IMPACT OF ELECTROMAGNETIC FIELDS ON CURRENT RATINGS AND CABLE SYSTEMS

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ABSTRACT

The work presented in this paper is a summary of the technical brochure being prepared by CIGRE Working Group B1.23 that focuses on single conductor, high voltage, ac, land cable systems, excluding pipe type and GIL cables. It considers extruded dielectric insulation, laminar dielectric insulation, single-point bonding or balanced cross-bonding, so that there is minimum ground return current. Magnetic field management techniques are discussed that are currently used for underground transmission cable systems and the shielding effectiveness of practical methods is quantified. The cable current de-rating aspects of the various field management methods are presented.

This paper does not cover any environmental or biological effects of EMF and does not discuss any specific levels of EMF.

KEYWORDS

impact of EMF, transmission cable (de) rating, EMF mitigation impact on cable rating.

INTRODUCTION

Numerous methods have been devised by electric utilities and various research organizations to manage power frequency magnetic fields levels in the vicinity of underground cable systems. Information is available in CIGRE TB 373, from Working Group C4.204 [1], concerning considerations for implementing the various methods, their impact on construction and their cost effectiveness. H their impact on cable rating, losses, installation and operational costs needs to be evaluated. In particular, there are differing opinions about the de-rating effects of HV transmission cables placed in ferromagnetic shielding enclosures such as pipes or casings. Past work at CIGRE and elsewhere addressed magnetic field calculation procedures (with and without ferromagnetic components); however, they do not address the current rating reduction of the magnetic field management methods or their practical applications to electric utility systems [1, 2, 3].

In most cases mitigation measures have disadvantages: either the current rating may decrease or the costs will increase. Some mitigation methods are very cost effective, for example, an optimal choice of the phase sequence for double circuits/systems.

The first question to answer is where mitigation is required:

a) to reduce the magnetic field directly above the cable circuit, or
b) to reduce the field to a certain limit at a specified distance from the cable circuit, or
c) to minimize the width of the corridor within which a specified field limit is exceeded.

Some mitigation devices are more suited for reducing the field directly above the cable circuit, while others are extremely effective in mitigating the field at a distance. Installation in air is easier than directly buried and in some cases de-rating is negligible. This paper deals only with systems of balanced currents; that is with limited zero sequence current

GENERAL PRINCPLES

The thermal design of HV underground cable circuits is calculated according to related international standards and commercially available software packages. It is calculated using the thermal properties of the cable and its surroundings and is referred to maximum conductor temperature of the cables.

The current carrying capacity of a cable circuit is the maximum steady state current that can be transmitted without exceeding the limit established for the conductor temperature at any point along the circuit, according to the local environmental conditions and load factor. The calculation method for continuous load (load factor 100%) is given in IEC 60287, whereas for cyclic loads (load factor less than 100%) is given in IEC 60853. For emergency situations where a magnetic field limit is to be achieved, the transient temperature calculations are performed according to IEC 60853.

The design of any mitigation device will be based upon either continuous, emergency or cyclic load conditions, and will be selected after defining the magnetic field limit. Most magnetic field mitigation devices are installed in urban areas, where there are variations in the laying configuration or depth, lengths of parallels with other circuits or crossings with heat sources, that locally modify the current carrying capacity of the cables. The HV system designer considers all these different conditions and finally determines the rating of the circuit as the minimum of all the local current carrying capacities of the cables.

The losses induced by the shielding devices introduce additional heat sources into the cable trench that increase the surrounding reference soil temperature seen by power cables, and the rating has to be recalculated. The possible reduction of current carrying capacity depends mainly on the shielding method, and on a variety of minor