The Need to Update / Upgrade Test Procedures for Connectors Used in MV Underground Joints

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ABSTRACT

The authors have investigated factors that contribute to overheating of connectors installed in medium voltage joints. Tests completed on connectors for 1/0 AWG and 750 kcmil conductors confirm that the currently used test for evaluating connectors for use in joints is insufficient. Furthermore, the Success Criteria for these tests cannot be modified to better align the results with connector performance within joints. Therefore, a new test procedure is required to ensure that connectors installed in joints on underground cable systems are better able to operate at their rated temperature.

KEYWORDS

Cable, Accessory, Connector, Reliability

INTRODUCTION

Although medium voltage (MV) cable systems are rated for operation at temperatures in the range of 90 to 105 °C, the vast majority operate at temperatures much lower than this (in the range 35 to 45 °C for North America). As a result, reports of problems / failures with overheating connectors are very rare. However, the authors have noted that overheating problems are more regularly being reported when the cable systems are operated above the normal 30 to 45 °C range, yet puzzlingly below the rated temperatures. The causes of this phenomenon were not clear though a number of hypotheses are being discussed. Consequently, it was decided to conduct a number of designed experiments to try and bring some clarity to this issue.

Initial work reported in Jicable11 [3] focused on reported problems that appeared to be particularly severe in applications such as feeders that were more heavily loaded and used conductor containing strand fill materials. Yet, the load did not exceed the cable design rating. This work confirmed that issues did indeed exist and indicated that there was a minimal impact of the strand fill material commonly used in North America. Thus, additional work was undertaken on a wider population of test samples.

The tests employed in the study reported here was patterned on the load cycle test of IEEE Standard 404™ [2] and the ANSI C119.4 [1] protocols. Both of the tests considered a range of cases with a large number of replicates and thereby provided a good level of confidence. The results indicated that, contrary to expectation, the connector inside many MV underground cable joints will overheat when the current is increased to achieve a cable conductor temperature of 90 °C, the rated temperature for typical cable systems. This implies that there is an increased risk that those cable joints may fail prematurely in the field if they are loaded up to or near their design rating.

The IEEE 404 test program is designed to be a design qualification test for the dielectric system of cable joints only, the connectors are not explicitly considered. It obliquely addresses the current carrying capability of connectors by requiring that connectors used for MV underground cable joints be qualified using the ANSI C119.4 test protocol. The ANSI standard is widely used to evaluate connectors in the overhead environment and tests bare connectors (without the splice housing) on bare conductors. It is important that the most recent embodiment [1, 2] of the ANSI standard is limited to temperatures below 93°C or 100°C for copper. Available data from the tests conducted by the authors indicate that the ANSI test protocol is likely not adequate for evaluating the performance of connectors installed in MV joint housings.

TEST MATERIALS

The components used to construct the test samples consist of different connectors (compression and bolted) for two conductor sizes 1/0 AWG (53.49 mm^2) and 750 kcmil (380 mm^2) Aluminium conductors employing the extruded mastic strand fill method common in North America. The test samples are described in Table 1.

Table 1: Cable Conductor Size, Connector & Connector Die used in the ANSI and IEEE style tests

Size	Connector	Die	Set ID
1/0 AWG 53.49 mm^2	Compression A (5/8 size)	Narrow	111
	Compression A (5/8 size)	Wide	112
	Compression B (840 size)	Narrow	121
	Compression B (840 size)	Wide	122
750 kcmil 380 mm^2	Compression C	1	711
	Compression C	2	712
	Compression D	1	721
	Compression D	2	722
	Shearbolt E	N/A	73
	Shearbolt F	N/A	74

All connections and joint installations were prepared strictly in accord with the manufacturers instructions. Where these instructions were unclear, the manufacturers were contacted for clarification. Heatshrink and Coldshrink joint bodies (7 types) and 25 kV jacketed cables with strandfilled Aluminium conductors (2 types) were used in the IEEE 404 style tests. All of the cables, connectors, and joint bodies were represented to have passed all of the relevant standards and are / could be used on North American cable systems.