



CARLISLE'S TUNNEL WATERPROOFING SYSTEM

Sure-Weld®/Sure-Flex™ “Blindside” Method

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August 2013

This specification outlines requirements for Carlisle's Tunnel Waterproofing System and is intended for use by engineers and waterproofing contractors involved with design or installation of underground tunnels. While the specification contains specific installation details pertaining to various methods of membrane termination, contractors may reference other Carlisle technical publications for in-depth application procedures.

PART I GENERAL

1.01 DESCRIPTION

This Tunnel Waterproofing System consists of a minimum of 1.5 mm (60-mil) thick, 2.4 m (8 feet) or 3 m (10 feet) wide, scrim-reinforced, Sure-Weld® Thermoplastic Polyolefin (TPO) membrane or 2 mm (80-mil) thick, 3 m (10 feet) wide, scrim-reinforced, Sure-Flex™ installed in conjunction with CCW MiraDRAIN 6000. The MiraDrain underlayment is anchored to structural concrete shell of the tunnel and the membrane is fastened through tabs hot air welded to the backside of the membrane approximately 1.2 m (4 feet) on center. Both underlayment and the membrane are fastened with pneumatic fasteners and 5 cm (2 inch) diameter heavy galvanized or stainless steel plates. Consecutive sheets of Sure-Weld or Sure-Flex membrane are overlapped a minimum of 10 cm (4 inches) and hot air welded using an Automatic Wedge Welding Machine resulting in a double weld 30 mm (1-1/4 inch) wide each.

1.02 QUALITY ASSURANCE

- A. The Sure-Weld and Sure-Flex membrane meets ASTM E-108 as a Class A, B or C external fire rating, Underwriters Laboratories (UL) 790 and UL 263 (ASTM E 119) “Fire Test of Building Construction and Materials” with an exposure rating of 704° C (1300° F) internal temperature and external temperature of 176° C (350° F).
- B. This system must be installed by an Authorized Contractor in compliance with project specification and drawings. Any deviations made from this published specification must be approved by Carlisle.
- C. Prior to installation, project shop drawings may be submitted to the manufacturer for review.
- D. Comply with applicable regulatory requirements, applicable codes, ordinances and laws.
- E. On-site technical assistance is available for a charge. Projects where technical assistance is required must have a manufacturer's approved drawing.

1.03 SUBMITTALS

- A. To ensure compliance with the applicable design criteria, project drawings, specification and pertinent details may be submitted for Carlisle's review.
- B. Requests for certification and/or formal drawing approval must be accompanied by a copy of the project specification and details.
- C. Substitution of a non-Carlisle supplied product is permitted upon review and approval. Samples of the product along with technical literature may be forwarded to Carlisle for consideration.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver materials to the job site in the original, unopened containers labeled with the manufacturer's name, brand name and installation instructions.
- B. Job site storage temperatures in excess of 32°C (90°F) may affect shelf life of curable materials (i.e., adhesive, sealants and cleaners).
- C. When sealants or cleaners are exposed to lower temperatures, restore to a minimum of 16°C (60°F) before use.

1.05 JOB CONDITIONS

- A. Comply with applicable codes and regulations pertaining to the operation and storage of heavy equipment.
- B. Coordination between various trades is essential to prevent damage to the waterproofing membrane.
- C. Do not allow waste products (i.e., petroleum, grease, oil, solvents) or direct steam venting to come in contact with the waterproofing membrane.
- D. Do not expose membrane and accessories to constant temperatures in excess of 82°C (180°F).
- E. Prior to the use of any product, consult the Material Safety Data Sheet and Technical Data Bulletin for cautions and warnings. Store adhesives, sealants and cleaners away from all sources of heat, flame or sparks.
- F. Cold temperatures will not restrict the installation of this system. Follow specified precautions for storage of materials.
- G. Coordinate waterproofing work with other trades. The contractor shall have sole right of access to the specified areas for the time needed to complete the application.
- H. Maintain work area in a neat and orderly condition, removing empty containers, rags and debris daily from the site.

1.06 WARRANTY

A 20 year Membrane Material Warranty is available for a charge. The Material Warranty will cover normal deterioration and is pro-rated.

PART II PRODUCTS AND RELATED EQUIPMENT

2.01 GENERAL

The components of this tunnel waterproofing system are to be products of Carlisle or accepted by Carlisle as compatible. The installation, performance or integrity of products by others, **when selected by the specifier and accepted by Carlisle, is expressly disclaimed** by Carlisle.

2.02 MEMBRANE

A. Sure-Weld, reinforced, 1.5 mm (60-mil) or 2 mm (80-mil) thick Thermoplastic Polyolefin (TPO) membrane is used for this system. Membrane is available in widths of 2.4 m (8') or 3 m (10') and 30 m (100') in length. Available in white, gray or tan. Refer to membrane physical properties, below.

PHYSICAL PROPERTY	ASTM D6878 Requirement	1.5 mm (60-mil)	2.0 mm (80-mil)
Tolerance on nominal thickness, % ASTM D751 test method	+15, -10	± 10	± 10
Thickness over scrim, mm (in.) ASTM D6878 optical method, average of 3 areas	0.305 (0.012) min.	0.610 (0.024) typical	0.864 (0.34) typical
Breaking strength, kN (lbf) ASTM D751 grab method	976 N (220) min.	1.1 (250) min. 1.6 (360) typ.	1.6 (350) min. 1.9 (425) typ.
Elongation break of reinforcement, % ASTM D751 grab method	15 min.	15 min. 25 typ.	15 min. 25 typ.
Tearing strength, N (lbf) ASTM D751 proc. B 8 by 8 in.	245 (55) min.	245 (55) min. 578 (130) typ.	245 (55) min. 578 (130) typ.
Brittleness point, °C (°F) ASTM D2137	-40 (-40) max.	-40 (-40) max. -46 (-50) typ.	-40 (-40) max. -50 (-46) typ.
Linear dimensional change, % ASTM D1204, 6 hours at 158 °F	± 1 max.	± 1 max. -0.2 typ.	± 1 max. -0.2 typ.
Ozone resistance, no cracks 7X ASTM D1149, 100 pphm, 168 hrs	Pass	Pass	Pass
Water absorption resistance, mass % ASTM D471-12a top surface only 166 hours at 158 °F water	± 3.0 max.	3.0 max. 2.0 typ.	3.0 max. 2.0 typ.
Factory seam strength, kN/m (lbf /in.) ASTM D751 grab method	290 (66) min.	290 (66) min.	290 (66) min.
Field seam strength, kN/m (lbf /in.) ASTM D1876-08 tested in peel	No requirement	4.4 (25) min. 10.5 (60) typ.	7.0 (40) min. 12.3 (70) typ.
Water vapor permeance, Perms ASTM E96 proc. B	No requirement	0.10 max. 0.05 typ.	0.10 max. 0.05 typ.
Puncture resistance, kN (lbf) FTM 101C, method 2031 (see supplemental section)	No requirement	1.3 (300) min. 1.6 (350) typ.	1.8 (400) min. 2.0 (450) typ.
Properties after heat aging ASTM D573, 670 hrs at 115°C (240 °F)			
Breaking strength, % retained	90 min.	90 min.	90 min.
Elongation reinf., % retained	90 min.	90 min.	90 min.
Tearing strength, % retained	60 min.	60 min.	60 min.
Weight change, %	± 1.0 max.	± 1.0 max.	± 1.0 max.

