Public Input No. 173-NFPA 70-2023 [Global Input]

In the pamphlet filename called "GroundingBondingFactSheet.pdf", which is titled "Grounding and Bonding Using the Tables in Article 250 of the NEC"

There is an image that shows the "Supply side equipment bonding jumper" going from the supply side conduit to the "Neutral Bus". To be consistent with your definitions this should be called "Grounded Conductor Bus" I think, but that is a side note. The main note is that in the image the "Supply Side Equipment Bonding Jumper", should go to to the "Equipment Grounding Bus" to avoid confusion. Electrically it wouldn't make a difference, but when going through the definitions as a person new to Article 250, this causes confusion. I am thinking it should go to the Equipment Grounding Bus instead.

Also, after I went through the laborious process to give some quick feedback about an image, I tried uploading a PDF with the graphic that I'm talking about so that it is more clear. I got an error that said "Unable to parse XML" and everthing locked up. I had to go back and start from the beginning.

Update: I think I am wrong about the "supply side equipment bonding jumper" going to the "Equipment grounding bus", but I'm leaving this comment up because it took so long to figure out how to submit suggestions. So my new suggestion is to have a noticeable tab to give feedback about anything website related and not just a particular standard.

Additional Proposed Changes

File Name	Description	Approved
Graphic_in_Question.JPG		
Error.JPG	I got this error when trying to upload a PDF. It doesn't say you can't upload a PDF but it locked everything up.	

Statement of Problem and Substantiation for Public Input

This is just a suggestion with an image in a pamphlet, I could not find any other way to submit feedback to NFPA.org. I went to the CHAT window and this was the only way I was told to submit a suggestion to NFPA.org. This is 30 minutes of time I will never get back for simply trying to give some quick feedback.

Submitter Information Verification

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Submittal Date: Tue Jan 17 11:17:43 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: The committee determined that errors in pamphlets or publications that are not the NEC are not within the purview of this committee.

Public Input No. 3333-NFPA 70-2023 [Global Input]

New Article X50 Grounding, Bonding, and Overvoltage Protection of Limited Energy Systems

Additional Proposed Changes

File Name	Description	Approved
Article_X50_Grounding_and_Bonding_Public_Input.docx		
Limited_Energy_TG_Substantiation.docx		

Statement of Problem and Substantiation for Public Input

See attached document.

Submitter Information Verification

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Submittal Date: Fri Sep 01 10:09:41 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8827-NFPA 70-2024

Statement: The NEC Correlating Committee has created several task groups for the 2026 cycle, but specifically, has created one group to look at the long-term enhancement of the National Electrical Code. This group has looked at and determined that the rapidly changing technology landscape requires that the Limited Power Articles of Chapter 7 and the Communication Articles of Chapter 8, be revised to provide greater usability and clarity for today’s world.

This Public Input is one of a series of Public Inputs to increase the usability of the existing limited energy requirements.

Nearly 30 industry professionals were split among five different Sub Task Groups. Additional meetings were held among the Sub Task Group Chairs to share ideas, complications, correlation issues and other information. Overall dozens of meetings were held to work on this project.

The Task group members for this work include: Derrick Atkins, Tom Domitrovich, Ernie Gallo, Scott Harding, Mark Hilbert, Chad Jones, Alan Manche, Ken McKinney, Nathan Phillips, Dan Ashton, George Bish, Trevor Bowmer, Shane Clary, Michael Cogbill, Jim Conrad, Adam Corbin, Dale Crawford, Ray Horner, Ryan Jackson, Stan Kaufman, Kyle Krueger, William McCoy, Tim Mikloiche, Samuel Rokowski, Anthony Tassone, Ron Tellas, Keith Waters, John Williams and George Zimmerman.

The task group recommends restructuring of the limited energy articles to include protection, cable installation requirements and equipment, similar in concept to the structure used in other parts of the NEC.

To accomplish this, the following is a suggested course of action:

1. Create a limited power NEC structure where the main focus is not the technology but rather the installation requirements of the cable.

2. Articles that look similar to general requirements, wiring, overcurrent protection and grounding.

3. Restructuring of Articles as follows:

a. Existing Article 722, will take on the look and theme of 310 and 315 and placed in new Article X22

b. New grounding and bonding Article X50 will be similar to 250.

c. New overcurrent protection Article X90 will be similar to current Article 240. New Article X90 was chosen in lieu of X40, since there currently is an Article 840 (in case the new Articles are placed in Article 800)

d. Existing Articles 724, 725, and 726, will take on the look and theme of branch circuits with the general requirements placed in new Article X00, the installation requirements in X22, the grounding requirements in X50 and the protection requirements X90.

The goal of these Articles both existing and new is to ultimately locate all content into one chapter in 2029.

The following information and diagrams are provided to outline the thought process.

Section X00.100 combines the separation requirements from 133, 136 and 139 in 725, 726, 760, 770 along with the separation requirements in 800, 805 and 815.

This was the logic the sub task group used to develop what we are calling the X00.100 separation requirements.

The structure follows this logic:

- The list of all limited energy cables is called for in X22.

- A Limited Energy cable has the following construction when placed in a Limited Energy System.

ARTICLE X50

Grounding, Bonding, and Overvoltage Protection of Limited Energy Systems

Part I. General

X50.1 Scope.

This article covers the grounding, bonding and overvoltage protection requirements for Class 1 Power-limited Circuits, Class 2 Circuits, Class 3 Circuits, Class 4 Circuits, Optical Fiber Systems, Communications Systems, Antenna Systems, Community Antenna Systems, Network-Powered Broadband Communications Systems, Premises-Powered broadband Communications Systems, and Power Limited Fire Alarm Systems.

X50.2 Listing.

(A) Grounding and Bonding Devices.

If grounding or bonding is required, devices used to connect a shield, a sheath, a non-current-carrying metal member of a cable, metal parts of equipment, or metal parts of antennas to a grounding electrode conductor or bonding conductor shall be listed or be part of listed equipment.

(B) Primary and Secondary Protectors.

Primary and secondary protectors shall be listed.

Informational Note: See ANSI/UL 497A-2019, Standard for Secondary Protectors for Communications Circuits, to determine applicable requirements for a listed secondary protector.

(C) Antenna Systems Lead-In Protectors.

Antenna lead-in surge protectors shall be listed.

Informational Note: See UL 497E, Outline of Investigation for Protectors for Antenna Lead-In Conductors, for information concerning protectors for antenna lead-in conductors.

X50.3 Reconditioned Equipment. The installation of the following reconditioned equipment shall not be permitted:

(1) Primary Protectors

(2) Secondary Protectors

(3) Antenna Lead-In Protectors

X50.5 Identification of Conductors.

(A) Grounded Conductors.

Grounded conductors shall be identified in accordance with 200.6. The use of conductors with white or gray insulation shall comply with 200.7.

Exception (1): Cables that do not contain a grounded conductor shall be permitted to use a conductor with white or gray insulation, or white or gray insulation with one or more colored stripes, for use other than as a grounded conductor.

Exception (2): The use of white or gray insulation shall be permitted for identification of ungrounded conductors, excluding Class I power-limited circuits.

(B) Wire-Type Equipment Grounding Conductors.

Wire-type equipment grounding conductors shall be identified in accordance with 250.119.

Part II. Conductors and Equipment Outside and Entering Buildings

X50.42 Metal Entrance Raceway Grounding.

Metal raceways containing entrance wire or cable shall be connected to a grounding electrode by a bonding conductor or grounding electrode conductor

X50.48 Grounding, Bonding, or Interruption of Non-Current-Carrying Metal Sheath Members.

Grounding, bonding, or interruption of non-current-carrying metallic sheath members shall comply with X50.48(A), (B), (C), or (D).

Informational Note: Selecting a grounding location to achieve the shortest practicable bonding conductor or grounding electrode conductor helps limit potential differences between limited energy circuits and other metal systems.

(A) Communications Cables.

Communications cables entering the building or terminating on the outside of the building shall comply with X50.48(A)(1) or (A)(2).

(1) Entering Buildings.

If the communications cable enters a building, the metal sheath members of the cable shall be grounded or bonded as specified in X50.100 or interrupted by an insulating joint or equivalent device. The grounding, bonding, or interruption shall be as close as practicable to the point of entrance.

(2) Terminating on the Outside of Buildings.
If the communications cable is terminated on the outside of the building, the metal sheath members of the cable shall be grounded or bonded as specified in X50.100 or interrupted by an insulating joint or equivalent device. The grounding, bonding, or interruption shall be as close as practicable to the point of termination of the cable.

(B) Grounding of Outer Conductive Shield of Coaxial Cables.

Coaxial cables entering buildings or attached to buildings shall comply with X50.48(B)(1) or (B)(2). If the outer conductive shield of a coaxial cable is grounded, no other protective devices shall be required. For purposes of this section, grounding located at mobile home service equipment located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, or at a mobile home disconnecting means grounded in accordance with 250.32 and located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, shall be considered to meet the requirements of this section.

(1) Entering Buildings.
If the coaxial cable enters the building, the outer conductive shield shall be grounded in accordance with X50.75. The grounding shall be as close as practicable to the point of entrance.

(2) Terminating Outside of the Building.
If the coaxial cable is terminated outside of the building, the outer conductive shield shall be grounded in accordance with X50.75. The grounding shall be as close as practicable to the point of attachment or termination.

(C) Metal Members of Network-Powered Broadband Communications Cables.

Network-powered communications cables entering buildings or attaching to buildings shall comply with X50.48(C)(1) or (C)(2).

For purposes of this section, grounding located at mobile home service equipment located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, or at a mobile home disconnecting means grounded in accordance with 250.32 and located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, shall be considered to meet the requirements of this section.

(1) Entering Buildings.

If the network-powered communications cable enters the building, the shield shall be grounded in accordance with X50.100, and metallic members of the cable not used for communications or powering shall be grounded in accordance with X50.100 or interrupted by an insulating joint or equivalent device. The grounding or interruption shall be as close as practicable to the point of entrance.

(2) Terminating Outside of the Building.

If the network-powered communications cable is terminated outside of the building, the shield shall be grounded in accordance with X50.100, and metallic members of the cable not used for communications or powering shall be grounded in accordance with X50.100 or interrupted by an insulating joint or equivalent device. The grounding or interruption shall be as close as practicable to the point of attachment of the Network Interface Unit (NIU).

(D) Premises-Powered Broadband Communications Systems.

Non-current-carrying metallic members of optical fiber cables, communications cables, or coaxial cables entering buildings or attaching to buildings shall comply with X50.48(D)(1), (D)(2), or (D)(3), respectively.

(1) Non-Current-Carrying Metallic Members of Optical Fiber Cables.

Non-current-carrying metallic members of optical fiber cables entering a building or terminating on the outside of a building shall comply with X50.48(D)(1)(a) or (b).

(a) Entering Buildings. If an optical fiber cable is exposed to contact with electric light or power conductors and the cable enters the building, the non–current-carrying metal members shall be either grounded or bonded as specified in X50.100 or interrupted by an insulating joint or equivalent device. The grounding or interruption shall be as close as practicable to the point of entrance.

(b) Terminating on the Outside of Buildings. If an optical fiber cable is exposed to contact with electric light or power conductors and the cable is terminated on the outside of the building, the non–current-carrying metal members shall be either grounded or bonded as specified in X50.100 or interrupted by an insulating joint or equivalent device. The grounding, bonding, or interruption shall be as close as practicable to the point of termination of the cable.

(2) Communications Cables.

The grounding or interruption of the metallic sheath of communications cable shall comply with X50.48(A).

(3) Coaxial Cables.
If coaxial cables are terminated at the network terminal (installed inside or outside of the building), then the outer conductive shield of coaxial cables shall comply with X50.48(B).

X50.60 Antenna Systems Grounding or Bonding.

(A) Lead-in Protectors.

If an antenna lead-in surge protector is installed, it shall be connected between the conductors and the grounded shield or other ground connection. The antenna lead-in protector shall be grounded using a bonding conductor or grounding electrode conductor installed in accordance with X50.66(F).

(B) Support Systems.

Masts and metal structures supporting antennas shall be grounded or bonded in accordance with X50.66, unless the antenna and its related supporting mast or structure are within a zone of protection defined by a 46 m (150 ft) radius rolling sphere.

> Informational Note: See NFPA 780, Standard for the Installation of Lightning Protection Systems, 4.7.3.1, for the application of the term rolling sphere.

(C) Discharge Unit – Receiving Stations.

The antenna discharge unit shall be grounded or bonded in accordance with X50.66.

(D) **Controls.**

All external metal handles and controls accessible to the operating personnel shall be connected to an equipment grounding conductor if the transmitter is powered by the premises wiring system or grounded with a conductor in accordance with X50.66.

X50.66 Antenna Systems and Receiving Stations - Bonding Conductors and Grounding Electrode Conductors.

Bonding conductors and grounding electrode conductors shall comply with X50.66(A) through X50.66(K).

(A) Material.

The bonding conductor or grounding electrode conductor shall be of copper, aluminum, copper-clad steel, copper-clad aluminum, bronze, or similar corrosion-resistant material. Aluminum or copper-clad aluminum bonding conductors or grounding electrode conductors shall not be used if subject to corrosive conditions or in direct contact with masonry or the earth or where subject to corrosive conditions. If used outside, aluminum or copper-clad aluminum conductors shall not be installed within 450 mm (18 in.) of the earth.

(B) Insulation.

Insulation on bonding conductors or grounding electrode conductors shall not be required.

(C) Supports.

The bonding conductor or grounding electrode conductor shall be securely fastened in place and shall be permitted to be directly attached to the surface wired over without the use of insulating supports.

Exception: If proper support cannot be provided, the size of the bonding conductors or grounding electrode conductors shall be increased proportionately.

(D) Physical Protection.

Bonding conductors and grounding electrode conductors shall be protected where exposed to physical damage. If the bonding conductor or grounding electrode conductor is installed in a metal raceway, both ends of the raceway shall be bonded to the contained conductor or to the same terminal or electrode to which the bonding conductor or grounding electrode conductor is connected.

(E) Run in Straight Line.

The bonding conductor or grounding electrode conductor for an antenna mast or antenna discharge unit shall be run in as straight a line as practicable.

(F) Electrode.

The bonding conductor or grounding electrode conductor shall be connected as required in X50.66(F)(1) through (F)(3).

(1) In Buildings or Structures with an Intersystem Bonding Termination.

If the building or structure served has an intersystem bonding termination as required by 250.94, the bonding conductor shall be connected to the intersystem bonding termination.

(2) In Buildings or Structures with Grounding Means.

If the building or structure served has no intersystem bonding termination, the bonding conductor or grounding electrode conductor shall be connected to the nearest accessible location on one of the following:

(1) The building or structure grounding electrode system as covered in 250.50

(2) The power service accessible means external to the building, as covered in 250.94

(3) The nonflexible metal power service raceway

(4) The service equipment enclosure

(5) The grounding electrode conductor or the grounding electrode conductor metal enclosures of the power service

(6) The grounded interior metal water piping systems, within 1.52 m (5 ft) from its point of entrance to the building, as covered in 250.52.

A bonding device intended to provide a termination point for the bonding conductor (intersystem bonding) shall not interfere with the opening of an equipment enclosure. A bonding device shall be mounted on nonremovable parts. A bonding device shall not be mounted on a door or cover even if the door or cover is nonremovable.

(3) In Buildings or Structures Without an Intersystem Bonding Termination or Grounding Means.

If the building or structure served has no intersystem bonding termination or grounding means as described in X50.66(F)(2), the grounding electrode conductor shall be connected to a grounding electrode as described in 250.52.

(G) Inside or Outside Building.

The bonding conductor or grounding electrode conductor shall be permitted to be run either inside or outside the building.

(H) Size.

The bonding conductor or grounding electrode conductor shall not be smaller than 10 AWG copper, 8 AWG aluminum, or 17 AWG copper-clad steel or bronze.

(I) Common Ground.

A single bonding conductor or grounding electrode conductor shall be permitted for both protective and operating purposes.

(J) Bonding of Electrodes.
A bonding jumper not smaller than 6 AWG copper or equivalent shall be connected between the radio and television equipment grounding electrode and the power grounding electrode system at the building or structure served if separate electrodes are used.

(K) Electrode Connection.
Connections to grounding electrodes shall comply with 250.70.

X50.68 Antenna Discharge Units – Transmitting Stations.

Each lead-in conductor for outdoor antennas shall be provided with an antenna discharge unit or other suitable means that drain static charges from the antenna system.

Exception No. 1: If the lead-in conductor is protected by a continuous metal shield that is grounded with a conductor in accordance with X50.70, an antenna discharge unit or other suitable means shall not be required for the lead-in conductor.

Exception No. 2: If the antenna is grounded or bonded with a conductor in accordance with X50.70, an antenna discharge unit or other suitable means shall not be required.

X50.70 Antenna Systems - Bonding Conductors and Grounding Electrode Conductors – Amateur and Citizen Band Transmitting and Receiving Stations.

Bonding conductors and grounding electrode conductors shall comply with X50.70(A) through X50.70(C).

(A) Other Sections.
All bonding conductors and grounding electrode conductors for amateur and citizen band transmitting and receiving stations shall comply with X50.66(A) through X50.66(C).

(B) Size of Protective Bonding Conductor or Grounding Electrode Conductor.
The protective bonding conductor or grounding electrode conductor for transmitting stations shall be as large as the lead-in but not smaller than 10 AWG copper, bronze, or copper-clad steel.

(C) Size of Operating Bonding Conductor or Grounding Electrode Conductor.
The operating bonding conductor or grounding electrode conductor for transmitting stations shall not be less than 14 AWG copper or its equivalent.

X50.75 Cable Bonding and Grounding of Coaxial Cables for Community Antenna Television and Radio Distribution Systems.

The shield of the coaxial cable shall be bonded or grounded as specified in X50.75(A) and (B).

Exception: For communications systems using coaxial cable completely contained within the building (i.e., they do not exit the building) or the exterior zone of protection defined by a 46 m (150 ft) radius rolling sphere and isolated from outside cable plant, the shield shall be permitted to be grounded by a connection to an equipment grounding conductor as described in 250.118. Connecting to an equipment grounding conductor through a grounded receptacle using a dedicated bonding jumper and a permanently connected listed device shall be permitted. Use of a cord and plug for the connection to an equipment grounding conductor shall not be permitted.

> Informational Note: See NFPA 780-2020, Standard for the Installation of Lightning Protection Systems, 4.7.3.1, for the application of the term rolling sphere.

(A) General Requirements.

The installation shall be in accordance with X50.100.

(B) Shield Protection Devices.

Grounding of a coaxial drop cable shield by means of a protective device that does not interrupt the grounding system within the premises shall be permitted.

X50.77 Equipment Grounding for Community Antenna Television and Radio Distribution Systems.

Unpowered equipment and enclosures or equipment powered by the coaxial cable shall be considered grounded if connected to the metallic cable shield.

X50.80 Premises Circuits of Premises-Powered Broadband Communications Systems Not Leaving the Building.

If the network terminal is served by a nonconductive optical fiber cable, or if any non-current-carrying metal member of a conductive optical fiber cable is interrupted by an insulating joint or equivalent device, and circuits that terminate at the network terminal are completely contained within the building (i.e., they do not exit the building), X50.80(A), (B), or (C) shall apply, as applicable.

(A) Coaxial Cable Shield Grounding.

The shield of coaxial cable shall be grounded by one of the following:

(1) Any of the methods described in X50.75 or X50.106

(2) A fixed connection to an equipment grounding conductor as described in 250.118

(3) Connection to the network terminal grounding terminal provided that the terminal is connected to ground by one of the methods described in X50.75 or X50.106 or to an equipment grounding conductor through a listed grounding device that will retain the ground connection if the network terminal is unplugged

(B) Communications Circuit Grounding.

Communications circuits shall not be required to be grounded.

(C) Network Terminal Grounding.

The network terminal shall not be required to be grounded unless required by its listing. If the coaxial cable shield is separately grounded as described in X50.80(A)(1) or X50.80(A)(2), the use of a cord and plug for the connection to the network terminal grounding connection shall be permitted.

> Informational Note: If required to be grounded, a listed device that extends the equipment grounding conductor from the receptacle to the network terminal equipment grounding terminal is permitted. Sizing of the extended equipment grounding conductor is covered in Section 250.122.

Part III. Grounding methods

X50.100 Cable and Primary Protector Bonding and Grounding

(A) Bonding Conductor or Grounding Electrode Conductor.

(1) Insulation.

The bonding conductor or grounding electrode conductor shall be listed and shall be permitted to be insulated, covered, or bare.

(2) Material.

The bonding conductor or grounding electrode conductor shall be copper or other corrosion-resistant conductive material, stranded or solid.

(3) Size.

The bonding conductor or grounding electrode conductor shall not be smaller than 14 AWG. The bonding conductor or grounding electrode conductor shall have an ampacity not less than the aggregate of the grounded metal cable sheath member, the metal strength member(s), and the protected conductor(s) of the communications cable, or the outer sheath of the coaxial cable, as applicable. The bonding conductor or grounding electrode conductor shall not be required to exceed 6 AWG.

(4) Length.

The bonding conductor or grounding electrode conductor shall be as short as practicable. In one- and two-family dwellings, the bonding conductor or grounding electrode conductor shall be as short as practicable, not to exceed 6.0 m (20 ft) in length.

