Splicing and Terminating of Portable Cables

ANACONDA® BRAND

General Cable

Obtaining Good Adhesion Between Dissimilar Polymers During Vulcanization

The following procedure has been tested and found to produce good adhesion between the uncured thermosetting tapes and the cable jacket in a standard vulcanized splice.

Preparation

1. The jacket must be thoroughly cleaned. Buff with 60 grit sand cloth until only virgin material remains. It should be free of grease, dirt, slipper coating, paraffin, etc.

2. Completely cover the freshly buffed surface of the jacket with a properly mixed adhesive.

3. Allow adhesive to dry until tacky to the touch.

4. Half-lap uncured tape over tacky surface. Exclude air voids.

NOTE: Some adhesives dry so rapidly that it is difficult to apply the tape over the entire area while still tacky. This will not reduce the degree of bonding.

5. Apply uncured tape until dimensions are *slightly* larger than cavity of mold.

6. Cure according to standard procedures. A general guide which has been proven successful is:
   a) Curing temperature: 280° F.
   b) Nominal time: 1 hour (varies slightly with cable size).
   c) Mold pressure: 275 lb/in². Pressure should be sufficient to completely close both halves of the mold and to cause immediate extrusion of the uncured tape compound from the relief openings in the mold. This pressure should be maintained throughout the curing time period.

7. After removing the cable from the vulcanizing mold, allow to cool for at least one hour before bending or stressing.

Suggested Items Needed for Splicing and Terminating Portable Cables

Tools

Concave roller
Crimping tool
Diameter measuring tape, ruler and marking pencil
Hose clamp and 0.010" shim stock (2 ea.)
Knife
Pliers
Scissors
Screwdriver
Soldering iron
Splicing separator
Vulcanizer(s)

Materials

Clean, lint-free rags
Cleaning solvent
Fusing semi-con tape
Insulation putty
Portable cable connectors
PVC electric tape
Shielding mesh or braid tape
60 grit sand cloth
Solder and flux

Vulcanizing

Cement
Cloth-backed cured rubber separator tape
Cured insulating tape
Neoprene, CSPE or CPE jacket tape
Semi-con tape
Uncured insulating tape

Precautions

Keep work clean and dry.
Do not nick insulation.
Do not pull semi-con away from insulation at cutoff.
Dimensions shown for single indent crimp-type connector. (see *Figure 1*)
We suggest soldering for flexibility.
Keep all power conductors of equal length so mechanical pull is equal on each.

Tape: Remove separator backing.
Half-lap all tape.
Stretch 8 - 10" strips of insulating tape to ½ original width.
Overstretch ends and roll each layer to prevent voids.
Start tape in middle of splice.
Use fresh tapes only.

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Shielded Cable *General Procedures and Techniques*

As a general rule, the higher the voltage rating of a system, the lower the margin of safety of that system. From this rule, it follows that the higher the voltage of a system, the more care should be exercised in engineering the system and supervising its actual installation. Further, splices and terminations, which are always a vital part of any cable system, become more susceptible to failure at higher voltages. Whether the splice or termination is accomplished by the use of hand-applied tapes, a filled or molded device, heat-shrinkable tubing, or a prefabricated device, care should be exercised during the application. Poor workmanship or improper choice of materials could jeopardize the reliability of the entire system.

I. Major Causes of Splice and Termination Failure

Before discussing details of splice and termination procedures, consider the following common causes for unsatisfactory service:

1. Ending up with a grounding or ground-check conductor which is shorter than the power conductors
2. Semi-conducting residue on the insulation surface that was not removed
3. Gaps, voids or soft spots in insulating tape build-up
4. Improper termination of shielding system, leaving inward-pointing projections
5. Damage to factory insulation by improper removal of shielding systems
6. Excessive slack in one or more individual conductors
7. Splice has low tensile strength and is easily pulled in two
8. Individual wires are damaged during application of connector
9. Splice is too bulky—will not pass through cable guides or over sheaves
10. Improper application of the outer covering allowing water to enter the cable interior

When using a commercially obtained splice or terminating kit, the splicer should always carefully follow the kit supplier's directions and instructions, including their dimensions and drawings. This should ensure a proper installation and use of the materials provided in the kit. Should such a kit not be at hand, but suitable materials are available, the following general procedures, techniques and design factors can be followed. On the basis of experience and laboratory tests, these instructions should result in satisfactory splices and terminations but are not intended to circumvent or replace approved kit suppliers' recommendations.

