Cable Lore

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by Power Cable Engineering and Research

ANACONDA

Cuts and Breaks in Cable Jackets and Insulations

Webster defines a troubleshooter as "A skilled workman employed to locate trouble and make repairs in machinery and technical equipment". A cable troubleshooter thus can be defined as a skilled cable man employed to determine the cause for a cable fault and suggest remedial action to prevent recurrence of the problem.

A cable troubleshooter's first reaction to a problem is to gather facts. These facts fall into two categories.

1.0 The stresses in the environment to which the cable was exposed.

- 1.1 Electrical
- 1.2 Thermal
- 1.3 Chemical
- 1.4 Physical or mechanical

2.0 A visual inspection of the cable exterior to see whether there are cuts or breaks in the jacket and if so, whether the insulation has also been damaged.

Breaks or cuts in the jacket or insulation provide valuable evidence toward attributing an assignable cause for cable failure. This Cable Lore is written primarily to assist in identifying evidence that is available upon close examination of such cuts or breaks.

Key IPEC personnel have more than 100 years of combined experience investigating failures of cables in the field or after destructive tests in the laboratory. Literally thousands of jacket and insulation breaks have been seen. These occurred either intentionally during destructive testing or inadvertently during cable installation or service. Three conclusions are apparent from this wealth of experience.

(1) Upon inspection, jacket and insulation cuts or breaks can be classified into one of eleven identifiable basic types.

(2) Each of the eleven basic types of cuts or breaks have identifying characteristics or fingerprints that are useful in tracing the cause of damage.

(3) An inspection and assignment of type should eliminate over 80% of the possible causes for cuts or breaks. This means the troubleshooter can concentrate, with a high degree of confidence, on the remaining 20% in his effort to establish the most likely cause of damage in a given cable failure.

The following outline has been prepared to assist in classifying the type of cut or break. It lists clues, symptoms and possible sources for damage. The facts together with knowledge of the environment will hopefully "drain the swamp and make the alligators visible."

S. Bunish

CABLE CUTS AND BREAKS (Continued)

TYPE OF CUT OR BREAK	APPEARANCE	CLUES	SOURCES	SYMPTOMS	OCCURRENCE	COMMENTS
(1) Knife	Edges are clean. Usually have a dull, polished appearance.	Length, direction and depth of cut.	(1) Lead stripper knife set too deep.	Cut parallel to the longitudinal axis of cable. Length varies from inches to a continuous cut for many feet.	Infrequent	Usually caught during rewind. If cut is deep enough to cut into the insulation the cable would probably fail the final voltage or corona test.
			(2) Knit line (extrusion) cold compound, cured lump of material or silicone or lubricant contamination.	Longitudinal break or weak spot in the insulation will usually separate when insulation is bent back, conductor side out.	Infrequent	Generally cable should fail factory voltage test. Difficult for those not experienced with extrusion to interpret.
			(3) Sharp instrument not permanently mounted, for example a hand held knife. Carelessness during termination, splicing, sabotage or vandalism.	Cut could be longitudinal or radial — shallow or deep. From less than 1" long to about 4" long.	Frequent	If cut occurred in the factory, it should be picked out during final voltage or corona testing.
			(4) Sharp instument permanently mounted. For example, sharp burrs in a conduit or sharp corners.	Cuts usually longitudinal shallow to deep and with a scoured appearance on the surface. Sometimes surface has shaved appearance, depending on the angle of the cutting edge. Damaged shields.	Frequent	Damage usually occurs during cable installation.

CABLE CUTS AND BREAKS (Continued)

TYPE OF CUT OR BREAK	APPEARANCE	CLUES	SOURCES	SYMPTOMS	OCCURRENCE	COMMENTS
(2) Compression cut or break	Edges of cut or break are ragged, rough or perforated.	Deformed cable, broken tapes, damage localized—pinched appearance—conductor damage.	Impact from falling objects, runovers, crushing, excessive sidewall pressure, dig-ins.	Damage usually confined to area under point of impact. Cut sometimes has a perforated appearance.	Frequent	With Power Cables, damage usually occurs during installation. With Portable Cables, damage usually occurs in service.
(3) Breaks resulting from exposure to temperature extremes.	Edges have appearance of broken glass. Cable exposed to high temps will often craze on bending.	*Low Temperature* Adjacent areas are flexible on returning to room temperature.	Long time exposure to arctic temperatures result in vitrification.	Usually a single radial break or a dendritic like fracture.	Frequent	Minimized by proper material selection.
		High Temperature Adjacent areas are permanently hardened.	Excessive overloading with poor heat dissipation or long term exposure to high ambient temperature.	Radial break or a crazed surface upon bending.	Frequent	Minimized by proper cable derating and ventilation.
(4) Tensile break	Edges usually ragged.	Conductor pulled in two.	Excessive tension during pulling.	Cable necked down.	There should be no occasion for this type of break.	Usually a laboratory occurrence—cables in service would have their conductor pulled in two much in advance of polymer components being pulled in two.
(5) Burn	Break shows evidence of carbonized char.	Charred jacket.	Flame impingement, arcing, molten metal, tracking.	Charred surface or charred dendritic patterns.	Frequent	Cables usually in vicinity of welders or under conditions favorable for tracking to occur.
(6) Electrical rupture	Charred round hole.	Burn through to the conductor with evidence of carbonized char and molten metal on conductor.	Dielectric breakdown of the insulation. A good probability preceded by mechanical damage to the insulation.	Charred opening extending to the conductor.	Frequent	Breakdown usually traceable to prior insulation damage. On very old cables could be result of deterioration due to natural aging.

CABLE CUTS AND BREAKS (Continued)

TYPE OF CUT OR BREAK	APPEARANCE	CLUES	SOURCES	SYMPTOMS	OCCURRENCE	COMMENTS
(7) Abrasion	Surface appears thinned and rougher than the original surface.	Cable surface shows wear and appearance of being rubbed away.	Rubbing against another object or dragging over an abrasive surface.	Jacket worn away. Usually localized.	Rare in Power Cables. More frequent in Portable Cables.	Would most probably occur during installation with Power Cables.
(8) Fatigue break from bending				Should not occur in Power Cables — conductors would break long before coverings.		
(9) Chemical	Crazing on bending, softening, swelling, vitrification.	Cracks and crazing — ozone; softening and swelling — hydrocarbons; vitrification — radiation sulfuric acid.	Neoprene jacket cables in vicinity of electrical arcing. Exposure to gamma rays exposure to certain chemicals.	Damage fairly universal — especially at sharp bends.	Potential for occurrence significant enough to warrant proper choice of materials for specific environments.	Ozone cracks most likely with Neoprene jackets.
(10) Extrusion defects	Skip in the covering or insulation of new cables.	Insulation under jacket or interior of cable visible.	Rubber starvation in the screw of extruder or an obstruction in the extrusion set-up.	Defect usually visible on inspection.	Infrequent	If occurrence is in insulation there is a high probability of picking up in subsequent voltage or corona tests. Jacket skip could theoretically get by a final test. Would have to be picked up visually on rewinding.
(11) Corona Cut	White deposit on surface and erosion.	Erosion of surface, white coating.	Unshielded cable in contact with a grounded surface.	White coating on jacket surface, cracking or sizzling noise and smell of ozone.	Significant enough to choose proper cable and materials.	Occurrence can be minimized by following guidelines for shielded cable in IPCEA.