



Very Large PRT-ES Installations (ZT07-98-003)

Background

When a heat shrinkable jacket is applied over a cable the jacket creates a secondary protective barrier that provides additional mechanical and electrical protection. However, under extreme environmental conditions moisture and contaminants can wick between this secondary jacket and the cable insulation. The resulting exposure can lead to corrosion of any exposed conductors and potentially cause circuit failure. Using Zippertubing's PRT-ES product is an effective way to eliminate this problem because it eliminates any voids or gaps between the secondary jacket and the cable jacket. This sealing process is commonly referred to as "Water Blocking" and the most reliable way to achieve this when using heat shrinkable parts is to apply a hot melt adhesive under the tubing material prior to shrinking. The hot melt adhesive melts and flows during the heating process and the constricting tubing drives the molten sealant into any voids or gaps. Once these voids have been filled there is no remaining air space between the two layers. The result is that no pressure differential exists between the inside and outside of the cable assembly and as a result changes in external atmospheric pressure or water pressure no longer causes moisture to migrate into the cable repair area.

Cable Diameters > 1.88 inch

The following procedure describes creating environmentally sealed PRT-ES style wire and cable repairs on cables with diameters larger than 1.88 inches using Zippertubing's PRT™ Tubing and Z-Block Tape as two separate components. Due to the large finished cable size multiple pieces of the PRT™ Tubing are required and must be lapped together to create the proper size. Table 1 shows the number and sizes of PRT™ Tubing pieces required to create these repairs. The end user may choose to order these components individually and assemble them as needed or order pre-packaged repair kits which contain five feet of the pre-assembled PRT™ tubing pieces, Z-Block Hot Melt Tape and installation instructions.

Note: For repairs on cable sizes of 1.88 inch and less use Zippertubing's standard one-piece PRT-ES product (p/n: ZT03-04-010-*) and install per process procedure ZT03-98-001

Materials

- Zippertubing Repair Kit: p/n: ZT**-KT-***-(size) or;
- Zippertubing PRT™ Tubing: p/n: ZT98-04-016-size
- Zippertubing Z-Block (135) Tape: p/n: ZT02-03-002
- Zippertubing Z-Block (100) Tape: p/n: ZT11-03-001
- Zippertubing Process Procedure: ZT07-98-003
- Hot Air Gun with Reducer Nozzel: Steinel HL1802E or equivalent
- Wood Popsicle Sticks

Important

Before beginning any assembly determine the operating temperature of the cable assembly you will be water blocking?

- a) For systems operating at temperatures of 100°C or less use Z-Block (100) Tape (p/n: ZT11-03-001).
- b) For systems operating at temperatures of 100°C to 135°C use Z-Block (135) Tape (p/n: ZT02-03-002).

Installation

For illustration purposes many of the repair photographs shown are of small wire or cable which has insulation damage. The repair sequence is similar for both small and large cables.

- 1) If you are using a Zippertubing pre-packaged repair kit designed specifically for your cable size proceed to step #2.

If you are assembling the repair parts from individual components, measure the outside diameter of the damaged wire or cable at a location away from the defect using a caliper or micrometer. Use Table 1 and find the closest measured cable diameter in column 1. Select the number of pieces and sizes of PRT™ Tubing required from column 2. Obtain a roll of the Z-Block (100 or 135) hot melt tape. These materials are only available in a 2.0 inch wide roll but may be cut to the desired width using scizzors.

Cut the selected PRT™ Tubing sections to the appropriate lengths. Cut the tubing using a straight edge and a razor knife to obtain a straight, snag free cut. Lay one of the cut tubing pieces on a flat surface with the paper covered adhesive strip facing up. Peel back several inches of the paper release liner covering the adhesive strip. Orientate the second piece of tubing so the adhesive strip also faces up and align the non-adhesive edge of the second piece of PRT™ Tubing over the exposed adhesive of the first so it just covers all of the adhesive and no more. Continue to remove

the release liner from the first piece of tubing in short section and align and bond the second piece in this fashion over the entire part length. Rub the completed lap joint with your thumb to insure a good bond. Repeat this procedure with additional pieces of tubing as necessary. When assembled correctly, you will have a large single piece of PRT™ Tubing (made of multiple piece sections) that when wrapped around the cable will allow you to seal it closed into a large single piece of tubing. See Photo #3A below for a typical view of an assembled piece of tubing.

