How Much Voltage Drop Is Acceptable?

The National Electrical Code (NEC) recommends that the combined voltage drop of the electrical system (branch circuit and feeders) not exceed 5% for optimum efficiency. This recommendation not only can improve safety but can insure proper equipment operation and power efficiency.

Important: Note that this is a recommendation. Local inspectors, or other governing bodies, may use their own judgment on an acceptable level of voltage drop for the electrical system.

For example, the Philadelphia Housing Development Corporation (PHDC) requires contractors to calculate the voltage drop prior to installing blown insulation in existing homes. If the voltage drop is 10% or higher, the contractor must replace/repair the circuit prior to proceeding with the insulation.

Why It’s Here
Prior to instituting this requirement, half a dozen smoldering fires resulted from the blown insulation installations. In the 2,500 homes insulated during a two-year period after this electrical integrity test was instituted, there were no fires reported.

At least 15 other municipalities have followed the PHDC’s lead in requiring the load test as part of their winterization programs.

Measuring Voltage Drop
When using a digital multimeter to calculate voltage drop, all loads for the circuit must be removed for the no-load measurement.

Next, find a load that will draw 60% to 80% of the maximum rating of the circuit. In this example we have a 15-amp circuit, so a 1400W load should do the trick.

Now take your first reading with no-loads on the circuit at the last device or receptacle. Apply your 1400-watt to the circuit and measure the loaded RMS voltage reading.

Voltage drop = (no-load voltage - loaded voltage)

% Voltage drop = (Voltage drop/no-loaded voltage) x 100

Total impedance of the circuit can be calculated if you know the current

Total resistance = Voltage Drop / Current. (R=E / I)

Example: If the voltage drop on a circuit was 3Volts and the load drew 12 amperes then the impedance of both conductors would be 0.25 ohms. (3 volts/12 amp)

Remember that voltage drop and impedance of the circuit are based on the load. So if you use an 800-watt hair dryer you are only drawing a little over 6 amperes. The voltage drop on a 120V circuit at 6 amperes would be about half compared with a 12 amperes load.

Using a Circuit Analyzer like the IDEAL Industries SureTest® Circuit Analyzer can make the job much easier. The SureTest® Circuit Analyzer can calculate Voltage Drop and Percent of Voltage drop measurements for 12, 15, and 20 amp loads in a matter of seconds. With its patented technology, it can perform this even if there are loads on the circuit, without tripping a breaker or interrupting the load.
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**Troubleshooting A Standard Circuit**

**Troubleshooting to identify the cause of the high impedance within the electrical system is actually quite simple.**

First, measure the voltage drop at the furthest receptacle from the panel on the branch circuit under test. If the voltage drop is high, then further investigation is necessary.

Test the remaining receptacles in sequence, from next furthest from the panel to the closest to the panel. This will help you identify were and what is causing the problem.

If the voltage drop reading changes significantly from one receptacle to the next, then the problem is likely between the two. It is usually located at a termination point, such as a bad splice or loose wire connection, but it might also be a bad receptacle.

If the reading steadily decreases as you get closer to the panel – with no significant decreases between receptacles – then the wire may be undersized for the length of run, or rated load for the circuit. Check at the panel to see if the wire is sized per code, for the circuit.

Some homes are wired with 14-gauge wire running in excess of 60 feet or more. Although this may not meet the NEC recommendation of 5% or less voltage drop, it may meet local code requirement and are acceptable runs.

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**Operating Voltage = 120 volts – 6.4 volts**

% of Voltage Drop = (6.4 volts/120 volts) x100

% of Voltage Drop = 5.3%

Operating Voltage = 113.6

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**Voltage Drop?**

First, let’s look at the wire and wire size. The resistance of 12-gauge wire is 2 ohms per 1,000 feet. Answer: “R” (Resistance of the wire) is equal to 0.4 ohms.

[We find the resistance of wire per 1000 feet in Chapter 9, Table 9 of the NEC codebook. (2 ohms/1000) x 200 feet = 0.4 ohms]

I know, where did the 200 feet come from? Remember you have 2 conductors at 100 feet each, Line and Neutral

Voltage Drop = Load Current X Circuit Resistance or

Voltage Drop = 16 amperes x 0.4 ohms

Voltage Drop = 6.4 volts,

% of Voltage Drop = (Voltage Drop/ No-load Voltage) x100

% of Voltage Drop = (6.4 volts/120 volts) x100

% of Voltage Drop = 5.3%

Operating Voltage = 120 volts – 6.4 volts

Operating Voltage = 113.6
Protect your people from arc flash.

Safety is your responsibility, so learn all you can about arc flash. Arc flash can burn, blind, or even kill in an instant. And there is no one, failsafe protection. But there is an excellent defense: knowledge. The more you know about how arc flash occurs, the more you can do to prevent it. Ferraz Shawmut has been heavily involved in arc flash research and testing for many years, amassing a large and valuable base of knowledge that's available to you—free—at the website below. You'll learn how arc flash safety is the sum of many factors: routine electrical safety analysis, staff training, appropriate circuit protection devices, and the right personal protective equipment (PPE). In fact, the site even includes a PPE calculator to help you determine the appropriate levels of protection for your operation. Don't let your safety go up in a flash. Find out more about arc flash, and the products that can mitigate it, at us.ferrazshawmut.com/arcflash1.
Ground Issues

Maintaining a Low Impedance Ground
A good electrical ground is more than following NEC requirements; it must also be a low impedance system. The ground path is the fault path for stray current.

If electricity follows the path of least resistance, than the ground circuit must have a lower resistance than an individual to protect them.

The rule of thumb for protecting people is to maintain a ground impedance of less than one Ohm. The IEEE recommends that any conductor impedance be less than 0.25 ohms. It is this writer’s belief that the impedance of the ground wire or grounding circuit path be equal or less than that.

Conditions that can result in higher-than-normal ground impedance include undersized wire and corroded or loose connections.

False Grounds
The neutral conductor can only be bonded to the ground conductor at the main neutral buss, where a large copper conductor carries all the return and faulted current back to the earth.

Sometimes (through error or ignorance), the neutral and ground are connected or unintentionally touch upstream from the service entrance. This is called a false, or bootleg ground.

When using common receptacle testers, this condition shows up as normally wired. This is a hazardous wiring condition but until the onset of new technology in branch circuit protection and testing it has gone undetected. AFCI circuit breakers will not function properly if a false ground is detected.

Earth Ground
The pathway to ground extends beyond the main panel to the earth ground system. The earth ground could be a single ground rod, multiple ground rods, a mat or a grid system.

Section 250-56 addresses the system by stating that if the ground electrode is not less than 25 ohms a second electrode should be added at least 6 feet from the first. The grounding system can be tested with a three-pole earth resistance tester, or a ground resistance clamp meter.

While testing the resistance of the ground electrode with a three pole or four poles tester it is necessary to supplement the ground with a secondary ground to perform the test.

The resistance of the ground electrode is heavily dependant on the soil resistivity. Soil resistivity is not just dependent on the earth or soil. Moisture and environment changes like temperature have an effect on the resistance of the ground system. To ensure a low impedance grounding system, include the ground electrode, or earth ground as part of your standard testing procedures in your facility.
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