



The True Cost of Undersizing Wire

A 40A circuit that is fine at 25 feet can force a jump from 8 AWG to 4 AWG at 250 feet. The load never changed. The distance did.

Every wire size decision starts with one question: how much current does it need to carry. That is ampacity, and it is the first thing that sets a minimum size. But ampacity is not the only thing in play. On a long run, voltage drop can force a bigger wire even when ampacity alone would have let you use something smaller. Undersizing for the run length, not just the load, is one of the most common and most expensive mistakes on a job.

Two different limits, same wire

Ampacity is about heat. A wire carrying more current than it is rated for gets hot enough to damage its insulation, so the code sets a maximum current for each size. Voltage drop is about distance. Every foot of wire has a small amount of resistance, and that resistance eats a little voltage as current pushes through it. Add up enough feet and the voltage that actually arrives at the load can drop meaningfully below what left the panel.

A wire can pass the ampacity check and still fail the voltage drop check, or the other way around. Whichever one demands the bigger wire is the one that governs, and the only way to know which is to run both numbers for the actual run length.

A worked example: the same 40A load, two run lengths

Take a 40A, 240V load on copper, 3% voltage drop target. At 25 feet, the smallest conductor that satisfies both checks is 8 AWG copper. Its ampacity is 50A, comfortably above the 40A load, and at that short distance the voltage drop is only 1.6V, 0.7% of 240V, well inside the 3% target. Ampacity is what sets the size here, and voltage drop is not even close to a factor.

Stretch the same 40A circuit to 250 feet and the picture changes completely. 8 AWG would drop far more than 3% over that distance, so it fails the voltage drop check even though it still passes ampacity easily. The smallest conductor that satisfies both checks at 250 feet is 4 AWG copper, with a 6.2V drop (2.6%). That is two full wire sizes larger than the 25-foot answer, for the exact same 40A load.

The crossover point for this circuit is about 115 feet. Under that distance, 8 AWG holds the 3% target. Past it, the wire has to go up.

What that jump actually costs

8 AWG copper and 4 AWG copper are not a small step apart. Larger conductor means more copper per foot, a stiffer, harder pull, bigger conduit or box fill, and a bigger breaker-panel lug in some cases. Guessing at "this circuit is basically the same as the one I ran last week" without checking the actual distance is how an installer ends up either under-sizing (a code violation and a fire-risk wire that runs hot) or over-sizing every run "just to be safe," which quietly inflates material cost on every job that does not need it.

Where the crossover point comes from

The crossover is not a fixed number, it moves with the load and the target. A higher-amperage load reaches its crossover distance sooner, because more current means more voltage lost per foot. A looser voltage-drop target (5% instead of 3%) pushes the crossover farther out, because there is more room to lose before the drop matters. This is why the wire size decision has to be run for the actual job, not assumed from memory.

Key takeaway. Ampacity sets a floor on wire size from the load alone. Voltage drop can push it higher once distance enters the picture. Always check both for the actual run length, the crossover point can be closer than it looks.

Assumptions

- 3% voltage drop target on the branch circuit, the common rule of thumb cited in an NEC informational note, not a hard code requirement.
- 240V single-phase copper circuit, 40A continuous-capable load, standard installation method.

Sources

- NEC Table 310.16 (conductor ampacity, 75°C column)
- NEC 210.19(A) informational note (3% branch-circuit voltage drop guideline)

Frequently asked questions

Does voltage drop ever make a wire too small for safety, not just performance?

Voltage drop is a performance and code-guideline issue (equipment runs poorly on low voltage, motors overheat), not the same fire-risk mechanism as an ampacity violation. But both can independently force a size increase, and the wire size engine checks both and reports whichever one governs for your run.

Is the 3% target a hard NEC requirement?

No. It comes from an informational note in the NEC, not a mandatory rule, so it is a strong recommendation rather than a code violation if exceeded. Most designers still treat it as the practical target because equipment performance and code officials often expect it.

Why does the crossover distance change with a different load?

A bigger load pushes more current through the same conductor, and voltage drop scales with current, so the same size wire loses more voltage per foot at a higher load. That moves the point where voltage drop overtakes ampacity as the governing factor to a shorter distance.

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