> Informational Note: Similar bonding conductor or grounding electrode conductor length limitations applied at apartment buildings and commercial buildings help to reduce voltages that may be developed between the building's power and communications systems during lightning events. See ANSI/TIA-607-D-2019, Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises, which includes useful information to reduce such voltages.

Exception:

In one- and two-family dwellings if it is not practicable to achieve an overall maximum bonding conductor or grounding electrode conductor length of 6.0 m (20 ft), a separate ground rod meeting the minimum dimensional criteria of X50.100(B)(3)(2) or (B)(3)(3) shall be driven, the bonding conductor or grounding electrode conductor shall be connected to the ground rod in accordance with X50.100(C), and the ground rod shall be connected to the power grounding electrode system in accordance with X50.100(D).

(5) Run in Straight Line.

The bonding conductor or grounding electrode conductor shall be run in as straight a line as practicable.

(6) Physical Protection.

Bonding conductors and grounding electrode conductors shall be protected where exposed to physical damage. If the bonding conductor or grounding electrode conductor is installed in a metal raceway, both ends of the raceway shall be bonded to the contained conductor or to the same terminal or electrode to which the bonding conductor or grounding electrode conductor is connected.

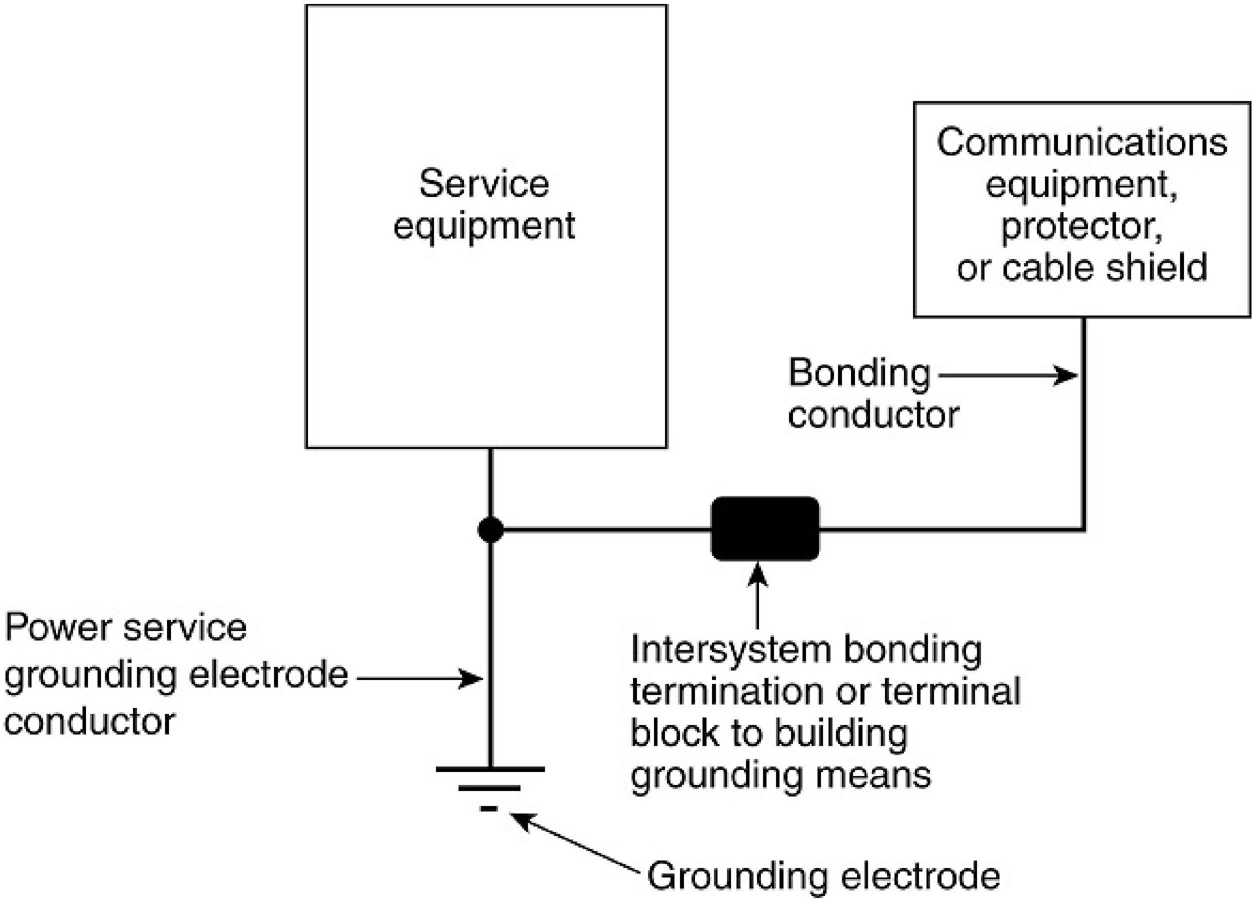
(B) Electrode.

The bonding conductor or grounding electrode conductor shall be connected in accordance with X50.100(B)(1), (B)(2), or (B)(3).

(1) In Buildings or Structures with an Intersystem Bonding Termination.

If the building or structure served has an intersystem bonding termination as required by 250.94, the bonding conductor shall be connected to the intersystem bonding termination.

> Informational Note:
> Informational Note Figure X50.100(B)(1) illustrates the connection of the bonding conductor in buildings or structures equipped with an intersystem bonding termination or a terminal block providing access to the building grounding means.



Informational Note Figure X50.100(B)(1) Illustration of a Bonding Conductor in a Communications Installation Equipped with an Intersystem Bonding Termination or Terminal Block Providing Access to the Building Grounding Means.

(2) In Buildings or Structures with Grounding Means.

If an intersystem bonding termination is established, 250.94(A) shall apply. If the building or structure served has no intersystem bonding termination, the bonding conductor or grounding electrode conductor shall be connected to the nearest accessible location on one of the following:

(1) The building or structure grounding electrode system as covered in 250.50

(2) The power service accessible means external to enclosures using the options indicated in 250.94(A), Exception

(3) The nonflexible metal power service raceway

(4) The service equipment enclosure

(5) The grounding electrode conductor or the grounding electrode conductor metal enclosure of the power service

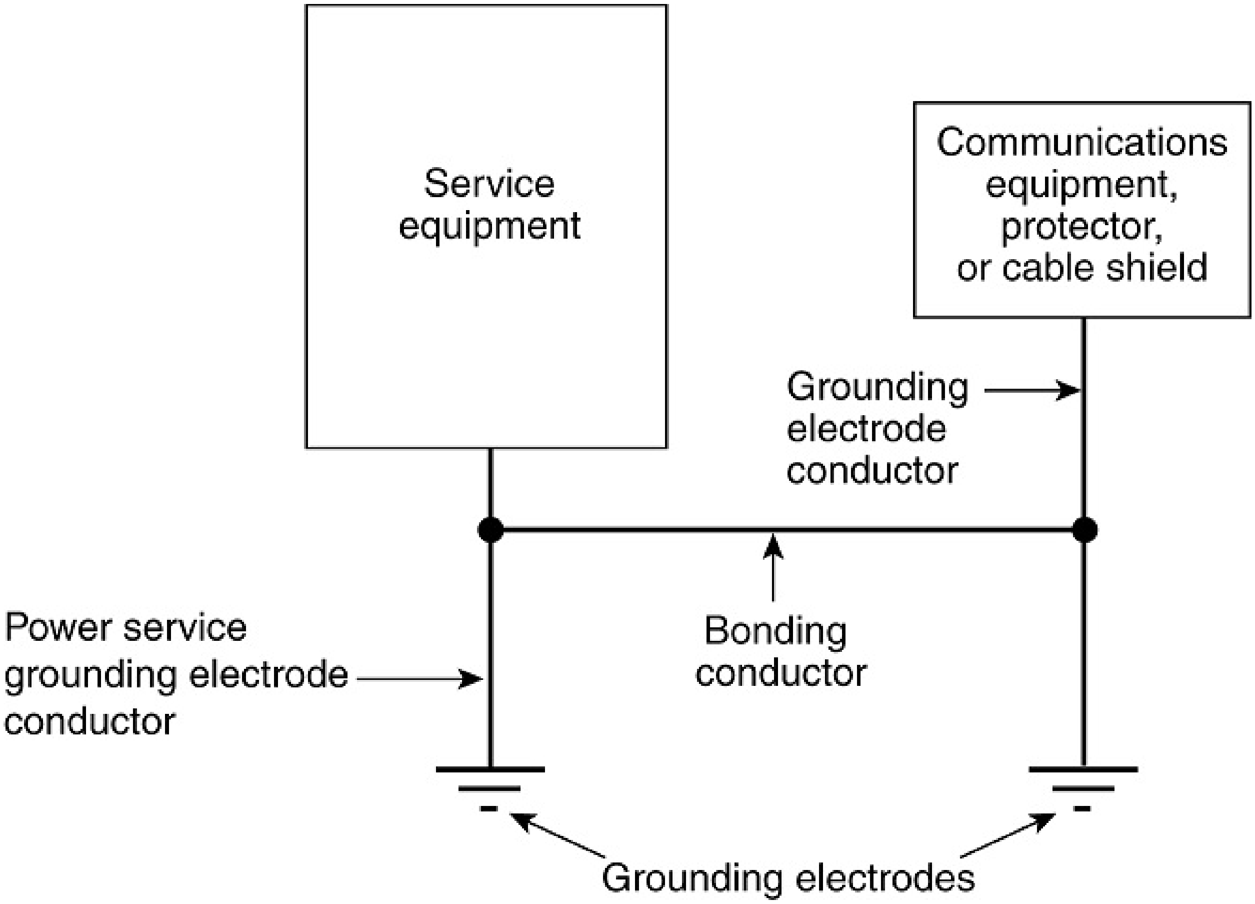
(6) The grounding electrode conductor or the grounding electrode of a building or structure disconnecting means that is connected to a grounding electrode as covered in 250.32

(7) The grounded interior metal water piping system, within 1.5 m (5 ft) from its point of entrance to the building, as covered in 250.52

A bonding device intended to provide a termination point for the bonding conductor (intersystem bonding) shall not interfere with the opening of an equipment enclosure. A bonding device shall be mounted on nonremovable parts. A bonding device shall not be mounted on a door or cover even if the door or cover is nonremovable.

For purposes of this section, the mobile home service equipment or the mobile home disconnecting means located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, or at a mobile home disconnecting means connected to an electrode by a grounding electrode conductor in accordance with 250.32 and located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, shall be considered to meet the requirements of this section.

> Informational Note:
> See Informational Note Figure X50.100(B)(2) for an illustration of a grounding electrode conductor and a bonding conductor in a communications installation not equipped with an intersystem bonding termination or terminal block.



Informational Note Figure X50.100(B)(2) Illustration of a Grounding Electrode Conductor and a Bonding Conductor in a Communications Installation Not Equipped with an Intersystem Bonding Termination or Terminal Block Providing Access to the Building Grounding Means.

(3) In Buildings or Structures Without an Intersystem Bonding Termination or Grounding Means.

If the building or structure served has no intersystem bonding termination or grounding means, as described in 800.20(B)(2), the grounding electrode conductor shall be connected to one of the following:

(1) To any one of the individual grounding electrodes described in 250.52(A)(1), (A)(2), (A)(3), or (A)(4)

(2) If the building or structure served has no intersystem bonding termination or grounding means, as described in X50.100(B)(2) or (B)(3)(1), to any one of the individual grounding electrodes described in 250.52(A)(5), (A)(7), and (A)(8)

(3) For communications circuits or network-powered broadband communications systems, to a ground rod or pipe not less than 1.5 m (5 ft) in length and 12.7 mm (0.5 in.) in diameter, driven, where practicable, into permanently damp earth and separated from lightning protection system conductors, as covered in X50.48, and at least 1.8 m (6 ft) from electrodes of other systems

Steam pipes, hot water pipes, or lightning protection system conductors shall not be employed as grounding electrodes or as a bonding or grounding electrode conductor for protectors and grounded metal members.

(C) Electrode Connection.

Connections to grounding electrodes shall comply with 250.70.

(D) Bonding of Electrodes.

A bonding jumper not smaller than 6 AWG copper or equivalent shall be connected between the grounding electrode and power grounding electrode system at the building or structure served if separate electrodes are used.

Exception:

Bonding of electrodes at mobile homes shall be in accordance with X50.106.

Informational Note No. 1: See 250.60 for connection to a lightning protection system.

Informational Note No. 2: Bonding together of all separate electrodes limits potential differences between them and between their associated wiring systems.

X50.106 Primary Protector Grounding and Bonding at Mobile Homes

(A) Grounding.

Grounding shall comply with X50.106(A)(1) and (A)(2).

(1) Mobile Home Service Equipment.

If there is no mobile home service equipment located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, grounding shall comply with one of the following:

(1) The following components (if present) shall be connected to a grounding electrode in accordance with X50.100(B)(3):

a. Primary protector grounding terminal

b. Network interface unit

c. Coaxial cable shield ground

d. Surge arrester grounding terminal

e. Network-powered broadband communications cable shield

f. Network-powered broadband communications cable metal members not used for communications or powering

(2) The non-current-carrying metal members of optical fiber cables shall be connected to a grounding electrode in accordance with X50.108(A)(1). The network terminal, if required to be grounded, shall be connected to a grounding electrode in accordance with X50.100(A)(1)(1). The grounding electrode shall be bonded in accordance with X50.108(B).

(2) Mobile Home Feeder Disconnecting Means.

If there is no mobile home disconnecting means grounded in accordance with 250.32 and located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, grounding shall comply with one of the following:

(1) The following components (if present) shall be connected to a grounding electrode in accordance with X50.100(B)(3):

a. Primary protector grounding terminal

b. Network interface unit

c. Network-powered broadband communications shield

d. Network-powered broadband communications cable metal members not used for communications or powering

(2) The non-current-carrying metal members of optical fiber cables shall be connected to a grounding electrode in accordance with X50.108(A)(2). The network terminal, if required to be grounded, shall be connected to a grounding electrode in accordance with X50.106(A)(2). The grounding electrode shall be bonded in accordance with X50.108(B).

(B) Bonding.

The primary protector grounding terminal or grounding electrode, network-powered broadband communications cable grounding terminal, or network interface unit grounding terminal shall be bonded together and connected to the metal frame or available grounding terminal of the mobile home with a copper conductor not smaller than 12 AWG under either of the following conditions:

(1) If there is no mobile home service equipment or disconnecting means as in X50.106(A)

(2) If the mobile home is supplied by cord and plug

X50.108 Grounding and Bonding of Optical Fiber Entrance Cables at Mobile Homes.

(A) Grounding.

Grounding shall comply with X50.108(A)(1) and (A)(2).

(1) Installations Without Mobile Home Service Equipment.

If there is no mobile home service equipment located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, the non-current-carrying metallic members of optical fiber cables entering the mobile home shall be grounded in accordance with X50.100(B)(3).

(2) Installations Without Mobile Home Disconnecting Means.

If there is no mobile home disconnecting means grounded in accordance with 250.32 and located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, the non-current-carrying metallic members of optical fiber cables entering the mobile home shall be grounded in accordance with X50.100(B)(3).

(B) Bonding.

The grounding electrode shall be bonded to the metal frame or available grounding terminal of the mobile home with a copper conductor or other equivalent corrosion-resistant material not smaller than 12 AWG under either of the following conditions:

(1) If there is no mobile home service equipment or disconnecting means as in X50.106(A)

(2) If the mobile home is supplied by cord and plug

PART IV. Primary and Secondary Protection

X50.150 Primary Protection

(A) Application.

A listed primary protector shall be provided on each communication circuit run partly or entirely in aerial wire or aerial cable not confined within a block. Also, a listed primary protector shall be provided on each circuit, aerial or underground, located within the block containing the building served so as to be exposed to accidental contact with electric light or power conductors operating at over 300 volts to ground. In addition, where there exists a lightning exposure, each interbuilding circuit on a premises shall be protected by a listed primary protector at each end of the interbuilding circuit.

Exception: Primary electrical protection shall not be required on the network-powered broadband communications conductors where electrical protection is provided on the derived circuit(s) (output side of the NIU) in accordance with 830.90(B)(3).

Informational Note No. 1: On network-powered broadband communications conductors not exposed to lightning or accidental contact with power conductors, providing primary electrical protection in accordance with this section helps protect against other hazards, such as ground potential rise caused by power fault currents, and above-normal voltages induced by fault currents on power circuits in proximity to the network-powered broadband communications conductors.

Informational Note No. 2: -Communications circuits are considered to have a lightning exposure unless one or more of the following conditions exist:

(1) Circuits in large metropolitan areas where buildings are close together and sufficiently high to intercept lightning.

(2) Areas having an average of five or fewer thunderstorm days each year and earth resistivity of less than 100 ohm-meters. Such areas are found along the Pacific coast.

Informational Note No. 3: On a circuit not exposed to accidental contact with power conductors, providing a listed primary protector in accordance with this section helps protect against other hazards, such as lightning and above-normal voltages induced by fault currents on power circuits in proximity to the communications circuit.

Informational Note No. 4: Interbuilding circuits are considered to have a lightning exposure unless one or more of the following conditions exist:

(1) Circuits in large metropolitan areas where buildings are close together and sufficiently high to intercept lightning.

(2) Interbuilding cable runs of 42 m (140 ft) or less, directly buried or in underground conduit, where a continuous metallic cable shield or a continuous metal conduit containing the cable is connected to each building grounding electrode system.

(3) Areas having an average of five or fewer thunderstorm days per year and earth resistivity of less than 100 ohm-meters. Such areas are found along the Pacific coast.

Informational Note No. 5: See NFPA 780-2020, *Standard for the Installation of Lightning Protection Systems,* for information on lightning protection systems.

(B) Fuseless Primary Protectors.

Fuseless-type primary protectors shall be permitted under any of the following conditions:

(1) If conductors enter a building through a cable with grounded metallic sheath member(s) and if the conductors in the cable safely fuse on all currents greater than the current-carrying capacity of the primary protector and of the primary protector bonding conductor or grounding electrode conductor

(2) If insulated conductors in accordance with 805.50(A) are used to extend circuits to a building from a cable with an effectively grounded metallic sheath member(s) and if the conductors in the cable or cable stub, or the connections between the insulated conductors and the plant exposed to accidental contact with electric light or power conductors operating at greater than 300 volts to ground, safely fuse on all currents greater than the ampere rating of the primary protector, or the ampacity of the associated insulated conductors and of the primary protector bonding conductor or grounding electrode conductor

(3) If insulated conductors in accordance with 805.50(A) or (B) are used to extend circuits to a building from other than a cable with metallic sheath member(s), if (a) the primary protector is listed as being suitable for this purpose for application with circuits extending from other than a cable with metallic sheath members and (b) the connections of the insulated conductors to the plant exposed to accidental contact with electric light or power conductors operating at greater than 300 volts to ground or the conductors of the plant exposed to accidental contact with electric light or power conductors operating at greater than 300 volts to ground safely fuse on all currents greater than the ampere rating of the primary protector, or ampacity of the associated insulated conductors and of the primary protector bonding conductor or grounding electrode conductor

(4) If insulated conductors in accordance with 805.50(A) are used to extend circuits aerially to a building from a buried or underground circuit that is unexposed to accidental contact with electric light or power conductors operating at greater than 300 volts to ground

(5) Where insulated conductors in accordance with 805.50(A) are used to extend circuits to a building from cable with an effectively grounded metallic sheath member(s), and where (a) the combination of the primary protector and insulated conductors is listed as being suitable for this purpose for application with circuits extending from a cable with an effectively grounded metallic sheath member(s) and (b) the insulated conductors safely fuse on all currents greater than the ampere rating of the primary protector and the ampacity of the primary protector bonding conductor or grounding electrode conductor

Informational Note: See ANSI/IEEE C2-2017, *National Electrical Safety Code*, Section 9, for examples of methods of protective grounding that can achieve effective grounding of communications cable sheaths for cables from which communications circuits are extended.

(C) Fused Primary Protectors.

Where the requirements listed under X50.150(B)(1) through (B)(5) are not met, fused-type primary protectors shall be used. Fused-type primary protectors shall consist of an arrester connected between each line conductor and ground, a fuse in series with each line conductor, and an appropriate mounting arrangement. Primary protector terminals shall be marked to indicate line, instrument, and ground, as applicable.

X50.160 Secondary Protection.

Any overvoltage protection, arresters, or grounding connection shall be connected on the equipment terminal side of the secondary protector current-limiting means.

X50.170 Installation of Primary and Secondary Protectors.

(A) Primary Protectors.

The primary protector shall consist of an arrester connected between each line conductor and the grounding electrode system in an appropriate mounting. Primary protector terminals shall be marked to indicate line and ground as applicable.

(B) Secondary Protectors.

The connection of overvoltage protection devices, arresters, or grounding and bonding conductors shall be made on the equipment terminal side of the secondary protector current-limiting means.

(C) Location.

If installed, a listed primary protector shall be applied on each community antenna and radio distribution (CATV) cable external to the premises. The listed primary protector shall be located as close as practicable to the entrance point of the cable on either side or integral to the ground block.

(D) Hazardous (Classified) Locations.

If a primary protector or equipment providing the primary protection function is used, it shall not be located in any hazardous (classified) location as described in 500.5 and 505.5 or in the vicinity of easily ignitable material.