Table 1. Very Large PRT-ES Sizes

Cable O.D.	2 – PRT’s Req’d	Cable O.D.	3 – PRT’s Req’d
2.0	2 - #9’s	3-3/4	3 - #11’s
2-1/8	1 - #9 & 1 - #10	3-7/8	2 - #11’s & 1 - #12
2-1/4	2 - #10’s	4.0	2 - # 12’s & 1 - #11
2-3/8	1 - #10 & 1 - #11	4-1/8	3 - #12’s
2-1/2	2 - #11’s	4-1/4	2 - #12’s & 1 - #13
2-5/8	1 - #11 & 1 - #12	4-3/8	2 - #13’s & 1 - #12
2-3/4	2 - #12’s	4-1/2	3 - #13’s
2-7/8	1 - #12 & 1 - #13	4-5/8	1 - #14 & 2 - #13’s
3.0	2 - # 13’s	4-3/4	2 - #14’s & 1 - #13
3-1/8	1 - #13 & 1 - #14	4-7/8	3 - #14’s
3-1/4	2 - #14’s	5.0	2 - #14’s & 1 - #15
3-3/8	1 - #14 & 1 - #15	5-1/8	2 - #15’s & 1 - #14
3-1/2	2 - #15’s	5-1/4	3 - #15’s
3-5/8	1 - #10 & 2 - #11		

2) Clean the cable repair area of all debris and oil contamination using a mild solvent like Isopropyl Alcohol (IPA).

Note: Any mild, non oil based solvent that will not attack the cable jacket insulation material is acceptable.

3) Use a razor knife to remove any protruding pieces of cable insulation that do not dress down smooth and flush with the original jacket. (Photo 1)

4) Use the Z-Block hot melt tape and helically wind the tape around the cable over the entire area to be repaired so that each tape wind butts up against the previous one or overlaps by approximately ¼ - ½ inches. (Photo 2) Be sure to remove the paper liner from the amber colored tape prior to wrapping the cable. If the damaged area of the cable has deep nicks or voids, cut pieces of the Z-Block tape and pack the void areas prior to applying the tape over wrap. The hot melt tape does not have a self-stick backing! You may find it advantageous to touch the hot edge of the heat gun to the first and last winds of tape as necessary to help fuse it together and hold it in place.

Caution:

Keep the tape wrap buildup to a minimum. A smooth single layer wrap is ideal. Too much tape could cause a seam rupture (Photo 7).



Photo 1: Typical wire or cable insulation damage.



Photo 2: Z-Block tape wrapped around cable.

- 5) Wrap the PRT™ Tubing around the cable so the split line is parallel to the cable length direction and the paper release liner covering the adhesive faces towards the installer. Peel back the first inch or two of the release liner and expose the adhesive. Align the non-adhesive edge of the tubing over the exposed adhesive so that the edge just covers all of the adhesive and no more. Once the first inch or two of the overlap has been sealed, continue removing short sections of the release liner and seal the

entire tubing length. Avoid contacting the adhesive with your fingers as much as possible. Continue sealing the seam in short sections to avoid creating wrinkles in the overlap area. Once the entire piece of tubing is installed, rub the overlap seam firmly using your thumb to insure good contact and work out any wrinkles. Minor wrinkles will disappear when the tubing shrinks.

Note: The pre-packaged PRT™ Tubing kits and material fabricated by the user from Table 1 components will consist of multiple pieces and have multiple overlap seam lines. In the pre-shrunk condition these materials will exhibit an unusual “star-like” appearance. (Photo 3A) This condition is normal for multi-piece PRT™ Tubing prior to applying heat. The fully shrunk PRT™ Tubing insulation jacket will have a smooth, round appearance. (Photo 3B)

