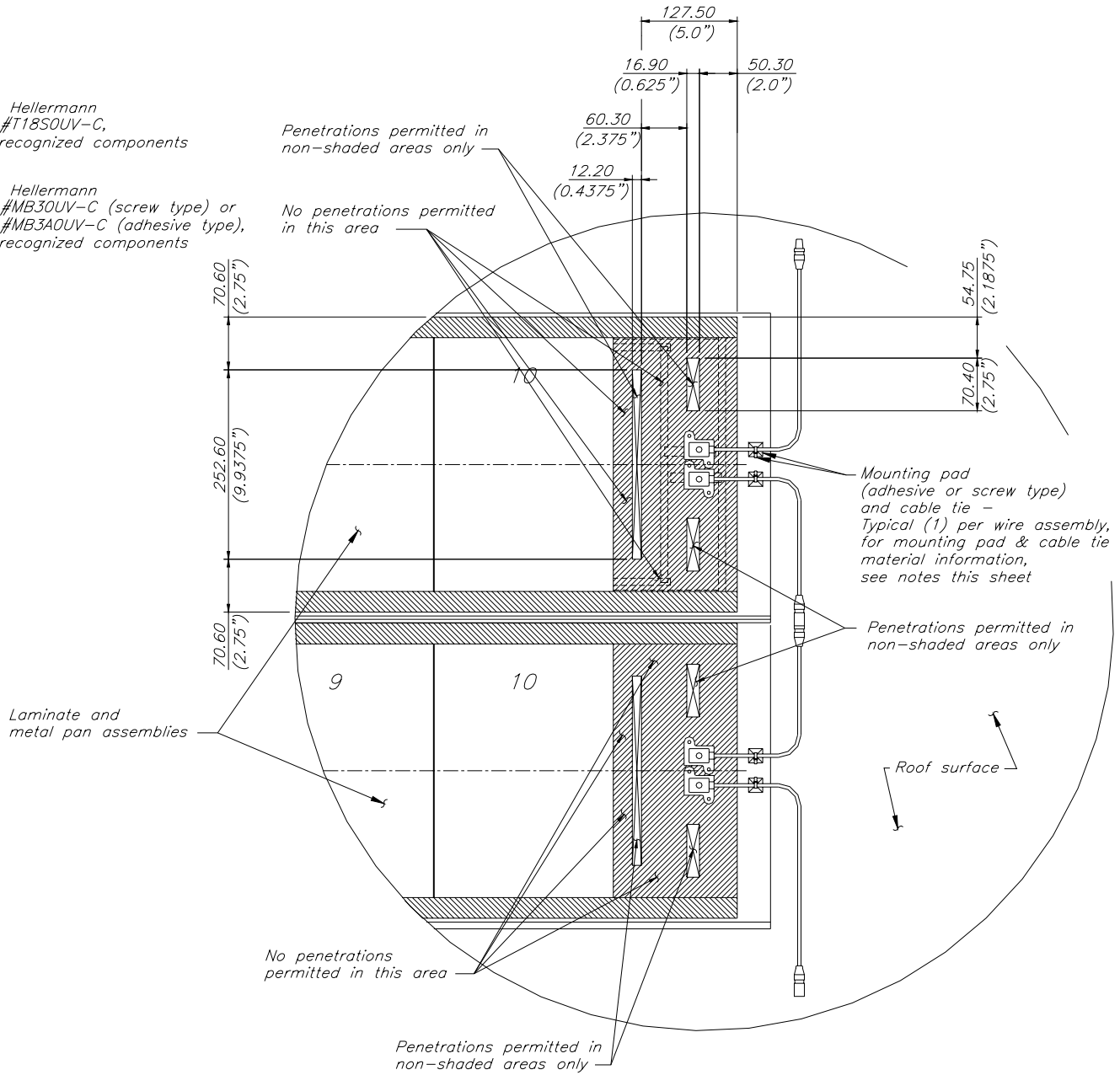
NOTE: The Quick Connect terminals are to be used as interconnection devices only. They are <u>not to be used as a means of disconnecting the solar array</u>.

25. PVL modules are wired together into strings of modules by plugging in a number of modules together (in "series", positive to negative), to form a higher voltage string of modules. (600V max)
26. Two penetrating screws (#12-1, self tapping, 5/16th inch, hex head with sealing washer) can only be put in certain areas at the top of the laminate. Installers should use the screw penetration template to guide them (see View 11).

Notes:

Cable ties – Tyton Hellermann part #T18S0UV–C, U.L. recognized components

Mounting Pad (Adhesive or screw type) – Tyton Hellermann part #MB30UV–C (screw type) or part #MB3A0UV–C (adhesive type), U.L. recognized components



SECTION #4
4.1. General Wiring Instructions for PVL Modules

Wire Selection

- 90ºC, wet rated conductors are necessary. If modules interconnect wires are exposed under the ridge cap, use conductor type USE-2, or USE. If module interconnect wires and/or cables going from the modules to the combiner box are to be run inside of a wire chase, you can use RHW-2, THWN or XHHW-2 conductors.

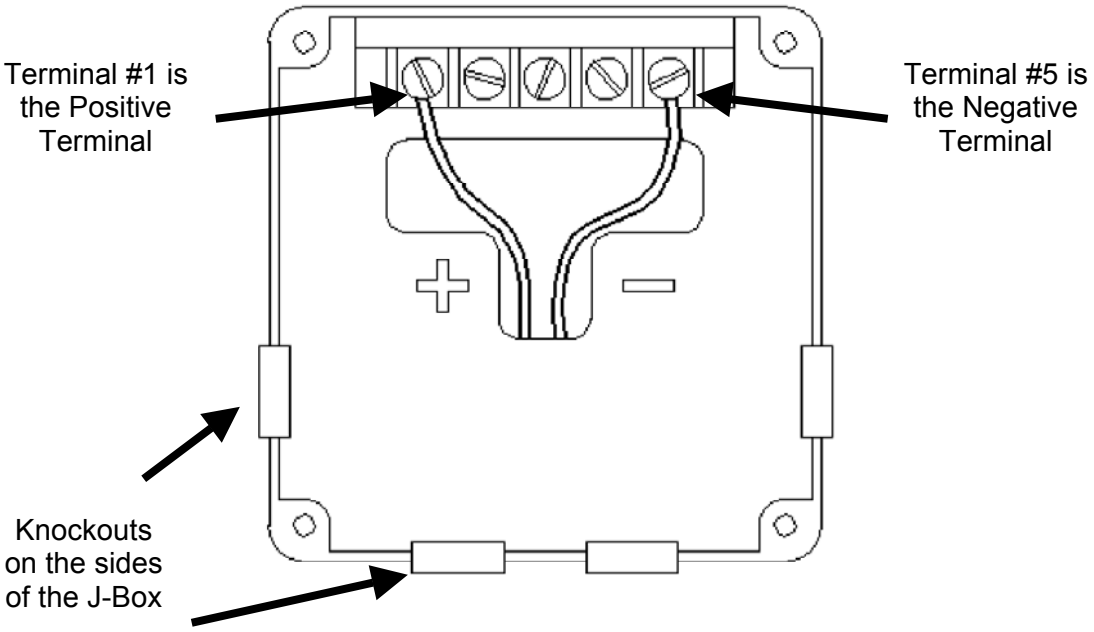
- Temperature de-rated ampacity calculations should be based on 156% of the short-circuit current (I_{sc}), and the de-rated ampacity must also be greater than the rating of the over-current device.

DC Wiring Configurations (48 Volt and High Voltage)

NOTE: If your solar modules come with "Quick Connect Wires and Terminals, see the Quick Connect Wiring Addendum at the end of this manual.

- The *UNI-SOLAR* module junction box contains five terminal screws. The first screw on the left (as you look into the box) is the positive terminal. The last screw on the right (as you look into the box) is the negative terminal.

- The second, third and fourth terminals are not wired to the active material in the module and can be used as extra spaces for wiring after installation of "jumpers" included with the hardware of every module.



- Modules can be configured using series wiring, parallel wiring, or a combination of series and parallel wiring.

Grounding

- Section 690.5 of the NEC requires that systems with PV modules on the roof of a dwelling have ground fault protection equipment.

- An equipment-grounding conductor will need to be attached to a ground rod. The conductor can be bare or insulated with green colored insulation. Either can be run inside conduit. The conductor should be sized according to Table 250-122 in the 2002 NEC.

- Final acceptance of the PV system may be contingent on passing a High Potential (HI-Pot) Test on the solar array. United Solar Ovonic recommends that a Hi-Pot test be done at every PVL installation to detect any ground faults caused by the laminates being in contact with the metal substrate. Instructions for conducting this test are detailed in Appendix 4 at the back of this Manual.

4.2 Four Termination (Wiring) Options for PVL Modules on Steel Roofs

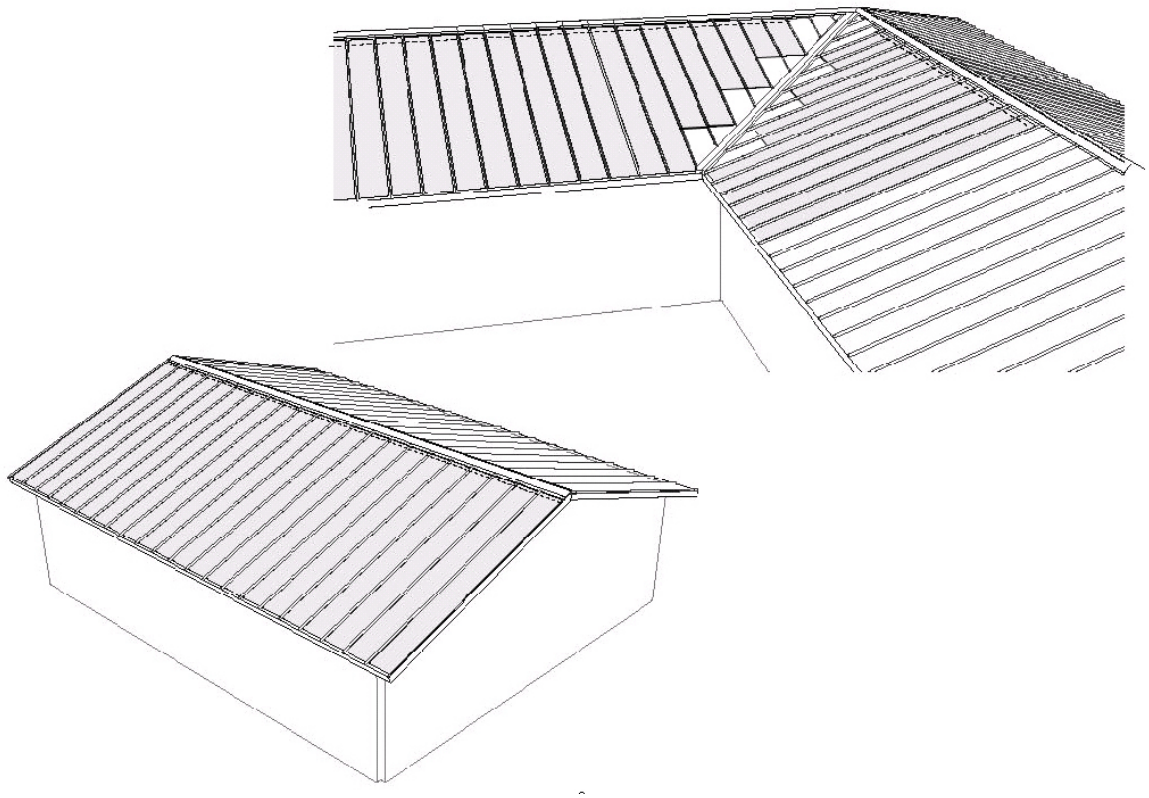
There are 4 basic options for wiring PVL arrays:

- ✓ Ridge Termination
- ✓ Mid-roof Head Flashing
- ✓ Mounted Wire Channel/UL listed Wire Way
- ✓ Engineered Snow Retention Channel.

Termination Option	Allowed Slopes	Allowed Locations	Comments
Ridge Termination	≥3,5° -≤60°	No restrictions	Standard when Z-closures are used.
Mid-roof Head Flashing	≥18° - ≤60° ≥14° - ≤60°	In snow country. In no snow country.	Metal roof pans need to be cut to the length of the laminate.
Mounted Wire Channel/UL listed Wire Way	≥3,5° -≤60°	Not in snow country unless rated for snow retention.	Allow by assessment where screws are not needed for that roof!
Engineered Snow Retention Channel.	≥18° - ≤60°	No restrictions	Only when a mid roof channel has been selected as the termination option.

Option 1. Ridge Termination

Ridge caps are a standard component on metal roofs. Ridge terminations are the preferred method of wiring PVL arrays because they offer easy access and superior aesthetics at minimum cost.