B. Sure-Flex 2 mm (80-mil) thick Polyester Reinforced PVC (Polyvinyl Chloride) Membrane is used for this system.

Membrane is available in widths of 2.05 m (81") or 3.04 m (10') and lengths of 30 m (100'). Available in white, gray or tan. Refer to membrane physical properties, below.

Sure-Flex Polyester Reinforced PVC Membrane			
Physical Property	Test Method	Property of Unaged Sheet	Property After ASTM D3045 aging 56 days @ 176° F
Tolerance on Nominal Thickness, %	ASTM D 751	± 10	
Thickness over scrim, in. (mm) 80-mil	ASTM D 4434 Optical Method (avg. of 3 areas)	0.025 (0.635) min.	
Breaking Strength, lbf/in. (kN/m)	ASTM D 751 (Grab Method)	200 (35) min. 300 (53) typical	90% min. retention of original breaking strength
Elongation at Break of fabric, %	ASTM D 751	15 min. 25 typical	90% min. retention of original elongation
Tearing Strength, lbf (N) 8 x 8 in. specimen	ASTM D 751 (B-Tongue Tear)	45 (200) min. 100 (445) typical	
Low Temperature Bend, ° F (° C)	ASTM D 2136	-40 (-40) max. -50 (-46) typical	
Linear Dimensional Change (shrinkage), % After 6 hours at 176° F (80° C)	ASTM D 1204	+/- 0.5 max. -0.3 typical	
Ozone resistance, 100 pphm, 168 hours	ASTM D1149	No cracks	
Resistance to water absorption After 7 days immersion 158° F (70° C) Change in mass, %	ASTM D 570	3.0 max. 2.0 typical	
Field seam strength lbf/in. (kN/m) Seam tested in peel after welding	ASTM D1876	25 (4.4) min. 60 (10.5) typical	
Water vapor permeance, Perms	ASTM E 96	0.10 max. 0.05 typical	
Puncture resistance, lbf (N) (see supplemental section for additional puncture data)	FTM 101C Method 2031	250 (1110) min. 380 (1690) typical 80-mil	
Resistance to xenon-arc weathering Xenon-Arc, 12,600 kJ/m ² total radiant exposure, visual condition at 10X (ASTM D 4434 light & spray cycle)	ASTM G155 0.35 W/m ² 63 ° C B.P.T. (10,000 hours)	No cracks No crazing	
B.P.T. is black panel temperature			

2.03 OTHER MATERIALS

- A. **CCW MiraDRAIN 6000 Drainage Composite:** A high strength drainage composite consisting of a three-dimensional, high-impact polystyrene core and a non-woven filter fabric on one side and a solid polymeric film on the other. Available in rolls of 1.2 m (4 feet) by 15 m (50 feet).
- B. **Sure-Weld Flashing:** Sure-Weld non-reinforced flashing is available in rolls 30 cm (12") and 60 cm (24") wide by 15 m (50') long. Flashing is used for splice intersections and electrical conduit penetrations.
- C. **Sure-Flex PVC non-reinforced Flashing:** 80-mil thick (white on gray) and available in rolls 30 cm (12") and 60 cm (24") wide by 15 m (50') long. Flashing is used for field fabricated flashings.
- D. **Water Cut-Off Mastic:** Used as a mastic to prevent moisture migration at membrane and flashing terminations with a coverage rate of approximately 3 m (10 feet) per tube or 30 m (100 feet) per 3.78 liters (1gallon).
- E. **Universal Single-Ply Sealant:** A 100% solids, solvent free, VOC free, one part polyether sealant that provides a weather tight seal to a variety of building materials. It is white in color and is used for general caulking such as above termination bars and metal counter flashings.
- F. **Weathered Membrane Cleaner:** Used to prepare TPO membrane that has been exposed to the elements for approximately 7 days prior to hot air welding at an approximate coverage rate of 300 m (1000 linear feet) per 3.78 liters (1 gallon) on a 10 cm (4 inch) wide surface.

- G. **PVC Membrane Cleaner:** Used to prepare membrane that has been exposed to the elements prior to heat welding or to remove general construction dirt at an approximate coverage rate of 37 square meters (400 square feet) per 3.78 liters (1 gallon) (one surface).
- H. **Cut-Edge Sealant:** A clear colored sealant used to seal cut edges of reinforced Sure-Weld membrane. A coverage rate of approximately 68 – 83 m (225 - 275 linear feet) per squeeze bottle can be achieved when a 3 mm (1/8") diameter bead is applied.
- I. **Water Swelling Waterbar (by others):** Used to provide efficient waterproofing of construction joints. When in contact with water, the waterbar will slowly increase in volume (20% to 200% depending on water salt concentration). The swelling action (limited to the side exposed to water) will cause the waterbar to profile itself into the joint filling all cavities and effectively stop water seepage. For added safety, wider joints can be filled using 2 waterbars. The Water Swelling Waterbar is used at the base of electrical conduits engaging through the shotcrete substructure and at any other joints or gaps.
- J. **Aerosmith® 144 Series Fasteners and Plates:** A fastener used for the securement of the Drainage Board and the Sure-Weld Waterproofing Membrane available in lengths up to 65 mm (2-1/2 inches) with 4 mm (.14 inch) shank diameter and head size of 8 mm (5/16 inch). Fasteners and Plates are available in steel or stainless steel. Listed below is a fastener performance chart based on 19 mm or 25 mm fastener penetrations into concrete from 141 kg/cm² to 211 kg/cm². The fasteners are installed in conjunction with heavy galvanized or stainless steel plates that are 5 cm (2 inches) in diameter.

Fastener Requirements			Installed in Stone Aggregate Concrete						Installed in Lightweight Aggregate Concrete	
			141 kg/cm ² (2000 psi)		211 kg/cm ² (3000 psi)		280 kg/cm ² (4000 psi)		211 kg/cm ² (3000 psi)	
Series	Shank Dia.	Min. Penetration	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear
144 Fasteners	4 mm (0.140 Inch)	19 mm (3/4 Inch)	20 kg (45 pounds)	36 kg (80 pounds)	32 kg (70 pounds)	52 kg (115 pounds)	41 kg (90 pounds)	66 kg (145 pounds)	36 kg (80 pounds)	39 kg (85 pounds)
		25 mm (1 Inch)	50 kg (110 pounds)	75 kg (165 pounds)	79 kg (175 pounds)	84 kg (185 pounds)	107 kg (235 pounds)	93 kg (205 pounds)	65 kg (143 pounds)	69 kg (152 pounds)

- K. **Inside/Outside Corners:** A pre-molded corner flashing used for outside corners of air shafts.
- L. **Termination Bar:** A 2.5 cm (1") wide and 2.5 mm (98-mil) thick extruded aluminum bar pre-punched 15 cm (6") on center which incorporates a sealant ledge and provides increased stability for membrane terminations.

