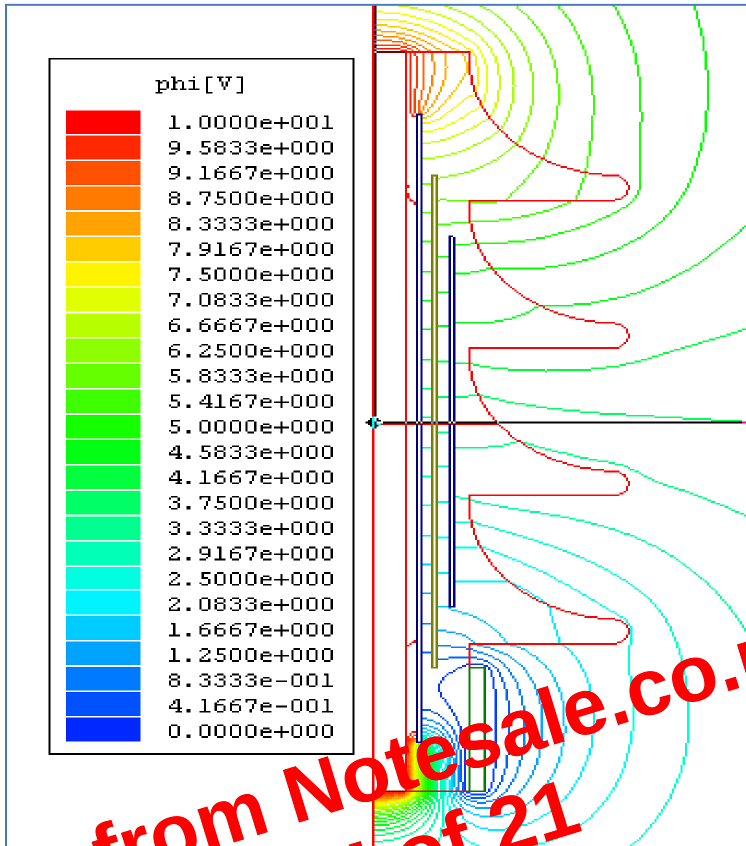
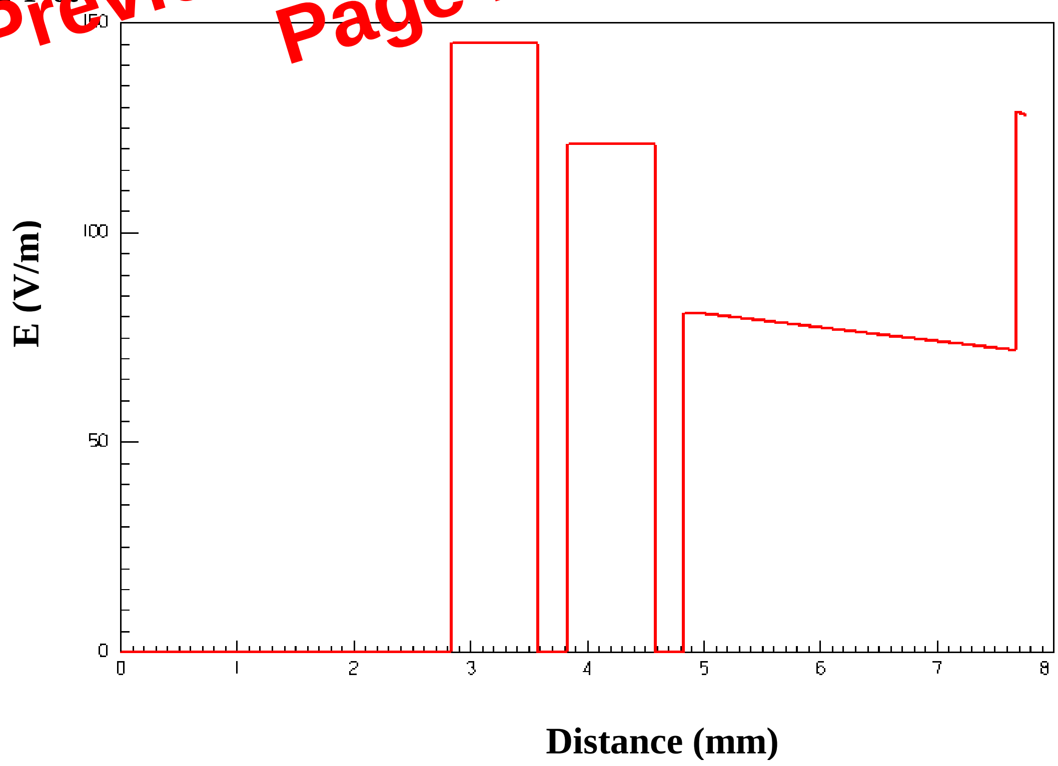
***Equipotential lines***