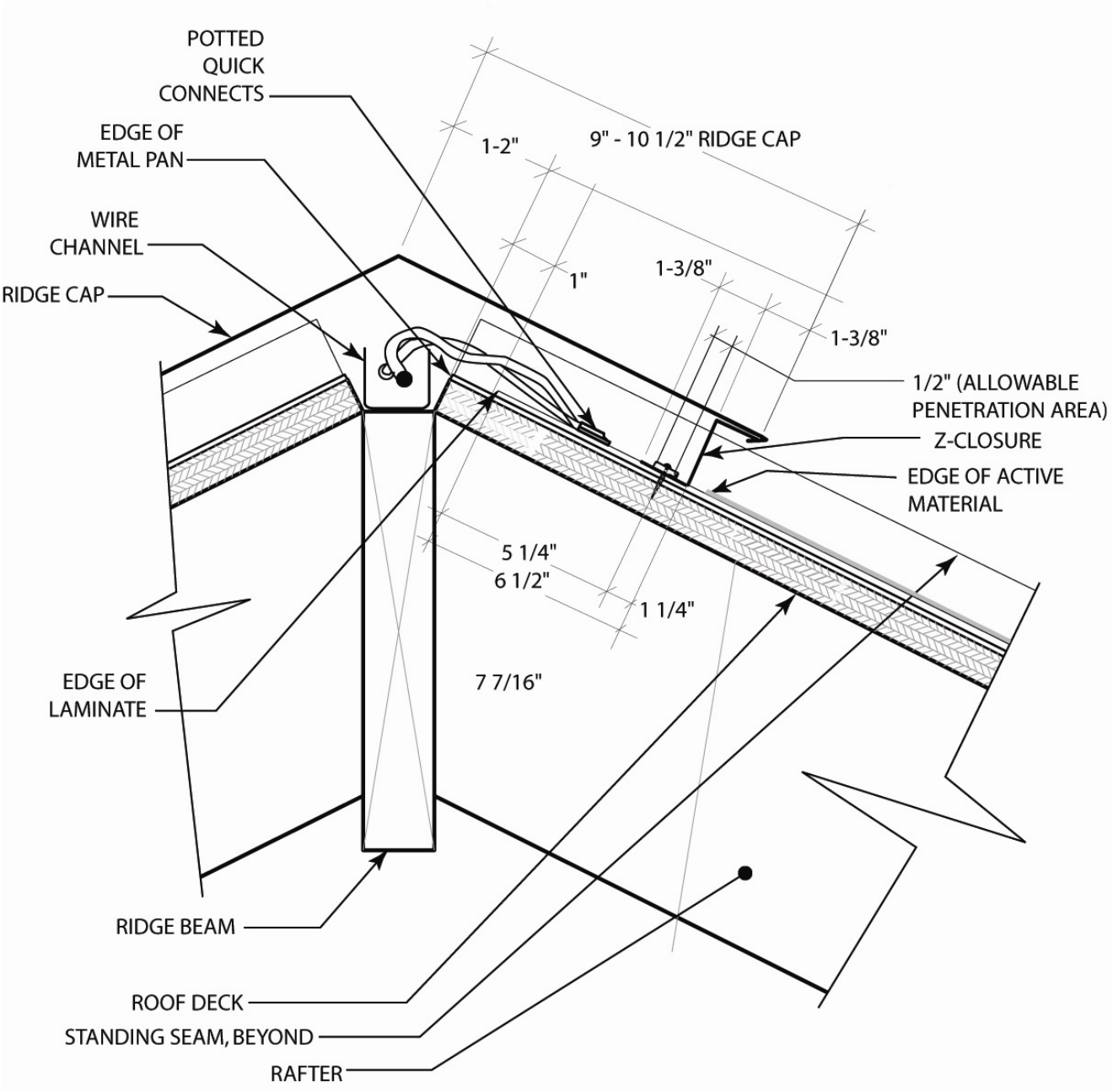


Examples of roofs with ridge terminations

Ridge termination installation instructions:
After laminates have been bonded to pans, roofing pans are installed as usual. Refer to Installation Guide for location of allowable penetration area. If a Z-closure is used to secure the ridge cap use two screws to mechanically fasten the Z-closure, taking care to drive screws into allowable area only.

Insert Quick Connects terminals into ridge and plug to adjoining Laminates to create series strings. Dimensions of ridge cap will be determined by the distance between the Z-Closure and the ridge. Secure ridge cap.

Similar installation procedures are used for high side trim for shed roofs, and sidewall trim for roof-to-wall conditions.



Section through ridge showing placement of Z-Closure.

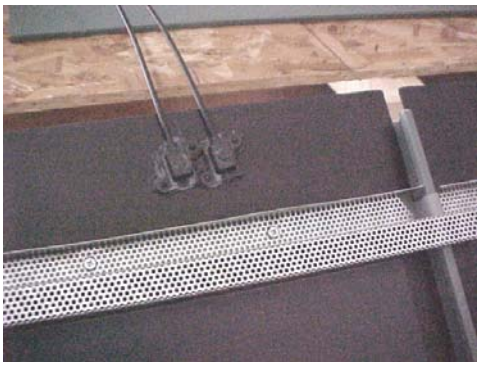
Vented Ridge Cap:

1) Hold ridge cap on peak and mark where lip of cap hits the roof.
2) From your marks, measure 2” towards the peak and snap a line.
3) Place Butyl strip just below the line.
4) Place baffles, then the Z-bar onto the Butyl strip so that the back of the Z-bar lines up with the snapped line.
5) Screw baffles and Z-bar down with screws installed 5” from each rib.

Wiring can now be done.

6) Apply cap, starter piece with 90-degree liquid tight strain relief cord and cable connector, if needed, and pieces lapping.
7) Screw through front lid of cap into Z-bar using #8 ½” pan head self-tapping screws (stainless).

Installing Z-Closure, taking care to put screws through areas where penetrations are allowed



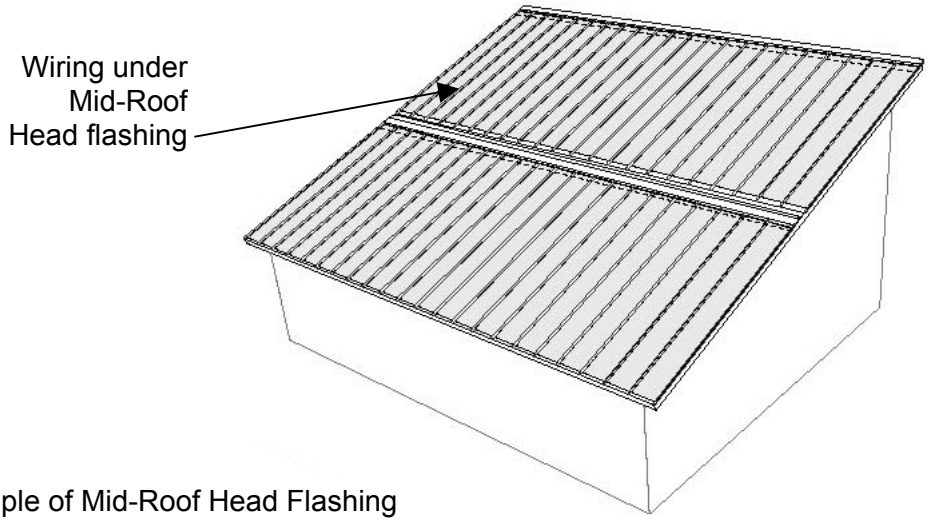
Installed Z-Closure, ready for quick connection

Vented Z Closure

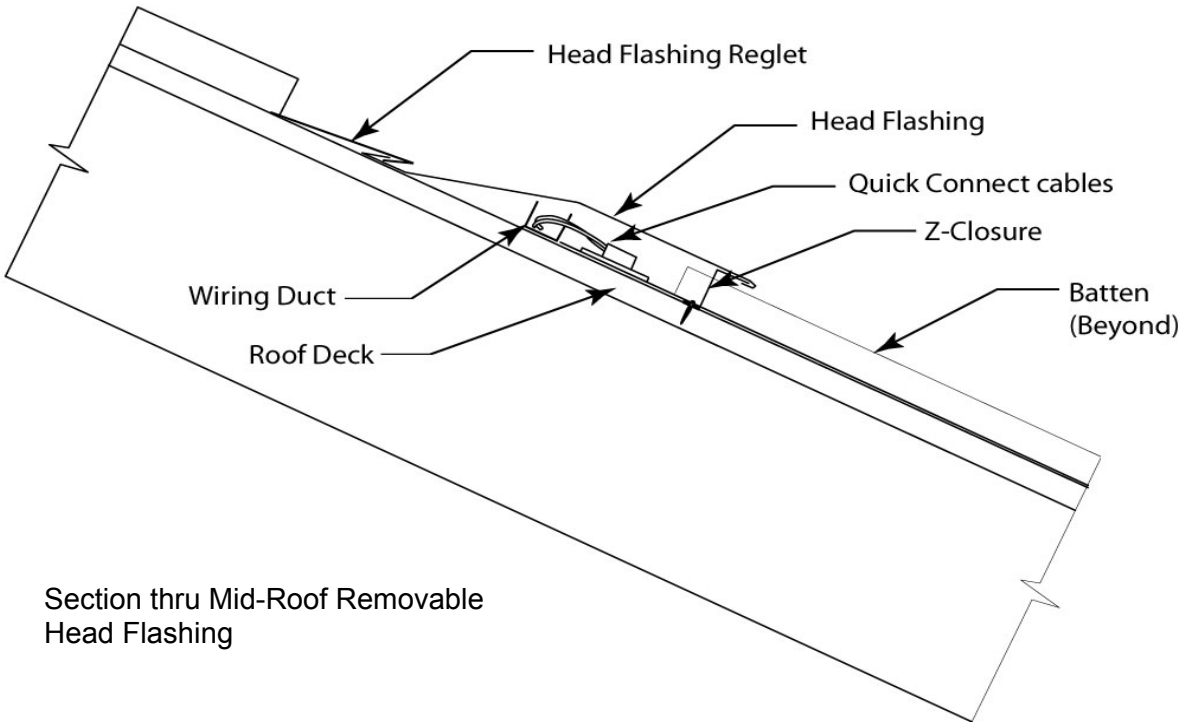
Vented Ridge Cap

Option 2. Mid-roof Head Flashing

A head flashing is a standard metal roofing detail used to make a transition in slope or roofing material. Low profile quick connects can fit easily under a head flashing. Most roofs do not require a head flashing detail, therefore this option adds cost to the installation and can compromise the aesthetics. Using a mid roof head flashing further means that the metal roof pans, which are usually continuous, must be cut to the length of the laminate and installed separately. Additionally, head flashings can only be installed on roofs that are over 4:12 (18 °) in slope in snow country and 3:12 (14 °) in areas without snow.



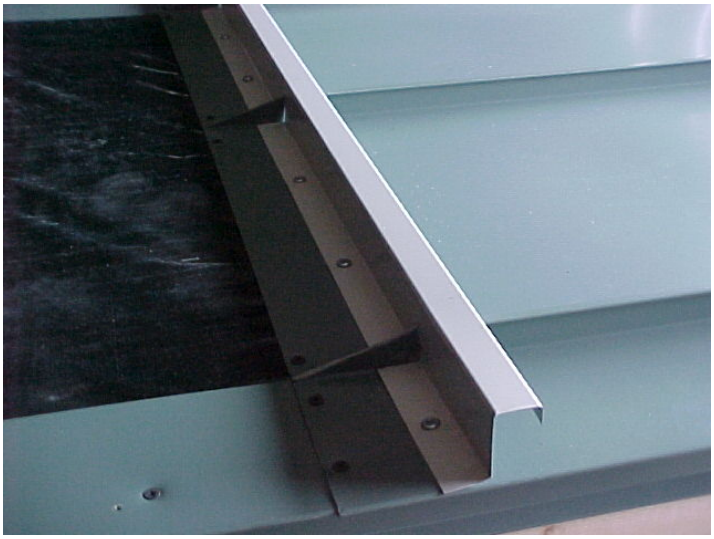
Example of Mid-Roof Head Flashing



Section thru Mid-Roof Removable
Head Flashing

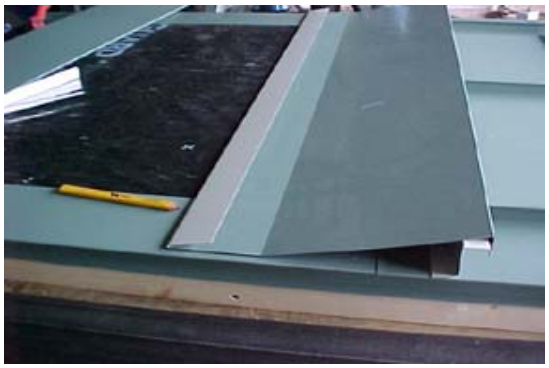
Mid-Roof Head Flashing installation instructions:
After laminates have been bonded to pans, bottom row of roofing pans are installed as usual. Refer to Installation Guide for location of allowable penetration area.

