TPO ULTRAPLY

Technical Guidelines

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INSTALLATION

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3 Installation

This chapter has been prepared mainly for roofing contractors and their crew to assure that the Firestone UltraPly™ TPO roofing systems are installed as per Firestone's requirements. In addition, it may serve as a reference for specifiers during inspections. This section therefore contains guidelines for job preparation, standard procedures and good practices for installation and information with regards to detailing.

For practical use, installation steps are organized in chronological order and are illustrated with a maximum of pictures.

The following topics will be discussed in this chapter:

It is important to highlight that hands-on training and a vast on-site experience are required to ensure a high quality installation of Firestone UltraPly™ TPO roofing systems. Installation can therefore only be done by trained installers who are familiar with Firestone's installation procedures and the conditions required to apply and weld the Firestone UltraPly™ TPO products properly.

3.1 Jobsite preparation

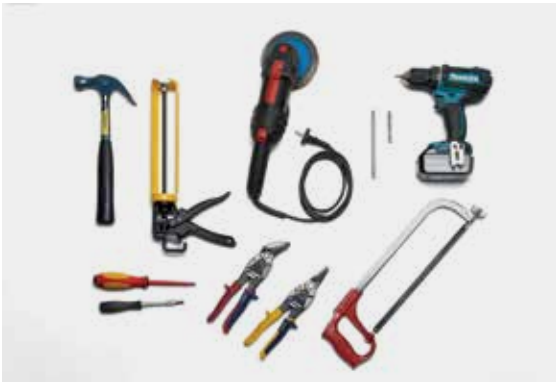
Picture 3.1

A smooth installation start with a good preparation. The following topics need always to be checked prior to and during installation.

- **TOOLS and EQUIPMENT** - Quality of installation depends to a large extent on the use of adequate tools.
- **POWER SUPPLY** - Supply of energy is extremely important and requires special attention, as it has a direct impact on the performance of welding.
- **JOBSITE CONDITIONS** - A site visit prior to job start may help to avoid unpleasant surprises.
- **SAFETY** - Firestone UltraPly™ TPO roofing systems require specific safety measures.

3.1.1 Tools and equipment

Picture 3.2



Picture 3.3

Picture 3.4

Picture 3.5

It is extremely important that welding equiments and tools that are used are appropriate and in good shape.

Roofing technicians need to be familiar with their use and must be experienced with welding conditions (welding properties of membranes and accessories, weather, job site conditions, etc...) to guarantee the required quality and performance of the installation.

Firestone recommends to strictly follow the instructions of the tool or equipment supplier with regards to its use, maintenance and performance and to contact a Firestone technician in case of doubt.

Refer to the information of the following pages to make sure that the appropriate tools are on site.

Tools to cut, mark and measure *(Picture 3.2)*

- Tape measure (5 lm)
- Scissors
- Hooked knife
- Plain cutter
- Cutting blades
- T-square
- Chalk-line
- Colored powder
- Marking pen/pencil

Make sure that the cutting tools are clean and appropriate to cut reinforced thermoplastic membranes. Hooked knifes will do the job for straight cuts, while scissors may be more practical to create rounded cuts and for installing specific details. Verify the sufficient supply of cutting blades prior to job start.

Tools to install metal profiles *(Picture 3.3)*

- Hammer
- Metal snips
- Metal saw
- Grinder and grinding disc
- Screwdriver
- Mastic gun
- Battery tool for fastening
- Drill bits (metal & concrete)

Verify the cutting capacity of metal snips and adjust when required.

Tools for cleaning *(Picture 3.4)*

- White cotton rags
- Squeegee
- Stiff brush
- Plastic bucket
- Firestone scrubbing tools

Make sure to have clean white cotton rags on site in sufficient quantity to clean the membrane surface without leaving dirty marks. Firestone scrubbing tools are recommended when more thorough cleaning is needed.

Tools to apply adhesive *(Picture 3.5)*

- SuperSpreader
- BetterSpreader
- Small and big rollers
- Mixer
- Paint brush
- Spraying pistol

Make sure rollers are in good condition to uniformly distribute the adhesive onto the substrate.

Hand rollers need to be solvent resistant and with short hair.

Paint brushes or small rollers are used to apply adhesive in angle changes with difficult access.

The SuperSpreader and BetterSpreader are used for a more uniformly and economical application of adhesive on the horizontal.

Tools for mechanical fastening

EQUIPMENT	DESCRIPTION
	Hammer drill with weight class 2-3 kg, impact energy 2.5 J
	Power screwdriver, min. 500 W, 300 - 700 rpm
	Battery-operated screwdriver, 300 -700 rpm, approx. 18 V, Battery with approx. 2.5 Ah
	Drill bits (metal, concrete, lightweight concrete)

Table 3.1

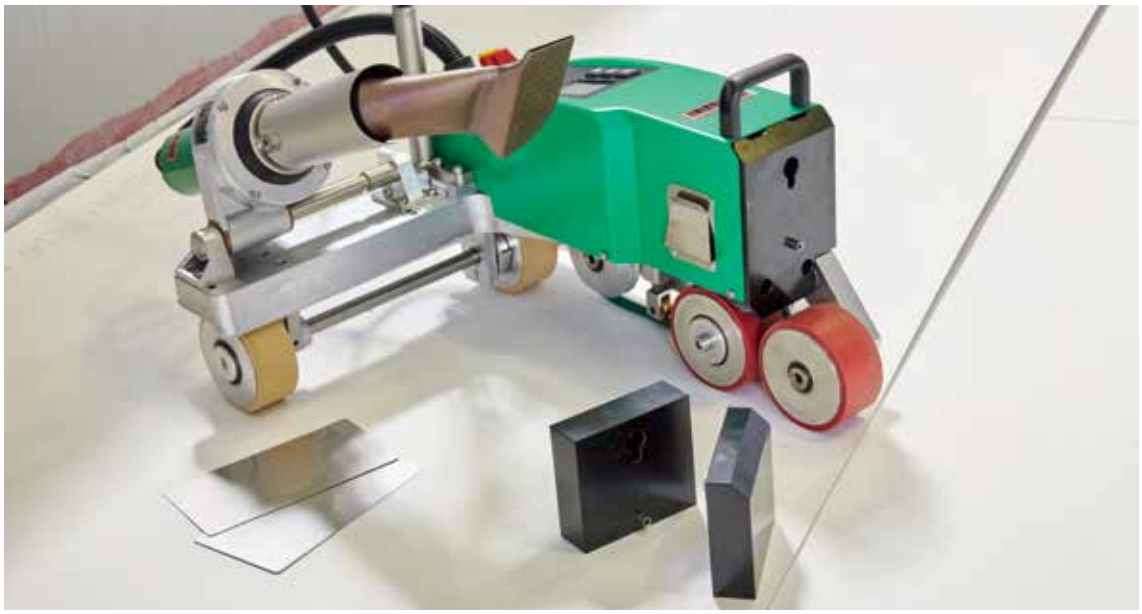
Use a hammer drill for pre-drilling and installation of fasteners into concrete decks and a power screwdriver or battery tool for the installation of fasteners into lightweight concrete. Do not use a percussion tool.

Automated setting tools (for pre-assembled fasteners and plates) or stand-up setting tools can be used for fastening of membrane and insulation over steel and wooden decks.

Verify size (diameter, length, working length) and type of drill bits. Carbide drill bits are used for concrete, ZVK drills for lightweight concrete.

Make sure to provide sufficient spare drill bits.

Automatic welder and accessories



Picture 3.6

- Use appropriate robots for welding long seams.
- Refer to Table 3.2 to identify a suitable equipment with proven performance and follow the instructions of the respective supplier for its use and maintenance.

TYPE OF EQUIPMENT	VOLTAGE (V)	POWER (Watt)	WEIGHT (kg)
LEISTER VARIMAT	230/400	4600/6300	35
LEISTER VARIMAT V	230/400	4600/6300	35
LEISTER VARIMAT V2	200I230I400	4200/4600/5700	35
LEISTER UNIROOF AT / ST	100/120/220-240	1500/1800/3450	17.5
HERZ LARON	230/400	4600/5700	35
SIEVERT TW 5000	220 -230/400	5000/6300	30

Table 3.2

- Small welders such as the Leister Uniroof AT/ST can be used to weld specific situations (e.g. base of upstands). They are less appropriate to do bigger projects.
- It is important to understand that different welders provide a different output of heating energy. The welding window and settings may therefore differ in function of the machine.
- Verify the proper functioning of the robot (alignment, build-up of temperature) prior to job start.
- Make sure pressure wheels and nozzles are clean and intact and verify that all accessories (weights, metal plates to start/stop welding, etc.) are available.
- When using a different welder than the ones listed above, consult Firestone's technical department or a Firestone technician for approval.

Hand welder and accessories

Picture 3.7

- Use appropriate hand welders for short welds and detailing.
  1 Hand welder
  2 Different nozzles
  3 Silicone roller
  4 Hard roller
  5 Metal pressure roller
  6 Wire brush
  7 Seam probe
- Refer to Table 3.3 to identify an appropriate hand welder and follow the instructions of the respective supplier for use and maintenance of the selected equipment.

EQUIPMENT	VOLTAGE (V)	POWER (Watt)
LEISTER TRIAC ST (manual)	100/120/200/230	1500/1600/1600/1600
LEISTER TRIAC AT (digital display)	100/120/230	1500/1600/1600
HERZ RION (manual)	120/230	1600
HERZ RION DIGITAL (digital display)	120/230	1600
SIEVERT DW 3000 (digital display)	230	2000

Table 3.3

- Use different rollers and nozzles in function of the situation.
- Verify the functioning of hand welders and make sure that all nozzles are clean prior to job start.
- When using a different welder than the ones listed above, consult Firestone's technical department or a Firestone technician for approval.

Induction welder and accessories

Picture 3.8

- Refer to the table below to select an appropriate induction welding equipment and follow the instructions of the respective supplier for use, adjustment of settings and maintenance.

EQUIPMENT	VOLTAGE (V)	POWER (Watt)	FREQUENCY (Hz)
FIRESTONE INVISIWELD-RHINOBOND (OMG)	110-125/230	1300	50-60
ISOWELD 3000 (SFS) - GUARDIAN WELD	100/230	1500	50-60

Table 3.4

- When using a different welding equipment than the ones listed above, consult Firestone's technical department or a Firestone technician for approval.
- Small hand induction tools are also available for induction welding against upstands.
- Verify the proper functioning of the induction welder and quality of energy supply and make sure that the contact surfaces of all cooling/clamping magnets are clean prior to job start.

3.1.2 Power supply

Picture 3.9

- Power supply differs usually from one job site to the other and therefore usually requires a specific study to guarantee the required quality.
- Always check that local safety and electrical regulations are observed. Consultation of a qualified electrician is therefore advisable.
- Ensure an uninterrupted and stable power supply for all your electric installation tools (welding equipment, drilling machines, fastening equipment, etc...).
- Current fluctuations will negatively affect automatic and hand welders and will result in irregularly and poor welded seams. In addition, it may disturb the turning moment (torque) of your mechanical fastening equipment.
- Systematically verify -at the beginning and during welding operations- the real voltage supply for each individual welder. In general, any welding equipment receiving too low on-load voltage will have difficulty to get the appropriate temperature. Welders with digital display indicate when voltage is too low.
- Off-load voltage shall not exceed:
  - 160 Volts for countries with 110/120 Volts nominal voltage
  - 240 Volts for countries with 230 Volts nominal voltage
- On-load voltage at the point of use (terminal with machine running) must be higher than:
  - 110 Volts for countries with 110/120 Volts nominal voltage
  - 200 Volts for countries with 230 Volts nominal voltage
- Install only one automated or induction welder per electrical circuit to avoid power surges from other equipment, e.g. drills.
- Never connect mechanical fastening equipment and hand welders on the same energy circuit as the one used for induction and automated welders.
- Follow the instructions hereafter to design an appropriate electrical circuit.

Generator

Picture 3.10

Use a portable generator in case power supplies on site do not provide the proper amount and quality of energy for consistent welding.

It is recommended to use a generator with a minimum power of 1.5 times the sum of the individual powers of all connected equipment. Refer to Table 3.5 to define the minimum power of the generator.

MINIMUM POWER GENERATOR	MAX. EQUIPMENT CONNECTED	OTHER CONDITIONS
7500 WATT (220 V)	1 robot	No other tools
5000 WATT (220 V)	2 induction welders	No other tools
3000 WATT (110 V)	2 hand welders or 1 induction welder	No other tools

Table 3.5

Additional generators are required for operating hand welders and other tools that require power.

Transformer

This is necessary in countries with a nominal voltage of 110 Volts if the voltage with the machine running falls below 110 Volts at the point of utilization.

Power cables and plugs

- There may be a significant voltage drop and insufficient power supply because of the cross section and/or length of the extension cable. Cable thickness and length depend on the power situation on the jobsite.
- Extension cables should be made of copper, be as short as possible and their cross section should be as big as possible. The shorter and thicker the cable, the better. Keep therefore the distance between energy source and welder as short as possible.
- Follow the instructions of the welding equipment manufacturer. We recommend a minimum cross-section of 1.5 mm^2 for cables feeding hand welders, 2.5 mm^2 for automatic and induction welders and 4.0 mm^2 for cables with longer length.
- Make sure to unroll all extension cables to minimize voltage drop. Plugs should be made for 20 Amperes and need a solid and safe connection.

Design electrical circuit

There are many different possibilities to design an appropriate electrical circuit between the power source at ground level and electrical equipment on the roof. If possible, start at ground level with a source of 400 V to feed a power distribution box on the roof that will provide 220 V for each individual equipment, as illustrated on the next page.

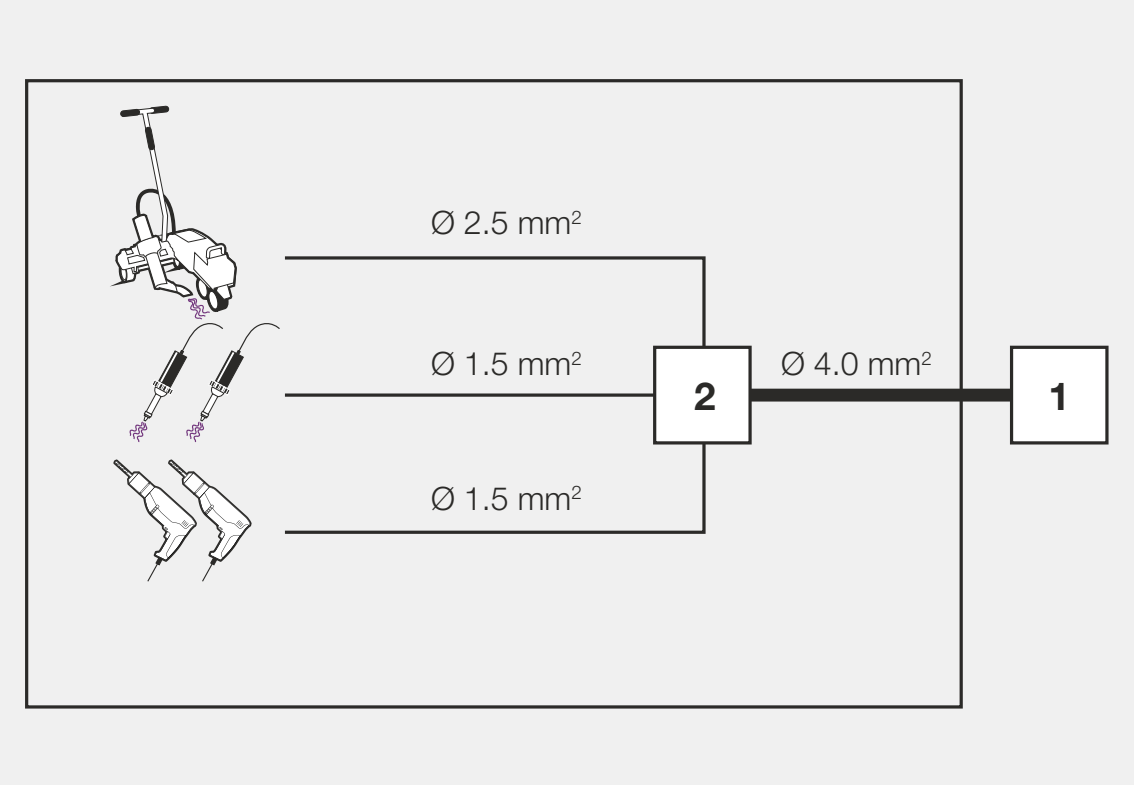


Figure 3.1

Power source (1)

Picture 3.11

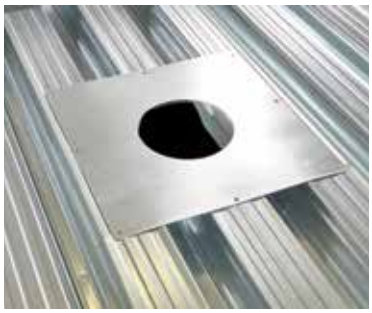
Power distribution box (2)

Picture 3.12

3.1.3 Jobsite conditions

Picture 3.13

Picture 3.14



Picture 3.15

Picture 3.16

- Site conditions should always be verified prior to job start to avoid any unpleasant surprises.
- Verify if roof deck and upstands are ready. They need to be completed and provide acceptable conditions for an efficient installation of the specified Firestone UltraPly™ TPO roofing system.
- Conditions for storage of materials and equipment must also be checked.
- Finally, roofs must guarantee a safe access that facilitates an efficient transport of goods and transit for personnel.

Deck and upstands

- Preparation of a quality deck is the responsibility of the building owner or roofing contractor. All defects must be reported to the general contractor, building owner or architect for assessment and need to be corrected prior to job start.
- Verify that the deck can accommodate the total weight of the roofing system, including construction loads and live loads.
- Check if the roof structure provides a positive slope and sufficient capacity to drain. Areas of pounding water should be eliminated by creating additional slope or by installing additional drains.
- Visually control the quality and condition of the deck. The deck must be sound and must be properly installed. Steel decks must be free of waves and depressions. All loose decking must be secured. Deteriorated or damaged decking need to be replaced *(Picture 3.16)*. Poured concrete decks must be properly cured and dry.
- In case of installation over existing decks, Firestone recommends to do a pull-out test to determine the suitability of the deck.
- Corrections of metal decks may be needed at the base of upstands, along skylight curbs, at drains, scuppers, etc. to provide a firm support for the insulation and a solid base for the mechanical fastening of the new roofing system.
- Verify that the height of upstands, skylight curbs, roof penetrations and equipment supports allows a safe installation of flashings.

Substrates

- Prepare all substrates to avoid that underlying deficiencies will jeopardize the quality of the new roofing system. Cracks or voids in the substrate bigger than 5 mm must be filled with an appropriate material. Refer to the section design criteria for specific recommendations.
- Keep in mind that uneven substrates or voids may cause problems during welding. Correct installation of the insulation layer is therefore extremely important and installation of a recovery board may eventually be required.
- In case of tear-off applications, it is recommended to remove all existing materials down to the roof deck, including wall flashings, metal edge profiles, drain inserts and pipe flashings.
- In re-cover applications, the existing roof substrate must be free of visible moisture such as pounding water, ice or snow. It is strongly recommended that a moisture survey is performed to check the condition of the existing roof materials, in particular when moisture-sensitive materials such as mineral wool or wood fiber boards are used.
- Clean the substrate and remove all debris and foreign materials prior to the installation of the covering layers.

Picture 3.17

Picture 3.18

Access *(Picture 3.17)*

- The roof must have an easy and safe access. Installation must be organized to avoid intensive traffic over completed roof areas. Protect the roofing system from damage where work must continue over areas that are already completed.
- In case aesthetics are an issue, foresee a pair of shoes with a specific rubber sole (for traffic on the roof without leaving any marks) and organize a place at the entrance of the roof where the crew can change their shoes.

Storage *(Picture 3.18)*

- Check conditions for loading and storage of roofing materials and equipment on the roof.
- When storing materials on the roof, verify that the structure provides sufficient load bearing capacity and is not temporarily overloaded. Make sure that roof materials and equipment are equally distributed over the roof.
- All products need to be delivered on site in their original sealed packaging with their original labels and stored in a clean, cool, dry, weather-protected environment.
- All materials stored outside must be raised above ground or roof level on pallets and covered with a waterproof protective covering. Refer to the product data sheets for specific storage requirements.
- Do not remove any protective plastic wrapping from Firestone UltraPly™ TPO rolls or insulation until the moment immediately before the product will be installed.
- Cover and protect materials always at the end of each working day.
- Protect all building surfaces against damage and contamination. Pay specific attention when using spray applied adhesives.

3.1.4 Safety

Picture 3.19

Picture 3.20

Picture 3.21

Picture 3.22

- Always refer to specific local jobsite safety rules.
- Specific safety measurements need to be taken to protect roofing crew against fall at roof edges without upstand and at roof penetrations (skylights, vents) that are still open *(Picture 3.20)*.
- Welding devices are electrical tools. For personal protection, we strongly recommend that electrical tools be connected to an Residual Current Circuit Breaker (RCCB) before using them on site.
- Grounding of all electrical equipment is required. Connect all machines to plugs with a protective earth conductor (CE/CEE) and connect all tools to a receptacle with protective earth terminal. Any interruption or disconnection of the protective conductor inside or outside the tool is potentially dangerous. If generators or power distribution boxes are used, they should have a Ground Fault Circuit Interrupter (GFCI).
- Use only extension cables with an earth conductor that are approved and marked for outdoor applications. Use of an electrical distribution box is recommended to protect connections against moisture.
- Systematically check all cables and plugs for damage *(Picture 3.21)*.
- Organize labor in such a way that electrical cables do not cross and installation can be executed in a safe and efficient way.
- Use of sunglasses is recommended on sunny days when installing white Firestone UltraPly™ TPO membranes. The highly reflective membrane may blind the installer *(Picture 3.22)*.
- Pay attention during rainy or cold days and in misty conditions. The top surface of the membrane is smooth and may become very slippery when covered with ice or moisture.
- Use gloves when applying solvent-based materials such as cleaning products, primer and bonding adhesive.
- Wear protective glasses when using a drilling machine.

3.2 Installation layers beneath the membrane

Picture 3.23

Pay specific attention and care during the installation of the layers installed under the Firestone UltraPly™ TPO membrane, since this has a significant impact on the overall performance and functioning of the roofing system. In this section you will find information with regard to:

- **VAPOR CONTROL LAYER/ AIR BARRIER** - need to be installed as per the manufacturer's requirements.
- **INSULATION AND/OR RECOVERY BOARD** - must provide an adequate substrate for installation of the membrane. The quality of the substrate has a direct impact on the quality of the welds.

3.2.1 Vapor control layer / air barrier

Picture 3.24

- Make sure that the vapor control layer provides a sealed connection at upstands, skylights and all roof penetrations.
- Verify that the vapor control layer exceeds the level of the insulation or cover board at these locations.
- Make sure that no water gets trapped underneath the membrane prior to completion of the Firestone UltraPly™ TPO roofing system.

3.2.2 Insulation and/or cover board

Picture 3.25

Picture 3.26

Positioning

- Poor installation or use of insulation with insufficient compressive strength may cause problems during welding. In some cases, installation of a cover board may be required.
- Insulation boards should have a minimum size of 600 x 600 mm.
- Firestone recommends the installation of multiple layers with all joints staggered a minimum of 150 mm.
- On steel deck, insulation boards should be installed perpendicular to the crowns with the short edges ending on top of the crown (flute) for bearing support. Verify that the thickness of the board is appropriate to bridge the flute span between the crowns of the deck, as mentioned in chapter 1.
- Insulation and/or cover boards need to fit together with a maximum space of 5 mm between adjoining boards to provide a smooth even surface after installation, without leaving voids. Cut boards to fit also closely at penetrations, upstands and around skylight curbs.
- Install a thinner piece of insulation of minimum 600 x 600 mm in size and a thickness of 10 mm inferior than adjoining boards at drains and at scuppers to create a sump area *(Picture 3.26)*. Tapered insulation can be used as an alternative.
- Remove and replace boards that are wet, warped or buckled. Boards that are broken or crushed must not be installed unless the damaged area is cut and discarded.
- Do not install more insulation or cover board than can be covered by membrane on the same working day.
- Use one of the 4 following methods to attach insulation or cover boards:

Methods of attachment

Loosely laid

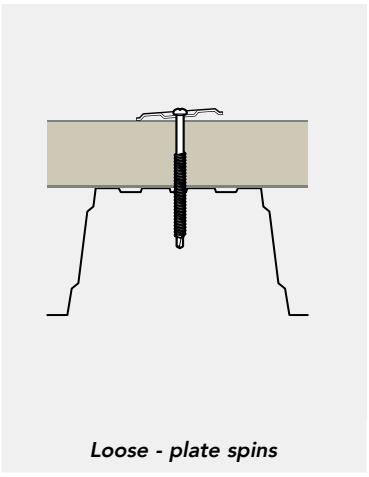
- This method can only be applied when Firestone UltraPly™ TPO membranes are covered with ballast. However, refer always to the technical information sheet of the respective manufacturer of the board to verify if this method of installation is allowed.
- Note that cover boards are not allowed to be installed loosely laid.
- Temporary ballast is required to prevent insulation and membrane from lifting prior to welding seams and/or detailing.
- Do not pile up or locally concentrate ballast to avoid overloading.
- Refer to Chapter 1 for specific requirements about type of ballast to be used and protection measures for the Firestone UltraPly™ TPO membrane.

Mechanically fastened with fasteners and plates (or sleeves)

Picture 3.27

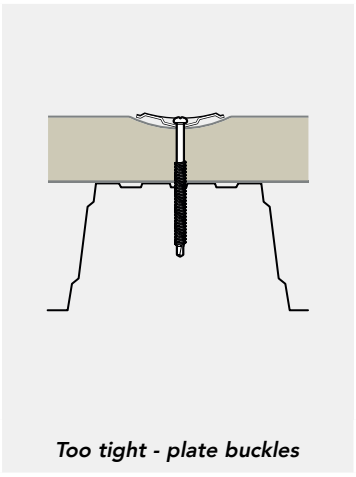
This method is usually applied when the Firestone UltraPly™ TPO membrane is mechanically fastened to the deck or fully adhered onto insulation/cover boards.

