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The additional losses in the metallic screens of high voltage cables

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Abstract:
The continuously increasing request for electric power implies a correct dimensioning of the cables conductor. The choice of cables with larger cross-sectional areas is a consequence of this, in order to reduce the energy losses.
An analytical study of the losses generated in the metallic screens has been done, it allows an appropriate calculation of the cable current carrying capacity applicable to copper wire screened H.V. extruded cables. The study has been carried out for EPR insulated cables but can also be extended to XLPE insulated cables up to 400 kV.

Résumé:
La demande sans cesse croissante d'énergie électrique nécessite un dimensionnement correct des conducteurs des câbles. La conséquence en est le choix de câbles avec des conducteurs de section plus grande et conçus pour réduire fortement les pertes d'énergie
Cette étude analytique des pertes générées dans les écrans métalliques permet un calcul correct de la capacité de transport des câbles H.T. à isolation EPR et écran fils cuivre, et peut être étendue également aux câbles XLPE jusqu'à 400 kV.

1 – Introduction

For oil filled or impregnated paper insulated traditional cables, as well as in some types of modern extruded insulated cables, the metallic screen is normally constituted by an impervious lead alloy or corrugated aluminium sheath, that combines the following electrical and protective functions:
a) Limiting the electrical field; carrying the capacitive and leakage current, carrying the earth fault current of the system and ensuring in some cases the continuity of the earthing.
b) Protecting from possible accidental electric contacts with the core and preserve the insulation against the entrance of moisture and contaminating agents that may be present in the cable surroundings.
The well proven experience gained from the early sixties with Ethylene Propylene Rubber (EPR) insulation has demonstrated that this cables do not need any water barrier. This is a consequence of the good resistance of the insulation to moisture that has also been confirmed by long term water treeing tests carried out in laboratory. This property allows to design a cable without any metallic sheath, replaced by a copper wires or tapes screen. A large amount of 132 kV cables made with this design have already been successfully installed since the seventies and are currently used now by ENEL up to the voltage of 150 kV.

Figure 1 - 150 kV E PR copper wire screen cable with large conductor

Additional losses in the screen
The current flowing in the conductor generates in the cable metallic screen currents that cause additional losses due to the Joule effect. These losses will cumulate with the conductor losses giving the result of reducing the cable permissible current capacity.
The thermal equilibrium of a single-core cable in which the current flows is obtained from the following formula:

$$\theta_C - \theta_A = (W_C + 1/2\, W_D)\, T_1 + (W_C + W_D + W_S)\,(T_3 + T_4)$$

Where the symbols are those indicated and calculated accordingly the IEC 60287 standard "Calculation of the continuous current rating of cables (100 % load Factor)" [1]
Taking into consideration the metallic screen losses, these are expressed as a function of the