2.04 RELATED EQUIPMENT

A. Generator/Electrical Requirements

Power supplies do not typically provide the proper amount of power necessary for consistent hot air welding. The use of a portable generator conforming to the following guidelines is strongly advised.

1. A **minimum 6500 watt generator** with a minimum output of 210 volts is required **for one Automatic Hot Air Welding Machine**. Reduced power availability will result if additional equipment is connected to the generator and may result in faulty hot air welded seams. GFI (Ground Fault Interrupter) protection is recommended. Additional generators will be required for operating other power tools and hand held hot air welders.
2. **Electrical cords** (3 conductor) of the maximum length indicated must be used with the corresponding wire as listed below:

Maximum Length	Wire Size
15 m (50 foot)	#12
30 m (100 foot)	#10
90 m (300 foot)	#8

3. **A minimum 3,000 watt generator** may be used to power a maximum of **two hand held welders** as long as no other equipment is connected. This generator should service a minimum of 110 volts and be GFI (Ground Fault Interrupter) protected.

Electrical cords (3 conductors) of the maximum length indicated must be used with the corresponding wire as listed below:

Maximum Length	Wire Size
15 m (50 foot)	#14
30 m (100 foot)	#12

For extension cords longer than 30 m (100 feet), consult an electrician or electrical contractor to ensure proper size of generator and wire.

- B. **Automatic Wedge Welding Machine:** A lightweight, approximately 7 kg (15.75 pounds) welding machine with a maximum temperature output of 420° C (788° F) capable of delivering a double hot air weld 30 mm (1-1/4 inch) wide each. The Automatic Wedge Welding Machine is manufactured by Leister and could be furnished by Carlisle. A welding seam test kit should be made available on site to ensure the integrity of the double welded seam. Consult a Leister Manufacturer Representative for appropriate test kit and recommended air pressure.
- C. **Hot Air Hand Welder:** An electrically powered, hand-held device that utilizes an electrical resistance heating element or heater and fan-forced super heated air to hot air weld Sure-Weld membrane and flashing. A hand-held **silicone** rubber roller is used in conjunction with the welder to apply the pressure that fuses the heated membrane surfaces to each other. The hand-held welder is typically used for seam overlays at “T” joints and flashing of electrical conduits and around tunnel airshafts.
- D. **Seam Prober:** Probing of hot air welded seams overlays is essential to ensure the continuous watertight seal at “T” joints and intersections between hot air welded seams and other penetrations (i.e., electrical conduit, air shafts, etc.). The use of a cotter pin puller is the recommended tool.
- E. **Silicone Rubber Roller:** A 40 mm (1-1/2 inch) wide rubber roller used for rolling hot air welded overlays at “T” joints, patches and flashing at airshafts and electrical conduits.
- F. **Aerosmith Fastening System:** A pneumatic fastening tool able to deliver 40 fasteners per minute into concrete surfaces with compressive strength up to 352 k/cm² (5000 psi) with a minimum fastener penetration of 19 mm (3/4 inch)

PART III EXECUTION

3.01 GENERAL

Prior to commencement of the work, manufacturer’s Material Safety Data Sheets, Technical Data Bulletins and product labels should be referenced for cautions and warnings and specific installation requirements.

Comply with shotcrete manufacturer’s published specification to ensure proper curing of the substructure prior to the installation of the CCW MiraDRAIN 6000 and the Sure-Weld or Sure-Flex Membrane.

3.02 INSTALLATION

A. CCW MiraDRAIN 6000 Drainage Composite Installation

1. Unroll and place CCW MiraDRAIN 6000 with the geotextile filter fabric side against the tunnel substructure. The drainage composite can be installed horizontally or vertically.
2. At end rolls, peel back filter fabric and overlap two rows of dimples approximately 40 mm (1-1/2 inches) and press to interlock the panels.

3. Along the length of the drainage composite, position drainage panels so the side of the panel with a flange overlaps the side of the panel without a flange.
4. Fasten drainage composite with pneumatic fasteners and fastening plates 1.2 m (4 feet) on center in all directions.

B. Wedge Welding Set Up

Due to a variety of heat welding equipment available, manufacturer's operating instructions and safety procedures should be referenced. Listed below are additional recommendations intended to extend the life expectancy of welders and ensure safe operation.

1. Before the machine is connected to the power source, make sure it is switched off to prevent a power surge that could damage the unit. Turn the unit on and allow the blower/heater unit to warm up for approximately 5 to 10 minutes to reach operating temperature.
2. Clean the heat nozzle with a wire brush to remove any build-up of membrane residue, as needed.
3. To extend the life of the heating element of the Hot Air Welding Equipment, always turn the temperature adjustment down, so the welder can cool prior to switching the machine off.
4. Follow all care and maintenance instructions recommended by the respective manufacturer.
5. It is recommended that two Automatic Hot Air Welding Machines and two generators be available at the project site in the event of mechanical failure.

C. Membrane Preparation / Tab Welding

1. Unroll Membrane and cut to proper length if necessary.
2. With the black/gray side of the membrane up, chalk lines so tabs, 15 cm (6 inches) wide and 23 cm (9 inches) long, can be positioned and welded at 1.2 m (4 feet) on center in all directions across the field of the sheet and 60 cm (24 inches) from all edges.
3. Using a hand held welder, weld one end of each tab approximately 40 mm (1-1/2 inches) in width to the back side of the membrane.

D. Membrane Positioning and Welding

The installation of the Sure-Weld or Sure-Flex membrane can be accomplished with a continuous sheet or multiple sheets. This can be determined by calculating the length of the tunnel arc.

1. Position the back side of the membrane against the previously installed drainage board extending one end of the membrane into the drainage pit.
2. Working from the bottom, begin securing each row of tabs by fastening through the center of the tab with pneumatic fasteners and fastening plates.
3. Prior to proceeding with the next row of tabs, fold the end of the tab over fastener head and plates to protect membrane against abrasion.
4. Working upward, secure consecutive rows until all tabs are secured.
5. With an overlap of 10 cm (4 inches), install adjacent membrane in a similar fashion. Install consecutive sheets prior to welding.
7. Weld adjoining membranes with a Hot Air Wedge Welder to achieve a double hot air weld 30 mm (1-1/4 inch) wide each.

Note: Follow manufacturer's operating procedures and published instructions to achieve proper

temperature output and welding speed. It is advisable to perform various test welds prior to seaming consecutive membrane sheets.

8. Membrane that has been exposed to the elements for approximately 7 days must be properly prepared. For TPO Membranes use Weathered Membrane Cleaner and for PVC Membranes use PVC Membrane Cleaner as follows:
 - a. Using a Scotch Brite Pad and Weathered Membrane Cleaner, scrub the area to be welded. (The cleaner will become white with membrane residue during this step of the procedure.
 - b. Clean all residue from the area to be welded with a HP Splice Wipe or clean natural fiber (cotton) rag.
 - c. Weld the cleaned material together with an appropriate hot air welder.
9. Using a compatible test kit and compressed air, examine every seam for defects in the double weld. Defective areas should be repaired using a patch of reinforced membrane large enough to extend 5 cm (2 inches) beyond the defective area. Intersections between the reinforced patch and the hot air welded seam in the membrane should be overlaid with Sure-Weld/Sure-Flex Flashing.

