Common Data and Formulas

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MINIMUM PERMISSIBLE BENDING RADII WHEN LAYING

Multi core cables		All single core cables
Up to $U_0/U=0.6/1kV$	Over $U_0/U=0.6/1kV$	
12 x d	15 x d	15 x d

d : outer diameter of the cable

PERMISSIBLE PULLING FORCES

Means of pulling	Type of cable	Formula	Factor
With pulling head attached to conductors	All types of cable	$P = \sigma . A$	$\sigma = 50$ N/mm² (Cu conductor) $\sigma = 30$ N/mm² (AL conductor)
With pulling stocking	All wire armored cables	$P = K . d^2$	K = 9 N/mm²

P Pull in N;
A Total cross sectional area in mm² of all conductors (but not screen or concentric conductor);
d Outside diameter of cable in mm ;
σ Permissible tensile stress of conductor in N/mm² .

INDUCTANCE :

$$L = 0.05 + 0.2\, ln\left(\frac{k.s}{r}\right) \text{ [mH/km]}$$

Where : In trefoil formation: k=1
In flat formation: k=1.26
s = distance between conductor axes (mm)
r = conductor screen radius (mm)

INDUCTIVE REACTANCE :

$$X = 2\pi\, f\frac{L}{1000} \text{ [Ω/km]}$$

Where : f = frequency (Hz)
L = inductance (mH/km)

CAPACITANCE :

$$C = \frac{\varepsilon}{18\, Ln\left(\frac{d_o}{d_i}\right)} \text{ [μF/km]}$$

Where : ε = relative permittivity of the insulation (for XLPE insulation ε =2.3)
d_o = external diameter of the insulation (mm)
d_i = diameter of conductor including conductor screen (mm)

IMPEDANCE :

$$Z = \sqrt{R_{ac}^2 + X^2} \text{ [Ω/km]}$$

Where : R_{ac} = AC resistance of conductor (Ω/km)
X = reactance (Ω/km)

SHORT CIRCUIT CURRENT :

Copper conductor : $$I_s = 226 \frac{S}{\sqrt{t}} \sqrt{Ln \frac{t_f + 234.5}{t_i + 234.5}} \quad [A]$$

Aluminum conductor : $$I_s = 148 \frac{S}{\sqrt{t}} \sqrt{Ln \frac{t_f + 228}{t_i + 228}} \quad [A]$$

Where : S = cross section (mm²)
t = short circuit duration (sec)
t_i = initial temperature before the short circuit (90°C for XLPE cables)
t_f = final temperature after the short circuit (250°C for XLPE cables)

TEMPERATURE CORRECTION FACTORS FOR CONDUCTOR RESISTANCE

FOR COPPER CONDUCTORS :

$$k_t = \frac{254.5}{234.5 + t} \qquad R_t = \frac{R_{20}}{k_t} \times \frac{L}{1000}$$

FOR ALUMINUM CONDUCTORS :

$$k_t = \frac{248}{228 + t} \qquad R_t = \frac{R_{20}}{k_t} \times \frac{L}{1000}$$

Where :

k_t is the temperature correction factor ;
R_{20} is the conductor resistance at 20°C, in Ω/km ;
R_t is the conductor resistance at t°C, in Ω/km ;
L is the length of cable, in m .

ELECTRICAL FIELD (FOR MV, HV & EHV CABLES):

Conductor screen : $E_i = \dfrac{U}{r_i \, Ln\left(\dfrac{r_o}{r_i}\right)}$ **[kV/mm]** ; **Insulation screen :** $E_o = \dfrac{U}{r_o \, Ln\left(\dfrac{r_o}{r_i}\right)}$ **[kV/mm]**

Where : r_i = radius of conductor screen (mm)

r_o = radius of XLPE insulation (mm)

U = voltage across insulation

CHARGING CURRENT (FOR MV, HV & EHV CABLES):

$$I_C = U_0\,\omega\, C = U_0\, 2\pi\, f\, C\, 10^{-3} \quad \text{[A/km]}$$

Where : U_0 = voltage (kV)

$\omega = 2\pi f$

f = frequency (Hz)

C = capacitance (µF/km)

DIELECTRIC LOSSES (FOR MV, HV & EHV CABLES):

$$W_d = \frac{U^2}{3}\, 2\pi\, f\, C.\tan(\delta) \quad \text{[W/km]}$$

Where : U = rated voltage (kV)

f = frequency (Hz)

C = capacitance (µF/km)

tan(δ) = loss angle