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Grounding Rod Electrodes and Grounding Rod Electrode Couplings

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Foreword

This Standards Publication provides practical information concerning construction, test, performance, and manufacture of ground rod electrodes and ground rod electrode couplings. This standard is intended for use by the electrical industry to provide guidelines for the manufacture and proper application of these products, and to promote the benefits of repetitive manufacture and widespread product availability.

One of the primary purposes of this Standards Publication is to encourage the manufacture and utilization of products, which, in themselves, function in accordance with these standards. While some sections of this publication are intended to eliminate misunderstandings between manufacturers and users, all sections when applied properly, contribute to safety in one way or another.

The proper manufacture of ground rod electrodes and ground rod electrode couplings is, however, only one consideration in promoting the safe utilization of electricity. Other safety considerations, including environmental conditions, system design, equipment selection and application, installation, operating practices and maintenance, involve the joint efforts of the system designer, the various equipment manufacturers, the installer, and the user. Information is provided herein to assist in proper selection and use.

This Standards Publication covers design and performance requirements for ground rod electrodes and ground rod Electrode couplings, and provides recommendations for their selection and use under normal or certain specific conditions. These standards have been promulgated with a view of promoting safety to persons and property when products conforming to them are selected, installed, and maintained in accordance with the *National Electrical Code*®.

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Comments from users of this standards publication are welcome. They should be sent to:

Vice President, Engineering
National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209

This Standards Publication was developed by the Ground Rod Electrodes and Accessories Section of the National Electrical Manufacturers Association. At the time it was approved, the Ground Rod Electrodes and Accessories Section had the following members:

Roger Montambo, Chairman
Khaled Masri, Secretary

Organization Represented	**Name of Representative**
Alabama Power Company	James L. Harris
Ameren Corporation	H. L. Hayes III
Chardon Electrical Components	Roy E. Jazowski
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Section 1
GENERAL

1.1 SCOPE

This Standards Publication applies to ground rod electrodes and ground rod electrode couplings that function in accordance with the *National Electrical Code®* (NFPA 70-1999). Included are materials, construction, and performance of copper bonded, hot dip galvanized ground rod electrodes. This standards publication also includes information for Electrode products that have been successfully used for many years but are not defined within the *National Electrical Code* (NFPA 70-1999). The items described in this Standards Publication are defined in Section 1.

1.2 NORMATIVE REFERENCES

This NEMA Standards Publication represents the results of research and investigation by the members of NEMA, its Sections and Committees. It has been developed through consultation among manufacturers, users, and national engineering societies. This publication references the following standards (all referenced documents use the latest document date):

American National Standards Institute
11 West 42nd Street
New York, NY 10036

ANSI C135.30-1988 *Zinc-Coated Ferrous Ground Rod Electrodes for Overhead or Underground Line Construction*

American Society for Testing and Materials
100 Barr Harbor Drive
Conshohocken, PA 19428-2959

ASTM A123/A123M-01 *Standard Specification for Zinc (Hot Dip Galvanized) Coatings of Iron and Steel Products*
ASTM A153/A153M-01 *Standard Specification for Zinc Coatings (Hot-Dip) on Iron and Steel Hardware*
ASTM A370-97a *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*
ASTM 571-97e1 *Standard Practice for Qualitative Testing* of Metallic Coatings
ASTM E 376-96 *Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods*

Underwriters Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062

ANSI/UL 467-1993 *Standard for Grounding and Bonding Equipment*

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1.3 UNITS OF MEASUREMENT

The primary units of measure in this Standards Publication are based on the conventional inch-pound system, which is commonly accepted and used by the electrical construction industry.

1.4 DEFINITIONS

adhesion: The physical bond between the applied metal and the core metal.

copper bond: The physical bond between the copper and the core metal.

coupling: A connecting device for mechanically and electrically joining two ground rod electrodes in series.

ground rod electrode: A solid metal electrode capable of being driven into the earth for use as a grounding electrode.

zinc coating:The layer of zinc around the core metal specified as either electroplated or hot dip galvanized.