- The top layer of insulation (or cover board) is mechanically anchored to the deck with fasteners and stress plates (or plastic sleeves). Refer to chapter 1 to select an appropriate combination of fastener and plate.
- Fasteners need to be installed as illustrated below without over-driving to firmly compress the plate to the surface of the insulation board. Fasteners must be tight enough so that the plate does not turn or wobble. Overdriving the fasteners will result in a deformation or "cupping" of the plate.



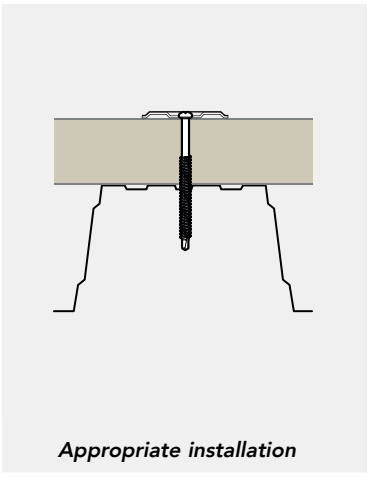
Loose - plate spins

Figure 3.2



Too tight - plate buckles

Figure 3.3



Appropriate installation

Figure 3.4

Under-driving the fasteners will result in a loose plate with insufficient clamping force and a protruding fastener head. Both situations could cause damage to the membrane during normal foot traffic.

- Pre-drilling is required on concrete decks. Always make sure to clean the substrate prior to the installation of the membrane.
- In mechanically fastened systems, fastening patterns of insulation and/or cover boards need to be designed independently from fixation of the membrane since a significant part of the wind uplift pressure must be absorbed by the layers installed underneath the membrane.
- The number of fasteners is in function of the type of insulation, size and thickness of the board, pull-out of the fastener and wind uplift requirements of the specific roof area (central, perimeter or corner).

Mechanically fastened with TPO induction welding plates

Picture 3.28

This method is exclusively applied when Firestone UltraPly™ TPO membranes are installed with the induction welding method.

- The top layer of insulation (or cover board) is mechanically fastened to the deck with fasteners and TPO induction welding plates. Refer to chapter 1 to select an appropriate combination of fastener and plate.
- The number of fasteners and plates is function of the type of insulation, size and thickness of the board, pull-out of the fastener and wind uplift requirements for insulation and membrane of the specific roof area (center, perimeter, corner). On a multilayer insulation assembly, fastening patterns are determined by type and thickness of the top layer of the insulation.
- Use a chalk line to mark each roof area and lay out a pattern for installation of fastening plates. Follow a straight linear pattern or grid pattern to position the plates. This allows the plates below the membrane to be located easily, resulting in an easier and faster installation. With a grid pattern, it is also much easier to inspect the condition of the welded plates and account for the number of plates welded.
- Install the proper number of fasteners per board as required per area. Multiple layers of insulation are installed using a common fastener.
- Fasteners need to be installed without over-driving, (as illustrated on page 3.18) to firmly compress the plate to the surface of the insulation board. Fasteners must be tight enough so that the plate does not turn or rock. Overdriving the fasteners will result in a deformation or "cupping" of the plate. This uneven surface may cause an inadequate bond of the membrane when welded. Under-driving the fasteners will result in a loose plate with insufficient clamping force and a protruding fastener head that could cause damage to the membrane during welding and through normal foot traffic.
- Overdriven fasteners that distort the top of the plate must be removed. Reinstall a new plate and fastener next to the previous one, but not into the same hole. Under-driven fasteners must be driven to proper depth.
- Remove any dirt or debris from the substrate when the installation of the fasteners is complete. Use a blower or broom the area to remove any contaminants. This is critical to avoid puncturing of the membrane or poor welding. Pay special attention when pre-drilling on concrete decks.

Bonded with foam adhesive

Picture 3.29

- Make sure that the substrate is clean, dry and free of contaminants. Foam adhesive cannot be applied on dirty, wet or damp substrates or on unweathered bitumen. Eliminate uneven surfaces to ensure positive contact between the insulation board and the substrate.
- This method of attachment can be applied in cold weather, but do not allow the adhesive to freeze. Keep the temperature of the cartridges between 15 and 25°C for 24 hours before use and do not store in direct sunlight or at temperatures that exceed 32°C.
- Use only appropriate dispensing equipment to apply the insulation adhesive and always check the equipment prior to use.
- Perform a trial at the start of each work day with a sample of insulation to verify the conditions of adhesion. Verify that proper mixing, set-up and overall adhesion of insulation is being achieved before proceeding.
- On roofs with slopes exceeding 5% Firestone recommends to start at the lowest point of the roof and work upwards to avoid slippage of the boards
- Apply the adhesive in ribbons that are 12 mm wide and evenly spaced in accordance to the specification of the adhesive supplier and national codes.
- As the adhesive is applied, immediately place the insulation boards into the wet adhesive. Do not allow the adhesive to skin over. Install the boards with long sides perpendicular to the ribbons of adhesive.
- Walk the boards into the adhesive. Roll with a 10 kg weighted steel roller or put temporary ballast on the boards to ensure full embedment. A continuous weight is imperative until the board is held in place by the adhesive.
- Unused adhesive can be applied at a later date by plugging the cartridges and using a new mixing nozzle.

3.3 Membrane installation

Picture 3.30

Picture 3.31

Picture 3.32

In this section, we explain the following topics:.

- **Panel selection -** Selection of the most appropriate panel size will reduce cutting and sealing.
- **Positioning and cutting** - Good positioning and straight cutting of the panels will facilitate welding.
- **Cleaning** - Is required when contamination does not provide appropriate conditions for welding.
- **Welding** - All seams of the system are to be heat-welded, using whenever possible an automatic welder. Use of hand welders is limited for detailing.
- **Membrane attachment in the field** - The different methods will be reviewed in detail.
- **Base tie-in** - This detail will improve the wind uplift resistance of the system, absorb differences in movement between horizontal and vertical construction elements and facilitate installation of wall flashings.
- **Wall flashings** - Need to be carried out correctly, not just for aesthetics but also to assure the wind uplift resistance of the system.
- **Joint covers** - Need to be installed at all locations with possible infiltration through capillaries.

A good execution of these practices will result in a smooth and efficient installation and will facilitate further detailing.

3.3.1 Panel selection

Firestone UltraPly™ TPO membranes are available in different widths. Use full width panels with sealed edges as much as possible to minimize the need for sealing cut edges.

In systems where the membrane panels are mechanically fastened in the seam, full width rolls are used in the center of the roof and smaller or half width (cut) rolls for perimeter and corner zones. In other systems, only full width rolls are applied.

Refer to Table 3.6 for recommendations with regards to maximum panel width.

FIRESTONE ULTRAPLY TPO ROOFING SYSTEM	FULL PANEL WIDTH (m)
MECHANICALLY FASTENED	1.0 – 1.5 – 2.0 – 2.44 – 2.65
INDUCTION WELDED	3.05
BALLASTED – INVERTED – FULLY ADHERED	3.05

Table 3.6

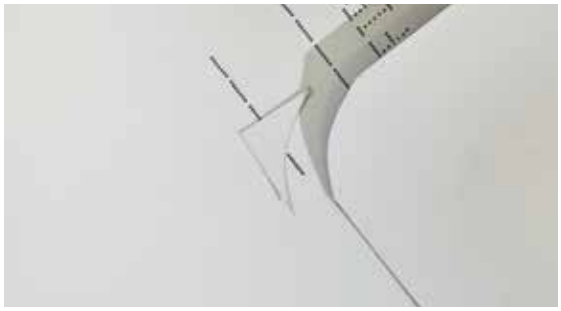
3.3.2 Positioning and cutting

Picture 3.33

Picture 3.34

Picture 3.35

Picture 3.36



Picture 3.37

Positioning

- Position the UltraPly™ TPO rolls as close as possible to their final position and wait to remove the plastic wrappings until final installation (attachment and welding) to minimize the need for cleaning.
- Membrane panels can be positioned either with all seams well aligned creating double T-joints at the intersection of side and end laps or with staggered joints *(Pictures 3.33 - 3.34)*.
- Wipe the substrate and remove all dirt and moisture prior to unrolling the membranes. Remove the plastic wrapping and inspect the membrane for damage before installation.
- Unroll the membrane without stretching. In mechanically fastened systems on metal decks, membranes should be unrolled perpendicular to the flutes of the decking. Panels are fastened at one end with a couple of plates (installed in the end lap), prior to being streched and secured towards the other end.
- Install adjoining membranes without any wrinkles. Refer to the marks on the membrane to position the overlapping membrane correctly at the overlap *(Picture 3.35)*. Verify that the membrane lays perfectly flat prior to permanent attachment to facilitate welding.
- Good roofing practice recommends TPO panels to be installed so that overlaps shed water towards drains. However, pay specific attention to installing overlaps in the sense of wind direction. When wind blows over the membrane closing the seam, there is less risk for lifting and distortion of the membrane.
- Allow each panel to relax prior to attachment, cutting or welding. Wait at least 30 minutes when temperature is below 15°C to compensate for any residual roll tension. This may be reduced to 20 minutes at temperatures above 15°C.
- Spot-weld the overlapping membrane as soon as possible to prevent it from moving or lifting.
- Round the exposed edges *(Picture 3.37)*.
- Consult the table below for minimum requirements for overlaps of adjoining sheets and flashings.

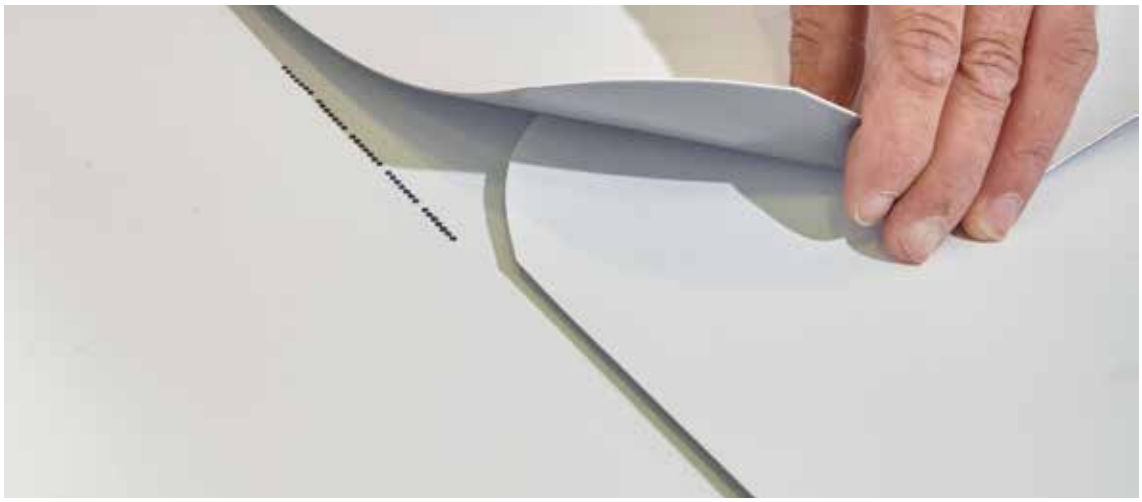
DETAIL	APPLICATION	MINIMUM OVERLAP (mm)
Field seam with mechanical attachment	Mechanically fastened system (side laps)	120-150
Field seam without mechanical attachment	All systems	75
Vertical seam	All systems	75
Base tie-in with horizontal tie-in	All systems	120-150
Base tie-in with vertical tie-in	All systems	100

Table 3.7

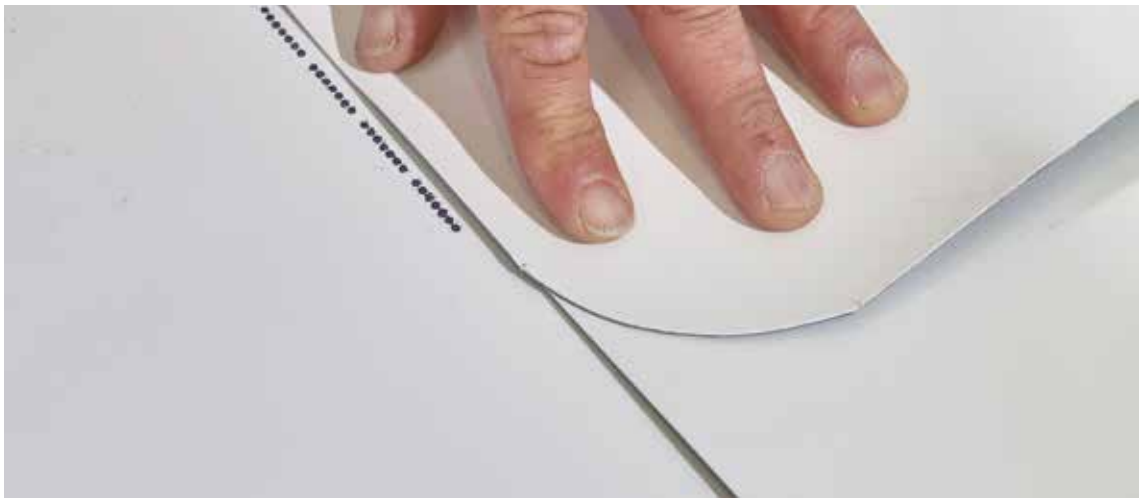
Cutting

- Straight cuts are very important for a neat and easy installation and required for correct welding with the automatic welder. Use a membrane cutting slitter or chalk line where needed to make straight cuts. An alternative method is to tear a fiber of the reinforcement to mark a straight line. Do never tear but always cut the membrane *(Picture 3.36)*.
- In case of sudden rainfall, cut immediately a cross-shaped opening above each drain to evacuate pounding water.

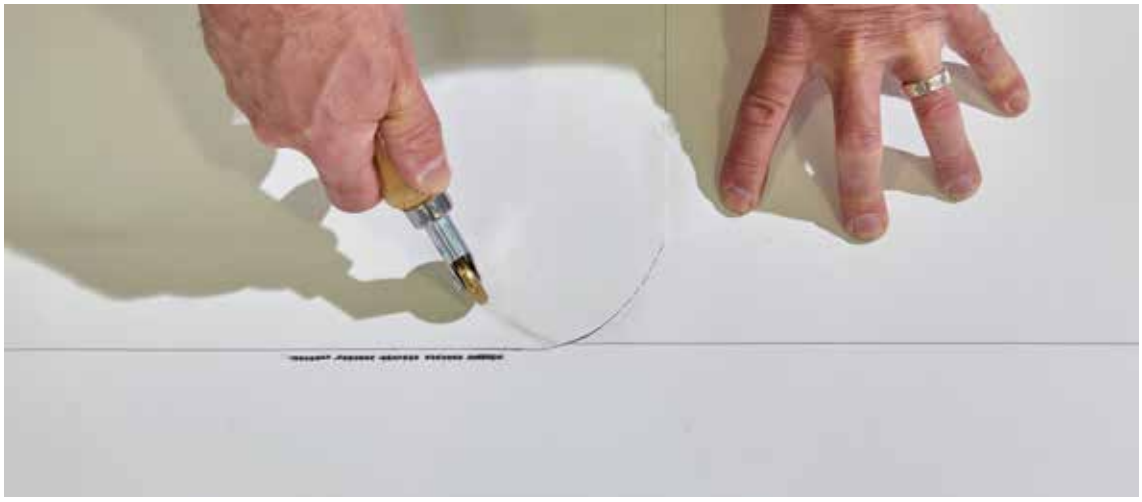
Cutting at single T-joint



Picture 3.38



Picture 3.39



Picture 3.40

- Pay attention to round the exposed edge of both membranes at the overlap, as illustrated, to minimize the risk for capillaries. It is important that the rounding of both edges starts at the same point to simplify the installation of the T-joint cover.

Cutting at double T-joint

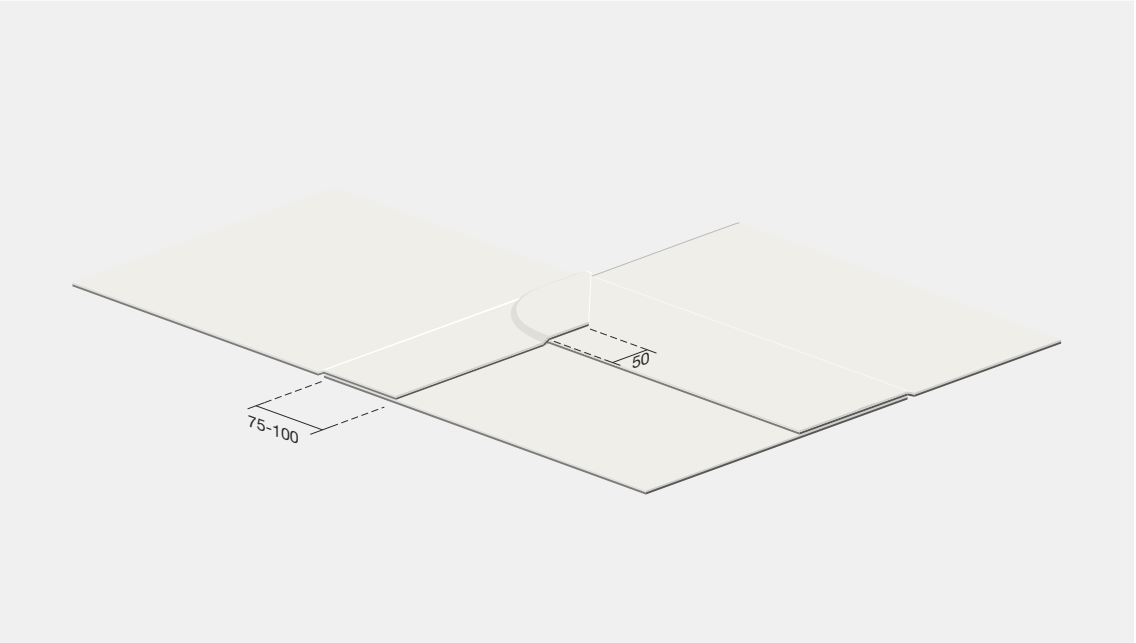


Figure 3.5

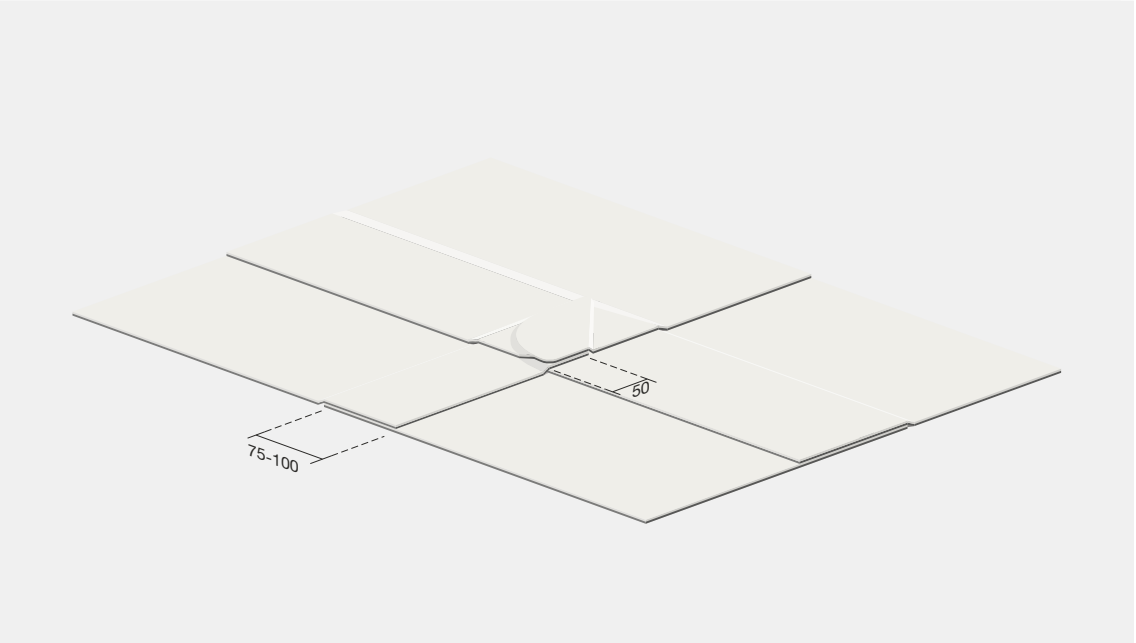


Figure 3.6

By proper arrangement of the panels, seams can be aligned to facilitate an optimum and efficient use of the automatic welder and straight welding. This will result in a double T-joint. When seams are well aligned and properly cut at the intersection, it will help to simplify welding.

Refer to Figure 3.5 and Fgure 3.6 for a correct installation of the membrane panels in case of a double T-joint.

Installation of the third panel will result in a first point of capillary. Cut the edge of the third panel to reduce the area of overlapping membranes (with 4 thicknesses) to a maximum width of 50 mm.

Installation of the fourth panel should result in a second point of capillary at 50 mm distance of the first one.

Firestone recommends the installation of a T-joint cover at all T-joints to close capillaries in case membranes have a thickness that exceeds 1.2 mm.

3.3.3 Cleaning

Picture 3.41

- If aesthetics are a concern, measures should be taken to avoid the contamination or discoloration of the reflective top surface resulting from excessive foot traffic. Either the membrane can be temporarily protected or the crew can use shoes with an adapted rubber sole.
- The surface of Firestone UltraPly™ TPO membranes (or TPO accessory) must be clean (without dirt or contaminants), not too long exposed to weathering and dry prior to welding. Dry means that the surface must be free of rain, dew or other sources of moisture.
- Firestone UltraPly™ TPO membranes and accessories coming directly from the factory and still in their original and closed package will not require cleaning prior to welding, provided that welding is performed within 8 hours after placement and final attachment.
- Firestone UltraPly™ TPO membranes and accessories that have been exposed for more than 12 hours or contaminated will require one of the following treatments, depending on the type of contamination.
  - **Light contamination** - This occurs when the surface of the UltraPly™ TPO membrane has been exposed overnight up to a few days to foot traffic, dust, dew or light precipitation. It is recommended to clean it with a clean white cotton rag moistened with Firestone Splice Wash or Firestone Cleaner.
  - **Heavy contamination** - This occurs when dirt is encrusted on the surface, eventually due to intense foot traffic. It is recommended to clean the membrane first with soapy water and a mildly abrasive scrubbing pad to remove the heaviest dirt. This must be followed by rinsing with clean water and cleaning with a white cotton rag moistened with Firestone Splice Wash or Firestone Cleaner.
  - **Contamination due to exposure** - This occurs when the membrane is weathered or oxidized. It is recommended to clean it first with Firestone Splice Wash or Firestone Cleaner and a mildly abrasive scrubbing pad to remove the weathered/oxidized top layer. This must be followed by cleaning with a white cotton rag moistened with Firestone Splice Wash or Firestone Cleaner.
  - **Contamination with chemical products** - This occurs when the membrane or accessory is contaminated with bonding adhesive, bitumen, grease, oil or other chemicals. With the exception of dried up adhesive, most contaminants cannot be removed sufficiently to create a clean surface, even after intensive cleaning as described above. In this case, the membrane should be removed and replaced.

Tips for cleaning

Picture 3.42

Picture 3.43

- Use only white rags to prevent discoloring of the membrane. Cleaning with a scrubbing pad is often recommended and will have a better result when the dirt cannot be removed easily or in case of aged membranes.
- Firestone Splice Wash can be used to clean long seams while Firestone Cleaner is more practical for smaller surfaces and detailing. In general, the Firestone Splice Wash takes more time to dry.
- Always check that the surface is completely dry and all solvents are flashed off prior to welding.

3.3.4 Welding

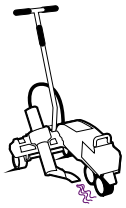
Picture 3.44

Picture 3.45

Picture 3.46

Picture 3.47

- All seams of the Firestone UltraPly™ TPO roofing system need to be hot-air welded and all welds must be continuous.
- Whenever possible, an automatic welder should be used to weld field seams, seams at the base of wall flashings, seams around skylights, cover-strips and walkway pads *(Picture 3.44)*.
- Use of hand welders should be limited to situations where an automatic welder is not practical, such as starts, ends and interruptions of welds made with the automatic welder, field seams on roofs with a significant slope, vertical seams, T-joints, corners, flashings at roof penetrations, tie-ins on TPO Coated Metal, to name the most important ones *(Picture 3.45)*.
- TPO membranes require different settings for welding than PVC membranes. Settings that work well for a PVC membrane usually do not work for TPO membranes. Equally, there are also significant differences between TPO membranes of different suppliers. Most differences in welding parameters can be explained by differences in formulation, thickness over scrim, surface texture or a combination of these properties.
- Other factors such as cleanliness of the membrane, time the top surface has been exposed to weathering, type of substrate underneath the membrane, type and compressibility of insulation and installation conditions need to be considered to define the appropriate welding parameters of speed, temperature and pressure (weight).
- Set-up of the welding equipment should therefore be the responsibility of an experienced installer. Only an experienced roofer (and not a technician who just understands the functioning of the welding equipment) will be able to assess all the different site parameters in a correct way and translate these into a correct combination of appropriate settings for the machine. He should define the appropriate combination of welding temperature, speed, air intake and pressure to create an appropriate weld.
- Depending on the situation, weights must be increased (automatic welder) or different rollers must be applied (hand welding).
- Test welds must be made on each project to define proper welding settings and this should be done systematically at the start of each working day, after interruptions (lunch breaks, drop of power supply) or when site conditions change. Use some spare membrane to adjust the welding machine. This is the only way to find out if welding settings are correct *(Pictures 3.46 - 3.47)*



Automatic welder

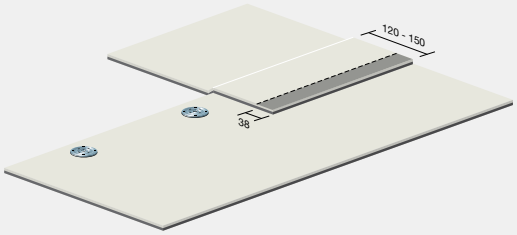
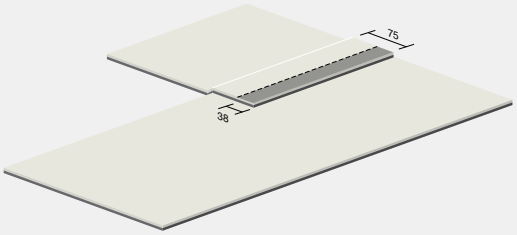
SEAM WITH PLATE	SEAM WITHOUT PLATE
	

Figure 3.7

Figure 3.8

Hand welder

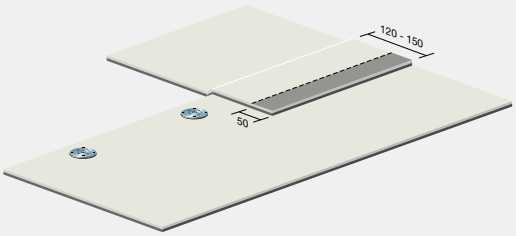
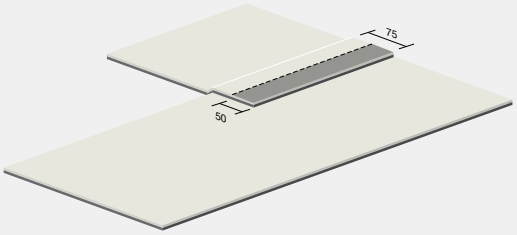
SEAM WITH PLATE	SEAM WITHOUT PLATE
	

Figure 3.9

Figure 3.10

Firestone recommends for welds made with an automatic welder a minimum width of 38 mm and for welds made with hand welders a minimum width of 50 mm.