E. Membrane Flashing

1. Ensure tight fitting between electrical conduits, tunnel air shafts and any other gaps by installing Water Swelling Waterbar in accordance with manufacturer's instructions.
2. Flash electrical conduit using uncured non-reinforced Sure-Weld/Sure-Flex membrane.
3. All intersections shall be overlaid with Sure-Weld/Sure-Flex non-reinforced flashing.
4. Around air shafts additional fasteners and plates shall be incorporated to mechanically secure the membrane approximately 30 cm (12 inches) on center. Sure-Weld/Sure-Flex Reinforced Membrane shall be used to flash the sidewall of the air shaft extending approximately 5 cm (2 inches) past the plates. Against the sidewall of the air shaft the Sure-Weld/Sure-Flex membrane is terminated using a 6 mm x 50 mm (1/4 inch x 2 inch) Termination Bar and pneumatic fasteners. Seal the end of the air shaft flashing with Universal Single-Ply Sealant.

F. Membrane Terminations

Membrane must be terminated around air shafts, electrical conduits, pipes and other penetrations.

1. At air shafts, when terminations bars are used, expansion anchors may be used to firmly secure the termination bar under constant pressure. If pneumatic fasteners are to be used, test trials must be performed to allow adjustments of air pressure, so that fasteners are properly seated and the bar is under constant pressure.

NOTE: Do not over fasten termination bar.

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Leister is a Copyright of Leister Process Technologies

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CARLISLE'S **TUNNEL WATERPROOFING SYSTEM**

Sure-Weld®/Sure-Flex™ “Blindside” Method

Installation Details

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August 2013

Details

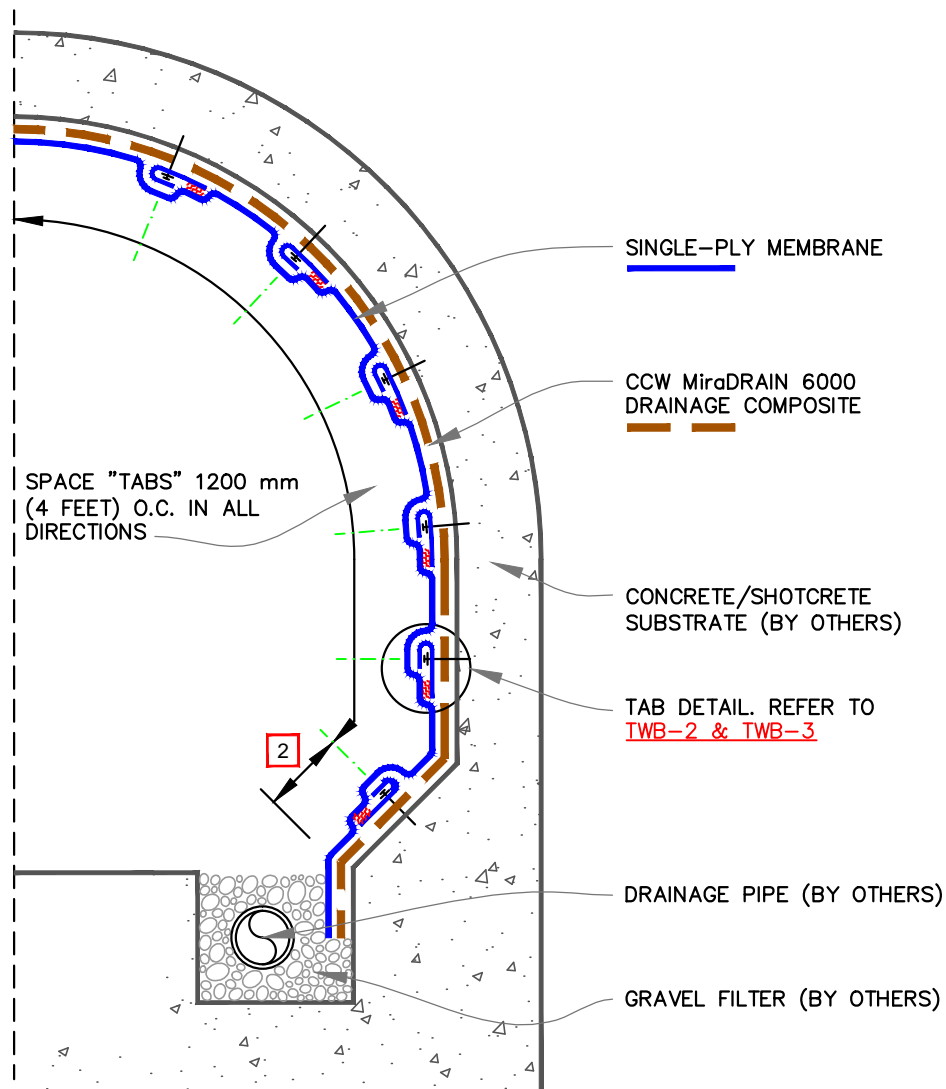
General

Tunnel Cross-section	TWB-1
Tab Anchoring Method	TWB-2
Tab Spacing/Seaming	TWB-3

Flashing

Tunnel Air Shaft Flashing	TWB-4
Conduit/Other Penetrations Flashing	TWB-5
Pre-molded Outside Corner Flashing	TWB-6
Field Fabricated Outside Corner Flashing	TWB-7

TUNNEL WATERPROOFING

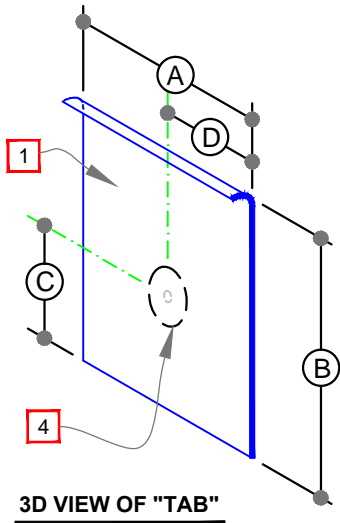


NOTES:

1. INSTALL THE CCW MiraDRAIN 6000 DRAINAGE COMPOSITE WITH THE GEOTEXTILE FILTER FABRIC AGAINST THE CONCRETE WALL OF THE TUNNEL.
2. SPACE THE FIRST ROW OF "TABS" 610 mm (2 FEET).
3. 610 mm (2 FEET) FROM THE EDGE OF THE SINGLE-PLY MEMBRANE, SPACE ALL OTHER "TABS" 1219 mm (4 FEET) ON CENTER.
4. IN ALL DIRECTIONS HOT AIR WELD TO THE SINGLE-PLY MEMBRANE AS SHOWN ON DETAILS [TWB-2](#) AND [TWB-3](#).
5. FASTEN "TABS" TO THE TUNNEL WALL WITH PNEUMATIC FASTENERS AND 51 mm (2 INCH) DIAMETER FASTENING PLATES.