***E-Plot***



**<u>DESIGN OF BUSHINGS – Non-Condensor and Condensor type</u> :**

**Design a bushing for 72 kV, 800 A and p.f test voltage – 140 kV (rms), Lightning impulse voltage – 325 kV, copper conductor area = 400 $mm^2$**

**Creepage distance = 1820 mm.**

## *I. <u>Non-Condensor Bushing</u>:*

**1. Air end clearance A :**

$V_{p.f}$ = 2.2 – 3.0 kV/cm (rms)
= (140/2.2 – 140/3)
= (63.63 – 46.67) cm
$V_{LI}$ = 4.8 - 5.5 kV/cm (pk)
= (325/4.8 – 325/5.5)
= (67.7 – 59.09) cm
A = Max [63.63, 46.67, 67.7, 59.09] = **67.7 cm**

**2. Oil end clearance B :**

$V_{p.f}$ = 8 - 10 kV/cm (rms)
= (140/8 – 140/10)
= (17.5 – 14) cm
$V_{LI}$ = 15 - 20 kV/cm (pk)
= (325/15 – 325/20)
= (21.67 – 16.25) cm
B = Max [17.5, 14, 21.67, 16.25] = **21.67 cm**



**3. Radius of the conductor :**

Given area of conductor = 400 $mm^2$

$(\pi D^2/4) = 400$
D = 22.567 mm
**$r_0$ = 11.28 mm**

4. Creepage distance :

(16 – 32) mm/kV of $V_r$

Creepage distance for clean surface = 16 * 72 = **1152 mm**
Creepage distance for polluted surface = 32 * 72 = **2304 mm**

Given that., Creepage distance = 1820 mm
Therefore, it lies between 1152 mm and 2304 mm.

Inception voltage $U_e$ :

$$U_e = K\,(S/\varepsilon_r)^{0.5} \quad \text{kV}$$

Let, K = 20 (since one end of the bushing in air and other end in oil)

$\varepsilon_r$ = 2.1 for mineral oil

S = 0.228 cm (minimum distance between two foils)

Inception voltage $U_e = 20*(0.228/2.1)^{0.5}$

**= 6.59 kV**

***<u>Calculation of capacitance between foils</u> :***

Let $C_1$ be the capacitance between the conductor and the first metal foil.

Length of the conductor $l_0$ = (A+B) = 893.7 mm

Length of first foil $l_1$ = (A+B) = 541.6 mm

Mean length ($l_{01}$) = ($l_0$ + $l_1$)/2 = (893.7 + 541.6)/2 = **717.65 mm**

**Capacitance (C) = $2\pi\varepsilon_0\varepsilon_r l$ / ln ($r_r/r_{r-1}$)**

**$C_0$= $2\pi\varepsilon_0\varepsilon_r l$ / ln ($r_1/r_0$)**



$C_1 = [2\pi*(8.854*10^{-12})*2.1*0.718]$ / ln (1.356/1.128)

**$C_0$ = 0.456 nF**

($l_{12}$) = ($l_1$ + $l_2$)/2 = (541.6 + 463.64)/2 = 502.62 mm

**$C_1$ = $2\pi\varepsilon_0\varepsilon_r l$ / ln ($r_2/r_1$)**

**=** $[2\pi*(8.854*10^{-12})*2.1*0.5026]$ / ln (1.584/1.356)

**$C_1$ = 0.378 nF**

($l_{23}$) = ($l_2$ + $l_3$)/2 = (463.64 + 405.3)/2 = 434.47 mm

**$C_2$ = $2\pi\varepsilon_0\varepsilon_r l$ / ln ($r_3/r_2$)**

**=** $[2\pi*(8.854*10^{-12})*2.1*0.4345]$ / ln (1.812/1.584)

**$C_2$ = 0.377 nF**

l = ($l_{16}$ + $l_{17}$)/2 = (153.77 + 146.76)/2 = 150.265 mm

**$C_{17}$ = $2\pi\varepsilon_0\varepsilon_r l$ / ln ($r_{16}/r_{17}$)**

= $[2\pi*(8.854*10^{-12})*2.1*0.718]$ / ln (5.004/4.776)

**$C_{17}$ = 0.377 nF**

**Hence, we prove that the capacitance between the foils is almost equal and thus the voltage distribution will be uniform.**