1) Secure Z-Closure with two screws, taking care to drive screws into allowable area only.

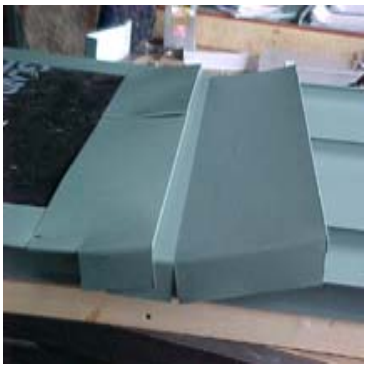


Z- closure

2) Insert Quick connects and plug to adjoining laminates to create series strings.
3) Place the head flashing tight to front edge of the Z-Closure.
4) At both sides of the roof make a mark on the roof deck by drawing against the back edge of the flashing.
5) Remove the head flashing.
6) Measure down towards the Z-Closure 2-1/2” from the marks and snap line.
7) Line up the front edge of the reglets with the line and attach them to the roof with roof nails in the top edge.
8) Push head flashing into reglet until they snap together.



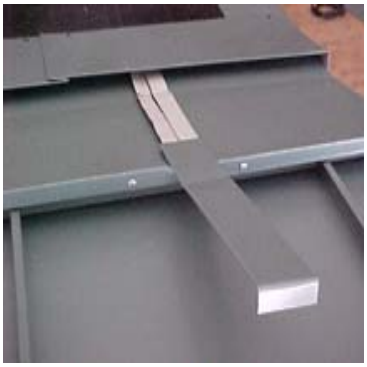
Head flashing before assembly



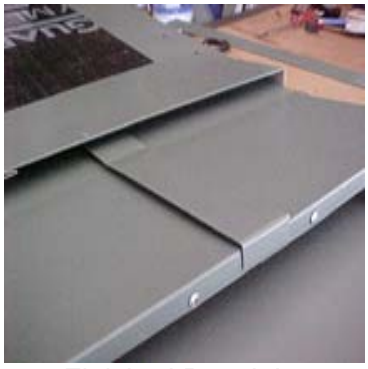
Head flashing after assembly

9) Pull the head flashing forward, clip it onto the Z-bar and screw them together with small screws through the front of the head flashing.
10) Butt head flashings together as they are applied and add joiner strips.

Butt joint



Joiner strip



Finished Butt Joint

Installation of Starter Cleat

Option 3. Mounted Wire Cover / UL listed Wire Channel

On large roofs that will have a row(s) of laminates without ridge or eave access a mounted wire cover can be used to conceal wire connections run in a UL listed wire channel. This option can be applied on low slopes down to 3.5° (3/4:12) and full length metal pans can be installed. Mounted wire covers cannot be used in snow country unless they are rated for snow retention. While this wiring option is less expensive compared to head flashing, it still may compromise aesthetics and should probably be limited to low slope applications where the roof will be less visible. On large roofs, the termination ends of the laminates can be butted end-to-end and connected in one wire raceway to minimize the number of wire channels necessary.

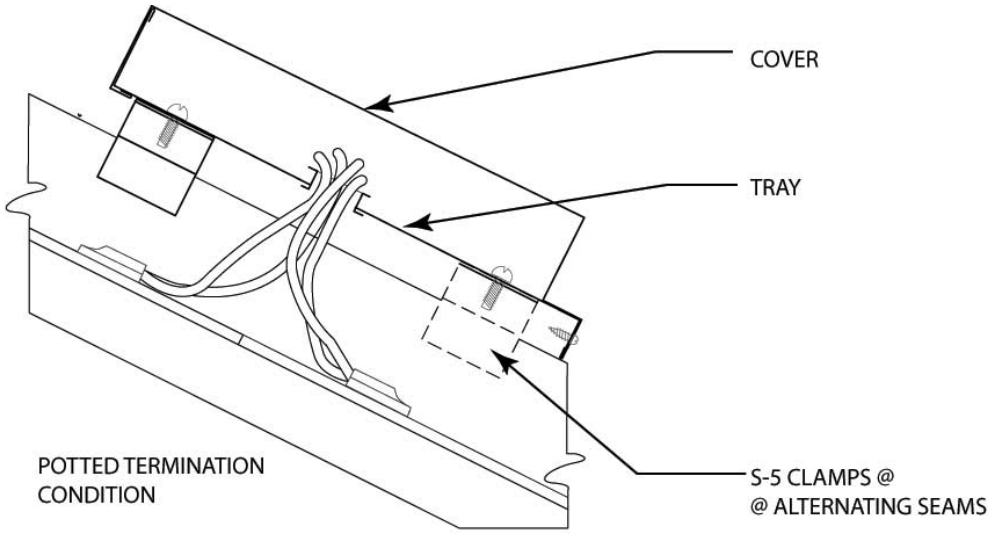
Attachment: The attachment of wiring channel systems to a metal roof system can be achieved with standard beam clamps or with blocks made for snow retention and air handling systems such as the S-5! mounting blocks. Again the material that the mounting block or clip is made out of has a large bearing on the price. UNI-SOLAR recommends aluminum S-5! Mounting blocks.

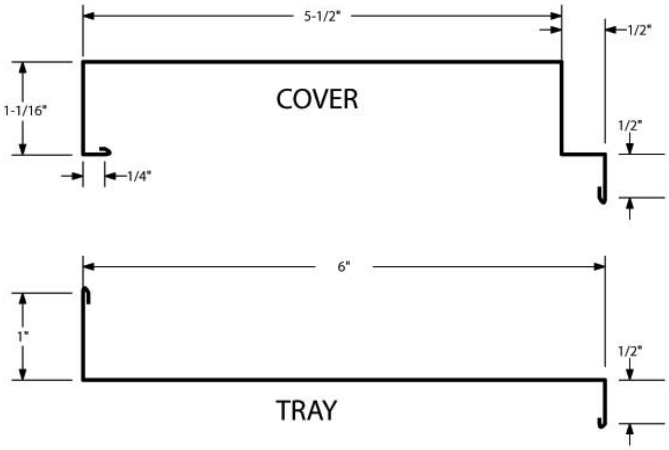
Wire Channel installation instructions:

1) After laminates have been bonded in an end-to-end configuration on the metal roofing pans, the S-5! Clamps are attached to every other standing seam directly above the joint where the laminates butt together.
2) The wire cover should be pre-punched so that the proper size holes are centered on each pan.
3) The wire channel is then attached to the S-5! Clamps and the quick connects are run up through bushings in the holes in the wire channel.
4) The quick connects are then plugged together in the desired series strings.

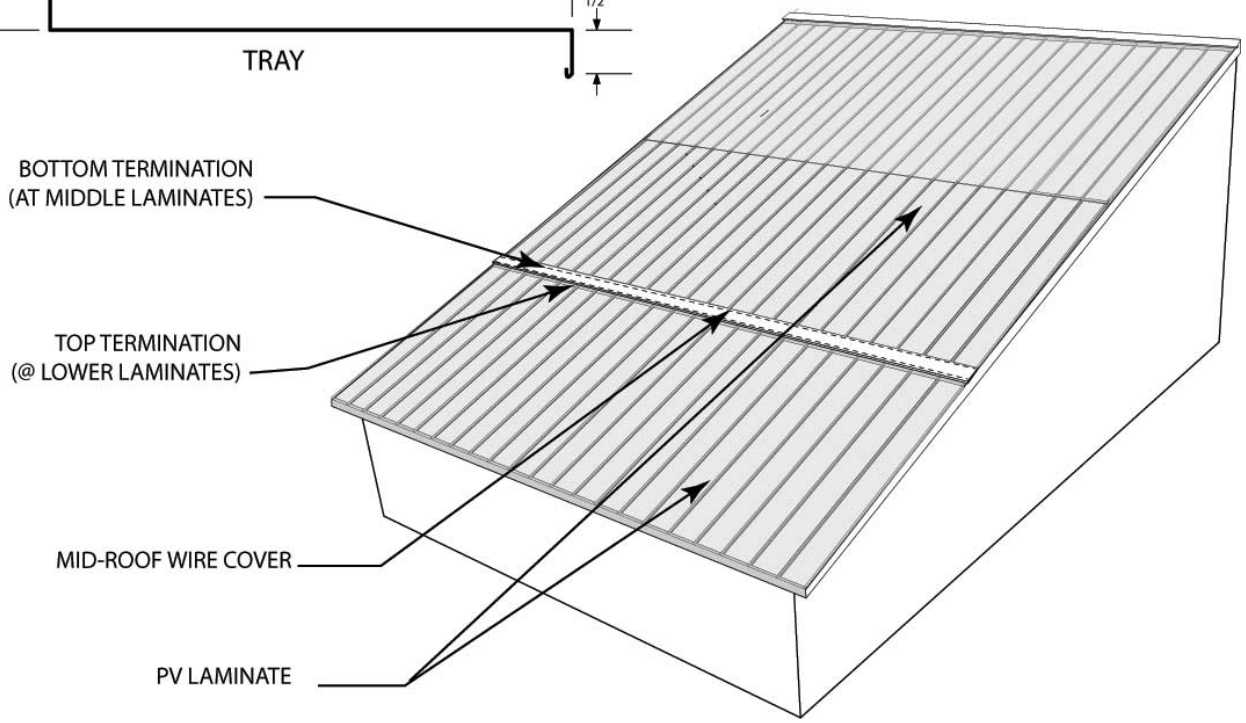
Wire channel covers can be fabricated out of the same metal as the roofing. This allows the use of less expensive wire channels. The cover can be secured to the top of the channel to both protect the wires and reduce the visual impact of the channel.

Mid-span connections in northern climates:
This type of wiring channel will act as a snow stop in northern climates that will hold up all snow and ice that accumulates behind it until the snow load overpowers it and tears it off the roof. Although the raceway and clamps depicted in this system are strong, there is no engineering at this point that accurately describes the snow loads it can handle. It is recommended that on steeper pitches in northern climates either a rated snow retention bar accompany this system or that a head flashing should be used.





SECTIONS THROUGH
MID-ROOF
WIRE COVER
SCALE: 1" = 2"

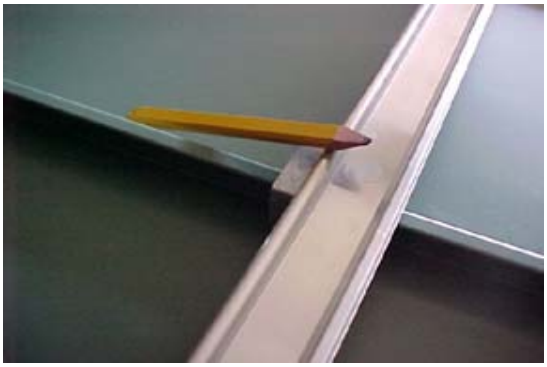


Option 4. Engineered Snow Retention Channel

In snow country where mid-roof wire channel has been selected as the termination option, a snow guard retention system will be required to protect the wire channel from damage. On projects where snow retention is required for safety reasons, a snow guard retention system in combination with a wiring channel may be a good option. In general, snow should be shed from solar arrays as quickly as possible to maximize performance.

Snow Guard Retention Channel Installation Instructions:

Mounting Blocks Installed



Snow Guard Channel in Place

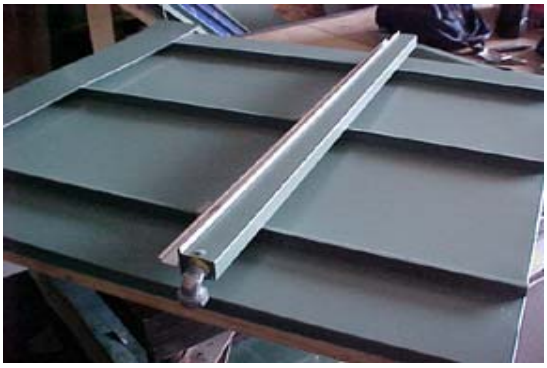
1) Place the snow guard channel on blocks.
2) Mark holes and pre drill with a 3/8” bit.

Hole Drilled in Channel

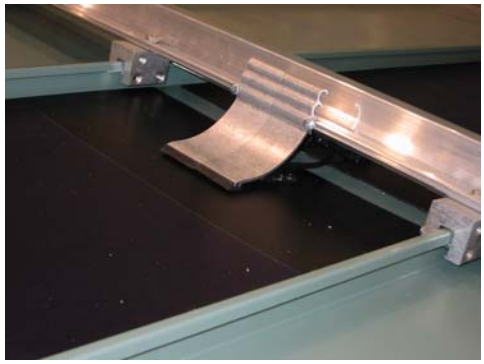
Channel Fastened

3) Fasten snow guard channel with snow diverters in place onto mounting blocks with 9/16” bolt and washer.
4) Prepare wire channel for use.

