Splicing and Terminating Excerpt from PRYSMIAN'S *WIRE AND CABLE ENGINEERING GUIDE*

700 Industrial Drive
Lexington, South Carolina 29072
Phone: 1.800.845.8507
Fax: 1.803.951.1142
www.na.prysmian.com/energy

Splicing and Terminating

Overview

All shielded power cables require terminations, which are typically rated by voltage class, from 5kV and up. Nonshielded 5kV power cables may also be terminated, but the termination is used to externally protect the cable and connection from surface erosion due to leakage currents flowing to ground and from adverse weathering conditions.

Why are power cables shielded? The shield provides an effective means of grounding the external surface of the cable. This ground eliminates surface charges on the shield , which could be a safety hazard. The shield also acts as a radial ground plane which symmetrically distributes the electric field within the cable insulation. For these reasons, it is imperative that the shield be properly grounded at both ends of a cable run (except for very short runs).

Terminations

When the end of the cable is prepared for connection to equipment, the shield must be removed (cut back away from the end). Otherwise, the voltage stress between the conductor and the shield would exceed the insulating ability of the air between them, and a flashover would result. Therefore, it is necessary to cut back the shield some distance proportional to the applied voltage.

Once the metallic shield and cable semiconducting layer have been removed, the remaining portion of the cable end acts as an unshielded cable. All the electrical stress in this section will seek the nearest ground, which is the semicon cutback. In other words, the electric field is distorted in the unshielded area, and it concentrates at the shield cutback. For this reason, a termination is employed to control, or spread out, the electric field (i.e. stress control).

There are different ways of controlling stress, all of which are effective if properly installed. These include geometric solutions (stress cones) and electrical solutions (linear and non-linear stress grading materials). Terminations may be taped, premolded, heat- or cold-shrink, and may have different designs for indoor and outdoor applications.

In addition to stress control, terminations typically provide some weathering protection. This usually takes the form of an outer jacket which can withstand UV, and the effects of varying conditions (rain, snow, fog, salt spray, etc.) as well as prevent or withstand tracking. Tracking is a phenomena whereby electrically conducting paths are formed on the surface of terminations by burning. The leakage currents which flow over the surface of the termination from the conductor to the ground cause small sections to dry out (forming dry bands). The currents arc across these bands generating intense heat and may burn either the underlying material or contamination on the surface. Electrically conducting paths, or tracks, are formed. Over time, enough tracks may occur to either erode through the material or cause an external flash over.

While much attention is paid to the outdoor performance of materials, it is worth noting here that indoor conditions can be much more severe. The by-products of electrical activity within a poorly ventilated, moist enclosure (such as a switch cubicle) may include ozone, nitrous oxides and nitric acid. The resulting environment may lead to corrosion of the metal parts within the enclosure as well as degradation of the electrical insulation present.

All terminations should be qualified to the latest revision of IEEE 48, and should be Class 1 devices.

700 Industrial Drive
Lexington, South Carolina 29072
Phone: 1.800.845.8507
Fax: 1.803.951.1142
www.na.prysmian.com/energy

Cable Preparation

GENERAL
Thoroughly read manufacturer's instructions before beginning installation, taking note of any special requirements. Make sure that the dimensions for cable prep are for the appropriate voltage class. Make sure that the connectors used are appropriate for the application (suitable for use on aluminum or copper, sealed lugs if outdoor, length, tapered, if required, etc.) and that the proper crimp tool (and dies, if needed) is available.

JACKETS
Clean the cable jackets to the specified distance. To eliminate the risk of damaging the underlying metallic shield, do not cut completely through the jacket. Instead, ring cut through at least 50% of the material and tear off the remainder.

METALLIC SHIELDS
Remove the metallic shield to the specified distance. Wires (concentric and drain) are typically folded back over the jacket and bundled. Consult instructions prior to bundling. In many cases, a mastic seal is made at the jacket, under and over the shield wires. In this case, it is imperative that the wires are kept separate for the distance required to make the seal. Crossed wires will create an area which is impossible to seal and could lead to moisture ingress and failure. If cable is unjacketed concentric neutral, bind the neutrals at the point specified in the instructions.

