Quality Assurance for Cables from the End User Perspective

Mark **SMITH**, Robert **REEPE**, Southern Company (USA) mrsmith@southernco.com, rbreepe@southernco.com
Michael **SMALLEY**, WEC (USA) michael.smalley@wecenergygroup.com
Josh **PERKEL**, EPRI (USA) JPerkel@epri.com
Andrew **MORRIS**, ComEd (USA) andrew.morris@ComEd.com
Nigel **HAMPTON** UL Solutions (USA) nigel.hampton@UL.com

ABSTRACT

The use of underground cables, both at HV and MV, continues to increase, driven primarily by the goals of integrating new power sources and improving customer reliability and resiliency whilst reducing utility operation and maintenance costs. A key enabler of this strategy is the reliability and longevity of the cables being used. This paper examines how the Quality Assurance *process may need to evolve in the future to continue to support the end user's underground grid.*

KEYWORDS

Quality, Asset Management, Process Improvement

INTRODUCTION

Although the historical performance of current generations of cables is generally good, [1] it is recognised that the cables installed today will see very different service environments than those of even the recent past. There will be higher expectations of reliability and longevity: life expectations may approach 50 to 60 years (rather than the 30 commonly discussed today). The loads / temperatures will be higher due to increased use of electric power, and the traditional use and generation patterns will become more peaked. The performance of cables, both extruded and lapped, has improved since the earliest days with the use of jackets, water blocking, engineered materials and improved factory processes. One of the processes that is shared with both the factory and the end user is that of Quality Assurance. This activity encompasses the checks on purity, dimensions, construction, and final withstand and partial discharge tests, with critical information being passed to the end user.

AVAILABLE SOURCES OF INFORMATION

The reliability of the installed cable system requires that a number of different processes [2] function correctly throughout to ensure a product that is consistent both within the production run and between different runs of similar cables. To accomplish this, a number of mutually supportive quality control activities are defined in the end-user and industry standards. The key activities involved are Factory Testing, Certified Test Report (CTR) Review, Receiving Inspection (end user and manufacturer), Field Observation and Qualification Testing. The end user and industry standards (AEIC, CENELEC, IEC, ICEA) describe the minimum tests / frequencies and minimum criteria for different voltage classes of cable.

The tests in Table 1 [2][3] and the electrical tests constitute a chain of custody from dimensions (conductor, insulation and screen thicknesses and concentricity, etc.), crosslinking (hot creep/set) to electrical testing (AC withstand and PD). Together, all these tests and associated documentation are the "Factory Test" that will establish the quality of the whole cable. A number of factors that impact the effectiveness of the "Factory Test":

- Appropriateness of the test – The tests must measure an attribute of the cable that impacts the performance of the cable system that the end user will install and operate.
- Skill/experience of the operator – These are crucial in ensuring that tests are executed correctly.
- Frequency of testing – The frequency at which the tests are carried out is important for the outcomes; if the frequency of testing is low, the chance of missing a nonconformance increases significantly.
- Criteria for success – Each test will have a set of values within which the performance meets the needs of the utility. These criteria must ensure that the cable system performance is not only consistent within a run of cable but also between different runs.

Table 1. MV production Sample Tests - Extruded

<table>
<tr><th rowspan="2">Tests</th><th colspan="2">Frequency of Tests</th></tr>
<tr><th>IEC</th><th>AEIC*</th></tr>
<tr><td>Conductor Dimension Exam</td><td rowspan="3">4-20 km
1 sample
20-40 km
2 sample
40-60 km
3 sample</td><td>Min 1 per 3 km</td></tr>
<tr><td>Dimension Check Extruded Layers</td><td>Min 2 for 3-19 reels
Min 10% for > 19 reels</td></tr>
<tr><td>Hot Set</td><td rowspan="2">Min 3 per extrusion run</td></tr>
<tr><td>Strip Tension</td><td rowspan="4">Testing not required</td></tr>
<tr><td>Water Penetration</td><td>Min 1 per 15 km</td></tr>
<tr><td>CPVC's**</td><td>Min 1 per 3 km</td></tr>
<tr><td>Material Ageing</td><td>Min 1 per Lot</td></tr>
</table>

* Based on typical production lengths
** Contaminants, Protrusions, Voids, Convolutions

Since the various specification and standard-writing organizations establish the documented requirements, limits are consensus-based. Many utilities and cable manufacturers have additional and tighter requirements to help ensure that cables are manufactured for their needs. The key is to specify appropriate requirements that help ensure that the cable is well-made without adding constraints that lead to unnecessary testing or unjustified costs. The most common enhancements to the consensus standards are increased frequency of testing (e.g., dimensions determined on every core reel) and / or tighter tolerances (e.g., maximum permitted strip force of 85 N rather than 107 N), etc.