Welding window

Picture 3.48

- Firestone UltraPly™ TPO membranes can be welded in a wide window of conditions of welding temperature and speed. Temperatures may vary between 350°C and 600°C and speeds between 1.8 and 5.0 meters per minute. This wide window gives the installer a big margin to operate and a lot of flexibility to adjust proper settings in function of changing conditions.
- In principle, welding speed can exceed easily 3.5 - 4.0 m/min. However, Firestone strongly recommends to start by defining appropriate settings for welding temperature and a moderate speed at the beginning of the working day. Starting with a moderate speed will give the technician a better margin for adjustments and reduce the risk for poor welds.
- It is recommended to use the starting temperature at the beginning of the working day as a reference throughout the day and to make continuous speed adjustments when weather or site conditions (see further) vary. Making a good weld is not only about selecting the proper temperature but about systematically bringing the required amount of energy into contact with the membrane. This also includes applying the correct pressure during the welding process.
- The welding window illustrated below presents appropriate welding conditions for Firestone UltraPly™ TPO membranes with a thickness of 1.2 mm using a Leister Varimat V2. Be aware that welding windows (conditions) change in function of the membrane thickness and welding equipment.

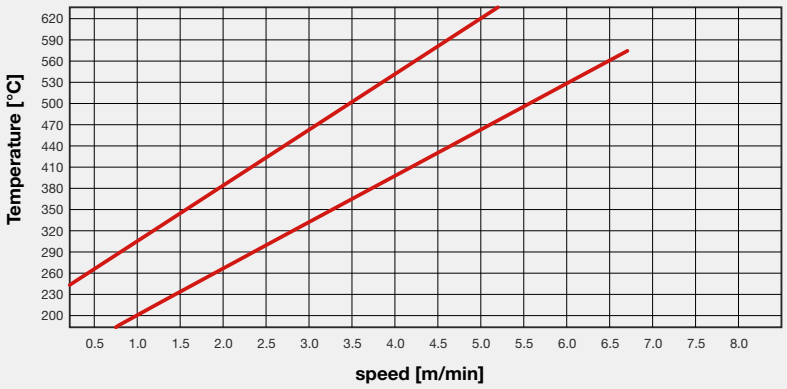
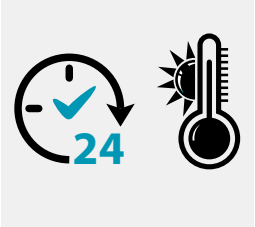


Figure. 3.11

- Typical welding conditions for UltraPly™ TPO membranes with a thickness of 1.2 mm on a 15°C day in the sun are:
  - Temperature: 350 - 600 °C
  - Speed: 2.5 - 5.0 m/min
  - Air flow: 80 -100 %
  - Weights: 2 pieces

Impact of climatic conditions

The specific guidelines below may assist to adjust your welding settings in a correct way.



Moment of the day

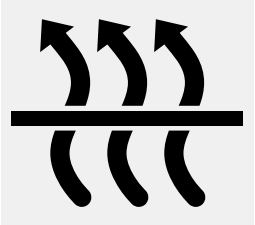
Welding speed should be set slower early in the morning than in the afternoon, due to the lower temperatures. When the surface temperature of the membrane increases, welding speed may have to be increased.

Shadow versus sunlight

Membrane surfaces in a shaded area are cooler than membrane surfaces exposed to direct sunlight. Welding speed may therefore have to be reduced when moving into shadow.

Wind

Wind has a cooling effect as it blows over the membrane, affecting the air flow in the seam and reducing the effectiveness of the welder. Welding temperature should be eventually increased or speed reduced.



Humidity

Dampness on the membrane from dew, rain shower or misty conditions will reduce the heat from the welder due to the evaporation of moisture. Water must therefore be wiped from the seam area prior to welding. Welding temperature should be eventually increased or speed reduced.

Impact of other site conditions

Type of substrate

The substrate directly under the membrane makes a difference in the amount of energy that is needed to make a proper weld. Substrates such as plywood, concrete and metal act as heat sinks and require a slower speed or higher temperature than insulation. Installation over insulation boards with high compressibility require an adjustment of the welding pressure. This can be achieved by using additional weights (automatic welder) or application of more pressure (hand welding).

Membrane thickness

Thicker membranes and flashing accessories require more energy (increase temperature or reduce speed) to be welded properly.

Bleed-out

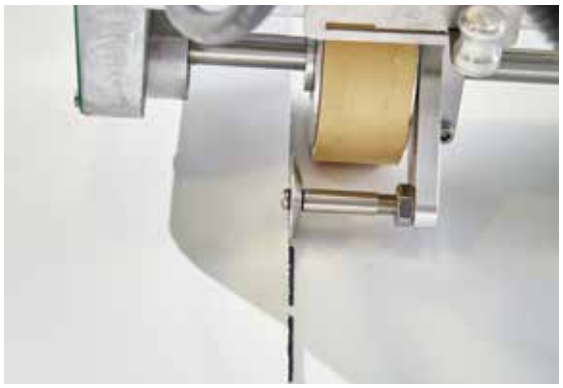
If bleed-out is occurring, it means that the grey underside of the membrane begins to melt and flow. Welding speed should then be increased or temperature reduced.

Automatic welder setup

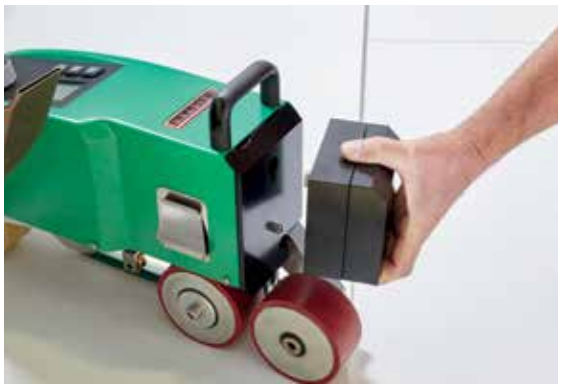
Picture 3.49

Picture 3.51

Picture 3.52



Picture 3.50



Picture 3.53

Follow the instructions of the manufacturer for use and maintenance of the welder.

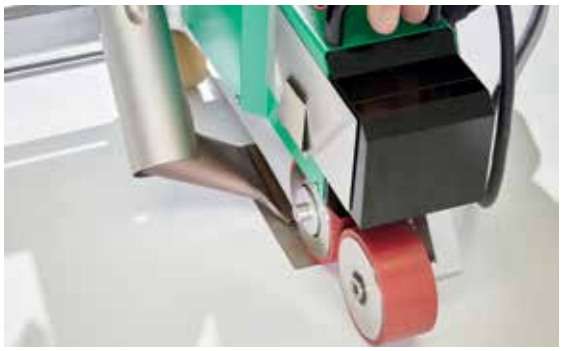
- Make sure that the welding machine is switched off before being connected to the power source, to prevent a power surge that could damage the unit. Check first the minimum voltage at start of the machine running to assure a quality supply of energy *(Picture 3.49)*.
- Check always the conditions of the welding equipment prior to welding. The following parts and/or functions must be verified and/or assured:
  - Welder must run straight *(Picture 3.50)*
  - Nozzle must be clean and distribute heat in a uniform way *(Picture 3.51)*
  - Rubber driving wheels must be clean and intact *(Picture 3.52)*
  - Weights need to be defined to provide sufficient pressure on driving wheels *(Picture 3.53)*
  - Allow the machine to warm up for 10 minutes to reach an approximate temperature setting.

Welding procedure automatic welder

Picture 3.54

Picture 3.56

Picture 3.55



Picture 3.57

Picture 3.58

- There is more than one combination of temperature and speed setting that will result in an acceptable weld. The colder the ambient temperature and surface temperature of the membrane, the higher the temperature or the slower the speed setting of the welder must be to produce an acceptable weld.
- Prepare always some test seams with pieces of scrap membrane (min. length 1.0 m) to define proper settings of temperature and speed and determine the weight that is required.
- Install first the rectangular shaped metal plates at beginning and end of the seam. These plates will help avoid local over-heating of the membrane during installation *(Picture 3.54)*.
- Dial in the temperature and speed settings that correspond with an acceptable test weld and mount the correct weight onto the welding machine *(Picture 3.55)*
- Position the welder properly along the seam with both pressing wheels above the metal plate. The guide handle must point in the same direction the welder will move. Verify if the welder is well aligned *(Picture 3.56)*.
- Lift the overlapping membrane up at the starting point and slide the nozzle completely into the overlap (50 mm) above the metal plate. When the back wheel is raised, the welder will immediately start running along the seam *(Picture 3.57)*.
- Proceed along the seam and make sure that the small guide wheel in front of the welder aligns with the edge of the top membrane. Watch the guide closely and make sure the welder stays on line. Surface irregularities can cause the pressure wheel to move slightly away from the seam. If this happens, tap slightly on the upper handle of the welder to keep it in a straight line *(Picture 3.58)*.

Picture 3.59

Picture 3.60

Picture 3.61

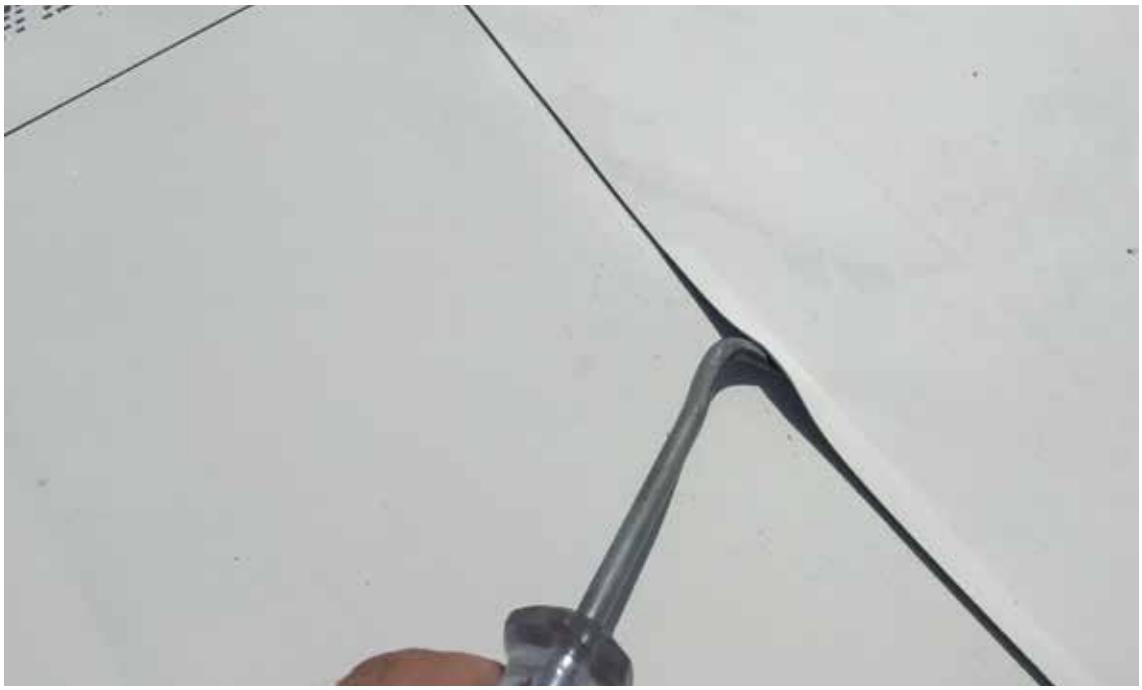
Picture 3.62

- Ensure that the power cable has plenty of slack for movement of the driving wheels. This may drag the welder off course.
- As the hot nozzle moves along the seam, a wide drive wheel behind the nozzle applies an immediate and uniform pressure to the heated overlap. The weights on the welder serve to prevent voids in the welded seam.
- The operator of the welder must apply foot pressure to the membrane during the welding process by kicking and sliding the membrane under the robot to keep the membrane tight and avoid the membrane from creeping and causing wrinkles *(Picture 3.59)*.

Firestone recommends the use of welding tracks to reduce the effect of membrane movement. Wooden planks or strips of plywood (300 mm X 2.4 m) can be used and installed along the seam. The operator can apply foot pressure on these tracks and move them as welding proceeds.

- Stop the movement of the welder when the nozzle reaches the metal plate at the end of the weld and remove the nozzle from the seam area to interrupt the welding process. Mark the end of the weld with a marker for easy identification later and remove the metal plate *(Picture 3.60)*.
- Use of a hand welder will be necessary to complete the weld in areas where the automatic welder has stopped and/or restarted.
- As the welder passes, roll the seam with a metal penny roller at all splice intersections to ensure a continuous welded seam. The membrane should be creased into any step-off using a metal penny roller, as illustrated *(Picture 3.61)*.
- Mark beginning and end of each weld prior to removing the plates *(Picture 3.62)*.

Tips to correct poor welding



Picture 3.63

- Check the nozzle when the membrane is overheated at one or other side of the seam. The heat is probably not evenly distributed between both sheets.
- Distortion of the membrane may occur due to heat expansion when the nozzle is too far away from the pressure wheel. Adjust the nozzle as close as possible to the pressure wheel.
- If the heat is bypassing the edge of the seam, producing a cold weld along the edge, make sure the nozzle is completely under the sheet and the air dam is in place.
- Check the speed when the test sample indicates that the seam is tight at the edge but presents a cold weld in the center. The welding machine is probably running too fast, melting both edges but not melting the center of the seam.
- Overheating the membrane will also cause poor welds. Make sure that the welder does not run too slow on days with an average temperature (min. 3 m per minute). Lower speeds are acceptable only on very cold days. Increase speed or decrease temperature if the membrane discolors or shows melting (starts flowing).
- Make sure that the silicone pressure wheel is intact without any voids and clean. Voids will result in incomplete welding.
- Clean dirt and debris on air inlets every day. Accumulation of dirt will reduce the air flow and heat output of the welder.

Hand welder setup

Picture 3.64

Picture 3.65

Follow the instructions of the manufacturer for use and maintenance of the welder.

- Check always the condition of the hand welder prior to each job start. This can be done by checking the melting picture while heating the membrane. Warm the welder up for a few minutes until working temperature (400°C - 450°C) and hold the nozzle parallel above the membrane at approx.10 mm. The melting picture should be uniform. If this is not the case, either the nozzle may be obstructed, there may be a defect with air supply or a defective heating element.
- Following corrective measures can be taken:
  - Clean the nozzles with a wire brush *(Picture 3.64)*
  - Change a defective heating element
  - Clean the filter
- Select the proper nozzle in function of the welding situation. Use a 40 mm wide straight nozzle for welding straight seams or parts of flashing details that are easily accessible for welding. Use a 20 mm wide nozzle for situations that are more difficult to access, such as welding of pre-molded corner pieces, pipe flashings, etc. *(Picture 3.65)*
- Adjust the welder temperature by making a few test seams prior to welding. Appropriate welding temperature depends on the following conditions:
  - Ambient temperature and humidity
  - Surface temperature of membrane and accessory
  - Type of material (reinforced, non-reinforced, Coated Metal)
  - Thickness of materials to be welded
  - Air supply (type and size of nozzle)
  - Welding speed

  Basic temperature settings for non-digital hand welders are "6" or "7" for welding TPO Unsupported Flashing and "8" for reinforced UltraPly™ TPO membrane. This corresponds with temperatures between 400°C and 450°C. These numbers may vary in function of site conditions (substrate, ambient temperature, etc.)
- Make sure that all surfaces to be welded are clean and dry, and verify that cleaning solvents are evaporated prior to welding.
- Use different rollers in function of the situation and substrate. Switch rollers whenever needed, as illustrated in detailing, to ensure a sufficient pressure.

Welding procedure with hand welder

Picture 3.66

Picture 3.67

Picture 3.68

Hand welding is always done, following three consecutive steps:

Step 1- Spot-weld the overlap of the membrane at the inner side of the seam to fix it in its final position. This way the pieces to be welded cannot move *(Picture 3.66)*.

Step 2 - Pre-weld the inner part of the overlap (small width of 10-15 mm) to create an area with a width of 35-40 mm at the outside edge that remains unwelded but closed for final welding *(Picture 3.67)*.

Step 3 - Weld the outer part of the overlap (area that remained un-welded during the previous step) using the following technique: insert the nozzle of the welder into the overlap under an angle of 45° with the edge of the seam and keep the pressure roller at 20-30 mm parallel to the outlet of the welding nozzle. Roll the pressure roller completely across the seam as you move the nozzle slowly simultaneously backwards along the edge of the seam *(Picture 3.38)*.

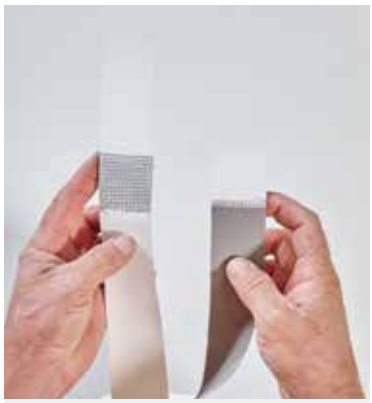
Roll only from the back to the front of the seam, as the membrane softens, to make welds without folds. The pressure roller should always be put flat onto the membrane to be welded. Do not turn the roller on its edge to prevent damaging the membrane or flashing.

Check the quality of the weld systematically during and after welding. The same welding method is applied when welding TPO Unsupported Flashing or a pre-molded piece.

Testing welds

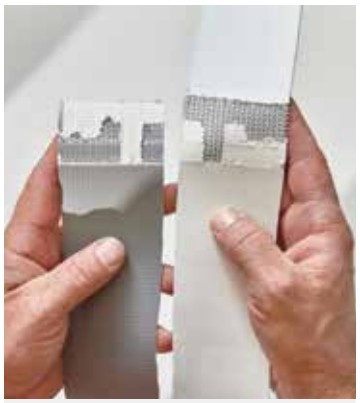
Picture 3.69

Picture 3.73



Correct weld

Picture 3.70



Incomplete weld

Picture 3.71

Cold weld

Picture 3.72

All welds systematically require a combination of visual inspection, mechanical testing and destructive testing to assure a consistent quality of the welded seams.

Visual inspection

- All seams should be systematically visually checked during welding to make proper adjustments to the settings of the welder.
- A properly welded seam must be continuous without any voids or wrinkles. Firestone recommends a width of at least 38 mm for automatic welds and 50 mm for hand welds.
- After cooling, a fine welding bead should be clearly visible at the edge of the Firestone UltraPly™ TPO membrane. This bead is more prominent during hand welding.
- A discoloration of the membrane next to or within the weld indicates that the welding temperature has been too high or welding speed too slow and needs to be corected.

Destructive testing *(Pictures 3.69 - 3.70 - 3.71 - 3.72)*

- Given the number of variables that have an impact on the welding result, it is required to systematically carry out some destructive testing on spare material (1 lm) prior to start welding.
- Tests must be performed at the beginning of each working day and every time there is an interruption in the welding process (i.e. power failure, welder shut down, change of site conditions and after lunch).
- Let the seam cool down sufficiently (min. 15 minutes) and cut some small strips of 50 mm wide across the weld (minimum length 150 mm on each side of the seam).
- The destructive test consists of a peel test and a visual seam check.
- Peel the samples apart and examine for a consistent weld. The seam must not separate (cold weld). Indication of a properly welded seam is a complete delamination of the membrane from the scrim reinforcement.

Mechanical testing / seam probing *(Picture 3.73)*

- All field seams have to be mechanically checked in a systematical way to do repairs before the end of the working day.
- Mechanical seam probing assists in locating seam areas that are not completely welded. Special attention should be paid to all membrane intersections, transversal seams (T-joints), flashings and penetrations.
- Allow the seam to cool for a minimum of 30 minutes before probing.
- Use a slotted screwdriver or a dull cotter pin puller type tool with rounded edges to probe the seam. Draw the tip of the probing tool along the edge of the welded seam and apply a slight pressure to the seam to check the junction of both sheets. Avoid putting pressure into the bottom sheet. In a properly welded seam the tool may not penetrate the lap area. If the tool penetrates the overlap, mark the seam with a marker at the beginning and end of the void or wrinkle and repair the deficiency as soon as possible with a piece of flashing, using a hand welder. Probe the repaired seams again after they have cooled completely.
- Welds found to be insufficiently welded over a longer length should also be repaired by installing a cover strip over the edge.

Sealing cut edges (reinforced membrane)

Picture 3.74

- All cut edges of reinforced membrane that remain exposed need to be protected with UltraPly™ TPO Cut Edge Sealant. It is recommended to do this when all repairs are done. The sealant must prevent water from entering the system through capillary action at places where the scrim is exposed.
- Application of sealant should ideally be done on the same day as welding, following the method described below.
- Dry any cut edges in case they remained exposed overnight to ensure a good adhesion of the sealant. Clean the edge with Firestone Cleaner and clean white rags.
- Apply UltraPly™ TPO Cut Edge Sealant with a squeeze bottle as illustrated, drawing the tip of the bottle smoothly along the cut edge of the membrane. Leave a uniform bead of 2-3 mm of liquid sealant on the edge and let dry.

3.3.5 Membrane attachment in the field

Picture 3.75

- Install membrane panels in a sequence to minimize the risk of infiltrations in areas where installation has been completed.
- Use temporary ballast to keep the membrane in place until it is finally secured to the substrate. Suggested temporary ballasting includes sand bags and other non-abrasive materials.
- Never leave the jobsite without ballasting loose laid panels. A sudden wind may lift and distort the membrane.
- Use one of the methods described hereafter to secure the membrane panels in the field.

Membrane attachment with fasteners and plates (or sleeves) in the seam

Picture 3.76

This method is used in mechanically fastened roofing systems, where the membrane panels are anchored to the deck using plates and fasteners that are installed in the side laps.

- Unroll the membrane panels without causing tension.
- On steel decks, membranes must be installed perpendicular to the flutes of the deck to allow wind loads to be distributed over multiple deck panels.
- When working on a continuous support (concrete, wood) an alternative layout may be used, for practical reasons.
- Consult the wind design calculation to define the dimensions of the different roof areas (central, perimeter, corner, ridge, base of penthouse, etc.)

Select for each roof area the appropriate panel size to meet wind uplift requirements (required densities of seam plates). Refer to the table below to identify the spacing between fastener rows when using full panel widths.

PANEL WIDTH (m)	SPACING BETWEEN FASTENER ROWS (m) - USING 150 MM OVERLAP
1.0	0.85
1.5	1.35
2.0	1.85
2.44	2.29
2.65	2.50

Table 3.8

When wind calculations require an even smaller spacing between fastener rows than mentioned in the table above, membranes may be cut in half on site. At perimeters, corners and in areas of higher wind pressure, membranes are usually smaller in width.

In case wind uplift requirements result in the application of too small panels, an alternative solution is to fully adhere the membrane or to change to an induction welded system. If this is the case, do not forget to adjust the fastening patterns of insulation/cover boards.

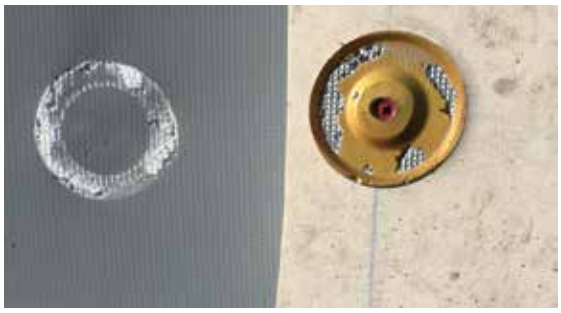
In case of a fully adhered perimeter area, care must be taken not to apply adhesive onto the inside portion of the perimeter sheets that will be welded and perimeter zones are separated from the central area of the roof by installing a row of plates and fasteners along the inside edge of the perimeter panels.

