




Fields and Waves I

Grounding

Zero Reference and Safety

K. A. Connor

Electrical, Computer, and Systems Engineering Department
Rensselaer Polytechnic Institute, Troy, NY



Grounding

- Examples
- Lightning
- Current Flow
- Resistance

Grounding of Electrical Systems

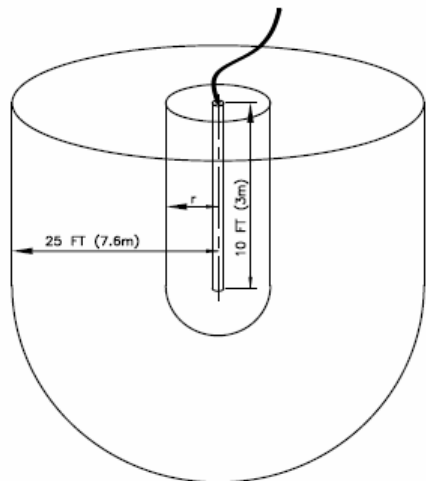
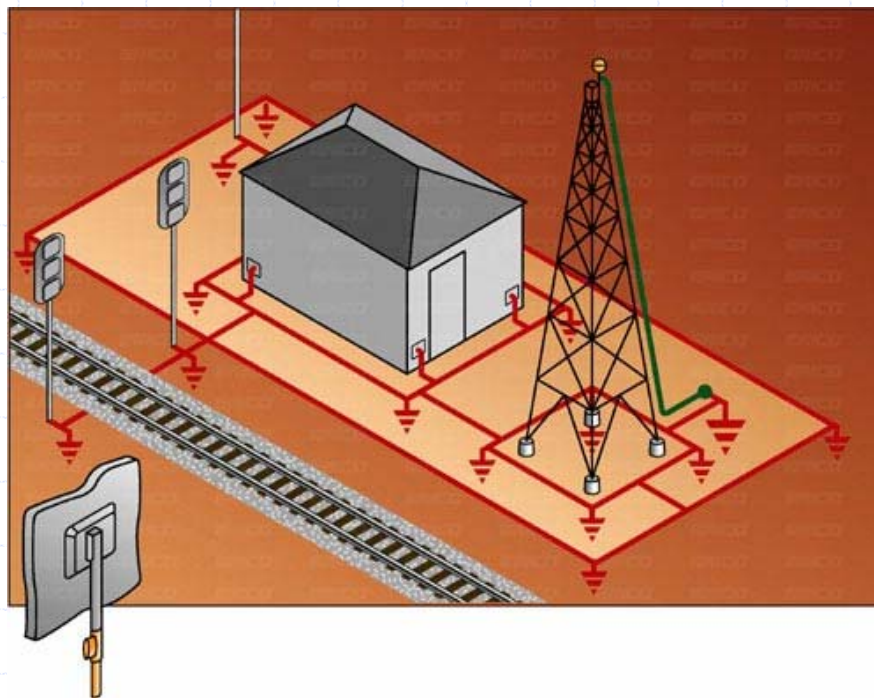
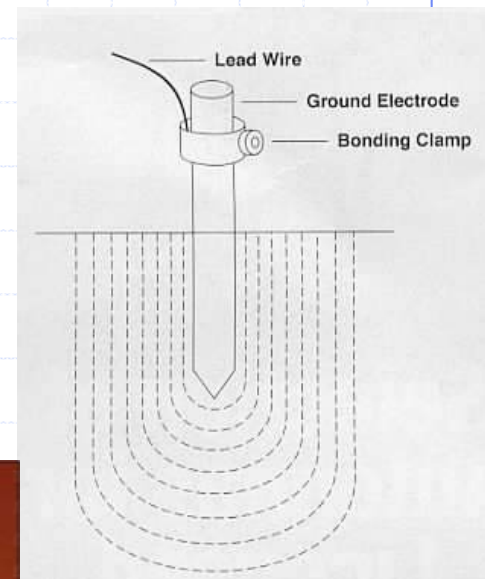