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SECTION 2
Copper Bonded Ground Rod Electrodes

2.1 STEEL CORE PROPERTIES

Upon inspection of the steel core, there shall be minimal signs of pitting and erosion. There shall be no gashes or cracks that protrude slivers from the surface of the electrode. The steel core, when tested in accordance with ASTM A370, shall have a tensile strength of no less than 80,000 pounds per square-inch and a Rockwell hardness of no less than B80.

2.2 COPPER THICKNESS

The copper thickness shall not be less than 0.010 inch for ground rod electrodes 0.50 inch or greater in diameter. The copper thickness shall be measured with a properly calibrated eddy-current (electromagnetic) device. The device shall be used in accordance with the manufacturer's instructions, and by following the standard practice for measuring coating thickness described in ASTM E 376.

2.3 LENGTH

Ground rod electrodes shall have a length as specified with a -0, +5/8 inch tolerance.

2.4 GROUND ROD ELECTRODE DIAMETERS

Finished ground rod electrodes for the trade sizes listed in Table 1 shall be cold drawn and fall within the specified finished diameter ranges.

Table 1
FINISHED DIAMETER RANGES FOR COPPER BONDED GROUND ROD ELECTRODES

	Finished Diameter Range			
	Threaded		Threadless	
Trade Size, Inches	Minimum, Inches	Maximum, Inches	Minimum, Inches	Maximum, Inches
1/2*	0.500	0.507	0.500	0.510
5/8	0.555	0.565	0.555	0.565
3/4	0.673	0.683	0.673	0.683
1	0.907	0.917	0.907	0.917

*An “L” or “★“ is typically used to indicate minimum 0.500 inch diameter

2.5 THREADS

Threads on copper bonded, sectional type ground rod electrodes shall be rolled onto both ends after copper bonding, and shall conform to the specifications in Figure 1.

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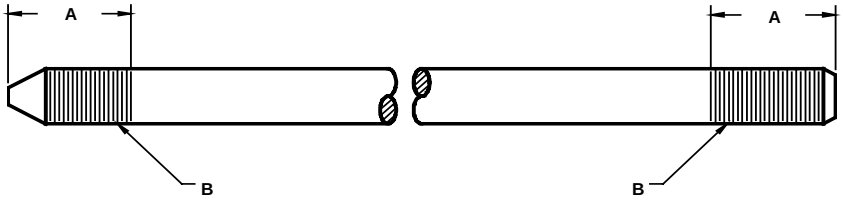

Figure 1

Table 2
THREAD SPECIFICATIONS

Trade Size	Dimension A, Inches +1/8, -1/16	Thread B Profile
1/2*	1-1/16	9/16-12
5/8	1-3/16	5/8-11
3/4	1-1/4	3/4-10
1	1-11/16	1-8

*An "L" or "★" is typically used to indicate minimum 0.500 inch diameter

2.6 END CONFIGURATIONS

The end configurations of a copper bonded ground rod electrode shall be in accordance with Figure 2. The diameter of the penetrating (pointed) end of a copper bonded ground rod electrode shall be as specified per Dimension A, of Table 3, for each trade size. The length of the chamfer on the driving (blunt) end shall be as specified per Dimension B of Table 3.

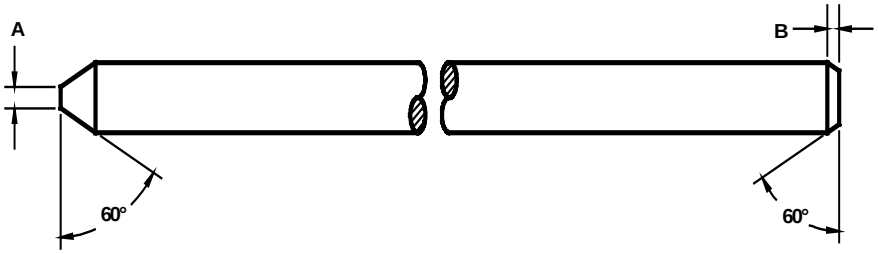

Figure 2

Table 3
END POINT CONFIGURATIONS

Trade Size	Diameter of End Points	
	Dimension A, Maximum, Inches	Dimension B, Minimum, Inches
1/2*	3/16	3/32
5/8	3/16	1/8
3/4	1/4	1/8
1	3/8	7/32

