

Understanding the Vital Role of Bushings in Power Lines

Power insulators

Insulators support and isolate electrical conductors, preventing current flow. Used in cables or equipment, they're called insulation. Specifically, insulators support power lines on poles or towers, preventing current flow to the ground.



Figure 1 - Overhead power line in Gloucestershire, England.

Figure 2 - Ceramic insulator used on electrified railways

CAD Model

The EMS electrostatic analysis module is utilized for examining 3D models of electrode devices and power-line insulators in power applications. In this example, we focus on a power-line pole featuring a three-phase insulation setup. The central-phase line operates at 80 kV rms (138.56 kV rms phase-to-phase), while the upper and lower lines operate at 40 kV rms. The model comprises aluminum conductor lines and copper

clamps connecting the conductors to silicon rubber and fiberglass insulators, which link to the tower. The electrostatic module computes the electric field and displacement field under these conditions. Results are visualized in both full 3D plots and 2D plots, including the electric field along a segment passing through air and silicon rubber ins

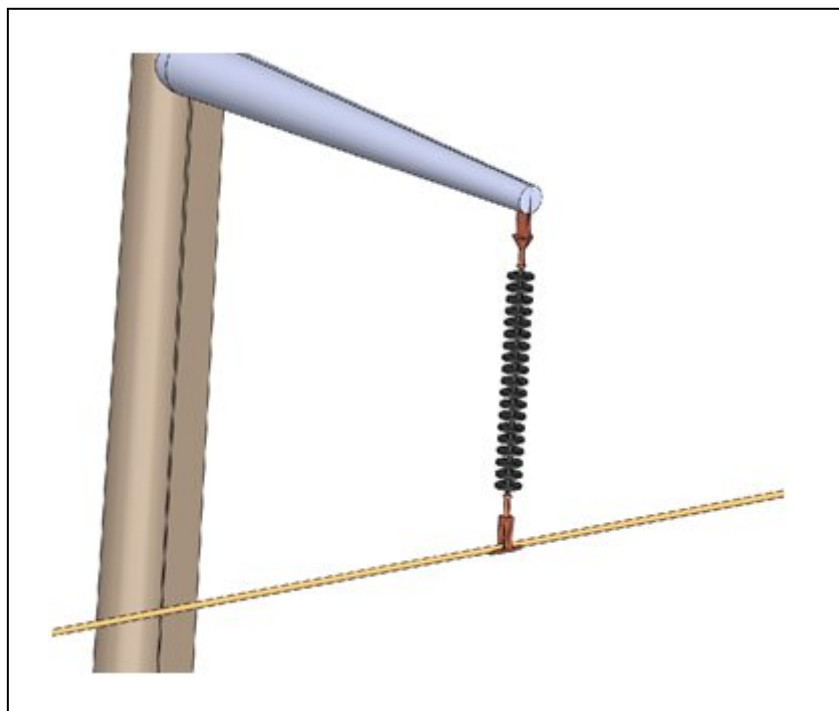
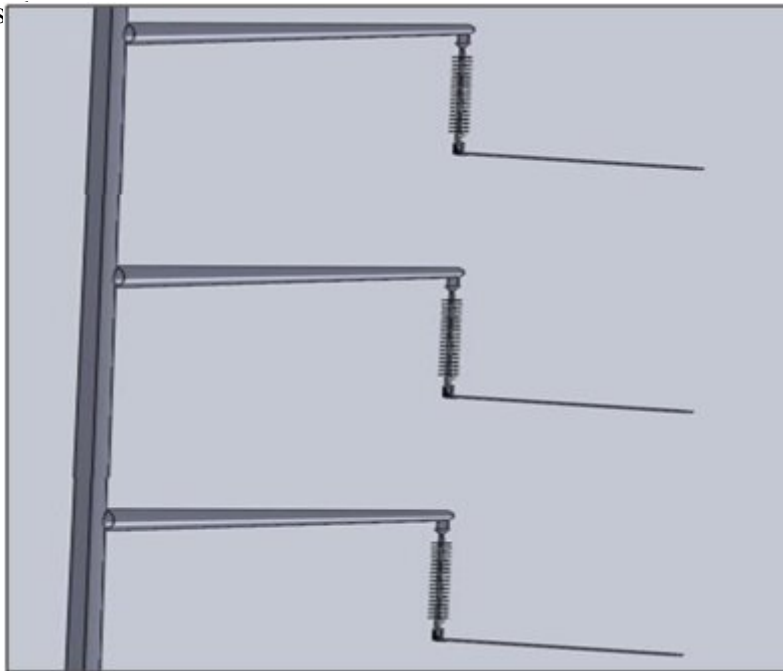


