4.4 INSULATION RESISTANCE OF A SINGLE-CORE CABLE

The cable conductor is provided with a suitable thickness of insulating material in order to prevent leakage current. The path for leakage current is radial through the insulation. The opposition offered by insulation to leakage current is known as insulation resistance of the cable. For satisfactory operation, the insulation resistance of the cable should be very high.

Consider a single-core cable of conductor radius r1 and internal sheath radius r2 as shown in Fig.4.4.1

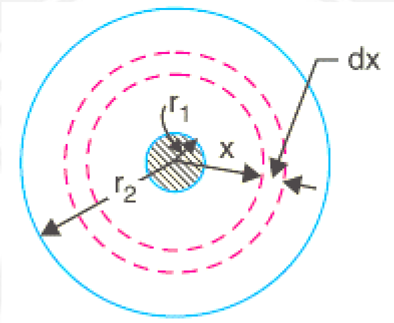

Figure 4.1.1 Single core cable

[Source: "Principles of Power System" by V.K.Mehta Page: 273]

Let l be the length of the cable and ρ be the resistivity of the insulation. Consider a very small layer of insulation of thickness dx at a radius x. The length through which leakage current tends to flow is dx and the area of X-section offered to this flow is 2π x l.

Insulation resistance of considered layer

$$= \rho \frac{dx}{2\pi x l}$$

Insulation resistance of the whole cable is

$$R = \int_{r_1}^{r_2} \rho \frac{dx}{2\pi x l} = \frac{\rho}{2\pi l} \int_{r_1}^{r_2} \frac{1}{x} dx$$

$$\therefore \quad R = \frac{\rho}{2\pi l} \log_e \frac{r_2}{r_1}$$

Problem 1

The insulation resistance of a single-core cable is 495 MΩ per km. If the core diameter is 2·5 cm and resistivity of insulation is 4·5 × 1014 Ω-cm, find the insulation thickness.

Solution:

Length of cable, $l = 1 \text{ km} = 1000 \text{ m}$

Cable insulation resistance, $R = 495 \text{ M}\Omega = 495 \times 10^6 \Omega$

Conductor radius, $r_1 = 2{\cdot}5/2 = 1{\cdot}25 \text{ cm}$

Resistivity of insulation, $\rho = 4{\cdot}5 \times 10^{14} \Omega\text{-cm} = 4{\cdot}5 \times 10^{12} \Omega\text{m}$

Let r_2 cm be the internal sheath radius.

$$R = \frac{\rho}{2\pi l} \log_e \frac{r_2}{r_1}$$

$$\log_e \frac{r_2}{r_1} = \frac{2\pi l R}{\rho}$$

$$= \frac{2\pi \times 1000 \times 495 \times 10^6}{4.5 \times 10^{12}}$$

$$= 0.69$$

$$2.3 \log_{10} \frac{r_2}{r_1} = 0.69$$

$$\frac{r_2}{r_1} = Antilog \frac{0.69}{2.3}$$

$$r_2 = 2r_1$$

$$r_2 = 2 \times 1.25$$

$$r_2 = 2.5\ cm$$

$$\therefore \quad Insulation\ thickness = r_2 - r_1$$

$$= 2.5 - 1.25$$
$$= 1.25\ cm$$