TUNNEL CROSS-SECTION			SHEET NO. TWB-1
0	SEE NOTE(S)	www.carlisle-syntec.com	
		www.carlisle-ccw.com	

TUNNEL WATERPROOFING



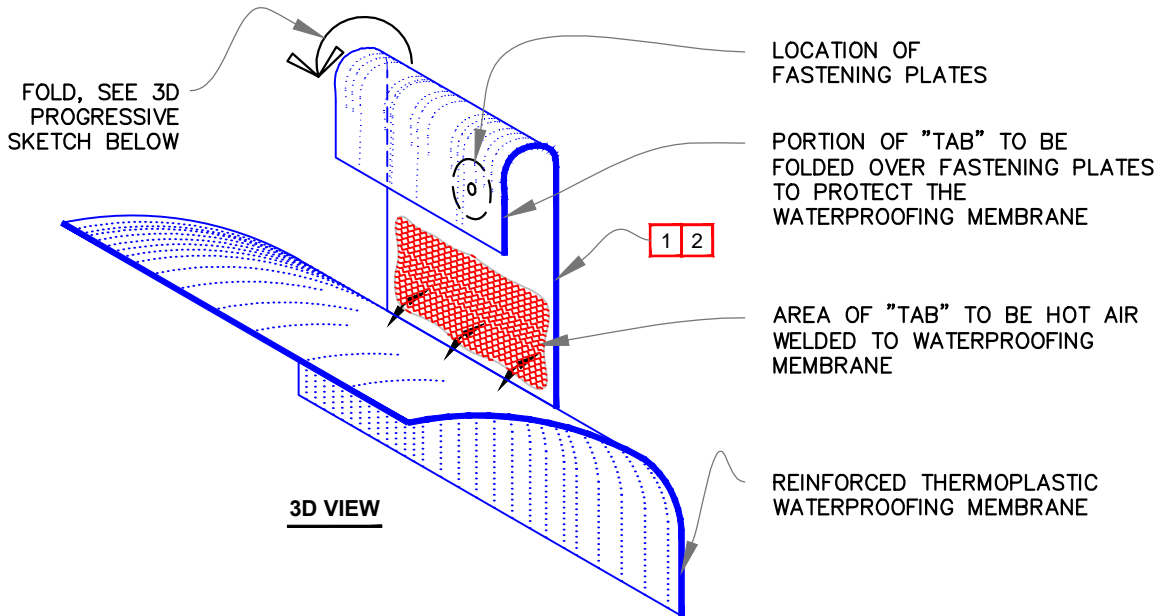
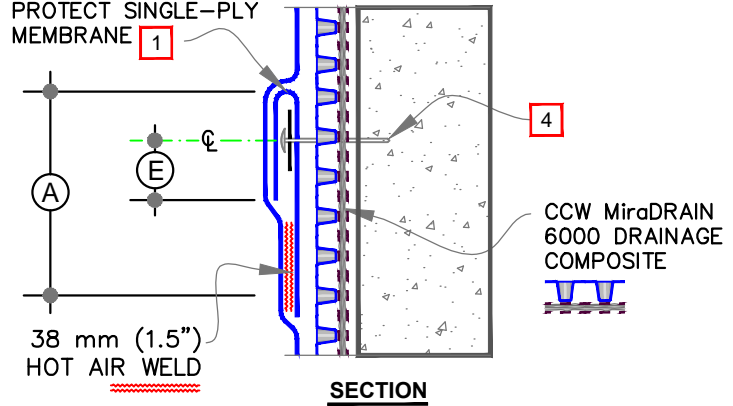
NOTES:

1. SINGLE-PLY MEMBRANE "TAB" WELDED TO BACKSIDE OF MEMBRANE AT 1219 mm (4 FEET) O.C.
2. THE MEMBRANE "TAB" IS USED FOR SECUREMENT OF THE SINGLE-PLY MEMBRANE TO THE TUNNEL WALL.
3. SPACE THE FIRST ROW OF "TABS" 610 mm (2 FEET) ABOVE THE PERIMETER DRAIN AS SHOWN ON DETAIL **TWB-1**, SPACE ALL OTHER "TABS" 1219 mm (4 FEET) O.C. IN ALL DIRECTIONS AND HOT AIR WELD TO THE SINGLE-PLY MEMBRANE. SEE DETAIL **TWB-3**.
4. FASTEN "TABS" TO THE TUNNEL WALL WITH PNEUMATIC FASTENERS AND 52 mm (2 INCH) DIAMETER FASTENING PLATES.

DIMENSIONS

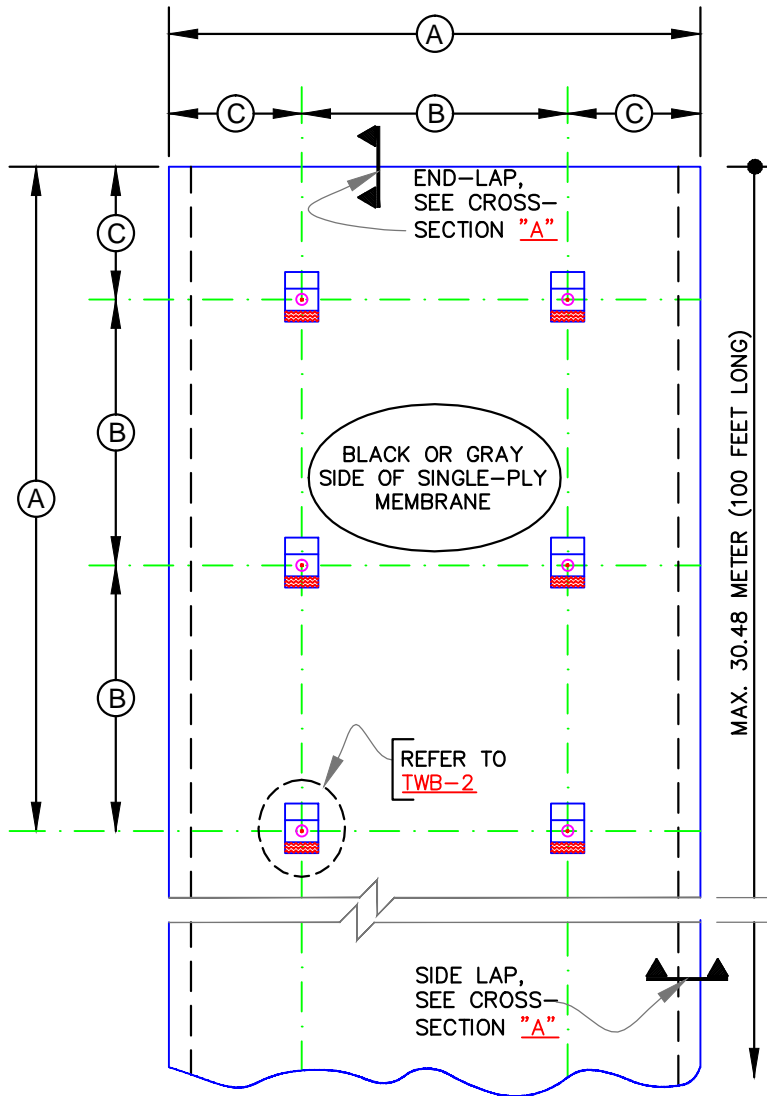
	mm	INCH	
(A)	152	6	APPROX.
(B)	229	9	APPROX.
(C)	102	4	APPROX.
(D)	76	3	
(E)	52	2	

