

NEC Compliant Ground Electrode Systems

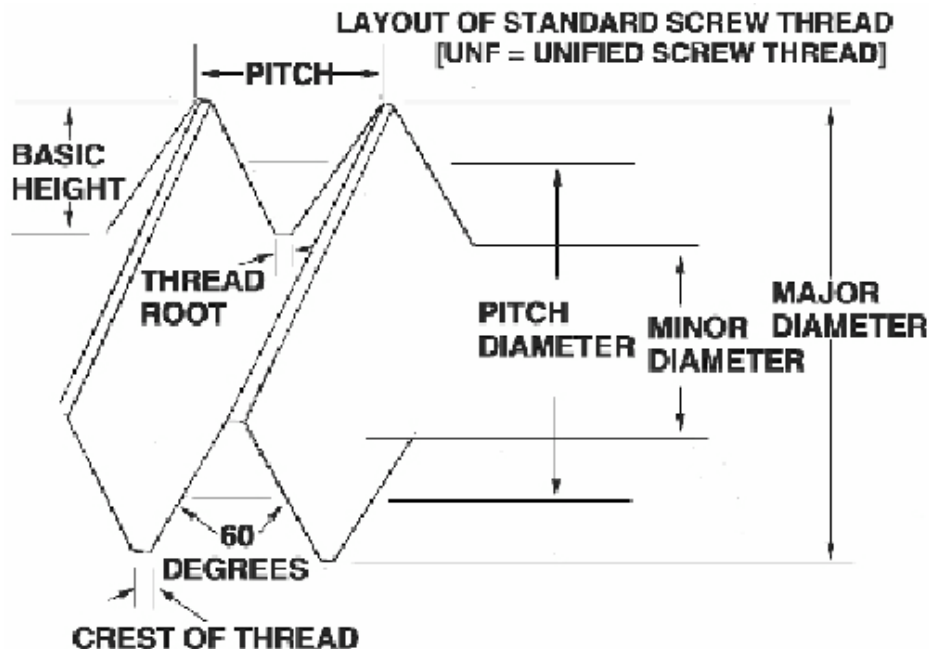
The long-term integrity of the electrode/conductor connection is critical to ground electrode system performance. The ground rod and the ground conductor bond is fundamental to a long term, low resistance ground system. Selection of a proper system is mandated by UL 467 NEC 250, which requires careful coordination of components to avoid dissimilar metals and their resulting galvanic corrosion problems.

Fifty plus years ago, UL defined a full 0.500", 10 mil copper bonded steel rod as the minimum non ferrous clad ground electrode to bear the UL marking based on testing by the National Bureau of Standards from 1910 -1955 that confirmed its long service conducted. The full 1/2" and the more common 5/8" 10 mil 8 foot UL Listed copper ground rod have served the industry exceptionally well, providing a 40+ year life, typically 4 times that of a 3/4" galvanized ground rod.

History of the 5/8" Ground Rod

The original "5/8" UL listed ground rod was a rolled threaded rod. Starting with a 0.560" rod, the 5/8" thread was formed via a rolled thread process, attaining the required major and minor diameters. The 0.560" rod with 10 mils of copper met the UL requirements. In the 1990's, when the threadless ground rod became the standard product, the 0.560" rod remained the standard rod material, and still met the UL requirements.

Utilities requiring compliance to the **NESC** were the energy behind the 5/8" galvanized ground rod, which has a tolerance that allows for a diameter up to 0.30" less than 0.625" diameter. The nominal galvanized rod meets the ANSI C135.30 standard, which is required by the NESC, but not compliant with NEC 250.52.



If a low cost ground rod is the critical decision point, and a non-UL listed ground electrode with 75% less service life is acceptable, the ANSI C135.30 compliant rod [which does not meet NEC 250.52] has been an option used by many contractors. The use of a galvanized ground rod requires the following issues to be considered if code compliance is important:

- **NEC requires a minimum 5/8" diameter if not listed**, NEC 2002 listed rods include 10mil copper or stainless clad steel rods of a minimum of 1/2" diameter.
- All galvanized rods have the same coating thickness, rod diameter is critical
- Per NEC 250.70, ground conductors are either copper or aluminum clad copper
- Per UL 467 - Ground rods need a clamp that is listed for the rod material and application

