Using Craftsmanship to Detect Defects and Improve Reliability

By Glen Bertini, Novinium

The P1816 guide, which will be available this year, begins where component installation instructions end. The P1816 guide, also known by its long title, "Guide for Preparation Techniques of Extruded Dielectric, Shielded Cable Rated 2.5 kV through 46 kV and the Installation of Mating Accessories," provides the consensus best practices required to provide decades of reliable service.

The guide includes cable construction fundamentals, jacket removal, insulation shield removal, insulation removal, conductor shield removal, insulation chamfering, insulation cleaning, strand preparation, connector installation and more. The writing group of P1816 included circuit owners, component manufacturers, consultants and myself.

My own interest in P1816 is the result of studying hundreds of component failures and working to determine the root causes of each. Our firm, Novinium, is in the reliability business. We get a close look at the craftsmanship of circuit owners and contractors throughout the world. An integral part of our business involves transplanting our craftsman into utility operations, learning each utility system, and adapting our practices to mesh with those of the circuit owner.

From our experience, very few component failures are manufacturing defects. They do occur, but at Novinium, we have observed manufacturing defects in components in less than five percent of those studied in 25 years. Instead, the vast majority of component failures are caused by lapses in craftsmanship.

When a craftsmanship error was implicated, our firm reviewed the accessory instructions to see if the craftsman had ignored a specific installation requirement. It turns out that there are two main cases of craftsmanship failure: surface preparation and cutback requirements.

Surface Preparation

A component manufacturer's installation instructions usually specify that a certain length of cutback is required, and further states that the interface should be free of defects and contamination. However, the instructions often fail to define what levels of defects and contamination are acceptable. Because there always are small defects and slight contamination, the issue is left to the subjective judgment of the craftsman.

For example, a Maryland utility provided craftsmanship training to allow guided tunneling crews to install medium-voltage splices. The utility trainer, a three-decade veteran, defined the size of an acceptable craft-induced defect (which is a euphemism for a knife cut) in the cable insulation using what he called the thumbnail test: If the thumbnail stopped at a suspected defect when one slid it around the circumference of the prepared insulation interface, it was considered a defect. Otherwise, it was acceptable craftsmanship.

The drilling crews used the thumbnail test for a couple of weeks. Several weeks and 24 failures later, I became involved. Using our quality guidelines, my team excavated and replaced 100 percent of the splices installed over the previous several weeks. The "thumbnail" standard was entirely subjective, open to interpretation, and plain wrong. In fact, as P1816 teaches, any prospective defect, visible to the naked eye, is a defect.

Cutback Dimensions

As I stated earlier, about half of all craftsmanship errors that lead to failure are dimensional. The appropriate cutback dimensions are found in the component instructions. Dimensions are commonly measured with a ruler by a craftsman, who knows the appropriate dimension, measures the dimension using the correct starting point, places the mark in the proper location, and makes the cutback with precision. Occasionally, cramped conditions, inclement weather, poor nighttime visibility, or a momentary distraction, can lead to a cutback that is not consistent with the design requirements of the component. If the craftsman is diligent, another measurement will be made of the actual cutback to confirm the result.

However, cutbacks are occasionally wrong, which create potential reliability issues.

At Novinium, we have virtually eliminated cutback errors by replacing the ruler with a life-size, "anatomically correct" template. Figure 3 illustrates such a template in use. The template shows the conductive insert length, which otherwise would be invisible. Another template feature is a pre-crimped view of the assembly (to the right in the illustration) and a post-crimped view. Since the process of crimping or swaging lengthens the assembly, having both views allows the craftsman to confirm all of the dimensions before committing to an irreversible crimp.

We create and use templates on all dead-front components at Novinium. To create our templates, we slice an actual component along its axis and make careful measurements of the internal and external dimensions. We then make an engineering drawing at a one-to-one scale with all of the

My Gripe with Grease

Silicone grease is applied to interfaces intended to be permanent. The grease reduces the assembly friction, making component installation easier. The grease is actually a mixture of silicone oil (branched siloxanes) and fumed silica. The oil provides the lubrication; the silica is there to give the grease body, making it easier to apply. Silica by itself is not a lubricant. The grease is also a good dielectric and fills imperfections on reliability-critical interfaces. The good news is that craft errors are mitigated by the presence of the grease; the bad news is that the oil portion of the grease is fugitive, so the mitigation is temporary. Put another way, grease hides the sins of poor craftsmanship for several years. The sins reappear in the future as deferred reliability issues.

Figure 3. A craftsman in Alberta uses a template to make sure all of the cutbacks line up within appropriate tolerances. The component is shown in cut-away, so that the craftsman can visualize how his work fits within the internal mechanisms of the component.

subcomponents accurately depicted. Important dimensions are added and the template is laminated, so that it may be used many times – even in foul weather. Unfortunately, component suppliers do not supply these today because end users do not require them. The cost of a disposable paper template is pennies and a more durable plastic template is just a few dollars. A single reliability problem with URD cable results in a cost of about $5,000, so the cost of purchasing a template can pay for itself quickly.

Reliability

Mastery of craftsmanship improves reliability. Because the cost of failure is so high, the cost of implementing the teachings of the forthcoming P1816 guide and the use of templates for dead-front component installation pay for themselves in much less than a year. More important, the surest way to improve end-user satisfaction is to avoid outages. At my firm (where we are rehabilitating aging circuits), our post-rehabilitation failure rate is less than 0.5% and improving. This level of performance is better than that obtained with most new cable installations.

Using the best available technology is important, but mastery of the craftsmanship is an absolute requirement. While the P1816 guide itself may not be published for months, there is a way that craftsman around the world can get started learning these best practices immediately. Because these practices are so critical to my firm's reliability mission, we created a five-part eLearning course covering the entirety of P1816. The free introductory lesson is available to all at www.knovinium.com. There is a nominal charge for each learner to take the remaining four modules of the course. The eLearning experience includes proficiency testing and certification of completion requiring a score of 80% or better.

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