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THE USE OF INSULATED WIRES MILLIKEN CONDUCTORS IN HIGH VOLTAGE POWER TRANSMISSION UNDERGROUND AC LINES

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ABSTRACT

These last years have pointed out a significant increase of the power that needs to be transported by underground power cables. As a consequence, large cross section conductors, up to 2500mm² are now customarily used.

The CIGRE group B1-03 has completed in 2005 a work that analyses the actual AC resistance of these large cross section conductors as a function of their design.

The authors discuss about the implication of this work on the design of typical high power transmission lines, from the cable production, accessories, unit length, transportation, civil works, and operation.
They sketch the limits of use of each conductor design as a function of the projects key parameters.

They give the AC resistance measurement results on some conductors of different designs.

KEYWORDS

HIGH VOLTAGE, CONDUCTOR, POWER LINK

INTRODUCTION

These last years have pointed out a significant increase of the power that needs to be transported by underground power cables. As a consequence, large cross section conductors, up to 2500mm² are now currently used.

These conductors have diameters in the range of 60mm, which is not small as compared to the skin effect depth. CIGRE set up in 2002 a working group B1-03 to assess the AC resistance of large conductors. Its final report was released in 2005 in the Technical Brochure 272 [1]. It showed the interest of Milliken conductors with insulated wires.

We will recall the conclusions of this work and give practical examples of the use of the recommended conductors.

AC RESISTANCE OF LARGE CONDUCTORS

CIGRE WG B1-03 chose a pragmatic approach that is based on measurements. It built the following table:

Type of conductor	**k_s Value**	**k_p Value**
For copper enamelled wires and aluminium wires	0.25	0.15
For copper oxidised wires (value based on study for uni-directional only)	0.35	0.20
For inter layer insulated copper.	0.50	0.37
For uni-directional stranding of copper bare wires	0.62	0.37
For bi-directional stranding of copper bare wires	0.80	0.37

The AC to DC resistance of a conductor is given by the formula :
$R=R'(1+y_s+y_p)$

$$y_s = \frac{x^4}{192 + 0.8\,x^4} \quad \text{with} \quad x^2 = \frac{\omega\mu}{\pi.R_{dc}}.k_s$$

$$y_p = 2.9\frac{x_p{}^4}{192+0.8\,x_p{}^4}\left(\frac{d_c}{s}\right)^2$$

with $$x_p{}^2 = \frac{\omega\mu}{\pi.R_{dc}}.k_p$$

d_c is the conductor diameter
and s is the axial distance between conductors.

Let's concentrate on the skin effect, as in practical conditions; the proximity effect is smaller than 1/10th of the skin effect.

The authors have manufactured cables of 1600mm², 2000mm² and 2500mm² cross section, which are in accordance with the last release of IEC 60228.
The resistance of these cables has been measured using the previously reported method [2, 3]
The samples length is 12m. All conductor wires are connected together at each end, the distance between voltage probes is 8m.