Figure 4-1—Electrode resistance development

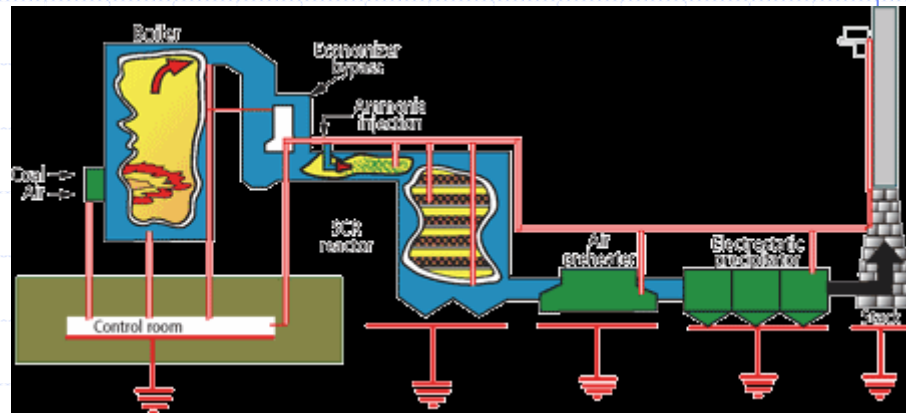
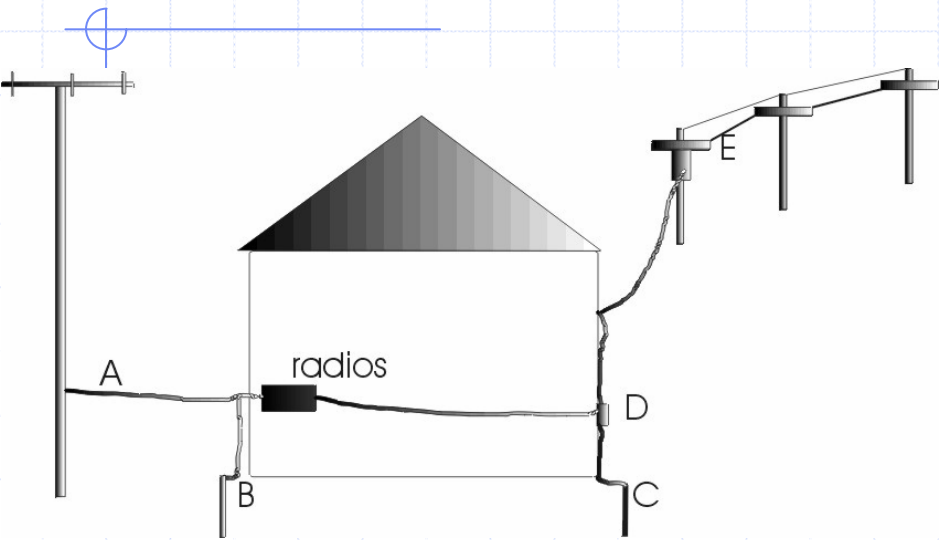
The Ground Connection Has a Finite Resistance