Figure 3 - Power line with Three-phase insulation scheme

middle-phase insulator

Figure 4 - Close-up view of the middle-

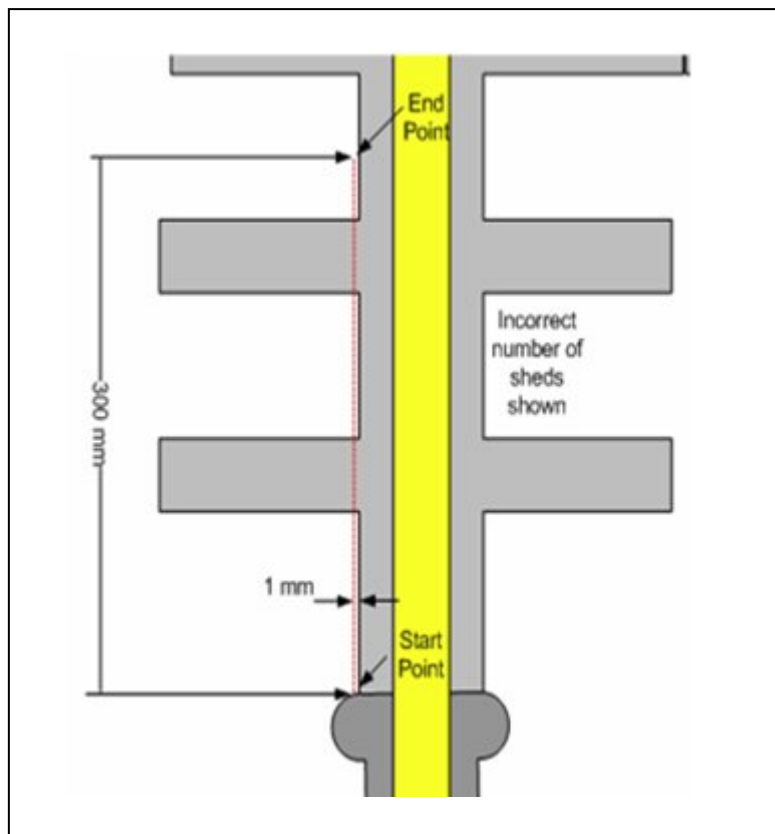
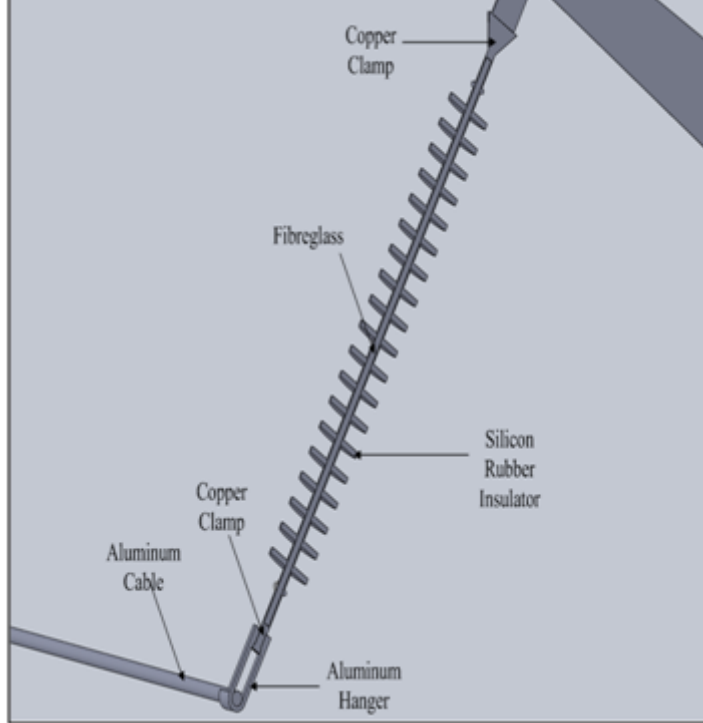