FOLD "TAB" OVER FASTENER AND PLATE TO PROTECT SINGLE-PLY MEMBRANE



TAB ANCHORING METHOD			SHEET NO. TWB-2
0 SEE NOTE(S)	www.carlisle-syntec.com	www.carlisle-ccw.com	

TUNNEL WATERPROOFING

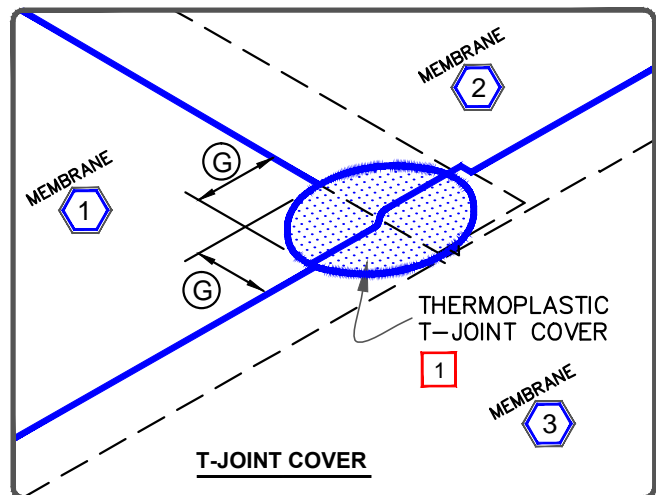
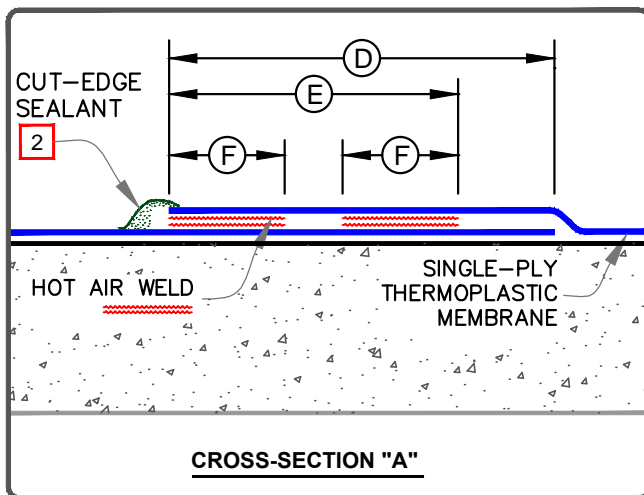


NOTE:

1. WHEN USING 1.5 mm OR 2 mm (60 OR 80 MIL) MEMBRANE, APPLY A 114 mm (4-1/2") DIAMETER "T-JOINT" COVER AT ALL FIELD SPLICE INTERSECTIONS.
2. APPROXIMATELY 3 mm (1/8") DIAMETER BEAD OF CUT-EDGE SEALANT IS REQUIRED ON CUT EDGES OF REINFORCED TPO MEMBRANE AND RECOMMENDED ON CUT EDGES OF SURE-FLEX PVC MEMBRANE.

DIMENSIONS

	mm	INCH	
(A)	2400	96	O.C.
(B)	1200	48	O.C.
(C)	600	24	O.C.
(D)	102	4	MIN.
(E)	76	3	MIN.
(F)	38	1.5	MIN.
(G)	57	2.25	MIN.



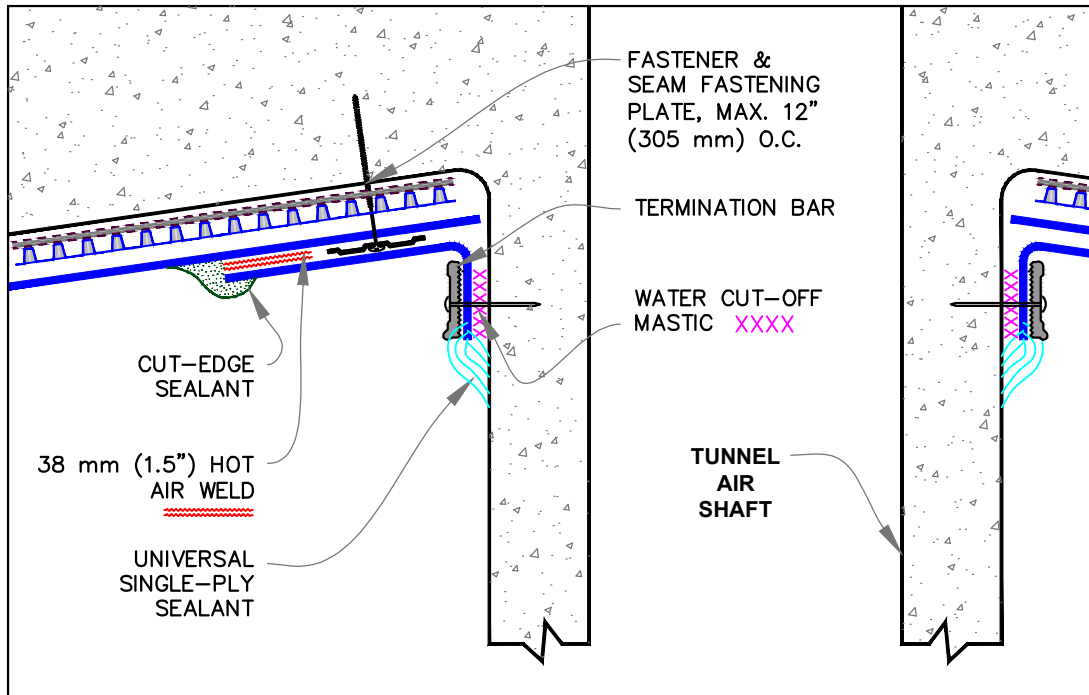
TAB SPACING / SEAMING

0 SEE NOTE(S) www.carlisle-syntec.com www.carlisle-ccw.com



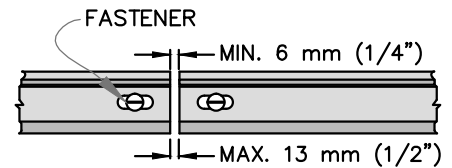
SHEET NO.

