AMPACITY CALCULATIONS FOR CABLES IN STEEL CASINGS AND MULTIPLE CABLES PER PHASE

Wael **MOUTASSEM**, USi (USA), wmoutassem@usi-power.com
George J. **ANDERS,** Technical University of Lodz (Poland), george.anders@p.lodz.pl

ABSTRACT

This paper analyzes the impact of phase arrangement on the total ampacity for two different installations. The first installation involves a three-phase circuit with two cables-per-phase directly buried in flat configuration and with multiple-point bonded shields. The second installation consists of two three-phase circuits with the cables in ducts inside a magnetic steel casing, with single cable per phase and cross bonded shields. The paper presents the results of the ampacity and current splits in the phases for over twenty phase arrangements in flat configuration, and identifies the configurations providing the best (highest) or worst (lowest) total ampacities. For cables buried in ducts inside a magnetic steel casing, the casing creates an electromagnetic interaction with the conductor and shield currents, which results in large cable deratings due to high eddy current and hysteresis losses in the steel casing wall. This paper presents the various possible phase arrangements within the steel casing and identifies the best and worst ones with respect to total ampacity.

KEYWORDS

Cable ampacity, magnetic casing, multiple cables per phase

INTRODUCTION

When large amount of power is to be transmitted, the limit on the currently manufactured cable sizes often forces a use of multiple cables per phase. When the sheaths are multipoint bonded, large circulating currents in the sheaths or screens can develop. The circulating current losses depend to a large extent on the phase orientation of the cables forming a single circuit. In this paper, about 20 different phase arrangements for circuits with 2 cables per phase are examined with the aim of identifying the worst and the best configurations from the ampacity point of view.

The second aspect considered in this paper is the influence of a magnetic casing on the cable ratings. Such installations are becoming quite common when the cable circuit has to cross a road or a railway tracks as well as in onshore landings of submarine export cables.

When cables are placed in magnetic pipes, the allowable conductor current can be significantly reduced due to the hysteresis and eddy current losses generated in the casing. Additionally, the pipe may have an aprecaible effect on the conductor and sheath currents. This effect depends to a large extent on the arrangement of the phases inside the magnetic casing. The topic is examined in this paper and illustrated with practical numerical examples.

INSTALLATIONS EXAMINED

Cables directly buried

The case study analyzes the methodology for solving the conductor and circulating current sheath currents in a single cable circuit consisting of two cables per phase. The final current distribution in the conductors and sheaths is computed herein according to the IEC60287-1-1 [1] and IEC 60287-1-3 [2] standards, with required alterations provided via guidance points of the CIGRE TB prepared by WG B1.72. The methodology applies the Complex Impedence Method (CIM) described also in [3] and [4].

The cables are directly buried as shown in Fig. 1, with several combinations of the phase arrangements.

The cables are laid out in a flat formation with equal spacing of 400 mm between two neighboring cables, and at burial depth of 1 m. The shields are assumed to be multiple-point bonded. The system frequency is 50 Hz.

The soil and backfill thermal resistivities are assumed to be the same and equal to 1.00 K-m/W. The ambient temperature is assumed to be 20 °C.

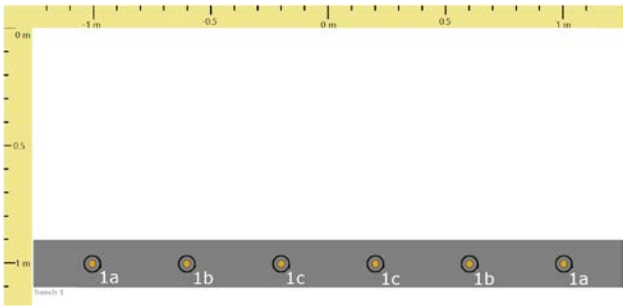

Fig. 1: Installation cross section (to scale)

Cables in a steel casing

In this installation, the cables are installed in plastic ducts, which in turn, are placed in a large magnetic pipe, referred to as casing, as illustrated in Fig. 2. Three different phase arrangements are investigated as indicated in this figure.

The steel casing has an inner diameter of 1220 mm, and a wall thickness of 8 mm. The cables are laid out in a circumferential formation with equal spacing at a radial distance of 457 mm from the center of the casing. The top of the casing is buried at a depth of approximately 2.5 m. The shields of the cables are cross bonded, and each circuit has a single cable per phase, resulting in two circuits in the casing.

The soil and casing fill thermal resistivities are assumed to be equal to 1.00 K-m/W and 0.50 K-m/W respectively. The ambient temperature is assumed to be 20°C. The system frequency is 60 Hz.