Concept of Corona

4

Corona

The complete disruption in dielectric strength or insulation of insulating material (air) near the surface of the conductor at certain point is called as concept of corona. Corona occurs only when the electric field intensity is greater than dielectric strength of air.

In general corona occurs around the power conductor due to two reasons:

(i) Electrical power transmission is at higher operating voltages.

(ii) Number of free electrons in the space surrounding the power conductor are more due to radio activity.

Critical Disruptive Voltage (V_d)

The voltage at which self field intensified localised ionization of air takes place is called as critical disruptive voltage (V_d).

Visual Critical Voltage

The voltage at which the visual corona begins is known as visual critical voltage. Visual glow of corona occurs at a voltage higher than the critical disruptive voltage.

Critical Voltage & Intensity

Relative density of air

$$\delta = \frac{p}{76}\left(\frac{273+\theta_0}{273+\theta}\right)$$

where, p = Barometric pressure, cm

θ = Temperature, °C

Assume relative density at θ_0 °C and 76 cm of Hg as 1

Critical Intensity

$$E_0 = \left(\frac{3\times10^6}{\sqrt{2}}\right)\delta\cdot m_0 \text{ V/m}$$

where, E_0 = Rms value of critical intensity

δ = Relative density of air

m_0 = Roughness factor

Note:

- For smooth conductors of large diameter in air at normal temperature and pressure corona begins at peak value of critical field intensity 30 kV/cm.
- m_0 = 1.0 for smooth conductors and 0.93 to 0.98 for rough conductors exposed to atmosphere.

Disruptive Critical Voltage.

(a) For 1-ϕ line

$$V_d = \frac{6\times10^6}{\sqrt{2}} r\delta m_0 \ln\frac{D}{r} \text{ Volts}$$

where, D = Spacing between conductors, in metres.

r = Radius of conductor, in metres.

V_d = Critical disruptive voltage, in volts

(b) For 3-ϕ line

$$V_d = \frac{3\times10^6}{\sqrt{2}} r\delta m_0 \ln\left(\frac{D_{eq}}{r}\right) \text{ Volts}$$

where, D_{eq} = Equivalent spacing between conductor, in metres.

Visual Critical Intensity

$$E_v = \frac{3\times10^6}{\sqrt{2}}\delta m_v\left(1+\frac{0.03}{\sqrt{\delta r}}\right) \text{ V/m}$$

where, m_v = Irregularity Factor

Visual Critical voltage

(a) For 1-ϕ line

$$V_v = \frac{6\times10^6}{\sqrt{2}} r\delta m_v\left(1+\frac{0.03}{\sqrt{\delta r}}\right)\ln\frac{D}{r} \text{ Volts}$$

(b) For 3-ϕ line

$$V_v = \frac{3\times10^6}{\sqrt{2}} r\delta m_v \left(1+\frac{0.03}{\sqrt{\delta r}}\right) ln\frac{D_{eq}}{r} \text{ Volts}$$

where, m_v = Irregularity factor
V_v = Visual critical voltage

Corona Loss

1. Peek's Formula (under fair weather conditions)

$$P_c = 243.5\frac{(f+25)}{\delta}\sqrt{\frac{r}{D}}\cdot(V-V_d)^2\times10^{-5} \text{ kW/km/phase}$$

where, V = Phase voltage, in kV (rms value)
V_d = Disruptive critical voltage in kV(rms value)
r = Radius of conductor, in metres
f = System frequency

Note:

Under stormy weather conditions use Vd as 80% of its fair weather value.

2. Peterson's Formula

$$P_c = \frac{21\times10^{-6} fV^2}{\left[\log_{10}\left(\frac{D}{r}\right)\right]^2}\times F \text{ kW/phase/km}$$

where, F = Factor which varies with the ratio (V/V_d).

Remember:

Peek's formula is used for ratio (V/Vd) greater than 1.8 and peterson's formula is used for ratio less than 1.8.

Disadvantages of Corona

- There is certain real power loss in the form of corona loss.
- Corona causes an interference with the neighbouring communication line.

Advantage of Corona

The corona will act as a safety wall to the transmission line conductors against lightening strock, in which the peak magnitude of lightning surge will dissipate in the form of corona loss.

Method to Reduce Corona

- By the use large size of conductor.
- Use bundle conductor.
- Use hallow conductor.

Remember:

- In 400/220 kV substation bus bar are in the form of hallow tube.
- DC corona loss $= \frac{1}{3}$ AC corona loss (for same line voltage).