



## NEW APPROACH TO MEASURE CONDUCTOR TEMPERATURE DURING TYPE TEST

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### ABSTRACT

*The latest edition of IEC 60840 gives guidance how to measure the conductor temperature during the heating cycle voltage test as part of the type test sequence. Although that method is very practical, sometimes a heating cycle test has to be interrupted because one of the thermocouples gives a too high or low temperature. To overcome the problem of biased temperature measurements, we slightly changed the way the thermocouple is in contact with the conductor. The new approach is described in detail as well as our experience. Also, recommendations are given to improve IEC 60840.*

### KEYWORDS

Type test, Heating cycle, Temperature measurement

### INTRODUCTION

A heating cycle test is an essential part of type test procedures for medium voltage, high voltage and extra high voltage cables and their accessories, usually combined with voltage application. The latest edition of IEC 60840 gives some possible methods how to determine the conductor temperature during the heating cycle test as part of the type test sequence. Before it was published, KEMA High Voltage Laboratory utilised already the method using a reference cable and we have seen that this method is very practical. Nevertheless, sometimes a heating cycle test has to be interrupted because one of the thermocouples measures incorrect and has to be re-installed.

To overcome the problem of biased temperature measurements, we have slightly changed the way the thermocouple is in contact with the conductor. The concept of two separate loops, one test loop and a reference cable, is maintained. Instead of drilling a hole through the insulation and inserting a spring-loaded thermocouple rod, a small section of the insulation is carefully taken out and some thermocouples are fixed between the wires of the stranded conductor or in the interface between a solid conductor and conductor screen. The insulation taken out is then inserted back which restores the thermal characteristics.

This IEC 60840 also advises to use thermocouples a certain distance apart to demonstrate minimum heat transfer in axial direction. Experience has learned that the heat transfer from the middle to the ends of the reference cable is negligible when this cable is of sufficient length.

### GENERAL

A heating cycle test is an essential part of type test procedures for medium voltage, high voltage and extra high voltage cables and their accessories, usually combined with

voltage application. During the heating phase, the cable conductor is heated by means of current until a certain temperature is reached and subsequently this temperature is maintained for some time. Based on IEC standards, this temperature is 5 to 10 K above the maximum conductor temperature during normal operation and is to be maintained for 2 hours. After these 2 hours, the cable is allowed to cool down to ambient, or close to ambient. This heating cycle test is to simulate expansion and contraction during operation and to thermally stress the insulation.

Since the cable under test is to be subjected to various voltage stresses, if not during the heating cycle test then after this test, a direct measurement of the conductor temperature is not possible. The procedure preferred by KEMA High Voltage Laboratory to perform this heating cycle test is by using two identical cables: one test loop and a so-called reference cable of sufficient length. The test loop contains the cable with or without accessories to be tested and is laid out on the floor of the laboratory. The reference cable is also laid out on the floor, near the test loop but avoiding thermal influence. Thermocouples are used to measure the conductor temperature of the reference cable. Small holes are drilled through the insulation and outer layers of the reference cable to allow small stainless steel rods containing the thermocouples to touch the conductor. By means of springs, sufficient contact pressure between rod and conductor is maintained throughout the whole test period. Figures 1 and 2 show the thermocouple and the mounting device. This contact pressure and the fact that the thermocouple is at the bottom of the rod ensures that the correct temperature of the conductor of the reference cable can be measured. The reference cable is heated by means of (induced) current through the conductor and this current is measured using a CT. As long as the (induced) current through the conductor of the test loop is kept on the same level as that of the reference cable, the conductor temperature of the test loop is the same as the reference cable. A small correction may be applicable for (extra) high voltage cables to compensate for dielectric losses.



Figure 1 Thermocouple rod (left) and mounting device (right)