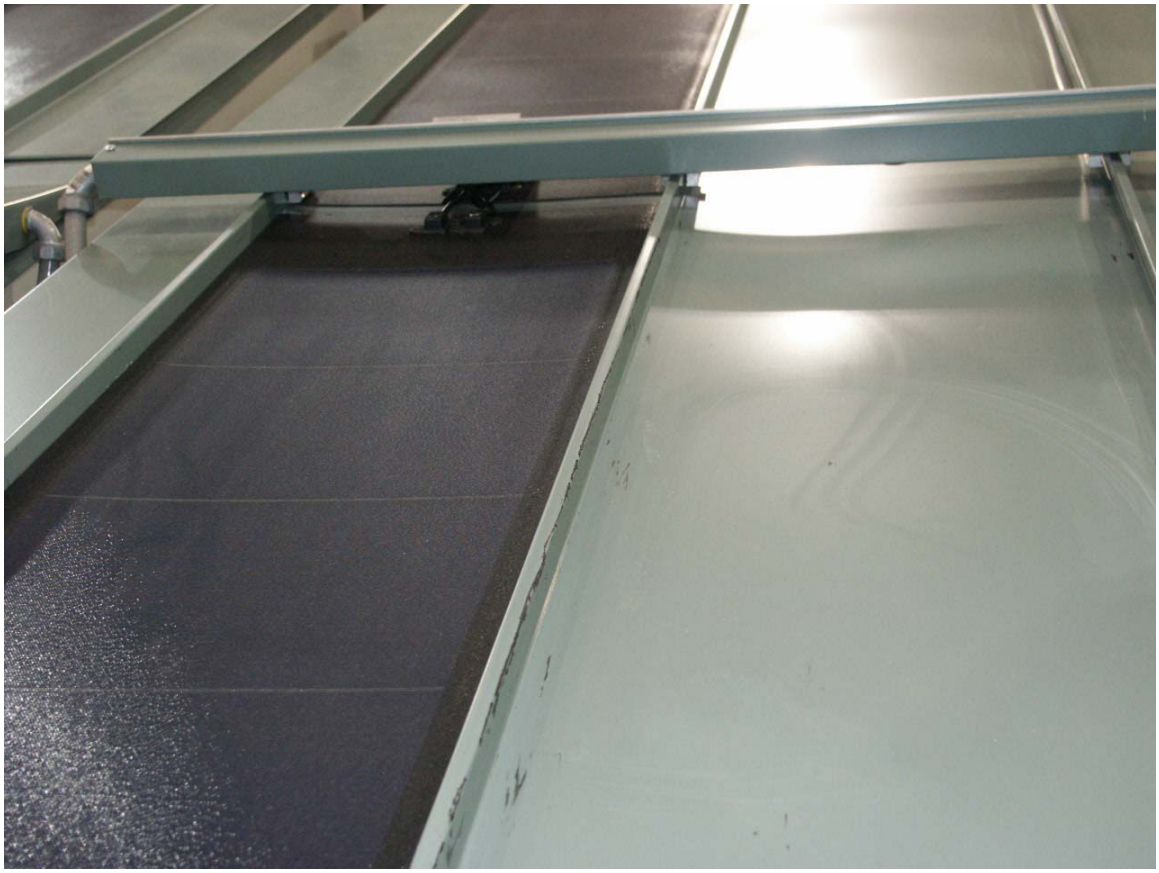
5) Snap wire channel into snow guard channel and wire up.



Wire Raceway Applied to Snow Guard



Snow Guard protects wiring



4.3 Maintenance

Steel Panels with PV Laminates

- Periodically check panel wiring connections for tightness and corrosion. The best time to check is just before and/or just after the winter (or rainy) season.

- Generally, a good rain is sufficient to clean the PV panels. However, in dusty arid locations the PV panels can be cleaned with mild soap and water. Do not use abrasive soaps or solvents.

- Do not spray water directly at leading edge of the PV panel. Use caution when cleaning PV panels, as the combination of water and electricity may present a shock hazard. Avoid cleaning the panels in the middle of the day.

- When working on the solar panels, always wear electrical gloves, disconnect all energy sources (i.e. battery and/or utility) and short-circuit the output of the PV panels.

System Commissioning and Troubleshooting

- With disconnect switches closed, record all system meters and status indicators.

- With the multi-meter, check array and battery voltage (check current between controller and battery if you have a clamp-on amp meter).

- Check for open circuit breakers or blown fuses.

- Open disconnect switches and use your multi-meter to **confirm that the power is actually cut off.**

- Check for loose wires or connections at the solar system controller (voltage regulator).
- Remove cabinet covers and visually inspect all equipment wiring.

- Close all disconnect switches and make sure loads are operating as designed.

- Clean system and loads once a year or as required.

- Confirm that no new loads have been added to the system and that loads are operating for the specified number of hours per day.

4.4 Designing a Solar Electric Steel Panel System

UNI-SOLAR PV products are the key components of a total solar electric system. There are many ways in which these systems can be designed and they include many other components, collectively known as the "balance of system" (BOS). This section is provided as background to assist owners and solar system installers in understanding the total system and the principles upon which it was designed. It is not intended to be a comprehensive guide to designing a solar system.

BOS (Balance of System) Components

BOS components vary depending upon the size and purpose of the power system. A solar power system used for water pumping may include only the solar modules, a combiner box and a pump. A small system used for lighting will include the modules, a charge controller, batteries and some small DC lights. Larger solar energy systems may include an inverter, combiner boxes, disconnect switches, metering, and various fuses as well as the modules, charge controller and batteries. Components common to most systems include the following:

- Battery storage - Stand-alone systems usually require energy storage capability for nighttime or other off-peak use of electric power. Most energy storage systems today consist of lead acid batteries.

- Combiner boxes - Outdoor rated (NEMA 3R or 4X) electrical boxes that will contain different combinations of compression terminals, module fuses and diodes. Combiner boxes provide a location for fuses and diodes and a place where wires from paralleled strings of modules can be terminated. They come in three sizes: 4-input, 8-input, and 12-input models.

- Charge controller - Used in systems with battery storage to prevent solar PV panels from overcharging the battery. The charge controller must be large enough to handle the solar array's open circuit voltage and total short circuit current. Follow the manufacturer's instructions for installation of the charge controller. The sequence of connections made at the controller can be very important. Check manufacturers instructions.

- Inverter - Used to convert DC power to AC power, and to control the power distribution in complex systems. Inverters can be configured to match the common AC supply in any country. Today, there are two main types of inverters; sine wave and modified sine wave. Sine wave inverters produce a cleaner waveform and the harmonic distortion is reduced. Modified sine waves are more efficient than sine-wave inverters and can be lower in cost. The most important factors to consider when using a grid connected inverter for power point tracking of a solar array is to match the array peak power with the inverter's efficiency curves. Different inverters reach their peak efficiency at different levels of capacity. By matching the array to the inverter, you will be operating the inverter at its peak efficiency, thereby reducing power loss and total harmonic distortion. See inverter literature to find efficiency curves.

- Bypass diodes - Every *UNI-SOLAR*® PV panel includes bypass diodes across each cell, resulting in superior shadow tolerance (i.e. reduced power loss under partial shadow conditions). When two or more panels are connected in series, a bypass diode can be installed in the module junction box providing further shadow tolerance.

Types of Systems

1. Stand Alone Systems – Stand alone systems are totally independent of utility supplied electricity. They are most commonly used in remote locations away from the grid. There are two basic types:

   - Low Voltage DC Systems - *UNI-SOLAR*® PV modules produce low voltage direct current, which can be used to charge batteries and operate low voltage (12V or 24V) DC appliances directly. This system is ideally suited for vacation homes, small cabins, or to operate pumps and other compatible appliances or equipment. Battery storage is usually required.

   - High Voltage AC Systems - The *UNI-SOLAR*® PVL system, in conjunction with an inverter, can provide high voltage AC and the same level of comfort and convenience available from the utility grid. For completely independent operation a battery pack and backup generator or other renewable energy sources are required.

2. Line-Tie Systems - Many states have net metering laws that require utilities to purchase power produced from renewable sources, such as solar systems. Line tie systems take advantage of these laws by selling unused power to the grid, thereby avoiding the expense and maintenance of a battery pack. When the PV system produces more energy than is used, the utility meter runs backwards. Line-tie systems use an inverter that synchronizes with the utility grid to make a direct connection with the solar roof. Line-tie systems do not provide backup power if the utility goes down.

3. Utility-Interactive Systems - This system uses a multifunctional inverter that keeps a battery pack charged to provide uninterrupted power. The inverter can use the power produced by the solar modules or power from the utility. The inverter can also be programmed to automatically turn on a generator, if available, when there is an extended utility outage and the battery pack is depleted. True sine wave multi-functional inverters can also direct (sell) excess power to the utility.

Selecting the "Right" System and Sizing

Selecting a solar system requires a detailed analysis of the site's power needs, the amount of insolation (usable sunlight) in the area, the availability of other power sources (utility, other renewable energy sources, a generator) and cost. In utility serviced areas, an inquiry into the utility's policy with respect to buying back excess power will be necessary. High summer peak power requirements and costs in an area may make selling all the produced power to the utility more economical than using the power on site, particularly if the site does not require much power during peak sunlight hours. However, the customer's desire to use solar energy and/or desire for energy independence will also be determining factors in selecting and sizing a solar system.

UNI-SOLAR® PVL panels are suitable for use in systems where system voltages do not exceed 600 volts. The panels can be wired in series, parallel or a combination of both to meet system load requirements. When modules are wired in series, the volts will add up while the amps remain the same. When modules are wired in parallel, the amps will add up while the volts remain the same. By combining series and parallel wiring, any requirement can be met. **Do not use *UNI-SOLAR*® PVL panels in systems having a maximum open circuit voltage greater than 600 volts DC.**

Roof Requirements

The modules should be mounted on an area of roof deck with maximum exposure to sunlight that is devoid of vents, air conditioners or any other obstructions that may shade the solar modules during the day or complicate the installation. Ideally the roof will face south in the Northern Hemisphere and north in the Southern Hemisphere. If the roof face is within 15 degrees of true south (in the Northern Hemisphere), there will be no substantial loss of power. If, however, the roof face is more than 15 degrees away from true south, the array will not perform at peak efficiency. The slope of the roof will also affect solar array output. For the best year-round performance, the angle of the roof slope should be at the area's latitude - 10 degrees.

Aesthetics

UNI-SOLAR® PV Laminates consist of a flexible, ETFE encapsulated solar cells bonded to a UL Listed flat steel panel. The color of the solar cell is a deep blue. The color of the steel panels can be chosen from a wide variety of colors, either to blend or contrast with the solar modules. The panels can also be integrated with other types of roofs.

Placement of BOS Components

The two most important factors to consider when mounting solar array combiner boxes and BOS components are environmental conditions and distance from the solar modules and batteries (when used.) The system designer must consider whether the components will be mounted outdoors or indoors. Factors such as proximity to a dirt road (large amounts of dust) or the sea (salt-water corrosion) must be considered. If conditions are especially harsh, more expensive enclosures must be used. If components will be mounted indoors, less expensive enclosures can be used.

The distance between the solar modules, the combiner boxes and the BOS will affect wire size and layout. Wire costs increase as the length and size of the wire increase so it is best if the solar modules are as close as possible to the BOS components. If it is not possible to decrease the distance from the modules to the BOS, system voltage is usually increased (e.g. to 48 VDC or more) to decrease the amps and consequently reduce the wire size and costs. Combiner boxes are usually mounted close to the array, commonly in the attic or by the inverter. With outdoor installations, they are often mounted directly under the array.

4.5 Addendum #1: Wiring *UNI-SOLAR* PVL Modules with Quick Connect Terminals

Subject

Proper use of the *UNI-SOLAR* Quick Connect Kit, for use with modules that have factory-installed "Quick Connect" terminals on *UNI-SOLAR* PVL and Power Module interconnect wires.

Introduction

UNI-SOLAR Power Modules and PVL products can be supplied with "Quick Connect" terminals on factory-installed module interconnect wires.

"Quick Connect" terminals are designed for exterior use and are UV resistant. By eliminating the need for conduit and by utilizing latching-type, male / female style terminals, *UNI-SOLAR* Power Modules and PVL products supplied with "Quick Connects" offer increased installation speed and installer productivity.

Although "Quick Connects" are well designed for fast connection of modules into groups (i.e. "strings") of modules, "**Quick Connects" are not designed to be used as module disconnects**. For this reason, installers should procure and use the *UNI-SOLAR* Quick Connect Kit for use with each series string of modules that utilize "Quick Connects".

Installation Instructions

Using the *UNI-SOLAR* Quick Connect Kit and the instructions below, PV system installers are prepared for safely connecting PV module strings to balance of system components.

The *UNI-SOLAR* Quick Connect Kit contains 2 pieces: a Male Cable Coupler Assembly and a Female Cable Coupler Assembly.