- Position adjoining sheets with a minimum overlap of 120-150 mm at side laps (depending on type of fastening device) and 75 mm at end laps. Allow to relax a minimum of 20 minutes prior to final anchoring. Allow more time in colder weather.
- Whenever possible, install the panels so that cut edges are positioned in the bottom ply of the seam (unexposed to weathering). This will minimize the need for application of Firestone UltraPly™ TPO Cut Edge Sealant.
- All full width membranes have marks to help the installer during positioning and installation of the fastening plates. Seam plates need to be positioned a minimum distance of 20 mm from the edge of the membrane. Space the plates in accordance with project specifications and/or deck profile.
- Start attachment of the membrane at one end of the sheet. Install a fastener and seam plate on the appropriate mark, go to the opposite end of the membrane and pull the sheet tight before installing another fastener and plate. Check if the membrane lays flat and install the remaining fasteners immediately as per requirements, beginning in the middle of the (side) seam. Work towards both ends of the panel to avoid wrinkles or permanent deformation of the membrane.
- Use an automatic setting tool or an electric screwdriver with an automatic clutch control to achieve a consistent installation of the fasteners. Incorrect positioning and/or installing of fasteners and plates may not only reduce the wind uplift performance of the system, but also create problems during seam welding.
- All fasteners must be properly engaged vertically in the deck. Use caution not to overdrive fasteners, as this will reduce the pull-out value of the fastener. When fasteners are correctly anchored with proper embedment depth, plates will be level with the membrane without causing any deformation.
- End and side laps of adjoining panels shall be welded and inspected as previously outlined as soon as possible to prevent wind lifting of the panels.
- Specific precautions need to be taken when installing during windy conditions. Limit the portion of membrane being unrolled (1.5 - 2.0 m) and fastened and start spot-welding the part of the overlap while it is being fastened.

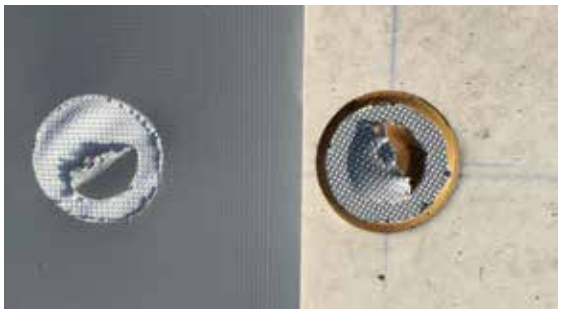
Membrane attachment with induction welding

Picture 3.77

Picture 3.78



Picture 3.79



Picture 3.80

This method is only used in the induction welded roofing system. Induction welding is an alternative fastening method where the UltraPly™ TPO membrane is welded onto TPO induction welding plates installed in a grid pattern across the roof.

- Verify that all fasteners are properly seated and plates are flush, leaving a smooth surface for welding.
- Check that the top surface of all TPO induction welding plates and the backside of the membranes to be welded are clean and dry prior to welding.
- Install the 3.05m wide membrane panels without stretching over the substrate and without creating wrinkles or fish-mouths in the seams *(Picture 3.78)*.

- Position adjoining sheets with a minimum overlap of 75 mm at side and end laps. Pay attention during lay out of the panels that seams are positioned to shed water. Seams may be installed over the TPO induction welding plates. Welding of the plate will not be affected; however, welding of the overlap may be affected due to the welder tracking over the plate.
- Allow the panels to relax a minimum of 20 minutes prior to welding. Allow for a longer time to relax in colder weather.
- Use only induction welders that are approved by Firestone Building Products. All contractors intending to use induction welding equipment must have successfully completed a training course prior to welding.
- Follow the instructions of the tool supplier to use the induction welder. A LED display provides detailed information including start-up, ready, energy level, number of plates welded/remaining, etc.
- Error messages will notify the operator when plates are not found and about conditions of high or low voltage.
- Perform first a tool calibration with the induction welder by making some test welds at various energy settings using Firestone UltraPly™ TPO membrane and TPO induction welding plates. Perform a peel test and set the device at the lowest energy setting that creates a bond covering 100% of the bonding area of the plate *(Pictures 3.79 - 3.80)*.

When the induction welding cycle is complete, immediately place a magnetic cooling clamp over the welded membrane/plate assembly. This will ensure adequate clamping between membrane and plate during cooling. The magnetic cooling clamp device must be left in place for at least 60 seconds while the weld cools and sets.

- Start the welding operation by working systematically across each roof area. TPO induction welding plates can easily be identified by putting some foot pressure over the plate and marking the membrane. Installation of a symmetrical grid pattern is therefore extremely important.
- Repeat the previous steps for every plate in the assembly and keep the bottom of the induction welder and the magnetic clamps clean to prevent scarring of the UltraPly™ TPO membrane. Wipe these surfaces frequently clean of debris.
- Continuous welding operations will cause the temperature of the magnetic clamps to rise. If the temperature has built up to a point that surface melting of the membrane becomes visually evident, cool the clamps by dipping them into a pail of clean water as often as required to avoid damaging the membrane,
- TPO induction welding plates may also be used for base tie-in securement at upstands.

Membrane attachment with contact adhesive

Picture 3.81

Picture 3.82

Picture 3.83

This method is used for fully adhered systems.

- Position adjoining sheets with a minimum overlap of 75 mm in side and end laps.
- Install all panels so that any cut edges are whenever possible positioned at the bottom of the seams. If cut edges are exposed, they must be sealed with Firestone UltraPly™ TPO Cut Edge Sealant.
- Allow the panels to relax a minimum of 20-30 minutes prior to bonding. Allow more time to relax in colder weather.
- Fold back the first membrane evenly onto itself to expose its backside and the substrate. The sheet should lay smooth to minimize the formation of wrinkles during and after installation.
- Verify the quality of the substrate. In case the insulation is mechanically fastened to the deck, all fasteners must be properly seated and fastening plates must be flush, leaving a smooth surface to receive adhesive.

- Remove excess dust or other contaminants before bonding. Wipe the substrate and the mating surface of the membrane with a stiff broom.
- The UltraPly™ TPO membranes are to be adhered to the substrate with Firestone TPO Bonding Adhesive or BA-2012. Stir the adhesive before and during application to achieve a uniform mix with no sediments on the bottom. Properly mixed adhesive is critical for a desired performance and uniformity of the bond.
- There are two methods for applying the adhesive: either using a hand roller or a mechanical dispenser. Firestone recommends a two-man operation to facilitate equal drying times (on membrane and substrate).
- Use large solvent-resistant rollers with short hairs to apply the adhesive evenly. Care must be taken not to apply adhesive over an area that is to be welded. Use a chalk-line or pen to mark the area that must remain clean *(Picture 3.81)*.
- Start application first on surfaces that are lighter colored and/or shady surfaces to minimize differences in drying times. Apply the adhesive in a thin even coat on both mating surfaces and avoid globs and puddles of adhesive. An excess of adhesive will prolong the drying time and reduce production.
- Let the solvents evaporate naturally until the adhesive is tacky. Drying time will differ with various climatic conditions and coverage rates. Never use a hot air dryer to accelerate this process. Solvent-based adhesives tend to surfaceflash during cold weather, forming an outer skin on the surface before the entire adhesive has had the time to flash-off *(Picture 3.83)*.

Touch the adhesive with a clean, dry finger to check for dryness. As you are touching the adhesive, push straight down to check the mass of adhesive underneath its surface for stringing. Push forward at an angle to ensure that the adhesive is dry throughout its thickness. If either motion exposes wet or stringy adhesive when the finger is lifted, then it is not ready for mating. Allow extra time for the adhesive film to properly flash-off before re-testing. Adhering two surfaces that have not completely flashed off will result in blisters and bubbles in the membrane, caused by trapped solvents.

Care must also be taken to avoid areas with too little adhesive. In these areas, over-drying can occur and proper adhesion may not be achieved.

Take special precautions when outside temperature is below 10°C or when the dew point is near the ambient outside temperature. Certain combinations of temperature and humidity may cause condensation on the surface of the bonding adhesive. This is referred to as "blushing". If this condition occurs, do not mate the surfaces. Wait until the ambient air conditions no longer cause condensation, dry the surface with clean, dry rags, apply a thin additional layer of adhesive and proceed.

- As the first sheet is flashing off, lay out adjoining sheets and allow them to relax.
- Bond the first sheet starting at the fold. Roll the previously coated part of membrane carefully into the coated substrate, slowly and evenly to minimize wrinkles.
- Compress the bonded half to the substrate with a stiff brush to ensure proper contact. Extra compression will help to strengthen the bond *(Picture 3.82)*.
- Fold back the other half of the membrane and repeat the bonding procedure to complete the bonding of the panel.
- Verify if end and side laps of adjoining panels are clean before welding.
- Do not place adhesive containers or lids directly on the membrane. These stains are usually hard to remove.

Membrane attachment with ballast

Picture 3.84

Picture 3.85

Picture 3.86

This technique is applicable for ballasted and inverted roofing systems.

- Position adjoining sheets with a minimum overlap of 75 mm at side and end laps and allow to relax a minimum of 20-30 minutes prior to welding or final ballasting. Allow more time to relax in colder weather.
- Install the panels so that any cut edges are (whenever possible not exposed) positioned at the bottom of the overlap. If cut edges are exposed, they need to be sealed with Firestone UltraPly™ TPO Cut Edge Sealant.
- End and side laps of adjoining panels must be welded and inspected as previously outlined prior to installation of the ballast.
- Cover loosely laid roofing sections with ballast as soon as possible.
- Install a geotextile or protection mat if required. Refer to Chapter 1 *(Picture 3.84)*.

For inverted systems, install the extruded polystyrene insulation directly over the UltraPly™ TPO membrane. Insulation boards shall be installed to fit neatly (within 6 mm) at all roof projections. Do not bond the insulation boards to the membrane or to each other. Install a protection mat over the insulation with a minimum overlap of 100 mm at side laps and 150 mm at end laps. The mat shall extend 10 mm above the ballast at all vertical upstands and penetrations.

- Do not stock pile ballast. Spread the ballast over the membrane as specified using soft tools (rubber tire buggies, squeegees). Avoid direct contact with the membrane when projected.
- Installation of walkway pads within an area of 3 m of the roof edge is not allowed on roofs with a flat edge. Use concrete pavers to prevent moving of the ballast also around drains. Any ballast that is displaced by a walkway pad should be distributed around the pad to maintain the specified average coverage rate *(Picture 3.85)*.

3.3.6 Base tie-in

Picture 3.87

All Firestone UltraPly™ TPO membranes should be mechanically fastened to the substrate at all locations where the membrane ends or passes through an angle change greater than 15%, such as bases of upstands, curbs, interior walls, around roof penetrations, etc. This type of attachment is called "base tie-in" and is required in all Firestone UltraPly™ TPO systems.

The base tie-in attachment serves to account for structural movement of the substrate, stresses induced during handling and installation of the panels, stresses induced during wind uplift and thermal variations. Attachment of the membrane panels in the field (horizontal attachment) may be inadequate to absorb these stresses.

Membrane panels may also pull away from the termination during installation. Correct installation of the base tie-in detail serves therefore another important purpose. It helps eliminate wrinkles in the membrane at the base of flashings and facilitates welding.

Exceptions where the base tie-in detail can be deleted are limited, i.e. round pipe penetrations with a diameter of less than 125 mm and square penetrations smaller than 100 mm x 100 mm.

Use a vacuum machine to pick up all dust at all locations where holes must be pre-drilled, prior to welding.

Preparation membrane prior to installation base tie-in

Picture 3.88

Picture 3.89

Picture 3.90

Picture 3.91

- The base membrane must be set up a minimum against vertical upstands and skylights to temporarily prevent water from entering the building. Verify further for correct dimensions to set up the membrane Use a metal penny roller to position and press the membrane in the angle change, as illustrated.
- Pay specific attention at inside and outside corners to fold the membrane in such a way that the roofing system is temporarily sealed.
- Use a hand welder to weld the base membrane at the inside corner *(Picture 3.91)*.

Base tie-in with seam plates

Picture 3.92

Picture 3.93

Plates and fasteners are installed either on the flat roof substrate or on the wall. The selection for horizontal or vertical attachment is related to the ease of application (thickness of insulation, nature of substrate, presence of metal profile at base of upstand).

Base tie-in with metal bars

Picture 3.94

Picture 3.95

Metal batten bars can be used as an alternative to plates. The bars can be installed either on the flat roof substrate or against the wall, depending on the ease of application.

Bars should be fastened with appropriate fasteners using the pre-drilled holes at maximum 300 mm o.c *(Picture 3.94)*.

Start installation of the fasteners at one end of the bar and work towards the opposite end to avoid buckling. Adjoining bars must overlap each other and be fastened with a common fastener *(Picture 3.95)*.

Positionning base tie-in

Horizontal tie-in

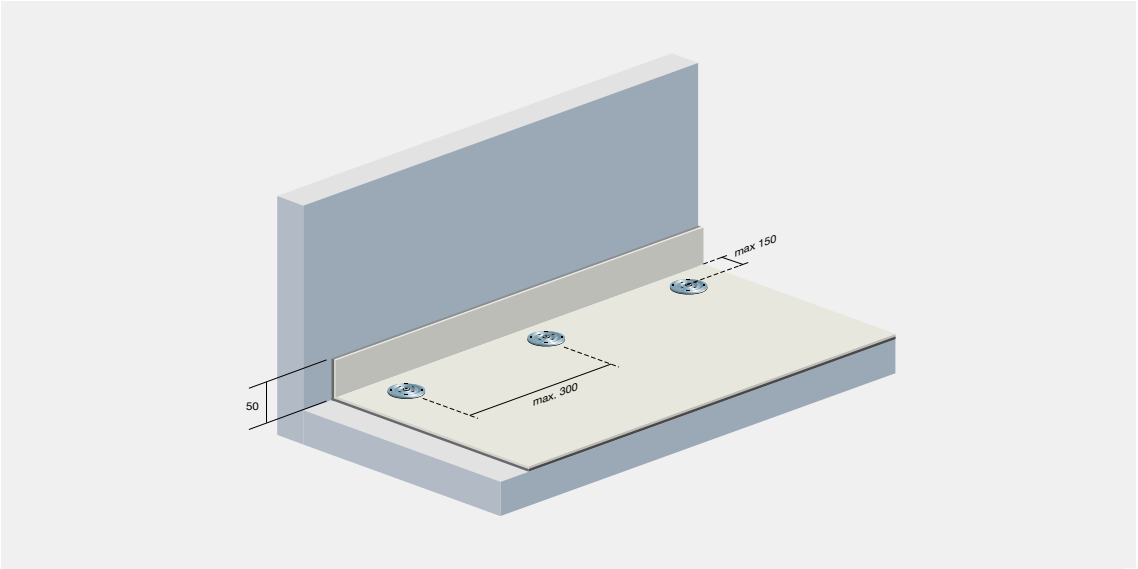


Figure 3.12

Install the plates as close as possible to the angle change but no closer than 15 mm. The UltraPly™ TPO membrane must extend a minimum of 15 mm beyond the edge of the plates.

Plates should be fastened at maximum 300 mm o.c. with appropriate fasteners. Install the plates on the vertical within 15 mm of the angle change to avoid bridging.

Bars must also be positioned as close as possible to the angle change, leaving maximum 15 mm between the edge of the bar and the angle change.

The UltraPly™ TPO membrane must extend also a minimum of 15 mm beyond the top edge of the bar.

Vertical tie-in

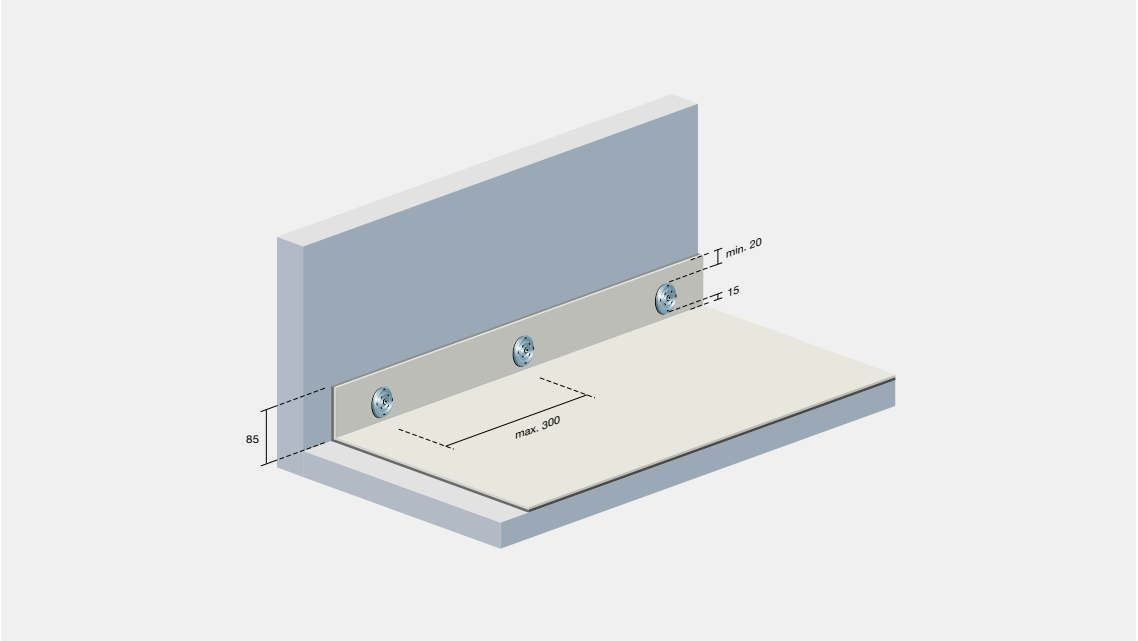


Figure 3.13

Inside corner

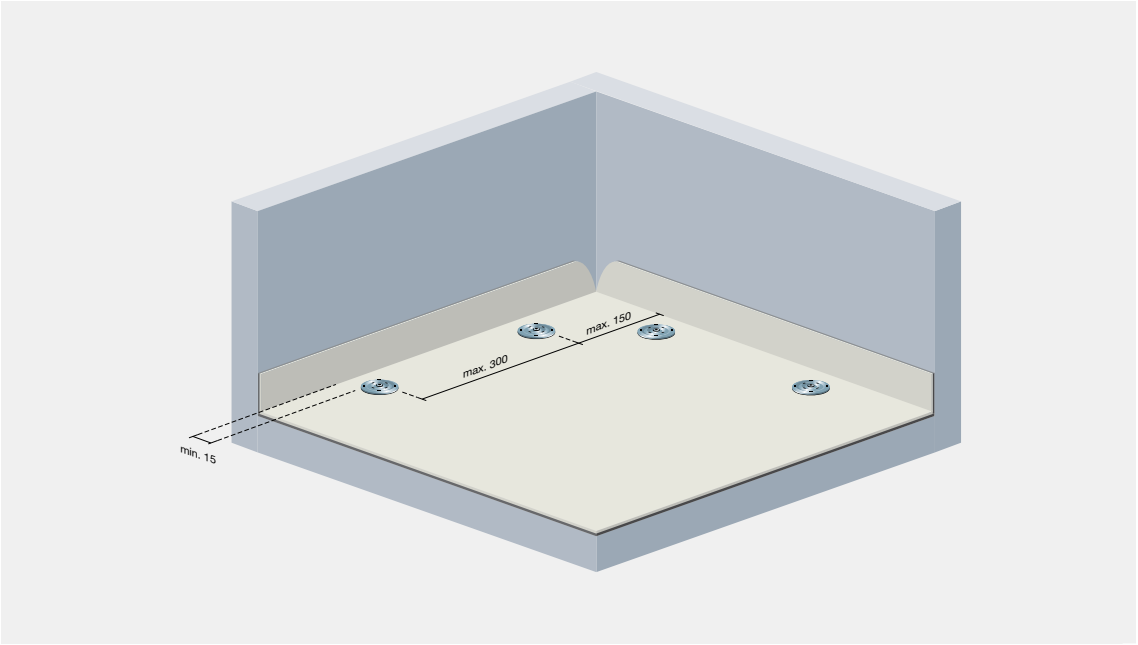


Figure 3.14

Position the plates as close as possible to inside corners but maintain 150 mm from the corners to facilitate welding of flashings.

Outside corner

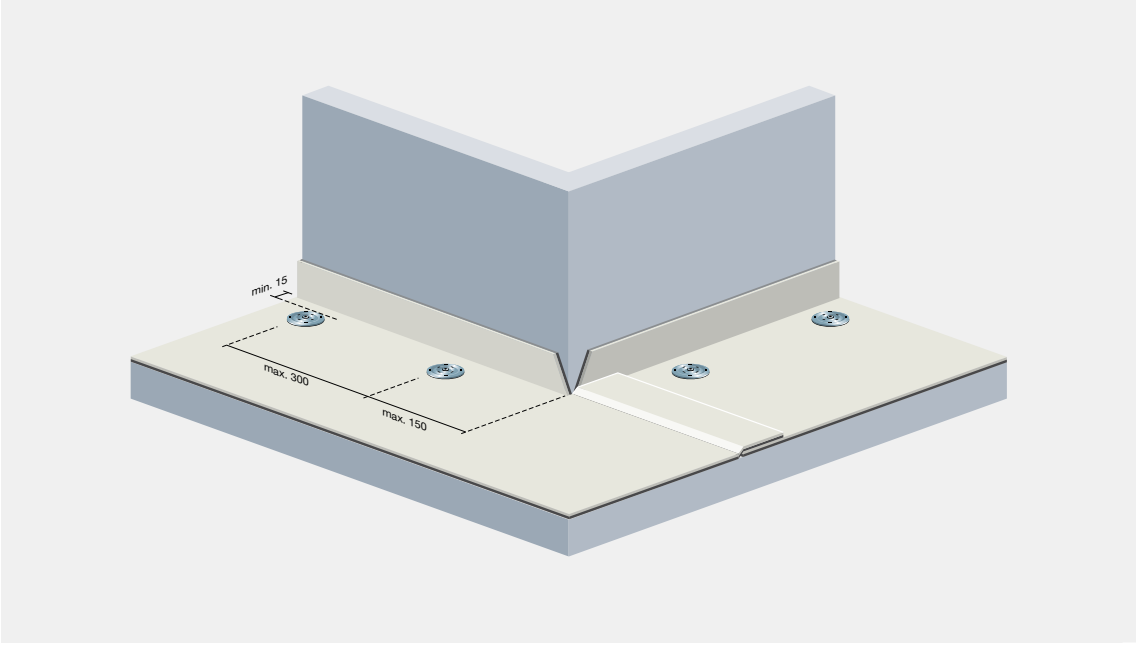


Figure 3.15

Position the plates as close as possible to outside corners but maintain 150 mm from the corners to facilitate welding of flashings

Stop installation of the bars as close as possible to inside and outside corners but maintain a distance of 150 mm from the corners to facilitate welding of flashings.

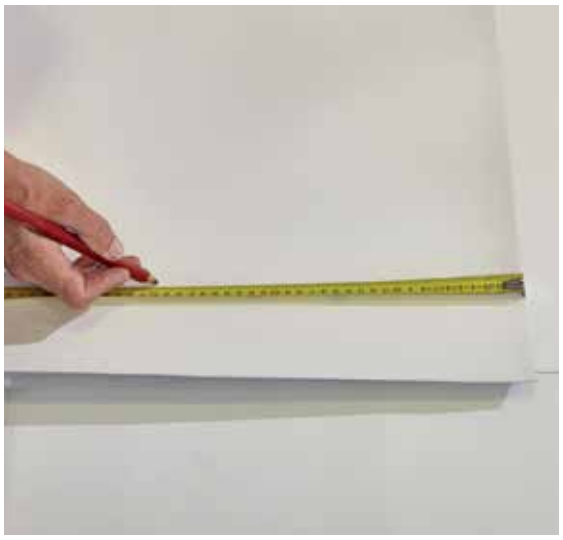
3.3.7 Wall flashings and vertical seams

Picture 3.96

- Evaluate always the substrate to be covered or the quality of the existing flashings prior to the installation of the new flashing. Substrates must be smooth and secure and existing flashings must be eventually removed or covered with an appropriate insulation or cover board.
- Install flashings of parapets and curbs as soon as possible (if possible at the same time as the field membrane) to avoid water penetration in the roofing system.
- It is recommended to use reinforced membrane for flashings so that all seams between flashing and field membrane can be welded with an automatic welder.
- Upstands can be flashed with separate strips of membrane that are either fully adhered to the wall or with strips that are mechanically fastened at the top. The second method is sometimes preferred onto walls or curbs with limited height.
- Refer to Chapter 1 for specific requirements regarding the intermediate attachment of wall flashings in both fully adhered and mechanically fastened applications.
- Use the longest piece that can be used to flash high walls to the specified height. Selecting the correct cut for TPO strips is a time saver.
- When measuring the width of the TPO material, allow the strip to cover the wall to the height required. Provide an extra 50 mm of membrane at the top, plus enough membrane for the seam at the base. In case of intermediate attachment, an additional 150 mm is required for every attachment.
- Wall flashings must overlap a minimum of 100 mm at the base in case of vertical tie-ins and 150 mm in case of horizontal tie-ins.

Bonding wall flashings

Step 1 - Positioning flashing membrane



Picture 3.97

Picture 3.98

Picture 3.99

Picture 3.100

- Position the TPO strip along the wall to be flashed, mark the required width of the base overlap and fold the membrane as illustrated. Do not fold the membrane with heavy pressure to avoid damaging *(Pictures 3.97 - 3.98)*.
- Position the flashing membrane and spot-weld the piece into the angle change using a hand welder. Take care when setting the membrane to avoid bridging. Crease the flashing into the angle change with a metal penny roller before bonding it to the vertical surface. Check that the overlap is aligned with the marks on the field membrane or verify that the base overlap is uniform over its entire length *(Picture 3.99)*.
- Fold the membrane back to expose its grey underside. Make sure the sheet fold lays perfectly smooth without any wrinkles *(Picture 3.100)*.
- Remove any excess of dust, moisture or other contaminants from the mating surfaces before bonding. If needed, wipe the exposed back of the sheet with a stiff broom.
- Firestone UltraPly™ TPO Bonding Adhesive or BA-2012 should be used and is applied using large solvent resistant rollers with short hairs. An alternative option is the use of Firestone Bonding Adhesive BA-2012 S, a spray adhesive.