TWB-3



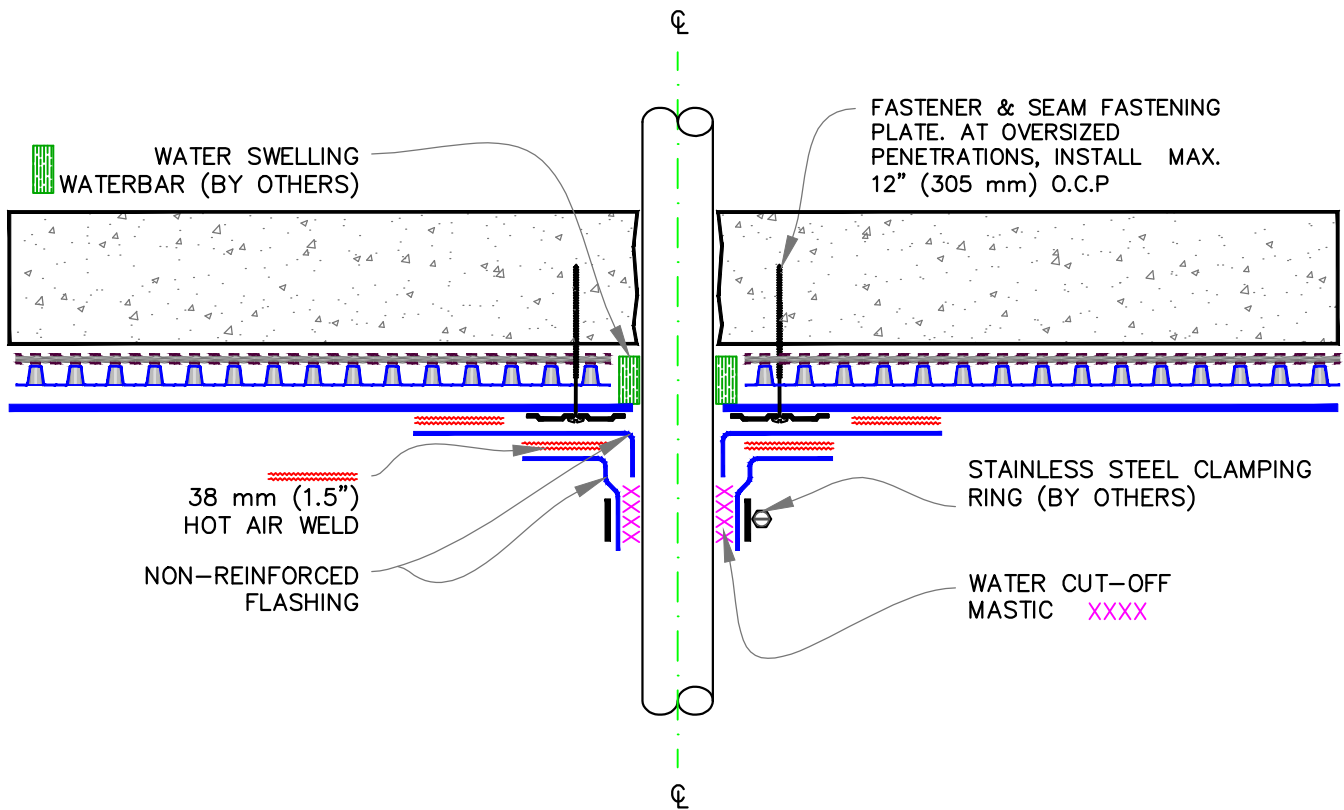
NOTES:

1. BEGIN INSTALLATION OF FASTENING PLATES APPROXIMATELY 150 mm (6 IN.) FROM CORNER OF AIR SHAFT.
2. POSITION FASTENING PLATES 13 mm TO 25 mm (1/2 TO 1 IN.) FROM EDGE OF WATERPROOFING MEMBRANE.
3. REFER TO DETAILS [TWB-6](#) AND [TWB-7](#) FOR ADDITIONAL INFORMATION.
4. DO NOT WRAP TERMINATION BAR AROUND CORNERS.



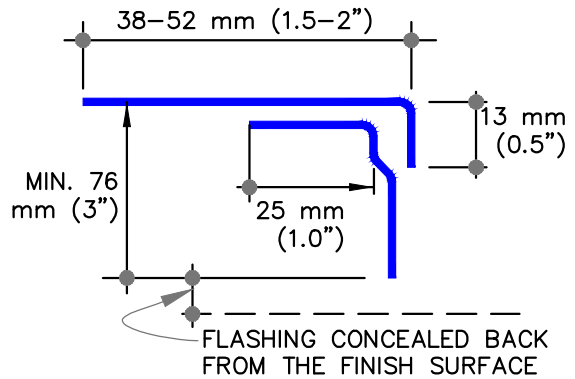
TERMINATION BAR ELEVATION

TUNNEL AIR SHAFT FLASHING			SHEET NO. TWB-4
0 SEE NOTE(S)	www.carlisle-syntec.com	www.carlisle-ccw.com	



NOTE:

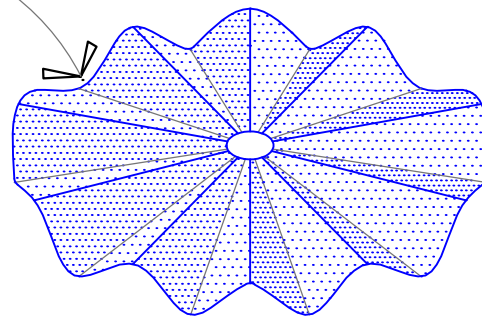
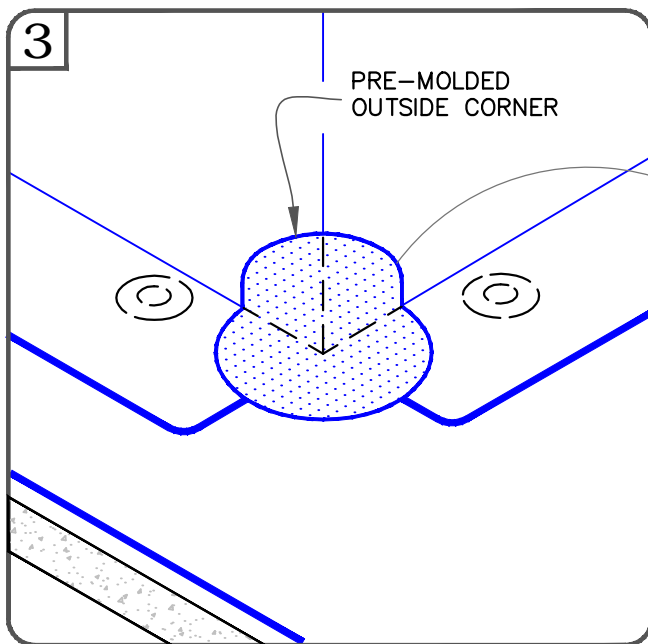
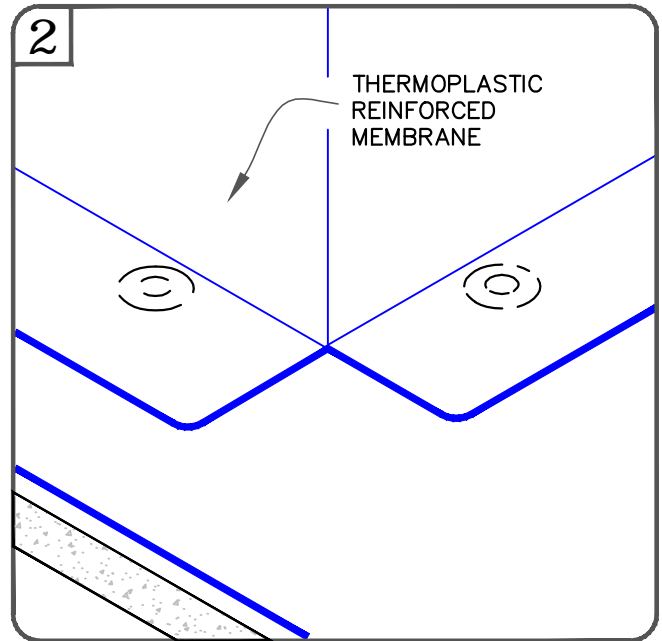
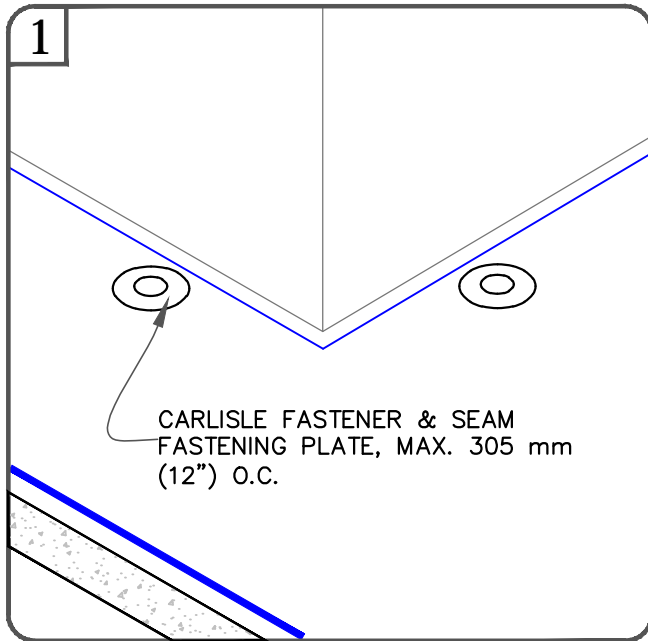
NON-REINFORCED MEMBRANE WRAPPED AROUND PIPE SHALL HAVE MINIMUM 38 mm (1-1/2 IN.) VERTICAL HOT AIR WELD.