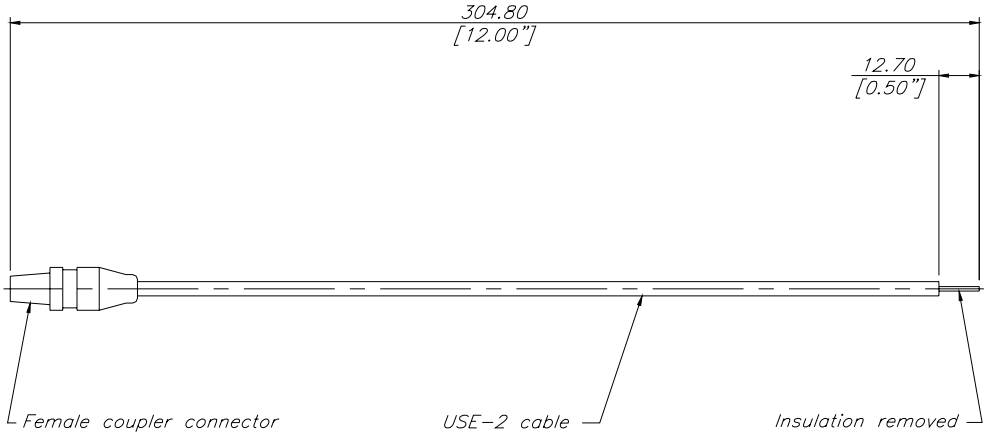
After series connecting (positive to negative) individual Power Modules or PVL's together into a group ("string") of Modules, there will be a male "Quick Connect" on one end of the string and a female "Quick Connect" on the other end of the string of modules.

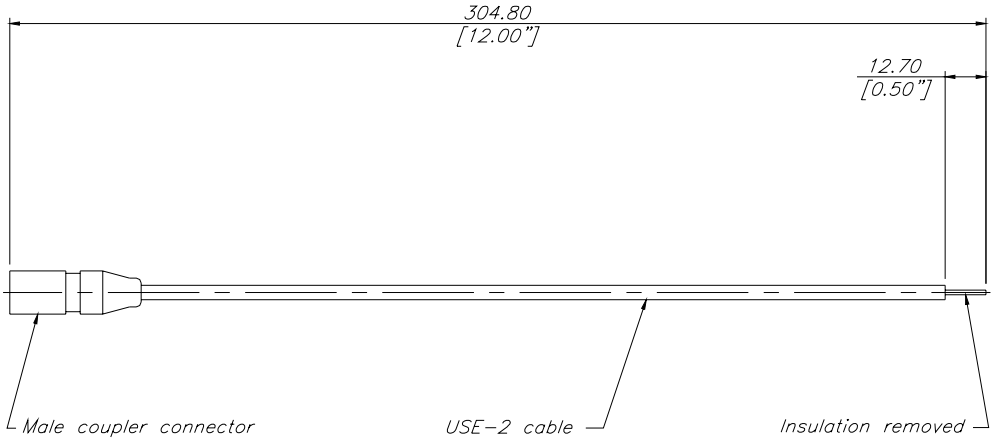
1. Determine that the group ('string") of solar modules has the correct number of modules connected together.
2. Find the male "Quick Connect" on one end of the string and the female "Quick Connect" on the other end of the string.
3. Attach appropriate outdoor-rated conductors to the ends of the *UNI-SOLAR* Cable Coupler Assemblies using standard wire terminals designed for exterior use.
4. Route positive and negative PV conductors to appropriate balance-of-system (BOS) components
5. Attach the *UNI-SOLAR* Male Cable Coupler Assembly on one end of the string.
6. Attach the *UNI-SOLAR* Female Cable Coupler Assembly on the other end of the string.

Technical Information:

1) Withdrawal and Plug-In Force:
   For new Cable Couplers, the withdrawal force is ≥50 N and the insertion force is ≤50N. The values may vary after a number of plugging cycles.
2) Rated Current:
   Maximum rated current is 8 amps for the *UNI-SOLAR* Male and Female Cable Coupler Assemblies.
3) Maximum System Voltage:
   Maximum voltage for a *UNI-SOLAR* PV system and the *UNI-SOLAR* Male and Female Cable Coupler Assemblies is 600 VDC.

Quick Connect Kit: Drawings and Bill of Materials

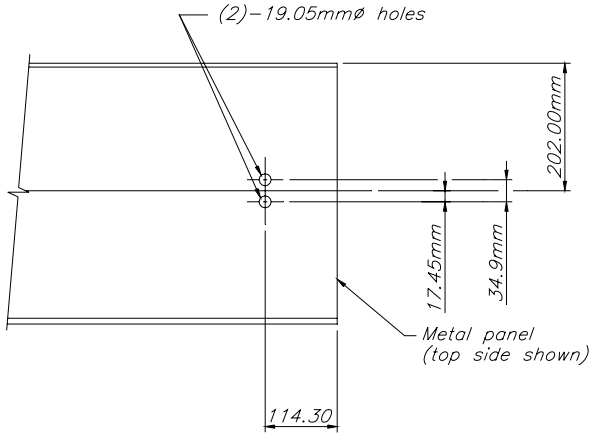




4.6 Addendum #2: Detailed PVL Application Instructions – With Bottom Mounted Junction Box

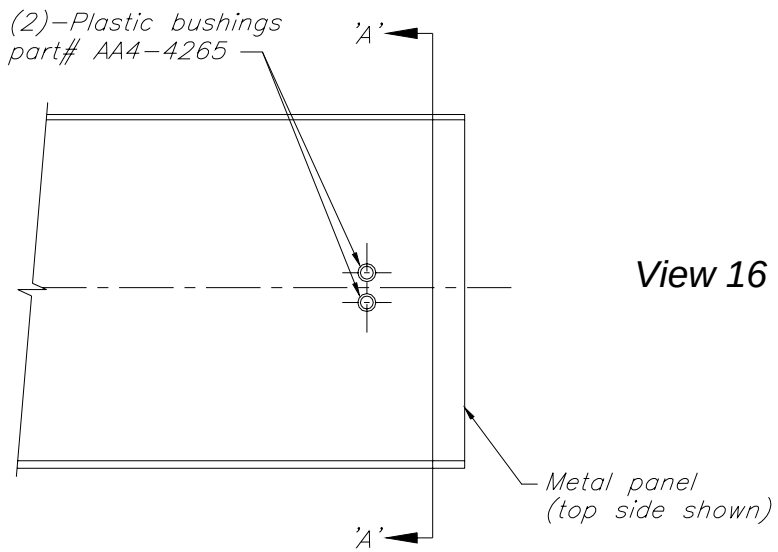
Laminate Installation

1. Cut two (2) ¾" (19 mm) holes in the metal panel for the terminations. The holes must be cut into the metal panel from the same side that the laminate assembly will be placed upon so that any burr is on the bottom side. The proper positioning of these holes is critical. There is just 1 mm of tolerance for the positioning of these holes, see View 15.

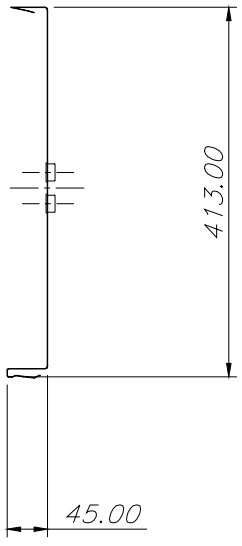


View 15

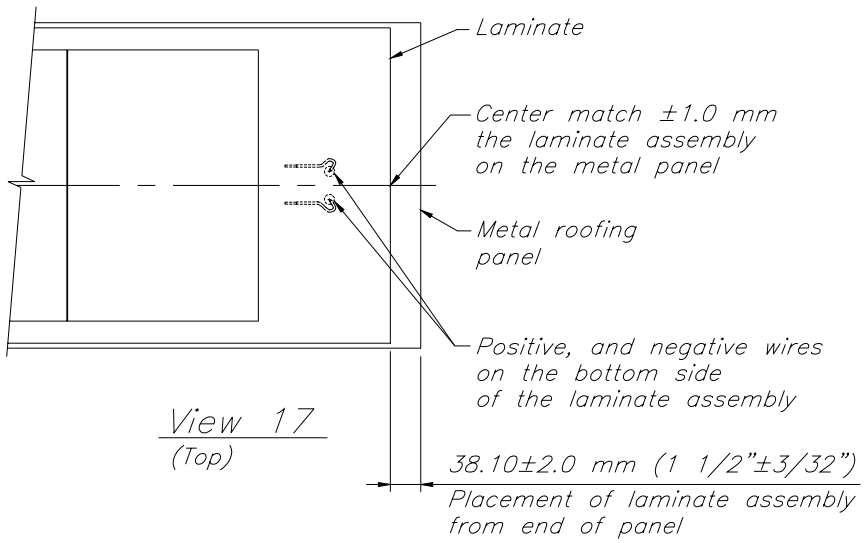
2. Remove any protective film from the face of the metal pan. Clean the metal pan with ISOPROPYL ALCOHOL (90% Alcohol - 10% Water) where the double stick and the laminate will be placed. If the pan is very dirty (part of an existing roof or material has been stored outside), the pan should be power washed with a cleaning solution (1/4 Cup Trisodium Phosphate, ½ Cup Detergent (ex. Tide®), and 5 gallons Water) and then rinsed before cleaning with alcohol solution



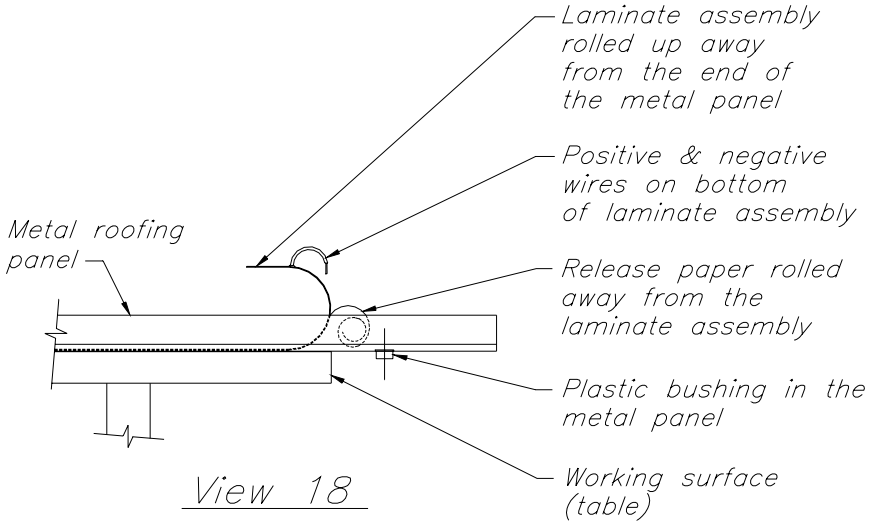
View 16



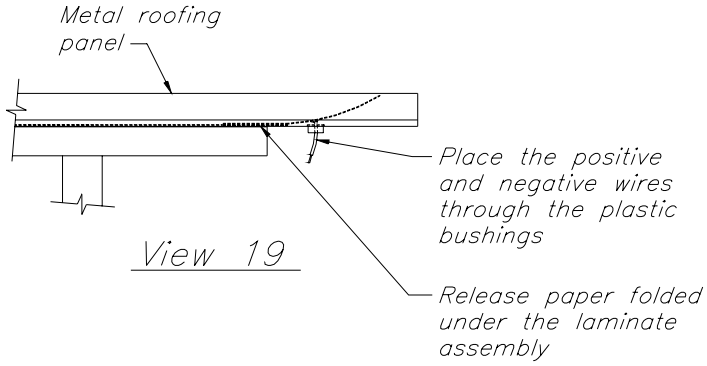
3. Insert (2) two plastic bushings (part AA4 – 4265) into the cut holes, one in each hole from the topside of the metal pan, see View 16 above.
4. The work surface should be flat and rigid. Make sure the end of the metal panel overhangs the flat rigid working surface just past the plastic bushing in the bottom of the metal panel.
5. Align the laminate and double stick assembly on the center of the metal roofing pan. The laminate assembly should be positioned approximately 1½ inches (38 mm) from the end of the metal panel, see View 17 below.



6. Then lift up the laminate and double stick assembly off the metal pan just past the edge of the wires (about 2" inches (51 mm) past the (2) two wires). Peel the release paper off of the double stick material approximately 6" inches (150 mm) and fold it under. Make sure the laminate is centered on the metal pan and the laminate assembly does not move on the metal pan during this process, See View 18. This is critical as **the laminate's position will be fixed after this fist six inches is bonded to the metal pan.**

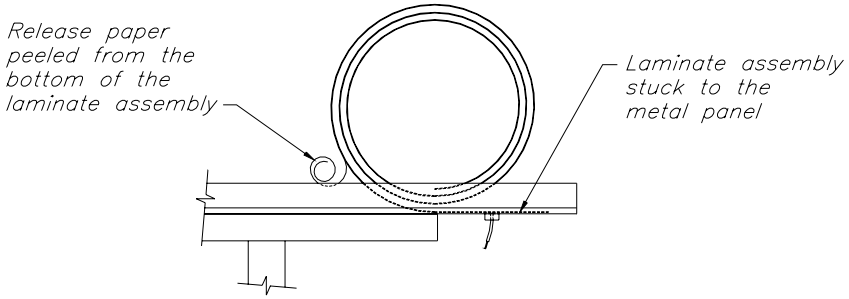


7. Carefully roll the laminate assembly back onto the metal pan while placing the two (2) wires through the plastic bushings in the metal pan, see View 19. Stick the peeled end of the laminate assembly onto the metal panel.