Figure 5- Close-up view of the middle-phase insulator.

*phase insulator
rubber components*

Figure 6 - Section view of the middle-

with fiberglass and silicon

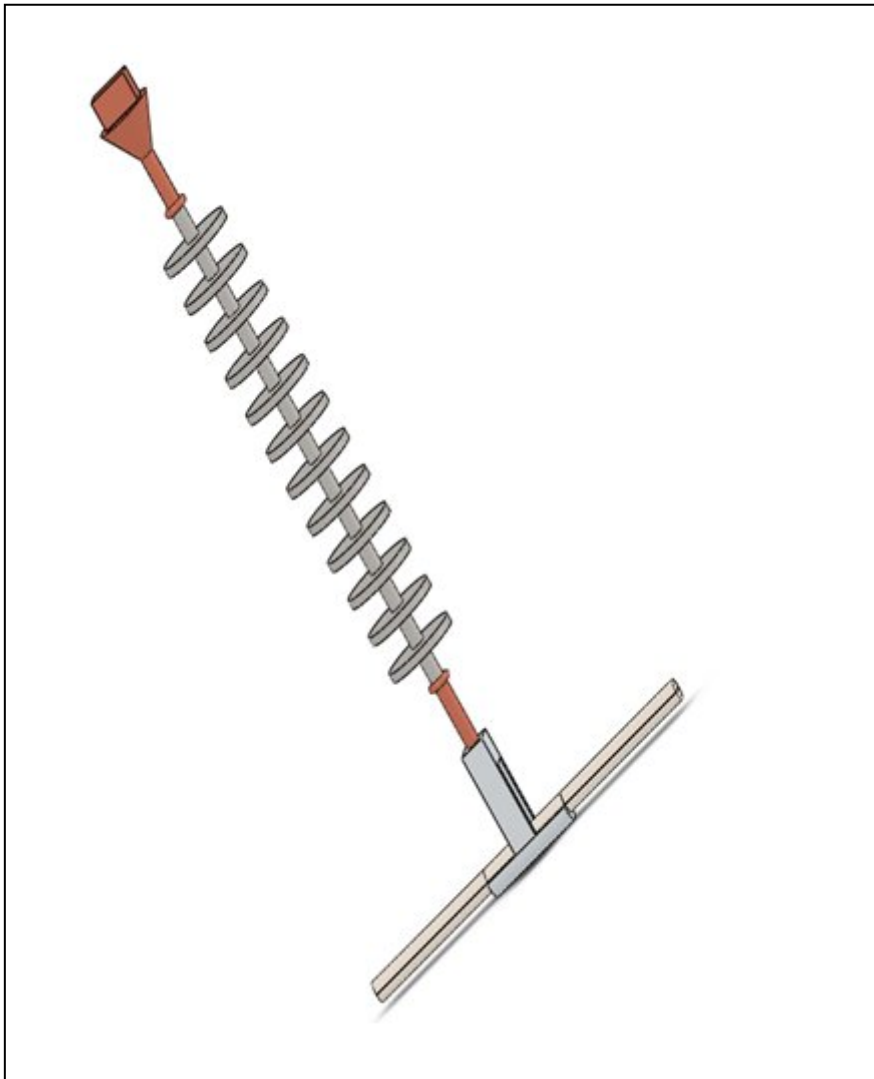


Figure 7 - 3D Model of insulator

The Study

In the EMS Electrostatic analysis, essential material properties include relative permittivity and dielectric strength, as outlined in Table 1. These parameters are crucial for accurately simulating electric fields and determining the breakdown voltage of non-conductor materials.