Step 2 - Bonding flashing membrane

Picture 3.101

Picture 3.102

Picture 3.103

Picture 3.104

- Apply the adhesive at about the same time to both membrane flashing and wall surface to allow approximately equal drying times. Apply the adhesive evenly, avoiding globs or puddles. An excess of adhesive will prolong the drying time and reduce production *(Pictures 3.101 - 3.102)*. Care must be taken not to apply adhesive over an area that is to be welded (vertical seams). Use a pen to mark the area that must remain clean.

- Let the solvents evaporate naturally until the adhesive is tacky. Drying time will vary depending on the ambient air condition, coverage rate and type of substrate. When flashing to metal work, metal will act as a barrier to the solvents. These solvents can only evaporate through one surface (adhesive), resulting in a slower drying process onto the wall in comparison with the membrane. Spray-applied adhesive has the characteristic to dry faster. Never use a hot air dryer to accelerate this process. Solvent-based adhesives tend to surface-flash during cold weather, forming an outer skin on the surface before the adhesive underneath has had the time to flash-off.
- Bond the TPO flashing, starting at the fold. Roll the previously coated part of membrane carefully upwards into the coated substrate, slowly and evenly to minimize wrinkles. For installation of long lengths, it is recommended to start installation in the center of the flashing piece and to complete installation working towards both ends *(Picture 3.103)*.
- Use circular moves to press the membrane against the upstand without making wrinkles. Press the bonded membrane to the substrate using a stiff brush to ensure proper contact. Extra pression will strengthen the bond *(Picture 3.104)*.
- Side laps (vertical laps) of adjoining panels, laps at inside and outside corners and horizontal laps shall be prepared and welded using a handwelder.

Mechanically fastening wall flashings

Step 1 - Installation bottom flashing

Picture 3.105

Picture 3.106

Picture 3.107

Picture 3.108

- Position the TPO strip along the wall to be flashed and fasten it at the top with a few seam plates and appropriate fasteners. Make sure the flashing is positioned correctly and provides sufficient overlap at the base with the field membrane. *(Picture 3.105)*
- Crease the flashing membrane into the angle change with a metal penny roller, as illustrated, and start welding the membrane into the angle change using a hand welder. Take care when setting the membrane to avoid bridging *(Picture 3.106)*.
- Complete the weld of the flashing membrane onto the field membrane at the base using a wide rubber pressure roller. Check continuously that the overlap remains aligned with the marks on the field membrane and correct where needed *(Picture 3.107)*.
- Whenever possible, horizontal seams at the base of flashings must be welded with an automatic welder *(Picture 3.108)*.
  Pay specific attention during welding at small differences in level of the substrate at drains and scuppers and at the base of vertical overlaps.
- Once the weld at the base is completed you may stretch the flashing and complete fixation at the top over the whole length. Flashings can either be welded at the top onto a TPO Coated Metal profile that is anchored with appropriate fasteners into the wall or flashings can be mechanically fastened into the wall using seam plates and appropriate fasteners. Plates and fasteners must be installed with a maximum spacing of 300 mm o.c.

Step 2 - Installation top flashing

Picture 3.109

Picture 3.110

Picture 3.111

- The second piece of flashing must overlap a minimum of 150 mm with the first installed flashing.
- All horizontal welds of overlapping flashings are welded with the hand welder, first spot-welded and then completely welded *(Pictures 3.110 - 3.111)*.
- Side laps (vertical laps) of adjoining panels and laps at inside and outside corners shall be prepared and welded as outlined in the following section.
- Finally, apply Firestone UltraPly™ TPO Cut Edge Sealant on all cut edges of vertical and horizontal seams.

Vertical seams

Picture 3.112

Picture 3.115

Picture 3.113

Picture 3.116

Picture 3.114

Picture 3.117

- It is recommended to complete first all vertical welds of flashings prior to executing the horizontal welds with the base membrane.
- Vertical welds are made with hand welders following the steps described below.
- Cut the edge of both base overlaps. Round the corners to minimize risks for capillaries. This will also facilitate the installation of T-joints *(Picture 3.112)* .
- Install a metal plate under the overlap to facilitate welding and avoid local overheating of the membrane *(Picture 3.115)*.
- Spot-weld the seam at the angle change to fix the overlapping membrane. Spot-weld the seam also at the top to prevent the membrane from moving at the overlap *(Pictures 3.113 - 3.114)*.
- Complete the weld starting at the bottom in the angle change and work up to the top following the procedure of hand welding (3-step method).
- Use a metal penny roller to weld correctly into the angle change and a rubber roller on locations that are flat and more accessible *(Pictures 3.115 - 3.116 - 3.117)*.

3.3.8 Joint covers

Picture 3.118

All membranes with a thickness of 1.5 mm or more require the installation of T-joint cover pieces over all single and double T-joints and at base of vertical seams.

Picture 3.119

Picture 3.120

Picture 3.121

Picture 3.122

- Pay specific attention to a proper installation of the membranes at the crossing of seams. Edges of overlapping membranes should be rounded at transversal seams to minimize the step-up (risk for capillary) at the intersection. The seam area should also be rolled immediately with a hard metal penny roller after the automatic welder has closed the seam. Make sure to clearly mark the step-off of the overlapping membranes to avoid gaps and capillaries.
- Prior to the installation of the Firestone UltraPly TPO T-joint Cover, check all seams at T-joints with a probing tool after cooling.
- Clean the area of the T-joint with Firestone Cleaner *(Picture 3.120)*.
- Spot-weld the T-joint Cover piece central over the T-joint to fix the piece *(Picture 3.121)*.
- Complete the welding working from the center towards the outside edge of the piece and use a metal penny roller to close all capillaries *(Picture 3.122)*.

Refer to Figure 3.17 and Figure 3.18 for correct dimensions of covering flashing pieces to meet minimum requirements of overlap.

Single T-joints

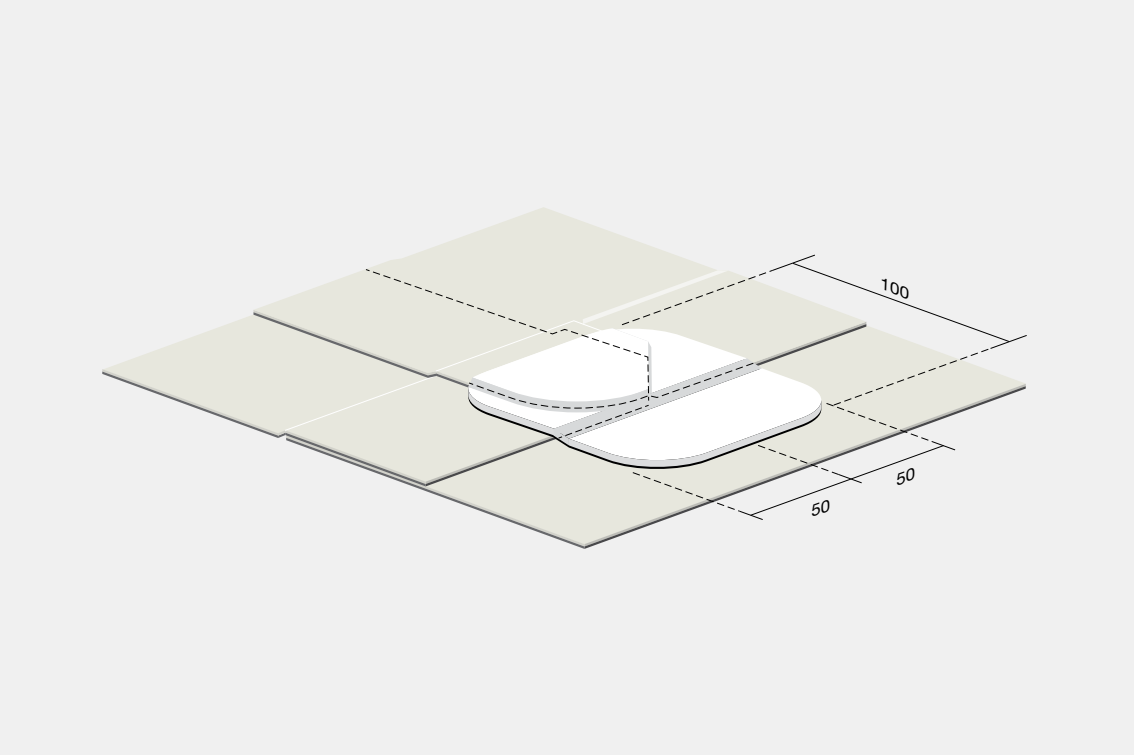


Figure 3.16

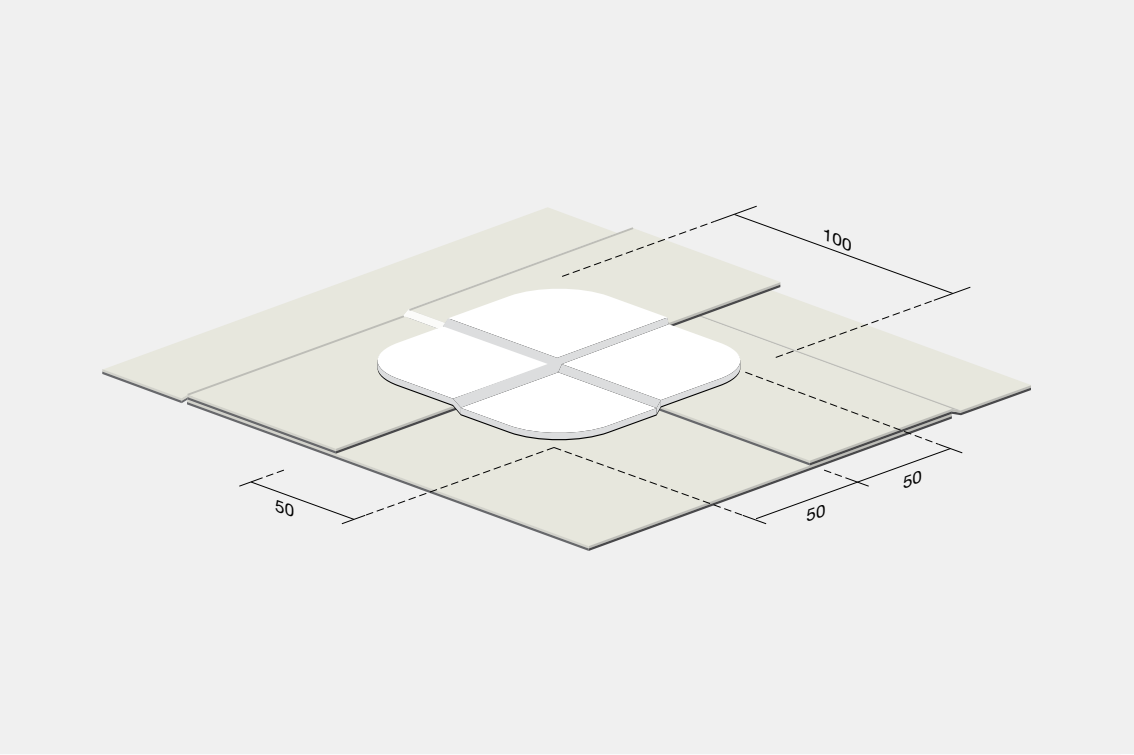


Figure 3.17

For single T-joints a standard cut T-joint cover piece of 100 x 100 mm should be installed.

Double T-joint

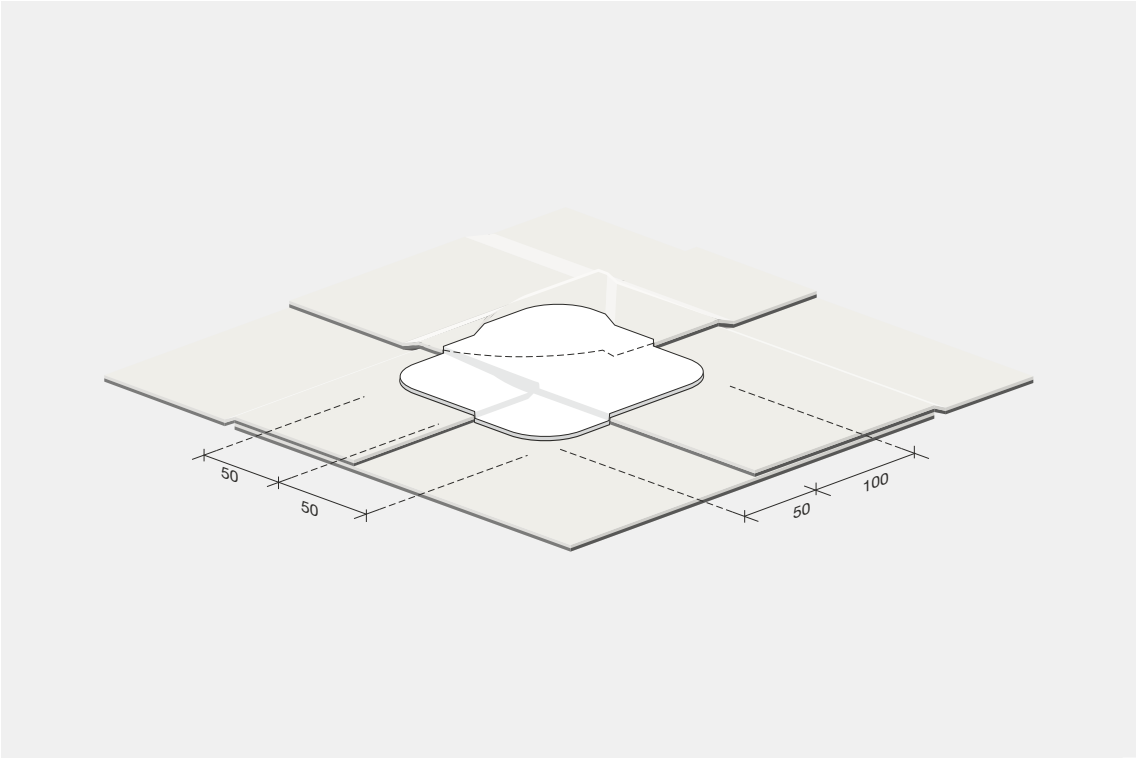


Figure 3.18

For covering pieces of double joints and at the base of vertical seams, Firestone recommends to cut a piece with appropriate dimensions out of a roll of Firestone UltraPly™ TPO Unsupported Flashing.

Base of vertical seam

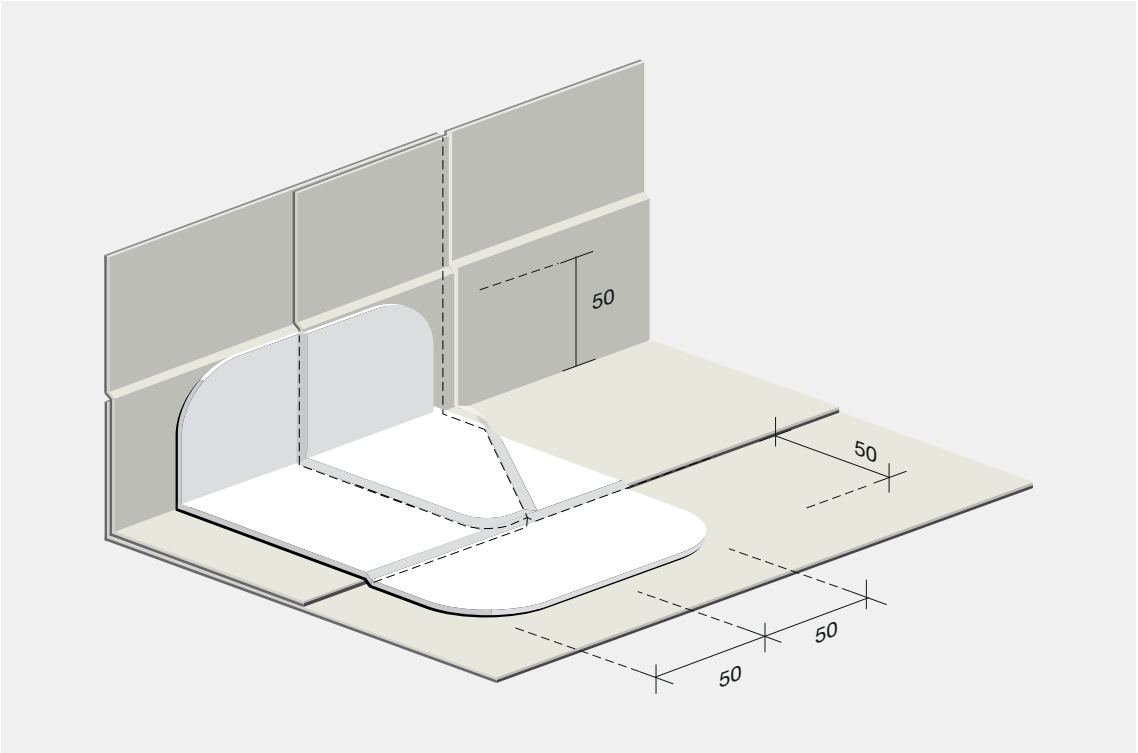


Figure 3.19

3.4 Flashing details

Picture 3.123

Picture 3.124

Picture 3.125

Picture 3.126

- In this section we provide information about different methods to install:
  - Corners
  - Skylights
  - Drains
  - Pipe penetrations
  - Wall and roof edge terminations
- Whenever possible, Firestone recommends to use pre-shaped pieces to complete the details of the UltraPly™ TPO roofing systems. Use of UltraPly™ TPO Unsupported Flashing is always an alternative.
- Check all dimensions of the flashing pieces to meet minimum requirements for overlaps.
- Pay attention to adjust welding settings and pressure in function of the situation. Welding non-reinforced membrane requires less heat and pressure than welding reinforced membrane. Pre-molded pieces are usually thicker than the membrane.
- Adjust nozzles and use a small metal penny roller to weld more efficiently in situations with difficult access.

3.4.1 Corners

Inside corner

Step 1 - installation flashing membranes that adjoin at corner

Picture 3.127

Picture 3.128

Picture 3.129

Picture 3.130

Picture 3.131

- A correct installation of both flashing membranes that join at the inside corner is required to facilitate completion of the detail.

Observe that there is only double thickness (overlap) of flashing membrane at one side of the corner. One membrane ends straight into the corner while the other flashing membrane turns around the corner and provides a vertical overlap of minimum 100 mm *(Picture 3.131)*.

- Verify that base overlaps with field membrane meet minimum requirements (refer to section of base tie-in).Round all edges of the overlaps to facilitate welding.
- All seams are welded with a hand welder using different types of rollers.

Step 2 - Installation pre-molded corner piece at roof level

Picture 3.132

Picture 3.133

Picture 3.134

Picture 3.135

Picture 3.136

Picture 3.137

- Firestone recommends to use a pre-molded corner piece to complete the detail.
- Cut the inside corner out of the pre-molded piece as illustrated and round all corners *(Picture 3.132)*.
- Make sure that the cut piece meets minimum overlap requirements (50 mm) with the flashing membranes in all directions.
- Position the piece into the corner and spotweld it onto the flashing membrane *(Pictures 3.133 - 3.134)*.
- Use a hand welder with a small nozzle and a metal penny roller during welding to make a continuous weld. Care should be taken to start welding from the center of the piece and to weld towards the outside edges, leaving an un-welded area at the center to allow for movement *(Pictures 3.135 - 3.136 - 3.137)*.
- Pay attention to avoid over-heating. This could damage the pre-molded piece.
- Check all welds always after cooling with a probing tool.

Production of alternative corner piece on site

Picture 3.138

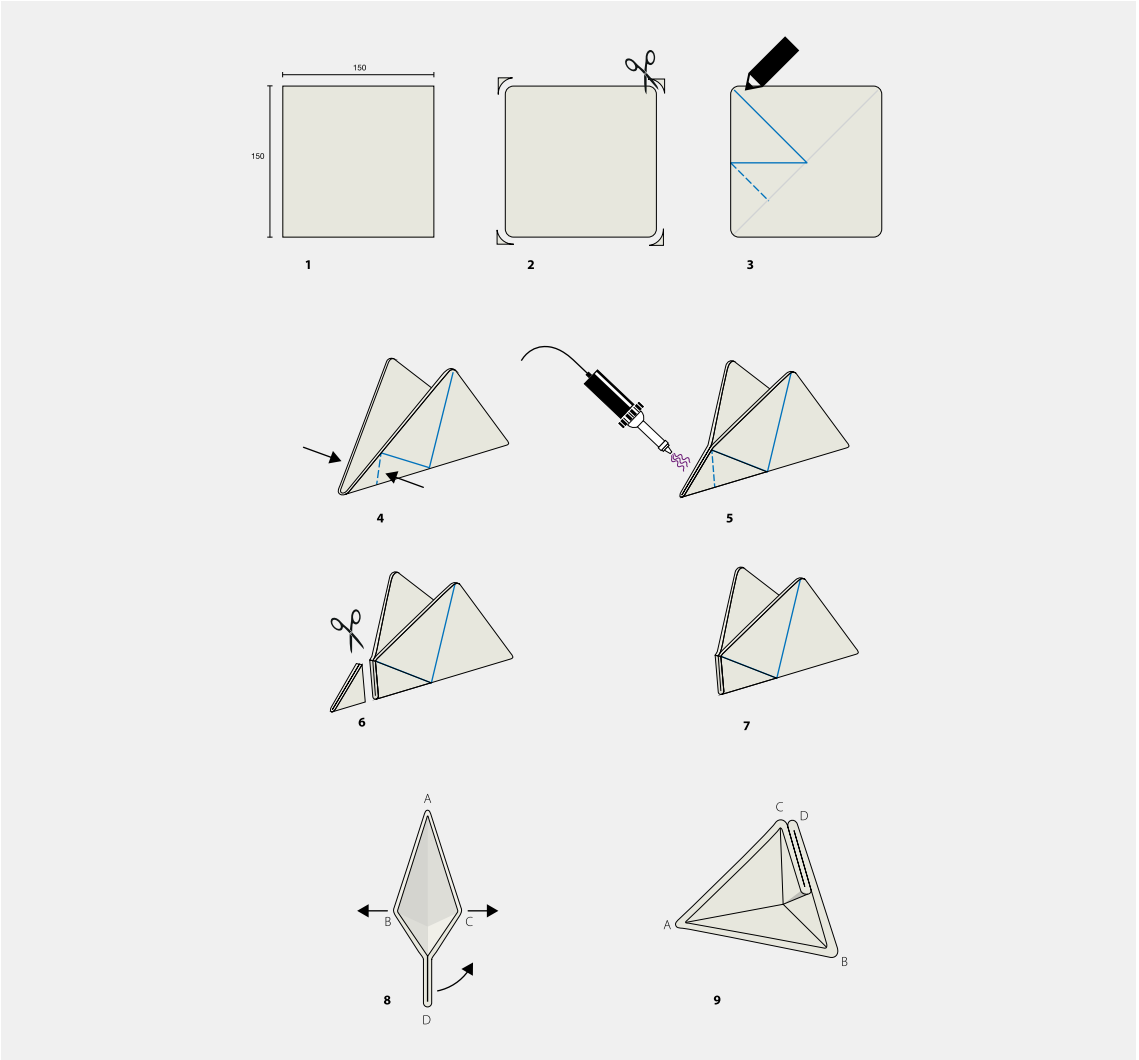


Figure 3.20

When pre-molded corners are not available, the installer can always use a T-joint cover piece (150 x 150 mm) or a piece of Firestone UltraPly™ TPO Unsupported Flashing as an alternative to produce a hand-made corner piece on site. Refer to the illustrations to produce this corner piece in a correct way.

Step 3 - Installation pre-molded corner piece on top of a wall flashing

Picture 3.139

Picture 3.140

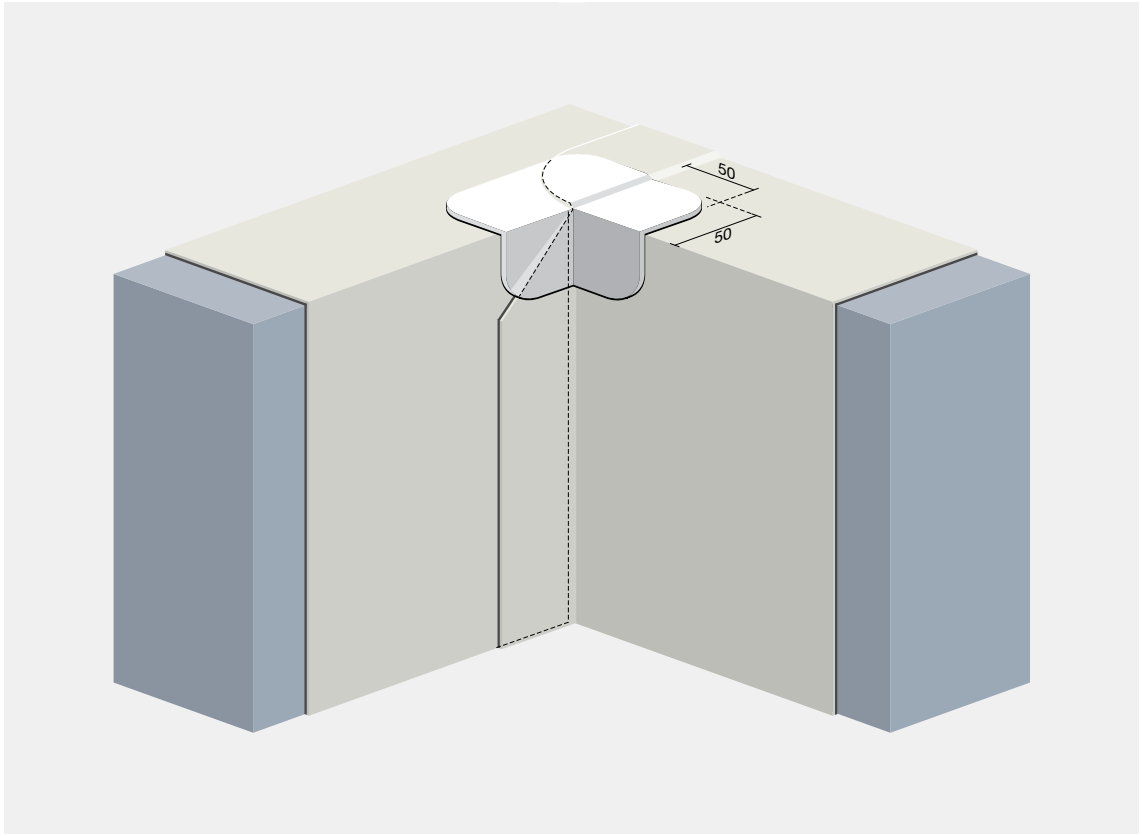


Figure 3.21

- Cut the corner out of the pre-molded piece and round all edges.
- Refer to Figure 3.23 for correct overlap dimensions and installation of the corner piece.
- Weld the piece onto the flashing membrane with a continuous weld. Use a hand welder with a small nozzle during welding and a metal roller to close the capillaries.
- Check all welds after cooling with a probing tool.