Exception: Primary protection equipment shall be used only if permitted by 501.150, 502.150, and 503.150.

Substantiation

The NEC Correlating Committee has created several task groups for the 2026 cycle, but specifically, has created one group to look at the long-term enhancement of the National Electrical Code. This group has looked at and determined that the rapidly changing technology landscape requires that the Limited Power Articles of Chapter 7 and the Communication Articles of Chapter 8, be revised to provide greater usability and clarity for today's world.

This Public Input is one of a series of Public Inputs to increase the usability of the existing limited energy requirements.

Nearly 30 industry professionals were split among five different Sub Task Groups. Additional meetings were held among the Sub Task Group Chairs to share ideas, complications, correlation issues and other information. Overall dozens of meetings were held to work on this project.

The Task group members for this work include: Derrick Atkins, Tom Domitrovich, Ernie Gallo, Scott Harding, Mark Hilbert, Chad Jones, Alan Manche, Ken McKinney, Nathan Phillips, Dan Ashton, George Bish, Trevor Bowmer, Shane Clary, Michael Cogbill, Jim Conrad, Adam Corbin, Dale Crawford, Ray Horner, Ryan Jackson, Stan Kaufman, Kyle Krueger, William McCoy, Tim Mikloiche, Samuel Rokowski, Anthony Tassone, Ron Tellas, Keith Waters, John Williams and George Zimmerman.

The task group recommends restructuring of the limited energy articles to include protection, cable installation requirements and equipment, similar in concept to the structure used in other parts of the NEC.

To accomplish this, the following is a suggested course of action:

1. Create a limited power NEC structure where the main focus is not the technology but rather the installation requirements of the cable.
2. Articles that look similar to general requirements, wiring, overcurrent protection and grounding.
3. Restructuring of Articles as follows:
    a. Existing Article 722, will take on the look and theme of 310 and 315 and placed in new Article X22
    b. New grounding and bonding Article X50 will be similar to 250.
    c. New overcurrent protection Article X90 will be similar to current Article 240. New Article X90 was chosen in lieu of X40, since there currently is an Article 840 (in case the new Articles are placed in Article 800)
    d. Existing Articles 724, 725, and 726, will take on the look and theme of branch circuits with the general requirements placed in new Article X00, the installation requirements in X22, the grounding requirements in X50 and the protection requirements X90.

The goal of these Articles both existing and new is to ultimately locate all content into one chapter in 2029.

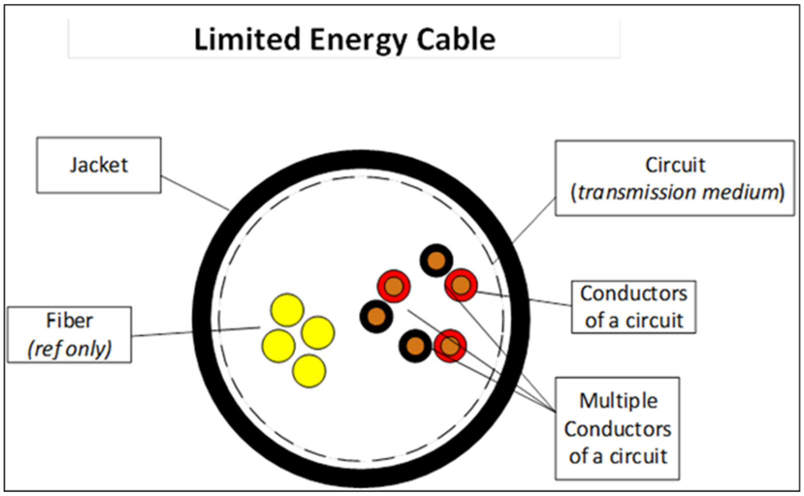
The following information and diagrams are provided to outline the thought process.

Section X00.100 combines the separation requirements from 133, 136 and 139 in 725, 726, 760, 770 along with the separation requirements in 800, 805 and 815.

This was the logic the sub task group used to develop what we are calling the X00.100 separation requirements.

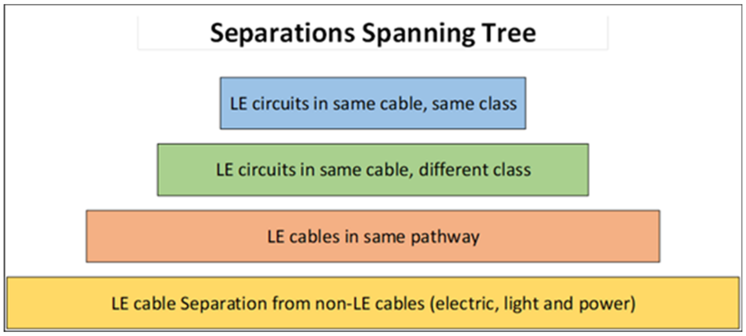
The structure follows this logic:

- The list of all limited energy cables is called for in X22.
- A Limited Energy cable has the following construction when placed in a Limited Energy System.



The structure of X00.100 follows the following hierarchy:

- X00.100 (A) is the blue block
- X00.100 (B) and (C) are the green block
- X00.100 (D) and (E) are the salmon block
- X00.100 (F) (G) (H) (I) are the yellow block



Public Input No. 304-NFPA 70-2023 [New Article after 100]

Objectionable current:

Current intended for a system grounded conductor unintentionally carried on normally non-current carrying conductors (EGCs) or metal parts due to improper bonding connections.

Statement of Problem and Substantiation for Public Input

Objectionable current doesn't have a definition. Through many years of teaching apprentice and journeyman level classes this is always a confusing subject

Submitter Information Verification

Submitter Full Name:	Robert Warren
Organization:	Montana Electrical JATC
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Feb 08 11:23:12 EST 2023
Committee:	NEC-P05

Committee Statement

Resolution: The committee has determined that the term objectionable current has too many variables and multiple examples that a single definition cannot fit. This is best determined by the local AHJ and the specific installation.

Public Input No. 3991-NFPA 70-2023 [Definition: Bonding Conductor (Bonding Jumper).]

Bonding Conductor (Bonding Jumper).

A conductor that ensures the required electrical conductivity between metal parts that are required to be electrically connected. (CMP-5)

Additional Proposed Changes

File Name	Description	Approved
PC_763_CMP_5.pdf	70_PC763	
PC_763_Attachment.pdf	70_PC763_Attachment	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as “Reject but Hold” in Public Comment No. 763 of the (A2022) Second Draft Report for NFPA 70 and per the Regs. at 4.4.8.3.1.

NOTE: The following CC Note No. 413 appeared in the First Draft Report on First Revision No. 8242. The Correlating Committee directs the panel to review the "Bonding Jumper" definitions to comply with the NEC Style Manual Section 2.2.2.3 concerning the use of the base term. The panel should consider the use of the term "bonding conductor" instead of the term "bonding conductor or jumper" for clarity and usability.

The Panel should reconsider PI-3413 referencing changing the term "Supply-Side Bonding Jumper" to "Supply-Side Bonding Conductor". The term "conductor" is more appropriate, since we are referring to a conductor that performs an action, and not the action itself ("the connection").

The following definitions also need to be revised:

Bonding Conductor or Jumper to Bonding Conductor (BC);

Bonding Jumper, Equipment to Bonding Conductor, Equipment (EBC) (Equipment Bonding Conductor);

Bonding Jumper, Supply-Side to Bonding Conductor, Supply Side (SSBC) (Supply-Side Bonding Conductor);

Bonding Jumper, Main to Bonding Conductor, Main (MBC) (Main Bonding Conductor)

Bonding Jumper, System to Bonding Conductor, System (SBC) (System Bonding Conductor)

The Correlating Committee directs that these definitions comply with the NEC Style Manual Section 2.2.2.3.1 for Defined Terms. To assist in electronic searching, the defined term shall then appear in parentheses as it would be found in the document. References throughout the document will need to be revised to reflect the changes. 2.2.2.5 Synonyms, Similar Terms or Alternate Terms could be added under these terms.

Submitter Information Verification

Submitter Full Name: CMP ON NEC-P05

Organization: Code-Making Panel 5

Street Address:
City:
State:
Zip:
Submittal Date: Wed Sep 06 12:45:37 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: There was no specific action requested by this public input. The panel made a series of first revisions that addressed the concerns in the PI substantiation.

Public Comment No. 763-NFPA 70-2021 [Definition: Bonding Conductor or Jumper (BJ).]

Bonding Conductor or Jumper (BJ).

A conductor that ensures the required electrical conductivity between metal parts that are required to be electrically connected. (CMP-5)

Additional Proposed Changes

File Name	Description	Approved
5_CN_413.pdf	5 CN413	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 413 appeared in the First Draft Report on First Revision No. 8242.

The Correlating Committee directs the panel to review the "Bonding Jumper" definitions to comply with the NEC Style Manual Section 2.2.2.3 concerning the use of the base term. The panel should consider the use of the term "bonding conductor" instead of the term "bonding conductor or jumper" for clarity and usability. The Panel should reconsider PI-3413 referencing changing the term "Supply-Side Bonding Jumper" to "Supply-Side Bonding Conductor". The term "conductor" is more appropriate, since we are referring to a conductor that performs an action, and not the action itself ("the connection").

The following definitions also need to be revised:

Bonding Conductor or Jumper to Bonding Conductor (BC);

Bonding Jumper, Equipment to Bonding Conductor, Equipment (EBC) (Equipment Bonding Conductor);

Bonding Jumper, Supply-Side to Bonding Conductor, Supply Side (SSBC) (Supply-Side Bonding Conductor);

Bonding Jumper, Main to Bonding Conductor, Main (MBC) (Main Bonding Conductor)

Bonding Jumper, System to Bonding Conductor, System (SBC) (System Bonding Conductor)

The Correlating Committee directs that these definitions comply with the NEC Style Manual Section 2.2.2.3.1 for Defined Terms. To assist in electronic searching, the defined term shall then appear in parentheses as it would be found in the document.

References throughout the document will need to be revised to reflect the changes.

2.2.2.5 Synonyms, Similar Terms or Alternate Terms could be added under these terms.

Related Item

- First Revision No. 8242

Submitter Information Verification

Submitter Full Name: CC on NEC-AAC

Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 04 09:31:43 EDT 2021
Committee: NEC-P05

Committee Statement

Committee Action: Rejected but held

Resolution: The impact of the changes proposed in the Comment is extensive and the panel sees that a more holistic review of article 250 and throughout the NEC regarding the use of the terms bonding jumper and its derivatives is warranted. Based on the amount of time involved in such a review, this comment is held in accordance with 4.4.8.3.1(c) of the regulations governing the development of NFPA standards. The acronym is addressed in a separate action on PC 274.

Correlating Committee Note No. 413-NFPA 70-2021 [Definition: Bonding Conductor or Jumper.]

Submitter Information Verification

Committee: NEC-P05

Submittal Date: Sun May 09 21:49:28 EDT 2021

Committee Statement

Committee Statement: The Correlating Committee directs the panel to review the "Bonding Jumper" definitions to comply with the NEC Style Manual Section 2.2.2.3 concerning the use of the base term. The panel should consider the use of the term "bonding conductor" instead of the term "bonding conductor or jumper" for clarity and usability. The Panel should reconsider PI-3413 referencing changing the term "Supply-Side Bonding Jumper" to "Supply-Side Bonding Conductor". The term "conductor" is more appropriate, since we are referring to a conductor that performs an action, and not the action itself ("the connection").

The following definitions also need to be revised:

Bonding Conductor or Jumper to Bonding Conductor (BC);

Bonding Jumper, Equipment to Bonding Conductor, Equipment (EBC) (Equipment Bonding Conductor);

Bonding Jumper, Supply-Side to Bonding Conductor, Supply Side (SSBC) (Supply-Side Bonding Conductor);

Bonding Jumper, Main to Bonding Conductor, Main (MBC) (Main Bonding Conductor)

Bonding Jumper, System to Bonding Conductor, System (SBC) (System Bonding Conductor)

The Correlating Committee directs that these definitions comply with the NEC Style Manual Section 2.2.2.3.1 for Defined Terms. To assist in electronic searching, the defined term shall then appear in parentheses as it would be found in the document.

References throughout the document will need to be revised to reflect the changes.

2.2.2.5 Synonyms, Similar Terms or Alternate Terms could be added under these terms.

First Revision No. 8242-NFPA 70-2020 [Definition: Bonding Conductor or Jumper.]

Ballot Results

✓ **This item has passed ballot**

12	Eligible Voters
0	Not Returned
12	Affirmative All
0	Affirmative with Comments
0	Negative with Comments
0	Abstention

Affirmative All

Ayer, Lawrence S.

Gallo, Ernest J.

Hickman, Palmer L.

Holub, Richard A.

Hunter, Dean C.

Johnston, Michael J.

Kendall, David H.

Kovacik, John R.

Manche, Alan

McDaniel, Roger D.

Porter, Christine T.

Williams, David A.

Correlating Committee Note No. 413-NFPA 70-2021 [Definition: Bonding Conductor or Jumper.]

Submitter Information Verification

Committee: NEC-P05

Submittal Date: Sun May 09 21:49:28 EDT 2021

Committee Statement

Committee Statement: The Correlating Committee directs the panel to review the "Bonding Jumper" definitions to comply with the NEC Style Manual Section 2.2.2.3 concerning the use of the base term. The panel should consider the use of the term "bonding conductor" instead of the term "bonding conductor or jumper" for clarity and usability. The Panel should reconsider PI-3413 referencing changing the term "Supply-Side Bonding Jumper" to "Supply-Side Bonding Conductor". The term "conductor" is more appropriate, since we are referring to a conductor that performs an action, and not the action itself (“the connection”).

The following definitions also need to be revised:

Bonding Conductor or Jumper to Bonding Conductor (BC);

Bonding Jumper, Equipment to Bonding Conductor, Equipment (EBC) (Equipment Bonding Conductor);

Bonding Jumper, Supply-Side to Bonding Conductor, Supply Side (SSBC) (Supply-Side Bonding Conductor);

Bonding Jumper, Main to Bonding Conductor, Main (MBC) (Main Bonding Conductor)

Bonding Jumper, System to Bonding Conductor, System (SBC) (System Bonding Conductor)

The Correlating Committee directs that these definitions comply with the NEC Style Manual Section 2.2.2.3.1 for Defined Terms. To assist in electronic searching, the defined term shall then appear in parentheses as it would be found in the document.

References throughout the document will need to be revised to reflect the changes.

2.2.2.5 Synonyms, Similar Terms or Alternate Terms could be added under these terms.

First Revision No. 8242-NFPA 70-2020 [Definition: Bonding Conductor or Jumper.]

Ballot Results

✓ **This item has passed ballot**

12	Eligible Voters
0	Not Returned
12	Affirmative All
0	Affirmative with Comments
0	Negative with Comments
0	Abstention

Affirmative All

Ayer, Lawrence S.

Gallo, Ernest J.

Hickman, Palmer L.

Holub, Richard A.

Hunter, Dean C.

Johnston, Michael J.

Kendall, David H.

Kovacik, John R.

Manche, Alan

McDaniel, Roger D.

Porter, Christine T.

Williams, David A.

Public Input No. 2138-NFPA 70-2023 [Definition: Bonding Jumper, Equipment. (Equipment Bonding J...]

Bonding Jumper, Equipment. (Equipment Bonding Jumper)

The connection between two or more portions of the equipment grounding conductor. The Equipment Bonding Jumper is part of the Effective Ground-Fault Current Path. (CMP-5)

Statement of Problem and Substantiation for Public Input

The effective ground-fault current path is made up of many parts, all connected together. The definition of the Effective Ground-Fault Current Path is an excellent definition. In the 2020 Code, "Effective Ground-Fault Current Path" was added to the definition of Equipment Grounding Conductor. This PI is part of a set of companion PIs to add "part of the effective ground-fault current path" to the rest of the components in Article 250.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2135-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2136-NFPA 70-2023 [Definition: Bonding Jumper, Supply-Side. (Supply-Side Bondi...]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2137-NFPA 70-2023 [Definition: Bonding Jumper, System. (System Bonding Jumper)]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2135-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]	
Public Input No. 2136-NFPA 70-2023 [Definition: Bonding Jumper, Supply-Side. (Supply-Side Bondi...]	
Public Input No. 2137-NFPA 70-2023 [Definition: Bonding Jumper, System. (System Bonding Jumper)]	

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Aug 12 22:47:37 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The suggested change is not necessary as “effective ground-fault current path” is well defined in other sections of the Code. The use of the term is not permitted to be used in a definition per 2.1.2.5 of NEC Style Manual.

Public Input No. 3952-NFPA 70-2023 [Definition: Bonding Jumper, Equipment. (Equipment Bonding J...]

Bonding ~~Jumper~~ Conductor , Equipment. (Equipment Bonding Jumper) (Equipment Bonding Conductor)

The connection between two or more portions of the equipment grounding conductor. (CMP-5)

Additional Proposed Changes

File Name	Description	Approved
PC_275_CMP_5.pdf	NEC_PC275	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as “Reject but Hold” in Public Comment No. 275 of the (A2022) Second Draft Report for NFPA 70 and per the Regs. at 4.4.8.3.1.

The panel added Equipment Bonding Jumper as a synonym to comply with the Manual of Style 2.2.2.5 Synonyms, Similar Terms, or Alternate Terms. If the defined term has synonyms, similar terms, or alternate terms associated with the main term that all are to be understood as having the same definition, the base term being defined shall be followed by the alternate term in parentheses. The panel added the searchable term to comply with the Manual of Style 2.2.2.3.1 Defined Term. To assist in electronic searching, the defined term shall then appear in parentheses as it would be found in the document. The panel removed the acronym as it did not add clarity. This is the result of the work CMP-5 Task Group for Definitions consisting of: Trevor Bowmer, Jon Coulimore, Lee Herron, Juan Lahera, Karin Manfredi, and Christine Porter.

Submitter Information Verification

Submitter Full Name: CMP ON NEC-P05
Organization: Code-Making Panel 5
Street Address:
City:
State:
Zip:
Submittal Date: Wed Sep 06 11:14:25 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8725-NFPA 70-2024

Statement: The term was revised to remove “jumper” in the term and replace it with the more technically accurate term of conductor. The synonym will be retained in the term for at least one cycle.

Public Comment No. 275-NFPA 70-2021 [Definition: Bonding Jumper, Equipment (EBJ).]

Bonding ~~Jumper~~ Conductor , Equipment (~~EBJ).~~ Equipment Bonding Jumper) (Equipment Bonding Conductor)

The connection between two or more portions of the equipment grounding conductor. (CMP-5)

Statement of Problem and Substantiation for Public Comment

The panel added Equipment Bonding Jumper as a synonym to comply with the Manual of Style 2.2.2.5 Synonyms, Similar Terms, or Alternate Terms. If the defined term has synonyms, similar terms, or alternate terms associated with the main term that all are to be understood as having the same definition, the base term being defined shall be followed by the alternate term in parentheses. The panel added the searchable term to comply with the Manual of Style 2.2.2.3.1 Defined Term. To assist in electronic searching, the defined term shall then appear in parentheses as it would be found in the document. The panel removed the acronym as it did not add clarity. This is the result of the work CMP-5 Task Group for Definitions consisting of: Trevor Bowmer, Jon Coulimore, Lee Herron, Juan Lahera, Karin Manfredi, and Christine Porter.

Related Item

- Correlating Committee Note No. 413-NFPA 70-2021 [Definition: Bonding Conductor or Jumper.]

Submitter Information Verification

Submitter Full Name:	Christine Porter
Organization:	Intertek Testing Services
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Jul 19 13:06:35 EDT 2021
Committee:	NEC-P05

Committee Statement

Committee Action:	Rejected but held
Resolution:	The impact of the changes proposed in the comment is extensive and the panel sees that a more holistic review of Article 250 and throughout the NEC regarding the use of the term bonding jumper and its derivatives is warranted. Based on the amount of time involved in such a review this comment is held in accordance with 4.4.8.3.1(C) of the regulations.

Copyright Assignment

I, Christine Porter, hereby irrevocably grant and assign to the National Fire Protection Association (NFPA) all and full rights in copyright in this Public Comment (including both the Proposed Change and the Statement of Problem and Substantiation). I understand and intend that I acquire no rights, including rights as a joint author, in any publication of the NFPA in which this Public Comment in this or another similar or derivative form is used. I hereby warrant that I am the author of this Public Comment and that I have full power and authority to enter into this copyright assignment.

☑ By checking this box I affirm that I am Christine Porter, and I agree to be legally bound by the above Copyright Assignment and the terms and conditions contained therein. I understand and intend that, by checking this box, I am creating an electronic signature that will, upon my submission of this form, have the same legal force and effect as a handwritten signature

Public Input No. 2135-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]

Bonding Jumper, Main. (Main Bonding Jumper)

The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service. The Main Bonding Jumper is part of the effective ground-fault current path. (CMP-5)

Statement of Problem and Substantiation for Public Input

The effective ground-fault current path is made up of many parts, all connected together. The definition of the Effective Ground-Fault Current Path is an excellent definition. In the 2020 Code, "Effective Ground-Fault Current Path" was added to the definition of Equipment Grounding Conductor. This PI is part of a set of companion PIs to add "part of the effective ground-fault current path" to the rest of the components in Article 250.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2136-NFPA 70-2023 [Definition: Bonding Jumper, Supply-Side. (Supply-Side Bondi...]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2137-NFPA 70-2023 [Definition: Bonding Jumper, System. (System Bonding Jumper)]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2138-NFPA 70-2023 [Definition: Bonding Jumper, Equipment. (Equipment Bonding J...]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2136-NFPA 70-2023 [Definition: Bonding Jumper, Supply-Side. (Supply-Side Bondi...]	
Public Input No. 2137-NFPA 70-2023 [Definition: Bonding Jumper, System. (System Bonding Jumper)]	
Public Input No. 2138-NFPA 70-2023 [Definition: Bonding Jumper, Equipment. (Equipment Bonding J...]	