Components / Bodies	Material	Relative permittivity	Dielectric Strength
Contact 1	Copper	1	None
Ground_ Contact	Copper	1	None

Conductor	Aluminum	1	None
Contact 2	Copper	1	None
Insulator	Silicon Rubber	4	25.00e+006 V/m
Fibre	Fibreglass	5.5	60.00e+006 V/m
Hanger	Aluminum	1	None
Inner_Air	Air	1	3.00e+006 V/m
Outer_Air	Air	1	3.00e+006 V/m

Table 1 - Table of materials, relative permittivity, and dielectric strength

Results

The folders include data on the Electric Field (E), Electric Displacement (D), Potential Distribution (V), Force Density (F), and the aforementioned Safety Factor. The accompanying results table presents the electrostatic energy alongside the total charge present within bodies at a fixed voltage. Moreover, these findings can be represented through multiple visualization formats, including fringe, vector, contour, section, line, and clipping plots, facilitating a comprehensive analysis. These results are readily exportable for further examination.

Upon concealing all components except for the fiber and the insulator, the Electric Field plot depicted in Figure 8 is revealed.

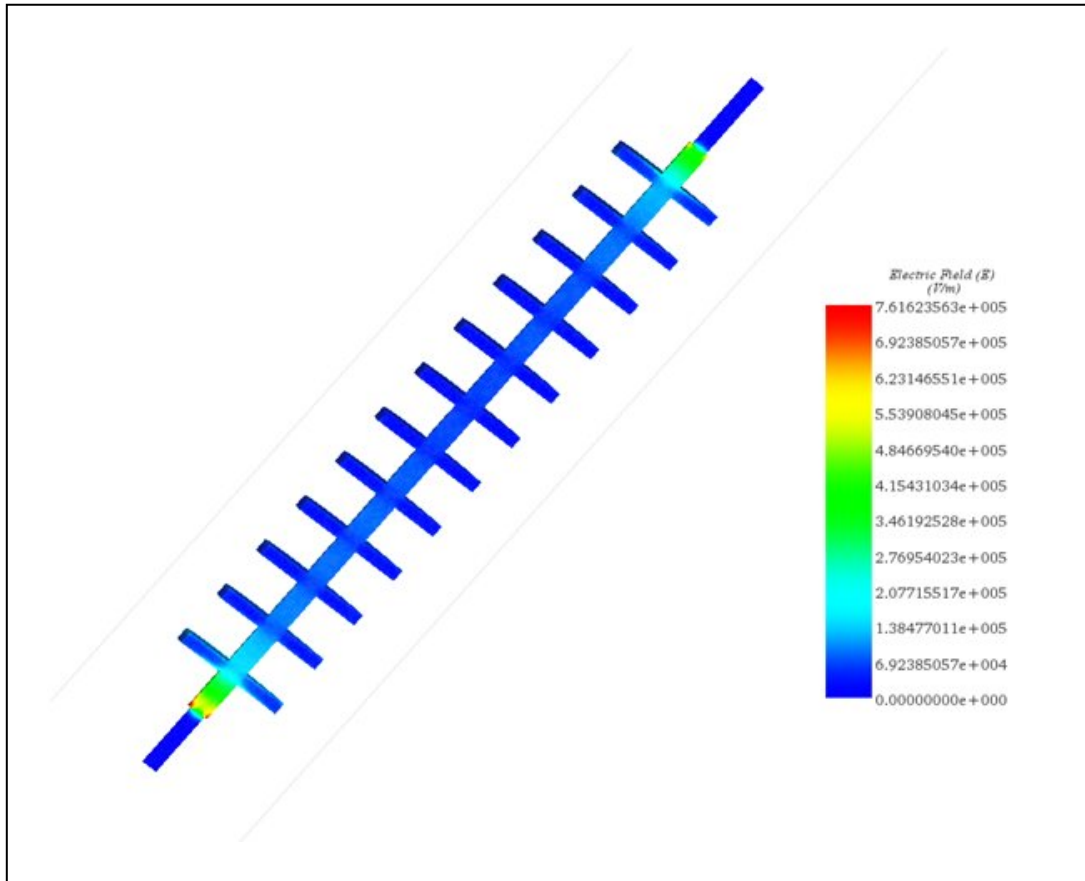


Figure 8 - Electric Field in the insulator and the fiber (fringe plot)