Outside corner

Step 1 - installation of flashing membranes that join at corner

Picture 3.141

Picture 3.142

Picture 3.143

- Pay specific attention to the installation of the flashing membranes that join at the corner.
- Install the first flashing membrane with an additional length of 75 mm that surpasses beyond the corner. Warm up the part of the flashing piece that surpasses with a hand welder prior to wrapping it around the corner. Bond this part onto the adjoining wall.
- Install the second flashing with the edge aligned with the corner to provide a vertical overlap of 75 mm. Observe that there is only double thickness (overlap) of flashing membrane at one side of the corner.
- Verify that base overlaps with the field membrane meet minimum requirements.
- Round all edges of base overlaps, as illustrated, to facilitate the installation of the finishing corner piece. Make sure to cut the flashing at the bottom in a rounded shape to avoid overstretching.
- Weld all seams with a hand welder using different types of rollers.

Step 2 - Installation pre-molded corner piece at roof level

Picture 3.144

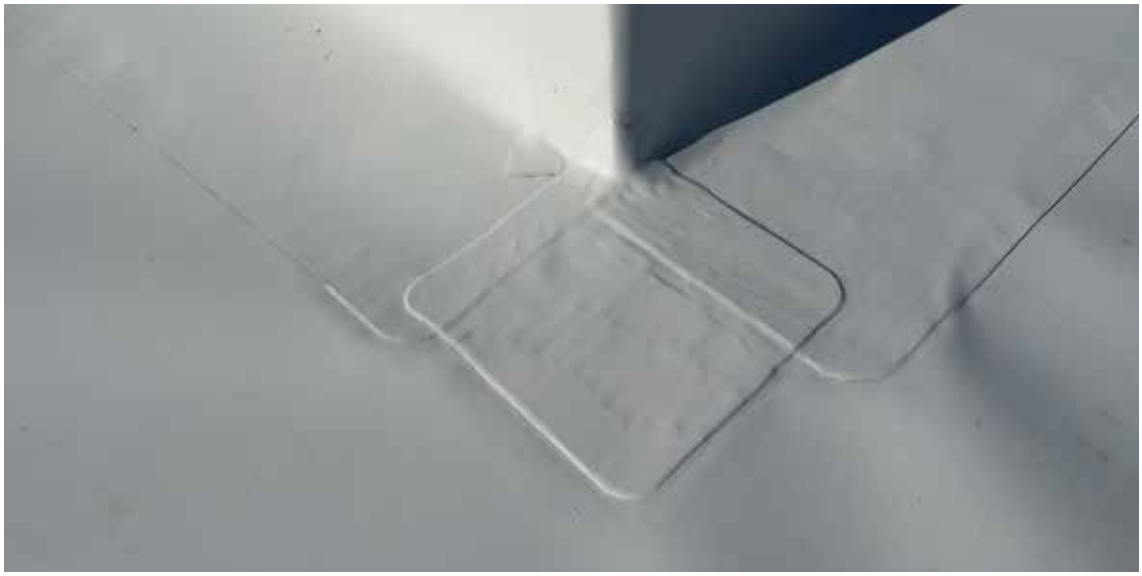
Picture 3.145

Picture 3.146

Picture 3.147

- Cut the outside corner out of the pre-molded piece and round all edges.
- Position the corner piece and weld it onto the flashing membrane with a continuous weld.
- Use a hand welder with a small nozzle at all locations with difficult access.
- Use a metal penny roller to close capillaries at all step-ups of the flashing membranes. Care must be taken to start welding from the center of the piece. Weld from rear to front and pay attention to avoid over-heating. This could damage the pre-molded corner.

Production of an alternative corner piece on site



Picture 3.148

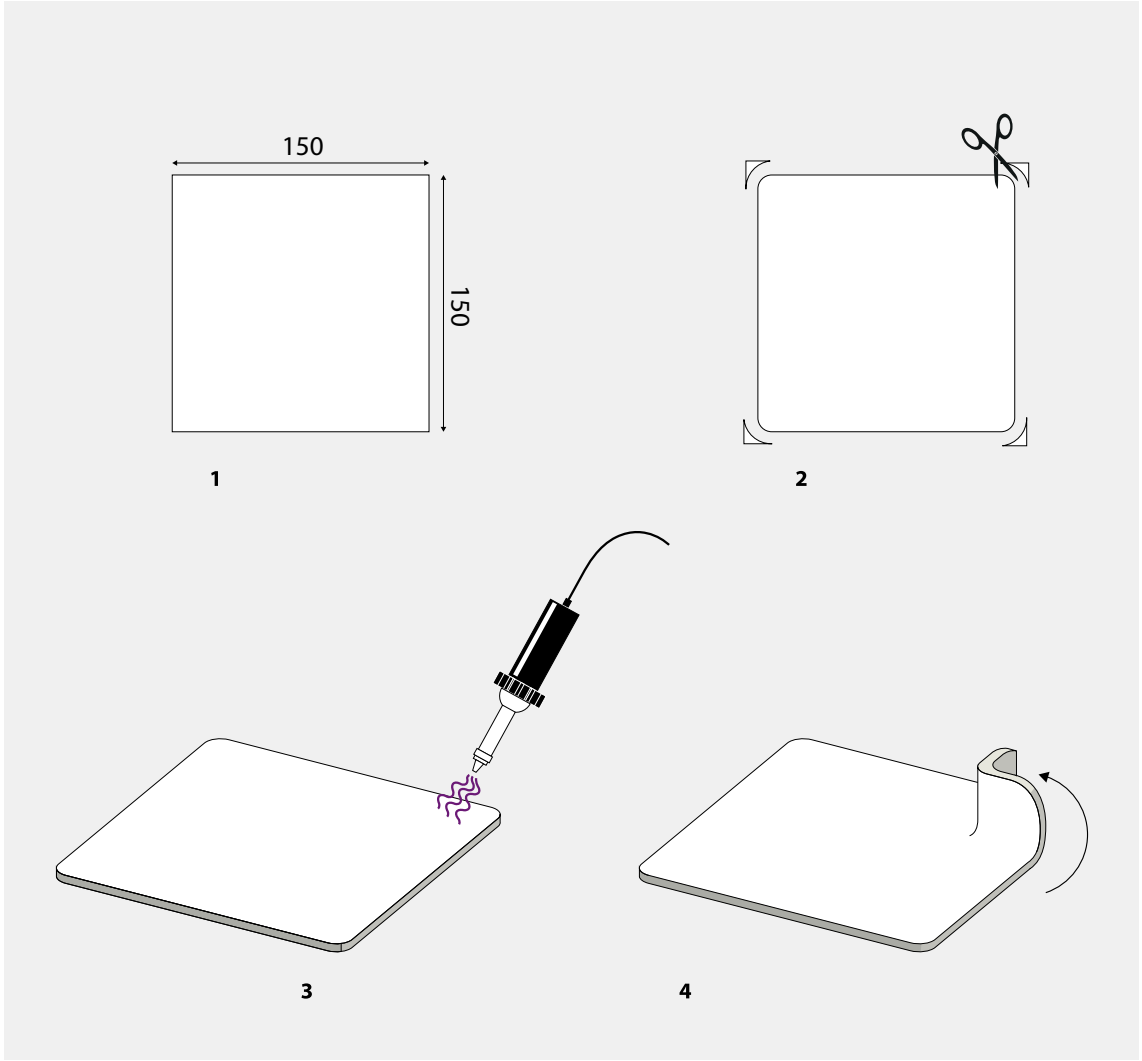


Figure 3.22

In case pre-molded corners are not available, the installer can always produce a handmade corner piece on site using TPO Unsupported Flashing. Refer to Figure 3.24 to produce a piece with the correct dimensions.

3.4.2 Skylights

Picture 3.149

Picture 3.150

Picture 3.151

Picture 3.152

- Firestone recommends to complete the installation of skylight flashings at the same time as the installation of the membrane in the field to facilitate welding (less need for cleaning) and to avoid water penetration in the roofing system.
- Whenever possible, use strips of reinforced membrane so that base welds can be made with an automatic welder. Round skylights can be dressed with TPO Unsupported Flashing.
- Always evaluate the substrate of the skylight upstand prior to the installation of the flashing material. Substrates must be appropriate to receive the flashing membrane.
- On retrofit projects, the quality of existing flashings should be checked. Existing flashings must eventually be removed or covered with an appropriate insulation or cover board.
- There are two methods for flashing skylight curbs. Flashings can either be fully adhered using a Firestone contact adhesive or mechanically fastened at the base and top of the curb. Both methods will be illustrated in this section.

Installation of curb flashings with adhesive

Step 1 - Position and spotweld first two flashings (at opposite sides)

Picture 3.153

Picture 3.154

Picture 3.155

- Flashing materials should cover the complete height of the upstand and end at the top, at the inner edge of the skylight. The size of the flashing must be calculated to include minimum requirements for overlap at the base (100 or 150 mm in function of base tie-in) and some extra material (50 mm) at the top beyond the inner edge of the skylight.
- Flashings of opposite sides of the skylight should be cut similar in size and should be installed simultaneously. The length of the first two flashings to be installed must provide an extra of minimum 75 mm at both ends for overlaps. The length of the two other flashings should cover exactly the width of the remaining upstands *(Picture 3.153)*.
- Round all corners of each flashing piece.
- Flashing strips are first folded to create a base overlap with the field membrane. Do not crease the membrane at the fold (*Picture 3.154)*.
- Spot-weld the flashings at the base of the skylight with a hand welder (*Picture 3.155)*.

Step 2 - Bond first two flashings and trim excess of material

Picture 3.156

Picture 3.157

Picture 3.158

Picture 3.159

Picture 3.160

- Fold both flashing membranes back and apply adhesive onto the exposed back of the flashing and onto the skylight curb. Do not forget to apply adhesive on the adjoining side of the corner that needs to be flashed (covered with part of flashing to be wrapped around the corner) *(Pictures 3.156 - 3.157)*.
- Let the adhesive dry before covering the upstands. Roll both flashings after bonding with a pressure roller *(Picture 3.158)*.
- Trim excess of flashing at both corners, leaving a minimum of 75 mm for the overlap (around the corner). Pay specific attention to round all edges when cutting the membrane at the base *(Pictures 3.159 - 3.160)*.

Step 3 - Complete installation of first two flashings at top and corner

Picture 3.161

Picture 3.162

Picture 3.163

Picture 3.164

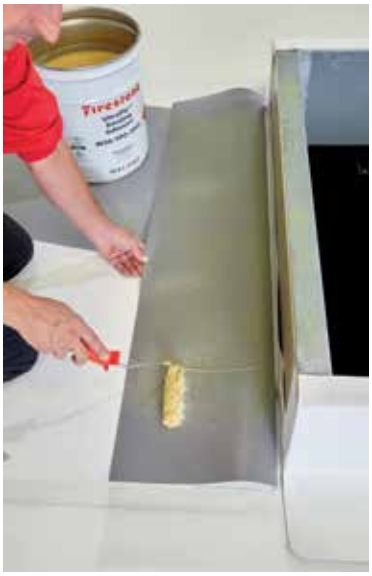
Picture 3.165

Picture 3.166

- Warm the flashings lightly up at the top of the curb before folding and completing the bond *(Picture 3.161 - 3.162 - 3.163)*.
- Trim excess of material that passes beyond the inner edge of the skylight.
- Warm the prevoiously installed flashings also up at both corners prior to wrapping the flashings around the corner. Weld the folded membrane as illustrated *(Pictures 3.164 - 3.165 - 3.166)*.

Step 4 - Install other flashings (adjoining curbs)

Picture 3.167



Picture 3.168

Picture 3.168

Picture 3.170

- Install both flashings of the adjoining curbs, as previously described.
- Apply adhesive but pay attention not to apply adhesive in areas to be welded (at corners) *(Pictures 3.167 - 3.168)*.
- Trim excess membrane at the inner part of the skylight and at corners *(Pictures 3.169 - 3.170)*.

Step 5 - Complete all welds at corners and install corner pieces

Picture 3.171

Picture 3.172

Picture 3.173

Picture 3.174

Picture 3.175

- Complete all horizontal welds at the base using an automatic welder *(Picture 3.171)*
- If needed, clean the corner areas prior to completing horizontal and vertical welds using a hand welder *(Pictures 3.172 - 3.173 - 3.174)*.
- Install a pre-molded TPO corner piece at each corner, as per instructions previously described *(Picture 3.175)*.
- Check all welds after cooling with a probing tool.
- Apply Cut Edge Sealant on all exposed edges of reinforced membrane.

Installation of curb flashing without adhesive

Step 1 - Verify conditions for mechanical fastening of flashings

Picture 3.176

Picture 3.178

Picture 3.177

- This method of installation is applicable for skylight curbs limited in height that provide conditions to mechanically anchor flashings at the top of the curb. The field membrane should ideally be mechanically fastened at the base of the skylight curb using a continuous linear system of attachment (metal bar, TPO Coated Metal profile). Spacing between fasteners may not exceed 250 mm.
- Verify first that field membranes are properly cut and installed around the skylight. All membranes must lay flat, without any wrinkles and turn up a minimum of 75 mm against the curb.
- Use a metal pressure roller to push, without damaging, the base membrane into the angle change prior to the fixation of the base tie-in detail. Make sure that the field membranes overlap at corners and are properly welded *(Picture 3.176)*.
- Keep a minimum distance of 75 mm between the edge of the base tie-in fixation and the corner of the skylight curb to avoid overlapping too many layers (welds) of flashing material.
- Install a TPO Coated Metal profile (L-shape 50 x 50 mm) at the top of the skylight *(Picture 3.178)*.
- Prepare the flashing strips. Verify their width and make sure they provide sufficient flashing height, including a minimum overlap at the base. Fold the base overlap *(Picture 3.177)*.

Step 2 - Install first two flashings (opposite sides)

Picture 3.179

Picture 3.180

Picture 3.181

- Position the flashing strips and spot-weld the flashings first at both corners onto the field membrane using a hand welder *(Picture 3.179)*.
- Make a continuous weld between flashing and field membrane. Use first a metal roller to push the membrane into the angle change and complete the weld at the base over a small width (40 mm) using a wider rubber roller *(Pictures 3.180 - 3.181)*.
- A correct installation of the base tie-in detail (metal bar or TPO Coated Metal profile) will help execute a proper welding.

Step 3 - Complete installation of first two flashings

Picture 3.182

Picture 3.184

Picture 3.183

Picture 3.185

- Stretch and weld the flashing onto the TPO Coated Metal at the top of the skylight. An alternative solution is to mechanically fasten the flashing with a metal bar or plates and appropriate fasteners *(Pictures 3.182 - 3.183)*.
- Fold the flashing strips at both corners and weld the folded membrane *(Pictures 3.184 - 3.185)*. Weld at the top and bottom.

Step 4 - Install other flashings (adjoining curbs)

Picture 3.186

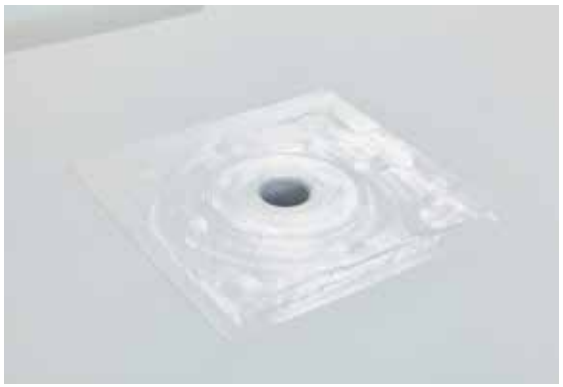
Picture 3.187

Picture 3.188

Picture 3.189

- Position and weld the flashings at the base following the same procedure as the first two flashings. *(Pictures 3.186 - 3.187)*.
- Trim the flashing strips at the corners and at the top (beyond the inner edge of the skylight) before completing the welds at both corners. The trimmed edge of the flashing should be aligned with the corner and inner edge of the curb *(Picture 3.188)*.
- Complete horizontal welds at the base with an automatic welder and use a hand welder to weld parts with difficult access *(Picture 3.189)*.
- Use pre-molded TPO corner pieces to complete outside corners.
- Check all welds after cooling with a probing tool.
- Apply Cut Edge Sealant on all exposed edges of reinforced membrane.

3.4.3 Drains



In this section, we introduce the most commonly applied drainage systems that are compatible with the Firestone UltraPly™ TPO roofing system.

- Drain with clamping system.
- Pre-molded insert drain made of flexible TPO.
- Insert drain with UltraPly TPO membrane flashing.

Drain inserts are typically used on roofs with little or no sump around drains and for re-roofing applications. On re-roofing projects, all existing drain inserts must be removed prior to the installation of the new drain.

Installation of a metal plate may be required on metal decks to facilitate the mechanical attachment of the UltraPly™ TPO membrane around the drain opening and to corect cutting of the deck.

Please contact Firestone's technical department to discuss alternative solutions.

Drain with clamping system

Picture 3.190

Picture 3.191

Picture 3.192

Picture 3.193

Picture 3.194

Picture 3.195

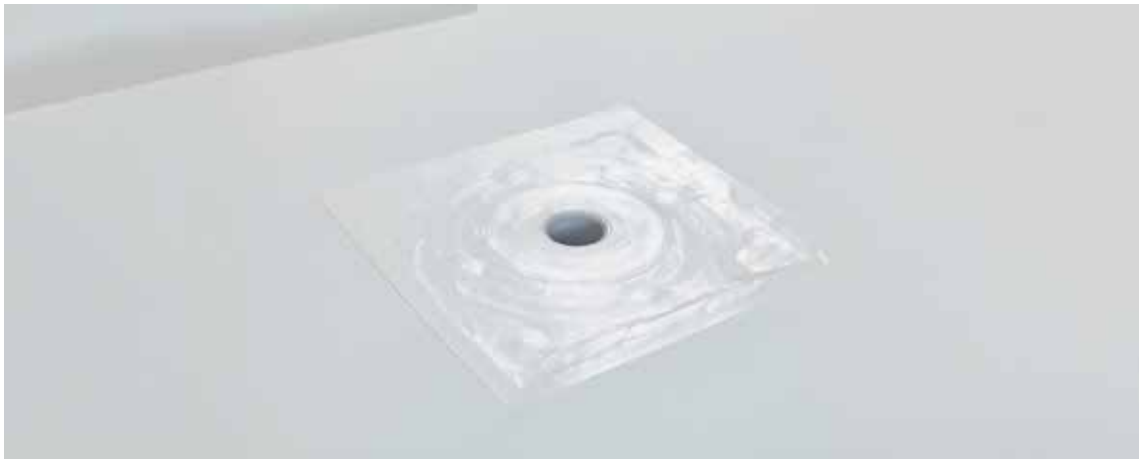
Picture 3.196

Picture 3.197

Roof drains with clamping system are designed for vertical drainage of new roofs.

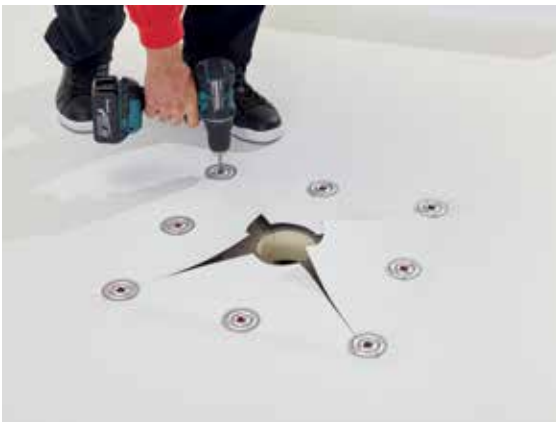
- Install the drain bowl in a sump of minimum 500 x 500 mm or taper the insulation around the drain to provide a smooth transition from the roof surface to the drain. Tapered insulation can be used to create a slope not exceeding 1:12. It is recommended to cut the insulation around the drain pipe in such a way that the drain bowl lays slightly deeper *(Picture 3.191)*.
- The drain bowl has to be fastened through the insulation onto the deck with appropriate fasteners *(Picture 3.192)*.
- Install the first rubber sealing onto the bowl before unrolling the membrane *(Picture 3.193)*.
- Position the UltraPly™ TPO membrane over the drain bowl and cut a circular hole above the drain with the same diameter as the underlying drainpipe *(Picture 3.194)*.
- Install the second rubber sealing ring on top of the membrane and make sure that both sealing rings are installed in dry conditions. Application of Firestone Water-Block Seal is required in case a clamping system is used without rubber rings *(Picture 3.195)*.
- Install the clamping ring over the UltraPly™ TPO membrane. It must fit exactly in the cut opening and provide a tight seal *(Picture 3.196)*.
- Install the clamping bolts on the indicated places and tighten the bolts to achieve a constant compression. Do not overtighten the bolts *(Picture 3.197)*.
- Finally, install the drain basket and twist-lock it.

Pre-molded insert drain made of flexible TPO



Picture 3.198

Picture 3.199



Picture 3.200

Picture 3.201

Picture 3.202

This drain system applies a prefabricated injection-molded insert piece made of flexible TPO that must be compatible with the Firestone UltraPly™ TPO membrane (polypropylene-based) for welding. Consult Firestone's technical department in case of doubt. The field sheet must be in place prior to installation of the insert piece.

- Cut a circular hole over the center of the drain. The hole should be as large as the drainpipe. In case the drain is in a sump, you may have to cut the membrane in cross shape *(Picture 3.199)*.
- The field membrane must be mechanically fastened with appropriate plates and fasteners in the area around the drain *(Picture 3.200)*.
- Install the drain insert in the hole and weld its flange onto the field membrane *(Pictures 3.201 - 3.202)*.

Picture 3.203

Picture 3.204

Picture 3.205

Picture 3.206

Picture 3.207

Picture 3.208

- Cut a square piece of TPO Unsupported Flashing to overlap all cut edges of the field membrane. Refer to the section of welding seams for overlap requirements *(Picture 3.203)*.
- Clean the area around the drain properly *(Picture 3.204)*.
- Weld the flashing with a hand welder to the flange and onto the field membrane. Start spot-welding the piece so that it cannot move and continue welding from the inside towards the outside, as illustrated. Make a continuous weld *(Pictures 3.205 - 3.206 - 3.207 - 3.208)*.
- Check all welds mechanically when they are sufficiently cooled down.

Drain insert with UltraPly™ TPO membrane flashing

Picture 3.209

Picture 3.210

Picture 3.211

Picture 3.212

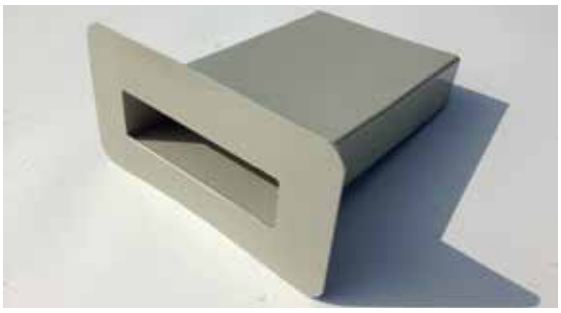
Picture 3.213

This system applies a prefabricated (injection-molded) drain insert made of polyurethane foam with a piece of Firestone Ultra Ply™ TPO membrane laminated to the flange.

- The field membrane must be cut leaving a circular hole over the center of the drain. The hole should be large enough to accommodate the installation of the drain insert. This may require some additional cutting *(Picture 3.210)*.
- In case the drain is not located in a sump, you may fasten the field membrane in the area around the drain to the deck with seam plates and appropriate fasteners *(Picture 3.211)*.
- Mark the edges of the flashing membrane on the field membrane to optimize the position of the seam plates.
- Install the drain insert in the hole and weld the UltraPly™ TPO membrane of the flange onto the field membrane *(Pictures 3.212 - 3.213)*.
- In case the drain is in a sump, it is recommended to proceed in a similar way as in the first system, where the base membrane has to be cut and repaired with a piece of TPO Unsupported Flashing.
- All cut edges with exposed scrim must be sealed with Firestone UltraPly™ TPO Cut Edge Sealant.

3.4.4 Scuppers and overflows

Picture 3.214



Picture 3.215

Scuppers are installed to drain roofs through vertical walls. Overflows serve as a safety measure to avoid accumulation of water in case the normal draining system does not function efficiently.

The position and dimension of overflows are critical for the safety of the roofing system.

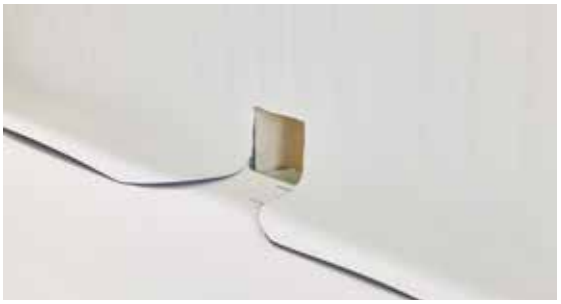
On re-roofing projects, existing scuppers and overflows need to be removed and replaced by new watertight pieces.