II. Suggested Dimensions for Splices and Terminations

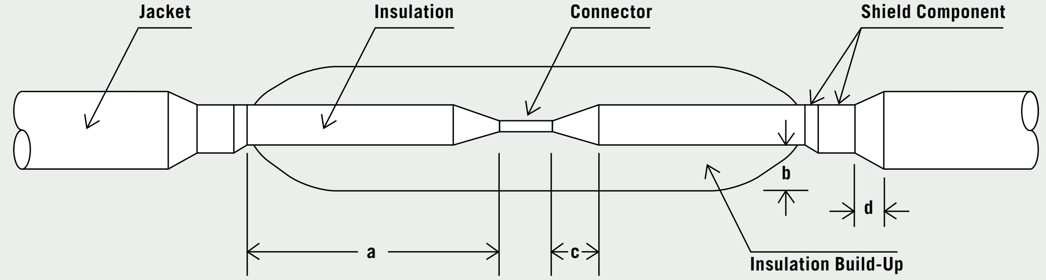
Figure 1 shows "rule-of-thumb" dimensions to be used in splicing cables with an extruded insulation.

Table 1: Suggested Dimensions for Vulcanized Splicing

	5 kV	8 kV	15 kV	25 kV
'a' = Creepage Distance (inches)	= 3*	3	4	5
'b' = Insulation Build-up	= 2 times insulation thickness			
'c' = Insulation Taper (inches)	= ¾	1½	2	3
'd' = Jacket Taper	= 6 times jacket thickness			

*This dimension is designed to give the splicer working room and may be considered over-designed for this voltage.

Figure 1



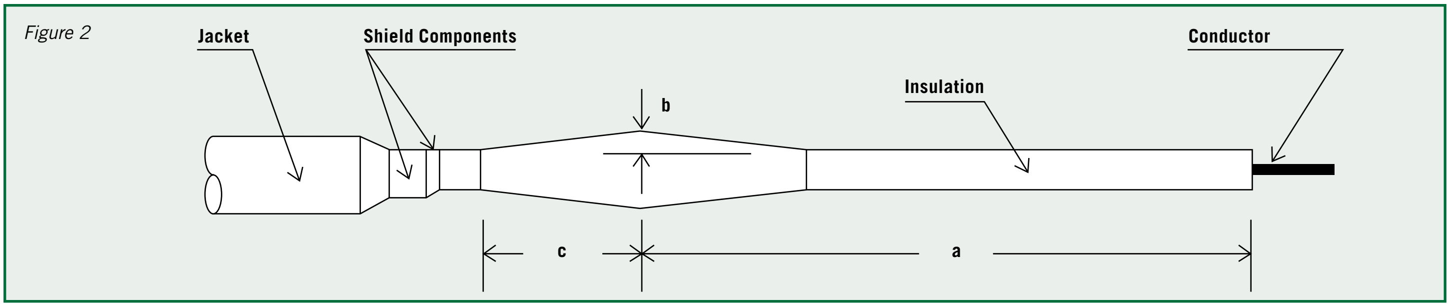


Figure 2 shows "rule-of-thumb" dimensions for terminating cables with an extruded insulation.