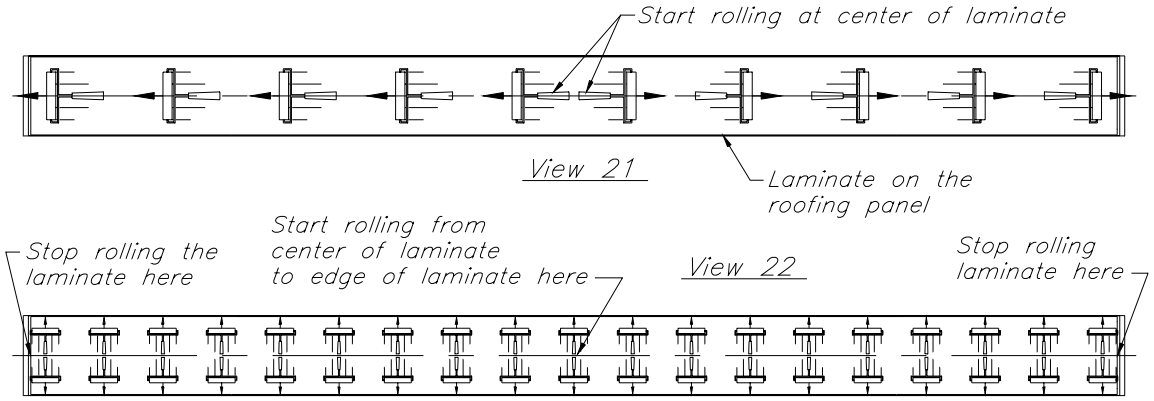
View 19

8. Roll up the rest of the laminate assembly up to the stuck portion of the laminate. After the laminate assembly is rolled up on the metal pan, one person should peel the release paper from the bottom of the laminate assembly as another person unrolls the laminate onto the metal pan. Stick the laminate assembly against the metal pan, see View 20



View 20

9. After the laminate has been applied completely onto the metal pan, use a roller to press the center of the laminate against the metal pan. Then use the roller to press the laminate assembly onto the metal pan, starting from the center of the laminate and rolling out to the edges of the laminate, see View 21 and 22.

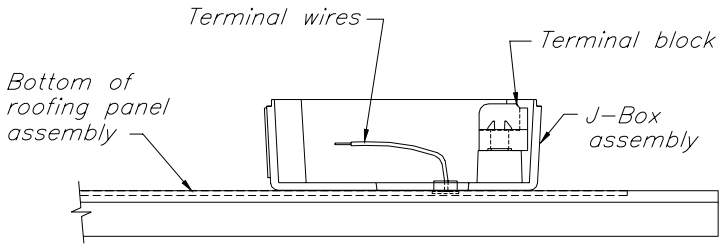


View 21

View 22

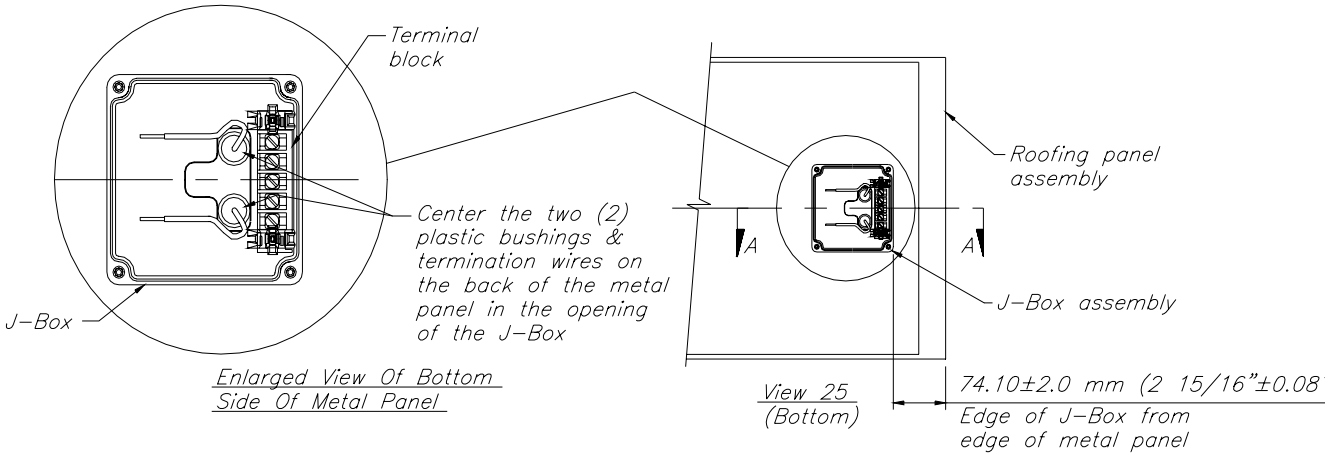
Bottom Mounted Junction Box Installation

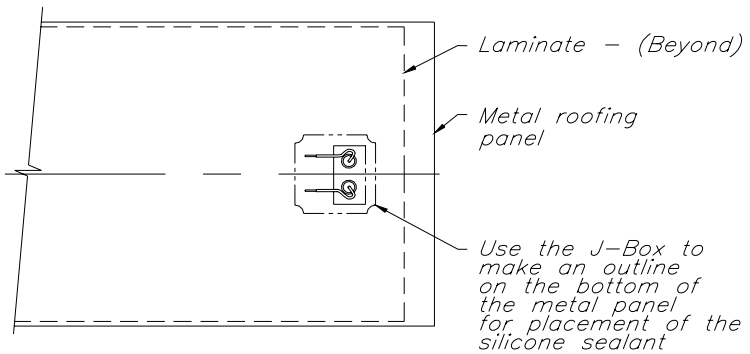
10. To prepare to place the J-Box on the metal panel assembly, turn over the metal pan so that the bottom side faces up.
11. Place the J-Box on the bottom of the metal pan with the two (2) wires and plastic bushings placed through the opening on the bottom of the J-Box, see View 24.



View 24

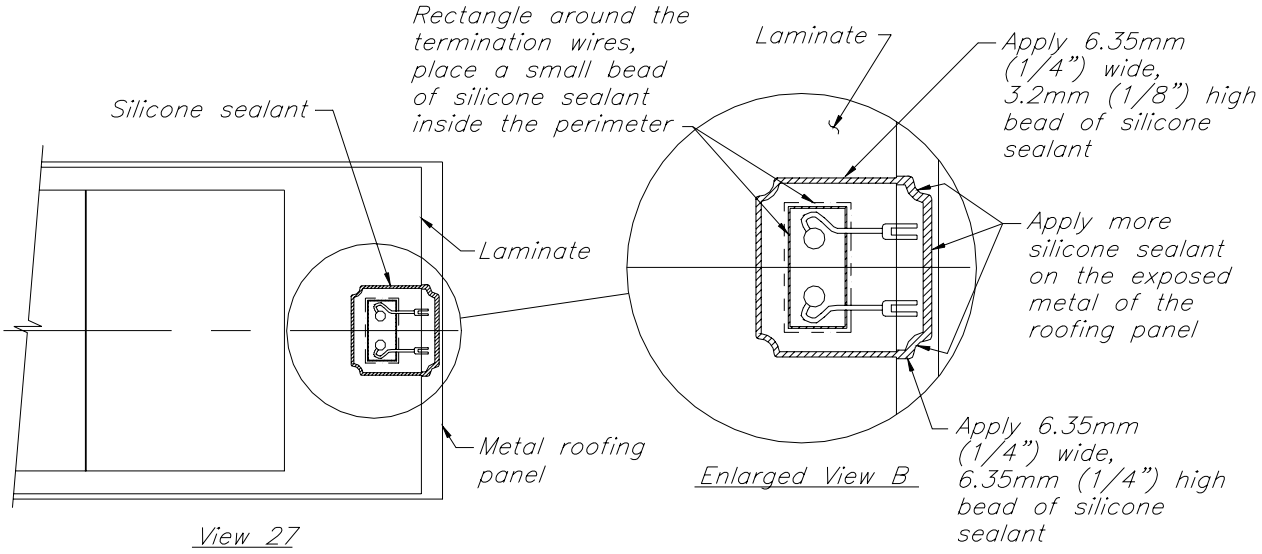
Center the two (2) plastic bushings and termination wires on the bottom of the metal pan in the center of the opening on the bottom of the J-Box, see View 25 and the Enlarged View, and make an outline of the J-Box on the metal pan, see View 26.

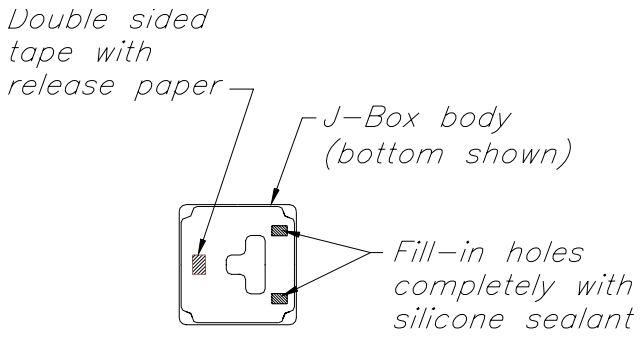




View 26 (Bottom)

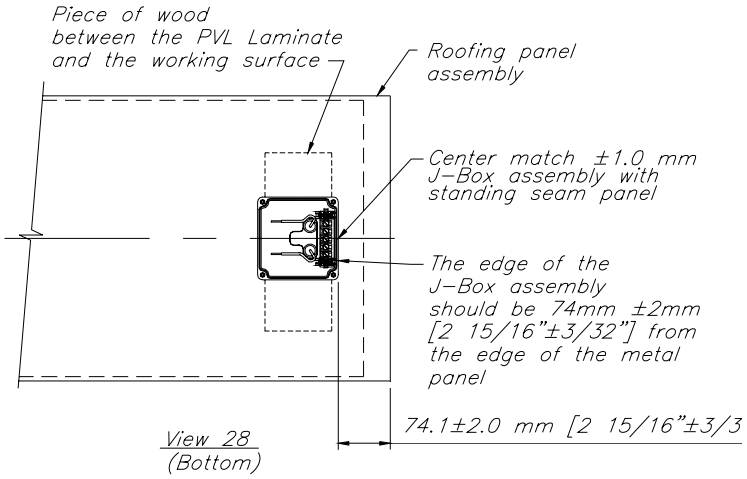
12. After you have made the outline of the J-Box on the bottom of the metal pan, set the J-Box aside.
13. Apply the silicone sealant caulking just inside the marked position on the laminate and metal pan as shown in View 27 and the Enlarged View B. Apply a generous bead (¼" x ¼") of silicone sealant. Apply a small bead (¼" x 1/8") of silicone sealant on the inside perimeter of the rectangular marking around the two (2) terminal wires (See Enlarged View B).
14. Make sure that the sealant bead is continuous and uniform.
15. Make sure there is a piece of double sided tape on the bottom of the J-Box. Fill in the two openings on the bottom of the J-Box with silicone sealant, see View 27 below. Remove the release paper from the double sided tape on the bottom of the J-Box.