To simplify installation, Firestone recommends to use pre-molded insert pieces made of flexible TPO or a termoplastic that is compatible for welding with UltraPly TPO products. In case metal pieces are used that are not welded watertight, the entire interior of the flange also needs to be flashed.

Consult Firestone technical department in case of doubt regarding the compatibility of insert pieces to be used.

Scuppers

Picture 3.216



Picture 3.217

Picture 3.218

Picture 3.219

- The TPO wall flashing membrane must be in place prior to the installation of the scupper insert.
- Cut a hole over the center of the drain. The hole should be as large as the section of the drainpipe. Remove part of the base overlap of the wall flashing in front of the drain opening, as illustrated. This facilitates the installation of the insert piece and the welding of the TPO Unsupported Flashing *(Pictures 3.216 - 3.217)*.
- Position the scupper insert piece in the parapet and weld its flange onto the wall flashing membrane. The insert piece must be mechanically fastened using plates and fasteners in case wall flashing membranes are not adhered. Make sure that fasteners do not protrude. Metal insert pieces always have to be mechanically fastened *(Pictures 3.218 - 3.219)*.

Picture 3.220

Picture 3.221

Picture 3.222

Picture 3.223

Picture 3.224

Picture 3.225

- Cut a piece of TPO Unsupported Flashing to flash in the insert piece. Dimensions of the piece must extend a minimum of 50 mm beyond the external edges of the installed insert piece.
- Round all corners of the TPO flashing prior to the installation and clean the area to be welded with Firestone Cleaner and white cotton rags *(Picture 3.220)*.
- Weld the piece of TPO Unsupported Flashing to the flange of the insert piece and onto the field membrane, as illustrated. Start by spot-welding the flashing piece into the angle change using a metal pressure roller. Once the flashing is fixed it will be easier to work *(Picture 3.221)*.
- Make a continuous weld, always working from the inside towards the outside. As you weld onto the flange of the insert piece you may use a wider roller to apply pressure. Use a metal penny roller on step-ups and areas where there is a possibility for capillaries *(Pictures 3.222 - 3.223 - 3.224 - 3.225)*.

Overflows

Picture 3.226

Picture 3.227

Picture 3.228

Picture 3.229

Picture 3.230

Picture 3.231

- Firestone recommends to use insert pieces made of plastic that are compatible for welding TPO membrane. In case metal pieces are used, the entire interior of the flange also needs to be flashed if the insert piece is not welded watertight.
- The TPO wall flashing membrane must be in place prior to the installation of the overflow insert. Cut a hole over the center of the drain as large as the section of the drainpipe. Trim excess of flashing *(Picture 3.227)*.
- Position the overflow insert piece in the parapet and secure it with at least 4 fasteners. Use the appropriate fasteners and make sure fasteners do not protrude *(Pictures 3.228 - 3.229)*.
- Installation of flashings at overflows occurs in a similar way. Start spot-welding the piece to keep it in its final position *(Picture 3.230)*.

Picture 3.232

Picture 3.233

Picture 3.234

Picture 3.235

Picture 3.236

- Check continuously during welding the quality of bond/weld between flashing and insert piece by pulling the welded piece *(Picture 3.232)*.
- Weld always from the bottom towards the top and use a metal pressure roller at all locations of step-offs to crush the flashing during welding *(Pictures 3.233 - 3.234 - 3.235)*.
- Wait until the detail is complete to cut an opening with a cutter knife *(Picture 3.236)*.

3.4.5 Pipe penetrations






All circular and odd-shaped roof penetrations passing through the membrane should be flashed using one of the following techniques:

- Pre-molded pipe flashing.
- Field-fabricated flashing with reinforced membrane.
- Field-fabricated flashing with TPO Unsupported Flashing.
- Penetration pocket.

For re-roofing applications, all existing flashings should be stripped off (i.e. existing roof membranes, mastic, etc.) prior to the installation of the new detail. The flashing seal must be made directly to the penetration.

Pipe penetrations must be anchored to the deck, as loose pipes move and may damage the flashing.

All TPO components should be protected from direct contact with steam or heat sources when the in-service temperature of the penetration is above 60°C. In such cases, Firestone recommends to create a double pipe and to install flashings directly onto an intermediate insulated cool sleeve.

In some cases, the field membrane must be cut at one side of the penetration to be able to install the membrane around the penetration. This cut must be repaired with a strip of reinforced membrane prior to the installation of the pipe flashing. The covering piece should overlap a minimum of 75 mm beyond the cut of the field membrane in all directions.

Pre-molded pipe flashings

Picture 3.237

Picture 3.238

Picture 3.239

Picture 3.240

Picture 3.241

Picture 3.242

Picture 3.243

Firestone UltraPly™ TPO pre-molded pipe flashings are specifically designed to flash round penetrations that are accessible from the top *(Picture 3.237)*.

This technique is not applicable on structural steel tubing, multiple penetrations close to one another, situations where the pipe is too close to the wall, flexible penetrations such as cables, pipes with uneven surfaces, thin metal stacks or hot pipes.

- Mechanical attachment of the field membrane is required in mechanically fastened and induction-welded systems for pipes with a diameter exceeding 100 mm. Pieces of metal bar can be used to facilitate overlapping with the flange of the pipe flashing *(Picture 3.238)*.
- Each pipe flashing will fit various penetrations and shall be cut at the correct diameter to insure a tight fit. The Firestone Universal Pipe Boot is designed for circular pipes from 25 to 88 mm, while the Firestone Large Pipe Flashing is designed for circular pipes from 106 to 203 mm in diameter.
- Pipe flashings cannot be cut and patched. Flanges may not overlap or be installed over angle changes.
- Select the pipe boot size that corresponds to the outside diameter of the penetration to be flashed. Cut out a circle on the level ring that is smaller than the outside diameter of the pipe *(Picture 3.239)*.
- Warm the top of the pipe flashing slightly up prior to installation. This facilitates stretching of the material *(Pictures 3.240 - 3.241)*.
- Check if the flange of the flashing provides sufficient overlap with the fixings prior to spot-welding it in place *(Pictures 3.242 - 3.243)*.
- Weld the flange onto the field membrane, starting from the inside towards the outside edge *(Pictures 3.244 - 3.245)*
- Install the stainless-steel clamping ring and tighten the locking screw. It is important that the clamping ring seats onto the flattened surface of the boot *(Pictures 3.246 - 3.247)*.
- Apply a bead of Firestone General Purpose Sealant around the entire circumference of the pipe and check the weld after cooling *(Pictures 3.248 - 3.249)*.

Picture 3.244

Picture 3.245

Picture 3.246

Picture 3.247

Picture 3.248

Picture 3.249

Field-fabricated pipe flashing using TPO Unsupported Flashing

Picture 3.250

Picture 3.251

Picture 3.252

Picture 3.253

This technique applies to circular pipes or supports where the top is not accessible and for accessible pipes with a diameter larger than 203 mm. This technique cannot be used for multiple penetrations, flexible conduits, cables, small pipes with a diameter of less than 25 mm, lightning rods and hot pipes.

- The field membrane is usually cut at one side of the pipe to facilitate a smooth positioning of the membrane around the penetration. This cut needs to be repaired with a strip of reinforced UltraPly™ TPO membrane prior to the installation of the pipe flashing *(Picture 3.250)*.
- Cut a circular piece of TPO Unsupported Flashing for installation of the base flashing. The piece must be sufficiently large in diameter to overlap the seam plates a minimum of 50 mm *(Picture 3.251)*.
- Use a hand welder to warm up the flashing around the hole and stretch the material to create a collar of 25 to 30 mm *(Picture 3.252)*.
- Clean the field membrane around the pipe and the base of the pipe with Firestone Cleaner *(Picture 3.253)*.

Picture 3.254

Picture 3.255

Picture 3.256

Picture 3.257

Picture 3.258

Picture 3.259

Picture 3.260

- Cut the flashing piece as illustrated and position it around the pipe to form a collar at the base *(Picture 3.254)*.
- Verify if dimensions of all overlaps meet with minimum requirements and spot-weld the flashing in its final position *(Picture 3.255)*.
- Trim excess of material at the overlap and round corners to avoid capillaries *(Picture 3.256)*.
- Weld the base of the flashing onto the field membrane, working from the inside towards the outside *(Pictures 3.257 - 3.258 - 3.259 - 3.260)*.
- Use a wide pressure roller for the parts that are easy accessible and a small metal pressure roller for the angle changes and areas that are less accessible.

Picture 3.261

Picture 3.262

Picture 3.263

Picture 3.264

Picture 3.265

Picture 3.266

Picture 3.267

Picture 3.268

Picture 3.269

- Cut a second piece of TPO Unsupported Flashing to flash against the pipe penetration. Warm one edge of the flashing and stretch the material to create a small collar of 25 to 30 mm *(Pictures 3.261 - 3.262)*.
- Spot-weld the flashing in its final position and close the overlap, starting from the bottom. Use a metal pressure roller to work the material correctly into the angle change during welding *(Pictures 3.263 - 3.264 - 3.265)*.
- Extend the flange a minimum of 25 mm onto the field membrane, stretch it and weld it continuously *(Pictures 3.266 - 3.267)*.
- Apply Firestone General Purpose Sealant behind the flashing and the pipe at the top and install a stainless steel clamping ring to put the sealant under pressure *(Pictures 3.268 - 3.269)*.

Ventilation pipe using TPO Unsupported Flashing

Picture 3.270

Picture 3.271

Picture 3.272

Picture 3.273

Picture 3.274

Ventilation pipes are usually fixed on top of the UltraPly™ TPO membrane and therefore require no additional fixation of the base membrane around the detail.

Installation of the TPO Unsupported Flashing piece is done in a similar way as the previous detail, detail, but requires some special attention during cutting because of the specific shape of the pipe at the base.

- Cut a circular flashing piece as illustrated and position it around the base of the ventilation pipe to form a collar. Warm the inner edge of the flashing slightly to facilitate its positioning *(Picture 3.273)*.
- Weld the base of the flashing continuously onto the field membrane *(Picture 3.274)*.

Picture 3.275

Picture 3.276

Picture 3.277

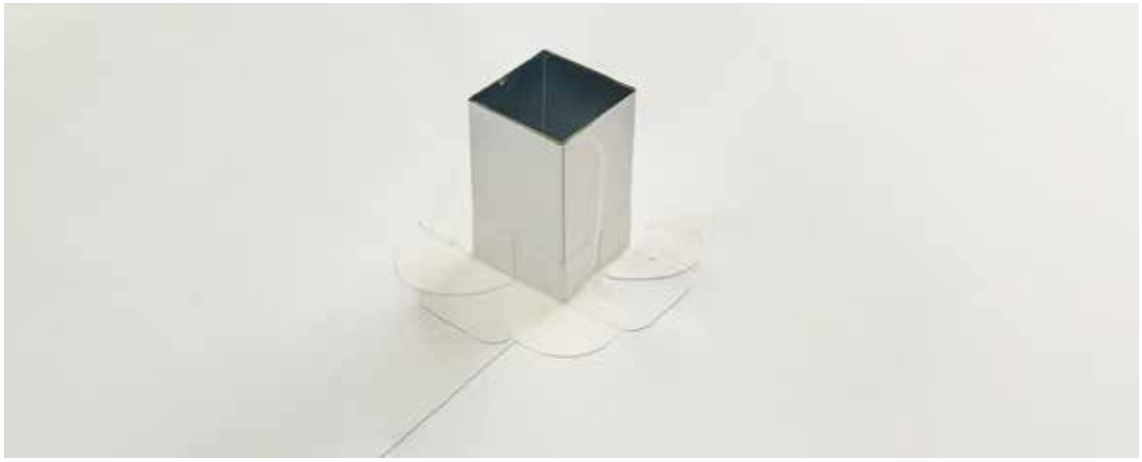
Picture 3.278

Picture 3.279

Picture 3.280

- Cut a second piece of flashing in the shape illustrated and position it around the pipe.
- Spot-weld the flashing piece at the base of the vertical overlap prior to start welding *(Picture 3.276)*.
- Complete welding by closing the vertical seam *(Pictures 3.277 - 3.278)*.
- Check all welds after cooling sufficiently *(Picture 3.280)*.

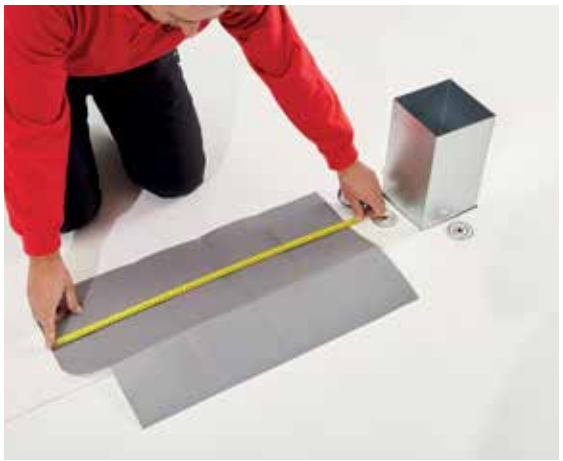
Rectangular pipe using reinforced membrane



Picture 3.281

Picture 3.282

Picture 3.283



Picture 3.284

Picture 3.285

This technique applies to pipes or supports with a rectangular shaped section.

- Repair the cut in the base membrane prior to the installation of the pipe flashing. The covering piece must overlap a minimum of 75 mm beyond the cut field membrane in all directions *(Pictures 3.282 - 3.283)*.
- Use reinforced TPO membrane to flash the rectangular support. Provide sufficient material to wrap around the penetration, including an additional 75 mm for the vertical overlap. The base overlap must extend a minimum of 50 mm beyond the fastening plates *(Pictures 3.284 - 3.285)*.

Picture 3.286

Picture 3.287

Picture 3.288

Picture 3.289

Picture 3.290

Picture 3.291

- Apply Firestone contact adhesive onto the pipe penetration and the back of the flashing. Pay attention not to apply adhesive in areas that need to be welded *(Pictures 3.286 - 3.287)*.
- Install the flashing when the adhesive is contact dry and roll firmly with a pressure roller to mate the membrane flashing. Make sure to have sufficient overlap at the base of the flashing *(Pictures 3.288 - 3.289 - 3.290 - 3.291)*.

Picture 3.292

Picture 3.293

Picture 3.294

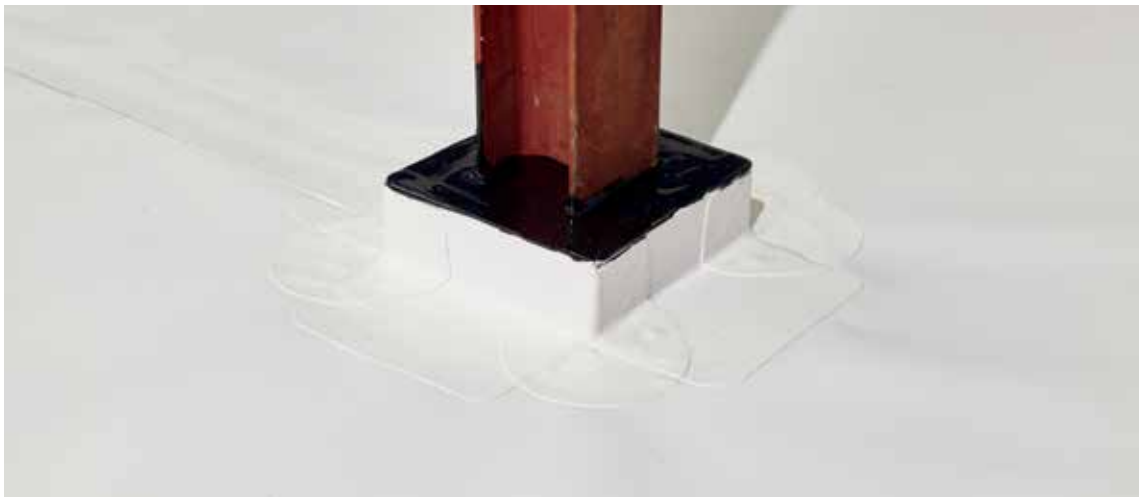
Picture 3.295

Picture 3.296

Picture 3.297

- Start welding the base overlap in the angle change and use a metal pressure roller *(Pictures 3.292 - 3.293)*.
- Complete the vertical weld starting at the bottom and working up *(Picture 3.294)*. Complete the base welds starting from inside towards the edges *(Picture 3.295)*.
- Install the four pre-shaped corner pieces as per the previously described technique *(Picture 3.296)*.
- Check all welds after cooling and apply Firestone UltraPly™ TPO Cut Edge Sealant on all exposed edges of reinforced membrane *(Picture 3.297)*.

Penetration pocket using Firestone TPO Coated Metal



Picture 3.298

Picture 3.299

Picture 3.300

Picture 3.301

Picture 3.302

Picture 3.303

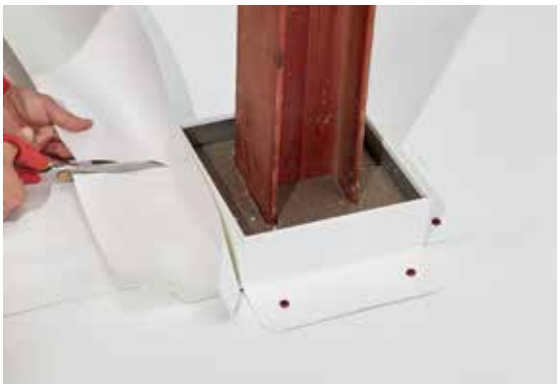
Picture 3.304

Penetration pockets are designed as a last resort for flashing penetrations that cannot be flashed using any of the previously described techniques. This applies to clusters of pipes, odd shaped roof penetrations, beams, small pipes with a diameter of less than 25 mm, pipes that are installed close to upstands, etc.

For larger penetrations, a pocket can be made of Firestone TPO Coated Metal *(Picture 3.298)*.

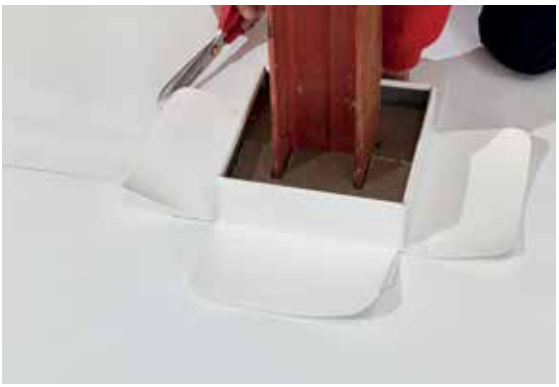
- Cut and bend a L-shape profile of TPO Coated Metal *(Pictures 3.299 - 3.300)*. The minimum height of the penetration pocket is 50 mm, being the minimum acceptable thickness of Pourable Sealer. In practice, profiles are 75 x 75 mm and the inner space of the pocket is partly filled up with insulation material. There must be 25 mm spacing between penetrations and between each penetration and the side of the pocket. Make sure to round all corners of each flange of the penetration pocket *(Picture 3.301)*.
- Secure the penetration pocket to the deck with appropriate fasteners and partially fill the space within the pocket *(Picture 3.302)*.
- Do not forget to seal the opening around the penetration with insulation prior to the installation of the penetration pocket to prevent the Pourable Sealer from flowing into the building. Use a polyurethane foam to seal the opening *(Pictures 3.303 - 3.304)*.
- Use TPO Unsupported Flashing to flash in the penetration pocket. The flashing should extend beyond the edge of the metal profile by at least 50 mm to assure a secure weld with the field membrane. Install the flashing using one piece *(Pictures 3.305 - 3.306 - 3.307)*.
- Round all corners of the base overlaps prior to welding onto the field membrane *(Pictures 3.308 - 3.309 - 3.310)*.

Picture 3.305



Picture 3.306

Picture 3.307



Picture 3.308

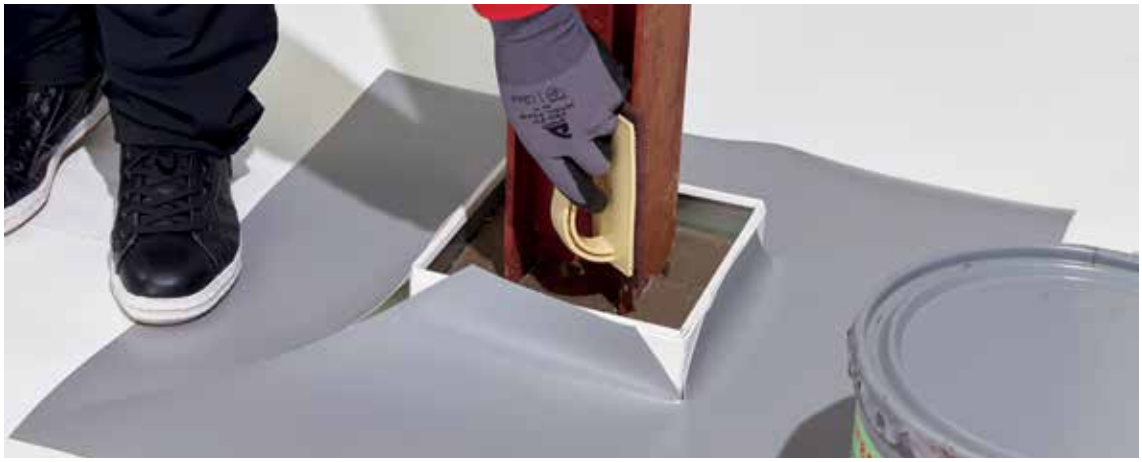
Picture 3.309

Picture 3.310

- Install the pre-molded corners as per previous instructions.
- Check all welds and apply Firestone UltraPly™ TPO Cut Edge Sealant on all cut edges of reinforced membrane prior to applying Firestone Pourable Sealer *(Pictures 3.311 - 3.312)*.
- Use a QuickScrubber™ to apply Firestone Single-Ply QuickPrime™ Primer to all areas of the penetration and all surfaces of the pocket that will have contact with the Pourable Sealer. Make sure that the top edge of the penetration pocket is primed too. Allow the primer to dry *(Picture 3.313)*.
- Refer to the Technical Information Sheet for information regarding storage, mixing, preparation and application of the Pourable Sealer. Pour the Sealer carefully within the penetration pocket so as to shed water away from the penetration.
- Use some scrap membrane and tape to protect the field membrane and flashing from becoming dirty *(Picture 3.314)*.
- Use a stick distribute the Sealer or to force the sealant between all penetrations while pouring it into the pocket. In case of a cluster of penetrations, make sure that the sealant is worked between all pipes *(Picture 3.315)*.
- Let the Pourable Sealer cure for 24 hours.

Picture 3.311

Picture 3.312



Picture 3.313

Picture 3.314

Picture 3.315

Firestone UltraPly TPO Penetration Pocket

Picture 3.316

Picture 3.317

Picture 3.318

Picture 3.319

Picture 3.320

Picture 3.321

For smaller penetrations, it may be easier to install a Firestone TPO Penetration Pocket.

The Firestone TPO Penetration Pocket Kit consists of two components: a PVC ring and a TPO based flange *(Picture 3.316)*.

- The field membrane should first be secured using seam plates. Use a piece of reinforced UltraPly™ TPO membrane to cover the seam plates. This cover piece will serve as base to install the Firestone UltraPly TPO Penetration Pocket *(Picture 3.317)*.
- Install the PVC ring around the detail and make sure that there remains sufficient space (min.50 mm) between the edge of the ring and the roof penetration *(Pictures 3.318 3.319)*.
- Install the TPO flange over the ring and weld it onto the base membrane with a continuous weld *(Picture 3.320)*.
- Use a QuickScrubber™ to apply Single-Ply QuickPrime™ Primer to all areas of the penetration and all surfaces of the pocket that will have contact with the Pourable Sealer within the cavity. Make sure that the top of the Penetration Pocket is primed too. Allow the primer to dry before pouring the sealant *(Picture 3.321)*.

3.4.6 Lightning conductors

Picture 3.322

Picture 3.323

Picture 3.324

Picture 3.325

Picture 3.326

Use small pre-molded flashing boots to flash lightning conductors.

- Clean the membrane around the conductor and the conductor itself with Firestone Cleaner and white cotton rags *(Picture 3.323)*.
- Warm the pre-molded flashing piece slightly prior to sliding it over the lightning conductor *(Picture 3.324)*.
- Slide the pre-molded flashing piece over the lightning conductor till the flange is in contact with the field membrane *(Pictures 3.325 - 3.326)*.

- Spot-weld the flange first in the center and start welding from the center towards the outside of the flange *(Pictures 3.327 - 3.328)*.
- Install a clamping clip at the top of the flashing piece and complete the detail applying a bead of General Purpose Sealant *(Pictures 3.329 - 3.330)*.
- Check the weld of the base flange after cooling *(Picture 3.331)*.

Picture 3.227

Picture 3.328

Picture 3.329

Picture 3.330

Picture 3.331

3.4.7 Wall and roof edge terminations

Picture 3.332

Picture 3.333

Picture 3.334

Picture 3.335

Wall and roof edge termination details should be installed as specified by the designer at all locations where the TPO flashing ends against wall or curb upstands and at flat roof edges.

In this section, some standard termination details are illustrated. These details are generally applicable for all UltraPly™ TPO roofing systems.

Coping stones, metal copings and metal edge profile details are used for upstands that are completely covered with UltraPly™ TPO membrane.

Counter-flashing and termination bar details can be used at upstands that are not flashed over the entire height. In these situations, the required height for TPO flashings should be determined by local regulations. In case of a blocked drainage system, Firestone requires that the flashing height exceeds at least the potential water level.

The roof edge details illustrated in this section apply profiles that are made of TPO Coated Metal. These details can be generally installed at all flat roof edges where the field membrane ends, including at internal and external gutters.

Consult Firestone's technical department for assistance when designing an alternative detail that is more suitable for a specific roof condition.