Electrical Systems Require a Solid Ground

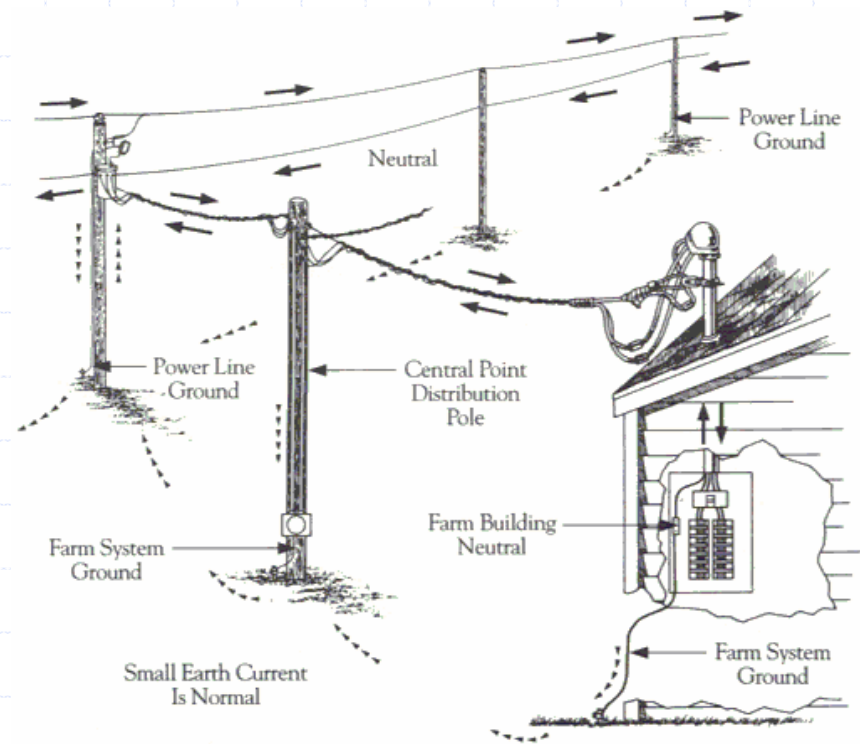


As Current Flows Away From the Ground Rod, the Voltage Drops to Zero

Examples



Grounding Can Occur at Several Locations



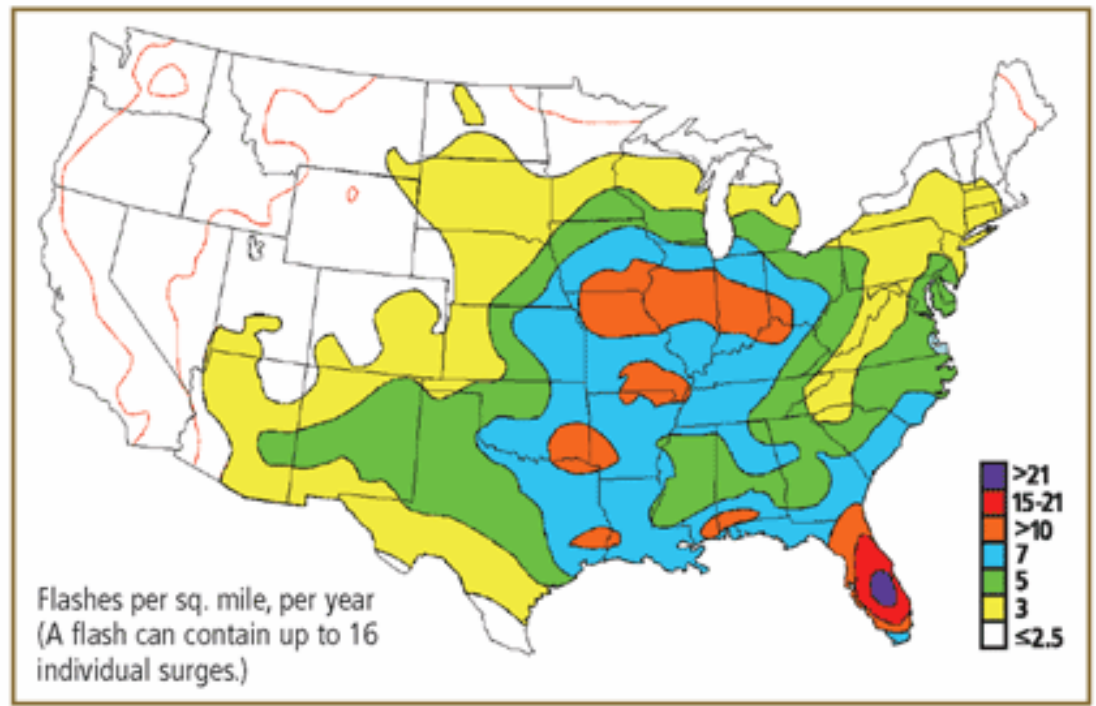
Grounds are Most Often
Provided by Driving a
Conducting Rod Into
the Ground