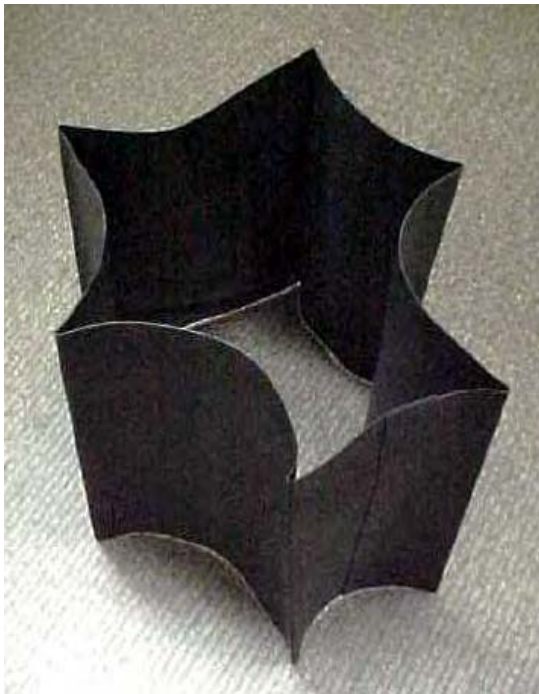


Photo 3A: Prior to shrinking.



Photo 3B: Fully shrunk condition.

6) Center the PRT Tubing over the cable damage area and the Z-Block Tape wrapped area.

7) Shrinking PRT Tubing

Caution:

PRT™ Tubing requires a two step heat application process. The adhesive overlap areas must be heat-set prior to completing full tubing recovery. **Do Not** use a tubing heat reflector or other device intended to spread heat uniformly around the tubing!

- a) PRT™ Tubing when used in conjunction with Z-Block hot melt tape requires the use of a hot air type of heat gun with a temperature setting of approximately 150-160°C to shrink the tubing and allow the hot melt adhesive to flow. Always use a heat gun with a small reducer nozzle that will localize the heat stream. (Photo 4)

Note: You may shrink the tubing in place immediately after sealing. The adhesive system has no cure time requirements.



Photo 4: Nozzle focused near tubing center on overlap seam

- b) Begin shrinking the PRT™ Tubing by directing the heat source at the adhesive overlap area near the center of the repair tubing. (Photo 4) Apply heat to the adhesive overlap area only and work from the center towards the ends! The overlap area will tend to curl up into a “U” shape as it is heated. (Photo 5) Continue applying heat in short bursts to this area until the surrounding tubing begins to pull the “U” shape back down flat. Do not be afraid to apply extra heat to the overlap area, as it will take extra dwell time for the inside layer of the overlap to begin to shrink. Do not be alarmed if the outer layer of the overlap flap tends to lift off the adhesive and curl back slightly during initial heat exposure. With continued heating this lifted area will generally lay back down on its own, if not, lightly tap the lifted edge as necessary with a wooden Popsicle stick? Do not squeeze the tubing when tapping the lifted lip down. Use extreme caution when touching the tubing as it will be hot and sticky. Shrink the multiple overlap seam areas over their entire part length before attempting to recover the remaining tubing.
- c) Be aware that applying too much heat, too quickly, in any one location may cause the hot melt adhesive to expand unevenly and possibly rupture the overlap seam. Refer to the Troubleshooting section at the of this document for details. The key to a successful installation is to “sneak up” on the tubing with the heat source. Do not be afraid to pull the heat

source away and let the tubing cool momentarily if it appears that the overlap seam is being pulled apart. Once the overlap seam has fully shrunk you may find that most of the remaining tubing has also shrunk. Apply the heat to any remaining tubing areas to smooth out any wrinkles and cold spots. Once the tubing is fully shrunk, apply heat over the entire tubing length and circumference in a smooth and even motion insuring that the hot melt adhesive is flowing and has oozed out from under both ends of the tubing evenly. The finished part should have a fillet of adhesive at each end. (Photo 6)



Photo 5: Overlap seams curled up prior to full shrinkage.