Coping stone

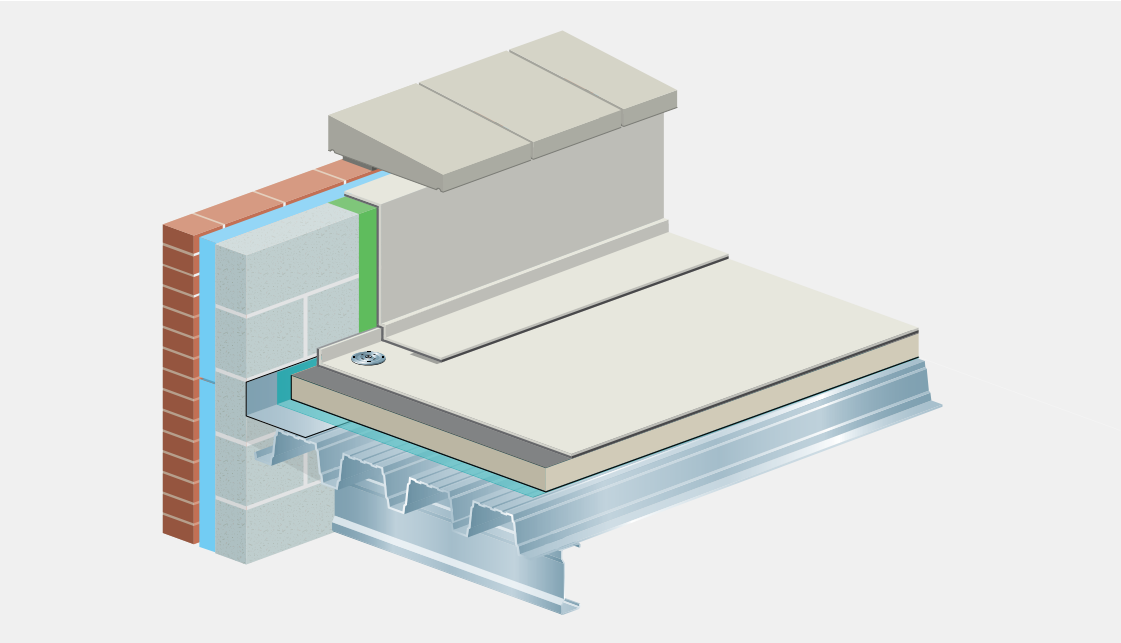


Figure 3.23

- TPO flashings should be fully adhered to the substrate over their entire length and need to stop at a sufficient distance of the wall edge to allow a good fixation (adhesion) of the coping stone to the wall without compromising the water tightness of the detail.
- Make sure that the TPO flashing extends beyond the top of the vertical wall and is secured by the coping stone.

Metal coping

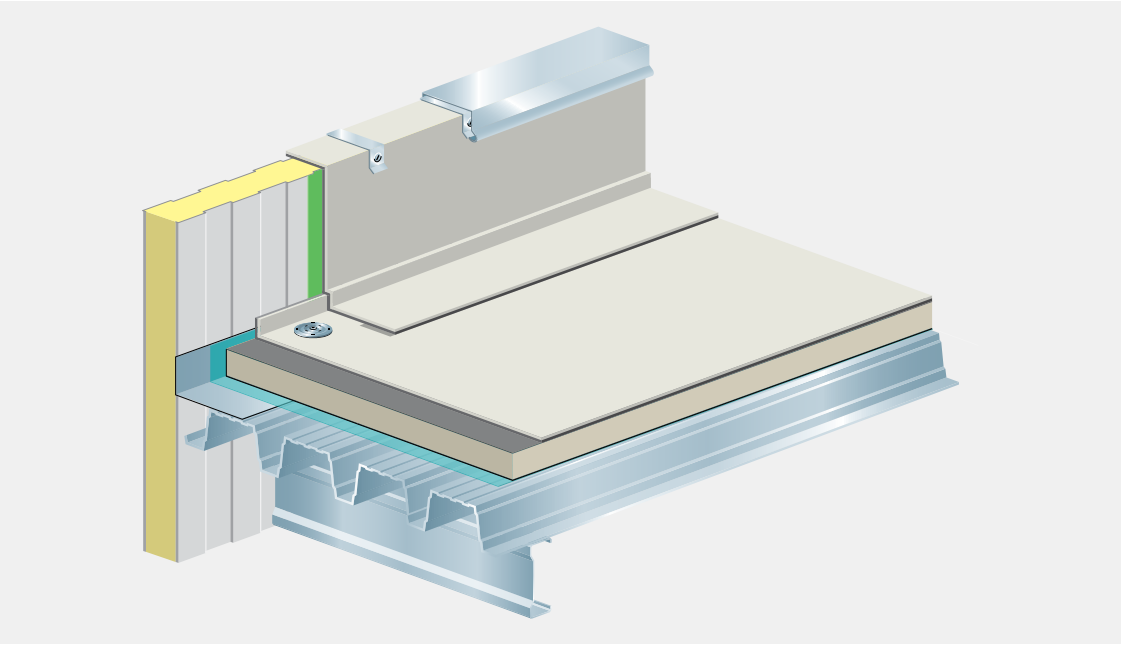


Figure 3.24

- Allow the TPO flashing to extend beyond the wall edge by minimum 50 mm.
- Ensure that the front part of the metal coping extends beyond the edge of the TPO flashing by a minimum of 25 mm.

Counter flashing

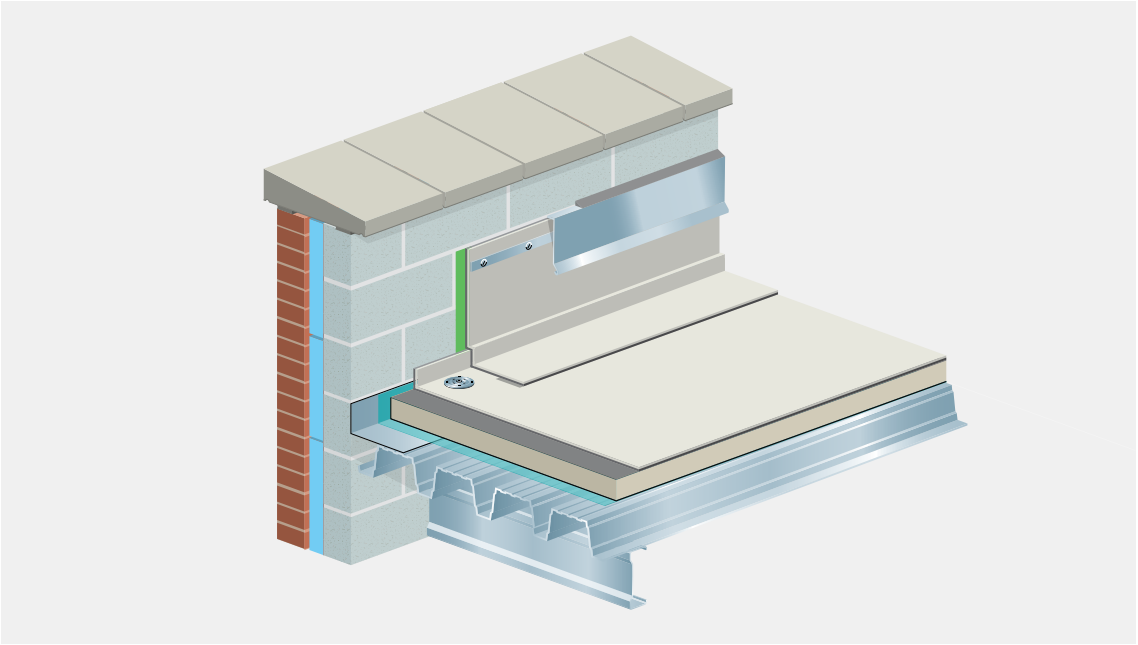


Figure 3.25

- TPO membrane flashings should be mechanically fastened at the top with a Metal Batten Strip.
- Apply a bead of General Purpose Sealant on the top side of the Metal Batten Strip and allow the counter-flashing to cover the Metal Batten Strip by minimum 100 mm.

Termination Bar

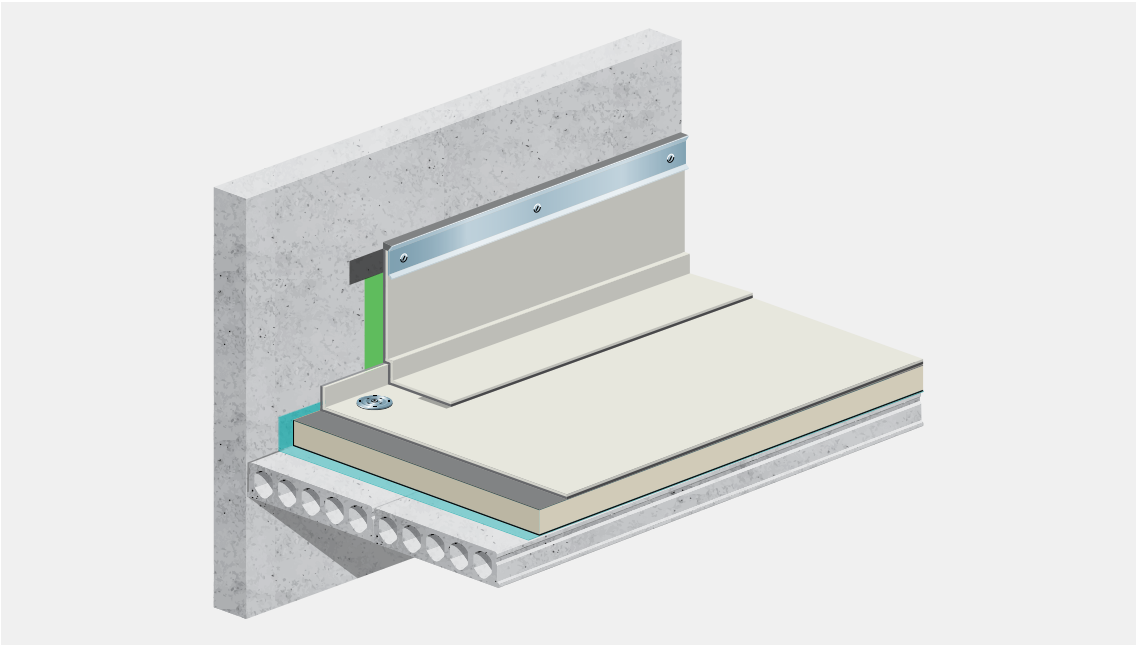


Figure 3.26

- Suitable substrates for installation of the Termination Bar are smooth concrete, smooth bricks, blocks or masonry and smooth SW panels (with minor relief). The Termination Bar may never be mounted to a wooden substrate.
- Termination Bars have to be installed directly to the wall surface, not to existing flashings, sheet metal, etc.

Installation procedure Termination Bar

Picture 3.336

Picture 3.337

Picture 3.338

Picture 3.339

Picture 3.340

Picture 3.341

- Pull back the top side of the membrane flashing 20 mm and apply a bead of Water-Block Seal between the membrane and the wall *(Pictures 3.336 - 3.337)*.
- Use appropriate fasteners to fasten the Termination Bar at maximum 200 mm o.c. A continuous compression of the Termination Bar is required and may need additional fastening. Each Termination Bar must be fastened a maximum of 25 mm from the end *(Picture 3.338)*.
- Keep a minimum of 5 mm between adjoining bars, as illustrated. Termination Bars must be cut at the inside and outside corners and may never be bent around the corners *(Picture 3.339)*.
- Pre-drilling of the substrate may be required. Pre-drill holes into brick work, masonry or concrete, but not into soft mortar joints.
- Finish the detail by applying a bead of General Purpose Sealant on the top of the Termination Bar *(Picture 3.340)*.
- Install the Termination Bar vertically at all locations where base flashings end. Apply a bead of General Purpose Sealant at both sides of the Termination Bar *(Picture 3.341)*.

Roof edge profile of TPO Coated Metal

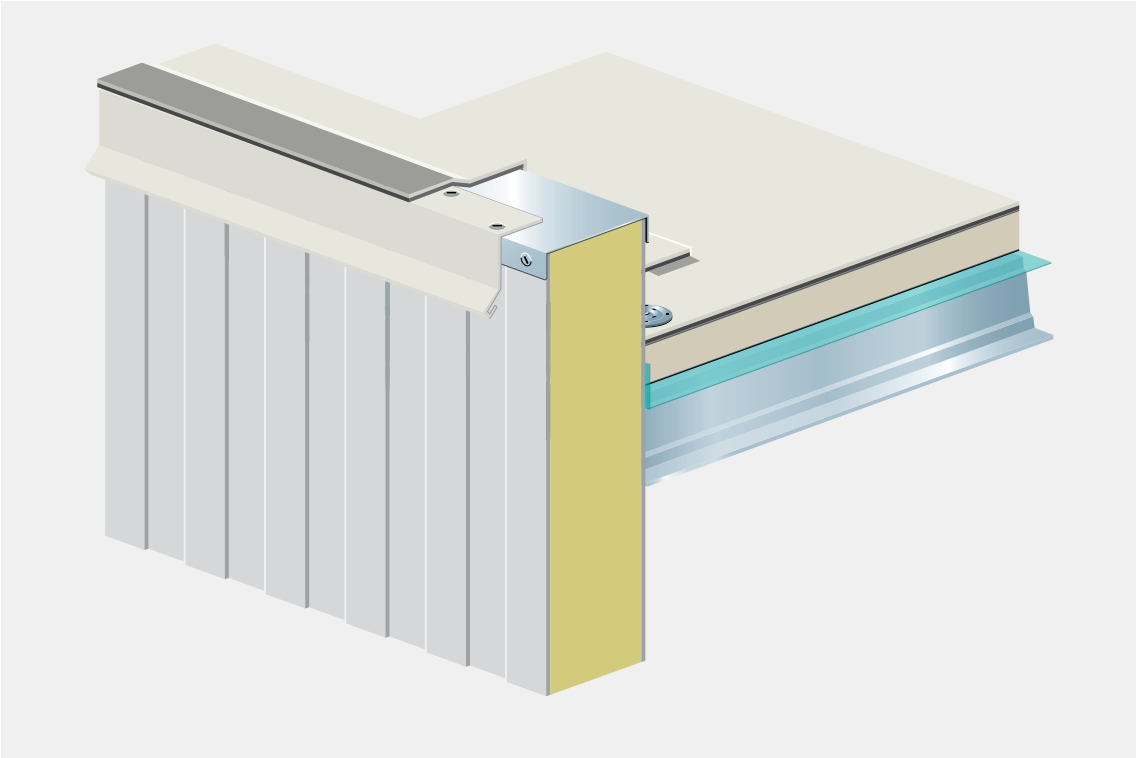


Figure 3.27

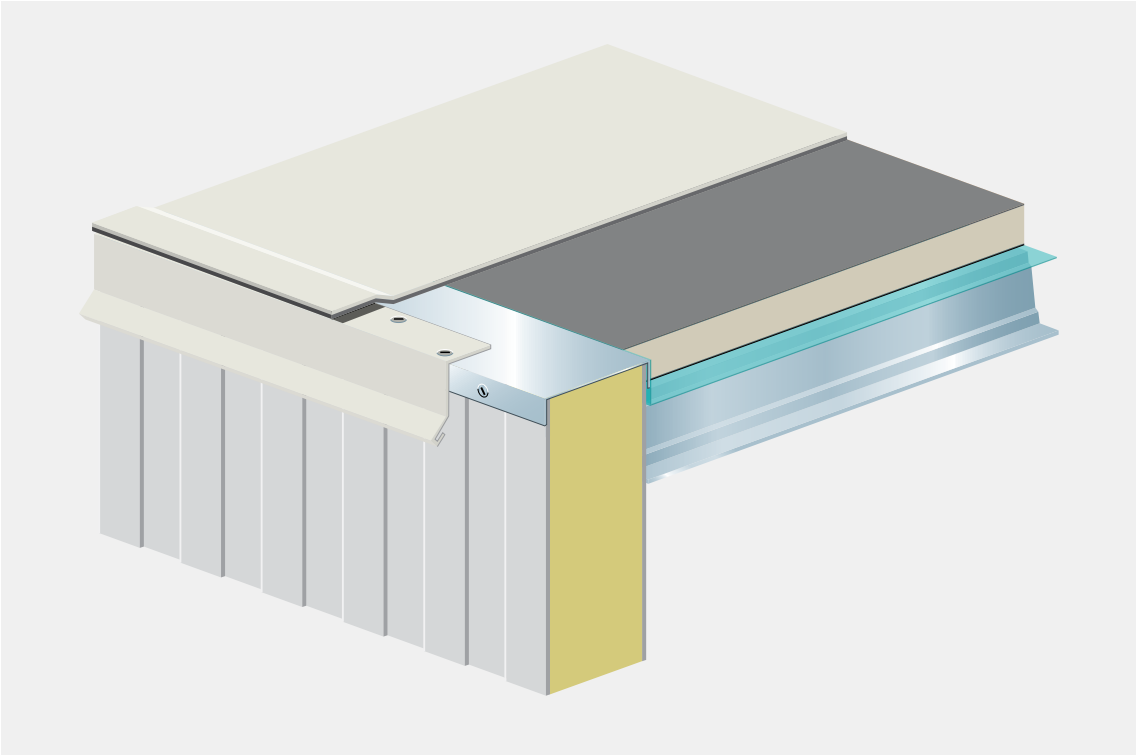


Figure 3.28

Roof edge details using profiles made of TPO Coated Metal offer the advantage that the TPO membrane can be directly welded onto the profile, assuring a secure termination.

Installation procedure - TPO Coated Metal profiles

Picture 3.342

Picture 3.343

Picture 3.344

Picture 3.345

- Verify the dimensions of the TPO Coated Metal profile. Make sure that the horizontal part of the profile provides sufficient width to assure a secure installation of the fasteners and a secure overlap for welding of the flashing membrane (extending minimum 50 mm beyond the external row of fasteners).
- Fastening pattern of the fasteners should be in zigzag. Fasten alternatively as close as possible to the edge of the flange and in the center of the flange *(Picture 3.342)*.
- Install the TPO Coated Metal profile and make sure that the front of the profile extends a minimum of 5 mm over the roof edge.
- Adjoining profiles should butt join, leaving a space of minimum 5 to 10 mm *(Picture 3.343)*.
- Weld a piece of TPO Unsupported Flashing over all joints with a minimum weld of 50 mm at both sides of the joint *(Picture 3.344)*.
- Fasten the metal edge profile at 100 mm o.c. with appropriate fasteners. Fasten the flange as close as possible to its edge to ensure sufficient overlap of the flashing material beyond the last row of fasteners.
- Clean the overlapping part of the membrane and the metal edge profile with Splice Wash or Cleaner using white clean cotton rags, as previously described.
- Use a hand welder to weld the TPO flashing membrane onto the TPO Coated Metal, assuring a homogeneous 50 mm wide weld *(Picture 3.345)*.
- Special considerations should be made at corners, at locations where adjoining pieces of metal profile butt join, at field splices and at the end of a roll of flashing.

Metal profiles made of TPO Coated Metal can also be used in termination details against upstands.

3.5 Measures to extend service life of the roofing system

3.5.1 Repairs

Picture 3.346

Picture 3.347

Picture 3.348

Picture 3.349

Picture 3.350

- In general, be careful when welding repairs. Welding on material that has previously been exposed to heat can eventually result in more damage by overheating. Turn the heat down to avoid burning and scorching.
- Always clean before repairing. Thoroughly follow the instructions for cleaning that are outlined in the welding section.
- In case welding onto the top surface of the existing membrane is not successful, there is always the possibility to weld a patch to the underside of the existing membrane after proper cleaning.

Voids in seams *(Picture 3.346)*

- Use a smaller nozzle when repairing voids in seams.
- Voids detected after probing have to be cleaned and re-welded. Use the probing tool to hold the fold open, insert the heat gun nozzle or position the welder facing into the void so as to force hot air between the overlapping membranes. Roll the top membrane with the rubber roller using pressure towards the outer edge until both heated membranes are fused.

Seams of poor or questionable quality

Membranes with exposed scrim-reinforcement (due to scorching of the membrane) and damaged membranes must be repaired with a separate piece of reinforced membrane *(Picture 3.347)*. When the entire seam has to be corrected, it is better to use a long strip and weld it over the area to be repaired with an automatic welder *(Picture 3.348)*.

- Strips must be a minimum of 150 mm wide and should extend a minimum of 75 mm beyond the area to be repaired. Round all corners of the new piece prior to welding.
- Use a pre-weld to hold the strip in place while welding. A 38 mm wide weld is required on all sides of the repair.
- Pay particular attention when welding in areas with a step-down to roll the membrane extra into these areas with a metal pressure roller during welding.
- Probe all edges of the repair once the material has cooled sufficiently to verify if a proper weld is made and seal all cut edges with Cut Edge Sealant.

Additional fixations *(Picture 3.349)*

In some cases, the installation of additional fasteners will be required to assure the wind uplift performance of the roofing system.

The most efficient way is to install an additional row of fasteners and plates on the top of the membrane and to cover these fasteners with a cover strip. This can be a hand welded strip of reinforced membrane or a Firestone TPO QuickSeam Flashing Cover Strip.

Contamination *(Picture 3.350)*

All membranes and components of the Firestone UltraPly TPO roofing system that have been contaminated with bonding adhesive, grease, oil (mineral or vegetable), organic based solvent, animal fat or fresh bitumen (less than 60 days old) that cannot be cleaned sufficiently to assure an adequate weld should be replaced.

- Remove excess of contaminant immediately and clean the membrane as previously described.
- TPO membranes or accessories that have been in contact with the above mentioned contaminants during a prolonged period should be replaced by new products.

Cuts and punctures

Picture 3.351

Picture 3.352

Picture 3.353

Picture 3.354

Picture 3.355

- Remove all water that has entered through the damaged membrane prior to any repair.
- Thoroughly clean the membrane to be repaired as per previous specifications and let all solvents evaporate completely prior to welding *(Picture 3.351)*.
- Punctures and cuts can be repaired using reinforced membrane or Unsupported Flashing. Repairs with non-Firestone products are not allowed.
- Large damage (cuts bigger than 50 mm) should be repaired with reinforced membrane.
- Unsupported membrane is to be used when repairing Unsupported Flashing and any details areas with angle changes such as pipe wraps, wall seams, corner patches and penetration pockets.
- Patches of reinforced membrane must be at least 150 mm x 150 mm and should extend a minimum of 75 mm on all sides of the repair area *(Picture 3.352)*.
- Patches of Unsupported Flashing must be at least 100 mm x 100 mm and should extend a minimum of 50 mm on all sides of the repair area.
- Round all corners and check all overlaps before welding.
- All patches must be welded with a continuous weld. First fix the patch with a spot weld. Start welding from the center towards the outside edges of the patch (*Pictures 3.353 - 3.354)*.
- Check all welds with a probing tool after cooling. Make repairs if needed and apply a bead of Cut Edge Sealant on all cut edges in case of using reinforced membrane (*Picture 3.355)*.

3.5.2 Walkways and protection

Picture 3.356

Picture 3.357

Picture 3.358

Firestone Walkway Pads have to be installed to protect the exposed roofing membrane at all locations with a concentration of traffic, such as access doors, stairs, ladders, roof hatches, roof equipment, etc. and in areas of intense and repeated roof traffic (i.e. maintenance once a month).

- Before the installation of Walkway Pads, the UltraPly™ TPO membrane has to be clean, dry and free of dust and debris.
- Allow the membrane to relax prior to welding the pad. For best results, installation of Walkway Pads should occur during the warmest part of the day. Installing walkways in colder temperatures can cause the sheet to expand later and create buckling.
- Prior to installation, mark with a marker the area where the Walkway Pads are to be installed. Clean the area where the Walkway Pads will be welded with Firestone Cleaner and white cotton rags.
- Cut the Walkway Pad into a manageable length (maximum 3 m) and place it over the UltraPly™ TPO membrane within the marked area.
- Adjoining Walkway Pads must be spaced a minimum of 25 mm and a maximum of 150 mm to allow for drainage.
- UltraPly™ TPO Walkway Pads are welded continuously around their perimeter onto the field membrane with a automatic welder. Use the same techniques as described in the welding section. Different welding settings may be required because of the thickness of the Walkway Pad. Use a hand welder for corners *(Picture 3.357)*.
- Make sure that the Walkway Pads are interrupted at field seams to avoid damage to the membrane because of welding on material that has been previously exposed to heat.
- At the perimeter, sections of shorter length (600 mm) should be used.

3.5.3 Temporary closure

Picture 3.359

Picture 3.360

- Temporary closures serve to prevent moisture from damaging the section of the new installation that is not 100% completed and are the responsibility of the roofing contractor.
- The roofing installation should be made watertight or protected at the end of each working day.
- Install all components of the roofing system (vapor control layer, insulation, cover board, membrane) in sections and complete all flashings and terminations as the roofing installation progresses.
- On steel decks, use UltraPly™ TPO membranes and scrap material to make safe temporary seals at the edges of the completed section. Extend the roofing membrane a minimum of 200 mm beyond the edge and fix the sealing membrane to the surrounding deck either with temporary ballast or with seam plates and fasteners.
- To avoid infiltration, also verify that parapets and roof penetrations are covered prior to leaving the site.
- On concrete decks, you may fold the membrane back a minimum of 200 mm and use a chalk line to mark a straight line on the substrate. Apply a bead of Water-Block Seal over the chalk line at a rate of 3 lin.m /tube and let the membrane fall freely into the Water-Block Seal before installing some temporary ballast to put the seam under continuous compression.
- The next working day, use a chalk line to trim a portion of 200 mm at the end of the membrane.

3.5.4 Inspection and control

Picture 3.361

- Inspect completed sections daily. It is the responsibility of the roofing contractor to probe all welded seams. He should also perform an adequate number of seam cuts to verify the consistency of the seams and organize a track record of tests ans welding conditions during installation.
- All defects and irregularities that are identified during inspections need to be repaired immediately, as per previous instructions.
- All repair work needs to be done with appropriate Firestone materials in a consistent way to minimize the number of patches. Excessive patchwork may require replacement of the entire affected section of the field membrane from one lap to the next.
- In accordance with good roofing practice, the roofing contractor should establish an inspection once a year to monitor the performance of his installation.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