

Five Percent Voltage Drop - A Closer Look!

John M. Birkby ~ July, 1999

National Electric Code Articles 210-19(a) FPN No. 4 and 215-2(d) FPN No. 2 state in part, "...and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency of operation." **Section 90-5, Mandatory Rules, Permissive Rules, and Explanatory Material** is defined as follows:

(a) Mandatory Rules. Mandatory rules of this *Code* are those that identify actions that are specifically required or prohibited and are characterized by the use of the terms *shall* or *shall not*.

(b) Permissive Rules. Permissive rules of this *Code* are those that identify actions that are allowed but not required, are normally used to describe options or alternative methods, and are characterized by the use of the terms *shall be permitted* or *shall not be required*.

(c) Explanatory Material. Explanatory material, such as references to other standards, references to related sections of this *Code*, or information related to a *Code* rule, is included in this *Code* in the form of fine print notes (FPN). Fine print notes are informational only and are not enforceable as requirements of this *Code*.

The *SureTest*[®] branch circuit wiring analyzer is becoming more and more, the tool of choice for many state, county, municipal and private electrical inspection agencies. The *SureTest*[®] is a true impedance tester and utilizes a patented **full 15 ampere load test** to analyze supply power and measure voltage drop and ground impedance. It is a hand-held, microprocessor controlled device with a digital display. The intent of the *SureTest*[®] is to identify and help isolate hazardous conditions in electrical circuitry. It will display the full load voltage drop in percent at the receptacle under test. A much higher than normal increase (2% or more) in voltage drop between adjacent receptacles on a circuit could indicate a potentially hazardous condition. These might include poor splices, high resistance or corroded connections, damaged conductors, improper wiring or inadequate connections at "back-stabbed" receptacles. A gradual, small increase in voltage drop along a circuit would not be indicative of a hazardous condition. This would be a normal increase in the total impedance of the conductors, splices, wiring devices, circuit breaker, service cable, etc.

In the **NEC** Fine Print Notes regarding voltage drops, it states a 5 percent maximum voltage drop "**will provide reasonable efficiency of operation**". Nowhere does it imply that a voltage drop in excess of 5 percent is deemed a hazard. Much to the chagrin of the electrical contractors, some inspectors have decided to enforce the 5 percent voltage drop as the maximum allowable in their area of jurisdiction. In **NEC Article 90-4**, it does state "...The authority having jurisdiction for enforcement of the *Code* will have the responsibility for making interpretations of the rules, for deciding on the approval of equipment and materials, and for granting the special permission contemplated in a number of the rules." Fine Print Notes (FPN) are not rules and, as defined, are clearly not enforceable.

Now, let's take a closer look at a voltage drop in excess of 5 percent. If concern is for "reasonable efficiency of operation" and protection of equipment, the initial line voltage should be taken into consideration. For example, with a nominal voltage of 120 volts at the receptacle under test, an 8 percent voltage drop under full load would result in an operating

voltage of 110.4 volts. 125 volts would drop to 115 and 114 volts to 104.9. Obviously, an 8 percent voltage drop at 120 to 125 volts is of little concern, while an 8 percent drop at 114 volts could seriously compromise the operation of equipment such as room air conditioners, refrigerators, high-amp vacuum cleaners, etc.

Some discretion should be considered when analyzing the voltage drops in a branch circuit. The *SureTest*[®] pulses a **full fifteen ampere load** to analyze the **circuit**, not just the receptacle under test. **NEC Table 210-21(b)(2)** allows a maximum total cord and plug connected load in amperes of 12 for a 15 ampere rated receptacle and 16 for a 20 ampere rated receptacle. Although there are appliances, such as hair dryers, available today with 15 ampere nameplate ratings, most UL listed appliances are rated at 12 amperes, maximum. Therefore, it may be anticipated that the maximum current flowing between the last receptacle on the branch circuit and the previous receptacle should be 12 amperes. Inasmuch as the *SureTest*[®] imposes a full 15 ampere load at the last receptacle, a reading of 6.25 percent voltage drop would be equivalent to 5 percent at 12 amperes.

Many inspector members of the IAEI (International Association of Electrical Inspectors), ASHI (American Society of Home Inspectors) and NAHI (National Association of Home Inspectors) have reported feeling comfortable with gradually increasing voltage drops as high as 8 to 10 percent where the line voltage is near the nominal 120 volts. Most of the controversy over the 5 percent maximum voltage drop occurs during residential inspections. Some very capable contractors who are required to comply with the 5 percent drop, have reported experiencing a great deal of difficulty trying to achieve this in homes of 3,000 square feet or more. Even after all connections have been inspected and tightened, all receptacles “pig-tailed” and circuit breakers checked, the voltage drop remains in excess of 5 percent and yet, below 8 percent. One means of compliance would be to install sub panels, but in many instances, this would be physically impractical and cost prohibitive.

The *SureTest*[®] has proved to be an invaluable tool for inspectors and contractors alike. In addition to performing a full 15 ampere load test, the model ST-1D will also display percent voltage drop for a 20 ampere load. Also provided, are readouts of line voltage, ground-to-neutral voltage, estimated load on line in amperes, ground impedance in ohms and indications of false grounds or ground-to-neutral shorts. A unique GFCI test will verify the trip point of the device within the milliampere-to-ground vs. time parameters set forth by Underwriters Laboratories, Inc. When used for its intended purpose, the *SureTest*[®] will identify hazardous conditions including poor splices, high resistance connections, damaged conductors, false grounds, poor grounding, improper wiring, undersized wire, overextended circuits and faulty or mis-wired GFCIs. **Visual inspections alone, cannot detect the hidden flaws in electrical circuitry which could result in a catastrophic fire or electrocution!**

As for the 5 percent voltage drop, it's still as it should be --- a Fine Print Note - with the inspector also considering wire gauge, length of run, no of receptacles in the circuit, and workmanship.

**This material has been reviewed and approved by Mike Holt of Mike Holt Enterprises, Inc
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