Automated Temperature Monitoring and Control System for Type and Design Testing of High Voltage XLPE Insulated Cable Systems

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ABSTRACT

Some tests under the electrical/design tests sequence in accordance with IEC and/or ANSI/ICEA standards involve testing of XLPE cable systems at particular conductor temperature while the system is energized at High Voltage (HV).

In this paper we discuss an upgraded temperature monitoring and control system, which is based on fibre-optic technologies for temperature monitoring under HV. Since the fibre-optic cables used to relay the temperature information from the temperature sensor to the receiver are insulated, the fibre-optic cable end (sensor) could be attached safely (directly) to energized conductors, which enables implementation of control of the heating current continuously and automatically.

KEYWORDS

IEC, ANSI, ICEA, XLPE, HV, temperature, heating cycle, fibre-optic, sensor.

INTRODUCTION

Polymeric insulated underground power cables are steadily replacing the oil and paper insulated cables to the extent that nowadays for the vast majority of the new cable system installations the only considered cable designs are the XLPE insulated cables.

One of the consequences is that there is an increased demand for testing of such systems at High Voltage (HV) test facilities around the globe.

Some of the required electrical type or design tests as per IEC [1], [2] and ANSI/ICEA [3] standards (and testing in accordance with combined standard test procedures and requirements [4]) involve testing of cable systems at particular conductor temperature while the system is energized at HV. In order to do that, in the standards, it is suggested to arrange a “dummy” cable loop that is heated in the same manner as the test loop, but not energized at HV. This method allows for temperature measuring that is straight forward and used at many test facilities.
However, the test loops for HV cable systems of 150kV and above require larger clearances and occupy a significant footprint. This would normally mean that test setup arrangements including a test loop and a “dummy” loop could only fit in very large test halls.

One way to fit HV XLPE insulated cable systems to test in smaller size labs would be if the footprint was reduced by elimination of the “dummy loop”. In that case another way of measuring the conductor temperature would be mandatory.
In our test facilities, initially, we came up and used a smart telemetry temperature monitoring system that was based on wireless temperature transmitters and receivers. That system had some shortcomings and we decided to develop another one that would be a superior replacement.

In this paper we discuss that newly developed upgraded temperature monitoring and control system (based on fibre-optic technologies) and its successful application during heating cycle voltage tests of HV cable systems.

ELIMINATION OF THE “DUMMY” LOOP

The test protocol used during a thermal cycling test requires that the cable system undergo a heat cycling voltage test for a relatively long period of time (20 days). The test involves heating, soaking, and cooling the cable system for 20 cycles while the system is energized at a specified HV dependent on the voltage class of the cable and accessories. Each cycle is 24 hours long. The heating is maintained for 8 hours. During the first 6 hours the cable conductor must reach a specified temperature and this temperature must be maintained within a 5^{o} C limit for the following 2 hours. After that the cable is allowed to cool down naturally for 16 hours.

As already mentioned, when performing this test, the standards suggest to build a control loop (“dummy loop”) utilizing an identical cable. This loop is heated in the same manner as the test loop and the temperature of its sheath and conductor are continuously recorded. The difference between the loops is that the “dummy loop” is not energized at HV and therefore thermocouples can be directly attached to the conductor in order to measure its temperature.

Due to space limitations of our facilities we have initially eliminated the need for building an extra loop by inventing a way to transmit data under voltage using a wireless data logging transmitting system. Basically, the conductor temperature was measured by means of a “smart link” telemetry system [5] which was installed on a length of the same cable as that which was under test. Thermocouples were directly attached onto the surface of the conductor of the control cable and were connected to a wireless transmitter nearby. The control cable was installed between the outdoor terminations as seen in Fig. 1 (in series with the test loop). The conductor in this length of cable carried the same current as the test loop conductor.
Such use of this “smart link” allowed for electrically insulated temperature measurement points directly on the conductor and on the sheath. However, the monitoring equipment used at the time in our HV labs during heat cycle voltage testing could not be used to automatically control the test loop’s heating cycles since it was unable to continuously transfer data under HV. The inability to automate the long duration testing used to directly lead to additional costs and extra time associated with the successful performance of a heating cycle voltage test.

Presently new fibre-optic based technologies for temperature monitoring under voltage are readily available on the market. We identified one that had the