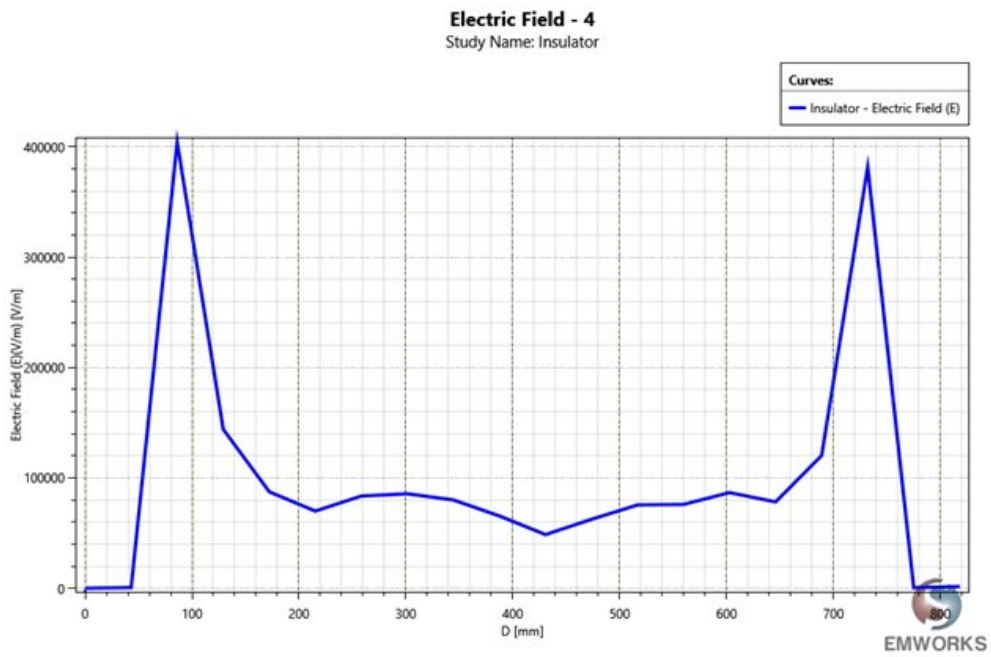


Figure 9 - Evolution of the Electric Field between two points located at the extremity of the fiber