Table 2: Suggested Dimensions for Terminating

'a' = Creepage Distance (inches)*	5 kV 10	8 kV 10	15 kV 18	25 kV 25
'b' = Stress Relief Cone Thickness	= 2 times factory insulation thickness			
'c' = Length of Cone Base	= 10 times stress relief cone thickness			

*These dimensions are designed for either wet or dry locations and may vary according to customer-specified requirements or physical requirements at transformers, etc.

The "Creepage Distance" 'a' in the Tables and Figures 1 and 2 is defined as that length between the conductor (at the connector area) over the taper and across the cable insulation surface to the nearest conducting or semi-conducting shield component. On occasion, this distance is also referred to as "leakage path". The terms are synonymous.

The minimum axial length of insulation taper shall be 6 times the thickness of the factory-applied insulation. The axial length of taper of the non-metallic outer covering is also approximately 6 times the thickness of the jacket except that in this case such tapering is considered optional.

Insulation build-up 'b' should be 2 times the factory insulation thickness.

III. Preparation of Cable for Splicing and Terminating

In preparation of cable ends for splicing and terminating, there are certain steps that require special attention and technique to prevent premature failure. These are listed below:

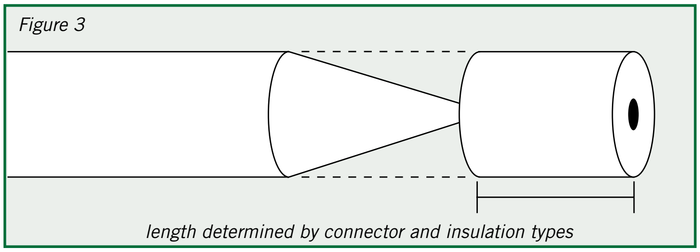
1. Cable ends should always be cut carefully and squarely.
2. The outer jacket should be removed without damaging shield tapes or braid by the following procedures:
   a) Ring jacket circumferentially through approximately 80 percent of the jacket thickness.
   b) Holding knife at an angle, cut the jacket longitudinally in such a manner so that repeated traverses of these cuts will only have penetrated approximately 80 percent of the jacket thickness.
   c) Using pliers, grip the edge of the jacket and pull in the direction of the slant cut. If the jacket does not readily tear at the cut, a knife may be used with tension applied to the jacket, still avoiding damage to the underlying shield tapes or braid.
3. Thoroughly clean jacket on both ends of the splice to obtain good adhesion between the factory jacket and the completed splice jacket.

IV. Making the Splice

1. The connector is compressed on the two cable ends to be joined. Any burrs on the connectors should be removed. Any indentations existing are filled, preferably with semi-conducting tape strips.

NOTE: The power conductors should be staggered to reduce the overall diameter of the completed splice. Grounding and ground-check conductors should be of equal length and approximately 1/4" longer than the power conductors.

2. Semi-conducting material is applied over the exposed conductor and connector to produce a smooth contour. Any saw-tooth effect created by laps in the tape injects stress points in a very crucial region, which could be more detrimental to the life of the splice than omitting the operation completely.
3. Pencilling of the insulation requires a 360° perpendicular cut through all but the last 1/16" of insulation, at a predetermined distance from the conductor end. This distance is directly dependent on the type of connector and type of cable insulations. Pencil and smooth the taper before removing the short section of insulation from the conductor. This buffer technique, illustrated in Figure 3, protects the conductor surface against undue abrasion and scoring.
4. The splice is re-insulated with an insulating tape applied half-lapped and in a smooth, rhythmical fashion, introducing uniform stretch as specified by the tape manufacturer. Frequent rolling of the work with a concave tool, screwdriver handle, or other round object helps to eliminate any entrapped air, which could otherwise ionize if sufficient voltage gradient is impressed across it. The insulating tape is wrapped to approximately 1/4" from the cable semi-



IV. Making the Splice (cont'd)

conducting component. This space allows for proper transition between materials in re-shielding. Dimensions are shown in *Table 1*.

