

# National Electrical Safety Code Committee, Accredited Standards Committee C2

## National Electrical Safety Code<sup>®</sup>

### Interpretation

#### Section 9. Grounding Methods

##### **Rule 96C, Ground Resistance Requirements (27 May 2003) IR532**

How should the “four per mile” rule of 96C be applied to underground systems? Does this mean a ground each ¼ mile of underground circuit? Does it mean the equivalent over an entire circuit length of four grounds per mile? (e.g., 2 miles with no grounds and then four grounds at each end?) Is the “four per mile” a Rule of Thumb or a requirement? Does each grounding electrode qualify as a “ground” or must there be physical and electrical separation between grounds? Does it apply equally to underground jacketed shielded cable and jacketed concentric neutral cable?

**Discussion:** I have reviewed the 1997 NESC and the NESC interpretations including IR 517. I am seeking clarification on Rule 96C. Rule 96C deals with “Ground Resistance Requirements.”

Rule 96C has the “four grounds per mile” rule. Application of the Rule to overhead electric systems is not in question. Rule 96C provides an exception for underwater cable crossings. Rule 92B2b(3) states jacketed cable shall be grounded where the sheath is exposed (no requirement on spacing). Rule 92D allows that some grounds can be removed to control objectionable current. Rule 93E6a allows insulated sheaths to remain ungrounded for control of circulating currents.

Typical cable lengths on a single reel of cable for underground jacketed cable (#2 Al, 15kV, 100% neutral, jacketed) can be 5000-6000 ft. It is not uncommon to direct bury (e.g., plow) an entire reel’s length of cable when providing a rural service. This would leave a 6000 ft length of unspliced jacketed cable inaccessible in the ground.

Rule 96C has been interpreted by some to mean that every ¼ mile a grounding electrode and ground to the neutral must be installed. This would require cutting into perfectly good cable and installing grounds just to satisfy Rule 96C. Others have interpreted that if enough grounding electrodes (miles x four per mile) to achieve a “multiplicity of grounding electrodes” are placed at each end of the cable, the requirement for grounds is met.

Since the purpose of grounding is safety, safety is decreased if the “ground every ¼ mile” interpretation is used because there are more points created where access to high voltage is possible. Reliability is also decreased by the addition of splices needed to install grounds.

Isn’t the purpose of 96C to have adequate grounds to provide effective grounding, and the “four per mile” is a “Rule of Thumb” only? Further, isn’t the four-per-mile rule of 96C, when applied to exclusively underground systems, a misapplication of traditional overhead construction practice recommendations to underground construction? Application of the four-per-mile rule to overhead construction is generally accepted practice and is not considered difficult to implement. The fine print note for 96C states it is the “multiplicity of grounding electrodes,” not grounds, that is critical. Finally, isn’t the overarching rule the need to maintain safety? Safety is enhanced by achieving

effective ground through the application of good engineering; and the number and spacing of grounds and grounding electrodes on underground systems should be based on good engineering, not arbitrary rules.

Guidance on the application of Rule 96C to underground cable systems from the Interpretations Committee would be appreciated.

## Interpretation

The Interpretations Subcommittee has considered the subject Interpretation Request and has developed a consensus report as follows:

“Rule 96C requires the neutral of a multi-grounded system to be connected to electrodes at each transformer location and at a sufficient number of additional points totaling not less than **four grounds in each mile of the entire line**, not including grounds at individual services (emphasis added). Note that the requirement of four grounds applies to each mile, not four grounds per mile as you state in your request for interpretation.

This difference is significant. The intent is to ensure that grounds are distributed at approximately ¼ mile, or smaller, intervals. While some of these intervals may exceed ¼ mile, four grounds are required in each and every one-mile segment of the line. Another way of expressing this requirement is that four grounds are required in each running mile or in a moving window one mile in length. This concept can also be stated mathematically. Using 100 ft increments for simplicity, a line  $n$  ft long must have four grounds in each of the following segments: 0 to 5280 ft, 100 to 5380 ft, 200 to 5480 ft... $n-5480$  to  $n-200$  ft,  $n-5380$  to  $n-100$  ft, and  $n-5280$  to  $n$  ft.

In answer to your specific questions, Rule 96C applies to both overhead and underground systems, except for underwater crossings meeting the provisions of the Rule 96C Exception. See Rule 314. Rule 96C applies to both cable in underground structures (conduit) and direct-buried cable. It applies equally to underground jacketed shielded cable and to jacketed concentric neutral cable, unless the exception for underwater crossings applies. Consequently, a two-mile underground run with four grounds at each end but no grounds in the two-mile length would not be Code-compliant. Physical separation between electrodes is required. Multiple electrodes at a single grounding point, used to reduce ground resistance at that point, constitute a single ground; each electrode in a multiple electrode assembly cannot be counted as a ground for the purpose of satisfying Rule 96C requirements.

You requested an interpretation for the 1997, 2002, and subsequent editions. This interpretation is for the current or 2002 Edition. Because the applicable rules did not change from the 1997 Edition, this interpretation also applies to the 1997 Edition. The interpretation will stand for future editions unless the rules are officially revised in accordance with NESC procedures.

The Interpretations Subcommittee has the following comments on some of your statements regarding Rule 96C:

1. The specific requirements in the rule are necessary to ensure adequate grounding of multi-grounded neutral systems. The rule is based on good engineering practice; it is neither arbitrary nor a rule-of-thumb.
2. The “multiplicity of grounding electrodes” in the note to the rule refers to grounding points rather than multiple electrodes at a single point.
3. Long runs of direct-buried cable can be grounded at intermediate points by connecting the grounding conductor to the cable neutral conductors. The cable does not have to be cut through and spliced.”