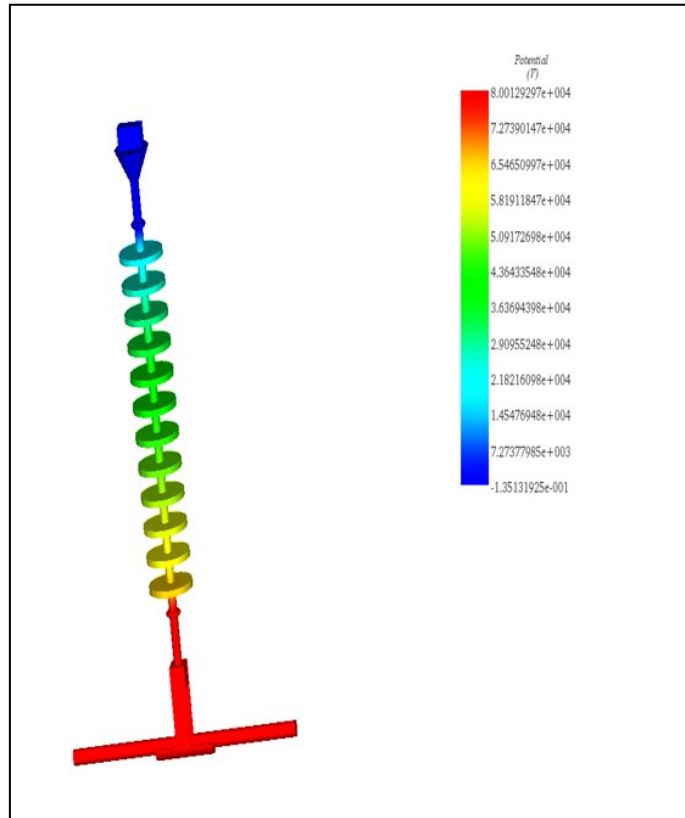


Figure 10 - Potential in the whole model

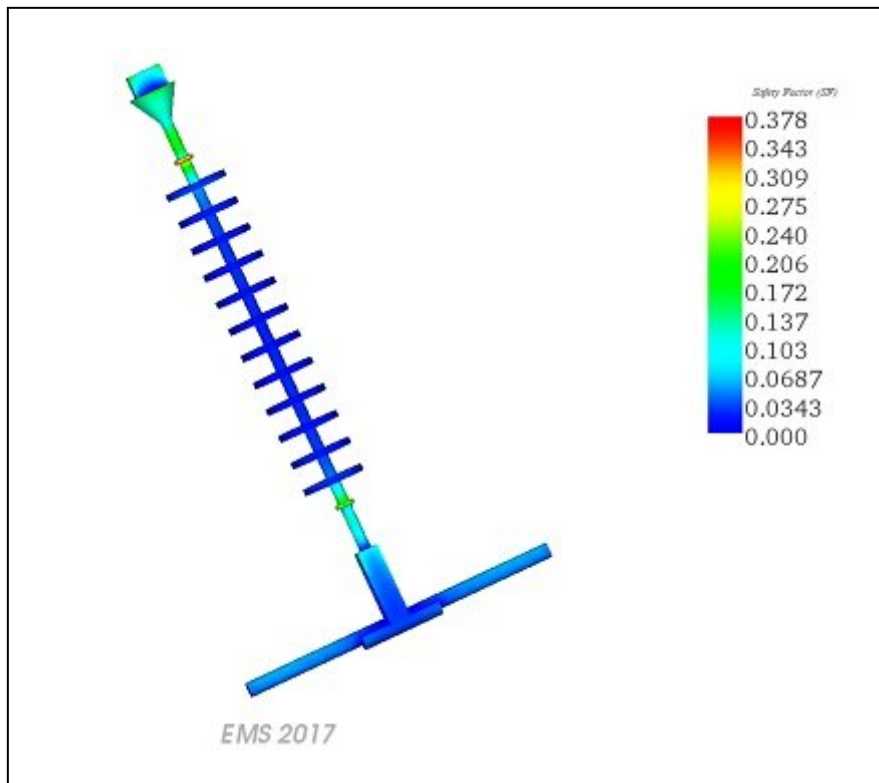


Figure 11 - Safety Factor

As illustrated in Figure 11, the peak value recorded is 0.378, indicating that our model does not experience any breakdown voltage.

Conclusion

The application note explores the role of power insulators in supporting and isolating electrical conductors to prevent current flow. Through electrostatic analysis using EMS, a 3D model of a power-line pole with a three-phase insulation setup is examined. The model consists of aluminum conductor lines and copper clamps connected to silicon rubber and fiberglass insulators. EMS computes electric fields and displacement fields, visualized through 3D and 2D plots. Key material properties like relative permittivity and dielectric strength are essential for accurate simulation. Results showcase the electric field distribution, potential distribution, and safety factor, indicating the absence of breakdown voltage. This thorough analysis aids in understanding insulator behavior and optimizing power distribution systems for efficiency and safety.

References

[1] [https://en.wikipedia.org/wiki/Insulator_\(electricity\)](https://en.wikipedia.org/wiki/Insulator_(electricity))