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Eddy current losses

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Currents flowing in power cables conductors induce currents in metallic screens which cause additional losses and result in a lower ampacity. Heating effect of circulating currents may be avoided when metallic screens are bonded at one point or are cross-bonded. However, losses due to eddy currents remain, irrespective of the bonding arrangement.

Accurate calculation of eddy currents losses is very complex because the eddy currents are the consequence of different and recurrent components. The first-order eddy current in a metallic screen is generated by the internal current of its own axial conductor and the external currents of neighbouring conductors. It induces in turn a magnetic field which originates a second-order eddy current. The calculation process has to be repeated until the successive subsidiary order currents have negligible effects on the total eddy current.

Cable ratings require metallic screen loss factor λ_1 computation whose exact development involves a summation of a series within a series... Early investigations, from years where no computer was available, led to analytical simplifications and semi-empirical equations, and have been included in today's IEC Standards. Calculation is made for single circuits with trefoil or flat formations. Three terms are used to approximate the first-order eddy current losses, subsidiary orders current losses and losses due to internal current.

The IEC Publication 287-1-2 provides a method for a three phase double circuit in flat formation. Fundamental formulae were made suitable in tabulated coefficients form because their evaluation « calls for expertise in computer programming which might not be readily available in general commercial situations ». Original formulae are indeed tedious and intractable for hand calculations. On the other hand, previous cable ratings according to IEC Publications are really suitable for a personal computer use. The integration of tables in a computer program for further interpolations may seem ambiguous, while coding a few overlapped loops is a basic practice. Moreover, the IEC document advertises in its scope that « the development of empirical formulae for a limited range of coefficient is under consideration ».

The following paper recalls some principles to calculate a series solution for eddy currents losses in metallic screens. It presents simple guidelines to implement the computation for any number of circuits, in any configurations, with high order currents. Some representative examples are illustrated by computations with a design aid software. They show that high orders are sometimes required to reach convergence, and diagrams compare these results with IEC approximations. Finally, the technology of different metallic sheaths is discussed (influence of the material, sheath thickness, distance between cables, spacing between circuits, time sequence of the currents,...).