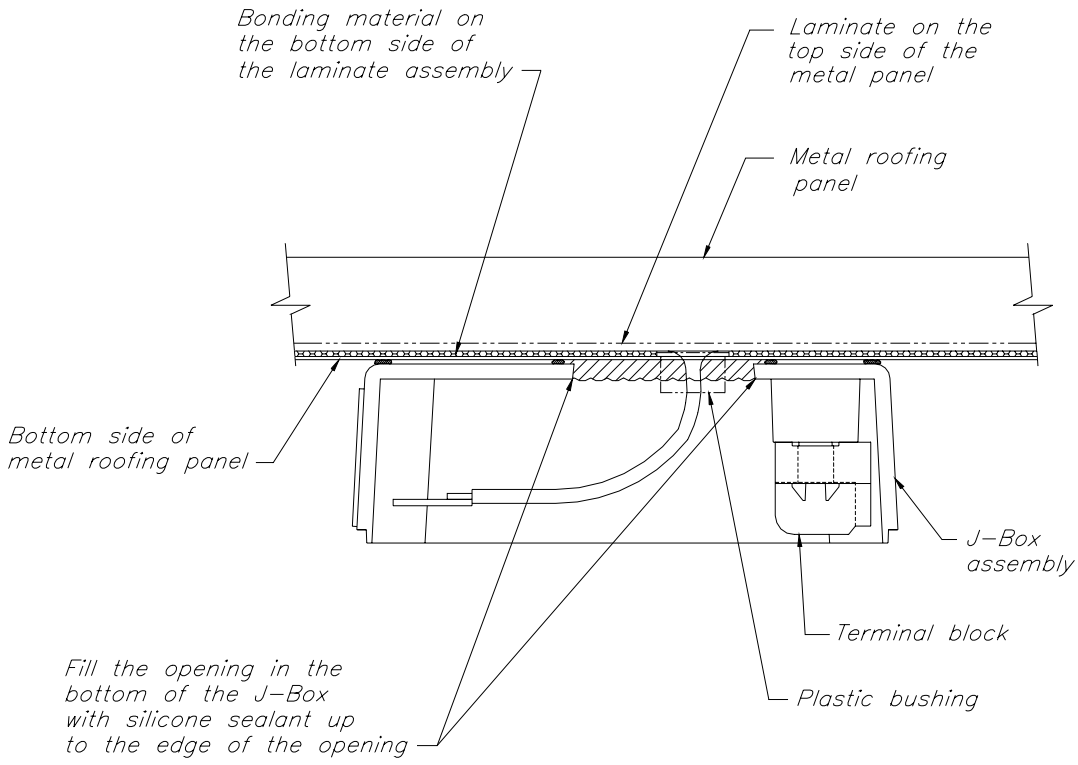


16. Place a wood block 2 x 4 x 10" inches long beneath the metal panel (between the PVL laminate and the working surface) in the area below the outline of the silicone sealant to help support the pan when applying the J-Box assembly, see View 28.

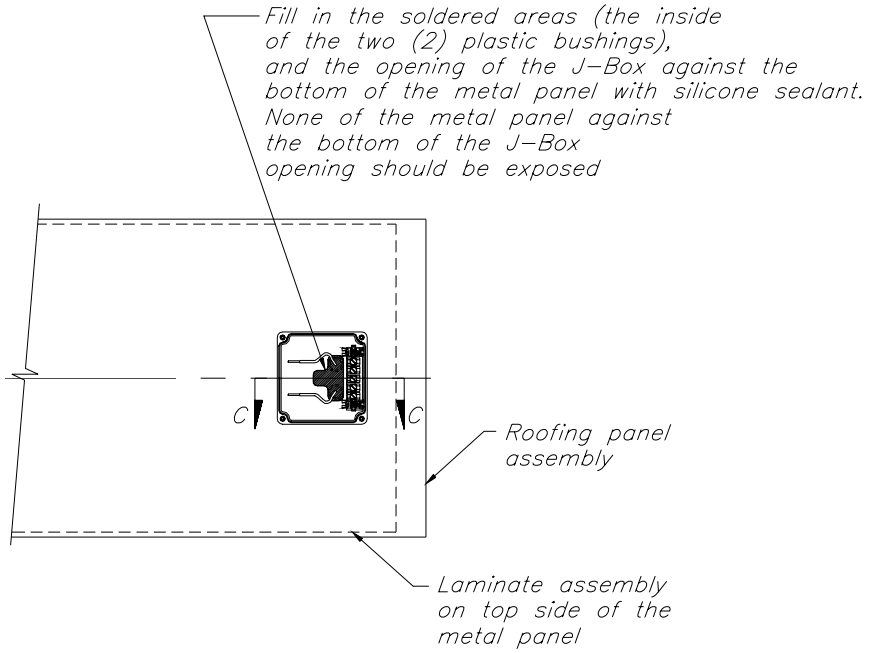
17. Align the J-Box case on the silicone sealant on the metal pan. Make sure the edges of the bottom of the J-Box are aligned properly with the silicone sealant on the metal pan.



18. Make sure that the two terminal wires are properly aligned within the opening on the bottom of the J-Box. The J-Box should be center matched and 2 15/16ths (74 mm) from the edge of the metal panel.
19. Check to make sure the terminal wires are not trapped or pinched between the J-Box case and the bottom of the metal pan.
20. Press the J-Box against the bottom of the metal pan so that the double-sided tape on the bottom side of the J-Box sticks to the metal pan.
21. Completely fill the opening in the bottom of the J-Box, including the inside and outside of the two (2) plastic bushings with silicone sealant, up to the inside edge of the opening. None of the metal pan should be exposed in the J-Box opening. Do not overfill the opening with sealant, see View 29 and 30. **NOTE: You must allow the silicone sealant to set up ("cure") for at least eight (8) hours before attaching the J-Box cover.**



View 29



View 30
(Bottom)

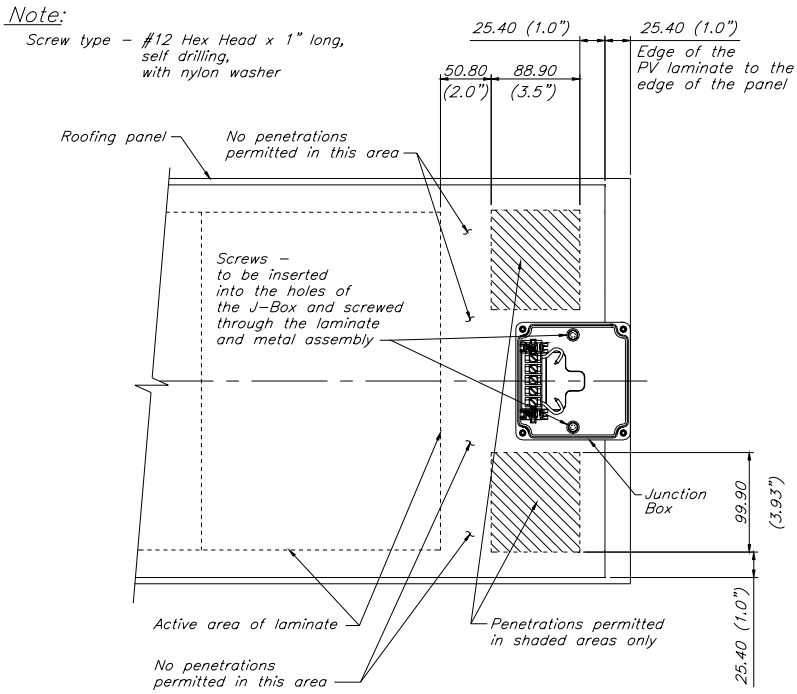
22. Place a J-Box lid on the top of the J-Box body.
23. Make sure that the direction of the UNI-SOLAR logo on the J-Box lid is properly placed with respect to the roofing pan.
24. Screw down the four screws of the four corners of the J-Box lid. The recommended torque range for the J-Box cover screws is 14 +/- 1 in-lb.

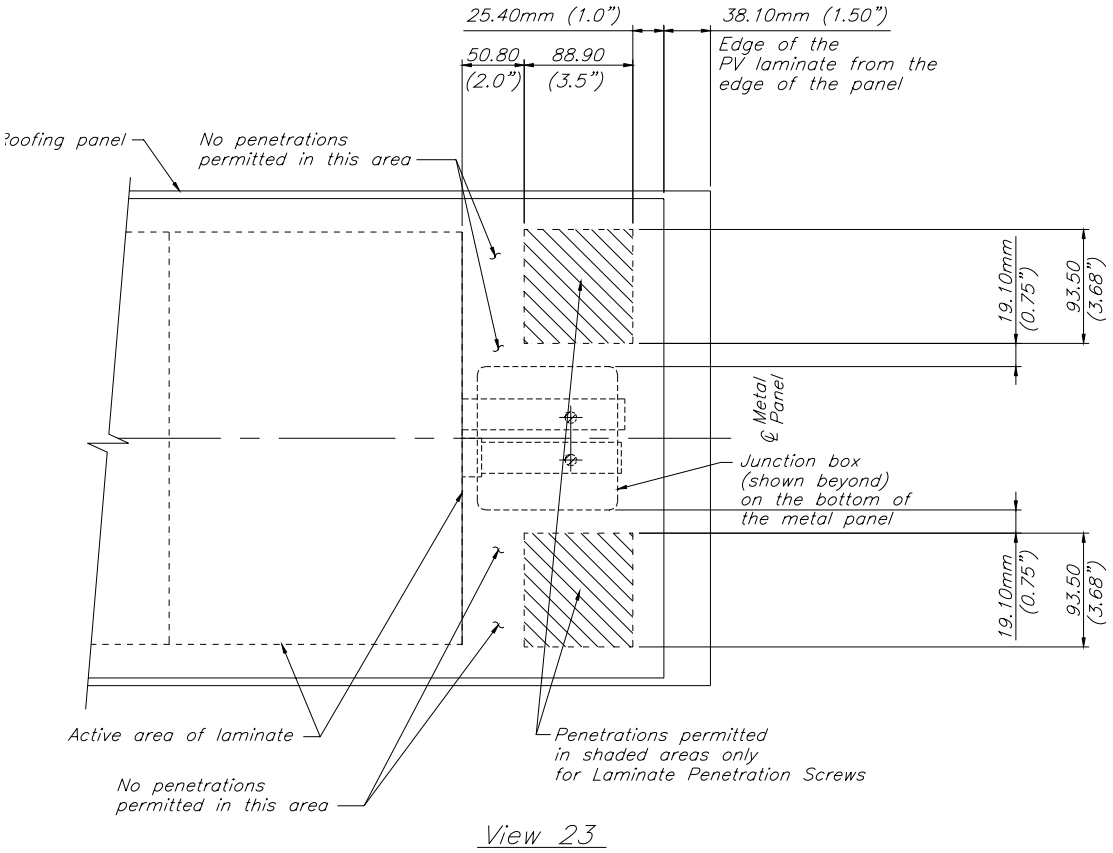
4.6 Addendum #3 UNI-SOLAR "Last Generation" Laminate Style, Part Numbers and Associated Screw Penetration Drawing

Introduction:
In 2002 Uni-Solar automated part of their Laminate manufacturing process and this necessitated a small change in the "top sub-assembly" of all the laminate products. The "top sub-assembly is the top 6 ½ inches of the laminate above the top solar cell. This area contains the bus bars from the module solar cells and the termination point where the Quick Connect Terminals or J-Box is located.

The best way to distinguish the Last Generation style top sub-assembly from the New Generation top sub-assembly is by identifying the part number of the laminate and determining whether it is a Last Generation laminate or a New Generation Laminate. Another way to distinguish between the two types is to look for three small holes in the laminate's black plastic trim material at the top of the laminate. These holes will be located an inch above the top solar cell and are intended to guide the roofer in the placement and fastening of a Z-closure (i.e. "Z-bracket") that is often used when attaching the ridge trim at the peak of the roof.

Installation of "Last Generation" Laminates:
Installation of the "last generation" laminates follows the same procedures described in this manual for the new generation laminates. They only difference is the position of the screws that are used in situations where the roof temperatures may exceed 70 C and the roof slope is greater than 60 degrees. When screwing fasteners through the laminate the following drawings can be used to ensure that the screws do not break any of the bus bars in the top sub assembly that carry power from the solar cells to the positive and negative terminal points at the top of the laminate.





Part Numbers for Last Generation Laminates:

Description	Model	Part Number
29 W, Bottom Termination, Std. J-Box with 4" Wires	PVL-29B S/S	A205837
29 W, Top termination, Std. J-Box with 4" wires	PVL29T S/S	A205838
29 W, Top termination, Std. J-Box with Quick Connects	PVL29T-JB/QC/S	A206601
29 W, Top termination, Terminal Housing with Quick Connects	PVL29T QC/S	A206104
58 W, Bottom termination, Std. J-Box with 4" wires	PVL58B S/S	A205833
58 W, Top termination, Std. J-Box with 4" wires	PVL58T S/S	A205834
58 W, Top termination, Std. J-Box with Quick Connects	PVL58T-JB/QC/S	A206602
58 W, Top termination, Terminal Housing with Quick Connects	PVL58T-QC/S	A206101

64 W, Bottom Termination, Std. J-Box with 4” wires	PVL64B S/S	A205830
64 W, Top termination, Std. J-Box with 4” wires	PVL64T- S/S	A205828
64 W, Top termination, Std. J-Box with Quick Connects	PVL64T-JB/QC/S	A206604
64 W, Top termination, Terminal Housing with Quick Connects	PVL64T QC/S	A206100
87 W, Bottom termination, Std. J-Box with 4” wires	PVL-87B S/S	A205835
87 W, Top termination, Std. J-Box with 4” wires	PVL87T S/S	A205836
87 W, Top termination, Std. J-Box with Quick Connects	PVL87T-JB/QC/S	A206605
87 W, Top termination, Terminal Housing with Quick Connects	PVL87T QC/S	A206606
116 W, Bottom termination, Std. J-Box with 4” wires	PVL116B S/S	A205831
116 W, Top termination, Std. J-Box with 4” wires	PVL116T S/S	A205832
116 W, Top termination, Std. J-Box with Quick Connects	PVL116T JB/QC/S	A206608
116 W, Top termination, Terminal Housing with Quick Connects	PVL116T QC/S	A205845
128 W, Bottom Termination, Std. J-Box with 4” wires	PVL128B S/S	A205829
128 W, Top termination, Std. J-Box with 4” wires	PVL128T S/S	A205827
128 W, Top termination, Std. J-Box with Quick Connects	PVL128T JB/QC/S	A206610
128 W, Top termination, Terminal Housing with Quick Connects	PVL128T QC/S	A206109

4.6 Addendum #4: Using a “Megger” to Test Module Groups (i.e. “strings”) after the Array is installed

High Potential Test

The purpose of this field test is to determine if any of the PV Laminates in the PV array have been damaged prior to or during the installation process. A damaged panel will result in a high reading during the hi-pot test.