Lightning



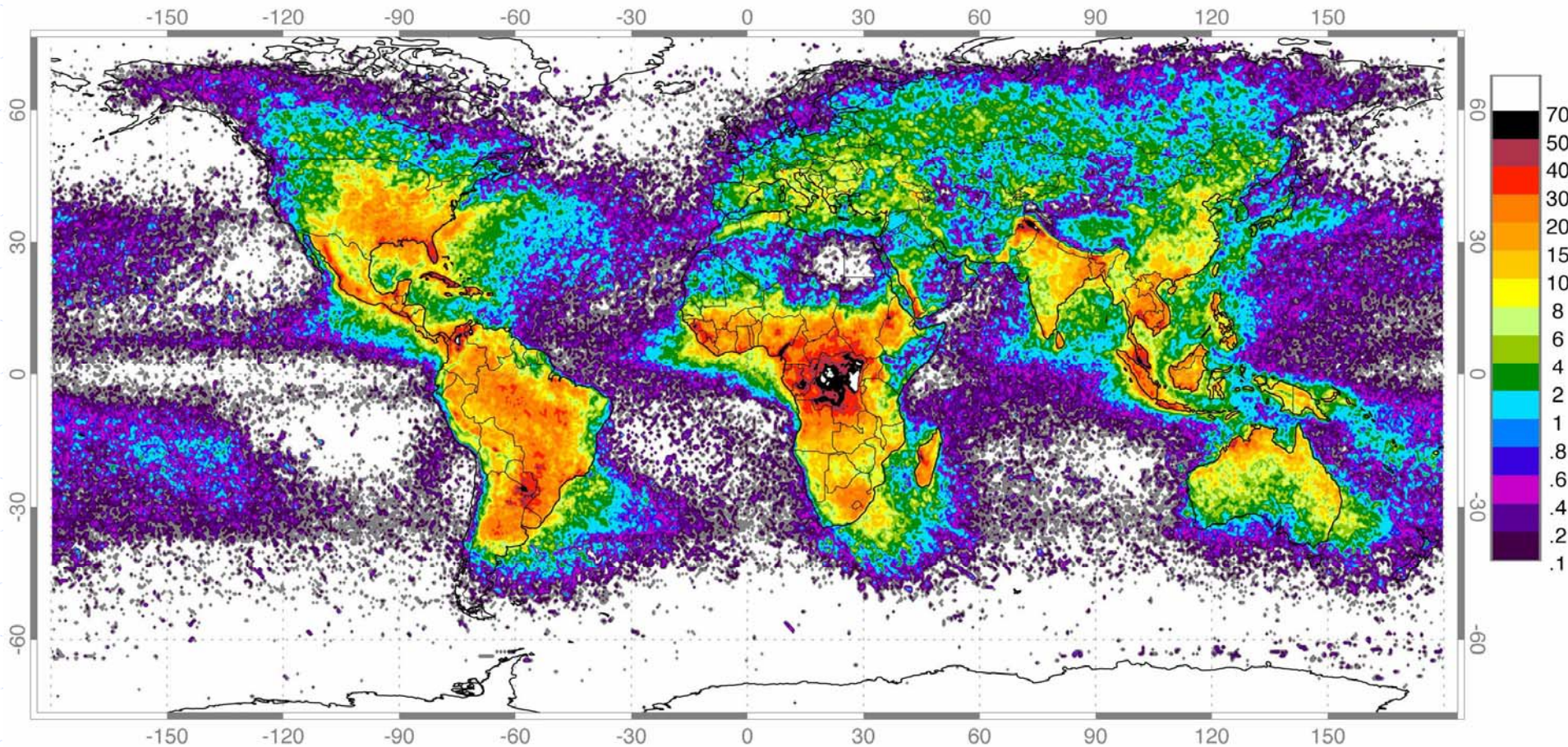
26 March 2008



Lightning strikes in the U.S.

Continent	Country / State	strikes / km ² / yr
Africa	Dem Rep of Congo	158
South America	Columbia	110
Asia	Northern Pakistan	87
North America	USA / Florida	59
Europe	Northern Italy	28