Copper tape shields may unravel after cutting. Use either a piece of adhesive-backed copper strip (if supplied) or solder tack the overlap where it will be removed. Use a hose clamp or constant tension roll spring to tear the copper tape against. For longitudinally-corrugated shields (LC), use the end of the knife blade to flip up the edge of the overlap at the desired cutback. The LC shield will tear around the cable at that point. For both LC and copper tape, ensure that no sharp edges are sticking out.

For cables with a lead sheath or continuously corrugated metallic shield, remove the tube without cutting through to the underlying semicon. Avoid belling the end of the sheath, unless specified in the instructions. Belled lead is common for lead-wiped joints only.

SEMICONDUCTIVE LAYER
Remove the extruded semiconductive layer. This is the most critical step in any splice or temination installation. Any nick through this layer into the insulation must be sanded out or discharge will occur and could lead to failure. A variety of semicon removal tools are available which limit the depth of the cutting blade to a dimension less that 90% of the semicon thickness. Any sharp knife will work as long as great care is taken to only score through the semicon part way.

When using a knife, make a ring cut at the desired length. Next make cuts along the cable length of 1/2" to 3/4" apart. The wider the strip, the more difficult the strip is to remove. Use pliers to raise the leading end of the semicon off the insulation. Once the edge is separated, the entire strip can be slowly peeled back to the ring cut. After removing the semicon layer, inspect the insulation surface for knife cuts. Rubber cables can be bent slightly to open up any cuts a the ring cut. The process of tearing off the strips at the cutback must not result in raising the remaining semicon off the insulation. Buff the exposed insulation with non-conductive abrasive grit to remove scratches and nicks. Deep cuts cannot be repaired and the damaged end should be cut off to start a new termination (or splice). Use 120 grit or finer to repair nicks and 240 grit to finish the insulation.

CLEANING SOLVENTS
Solvents should be used with lint-free cloths. Do not pour solvents directly onto cable insulation. Read solvent manufacturer's instructions thoroughly. Many cleaners have been developed to replace 1,1,1 - trichloroethane, and these may leave a residue which will not evaporate. Be sure to wipe off this residue prior to continuing with the installation. Wipe cloths in the direction of the semicon layer, but avoid direct contact with the semicon. Solvents will remove carbon from the semicon and deposit it on the insulation.

700 Industrial Drive
Lexington, South Carolina 29072
Phone: 1.800.845.8507
Fax: 1.803.951.1142
www.na.prysmian.com/energy

CONNECTOR

Remove the insulation to fit the connector. Avoid nicking the conductor strands. Remove enough insulation to allow crimp connectors to "grow" without pushing into insulation. Follow connector manufacturer's instructions for use of oxide inhibiting compounds, crimp tools, dies, etc. When splicing, be sure to slide on components prior to crimping the connector. This includes LC connecting rings, if used. When terminating with large pad terminals, ensure components will fit over the pad before crimping.

Recommendation are believed to be reliable. Prysmian assumes no liability whatsoever in connection with this information.

Splicing

GENERAL

Splices are more than just back to back terminations. Terminations are typically live-front (except for elbows), which means that the surface is not at ground potential. Splices are fully shielded devices, and therefore, have significant internal electrical stress over the connector area and the semicon cutbacks. Stress grading at the two semicon cutbacks is accomplished as in terminations, i.e. with stress cones or stress grading layers of either tape, premolded rubber, heat- or cold-shrink components. Over the connector area, a conductive electrode, or Faraday cage, may be employed, or stresses may be controlled with stress grading layers. In addition to handling the electric stress, a splice "rebuilds" the cable, replacing insulation, shielding and jacketing. Splices should meet the requirements of the latest revision of IEEE 404.

Pay particular attention to the connector requirements of the manufacturer. Improper selection or installation can lead to a thermally unstable connection and to failure.

When reshielding splices, ensure that the metallic shielding applied (typically tinned copper mesh or braid) is of adequate size for the application. Shielding should match the cable's shield if it is to carry neutral current of meet the same short circuit rating of the cable. When externally grounding splices, any wires or braid exiting the splice jacket must be sealed. Braids must be solder blocked to prevent wicking of moisture into the splice. Also ground leads must be encapsulated in sealing mastic at the splice jacket.

700 Industrial Drive
Lexington, South Carolina 29072
Phone: 1.800.845.8507
Fax: 1.803.951.1142
www.na.prysmian.com/energy