Answer to Question #70113, Physics / Electromagnetism

Question:

The greater the diameter of the wire used in household wiring, the greater the maximum current that can safely be carried by the wire. Why is this?
Does the maximum permissible current depend on the length of the wire?
Does it depend on what the wire is made?

Solution:

The wires are cylindrical and their resistance can be calculated as

$$R = \frac{\rho L}{S} = \frac{4\rho L}{\pi d^2}$$

Where ρ is called electrical resistivity and is a constant depending on the material, L is a length of the wire, and d is the radius.

When the current pass through the resistance it produces heat in agreement with

$$Q = I^2 R = \frac{4I^2 \rho L}{\pi d^2}$$

To be able to transport any current safely the wire has to be able to get rid of this heat. The energy dissipated per a unit of time per a mater is more or less constant and depends mainly on the medium the wire is installed in (the wall) and the temperature of the medium (it does not depend on the current in the wire),

$$Q = kL(T_{wire} - T_{wall})$$

so the greater the diameter the higher current can be safely transferred with it.

The length does not mater, despite the fact that the resistance of the wire is getting higher so does the ability of the wall to absorb it.

The material the wire is made from influences the equation via ρ. The lower the resistivity of the material the wire is made from the higher current it can transmit (ie copper wire is better than aluminum wire)