FLASHING DIMENSIONS

CONDUIT / OTHER PENETRATIONS FLASHING			SHEET NO. TWB-5
0 SEE NOTE(S)	www.carlisle-syntec.com	www.carlisle-ccw.com	

TUNNEL WATERPROOFING

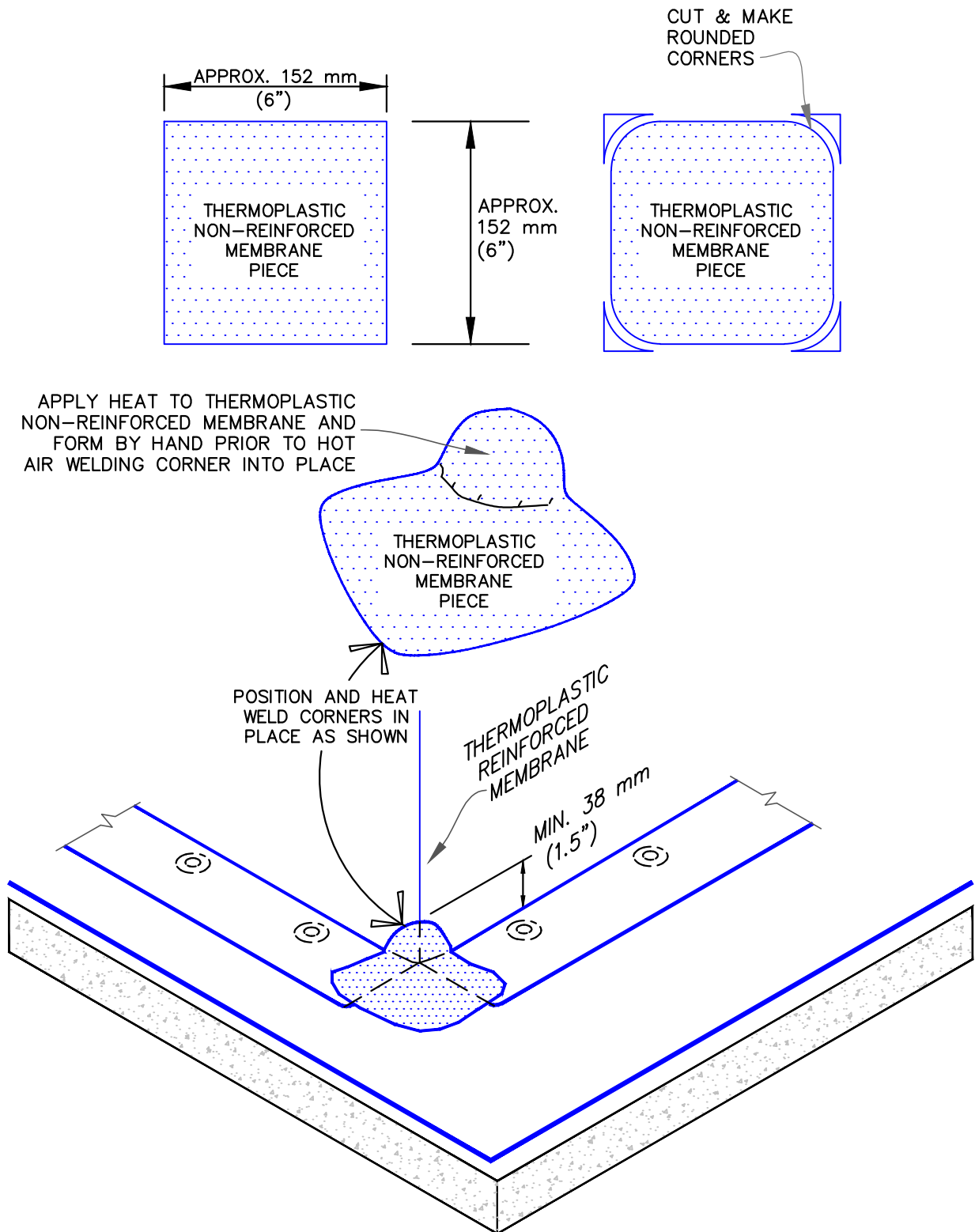


PRE-MOLDED OUTSIDE CORNER BEFORE INSTALLATION

NOTES:

1. POSITION FASTENING PLATES 152 mm (6") FROM THE CORNER AND 13 TO 25 mm (1/2" TO 1") FROM EDGE OF MEMBRANE.
2. APPROXIMATELY 3 mm (1/8") DIAMETER BEAD OF CUT-EDGE SEALANT IS REQUIRED ON CUT EDGES OF REINFORCED TPO MEMBRANE AND RECOMMENDED ON CUT EDGES OF SURE-FLEX PVC MEMBRANE.
3. REFER TO CARLISLE SPECIFICATIONS FOR ACCEPTABLE CARLISLE FASTENERS AND PLATES.

PRE-MOLDED OUTSIDE CORNER FLASHING			SHEET NO. TWB-6
0 SEE NOTE(S)	www.carlisle-syntec.com	www.carlisle-ccw.com	



FIELD FABRICATED OUTSIDE CORNER FLASHING		SHEET NO.
0 SEE NOTE(S) www.carlisle-syntec.com www.carlisle-ccw.com		
		TWB-7