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Aug 12 22:34:30 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: The suggested change is not necessary as “effective ground-fault current path” is well defined in other sections of the Code. The use of the term is not permitted to be used in a definition per 2.1.2.5 of NEC Style Manual.

Public Input No. 3100-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]

Bonding Jumper, Main. (Main Bonding Jumper)

The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service equipment . (CMP-5)

Statement of Problem and Substantiation for Public Input

Revising text from ‘at the service’ to ‘at the service equipment’ because in accordance with 250.24(C) the main bonding jumper is installed to connect the equipment grounding conductor and the service disconnect enclosure to the grounded conductor at each service disconnect. This revision will bring clarity and make the definition technically correct.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 11:45:49 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8731-NFPA 70-2024

Statement: The term was revised to remove “jumper” in the term and replace it with the more technically accurate term of conductor. The synonym will be retained in the term for at least one cycle.

The correlating committee may want to direct all panels to review use of this term for consistency with the revised definition.

Public Input No. 3182-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]

Bonding Jumper, ~~Main~~ Service . (~~Main~~ Service Bonding Jumper)

The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service. (CMP-5)

Statement of Problem and Substantiation for Public Input

By its own definition, the Main Bonding Jumper must be at the service. The code defines service but does not define "main". The term "main" is commonly used vernacular in the electrical industry to describe many different locations or disconnects. The term "main" is commonly used to describe the first disconnect or OCPD after a separately derived system. It's also used to describe the first disconnect or OCPD at any building or structure that is not necessarily the service such as a sub-panel at a garage or barn. A disconnect at a generator might be referred to as the "main" for the generator. Main is often used to describe the first breaker at any distribution or sub-panel anywhere on a distribution system. The use of such a widely used term in the title of a definition can be misleading to a new or occasional code user. Service is a defined term and is used in the definition of Main Bonding Jumper, Changing the title to Service Bonding jumper creates clarity. It removes any doubt as to the location and use of the bonding jumper. Misapplying a bond between the Grounded Conductors and the Equipment grounding conductors can create various problems and safety concerns. Any opportunity to be as clear as possible should be applied.

Submitter Information Verification

Submitter Full Name: Beau Burton
Organization: Metropolitan Detriot Electrcal Industry Training Center
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 30 08:37:37 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The term “main” is used to indicate that it is the primary bonding conductor of the system as well as being located at the service. In addition, the term is well understood and has been in use for years.

Public Input No. 3956-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]

Bonding ~~Jumper~~ Conductor , Main. (Main Bonding Jumper) (Main Bonding Conductor) (MBC)

The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service. (CMP-5)

Additional Proposed Changes

File Name	Description	Approved
PC_276_CMP_5.pdf	NEC_PC276	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as “Reject but Hold” in Public Comment No. 276 of the (A2022) Second Draft Report for NFPA 70 and per the Regs. at 4.4.8.3.1.

The panel added the synonym for Main Bonding Conductor to comply with the Manual of Style 2.2.2.5 Synonyms, Similar Terms, or Alternate Terms. If the defined term has synonyms, similar terms, or alternate terms associated with the main term that all are to be understood as having the same definition, the base term being defined shall be followed by the alternate term in parentheses. The panel added the searchable term to comply with the Manual of Style 2.2.2.3.1 Defined Term. To assist in electronic searching, the defined term shall then appear in parentheses as it would be found in the document. The added an acronym for Main Bonding Conductor to comply with the Manual of Style 3.2.3 Acronyms and Uncommon Abbreviations keeping the acronym Main Bonding Jumper as that is also a term used in manufacturing documentation. This is the result of the work CMP-5 Task Group for Definitions consisting of: Trevor Bowmer, Jon Coulimore, Lee Herron, Juan Lahera, Karin Manfredi, and Christine Porter

Submitter Information Verification

Submitter Full Name:	CMP ON NEC-P05
Organization:	Code-Making Panel 5
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Sep 06 11:18:43 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8731-NFPA 70-2024

Statement: The term was revised to remove “jumper” in the term and replace it with the more technically accurate term of conductor. The synonym will be retained in the term for at least one cycle.

The correlating committee may want to direct all panels to review use of this term for consistency with the revised definition.

Public Comment No. 276-NFPA 70-2021 [Definition: Bonding Jumper, Main (MBJ).]

Bonding Conductor, Main (Main Bonding Jumper,) (Main Bonding Conductor) (MBC) (MBJ).

The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service. (CMP-5)

Statement of Problem and Substantiation for Public Comment

The panel added the synonym for Main Bonding Conductor to comply with the Manual of Style 2.2.2.5 Synonyms, Similar Terms, or Alternate Terms. If the defined term has synonyms, similar terms, or alternate terms associated with the main term that all are to be understood as having the same definition, the base term being defined shall be followed by the alternate term in parentheses. The panel added the searchable term to comply with the Manual of Style 2.2.2.3.1 Defined Term. To assist in electronic searching, the defined term shall then appear in parentheses as it would be found in the document. The added an acronym for Main Bonding Conductor to comply with the Manual of Style 3.2.3 Acronyms and Uncommon Abbreviations keeping the acronym Main Bonding Jumper as that is also a term used in manufacturing documentation. This is the result of the work CMP-5 Task Group for Definitions consisting of: Trevor Bowmer, Jon Coulimore, Lee Herron, Juan Lahera, Karin Manfredi, and Christine Porter

Related Item

- Correlating Committee Note No. 413-NFPA 70-2021 [Definition: Bonding Conductor or Jumper.]

Submitter Information Verification

Submitter Full Name:	Christine Porter
Organization:	Intertek Testing Services
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Jul 19 13:41:50 EDT 2021
Committee:	NEC-P05

Committee Statement

Committee Action:	Rejected but held
Resolution:	The impact of the changes proposed in the comment is extensive and the panel sees that a more holistic review of Article 250 and throughout the NEC regarding the use of the term main bonding jumper and its derivatives is warranted. Based on the amount of time involved in such a review this comment is held in accordance with 4.4.8.3.1(C) of the regulations.

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Public Input No. 4005-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]

Bonding Jumper, ~~Main~~ Service . (~~Main Bonding Jumper~~ SBJ)

The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service. (CMP-5)

Additional Proposed Changes

File Name	Description	Approved
PC_961_CMP_5.pdf	70_PC961	
PC_961_Attachment_1.pdf	70_PC961_Attachment1	
PC_961_Attachment_2.pdf	70_PC961_Attachment2	

Statement of Problem and Substantiation for Public Input

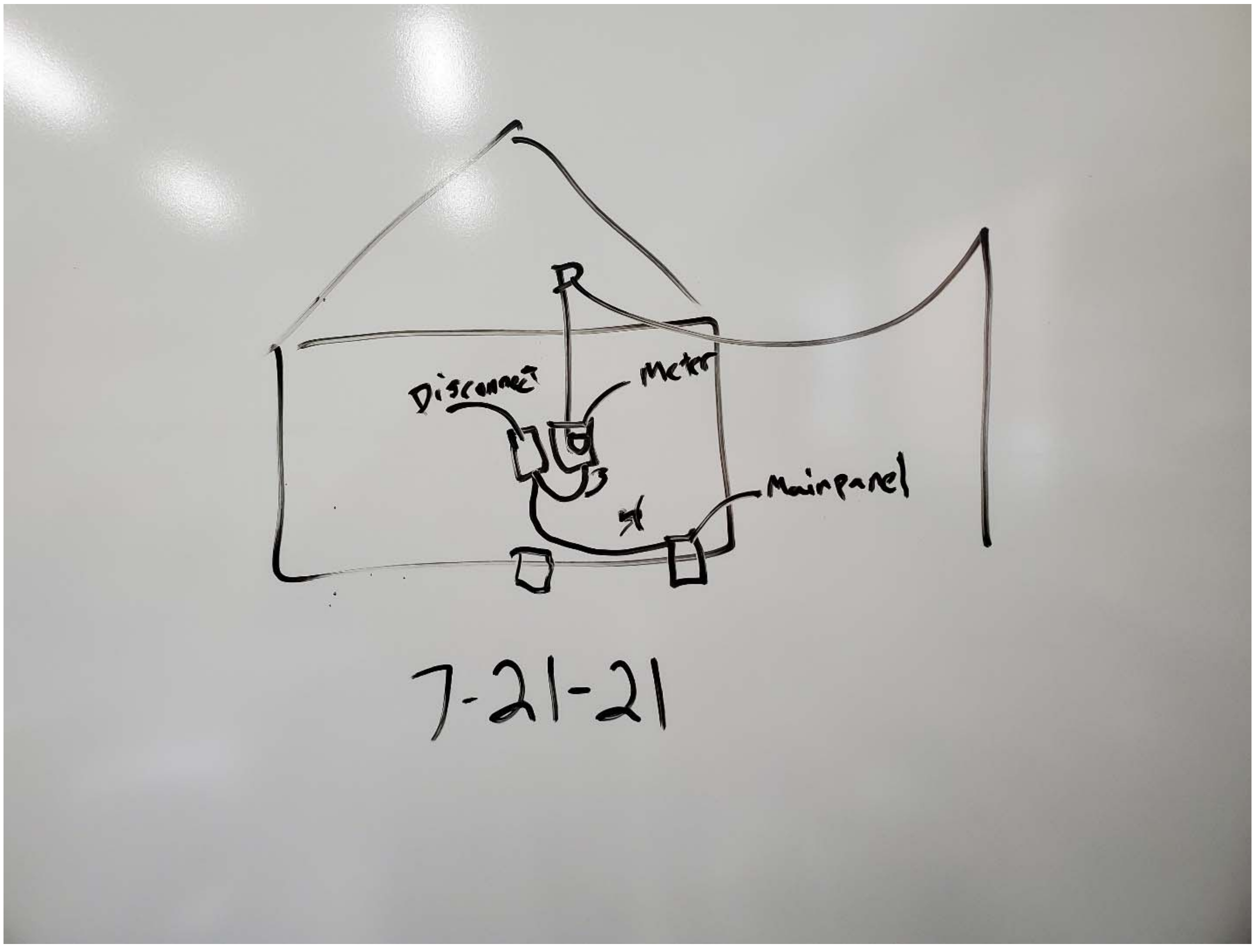
NOTE: This Public Input appeared as “Reject but Hold” in Public Comment No. 961 of the (A2022) Second Draft Report for NFPA 70 and per the Regs. at 4.4.8.3.1.

Submitter Information Verification

Submitter Full Name:	CMP ON NEC-P05
Organization:	Code-Making Panel 5
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Sep 06 13:27:27 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The term “main” is used to indicate that it is the primary bonding conductor of the system as well as being located at the service. In addition, the term is well understood and has been in use for years.



The above drawing was presented to the code change submitter with a question; Where do I make the main bonding connection, at the main panel or the service disconnect?

The question came from a state licensed journeyman electrician with more than 8 years' experience in the electrical industry. The journeyman made the drawing on a whiteboard.

The drawing shows the meter enclosure on the exterior of the house, with the disconnect, main panel, and sub panel all in the house. The 3-conductor cable between the meter can and the disconnect is because the serving utility will not allow an equipment grounding connection inside the meter enclosure.

The journeyman was questioning the bonding location for two reasons:

1. the green screw in the main panel that is traditionally used as the bonding jumper
2. the definition "Bonding Jumper, Main"

In this case the questions reflects the conflict between the title of the term Bonding Jumper, Main and the definition of the term. The title and definition are in conflict because the word main is not specific or clear.

Bonding Jumper, Service

Public Input No. 1431-NFPA 70-2020 [Definition: Bonding Jumper, Main.]

Resolution: The panel affirms that the term main bonding jumper is limited to the service. The term "main" is well understood.

The submitter of the proposed code change disagrees with the panel that the term "main "is well understood.

Having taught Grounding and Bonding through an IBEW/NECA JATC for over 13 years the submitter has often fielded questions from apprentices, journeymen, master electricians, inspectors, and estimators with regard to the location of bonding the grounded conductor, the grounding electrode conductor, and the equipment grounding conductor. See attached "Case in Point".

There is often confusion when the service equipment is not in the same cabinet as the "main" panelboard. The regular code user and often electrical inspector will question whether the bonding point should be in the separate service disconnect or the "main" panelboard cabinet. The term "bonding jumper, main" is the root of the problem. The term "main" is not well understood or defined. Fortunately, the term "service" is defined.

It is common in the electrical industry to use the word main at locations other than the service equipment. The first disconnecting means at a separate building or structure is referred to as the main. The first or controlling breaker, or fuse, to a sub-panel is called the main breaker. The main can be used to describe the disconnect on industrial machinery. The word main is used in the definition of "service equipment". Reading the definition of service equipment without the word main doesn't affect the meaning of the term service equipment because main is not specific or clear in meaning. Fortunately, the term service is defined, specific, and clear in meaning.

Section 3.3.4 of the NEC style manual requires that,
"Words and terms used in the NEC shall be specific and clear in meaning,
and shall avoid jargon, trade terminology, industry-specific terms…"

Public Comment No. 961-NFPA 70-2021 [Definition: Bonding Jumper, Main (MBJ).]

Bonding Jumper, ~~Main~~ Service (~~MBJ~~ SBJ).

The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service. (CMP-5)

Additional Proposed Changes

File Name	Description	Approved
Case_in_Point.docx	Case in Point	
Bonding_Jumper_Service.docx	Public Comment explanation	

Statement of Problem and Substantiation for Public Comment

Public Input No. 1431-NFPA 70-2020 [Definition: Bonding Jumper, Main.]

Related Item

- Public Input No. 1431-NFPA 70-2020 [Definition: Bonding Jumper, Main.]

Submitter Information Verification

Submitter Full Name:	Beau Burton
Organization:	Detroit Electrical JATC
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Aug 05 12:13:02 EDT 2021
Committee:	NEC-P05

Committee Statement

Committee Action:	Rejected but held
Resolution:	The committee affirms that the word choice of Main to indicate the bonding conductor at the service is well established. The panel sees that a more thorough review of the NEC along with other codes and standards regarding the use of the term and its derivatives must be performed. Based on the amount of time involved in such a review this comment is held in accordance with 4.4.8.3.1(C) of the regulations.

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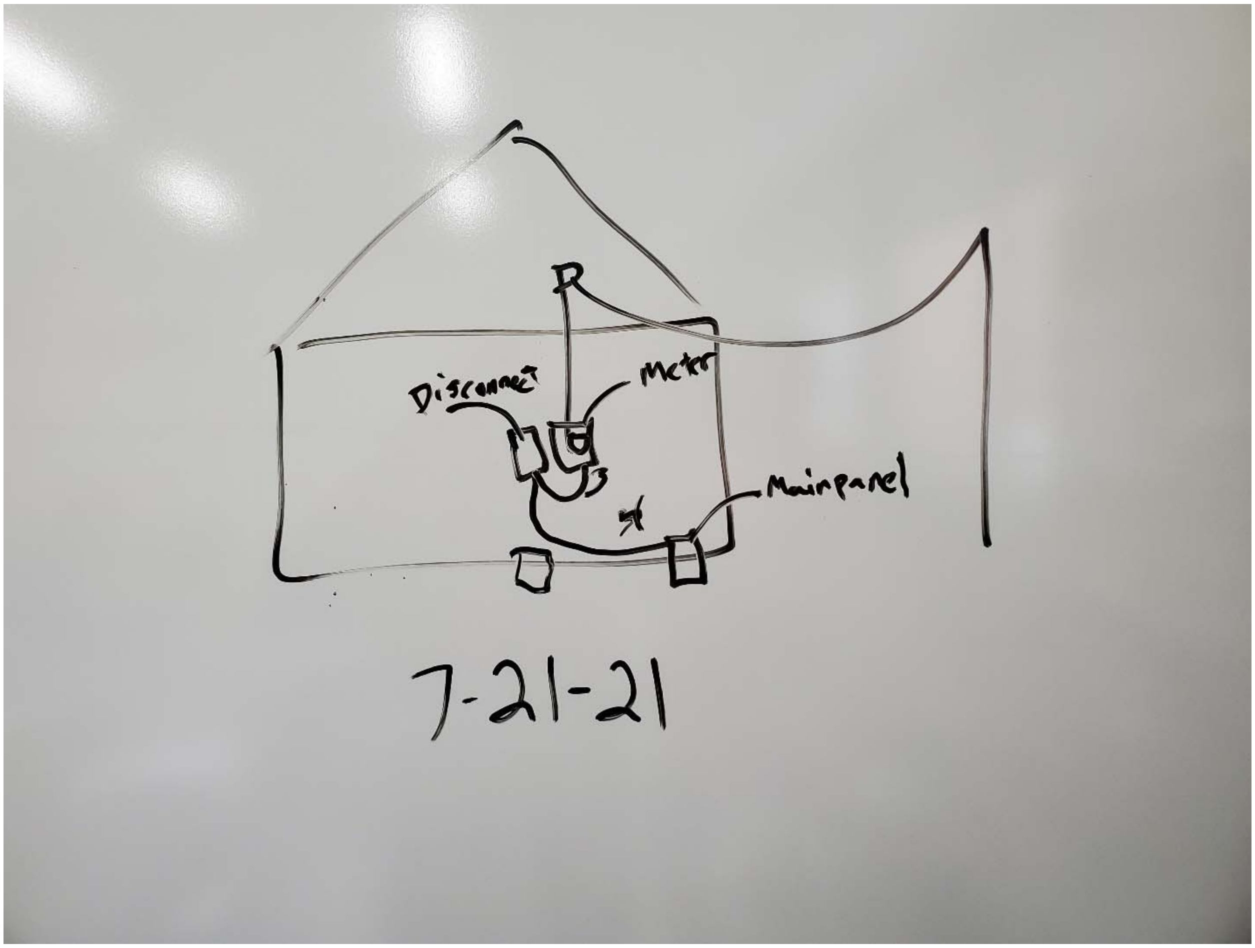

The above drawing was presented to the code change submitter with a question; Where do I make the main bonding connection, at the main panel or the service disconnect?

The question came from a state licensed journeyman electrician with more than 8 years' experience in the electrical industry. The journeyman made the drawing on a whiteboard.

The drawing shows the meter enclosure on the exterior of the house, with the disconnect, main panel, and sub panel all in the house. The 3-conductor cable between the meter can and the disconnect is because the serving utility will not allow an equipment grounding connection inside the meter enclosure.

The journeyman was questioning the bonding location for two reasons:

1. the green screw in the main panel that is traditionally used as the bonding jumper
2. the definition "Bonding Jumper, Main"

In this case the questions reflects the conflict between the title of the term Bonding Jumper, Main and the definition of the term. The title and definition are in conflict because the word main is not specific or clear.

Bonding Jumper, Service

Public Input No. 1431-NFPA 70-2020 [Definition: Bonding Jumper, Main.]

Resolution: The panel affirms that the term main bonding jumper is limited to the service. The term "main" is well understood.

The submitter of the proposed code change disagrees with the panel that the term "main "is well understood.

Having taught Grounding and Bonding through an IBEW/NECA JATC for over 13 years the submitter has often fielded questions from apprentices, journeymen, master electricians, inspectors, and estimators with regard to the location of bonding the grounded conductor, the grounding electrode conductor, and the equipment grounding conductor. See attached "Case in Point".

There is often confusion when the service equipment is not in the same cabinet as the "main" panelboard. The regular code user and often electrical inspector will question whether the bonding point should be in the separate service disconnect or the "main" panelboard cabinet. The term "bonding jumper, main" is the root of the problem. The term "main" is not well understood or defined. Fortunately, the term "service" is defined.

It is common in the electrical industry to use the word main at locations other than the service equipment. The first disconnecting means at a separate building or structure is referred to as the main. The first or controlling breaker, or fuse, to a sub-panel is called the main breaker. The main can be used to describe the disconnect on industrial machinery. The word main is used in the definition of "service equipment". Reading the definition of service equipment without the word main doesn't affect the meaning of the term service equipment because main is not specific or clear in meaning. Fortunately, the term service is defined, specific, and clear in meaning.

Section 3.3.4 of the NEC style manual requires that,
"Words and terms used in the NEC shall be specific and clear in meaning,
and shall avoid jargon, trade terminology, industry-specific terms…"

Public Input No. 2136-NFPA 70-2023 [Definition: Bonding Jumper, Supply-Side. (Supply-Side Bondi...]

Bonding Jumper, Supply-Side. (Supply-Side Bonding Jumper)

A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected. The Supply-Side Bonding Jumper is part of the Effective Ground-Fault Current Path. (CMP-5)

Statement of Problem and Substantiation for Public Input

The effective ground-fault current path is made up of many parts, all connected together. The definition of the Effective Ground-Fault Current Path is an excellent definition. In the 2020 Code, "Effective Ground-Fault Current Path" was added to the definition of Equipment Grounding Conductor. This PI is part of a set of companion PIs to add "part of the effective ground-fault current path" to the rest of the components in Article 250.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2135-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2137-NFPA 70-2023 [Definition: Bonding Jumper, System. (System Bonding Jumper)]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2138-NFPA 70-2023 [Definition: Bonding Jumper, Equipment. (Equipment Bonding J...]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2135-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]	
Public Input No. 2137-NFPA 70-2023 [Definition: Bonding Jumper, System. (System Bonding Jumper)]	
Public Input No. 2138-NFPA 70-2023 [Definition: Bonding Jumper, Equipment. (Equipment Bonding J...]	

