The need to update / upgrade test procedures for connectors used in MV underground joints

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Although 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). Consequently 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.

The testing, patterned on the load cycle test of IEEE Standard 404, was undertaken on a range of cases with a large number of replicates and provided a good level of confidence. The results indicated that, contrary to expectation, the connector inside many medium voltage (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 for the qualification of the dielectric system of cable joints. It obliquely addresses the current carrying capability of connectors by requiring that connectors used for medium voltage 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 the connector bare (without the splice housing). Available data from the tests conducted by the authors indicates that the ANSI protocol is likely not adequate for evaluating the performance of connectors installed in MV joint housings.

Data was gathered in such a way that it was possible to compare the thermal performance (temperature achieved and the temperature stability) of connectors in tests patterned after the IEEE 404 load cycle test protocol with the results of the ANSI C119.4 Current Cycle Submersion Test (CCST). The results showed:

- Very different temperature performances between the approaches
- The temperatures achieved by connectors at quite moderate conductor temperatures are likely to have very deleterious consequences for the components of joints
- The ranking of connector thermal performance seen in the full scale tests did not match that of the ANSII test

This paper will describe

- Industry Background
- Experimental Design (Connectors, Dies, Joint Technologies, Sizes)
- Equilibrium temperatures achieved for selected cable conductor temperatures
- Effects that may be ascribed to the experimental factors
- Attempts to reconcile ANSI C119.4 results with those of practical cable joints
- Nonlinearities observed and the challenges of a thermal modeling approach
- Implications for infrared (IR) monitoring programs
- Potential for the development of an improved test protocol

The data suggest that, for the cable accessories currently being installed:

- Most connectors (>90%) will operate at temperatures higher than the cable conductor
- The positive delta between connector and conductor temperatures does not lead to significant performance issues for cable conductor temperatures below 70 to 80°C (Figure 1)
- Continual operation close to or above 90°C is likely to result in quite large (>15°C) temperature deltas
- The expedient approach of using the ANSI tests for overhead connectors to demonstrate that connectors may perform well for MV cable joints (data would be expected to fall upon the diagonal line in Figure 2) is very likely not robust - see variations in connector rank for installations i, VI, IX {XI shows best performance [lowest temperature] within the application but is non compliant in the simple ANSI test} and inconsistent compliance i & ii, iii & iv, V & VI
- There does not appear to be a practical way by which the ANSI C119.4 criteria (compliant / non compliant) can be made to correlate with the real connector thermal performance seen in the IEEE 404 style load cycle tests, which better represent how the connectors are used
- The use of models of the cable accessory to qualify connectors in cable joints is believed to be practical and attractive as it provides information on the particular architecture of interest

Figure 1: Maximum temperatures achieved by connectors inside joints for selected conductor temperatures (40°C and 90°C on x axis) in a Box and Whisker format

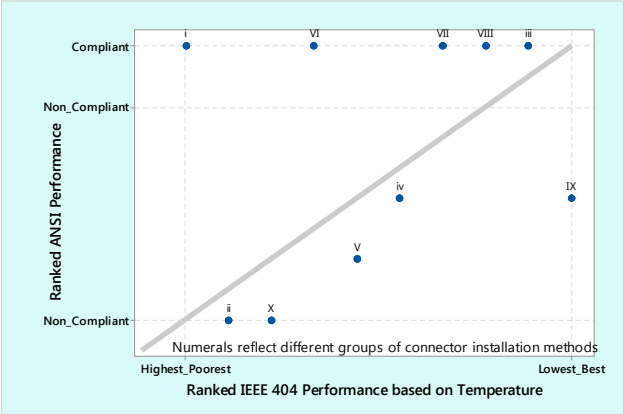

Figure 2: Correlation of rank order from IEEE 404 style and ANSI tests - the diagonal line indicates good agreement between the ranks