*An "L" or "★" is typically used to indicate minimum 0.500 inch diameter

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2.7 ADHESION

2.7.1 Test Method

An 18-inch length of ground rod electrode with one end cut to a 45 degree point shall be driven between two steel clamping plates or the jaws of a vise set 0.04 inches less than the diameter of the ground rod Electrode, so as to shear off sufficient metal to expose the bond between the copper and the ground rod Electrode.

2.7.2 Evaluation

There shall be no evidence of separation of the copper and the steel core.

2.8 DUCTILITY

2.8.1 Test Method

At room temperature (25ºC ±5ºC), a length of ground rod Electrode shall be rigidly held in a clamp or vise and the free end bent by applying a force normal to the ground rod Electrode at a distance from the clamping device equal to 40 times the ground rod Electrode diameter. The magnitude of the force and the direction of application shall be such that the ground rod Electrode is permanently bent through a 30-degree angle.

2.8.2 Evaluation

There shall be no evidence of cracking of the copper.

2.9 FINISH

The surface of a ground rod Electrode shall be smooth and free from blisters, slivers, and other types of projections.

2.10 STRAIGHTNESS

The deviation from straight for any ground rod Electrode shall be determined and evaluated in accordance with the following:

2.10.1 Test Method

The selected ground rod Electrode shall be supported by two "V" blocks, with a dial feeler gage located at the mid-point of the "V" blocks in accordance with Figure 3. While rotating the ground rod Electrode by hand, the maximum and minimum readings shall be recorded. The readings are then subtracted for the total deviation. The average deviation from straight for the length of the ground rod Electrode located between the "V" blocks is determined by the following formula:

$$AverageDeviation = \frac{Maximum\ Deviation\ (inches) - Minimum\ Deviation\ (inches)}{2\ x\ 3\ feet}$$

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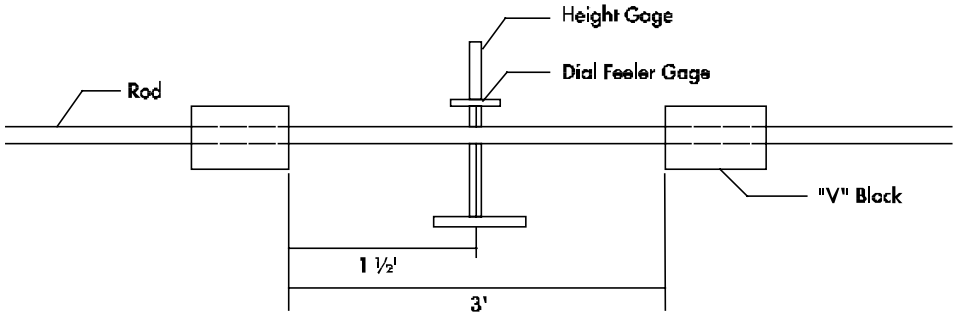
2.10.2 Evaluation

Straightness of the ground rod Electrode shall not vary more than 0.010 inch per foot.

Figure 3
APPARATUS FOR STRAIGHTNESS TEST



2.11 MARKINGS

A ground rod electrode shall be permanently and legibly marked with the manufacturer's identification, and the catalog or equivalent designation, within 12 inches of the driving end of the ground rod electrode.

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Section 3
ZINC COATED GROUND ROD ELECTRODES

3.1 STEEL CORE PROPERTIES

Upon inspection of the steel core, there shall be minimal signs of pitting and erosion. There shall be no gashes or cracks that protrude slivers from the surface of the ground rod electrode. The steel core, when tested in accordance with ASTM A 370, shall have a tensile strength of no less than 80,000 pounds per square inch.