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Aug 12 22:40:51 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: The suggested change is not necessary as “effective ground-fault current path” is well defined in other sections of the Code. The use of the term is not permitted to be used in a definition per 2.1.2.5 of NEC Style Manual.

Public Input No. 3989-NFPA 70-2023 [Definition: Bonding Jumper, Supply-Side. (Supply-Side Bondi...]

Bonding ~~Jumper~~ Conductor , Supply-Side. (Supply-Side Bonding Jumper) (Supply-Side Bonding Conductor) (SSBC) (SSBJ)

A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected. (CMP-5)

Additional Proposed Changes

File Name	Description	Approved
PC_277_CMP_5.pdf	NEC_PC277	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as “Reject but Hold” in Public Comment No. 277 of the (A2022) Second Draft Report for NFPA 70 and per the Regs. at 4.4.8.3.1.

The panel added Supply-Side Bonding Jumper as a synonym to comply with Manual of Style 2.2.2.5 Synonyms, Similar Terms, or Alternate Terms, added electronic searchable terms to comply with 2.2.2.3.1 Defined Term. The panel added the acronym for Supply-Side Bonding Conductor per Manual of Style 3.2.3 Acronyms and Uncommon Abbreviations. The panel kept the acronym for Supply-Side Boding Jumper as the term jumper is widely used and understood. This is the result of the work CMP-5 Task Group for Definitions consisting of: Trevor Bowmer, Jon Coulimore, Lee Herro, Juan Lahera, Karin Manfredi, and Christine Porter

Submitter Information Verification

Submitter Full Name:	CMP ON NEC-P05
Organization:	Code-Making Panel 5
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Sep 06 12:36:29 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8738-NFPA 70-2024

Statement: The term was revised to remove “jumper” in the term and replace it with the more technically accurate term of conductor. The synonym will be retained in the term for at least one cycle.

Public Comment No. 277-NFPA 70-2021 [Definition: Bonding Jumper, Supply-Side (SSBJ).]

Bonding ~~Jumper~~ Conductor , Supply-Side (Supply-Side Bonding Jumper) (Supply-Side Bonding Conductor (SSBC) (SSBJ).

A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected. (CMP-5)

Statement of Problem and Substantiation for Public Comment

The panel added Supply-Side Bonding Jumper as a synonym to comply with Manual of Style 2.2.2.5 Synonyms, Similar Terms, or Alternate Terms, added electronic searchable terms to comply with 2.2.2.3.1 Defined Term. The panel added the acronym for Supply-Side Bonding Conductor per Manual of Style 3.2.3 Acronyms and Uncommon Abbreviations. The panel kept the acronym for Supply-Side Boding Jumper as the term jumper is widely used and understood. This is the result of the work CMP-5 Task Group for Definitions consisting of: Trevor Bowmer, Jon Coulimore, Lee Herro, Juan Lahera, Karin Manfredi, and Christine Porter

Related Item

- Public Input No. 2973-NFPA 70-2020 [Definition: Bonding Jumper, Supply-Side.]

Submitter Information Verification

Submitter Full Name: Christine Porter
Organization: Intertek Testing Services
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 19 13:51:23 EDT 2021
Committee: NEC-P05

Committee Statement

Committee Action: Rejected but held

Resolution: The impact of the changes proposed in the comment is extensive and the panel sees that a more holistic review of Article 250 and throughout the NEC regarding the use of the term bonding jumper and its derivatives is warranted. Based on the amount of time involved in such a review this comment is held in accordance with 4.4.8.3.1(C) of the regulations.

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Public Input No. 4002-NFPA 70-2023 [Definition: Bonding Jumper, Supply-Side. (Supply-Side Bondi...]

Bonding Conductor or Jumper, Supply-Side. (Supply-Side Bonding Jumper) (SSBC)

A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected. (CMP-5)

Additional Proposed Changes

File Name	Description	Approved
PC_909_CMP_5.pdf	NEC_PC909	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as “Reject but Hold” in Public Comment No. 909 of the (A2022) Second Draft Report for NFPA 70 and per the Regs. at 4.4.8.3.1.

I agree with the CMP that Supply Side Bonding Jumper is a term well understood by electricians familiar with the Code. However, we may not share that understanding. With 40-odd years in the trade, when I think of a MBJ, I think of a screw through a neutral bar, or a small clip attached to it, even though I know that theoretically it can be something else, and we have means to calculate that. I also agree with IAEI that at first glance, it does mislead less-experienced people to think of the dictionary meaning of “Jumper, Elect: a short length of conductor used to make a connection, . . .” Agin, the dictionary specifies “short.” There is minimal cost to changing the term, compared to the benefit. Using “Conductor or Jumper” here, and in fact globally, will allow users who inherently understand “jumper” to imply something short to more easily recognize that that limit is not true, because “conductor” doesn’t carry that implication.
The understanding of “Jumper” as meaning something that typically is short is documented by CMP 9 in their response to P.I. 1291. For 314.16, viz
"Statement: CMP-9 has decided to revisit the action taken in the comment period of the 1996 cycle, when the reference to equipment bonding jumpers was initially added (Comment 9-5). It was substantiated on the basis that these components can run within raceways. CMP-9 now concludes that any such application, if even possible, would constitute an extension of an equipment grounding conductor, and would be addressable as such. In general, such jumpers begin and end within the box. As such, counting them would conflict with the general principle of not counting such wires, as stated in the final sentence of 314.16(B)(1)"
Perhaps this is worth referring to the TCC to ensure consistent usage.

Submitter Information Verification

Submitter Full Name: CMP ON NEC-P05
Organization: Code-Making Panel 5
Street Address:
City:
State:
Zip:
Submittal Date: Wed Sep 06 13:22:27 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8738-NFPA 70-2024

Statement: The term was revised to remove “jumper” in the term and replace it with the more technically accurate term of conductor. The synonym will be retained in the term for at least one cycle.

Public Comment No. 909-NFPA 70-2021 [Definition: Bonding Jumper, Supply-Side (SSBJ).]

Bonding Conductor or Jumper, Supply-Side (~~SSBJ~~ SSBC).

A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected. (CMP-5)

Statement of Problem and Substantiation for Public Comment

I agree with the CMP that Supply Side Bonding Jumper is a term well understood by electricians familiar with the Code. However, we may not share that understanding. With 40-odd years in the trade, when I think of a MBJ, I think of a screw through a neutral bar, or a small clip attached to it, even though I know that theoretically it can be something else, and we have means to calculate that. I also agree with IAEI that at first glance, it does mislead less-experienced people to think of the dictionary meaning of "Jumper, Elect: a short length of conductor used to make a connection, . . ." Agin, the dictionary specifies "short." There is minimal cost to changing the term, compared to the benefit. Using "Conductor or Jumper" here, and in fact globally, will allow users who inherently understand "jumper" to imply something short to more easily recognize that that limit is not true, because "conductor" doesn't carry that implication.
The understanding of "Jumper" as meaning something that typically is short is documented by CMP 9 in their response to P.I. 1291. For 314.16, viz

"Statement: CMP-9 has decided to revisit the action taken in the comment period of the 1996 cycle, when the reference to equipment bonding jumpers was initially added (Comment 9-5). It was substantiated on the basis that these components can run within raceways. CMP-9 now concludes that any such application, if even possible, would constitute an extension of an equipment grounding conductor, and would be addressable as such. In general, such jumpers begin and end within the box. As such, counting them would conflict with the general principle of not counting such wires, as stated in the final sentence of 314.16(B)(1)"
Perhaps this is worth referring to the TCC to ensure consistent usage.

Related Item

- PI3413 • PI 1291

Submitter Information Verification

Submitter Full Name: David Shapiro
Organization: Safety First Electrical
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 04 16:58:42 EDT 2021
Committee: NEC-P05

Committee Statement

Committee Rejected but held

Action:

Resolution: The impact of the changes proposed in the comment is extensive and the panel sees that a more holistic review of Article 250 and throughout the NEC regarding the use of the term bonding jumper and its derivatives is warranted. Based on the amount of time involved in such a review this comment is held in accordance with 4.4.8.3.1(C) of the regulations

Copyright Assignment

I, David Shapiro, hereby irrevocably grant and assign to the National Fire Protection Association (NFPA) all and full rights in copyright in this Public Comment (including both the Proposed Change and the Statement of Problem and Substantiation). I understand and intend that I acquire no rights, including rights as a joint author, in any publication of the NFPA in which this Public Comment in this or another similar or derivative form is used. I hereby warrant that I am the author of this Public Comment and that I have full power and authority to enter into this copyright assignment.

☑ By checking this box I affirm that I am David Shapiro, and I agree to be legally bound by the above Copyright Assignment and the terms and conditions contained therein. I understand and intend that, by checking this box, I am creating an electronic signature that will, upon my submission of this form, have the same legal force and effect as a handwritten signature

Public Input No. 2137-NFPA 70-2023 [Definition: Bonding Jumper, System. (System Bonding Jumper)]

Bonding Jumper, System. (System Bonding Jumper)

The connection between the grounded circuit conductor and the supply-side bonding jumper, or the equipment grounding conductor, or both, at a separately derived system. The System Bonding Jumper is part of the Effective Ground-Fault Current Path. (CMP-5)

Statement of Problem and Substantiation for Public Input

The effective ground-fault current path is made up of many parts, all connected together. The definition of the Effective Ground-Fault Current Path is an excellent definition. In the 2020 Code, "Effective Ground-Fault Current Path" was added to the definition of Equipment Grounding Conductor. This PI is part of a set of companion PIs to add "part of the effective ground-fault current path" to the rest of the components in Article 250.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2135-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2136-NFPA 70-2023 [Definition: Bonding Jumper, Supply-Side. (Supply-Side Bondi...]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2138-NFPA 70-2023 [Definition: Bonding Jumper, Equipment. (Equipment Bonding J...]	Companion PI to add 'part of effective ground-fault current path' to the definitions.
Public Input No. 2135-NFPA 70-2023 [Definition: Bonding Jumper, Main. (Main Bonding Jumper)]	
Public Input No. 2136-NFPA 70-2023 [Definition: Bonding Jumper, Supply-Side. (Supply-Side Bondi...]	
Public Input No. 2138-NFPA 70-2023 [Definition: Bonding Jumper, Equipment. (Equipment Bonding J...]	

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Aug 12 22:44:30 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: The suggested change is not necessary as “effective ground-fault current path” is well defined in other sections of the Code. The use of the term is not permitted to be used in a definition per 2.1.2.5 of NEC Style Manual.

Public Input No. 3990-NFPA 70-2023 [Definition: Bonding Jumper, System. (System Bonding Jumper)]

Bonding ~~Jumper~~ Conductor , System. (System Bonding Jumper) (System Bonding Conductor) (SBC) (SBJ)

The connection between the grounded circuit conductor and the supply-side bonding jumper, or the equipment grounding conductor, or both, at a separately derived system. (CMP-5)

Additional Proposed Changes

File Name	Description	Approved
PC_286_CMP_5.pdf	NEC_PC286	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as “Reject but Hold” in Public Comment No. 286 of the (A2022) Second Draft Report for NFPA 70 and per the Regs. at 4.4.8.3.1.

The panel added System Bonding Jumper as a synonym to comply with Manual of Style 2.2.2.5 Synonyms, Similar Terms, or Alternate Terms, and added searchable terms to comply with Manual of Style 2.2.2.3.1 Defined Term. The panel added acronyms to make the code easier to use and comply with the Manual of Style 3.2.3 Acronyms and Uncommon Abbreviations. This is the result of the work CMP-5 Task Group for Definitions consisting of: Trevor Bowmer, Jon Coulimore, Lee Herron, Juan Lahera, Karin Manfredi, and Christine Porter.

Submitter Information Verification

Submitter Full Name:	CMP ON NEC-P05
Organization:	Code-Making Panel 5
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Sep 06 12:39:45 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8740-NFPA 70-2024

Statement: The term was revised to remove “jumper” in the term and replace it with the more technically accurate term of conductor. The synonym will be retained in the term for at least one cycle.

Public Comment No. 286-NFPA 70-2021 [Definition: Bonding Jumper, System (SBJ).]

Bonding ~~Jumper~~ Conductor , System (System Bonding Jumper) (System Bonding Conductor) (SBC) (SBJ).

The connection between the grounded circuit conductor and the supply-side bonding jumper, or the equipment grounding conductor, or both, at a separately derived system. (CMP-5)

Statement of Problem and Substantiation for Public Comment

The panel added System Bonding Jumper as a synonym to comply with Manual of Style 2.2.2.5 Synonyms, Similar Terms, or Alternate Terms, and added searchable terms to comply with Manual of Style 2.2.2.3.1 Defined Term. The panel added acronyms to make the code easier to use and comply with the Manual of Style 3.2.3 Acronyms and Uncommon Abbreviations. This is the result of the work CMP-5 Task Group for Definitions consisting of: Trevor Bowmer, Jon Coulimore, Lee Herron, Juan Lahera, Karin Manfredi, and Christine Porter.

Related Item

- First Revision No. 8280-NFPA 70-2020 [Global Input]

Submitter Information Verification

Submitter Full Name:	Christine Porter
Organization:	Intertek Testing Services
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Jul 19 19:11:08 EDT 2021
Committee:	NEC-P05

Committee Statement

Committee Action:	Rejected but held
Resolution:	The impact of the changes proposed in the comment is extensive and the panel sees that a more holistic review of Article 250 and throughout the NEC regarding the use of the term bonding jumper and its derivatives is warranted. Based on the amount of time involved in such a review this comment is held in accordance with 4.4.8.3.1(C) of the regulations

Copyright Assignment

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☑ By checking this box I affirm that I am Christine Porter, and I agree to be legally bound by the above Copyright

Assignment and the terms and conditions contained therein. I understand and intend that, by checking this box, I am creating an electronic signature that will, upon my submission of this form, have the same legal force and effect as a handwritten signature

Public Input No. 3101-NFPA 70-2023 [Definition: Ground-Fault Current Path.]

Ground-Fault Current Path.

~~An electrically conductive~~ A path from the point of a ground fault on a wiring system through normally non–current-carrying conductors, grounded conductors, equipment, or the earth to the electrical supply source. (CMP-5)

Informational Note: Examples of ground-fault current paths are any combination of equipment grounding conductors, metallic raceways, metallic cable sheaths, electrical equipment, and any other electrically conductive material such as metal, water, and gas piping; steel framing members; stucco mesh; metal ducting; reinforcing steel; shields of communications cables; grounded conductors; and the earth itself.

Statement of Problem and Substantiation for Public Input

Removing “electrically conductive” from the definition since it can be confusing to Code users because the Earth is included in the definition. The ground-fault current path is a path; it doesn't need to be identified as “electrically conductive”.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 11:48:27 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The current definition is clear and the proposed change does not add clarity. Retaining the words “electrically conductive” is needed because a non-conductive path will not carry current.

Public Input No. 3256-NFPA 70-2023 [Definition: Ground-Fault Current Path.]

Ground-Fault Current Path.

An electrically conductive path from the point of a ground fault on a wiring system through normally non–current-carrying conductors, grounded conductors, equipment, or the earth to the electrical supply source. (CMP-5)

Informational Note: Examples of ground-fault current paths are any combination of equipment grounding conductors, metallic raceways, metallic cable sheaths, electrical equipment, and any other electrically conductive material such as metal ~~,~~ water, and gas piping that is not interrupted by any dielectric fitting or section ; steel framing members; stucco mesh; metal ducting; reinforcing steel; shields of communications cables; grounded conductors; and the earth itself.

Statement of Problem and Substantiation for Public Input

1. The comma after "metal" is inappropriate, as the word is modifying "water and gas piping.".It is serving as an adjective, even though it is in the noun form rather than "metallic."
2. Far more important, the emphasis on dielectric fittings warrants highlighting because it's increasingly likely that some plumber or handyperson will splice a section of CPVC or the like into pinholed metallic tubing or simply will use push fittings for connections of metallic water tubing. Many of these, such as Sharkbite (TM) warn that they interrupt electrical continuity. Not everybody heeds that part of the instructions.

Submitter Information Verification

Submitter Full Name: David Shapiro
Organization: Safety First Electrical
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 30 20:08:30 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The current definition is clear and the proposed change does not add clarity.

Public Input No. 1793-NFPA 70-2023 [Definition: Ground.]

Ground.

The ~~earth~~ Earth . (CMP-5)

Statement of Problem and Substantiation for Public Input

The lowercase "e" in the current definition denotes a common noun, meaning soil. An uppercase "E" makes "Earth" a proper noun meaning the planet. This would make clear that any connection to ground or any conductor extending the ground connection should be bonded to the planet, not just any container holding soil.

Submitter Information Verification

Submitter Full Name: Nick Bryant
Organization: UETA
Street Address:
City:
State:
Zip:
Submittal Date: Thu Aug 03 09:00:06 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8742-NFPA 70-2024
Statement: The committee determined that the term is a proper noun and should be capitalized.

Public Input No. 3489-NFPA 70-2023 [Definition: Grounded (Grounding).]

Grounded (Grounding).

Connected (connecting) to ~~ground or to~~ a conductive body that extends the ground connection. (CMP-5)

Statement of Problem and Substantiation for Public Input

We never connect directly to ground (the Earth) but rather to an electrode which is a conductive body that extends the ground connection. This is true for every electrode including the ground rod, concrete-encased electrode, metal water piping, structural steel, and etc. This change will make the requirement technically correct.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Sep 04 13:44:02 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: A grounding electrode is used to make a connection to earth.

Public Input No. 6-NFPA 70-2023 [New Definition after Definition: Emergency Systems.]

Emotionally Grounded Wye Distribution System

Those medium voltage distribution systems commonly found on government installations, where use of the a ground/neutral conductor on the grounded wye system is so whimsical and inconsistent throughout the campus as to be ineffective, and where its use is so inconsistent as to make a professional think they may be working with a Delta connected system. These systems differ from uni-grounded wye distribution systems, where design may stipulate that no ground/neutral conductor be extended from the grounded wye power source.

Statement of Problem and Substantiation for Public Input

New definition seeks to define a type of system professionals may encounter in the field.

Submitter Information Verification

Submitter Full Name: John Doe
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 03 20:16:36 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: The term is not used anywhere within this Code.

Public Input No. 1673-NFPA 70-2023 [New Definition after Definition: Grounding Electrode Conduc...]

Grounding Terminal Block

A device with one or more terminal lugs for solid connection of equipment grounding conductors to be used in device type boxes .

Type your content here ...

Statement of Problem and Substantiation for Public Input

There is not a definition of this type of connection . The term terminal block is used in the 2023 NEC 314.16 (B) (6) the purpose of this addition in 2023 was to allow for a grounding type block as used in a deck box in 680.23. I could not find the term Terminal Block in the NEC and think this would help identify what the Panel was trying to convey.

Submitter Information Verification

Submitter Full Name: George Tidden
Organization: IES Residential
Affiliation: IEC
Street Address:
City:
State:
Zip:
Submittal Date: Fri Jul 28 13:32:42 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The connections of bonding and grounding conductors is covered in Section 250.8.

Public Input No. 2318-NFPA 70-2023 [New Definition after Definition: Grounding Electrode Conduc...]

Grounding Electrode Bonding Jumper

The bonding jumper(s) used to connect the grounding electrodes together to form the grounding electrode system.

Statement of Problem and Substantiation for Public Input

This new definition is needed to differentiate the requirements for grounding electrode conductors and bonding jumpers. This term is used in 250.53(E) and 250.64(B)(4). The proposed definition will enhance usability throughout the NEC.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 16 11:08:22 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution:	FR-8750-NFPA 70-2024
Statement:	This new term clarifies the difference between bonding conductors and the grounding electrode conductor. A conductor used to interconnect grounding electrodes together is a bonding conductor and not the grounding electrode conductor.

Public Input No. 2315-NFPA 70-2023 [New Definition after Definition: Grouped.]

Grounding Electrode System.

All grounding electrode(s) bonded together by the grounding electrode conductor and grounding electrode bonding jumper(s) present at each building or structure.

Statement of Problem and Substantiation for Public Input

The term "grounding electrode system" is used 64 times in the NEC and in Part III of Article 250, used in the definition of Grounding Electrode Conductor and Intersystem Bonding Termination. This definition is needed in the Code to clearly define where the grounding electrode system starts and ends, what the grounding electrode system consist of, and what does it mean to bond the lightning protection system to the grounding electrode system. The proposed definition will enhance usability throughout the NEC.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 16 10:59:37 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The system is already described in 250.50 and does not need further clarification.

Public Input No. 3795-NFPA 70-2023 [New Definition after Definition: Line Isolation Monitor.]

Line-to-Ground.

An electrical reference between a normal current-carrying conductor and an equipment grounding conductor, grounded equipment, or ground.

Line-to-Line.

An electrical reference between two normally current-carrying conductors in a circuit, other than neutrals.

