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Technical Note 105

Branch Circuit Resistance and AFCI Testing

A property of branch circuit wiring is its resistance to current flow. Wiring resistance is a function of wire gauge, length and the quality and quantity of splices. The effect that resistance has on a branch circuit is to reduce the available voltage at the use end of the circuit. This lost voltage is dissipated in the form of heat in the wire, which also causes the copper wire resistance to increase, further aggravating the situation. This loss is expressed as line loss, which is the percentage of the voltage drop that exists at 80% rated load, i.e. a 15 amp circuit would be tested at 12 amps. Various industry recommendations list a 3% voltage drop as ideal, a 6% drop as OK and a 9% drop as a problem.

The table lists the capabilities of residential wire gauge and offers a rule of thumb recommendation for maximum branch circuit lengths. NEC recommends a 3% drop at the branch with a 2% drop at the panel, Panel or source drop is usually negligible and is not a factor in this discussion. Pig-tail taps are not considered to add significant resistance to a branch circuit. A mechanically secure wire nut with 3, 14 Ga. wires is the equivalent of 6" of 14 Ga. wire. However a poorly applied wire nut can cause significant voltage drop and can pose a fire hazard.

Ga. 2 Conductor	Per 50' of branch circuit @ 12 Amps			Suggested maximum lengths		
	Resistance	V drop	% loss	3% loss	6% loss	9% loss
14	0.3 Ohm	3.6 volts	3%	50'	100'	150'
12	0.2 Ohm	2.4 volts	2%	100'	200'	300'
10	0.1 Ohm	1.2 volts	1%	150'	300'	450'

The effect that line loss has on AFCI breaker testing is the fact that these breakers are looking at the current signature on the branch circuit. Branch circuit resistance reduces the current signature that the breaker sees. If there is 120 to 150 feet of 14 Ga. wire in a branch circuit it is possible that the farthest outlets may not trip the breaker when tested, this is because the line resistance has reduced the current to the point that it appears as a nuisance current to the breaker. This is why it is important to test all outlets on an AFCI branch circuit, tested outlets that fail to trip the breaker may not be arc fault protected. The remedy to ensure all outlets are protected is to increase the wire gauge feeding the branch circuit.

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