Fields and Waves I

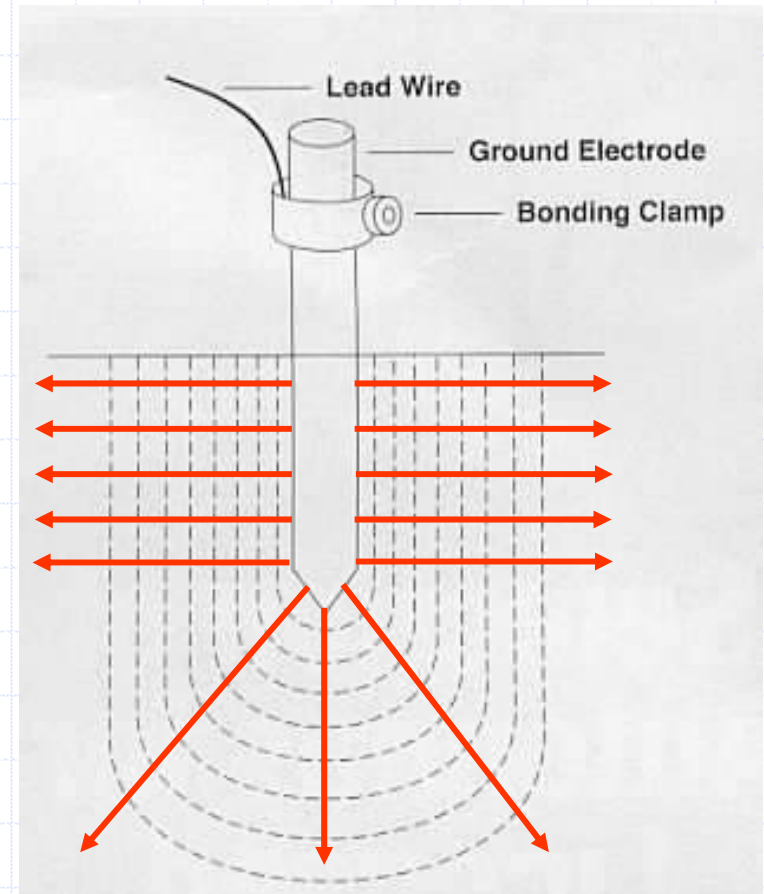


High Resolution Full Climatology Annual Flash Rate

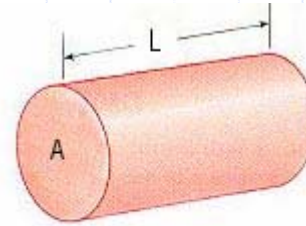
Global distribution of lightning April 1995-February 2003 from the combined observations of the NASA OTD (4/95-3/00) and LIS (1/98-2/03) instruments

Current Flow From Ground Rod

- The current flows into the soil
- The contact with the soil has a finite resistance
- Driving a large current (from lightning) will produce a very large voltage