Informatiional Note: In corner grounded delta and 3-wire grounded systems, the line-to-line voltage may be the same as the line-to-ground voltage

Line-to-Neutral.

An electrical reference between a normal current-carrying conductor and a neutral conductor or neutral point in a circuit.

Statement of Problem and Substantiation for Public Input

The term "Line" is used through this Code in a variety of different ways. While a common use of it is to describe the supply-side connections of equipment, it is also frequently used to describe a current-carrying conductor. Most often this usage is in voltage references to another conductor or ground path. Though many users of this Code might consider this term to describe an ungrounded conductor, there are cases where its use could apply to a grounded conductor (i.e. corner grounded delta and 3-wire grounded systems). Additionally, though many users might believe it refers to conductors only in an ac supply, there are cases where it could apply to dc circuits as well, regardless of polarity (see 240.15(B)(4) for 3-wire dc systems).
Three phrases that use the term "line" stand out as being particularly important and are presented here as new proposed definitions. These suggested additions are the result of discussions I had with specific members of the CC DC Taskgroup, of which I am also a member. Unfortunately there was not enough time to discuss them adequately as a full task group, so I am submitting them myself. They are intended to add clarity as to how these phrases when used throughout the Code, should be applied to installations regardless of the supply system design or system grounding. As more dc circuits are installed, it will become increasingly important to add clarity such as these definitions so that general requirements are properly applied. By not explicitly mentioning ac or dc in these definitions, clarity is added that where these phrases are used in existing text, the requirements should apply generally to both ac and dc (unless otherwise modified). While these three terms alone do not address all uses of the term "line" in the NEC, they do represent a large number of requirements where important safety conditions are established.

Here is a partial list of sections where these phrases are used:
"Line to Neutral Loads", "Line to ground" or similar

- 100 (GFPE)
- 214.4(C)
- 240.60(A)
- 240.15(B)(1)
- 240.50(A)
- 250.187
- 250.36
- 310.15(E)
- 404.2(C)
- 517.20(A)
- 517.160(A)(6)
- 520.44(C)(2)

  - 805.90(A)(2)
  - 805.170(A)
- "Line to Line"
  - 240.15(B)(2)
  - 240.15(B)(4)
  - 240.15(B)(3)
  - 430.11(C)(1)
  - 547.42
  - 551.40(A)
  - 551.40(A)
  - 551.72(D)
  - 647.1
  - 647.8(B)
  - 726.124(A)
  - 726.121(A)

Submitter Information Verification

Submitter Full Name: Jason Fisher
Organization: Solar Technical Consulting Llc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 05 16:39:41 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The proposed terms are well understood, and a definition is not necessary. This is basic electrical training and would be more fitting for a training manual.

Public Input No. 1567-NFPA 70-2023 [New Definition after Definition: Nursing Home.]

Objectionable Current.

Lasting undesired currents present on conductors or equipment not considered to be current carrying under normal conditions.

Statement of Problem and Substantiation for Public Input

The term "Objectionable Current" is used in the NEC but is not defined. Providing a definition in Article 100 will aid in application and enforcement of the rules referencing this term. The provided definition has been derived partially from the Merriam-Webster Dictionary definition of the word "Objectionable" - Undesired or offensive.

Submitter Information Verification

Submitter Full Name: Kyle Krueger
Organization: NECA
Affiliation: NECA
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jul 25 15:09:07 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The committee has determined that the term objectionable current has too many variables and multiple examples that a single definition cannot fit. This is best determined by the local AHJ and the specific installation.

Public Input No. 1681-NFPA 70-2023 [Section No. 200.2(A)]

(A) Insulation.

The grounded conductor, if insulated, shall have insulation that complies with either one of the following:

(1) Is suitably rated, other than color, for any ungrounded conductor of the same circuit for systems of 1000 volts or less.

(2) Is rated not less than 600 volts for solidly grounded neutral systems of over 1000 volts in accordance with 250.184(A)(1)

Statement of Problem and Substantiation for Public Input

The reference to 250.184(A) should only include a reference to item 1 as item 2 of 250.184(A) pertains to the ampacity of the conductor. Since this section is specific to the insulation rating it should only reference 250.184(A)(1).

Submitter Information Verification

Submitter Full Name: Dennis Querry
Organization: Trinity River Authority
Street Address:
City:
State:
Zip:
Submittal Date: Fri Jul 28 16:21:36 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8635-NFPA 70-2024

Statement: The panel added the suffix (1) at the end of the 250.184(A) to clarify that only the insulation requirement is being referenced.

Public Input No. 2455-NFPA 70-2023 [Section No. 200.2(A)]

(A) Insulation.

The grounded conductor, if insulated, shall have insulation that complies with either one of the following:

(1) Is suitably rated, other than color, for any ungrounded conductor of the same circuit for systems of 1000 volts or less.

(2) Is rated not less than 600 volts for solidly grounded ~~neutral~~ systems of over 1000 volts in accordance with 250.184(A)

Statement of Problem and Substantiation for Public Input

Solidly grounded neutral systems is an undefined term, but solidly grounded is defined in Article 100. Removing ‘neutral’ will make the language technically correct.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Aug 17 13:09:40 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The word neutral was not removed in list item (2) as the title of 250.184 is Solidly Grounded Neutral Systems.

Public Input No. 703-NFPA 70-2023 [New Section after 200.4]

TITLE OF NEW CONTENT

Type your content here ... **200.4 (C) Ground-Fault Circuit Interrupter**

The grounded white conductor of a ground-fault protected circuit shall be identified by one continuous black, red or blue colored stripe.

Statement of Problem and Substantiation for Public Input

This addition would prevent crossed grounded conductors from causing "Phantom" tripping on ground-fault circuits. Without this amendment all terminations, connections and splice points would have to be checked to find the crossed grounded conductors. This is one of the hardest and most common problems to solve on a service call and is one of the most elusive to trouble shoot. On commercial wiring this is done almost automatically and should be required on residential wiring. This would also prevent the overloading of grounded conductors.

Submitter Information Verification

Submitter Full Name:	Michael Olson
Organization:	Mountain Electric Company, Post Office Box 8201, La Crescenta, California, 91224-0201
Affiliation:	MountainElectricCompany.com
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Apr 20 17:45:43 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The installation of a conductor with white insulation and a colored stripe is not prohibited by 200. 4 but should not be required. The requirement to specify the colors of the stripe does not allow for use plain white, or the use of other colors and could be difficult with some acceptable wiring methods

Public Input No. 1213-NFPA 70-2023 [New Section after 200.6(A)]

TITLE OF NEW CONTENT

Type your content here ...(9) For multiwire branch circuits, the identification shall be a continuous black, red, or blue colored stripe.

Statement of Problem and Substantiation for Public Input

This addition would prevent the connection of the grounded multiwire conductor to a non-multiwire circuit conductor. This is one of the hardest and most common problem to solve on a service call and is one of the most elusive to trouble shoot. This would also prevent the overloading of grounded conductors.

Submitter Information Verification

Submitter Full Name:	Michael Olson
Organization:	Mountain Electric Company, Post Office Box 8201, La Crescenta, California, 91224-0201
Affiliation:	MountainElectricCompany.com
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Jun 26 14:21:26 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The installation of a conductor with white insulation and a colored stripe is not prohibited by 200. 4 but should not be required. The requirement to specify the colors of the stripe does not allow for use plain white, or the use of other colors and could be difficult with some acceptable wiring methods

Public Input No. 180-NFPA 70-2023 [Section No. 200.6(A)]

(A) Sizes 6 AWG or Smaller.

The insulation of grounded conductors of 6 AWG or smaller shall be identified by one of the following means:

(1) A continuous white outer finish.

(2) A continuous gray outer finish.

(3) Three continuous white or gray stripes along the conductor's entire length on other than green insulation.

(4) Conductors with white or gray insulation and colored tracer threads in the braid identifying the source of manufacture.

(5) A single-conductor, sunlight-resistant, outdoor-rated cable used as a solidly grounded conductor in photovoltaic power systems, as permitted by 690.31(C)(1), shall be identified at the time of installation by markings at terminations in accordance with 200.6(A)(1) through (A)(4).

(6) The grounded conductor of a mineral-insulated, metal-sheathed cable (Type MI) shall be identified at the time of installation by a distinctive white or gray marking at its terminations The marking shall encircle the conductor insulation.

(7) Fixture wire shall comply with the requirements for grounded conductor identification in accordance with 402.8.

(8) For aerial cable, the identification shall comply with one of the methods in 200.6(A)(1) through (A)(5), or by means of a ridge located on the exterior of the cable so as to identify it.

(9) Conductors with a continuous white or gray outer finish shall be permitted to have a single colored stripe, other than green, for circuit identification.

Statement of Problem and Substantiation for Public Input

It is a common practice, on some projects, to identify grounded conductors with a single colored stripe that corresponds to the phase identification of the associated ungrounded conductor. This will clarify that this practice is permitted. Some AHJs have been reluctant to approve the white or gray insulation with a colored stripe.

Submitter Information Verification

Submitter Full Name: Don Ganiere
Organization: none
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 17 13:22:53 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8638-NFPA 70-2024

Statement: The addition of the list item (9) offers a way to associate grounded conductors of the same voltage system with the circuit conductors where multiple grounded conductors are present such as in a wireway.

Public Input No. 433-NFPA 70-2023 [Section No. 200.6(A)]

(A) Sizes 6 AWG or Smaller.

The insulation of grounded conductors of 6 AWG or smaller shall be identified by one of the following means:

(1) A continuous white outer finish.

(2) A continuous gray outer finish.

(3) Three continuous white or gray stripes along the conductor's entire length on other than green insulation.

(4) Conductors with white or gray insulation and colored tracer threads in the braid identifying the source of manufacture.

(5) A single-conductor, sunlight-resistant, outdoor-rated cable used as a solidly grounded conductor in photovoltaic power systems, as permitted by 690.31(C)(1), shall be identified at the time of installation by markings at terminations in accordance with 200.6(A)(1) through (A)(4).

(6) The grounded conductor of a mineral-insulated, metal-sheathed cable (Type MI) shall be identified at the time of installation by a distinctive white or gray marking at its terminations The marking shall encircle the conductor insulation.

(7) Fixture wire shall comply with the requirements for grounded conductor identification in accordance with 402.8.

(8) For aerial cable, the identification shall comply with one of the methods in 200.6(A)(1) through (A)(5), or by means of a ridge located on the exterior of the cable so as to identify it.

Exception No. 1:

Conductors within multiconductor cables shall be permitted to be re-identified at their terminations at the time of installation by a distinctive white or gray marking or other equally effective means.

Exception No. 2:

The grounded conductor of a multiconductor varnished-cloth-insulated cable shall be permitted to be identified at its terminations at the time of installation by a distinctive white marking or other equally effective means.

Informational Note:

The color gray may have been used in the past as an ungrounded conductor. Care should be taken when working on existing systems.

Statement of Problem and Substantiation for Public Input

This is a companion PI to a PI recommending the deletion of 200.6(E). 200.6(E) states the same thing as 200.6(A). The exception for mulitconductor cables might as well be in 200.6(A).

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 434-NFPA 70-2023 [Section No. 200.6(E)]	Move the exceptions in (E) to (A)
Public Input No. 434-NFPA 70-2023 [Section No. 200.6(E)]	

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sun Mar 05 14:43:11 EST 2023
Committee:	NEC-P05

Committee Statement

Resolution: The existing text of 200.6(E) is specific regarding conductor insulation for conductors that are smaller and larger than 4 AWG.

Public Input No. 434-NFPA 70-2023 [Section No. 200.6(E)]

~~**(E)** Grounded Conductors of Multiconductor Cables.~~

~~The insulated grounded conductor(s) in a multiconductor cable shall be identified by a continuous white or gray outer finish or by three continuous white or gray stripes on other than green insulation along its entire length. For conductors that are 4 AWG or larger in cables, identification of the grounded conductor shall be permitted to comply with 200.6(B) . For multiconductor flat cable with conductors that are 4 AWG or larger, an external ridge shall be permitted to identify the grounded conductor.~~

~~*Exception No. 1: Conductors within multiconductor cables shall be permitted to be re-identified at their terminations at the time of installation by a distinctive white or gray marking or other equally effective means.*~~

~~*Exception No. 2: The grounded conductor of a multiconductor varnished-cloth-insulated cable shall be permitted to be identified at its terminations at the time of installation by a distinctive white marking or other equally effective means.*~~

> ~~Informational Note: The color gray may have been used in the past as an ungrounded conductor. Care should be taken when working on existing systems.~~

Statement of Problem and Substantiation for Public Input

This is a companion proposal to move the excepts from (E) to (A). 240.6(E) is simply a repeat of the requirements of (A). Moving the exceptions to (A) brings all the requirements together in a more concise form.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 433-NFPA 70-2023 [Section No. 200.6(A)]	Move the exceptions in (E) to (A)
Public Input No. 433-NFPA 70-2023 [Section No. 200.6(A)]	

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sun Mar 05 14:50:14 EST 2023
Committee:	NEC-P05

Committee Statement

Resolution: The existing text of 200.6(E) is specific regarding conductor insulation for conductors that are smaller and larger than 4 AWG.

Public Input No. 3643-NFPA 70-2023 [Section No. 200.7(C)]

(C) Circuits of 50 Volts or More.

The use of insulation that is white or gray or that has three continuous white or gray stripes for other than a grounded conductor for circuits of 50 volts or more shall be permitted only as in the following:

(1) Cable Assembly

(a) Reidentification Method. If part of a cable assembly that has the insulation permanently reidentified to indicate its use as an ungrounded conductor by marking tape, painting, or other effective means at its termination and at each location where the conductor is visible and accessible. Identification shall encircle the insulation and shall be a color other than white, gray, or green.

(b) Switches. If used for single-pole, 3-way or 4-way switch loops, the reidentified conductor with white or gray insulation or three continuous white or gray stripes shall be used only for the supply to the switch, but not as a return conductor from the switch to the outlet.

(2) A flexible cord having one conductor identified by a white or gray outer finish or three continuous white or gray stripes, or by any other means in accordance with 400.22 , that is used for connecting an appliance or equipment in accordance with 400.10 . This shall apply to flexible cords connected to outlets whether or not the outlet is supplied by a circuit that has a grounded conductor.

> Informational Note: The color gray may have been used in the past as an ungrounded conductor. Care should be taken when working on existing systems.

Statement of Problem and Substantiation for Public Input

Breaking up 200.7(C)(1) into a list item format to facilitate understanding for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Sep 05 11:30:18 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-9249-NFPA 70-2024

Statement: The list item (1) of 200.7(C) was broken up into subdivisions to comply with the NEC Style Manual 3.5.1.2

Revised the Informational Note to comply with the NEC Style Manual and be consistent with the IN at 200.6(E)

Public Input No. 1850-NFPA 70-2023 [New Section after 250.4]

TITLE OF NEW CONTENT

Type your content here ...250.5 Connections to grounding and bonding conductors.

No connection shall be made to grounding and bonding conductors that will result in that conductor carrying current under normal conditions unless permitted otherwise by a provision of this code.

Statement of Problem and Substantiation for Public Input

While we all "know" that we can't use a bonding or grounding conductor to carry current under normal conditions, there is no code rule that says this directly. You can get to it by applying 250.6, but there should be a direct rule. Had such a rule existed in previous codes, we never would have had the problem with occupancy sensors and other electronic switches that we had a few cycles ago.

Submitter Information Verification

Submitter Full Name:	Don Ganiere
Organization:	none
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sun Aug 06 15:12:12 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The elimination of current on the equipment grounding conductor is already covered by the requirements of 250.6(A), 250.24(B), 250.30(A) and 250.32(B)(1). Equipment may have small amounts of current in normal operation that is introduced into the equipment grounding conductor, and this requirement would prohibit this type of operation.

Public Input No. 1087-NFPA 70-2023 [Section No. 250.4(A)(4)]

(4) Bonding of Electrically Conductive Materials and Other Equipment.

Normally non-current-carrying electrically conductive materials that are likely to become energized shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path. Every exposed external bonding conductor not protected by a raceway shall be installed either so as to follow equipment that it bonds such as pipe or tubing; or else so it follows the building surface or a running board except where it has to go across to the points of bonding. See 250.104(A)(1), 250.130 (C) and 250.134(2).

Statement of Problem and Substantiation for Public Input

Bonding around a fitting such as a push-in connector that does not maintain electrical continuity (e.g. Sharkbite TM) normally uses a short piece of conductor, unsecured except at the bonding fittings. In the field, this frequently is approved without question when not secured, even though not securing it can be seen as violating the letter of the code. The alternative of extending it so that it can be secured can put it at risk in situations where it would not be subject to damage if it simply followed the pipe or tubing, much as a circuit grounding conductor is permitted to follow the outside of a raceway. The same principle would apply to a discontinuous length of metal duct.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1091-NFPA 70-2023 [Section No. 250.4(A)(5)]	Similarly acknowledges and endorses the common use of shorter bonding conductors without independent support.
Public Input No. 1091-NFPA 70-2023 [Section No. 250.4(A)(5)]	

Submitter Information Verification

Submitter Full Name:	David Shapiro
Organization:	Safety First Electrical
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Jun 14 16:53:42 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed revision does not add usability to the current Code language. Section 250.4 contains performance requirements for the purposes of grounding and bonding for all electrical installations and should not contain prescriptive requirements. The proposed requirement is addressed in 250.102(E)(3).

Public Input No. 2412-NFPA 70-2023 [New Section after 250.4(A)(5)]

(6) Protection of Electrical Connections.

Electrical connections using dissimilar metals that are exposed to damp, wet, or corrosive conditions shall be environmentally sealed (as air-tight and water-tight) against the effects of corrosion or otherwise protected using materials listed for the purpose .

Additional Proposed Changes

File Name	Description	Approved
PI_2412_Attachment_C_.pdf		

Statement of Problem and Substantiation for Public Input

Secure grounding and bonding connections are essential to a safe electrical system. Grounding is essential to ensure a safe return path for electrical current. Bonding ensures that all metal parts of electrical equipment have the same electrical potential, reducing the risk of shock hazard and damage. Both grounding and bonding are necessary for an electrical system to ensure safety, reliability, and performance.

The effects of corrosion on grounding and bonding connections, especially outdoors or in humid or corrosive environments are significant. Humidity causes metals to corrode and can accelerate the galvanic action caused by using dissimilar metals used to bond electrical equipment. Corrosive atmospheres, such as in a swimming pool equipment room can quickly corrode grounding and bonding connections, rendering them unsafe.
Galvanic corrosion is an electrochemical process in which one metal corrodes preferentially when it is in electrical contact with another, in the presence of an electrolyte, such as water. By keeping the electrolyte away from the connection, corrosion can be significantly reduced.

Connections using dissimilar metals will quickly corrode when exposed to weather or corrosive conditions, causing failure of the bonding pathway. Corrosion is a major problem for electrical connections, as it can lead to increased resistance and heating. Corrosion can lead to connections becoming oxidized, creating a high resistance contact, and can ultimately lead to the failure of the connection. Poor grounding and bonding connections can result in an electrical potential on exposed metal parts, which may result in property damage, injury, or death.

Corrosion is a natural phenomenon which occurs under certain moisture, temperature and atmospheric conditions; it cannot be avoided, only mitigated. Corrosion weakens products therefore affecting their function and integrity.

Corrosion is a large problem. A 2002 study by the National Association of Corrosion Engineers, backed by the Federal Highway Administration, estimated corroding metals in various industries, infrastructure and manufacturing cost $276 billion annually.

For example, the United States Consumer Product Safety Commission (CPSC) ordered a recall of 1.3 million grounding lugs due to corrosion issues in 2014. Although no deaths were attributed to the recall, the cost to replace the lugs was significant.

In another case, a recent article illustrated significant lightning damage to Orange County Florida’s public emergency communications equipment. 1 The damage was caused by lightning strikes and corrosion of bonding connections on lightning protection conductors. These damages were between one and two million dollars over a ten-year period.

According to the CPSC, approximately 90 people are electrocuted annually in the United States due to appliances or wiring issues. There are also at least 30,000 non-fatal shock incidents per year in the United States. Each year, approximately 5% of all burn unit admissions in the United States occur because of electrical injuries.

Preventing corrosion of grounding and bonding connections in wet, damp, or corrosive atmospheres can be challenging. Equipment located in these conditions are exposed to the elements, which can result in atypical situations where the usual practices for bonding may not perform as intended. For example, many listed grounding lugs are not designed to be installed outdoors; using a lug that is not rated for outdoor use can lead to premature failures in the intended path for fault current, impairing the functionality of overcurrent and ground-fault protection devices. Other issues include corrosion of bonding connections due to galvanic action.

Grounding lugs can damage the protective anodized coating on aluminum module frames and rails. For example, some manufacturers suggest scraping, cutting, or scuffing the anodized coating. Unless the connection is sealed (as air-tight and water-tight) from the elements, the aluminum becomes exposed to the environment which increases the rate of oxidation and galvanic corrosion. Corrosion at the connection will cause an increase in the connection's resistance, and eventual failure of the bond. However, some equipment manufacturers do not permit removal of the protective anodized coating, such as galvanization, to make electrical contact. This is because removal of the coating will facilitate corrosion.

