Choice of electrically conductive plate for shielding the magnetic field from underground high voltage cables

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ABSTRACT

This paper reports the Finite Element Method (FEM) simulation of electromagnetic shielding for a 275 kV underground power system. The allocations and current rating of high voltage cables are predefined. The maximum magnetic field exposed to public area should be limited to 100 µT. FEM simulations are executed for selecting the best solution, considering the shielding effect, installation, additional energy loss and cost etc.

KEYWORDS

Electromagnetic shielding, resistive energy loss, FEM simulation

INTRODUCTION

A 275 kV underground power system will be installed in allocations as shown in Fig. 1 and Fig. 2. The current rating of high voltage cables is predefined. The maximum magnetic field exposure to public areas should not be over 100 µT.

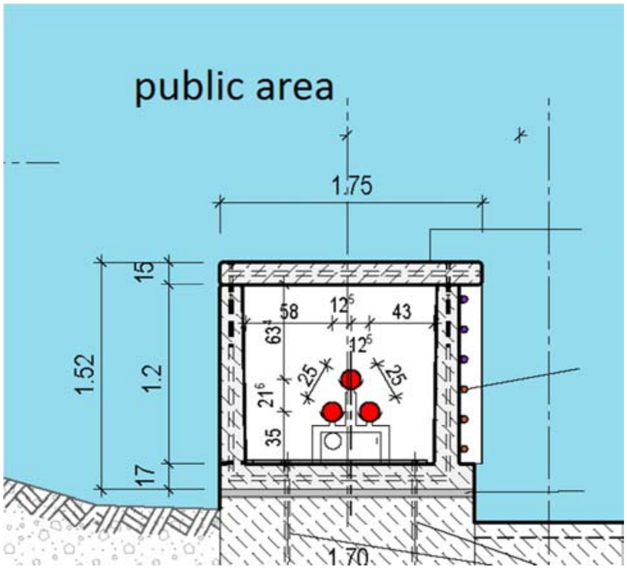

Fig.1 allocation of high voltage cables, shown as color circles. They are surrounded in a concrete wall.

METHODS FOR REDUCING MAGNETIC FIELD FROM HIGH VOLTAGE CABLE

For high voltage cable loaded with current a magnetic field is generated according to Biot-Savart law.

$$B=\mu_0 H = 2e\text{-}7 * I/r \qquad [1]$$

Where I: loading current in Ampere, r: distance to cable in meter, and B: magnetic field in Tesla. As seen from the equation of [1] the magnetic field can be reduced by either increasing the burial depth r or reducing the total current I.

In a balanced three phase's circuit the summed current of three phases is zero, the magnetic field at large distance should be zero. At small distance a trefoil distribution of symmetric geometry with phases as close as possible results in best reduction of magnetic field. If space allowed trefoil distribution is therefore preferred, as for the case of Fig.1. If cables have to be installed in parallel flat formation like in Fig.2, smaller magnetic field can be obtained by arranging the current phases in a right way.

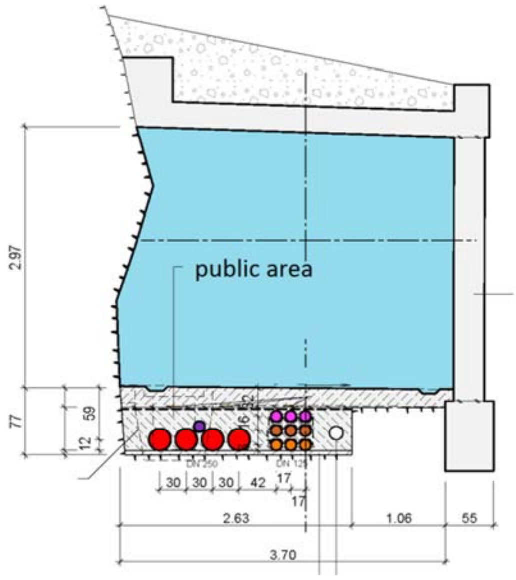

Fig.2 allocation of high voltage cables, shown as color circles. They are buried in earth.

If the maximum magnetic field limit cannot be obtained by optimum of cable allocation, magnetic shielding has to be applied using additional conductive or magnetic material. Induced current with opposite phase will be generated in the conductive shielding material and the corresponding magnetic field compensates the original magnetic field from the high voltage cable. The shielding effect of using magnetic material is due to its high permeability. It provides an easy path for magnetic field to which it is exposed, and collects and concentrates magnetic field in it and hence has shielding effect for outside area.

A well-known side effect of using magnetic shielding is the additional energy loss in the shielding material. It depends on the character and geometry of the material. Large energy loss heats the cable system additionally and can reduce the current rating. It should be limited to an accepted range.