The following safety precautions must be observed when using the BM21 Megger:

- ✓ During the hi-pot test, the leads should not be touched or removed during any part of the test
- ✓ The test should be terminated if there is a high voltage warning symbol on the LED display (A test can be stopped manually by pressing the red "TEST" button which discharges the load).
- ✓ At the end of a test, the capacitive load should be fully discharged to zero volts before disconnecting test leads.
- ✓ For the wet hi-pot test, do not spray water while the test while test is in progress (i.e. while voltage is applied)

Figure 1

High Potential Test Procedures

The following procedure indicates how to use the MEGGER BM21 to execute a High Potential ("Hi Pot") test of a PVL module array. Although the procedure follows the use of the MEGGER BM21, any quality Megger can be used with little deviation for the procedural steps below.

The Megger BM21 consists of the following parts (see Figure 1).

A) Screen
B) Megger terminals
C) Test leads
D) On/Off button
E) Voltage / time selector
F) Up / Down – I/R Selector
G) Test Voltage
H) Test time
I) Current Value
J) Current/Resistance Selector
K) Indicator LED
L) On/off Test Button

How to do the Hi Pot Test:

1) Right arrow must point to "I" on the right side of the screen. To do this, move the voltage / time selector to any value except "ramp' or "clock" and move the I/R selector to the "I" value.

2) Test voltage must be set at 600 volts. To set the voltage, push the voltage / time selector until the left arrow points to the "ramp" (triangle figure on Megger) on the left side of the screen. Two (2) arrows will be shown on the screen (up and down) to select the voltage value in steps of 25 volts. Push the selector until 600 is shown on the top of the screen (G).

3) Test time must be set at 19 seconds. To set the time, push the voltage / time selector until the left arrow points to the clock on the lower left of the screen. To set the time, push the right selector (F) to reach the desired time.

4) For each series string of PV modules, connect the positive (+) and negative (-) terminals together using a jumper with insulated terminals. The PV strings must be electrically separated for this test.

5) Connect the test leads on the positive (+) and negative (-) terminals on the Megger in their corresponding terminals.

6) Connect the positive (+) test lead to the shorted array wires.

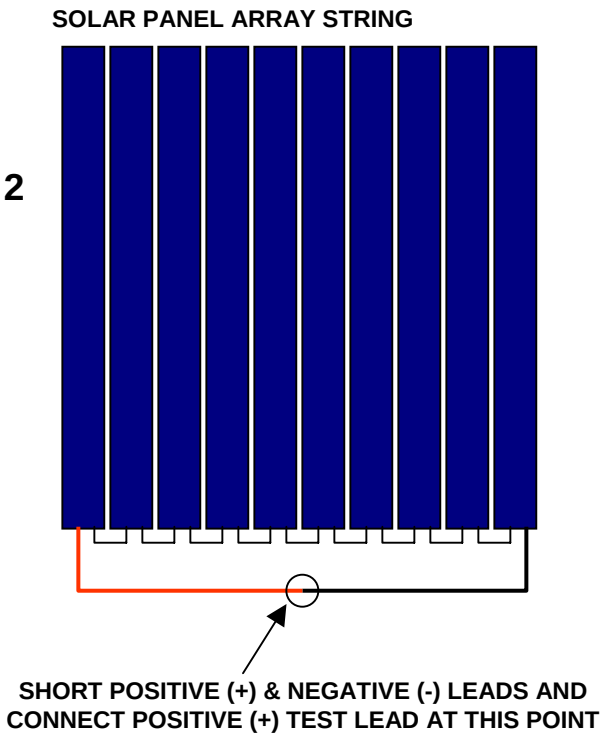
7) Connect the negative (-) test lead to the metal roofing at the grounding point or any earth-ground point.

8) Thoroughly wet the array string to be tested.

9) Before starting the test, make sure that

   a. Voltage on the Megger is set to 500 volts
   b. Time on the Megger is set to 19 seconds
   c. Right arrow is pointing to Current (I). Figure 1 shows the Megger screen for a, b, and c settings.
   d. Negative terminal is connected to ground (metal)
   e. Positive terminal is connected to both terminals on the module string.

Figure 2



10) To start the test, push the red button (I) until the indicator LED (K) begins to blink. Release the button. The LED will keep blinking until the 19 seconds has passed and the test has finished.

11) When the test has finished, push the red button one more time to reset the Megger.

12) Figure 3 shows the screen when the test is running. When the array has no Hi Pot problem, the voltage on the screen will go higher than 600 volts and the current value will go lower than 50 μA even before the 19 seconds has passed.

13) If any module in the string has a Hi Pot problem, (due to scratches, inclusion, etc.), the screen will show 0 volts for the voltage value and >999 μA on the current value. This indicates that one or more modules is damaged (see figure 4 as a reference).

14) Repeat test for all array strings in the PV power system.

Hi Pot Criteria

Maximum Leakage Current: I < 50μA per module string
Example: For an 11-module string, I < 600μA

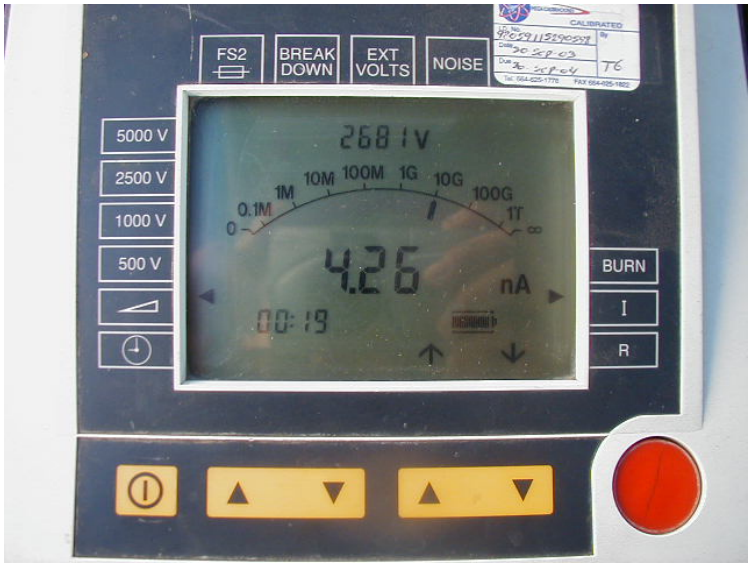


Figure 3

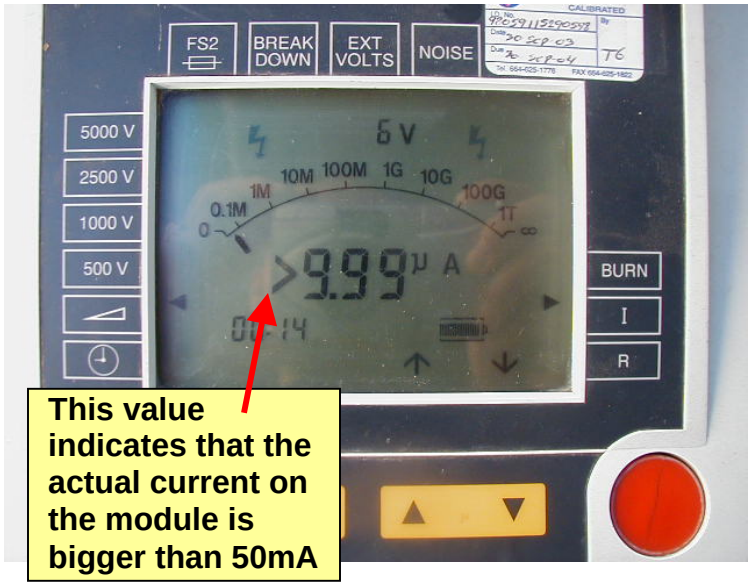


Figure 4

SECTION #5

5.1. PVL Installation Check List and Final Report

The purpose of this Report is to certify that the undersigned installer has completed installation of *UNI-SOLAR* PVL Laminate described below in accordance with the manufacturer's installation guidelines and has fully complied with the PVL bonding instructions.

To ensure that the PVL laminate was properly installed, it will be required that all Certified PVL Installers copy the Installation Checklist and Final Report from this manual, fill in the Checklist and Report after installation of the product at any given site. The Check List and Report is then signed, dated and returned to:

United Solar Ovonic LLC
BIPV Applications Engineering Department
3800 Lapeer Road
Auburn Hills, MI 48326

Installation Location:

Customer / Project Name:……..

Site Address:…….……

Customer Telephone / Email: …….

Pre-Installation:

QUESTION	YES	NO
1. Are the pans flat (no decorative stucco finish or pencil beads)?		
2. Are the pans a part of a UL Listed roofing system?		
3. Are the pans made of Galvalume (steel pans with the AZ-55 or AZ-50 treatment)?		
4. Are the pans painted with a Kynar 500 type PVDF topcoat?		
5. What is the width of the pans (Minimum width = 16")		
6. Did the roofer install the metal roofing system properly?		

Note to End User:
If the PVL Solar Electric Laminates will not be bonded to Galvalume pans and/or any of the Pre-Installation questions were answered negatively, the end user must sign below indicating that he/she will accept a ONE YEAR LIMITED WARRANTY on the adhesion and electrical/physical integrity of the module.

Signature (End User): _____

Application of the PVL Product:

QUESTION	YES	NO
1. If the PVL application will take place on an existing roof, were the pans washed with a pressure sprayer and cleaning solution (ex. TSP, Detergent and Water) to remove collected dirt, pollen, grime etc.?		
2. Were the pans washed with Isopropyl Alcohol (90% alcohol to 10% water) before application of the laminates?		
3. Was the pan temperature at least 50º F during the bonding process?		
4. Were all laminates aligned properly on the pans?		
5. Did all the laminates adhere to pan completely?		
6. Was every square inch of the laminate pushed down to the metal pan surface with the laminate roller to ensure a complete bond to the metal pan?		
7. Was the Junction Box or Quick Connect Terminals aligned properly?		
8. Did the laminates come with Quick Connect Terminals, a standard J-Box or a J-Box w/ Quick Connects?		
9. How long did it take (on average) to bond the laminate and J-Box to the pan?		Minutes

Post-Installation:

QUESTION	YES	NO
1. Did the roofer install the pans properly?		
2. Was their any damage to the solar module (laminate) during installation?		
3. Are any ripples or other defects in the PVL application seen from the ground?		
4. Is the J-Box or Quick Connect wiring adequately protected from UV by metal roofing trim (or an approved wire cover)?		

System Information:

QUESTION	
1. What is the operating voltage of the PV array?	
2. Which laminates were installed at this site (PVL-29, PVL-58, PVL-64, PVL-87, PVL-116, or PVL-128)?	
3. How many PVL laminates were installed on the UL Listed Roofing System at this site?	
4. What type of inverter was installed at this site?	
5. What type (if any) of battery was installed at this site? What is the total amp-hour capacity of the battery?	

Note to Installer:
The quality and acceptance of PVL installations are the prime responsibility of the installer. United Solar Ovonic LLC reserves the right to inspect any and all installations to verify the accuracy of this report. Providing inaccurate or misleading information will cause immediate cancellation of the installer's certification.

Installer:

Signature:…….Date:……./…..…/…...…

Name:……

Address…….……..……..……..…

Telephone: ……

Email: ……

Contacts:

United Solar Ovonic
Corporate Office
3800 Lapeer Road
Auburn Hills MI 48326
(800) 843-3892
(248) 475-0100
Fax (248) 364-0510
www.uni-solar.com

United Solar Ovonic
North American Sales Office
8920 Kenamar Dr. Suite 205
San Diego, CA 92121 USA
Tel: 858.530.8586
Fax: 858.530.8686
Email: westerninfo@uni-solar.com

United Solar Ovonic
European Office
Dennewarststrasse 25-27
D-552068 Aachen – Germany
Tel: +49.241.963.1131
Fax: +49.241.963.1138
Email: europeinfo@uni-solar.com

McElroy Metal Inc.
Corporate Office
PO Box 1148
Shreveport, LA 71163
Telephone: (318) 747-8045
Toll Free: (800) 950-6531
Fax: (318) 747-8029
Website: www.mcelroymetal.com

BHP Steel
Level 11, 120 Collins St.
Melbourne
Victoria 3000
Australia
PH: +61 3 9666 4000
Fax: +61 3 9666 4111