Tests conducted on a variety of bonding connections indicated that most typical connections failed quickly when exposed to deteriorating agents. Damp-heat resistances were relatively unchanged over a 20-week period. However, most samples corroded in just a few weeks for the salt-mist tests. Samples using an antioxidant lasted slightly longer before failing. Lay-in lugs with washers and grounding clips and compound lasted more than 20 weeks in the salt mist condition, but still failed. 2

Using connection hardware that is environmentally sealed (as air-tight and water-tight) against the effects of corrosion will not only make installations safer but will reduce costs for the owner/operator.

Using an environmentally sealed electrical bonding device and bonding fastener with environmental seals creates an air-tight and water-tight seal around the teeth which make the electrical bonding connection and protect it from corrosion. As the nut and bolt are tightened the twisted teeth bite into the facing surfaces of the frames to penetrate any surface corrosion or coating and create a solid electrical connection that is air-tight and water-tight sealed against the elements and the effects of corrosion. Please refer to Attachments 1-4 for photographs of environmentally sealed washers. As can be seen in Attachments 3 and 4, the washer clearly provided good contact with the aluminum surface, while the silicone protects the connection from corrosion.

Environmentally sealed hardware creates more secure electrical connections by providing 360-degree protection against corrosion and degradation. This is achieved by embedding the washer in an air and watertight silicone layer. The silicone layer prevents moisture and other contaminants from coming into contact with the washer and mating surface, which can help to prevent corrosion and degradation of the electrical connection.

As a result of these benefits, environmentally sealed hardware can help to create more secure electrical connections that are less likely to fail. This is important for safety, as it can help to prevent electrical fires and other hazards. Environmentally sealed hardware is also important for reliability, as they can help to ensure that electrical connections remain functional for longer periods of time.

Here are some of the specific benefits of using environmentally sealed connections:

- Increased resistance to corrosion
- Reduced risk of electrical fires and shock hazards
- Improved reliability
- Longer lifespan

Notes:

1. All-Copper Grounding Systems End Million Dollar Losses at Emergency Response System. [West, Donnelly, Sorley, 2016]
2. Accelerated Aging Tests on PV Grounding Connections [Wang et al., 2011]

Submitter Information Verification

Submitter Full Name:	Merton Bunker
Organization:	Merton Bunker & Associates, LLC
Affiliation:	Evan W. Lipstein, Hyline Safety Company
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Aug 17 06:05:53 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed requirement is addressed in 110.11 and 110.14 and in accordance with the NEC Style Manual Section 4.1.2, the general requirements contained in Chapter 1 should not be repeated.

Merton Bunker & Associates, LLC
22 Gray Birch Ln
Stafford, VA 22554
September 2, 2023

National Fire Protection Association
Attn: Standards Administration
1 Batterymarch Park
Quincy, MA 02169

Please see the attached supporting material and related permission to use the material for Public Inputs 2411, 2412, 2413, 2414, 2415, 2492, and 2493. These attachments are the same for all referenced Public Inputs.

I am submitting this PI on behalf of HYLINE SAFETY COMPANY.

The material in all four attachments is not copyrighted; however, I have included permission to publish them from the originator of these attachments, Mr. Evan W. Lipstein.

Thank you in advance for your attention to this matter. If you have any questions or concerns, please contact me at the phone number below.

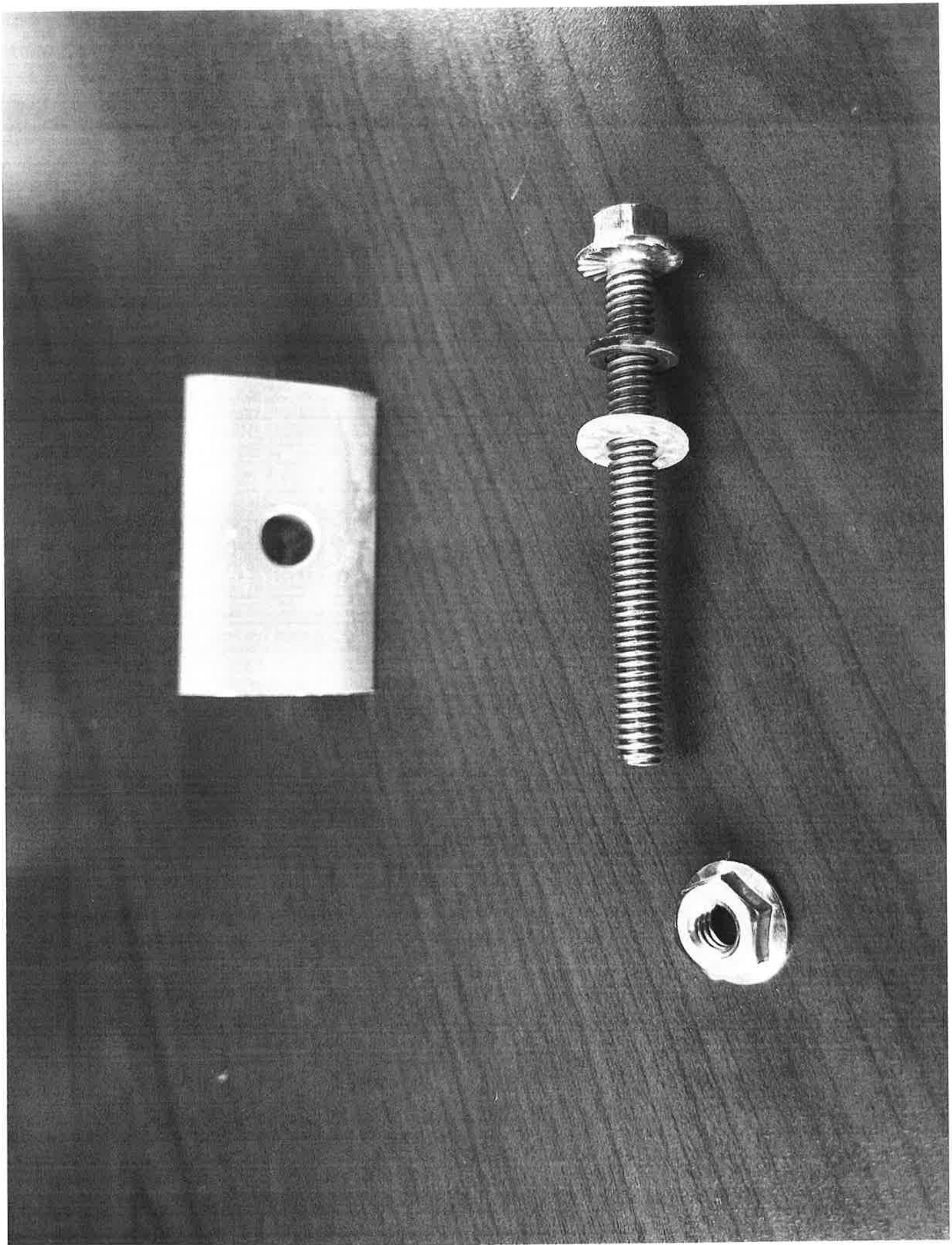
Very truly yours,

Merton Bunker, PE.

Attachment #1

Hardware with an environmentally sealed washer.

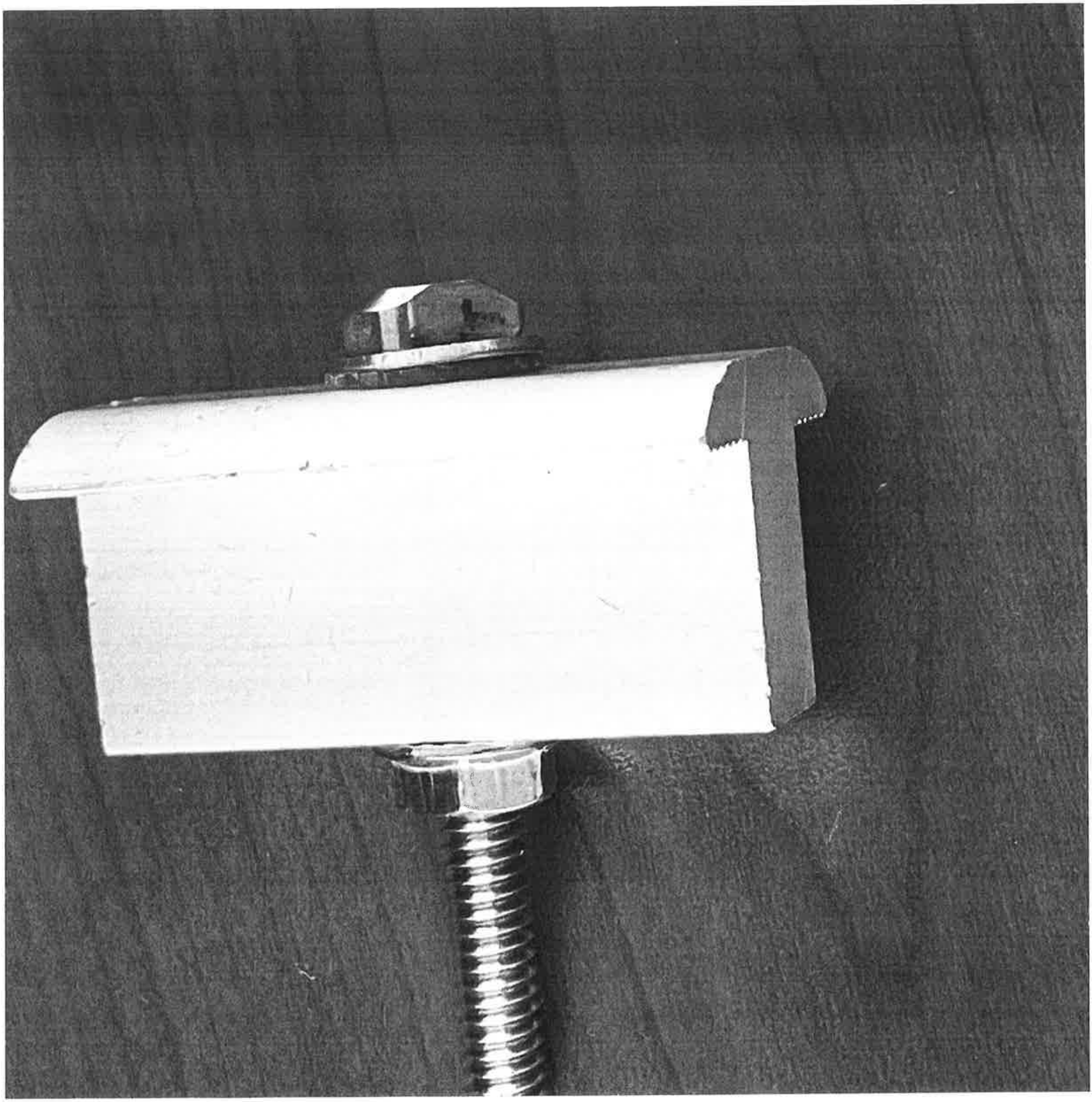
For Public Inputs 2411, 2412, 2413, 2414, 2415, 2492, and 2493.



Attachment #2

Hardware with an environmentally sealed washer.

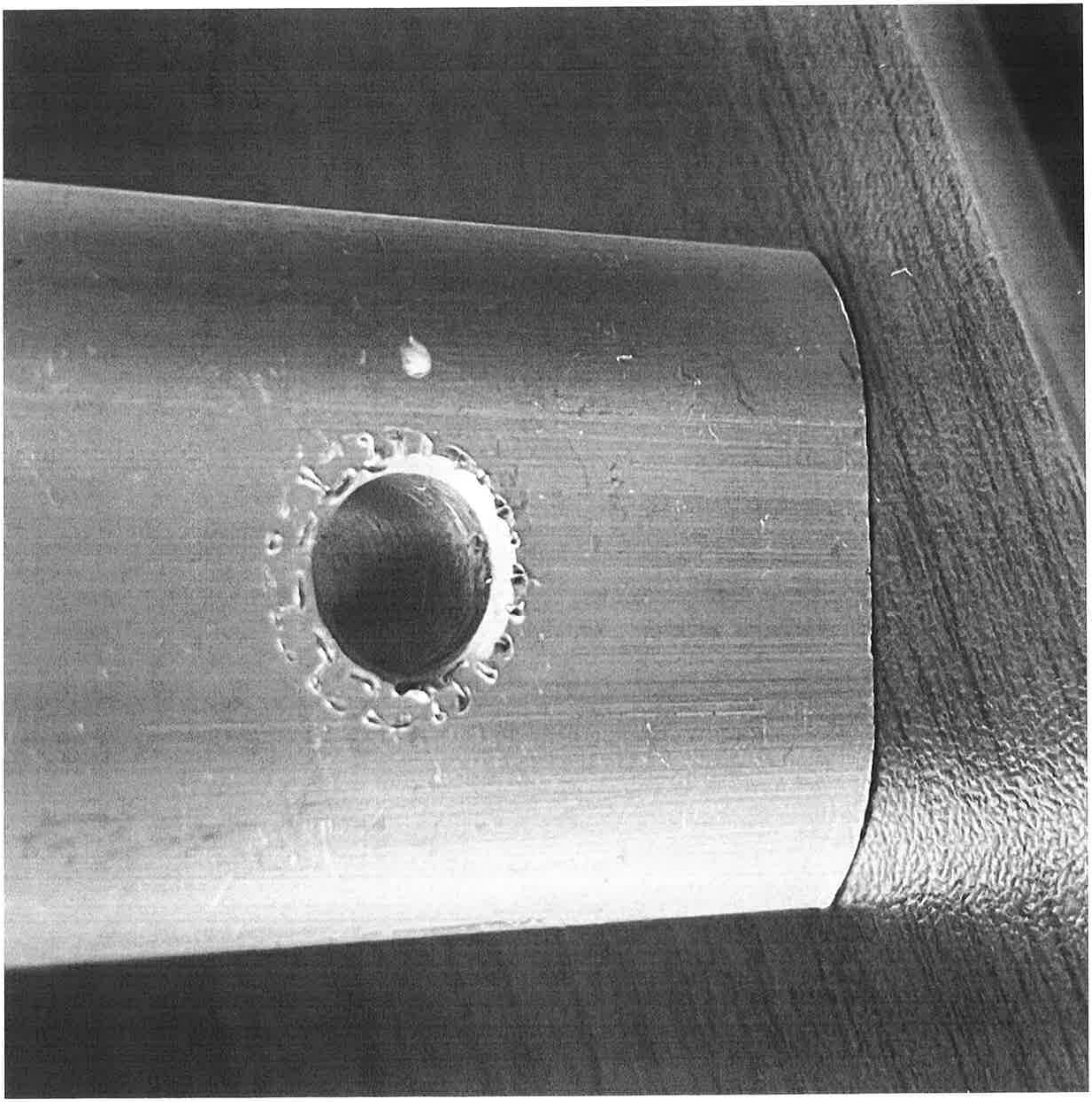
For Public Inputs 2411, 2412, 2413, 2414, 2415, 2492, and 2493.



Attachment #3

Aluminum surface showing contact by environmentally sealed washer.

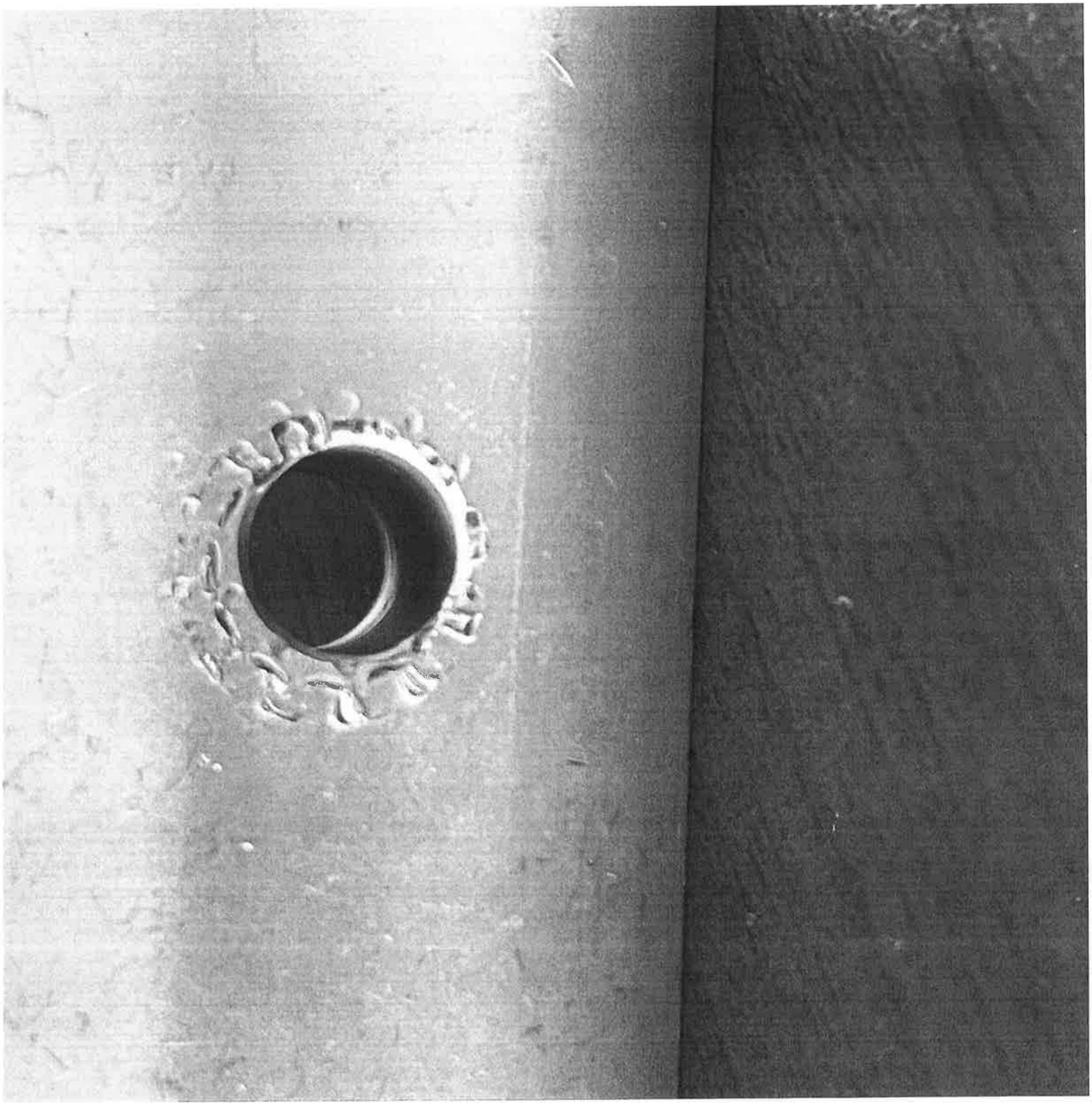
For Public Inputs 2411, 2412, 2413, 2414, 2415, 2492, and 2493.



Attachment #4

Aluminum surface showing contact by environmentally sealed washer.

For Public Inputs 2411, 2412, 2413, 2414, 2415, 2492, and 2493.



Public Input No. 1091-NFPA 70-2023 [Section No. 250.4(A)(5)]

(5) Effective Ground-Fault Current Path.

Electrical equipment and wiring and other electrically conductive material likely to become energized, such as are addressed in Section 250.104, shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for impedance grounded systems. Where nonconductive fittings or nonmetallic sections are introduced into metallic systems such as water supply tubing, bonding conductors shall be installed, sized to carry the largest current likely to energize the metal, in accordance with Table 250.122. Where not installed in a raceway, it shall either follow equipment that it bonds such as pipe or tubing, or else follow the building surface or a running board except where it has to leave it for the points of bonding. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault occurs to the electrical supply source. The earth shall not be considered as an effective ground-fault current path.

Statement of Problem and Substantiation for Public Input

This offers two improvements. One acknowledges a commonly accepted practice that can be interpreted as violating the literal language of the code. Short bonding jumpers with just enough length to allow replacement of fittings usually are safer than would be bonding conductors that were extended to where they could be supported to structure.

The other recognizes that plumbers and pipefitters usually don't consider electrical continuity when they choose and install their fittings. This means it falls on us to make sure the path back to the electrical system bond remains continuous.

To avoid the risk of shock and explosion, we can't leave this to faith and hope.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1087-NFPA 70-2023 [Section No. 250.4(A)(4)]	Similarly acknowledges and endorses the common use of shorter bonding conductors without independent support.
Public Input No. 1087-NFPA 70-2023 [Section No. 250.4(A)(4)]	

Submitter Information Verification

Submitter Full Name: David Shapiro
Organization: Safety First Electrical
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 14 21:29:47 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Section 250.4 contains performance requirements for the purposes of grounding and bonding for all electrical installations and should not contain prescriptive requirements. No technical substantiation was provided to indicate the need to require 10 seconds for a clear time of an overcurrent protective device.

Public Input No. 3146-NFPA 70-2023 [Section No. 250.4(A)(5)]

(5) Effective Ground-Fault Current Path.

Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault occurs to the electrical supply source. The earth shall not be considered as an effective ground-fault current path.

Informational Note: For the purposes of 250.4(A)(5), facilitation of the overcurrent device means activation of the overcurrent device within the short time rating of that device to eliminate voltage on the faulted conductor in the least amount of time possible within the design parameters of the system.

Statement of Problem and Substantiation for Public Input

During discussions on the development of the 2023 Edition of NFPA 70, there was discussion on the relevance and meaning of the term "facilitate the operation of the overcurrent device." This IN clarifies that the intent is to clear a ground fault in the least amount of time possible within the design criteria. The language recognizes that the term instantaneous trip should not be used because there are times when a delay is intentionally built into the design in order to accomplish selective coordination. Operation of the overcurrent device as a function of overload is not adequate to mitigate the effects of a ground fault and would present a safety and fire hazard.

