BONDING AND GROUNDING OF POWER CABLE SCREENS

(M. Dmitriev, 152 pages, 2010)

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Introduction

High-voltage 6-500 kV power cables of modern designs have been increasingly used for transmission and distribution of electricity, especially in large cities and industrial enterprises, where the level of electricity consumption and load density are quite significant. The most widespread are single-phase power cables with insulation made of cross-linked polyethylene.

The high voltage level of the core of a single-phase cable in networks of classes 6 kV and above leads to the need of use a metallic screen made in the form of wires and/or tape. Its main purpose is to ensure the uniformity of the electric field acting on the main insulation of the cable, which is achieved only in the case of screen's grounding. It is convenient to ground the screen at the ends of the cable, since there are switchgears with good quality grounding. The screens of single-phase 6-500 kV cables are made of a well-conducting material (copper or aluminum); their grounding simultaneously at both ends of the line, unless special measures are taken, leads to the appearance of significant currents in the screens comparable to the current of the core, both in normal mode and in short circuits.

Currents and voltages in the screens of single-phase cables are caused only by the single-phase design of these cables and have no relation with their insulation material (cross-linked polyethylene, etc.). Measurements made on many cable lines of various voltage classes of 6-500 kV indicate that when using single-phase cables, it is necessary to pay increased attention to the choice of screens connecting and grounding and to carry out appropriate calculations.

As an example, for a typical 10 kV cable line let's present the results of measurements of currents in screens grounded at both ends of the line. Cable parameters: core cross-section 500 mm^2, screen cross-section 95 mm^2, length 2500 m, three phases laying in flat-formation. In normal steady-state operation with currents of 186 A in the cores of the three phases, the measured current in the screen of each phase was 115 A. If the specified cable line reaches the rated load (the current in each core is about 700 A), the current in each screen will increase proportionally and become 430 A, which is unacceptably much for a screen section of 95 mm^2. Fortunately, the cable under consideration is saved from damage caused by an uncalculated thermal regime only by its relatively small core load, this also saves many other incorrectly designed and already in operation cable lines with single-phase cables.

Another example is a group of single-phase cables 630/35 mm^2 of voltage class 35 kV (1500 m long, three phases laying in flat-formation), feeding one of the metallurgical plants. Measurements in normal steady-state operation showed that with a current in the cores of about 900 A, the current in the screens was approximately 300 A. Such a large current, flowing for a long time in the screen with a cross section just of 35 mm^2, led to the screen melting into the cable insulation, i.e., in fact, to damage the cable along whole its entire length.

The method of connecting and grounding the cable screens noticeably affects:

- the current in the screen, and if the screen is incorrectly grounded, it can damage the cable;
- on the power losses in the screen, which means – on its thermal regime and throughput;
- on the magnitude of the voltage on the screen relative to the ground, i.e. on the reliability of the cable and the safety of its maintenance;
- on the electrical parameters of the cable (longitudinal active and inductive impedances).

A curious fact is that as of 2008-2009 in Russia, many of designing and operating organizations have no idea about the problems caused by incorrect grounding of single-phase cable screens. That’s why the book was prepared and contains a lot of necessary information:

- the issues of connection and grounding of screens of three-phase groups of single-phase cables 6-500 kV;
- analytical expressions for the currents and voltages of the cable screens are obtained, allowing to justify the choice of the method of grounding the screen, the need for partial grounding of screens, partitioning screens, the use of transposition screens (cross bonding);
- formulas for determining the longitudinal active and inductive impedances of the cable (positive and zero sequences) are presented, which should be used in the calculations of normal modes and in the analysis of short-circuit currents in the network;
- the results of generalizing calculations for 6-500 kV cables, calculation examples are given;
- recommendations for improving the thermal resistance of screens and protecting the outer sheath from overvoltage are provided;
- there is also the necessary background information for screens bonding calculation for any three-phase group of single-phase 6-500 kV cables.