TECHNICAL NEWS
from
THE OKONITE COMPANY

Engineering Information for the Professional Engineer

July, 2005 Edition: 0018

# Voltage Drop Considerations

Conductors are generally sized for two purposes. The first is to provide a low enough resistance to carry the desired current load without overheating the cable. The second purpose is to assure that the voltage at the load is sufficient to operate the equipment. For typical resistive and inductive loads, the voltage will decrease from the supply to the load. The decrease is due to the conductor resistance, inductive reactance and the load itself. This voltage decrease is normally called voltage drop or voltage regulation. It can often be the limiting factor when selecting the conductor size or cable design. Voltage drop is defined as the difference between the voltages at the transmitting and receiving ends of a feeder, main, or service. It is normally expressed as a percentage and is calculated from the following equation:

$$V = \frac{(V_S - V_L) \times 100}{V_L}$$

Where:
- $V$ = the voltage drop in percent
- $V_S$ = the transmitting or source voltage
- $V_L$ = the receiving or load voltage

The receiving or load voltage is dependent upon the conductor resistance, the inductive reactance between the conductors, the load current and the load power factor. The source voltage required for a given load voltage can be calculated from the following equation.

$$V_S = \sqrt{(V_L \cos\theta + RI)^2 + (V_L \sin\theta + XI)^2}$$

Where:
- $R$ = the total ac resistance of the feeder
- $X$ = total inductive reactance of the feeder
- cos 2 = power factor of the load
- $I$ = Load current

**Why is it important?**

Some types of equipment can be damaged if the load voltage is not high enough. Inductive equipment, such as motors or fluorescent light ballasts, will draw more current if the load voltage is not high enough. The higher current can cause overheating and reduce operating life. Too low of load voltage could cause data loss or damage to sensitive equipment such as computers, printers, etc. Resistive loads, such as electrical heaters or incandescent light bulbs will not draw more current but will only produce less power (e.g., less heat or light).

**Voltage Drop and the NEC**

The 2005 National Electrical Code recommends that conductors for branch circuits should be sized to prevent a 3% maximum voltage drop (see 210.19 (A) FPN No. 4). For feeder circuits, the recommended limit is 3%. For combination feeder and branch circuits the recommended limit is 5% (see 215.2 (A) (3) FPN No. 2). Also, the NEC requires that grounding conductors must be increased in size when the circuit conductors are increased for voltage drop. The NEC should be reviewed for other more specific application requirements with respect to voltage drop.

**More Information**

For more information on calculating voltage drop, visit our "Engineering Technical Center" at the Okonite website: http://www.okonite.com/engineering/voltage-regulation.html or see back for the office nearest you.

John R. Cancelosi
Manager, Application Engineering