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Selection and dimensioning of DC overhead line insulation

Current and future technical network solutions, standardization Harmonization of African Standards through adoption of international standards; or where necessary their adaptation to African conditions

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General

Selection of DC overhead line insulation in Russia have stemmed from approaches that were developed while generalizing the service experience of the world's first ±400 kV DC Volgograd-Donbass, overhead line and designing of the ±750 kV DC and 1150 kV AC lines from Kazakhstan to Russia. More recently the techniques were supplemented by state-of-the-art findings on comparative breakdown strength and pollution resistance of different insulators.

It can be assumed that technique of selection of DC overhead line insulation, developed and tested in Russia, will be useful for UHV OH DC line projects in Africa.

1. Determination of pollution level (PL)

Thus field studies of the UHV DC overhead line route permit determination of the flashover performance ($\overline{\lambda}_{flash}$), the pollution degree of insulators $\overline{\chi}$ and consequently, according to Table 1, standard specific creepage distance λ and PL.

Table 1

Determination of λ and PL

$\overline{\lambda}_{flash}$, cm/kV	$\overline{\chi}$, μS	λ, cm/kV		PL
		λ_{ac}	λ_{dc}	
>1.2 to 1.5	>1 to 3	1.6	2.8	1
>1.5 to 1.9	>3 to 6	2.0	3.5	2
>1.9 to 2.3	>6 to 12	2.5	4.3	3
>2.3 to 2.7	>12 to 20	3.1	5.4	4

>2.7 to 3.3	>20 to 30	3.7	6.4	>4

2. Selection of an insulator type

Three basically different line insulators can be considered as likely candidates of use on UHV DC overhead lines, viz. glass and porcelain cap-and-pins, porcelain long-rods, and composite insulators.

The guiding principle of selecting optimum insulator type is to make allowance for standard hazardous service conditions, i. e. exposure of wet polluted insulation to the operating voltage. On the final account, it is this exposure that determines the string length, the tower height, and thus the cost of the line as a whole.

AC and DC tests of artificially polluted cap-and-pins, porcelain and composite longrods have made it possible to compare their dielectric strength at identical pollution levels and to find a number of coefficients/

3. Selection of insulation levels

To find the creepage distance L one must use the following additional coefficients:

K_L: structural features of the insulating part;

K_n: non-linear flashover voltages of wet polluted insulators and their length;

K_d: difference between DC and AC flashover voltages of insulators;

K_m: different pollution resistance of different insulating materials;

K_c: effect of different string configurations on the flashover performance of the wet polluted strings;

The creepage distance L selected from the needed λ_{dc}, the maximum operating pole-ground voltage U_{m0} and the additional correction coefficients:

$$L = \lambda_{dc} \cdot U_{m0} \cdot K_L \cdot K_n \cdot K_d \cdot K_m \cdot K_c .$$

4. Selection of insulators on the basis of their wet polluted flashover performance

The 50% DC flashover voltages of a wet polluted string must not be below the specified test voltage $U_{test} = K_s \cdot U_{m0}$ at the specified test specific surface conductivity χ_{test} of the pollutant layer, where K_s is the safety factor.

Values of χ_{test} are found in Table 2 with allowance for the PL and the material of the insulating body.

Table 2

PL	χ_{test}, µS	
	Porcelain and glass units	Composite insulators
1	5	2
2	10	5
3	20	10
4	30	20