5. The joint is re-shielded by using, where required, semi-conducting insulation shield tape applied half-lapped across the joint, starting by overlapping the 1/4" of exposed, terminated, insulation semi-conducting layer at one end of the joint and finishing by overlapping the exposed semi-conducting layer at the other end. Roll this layer of tape as described above to eliminate any air voids.

   For proper metallic shielding, a tinned all-copper knit mesh or braid tape should be used for adequate conductance. This tape should be applied half-lapped across the joint and soldered to the cable shield at both ends of the splice.

6. Attempting to rebuild the cable as close to its original condition as possible includes consideration of the jacketing material. Neoprene, CSPE and CPE tapes have been used for this purpose with considerable success. Vulcanization in a mold is suggested for best results.

   Place all the cable components back into their original configuration as close as possible with the proper lay or twist. If the cable fillers are no longer intact or are insufficient in body to fill the interstices of the spliced conductors, use cut lengths of tape to build up the fillers to produce a round joint. Tape over all with uncured jacketing tape if a mold is to be used, extending the tape out over the cleaned areas of the original cable jacket. Build up the jacket thickness to a diameter slightly larger than the mold cavity to ensure that the cavity will be completely filled out and that the excess material will be squeezed out in the form of a flashing. The tape manufacturers' recommendations for temperature and mold pressures should be followed.

V. Building a Termination

1. Following either the supplied kit drawings or dimensions of those found in *Figure 2*, terminate the shielding components, both metallic and semi-conducting portions, as described in the splicing instructions. Clean the entire exposed length of insulation along the creepage path as indicated for splicing.

   The three most common types of stress cones in use for terminations are pre-molded, pennant or hand-taped. Pre-molded and pennant types are usually in kit form, and instructions for application are supplied.

   a) If a hand-taped stress cone is to be formed using materials at hand and the dimensions in *Figure 2*, start applying half-lapped insulating tapes at the center of the stress cone, taping to within 1/4" of the terminated semi-conducting component. Tape back up across the center to the prescribed length of the stress cone and build up the cone to the proper dimensions.

2. Apply half-lapped semi-conducting tape from 1/8" below the peak of the stress cone, down the slope and over the semi-conducting layer of the cable.

3. Apply half-lapped, tinned all-copper knit mesh or braid tape from 1/8" below the edge of the semi-conducting tape, down the slope and over the shielding tapes or braid of the cable. Attach the external ground strap or pigtail at this location.

4. Re-jacket the entire termination using either uncured tape and molds where available or self-curing tapes applied half-lapped, with the last layer applied from the cable jacket upward to the lug. This last layer then provides a "shingle" type layer and reduces the amount of contaminants that would be accumulated at the edges of the tape.

Nonshielded Cable
General Procedures and Techniques

Most temporary and permanent low-voltage, nonshielded cable splices and terminations are usually made with "off the shelf" kits or with approved materials stocked by the user. In the absence of shielding, less consideration has to be given to creepage distances and the other critical dimensions of shielded cable splices and terminations. Although considered advisable, in most cases the insulation is not even pencilled. Thus, the splice consists of a mechanically applied connector, hand-applied insulation and jacket replacement.

There are, however, some splicing procedures that require special care, especially in multi-conductor cables. It is most important in splicing these cables that:

1. The power conductors are staggered in such a manner as to reduce the overall diameter of the completed splice.

2. That both the ground-check and grounding conductors are approximately 1/4" longer than the power conductors. The shorter conductor, should the lengths differ, will have most of the tensile load to carry and will therefore fail prematurely due to connector pullout or strand breakage.

3. Adequate insulation over the exposed strand and connector must be provided. Refer to the kit instructions or provide at least two (2) times the factory-applied insulation thickness.

4. The splice or termination should be properly jacketed and sealed against the entrance of moisture.

Good judgement should be exercised in the type of kit used or materials chosen. The decision should be based upon the end use of the cable, its normal or possible environment, the physical requirements of the cable, and its splices and terminations.

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