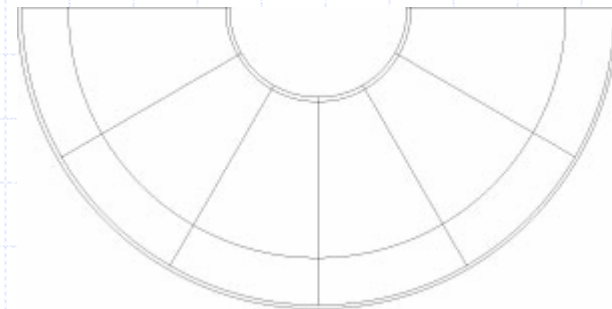
Calculating Resistance



- Recall the resistance of a cylinder of length L and area A

$$R = \frac{\rho L}{A} = \frac{L}{\sigma A}$$

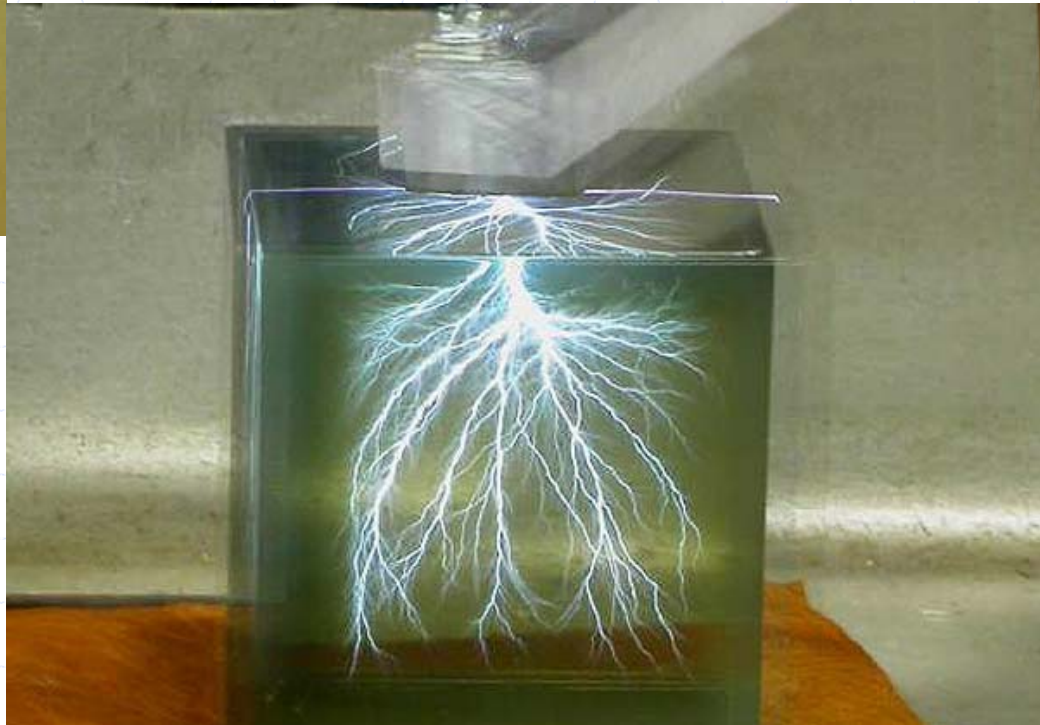
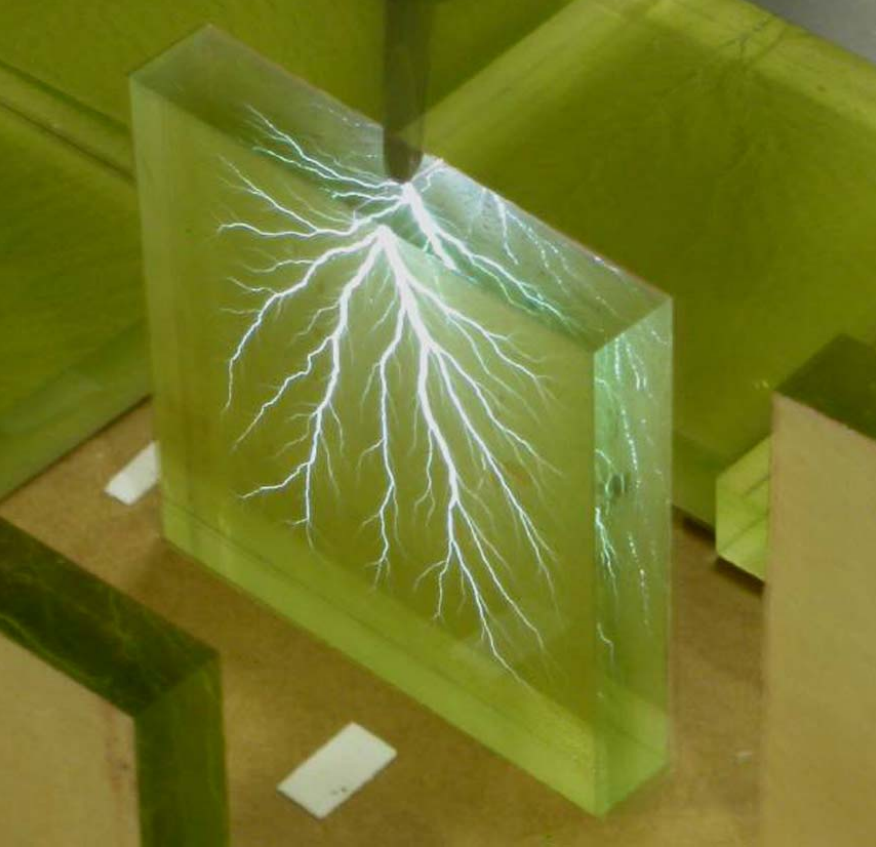
- What is the resistance of a hemisphere?



NEC guidelines require the ground resistance to be less than 25 Ohms.

Stoneridge Engineering

<http://205.243.100.155/frames/home.html>



References

- Wikipedia
 - [Ground](#)
 - [Resistance](#)
- Ground Rods & Grounding
 - [From Hubbell](#)
 - [From USDA](#)
 - [From IEEE](#)
 - [From Fluke](#)
- [IEEE Standard 142-2007](#)