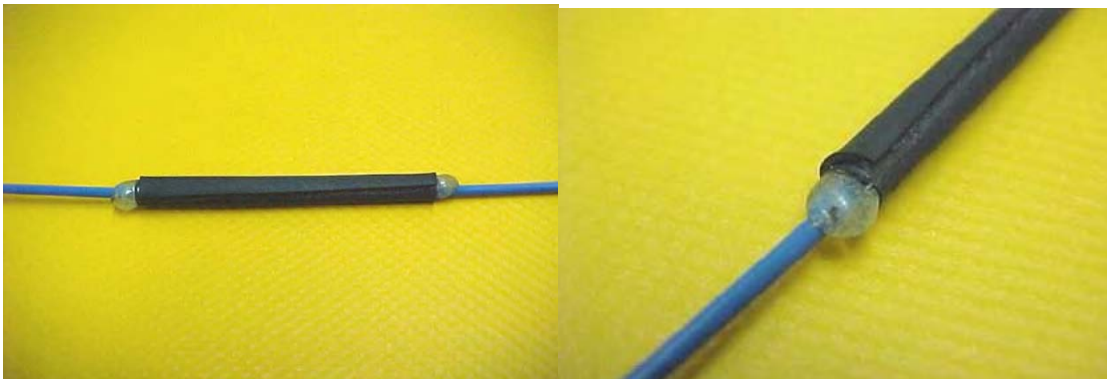


Photo 6: Adhesive fillet

- d) Do not attempt to remove the hot melt adhesive fillet! Do not be alarmed if the adhesive fillets are uneven around the circumference of the cable or undesirable looking cosmetically. In general, a fillet that covers the entire jacket end circumference of the repair sleeve is what's important and not the cosmetic look of the fillet.

- e) While the assembly is still slightly warm to the touch, use your thumb and rub all tubing overlap seam edges to remove any exposed closure adhesive. Excess adhesive will ball up ahead of your thumb. Discard.

Caution:

Never attempt to remove excess adhesive using solvents.

- f) Allow the finished assembly to completely cool to room temperature prior to placing into service.

Troubleshooting

The most common problem likely to occur when installing PRT™ Tubing and Z-Block tape materials is a seam rupture. This condition is where the molted Z-Block hot melt tape breaks through a section of the overlap seam during installation. (Photo 7) Seam ruptures are most likely to occur during the learning phase of PRT-ES installation. Once the proper installation technique has been mastered this problem will disappear. Seam ruptures occur for two main reasons and both can be controlled by the installer.

- 1) Sizing:** The PRT™ Tubing selected in Table 1 was too small for the cable diameter being repaired.
- 2) Heating:** The installer applied too much heat, too quickly to the PRT™ Tubing and Z-Block tape.



Photo 7: Typical overlap seam rupture

If a rupture occurs, verify that the correct size tubing was used? If the cables outside diameter is very close to the upper limit of a size range shown in Table 1 consider increasing the PRT™ Tubing to the next larger size. Correct as necessary and attempt a new installation. If sizing is not the cause of the failure, then adjust the heating technique by applying the heat more slowly

and evenly. Review the “sneak up on it” technique described in Step #7c.

It is possible to repair a seam rupture and still provide a good environmental seal. As a general rule, a seam rupture that is 2.0 inches away from the cable defect area can be repaired with prior approval. Always consult with in-house Engineering and Q/A departments and obtain approval to proceed with a repair versus removing and replacing the entire PRT-ES tubing repair.

Repair Technique

If you experience a seam rupture stop applying heat in that area and allow it to cool. Adjust the heating technique as described above and finish the installation. Obtain approval to attempt a seam rupture repair. With the entire assembly at room temperature return to the seam rupture and re-heat the area until the hot melt adhesive is soft. Use the end of a Popsicle stick and gently work the raised tubing lip down as smooth as possible. Use the radius end of the Popsicle stick and scrape away the excess adhesive in a direction parallel to the overlap split line. You may need to repeat this process several times to obtain a nice appearance. Allow the area to cool.

A repaired seam rupture will never look quite as good cosmetically as the seam areas that were properly installed. However, that does not mean that a seam repair cannot be used. As long as there is a thin bead of the “Z-Block” hot melt adhesive present along the overlap split line in the area of the rupture you have a usable assembly. Since the entire jacket is sealed with the hot melt adhesive there is no way for the environment to find its way to the repaired defect area. The same condition would exist if the rupture were not repaired. However, repairing a rupture is desirable since it eliminates the raised lip condition (Photo 7) which could create a potential snag problem resulting in further damage.

Installer Note:

Using the PRT-ES method of wire and cable repair will generally eliminate a very large amount of cable harness disassembly, rework, reassembly and potential hardware damage. As a result, don't be in a big rush to complete the installation. Take a few extra minutes to plan the installation, heat the sleeve slowly and work the materials as necessary to insure a good first time repair. The extra time spent doing this will pale in comparison to the time required to perform a classic repair that involves connector disassembly.