NEC 250.52.A.5.b. *"Electrodes of rod or steel shall be at least 15.87mm [5/8"] in diameter. Stainless steel rods less than 16mm [5/8"] in diameter, nonferrous rods, or their equivalent shall be listed and shall not be less than 13mm [1/2"] in diameter.*

NEC 250.62 *"The grounding electrode conductor shall be copper, aluminum, or copper clad aluminum. The material selected shall be resistant to any corrosive condition..."*

NEC 250.70 *"...Ground clamps shall be listed for the materials of the grounding electrode and the grounding electrode conductor ..."*

UL 467 3.3 *"A grounding or bonding device shall be constructed of a metal or materials that, when the device is installed under conditions of actual service and exposed to moisture, will not be likely to be adversely affected by electrolysis".* Section 3.4 defines the bonding device as "a) Copper or a copper alloy containing not less than 80% copper, or b) stainless steel. Exception: A material other than those specified in 3.4 may be used for a device intended for burial in earth or embedded in concrete if it has been investigated and found to be acceptable for the application. Among the factors that shall be taken into consideration when judging the acceptability of such a material are the: a) Change of resistance across the bonding-grounding joint, and b) Amount and degree of corrosion".

The galvanized rod system should consist of the following:

1. NEC 250 compliant rod - 0.625" diameter, 3 mil galvanized rod [Eritech cat. # 815980]
2. Galvanized or tin plated bronzed ground clamp

Cost effective UL Listed copper bonded ground electrode system alternative:

1. UL listed rod - 0.500" diameter, 10 mil copper rod [Eritech cat. # 611380]
2. A copper alloy ground clamp

Tests Reveals Copper Bonded Rods Have A Significantly Longer Life Than Galvanized Rods In The Same soil Conditions

Research from 1910 -1955 by the National Bureau of Standards, Circular 579, and the 1970 Naval Civil Engineering Laboratory R660 Report, as well as current testing being conducted by the National Electrical Grounding Research Project [NEGRP] demonstrate the long life of 10 mil copper bonded and stainless steel bonded ground rods as compared to galvanized ground rods. NEGRP is a test started by Southern Nevada Chapter of IAEI in 1992, and still an active project reveal that after just 10 years the 3/4" galvanized ground rod sample show significant deterioration while the 5/8" UL listed rod was free of corrosion.

National Electrical Grounding Research Project – Pawnee Site Exhumation

The NEGRP was started in 1992 to compare the long-term performance of different types of grounding electrodes. Originally organized by the Southern Nevada Chapter of the IAEE, the study is now governed by the Fire Protection Research Foundation. In 2003, one of the original sites (Pawnee) was excavated and the rod electrodes removed. 5/8" copperbonded and 3/4" galvanized rod samples were exhumed. The results were definitive. The 5/8" copperbonded rod was virtually free of corrosion while the 3/4" galvanized rod showed significant deterioration (see pictures below).



1. galvanized rod



2. copper bonded rod



3. galvanized rod



4. copper bonded rod

REFERENCES

1. "Underground Corrosion," Melvin Romanoff, United States Department of Commerce, National Bureau of Standards, Circular 579 (April 1957).
2. "Field Testing of Electrical Grounding Rods," Naval Civil Engineering Laboratory, Naval Facilities Engineering Command, Technical Report R660 (February 1970).

GALVANIC SERIES

<i>Alloy</i>		<i>Voltage Range of Alloy vs. Reference Electrode*</i>
Magnesium	Anodic or Active End	-1.60 to -1.63
Zinc		-0.98 to -1.03
Aluminum Alloys		-0.70 to -0.90
Cadmium		-0.70 to -0.76
Cast Irons		-0.60 to -0.72
Steel		-0.60 to -0.70
Aluminum Bronze		-0.30 to -0.40
Red Brass, Yellow Brass		-0.30 to -0.40
Copper		-0.28 to -0.36
Lead-Tin Solder (50/50)		-0.26 to -0.35
Manganese Bronze		-0.25 to -0.33
Silicon Bronze		-0.24 to -0.27
400 Series Stainless Steels		-0.20 to -0.35
17-4 PH Stainless Steel		-0.10 to -0.20
Silver		-0.09 to -0.14
300 Series Stainless Steels	Cathodic or Noble End.	-0.00 to -0.15

Note that Zinc is more reactive than Aluminum Alloys, and therefore more susceptible to corrosion. UL 467 specifically prohibits the use of aluminum alloys for a grounding clamp for this reason.