3.2 ZINC COATING

3.2.1 Coating Method

All ground rod electrodes manufactured in accordance with this section shall be coated utilizing a method in accordance with applicable ASTM standards. Hot dip galvanized ground rod electrodes shall be manufactured in accordance with ASTM A 123.

3.2.2 Thickness

The zinc deposit thickness shall not be less than 0.0039 inch.

3.2.3 Measurement

The measurement for zinc thickness shall be made with a properly calibrated eddy-current (electromagnetic) device. The device shall be used in accordance with the manufacturer's instructions, and by following the standard practice for measuring coating thickness described in ASTM E 376.

3.3 LENGTH

Ground rod electrodes shall have a length as specified with a -0, +5/8 inch tolerance.

3.4 GROUND ROD ELECTRODE DIAMETERS

Finished ground rod electrodes for the trade sizes listed in Table 4 shall fall within the specified diameter ranges.

Table 4
FINISHED DIAMETER RANGES FOR ZINC COATED GROUND ROD ELECTRODES

Trade Size, Inches	Finished Diameter Range, Inches	
	Minimum	Maximum
1/2	0.484	0.500
5/8	0.539	0.555
3/4	0.657	0.675

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3.5 ADHESION

The zinc coating shall withstand handling consistent with the nature and thickness of the coating and the normal use of the ground rod electrode without peeling or flaking.

3.5.1 Test Method

Proper adhesion of the zinc coating to the base metal surface shall be determined by cutting or prying the coating with the point of a stout knife, applied with a pressure sufficient to remove a portion of the coating.

3.5.2 Evaluation

Adhesion shall be considered inadequate if flaking occurs, exposing the base metal in advance of the knife point. Adhesion shall not be evaluated at edges or corners.

3.6 FINISH

The surface of ground rod electrodes shall be uniform in appearance, clean, and free of visible coating defects, such as blisters, flux, inclusions, pits, roughness, slivers, sharp spikes, nodules, bare spots, burning, cracks, or unplated areas, and other defects that may affect function of the coating. The coating shall not be stained or discolored. However, superficial staining that results from rinsing or slight discoloration resulting from any drying or baking operation to relieve hydrogen embrittlement shall be acceptable.

3.7 STRAIGHTNESS

The deviation from straight for any ground rod electrode shall be determined and evaluated as follows:

3.7.1 Test Method

Ground rod electrodes shall be prepared for straightness testing in accordance with 2.10.1.

3.7.2 Evaluation

Straightness of the ground rod Electrode shall not vary more than 0.010 inch per foot.

3.8 END CONFIGURATIONS

End configurations of a zinc coated ground rod electrode shall be in accordance with Figure 4. The diameter of the penetrating (pointed) end of the zinc coated ground rod electrode shall be as specified per Dimension A of Table 5 for each trade size. The length of the chamfer, Figure 4, on the driving (blunt) end shall be as specified per Dimension B of Table 5.

3.9 MARKINGS

A ground rod electrode shall be permanently and legibly marked with the manufacturer's identification within 12 inches of the driving end of the ground rod electrode.

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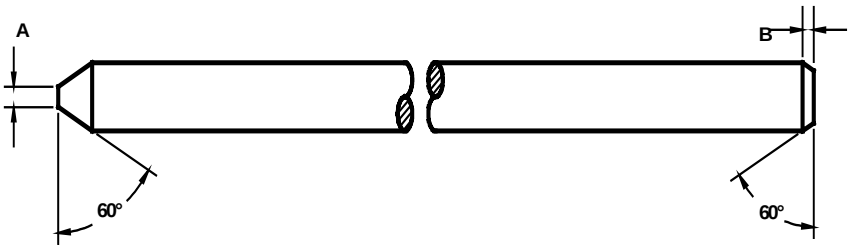

Figure 4

Table 5
END POINT CONFIGURATIONS

Trade Size	Diameter of End Points	
	Dimension A Maximum, Inches	Dimension B Minimum, Inches
1/2	3/16	3/32
5/8	3/16	1/8
3/4	1/4	1/8

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Section 4
COUPLINGS FOR COPPER BONDED GROUND ROD ELECTRODES

4.1 PHYSICAL PROPERTIES

4.1.1 Surface Condition

The surface of the coupling shall be smooth and free of cracks, burrs, or sharp corners.

4.1.2 Material

Coupling material shall be copper or a copper alloy containing not less than 80% copper, and shall be suitable for burial in earth.

4.2 CONSTRUCTION

4.2.1 Length

The length of threaded couplings shall be sufficient to cover the threaded portion of two coupled ground rod Electrodes. In addition, the lengths of both threaded and threadless couplings shall be sufficient to meet the performance requirements of Section 4.3 of this standard.

4.2.2 Application Diameter

4.2.2.1 Threaded Ground Rod Electrode Couplings

A threaded coupling shall be symmetrical and shall accept threaded ground rod electrodes of the trade sizes in Table 6.

Table 6
COUPLING THREAD SIZES FOR THREADED COPPER BONDED GROUND ROD ELECTRODES

Trade Size	Thread Profile
1/2*	9/16-12
5/8	5/8-11
3/4	3/4-10
1	1-8

*An “L” or “★“ is typically used to indicate minimum 0.500 inch diameter

4.2.2.2 Threadless Ground Rod Electrode Couplings

A threadless ground rod Electrode coupling shall be symmetrical and shall accept threadless ground rod Electrodes of the trade sizes in Table 7.

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Table 7
APPLICATION DIAMETERS FOR THREADLESS COUPLINGS FOR THREADLESS COPPER BONDED GROUND ROD ELECTRODES

Trade Size	Application Diameter, Inches
1/2*	0.500 - 0.510
5/8	0.555 - 0.565
3/4	0.673 - 0.683
1	0.907 - 0.917

*An "L" or "★" is typically used to indicate minimum 0.500 inch diameter

4.3 PERFORMANCE

4.3.1 Conductivity

When used to join two copper bonded ground rod electrodes of the minimum diameters specified in Table 1, couplings shall provide to joined ground rod electrodes, no less than 95% of the conductivity of an unspliced copper bonded ground rod electrode of equal length.

4.3.2 Impact

4.3.2.1 Test Method

Two 18-inch copper bonded ground rod electrodes of the diameters specified in Table 1, shall be coupled and held vertically in a tubular fixture that is at least 0.010 inch greater than the copper bonded ground rod electrode diameter. The penetrating end of the bottom ground rod electrode shall be rested on a fixed plate of a weight sufficient to withstand the test impact, and located in a hole at least 4 inches in depth. The coupling shall not rest on or be contained within the tubular fixture or the fixed plate. The top ground rod electrode shall be subjected to an impact force of 40 foot-pounds.

4.3.2.2 Evaluation

After 25 impacts, couplings shall not break, split, or be subjected to damage that impairs performance.

4.3.3 Pullout

When used to join two copper bonded ground rod electrodes of the minimum diameters specified in Table 1, the joining coupling and copper bonded ground rod electrodes must withstand a pullout force of no less than 1500 pounds before separation.

4.3.4 Bend

4.3.4.1 Test Method

Two copper bonded ground rod electrodes coupled together shall be subjected to the same bending requirements as an individual ground rod electrode. The test specimen shall be gripped in a suitable rigid clamp or vise and the ground rod electrode bent by applying a force normal to the ground rod electrode, at a distance of 40 times the ground rod electrode diameter from the clamping device. The coupling shall be located midway between the clamping device and the point of applied force. The force shall be applied until the ground rod electrode is permanently bent through an angle of 30 degrees.

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4.3.4.2 Evaluation

The coupling shall not exhibit any signs of cracking or separation from the ground rod electrode.

4.3.5 Mechanical Strength

Couplings shall provide sufficient mechanical strength to permit driving under normal conditions and not exhibit deformation or splitting under such conditions. This is demonstrated by successful compliance to sections 4.3.2 through 4.3.4.

4.4 MARKINGS

Each coupling shall be marked with the manufacturer’s name or trademark and trade size. Each container, packaged as required by the end user, shall be marked with the manufacturer's name or trademark, and trade size.

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