Submitter Information Verification

Submitter Full Name: Joseph Andre
Organization:
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 29 16:45:18 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The PI makes an interpretation of the Code in violation of 2.1.10.2 of the NEC Style Manual.

Public Input No. 3805-NFPA 70-2023 [Section No. 250.4(A)(5)]

(5) Effective Ground-Fault Current Path.

(a) Opening Overcurrent Protective Device. Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for impedance grounded systems.

(c) Carrying Ground-Fault Current. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault occurs to the electrical supply source.

(b) Earth Not Suitable as Effective Ground-Fault Current Path. The earth shall not be considered as an effective ground-fault current path.

Statement of Problem and Substantiation for Public Input

Breaking up 250.4(A)(5) into a list item format to facilitate understanding for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Sep 05 17:13:54 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8247-NFPA 70-2024

Statement: The language in the subdivision has changed to multiple subdivisions to increase usability of the Code. This complies with 3.5.1.2 of NEC Style Manual.

Public Input No. 796-NFPA 70-2023 [Section No. 250.4(A)(5)]

(5) Effective Ground-Fault Current Path.

Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device within a period not exceeding 10 seconds or ground detector for impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault occurs to the electrical supply source. The earth shall not be considered as an effective ground-fault current path.

Statement of Problem and Substantiation for Public Input

During a ground fault the ungrounded and equipment grounding conductors become an impedance potential divider with upwards of half the nominal line to neutral voltage appearing between the metal frame of faulting equipment and other objects referenced to ground within the vicinity. For a 208Y/120 volt system this can be in excess of 60 volts, for a 480Y/277 volt system this can be in excess of 139 volts. With no explicit limit in the National Electrical Code regarding maximum over current protective device clearing time in regards to a ground fault, a legal argument can be made that a ground fault and its accompanying touch voltage can persist for any length of time provided the over current device clears eventually.

Further standard ICEA P-32-382 as noted in the code only deals with short circuit and ground fault currents up to 10 seconds in duration.

Submitter Information Verification

Submitter Full Name:	Scott Tee
Organization:	[Not Specified]
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri May 12 11:13:22 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Section 250.4 contains performance requirements for the purposes of grounding and bonding for all electrical installations and should not contain prescriptive requirements. No technical substantiation was provided to indicate the need to require 10 seconds for a clear time of an overcurrent protective device.

Public Input No. 751-NFPA 70-2023 [New Section after 250.4(B)(4)]

TITLE OF NEW CONTENT

A grounding electrode from an air hander unit with metal ducting that contains a flexible collar installed in a house or commercial applications that has metal ducts. A simple inexpensive piece of wire would be a such a solution, and inexpensive to do.

Statement of Problem and Substantiation for Public Input

The metal duct that would be run in a house for example a wire comes loose somewhere on the duct, not tripping any breakers. A child crawling on the floor may reach out and play with the lever on the grate. Crawling across the floor they would have an an enormous amount of static electricity built up, touching the grate could end in death. On a commercial site, the General Contractor doesn't always use metal studs, they go with what is cheaper at the time, metal or wood. The metal is usually tied to the building structure, wood on the other hand wouldn't be grounded, so someone on the duct could get shocked by touching something metal

Submitter Information Verification

Submitter Full Name:	jim mongelluzzo
Organization:	N/A
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Apr 29 07:47:58 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Technical information or substantiation has not been provided to create such a requirement.

Public Input No. 580-NFPA 70-2023 [Section No. 250.4 [Excluding any Sub-Sections]]

The following general requirements identify what grounding of electrical systems and grounding and bonding of electrical ~~systems~~ equipment are required to accomplish. The prescriptive methods contained in this article shall be followed to comply with the performance requirements of this section.

Statement of Problem and Substantiation for Public Input

250.4 address two things: System grounding (or the lack thereof) and equipment grounding and bonding.

Submitter Information Verification

Submitter Full Name: Ryan Jackson
Organization: Self-employed
Street Address:
City:
State:
Zip:
Submittal Date: Mon Apr 10 14:18:50 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8244-NFPA 70-2024

Statement: The parent text of 250.4 is revised to clarify that grounding and bonding applies both to electrical equipment and electrically conductive materials as listed in the subdivisions of 250.4(A) and (B).

Public Input No. 2131-NFPA 70-2023 [New Section after 250.6]

250.7 Equipment Grounding Conductors not to be used to intentionally carry non-fault current

Equipment Grounding Conductors shall not be used to carry current from devices that require current to operate. Where connections to the enclosure/raceway system are required, such as in 250.142(B), non-metallic raceways shall be used to connect the enclosures such that a parallel path is not created.

Exception No. 1: installations, installed prior to 1.Jan.2026, with existing devices that impress currents on the equipment grounding conductor.

Exception No. 2: Existing installations where neural current flows on equipment grounding conductors due to required connections.

Informational note 1: An example of a device that requires current to operate is a motion sensor,

Informational note 2: An example of current flowing on equipment grounding connections due to required connections is current flow on a metallic raceway that is connected between a meter socket enclosure and the service disconnect enclosure. Whereas NFPA 70 does not require this raceway to be metallic, some municipalities do.

Statement of Problem and Substantiation for Public Input

NFPA70 now requires for motion sensors and devices that require current to operate, to be connected to a neutral conductor. Placing this new requirement in the Code can help alleviate objectionable current, and tripping of GFCIs.

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Aug 12 16:56:28 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The elimination of current on the equipment grounding conductor is already covered by the requirements of 250.6(A), 250.24(B), 250.30(A) and 250.32(B)(1). Equipment may have small amounts of current in normal operation that is introduced into the equipment grounding conductor, and this requirement would prohibit this type of operation.

Public Input No. 2991-NFPA 70-2023 [Section No. 250.6(A)]

(A) Arrangement to Prevent Objectionable Current.

(1) The grounding and bonding of electrical systems, circuit conductors, surge arresters, surge-protective devices, and conductive normally non-current-carrying metal parts of equipment shall be installed and arranged in a manner that will prevent objectionable current.

(2) The equipment grounding conductor shall not be used as a current-carrying conductor, except as permitted in 250.6(C).

Statement of Problem and Substantiation for Public Input

This added language will make it clear that the equipment grounding conductor cannot be used to carry current under any circumstances unless as permitted in 250.6(C) for temporary ground faults. There is no requirement in the NEC that specifically prohibits the equipment grounding conductor to be used a current carrying circuit conductor. The proposed language will increase electrical safety.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Mon Aug 28 14:42:17 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The proposed revision does not add additional clarity to this section.

Public Input No. 186-NFPA 70-2023 [Section No. 250.8(A)]

(A) Permitted Methods.

Equipment grounding conductors, grounding electrode conductors, bonding jumpers, and grounding and bonding ~~jumpers~~ equipment shall be connected by one or more of the following means:

(1) Listed pressure connectors

(2) Terminal bars

(3) Pressure connectors listed as grounding and bonding equipment

(4) Exothermic welding process

(5) Machine screw-type fasteners that engage not less than two threads or are secured with a nut

(6) Thread-forming machine screws that engage not less than two threads in the enclosure

(7) Connections that are part of a listed assembly

(8) Other listed means

Statement of Problem and Substantiation for Public Input

This section does not currently address the connection of grounding and bonding equipment such as terminals to enclosures. This will clarify that where terminals and other grounding and bonding equipment are used to connect grounding and bonding conductors, that the terminals must also be connected to the enclosures using one of the listed methods. The current language does not prohibit the use of a sheet metal screw to connect a terminal to an enclosure.

Submitter Information Verification

Submitter Full Name: Don Ganiere
Organization: none
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 17 14:07:04 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8259-NFPA 70-2024

Statement: Adding the term grounding and bonding terminations clarifies the intent of the requirement to apply to the terminations as well as to the conductors.

Public Input No. 1984-NFPA 70-2023 [Section No. 250.8(A)]

(A) Permitted Methods.

Equipment grounding conductors, grounding electrode conductors, and bonding jumpers shall be connected by one or more of the following means:

(1) Listed pressure connectors

(2) Terminal bars

(3) Pressure connectors listed as grounding and bonding equipment

(4) Exothermic welding process

(5) Machine screw-type fasteners that engage not less than two threads or are secured with a ~~nut~~ nut Only one conductor shall be permitted for each machine screw-type fastener unless listed for more than one conductor.

(6) Thread-forming machine screws that engage not less than two threads in the enclosure

(7) Connections that are part of a listed assembly

(8) Other listed means

Statement of Problem and Substantiation for Public Input

250.8 (A) (5) - Clarify that only one equipment grounding conductor (EGC), grounding electrode conductor or bonding jumper may be connected per machine screw unlike some terminal bars which may be listed for multiple conductors.

Submitter Information Verification

Submitter Full Name: Gary Hein
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 09 12:43:46 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Machine screws are not required to be listed for grounding and bonding.

Public Input No. 2342-NFPA 70-2023 [Section No. 250.8(A)]

(A) Permitted Methods.

Equipment grounding conductors, grounding electrode conductors, bonding jumpers, and grounding and bonding ~~jumpers~~ terminations shall be connected by one or more of the following means:

(1) Listed pressure connectors

(2) Terminal bars

(3) Pressure connectors listed as grounding and bonding equipment

(4) Exothermic welding process

(5) Machine screw-type fasteners that engage not less than two threads or are secured with a nut

(6) Thread-forming machine screws that engage not less than two threads in the enclosure

(7) Connections that are part of a listed assembly

(8) Other listed means

Statement of Problem and Substantiation for Public Input

Adding ‘grounding and bonding terminations’ makes this requirement apply to the connection points were grounding and bonding conductors terminate to equipment. Currently this requirement only applies to the connection between grounding and bonding conductors and the terminals, not between the grounding and bonding terminal and equipment. This proposed revision will bring clarity to Code users and make the intent of the requirement actually apply.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 16 13:40:31 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8259-NFPA 70-2024

Statement: Adding the term grounding and bonding terminations clarifies the intent of the requirement to apply to the terminations as well as to the conductors.

Public Input No. 2413-NFPA 70-2023 [Section No. 250.8(A)]

(A) Permitted Methods.

Equipment grounding conductors, grounding electrode conductors, and bonding jumpers shall be connected by one or more of the following means:

(1) Listed pressure connectors

(2) Terminal bars

(3) Pressure connectors listed as grounding and bonding equipment

(4) Exothermic welding process

(5) Machine screw-type fasteners that engage not less than two threads or are secured with a nut

(6) Thread-forming machine screws that engage not less than two threads in the enclosure

(7) Connections that are part of a listed assembly

(8) Listed hardware that is environmentally sealed (as air-tight and water-tight) against the effects of corrosion

(9) Other listed means

Additional Proposed Changes

File Name	Description	Approved
PI_2413_Attachment_C_.pdf		

Statement of Problem and Substantiation for Public Input

Secure grounding and bonding connections are essential to a safe electrical system. Grounding is essential to ensure a safe return path for electrical current. Bonding ensures that all metal parts of electrical equipment have the same electrical potential, reducing the risk of shock hazard and damage. Both grounding and bonding are necessary for an electrical system to ensure safety, reliability, and performance.

The effects of corrosion on grounding and bonding connections, especially outdoors or in humid or corrosive environments are significant. Humidity causes metals to corrode and can accelerate the galvanic action caused by using dissimilar metals used to bond electrical equipment. Corrosive atmospheres, such as in a swimming pool equipment room can quickly corrode grounding and bonding connections, rendering them unsafe.
Galvanic corrosion is an electrochemical process in which one metal corrodes preferentially when it is in electrical contact with another, in the presence of an electrolyte, such as water. By keeping the electrolyte away from the connection, corrosion can be significantly reduced.

Connections using dissimilar metals will quickly corrode when exposed to weather or corrosive conditions, causing failure of the bonding pathway. Corrosion is a major problem for electrical connections, as it can lead to increased resistance and heating. Corrosion can lead to connections becoming oxidized, creating a high resistance contact, and can ultimately lead to the failure of the connection. Poor grounding and bonding connections can result in an electrical potential on exposed metal parts, which may result in property damage, injury, or death.

Corrosion is a natural phenomenon which occurs under certain moisture, temperature and atmospheric conditions; it cannot be avoided, only mitigated. Corrosion weakens products therefore affecting their function and integrity.

Corrosion is a large problem. A 2002 study by the National Association of Corrosion Engineers, backed by the Federal Highway Administration, estimated corroding metals in various industries, infrastructure and manufacturing cost $276 billion annually.

For example, the United States Consumer Product Safety Commission (CPSC) ordered a recall of 1.3 million grounding lugs due to corrosion issues in 2014. Although no deaths were attributed to the recall, the cost to replace the lugs was significant.

In another case, a recent article illustrated significant lightning damage to Orange County Florida's public emergency communications equipment. 1 The damage was caused by lightning strikes and corrosion of bonding connections on lightning protection conductors. These damages were between one and two million dollars over a ten-year period.

According to the CPSC, approximately 90 people are electrocuted annually in the United States due to appliances or wiring issues. There are also at least 30,000 non-fatal shock incidents per year in the United States. Each year, approximately 5% of all burn unit admissions in the United States occur because of electrical injuries.

Preventing corrosion of grounding and bonding connections in wet, damp, or corrosive atmospheres can be challenging. Equipment located in these conditions are exposed to the elements, which can result in atypical situations where the usual practices for bonding may not perform as intended. For example, many listed grounding lugs are not designed to be installed outdoors; using a lug that is not rated for outdoor use can lead to premature failures in the intended path for fault current, impairing the functionality of overcurrent and ground-fault protection devices. Other issues include corrosion of bonding connections due to galvanic action.

Grounding lugs can damage the protective anodized coating on aluminum module frames and rails. For example, some manufacturers suggest scraping, cutting, or scuffing the anodized coating. Unless the connection is sealed (as air-tight and water-tight) from the elements, the aluminum becomes exposed to the environment which increases the rate of oxidation and galvanic corrosion. Corrosion at the connection will cause an increase in the connection's resistance, and eventual failure of the bond. However, some equipment manufacturers do not permit removal of the protective anodized coating, such as galvanization, to make electrical contact. This is because removal of the coating will facilitate corrosion.

Tests conducted on a variety of bonding connections indicated that most typical connections failed quickly when exposed to deteriorating agents. Damp-heat resistances were relatively unchanged over a 20-week period. However, most samples corroded in just a few weeks for the salt-mist tests. Samples using an antioxidant lasted slightly longer before failing. Lay-in lugs with washers and grounding clips and compound lasted more than 20 weeks in the salt mist condition, but still failed. 2

Using connection hardware that is environmentally sealed (as air-tight and water-tight) against the effects of corrosion will not only make installations safer but will reduce costs for the owner/operator.

Using an environmentally sealed electrical bonding device and bonding fastener with environmental seals creates an air-tight and water-tight seal around the teeth which make the electrical bonding connection and protect it from corrosion. As the nut and bolt are tightened the twisted teeth bite into the facing surfaces of the frames to penetrate any surface corrosion or coating and create a solid electrical connection that is air-tight and water-tight sealed against the elements and the effects of corrosion. Please refer to Attachments 1-4 for photographs of environmentally sealed washers. As can be seen in Attachments 3 and 4, the washer clearly provided good contact with the aluminum surface, while the silicone protects the connection from corrosion.

Environmentally sealed hardware creates more secure electrical connections by providing 360-degree protection against corrosion and degradation. This is achieved by embedding the washer in an air and watertight silicone layer. The silicone layer prevents moisture and other contaminants from coming into contact with the washer and mating surface, which can help to prevent corrosion and degradation of the electrical connection.

As a result of these benefits, environmentally sealed hardware can help to create more secure electrical connections that are less likely to fail. This is important for safety, as it can help to prevent electrical fires and other hazards. Environmentally sealed hardware is also important for reliability, as they can help to ensure that electrical connections remain functional for longer periods of time.

Here are some of the specific benefits of using environmentally sealed connections:
- Increased resistance to corrosion
- Reduced risk of electrical fires and shock hazards
- Improved reliability
- Longer lifespan

Notes:
1. All-Copper Grounding Systems End Million Dollar Losses at Emergency Response System. [West, Donnelly, Sorley, 2016]
2. Accelerated Aging Tests on PV Grounding Connections [Wang et al., 2011]

Submitter Information Verification

Submitter Full Name:	Merton Bunker
Organization:	Merton Bunker &; Associates, LLC
Affiliation:	Evan W. Lipstein, Hyline Safety Company
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Aug 17 06:12:12 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed requirement is addressed in 110.11 and 110.14, and in accordance with the NEC Style Manual Section 4.1.2, the general requirements contained in Chapter 1 should not be repeated.

Merton Bunker & Associates, LLC
22 Gray Birch Ln
Stafford, VA 22554
September 2, 2023

National Fire Protection Association
Attn: Standards Administration
1 Batterymarch Park
Quincy, MA 02169

Please see the attached supporting material and related permission to use the material for Public Inputs 2411, 2412, 2413, 2414, 2415, 2492, and 2493. These attachments are the same for all referenced Public Inputs.

I am submitting this PI on behalf of HYLINE SAFETY COMPANY.

The material in all four attachments is not copyrighted; however, I have included permission to publish them from the originator of these attachments, Mr. Evan W. Lipstein.

Thank you in advance for your attention to this matter. If you have any questions or concerns, please contact me at the phone number below.

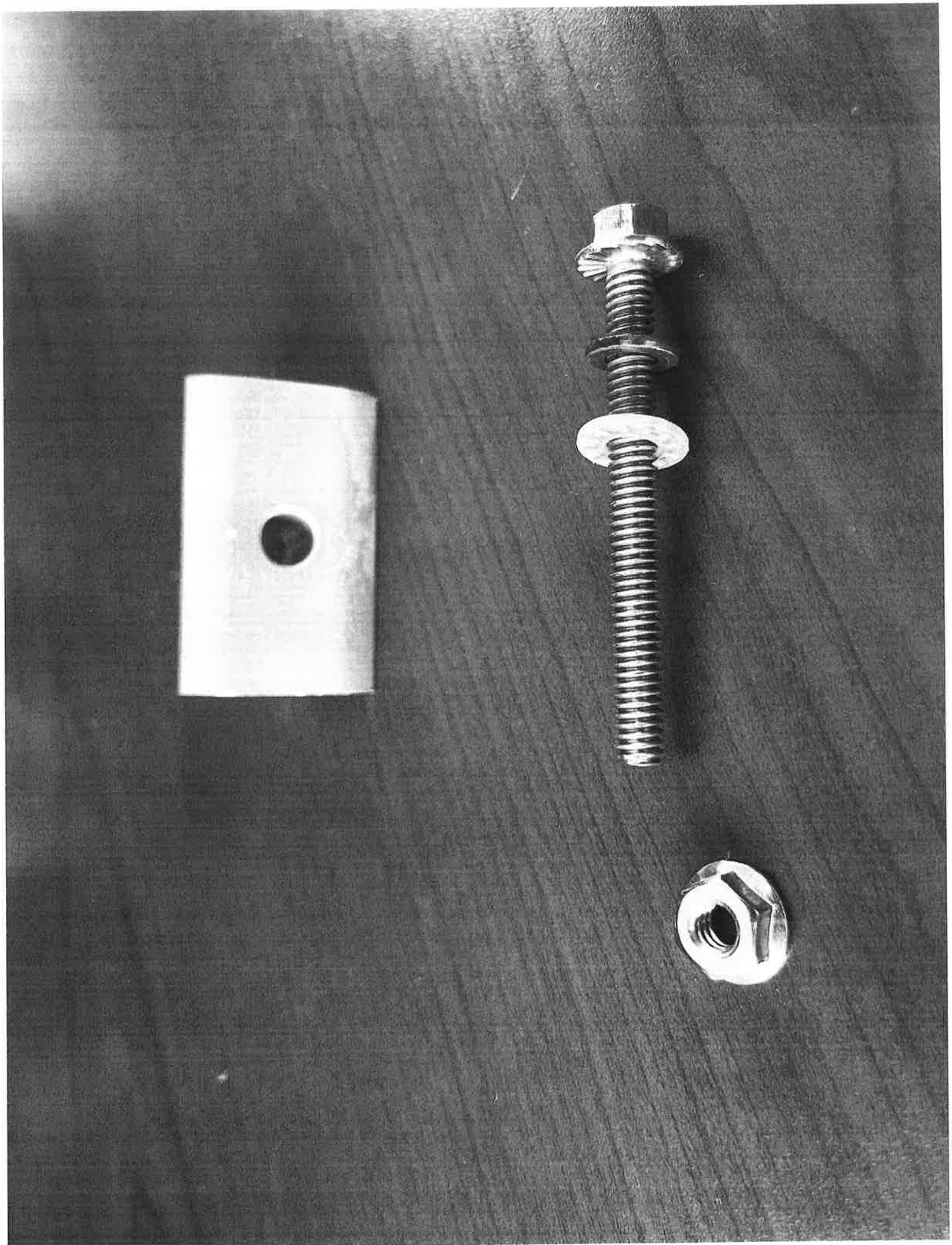
Very truly yours,

Merton Bunker, PE.

Attachment #1

Hardware with an environmentally sealed washer.

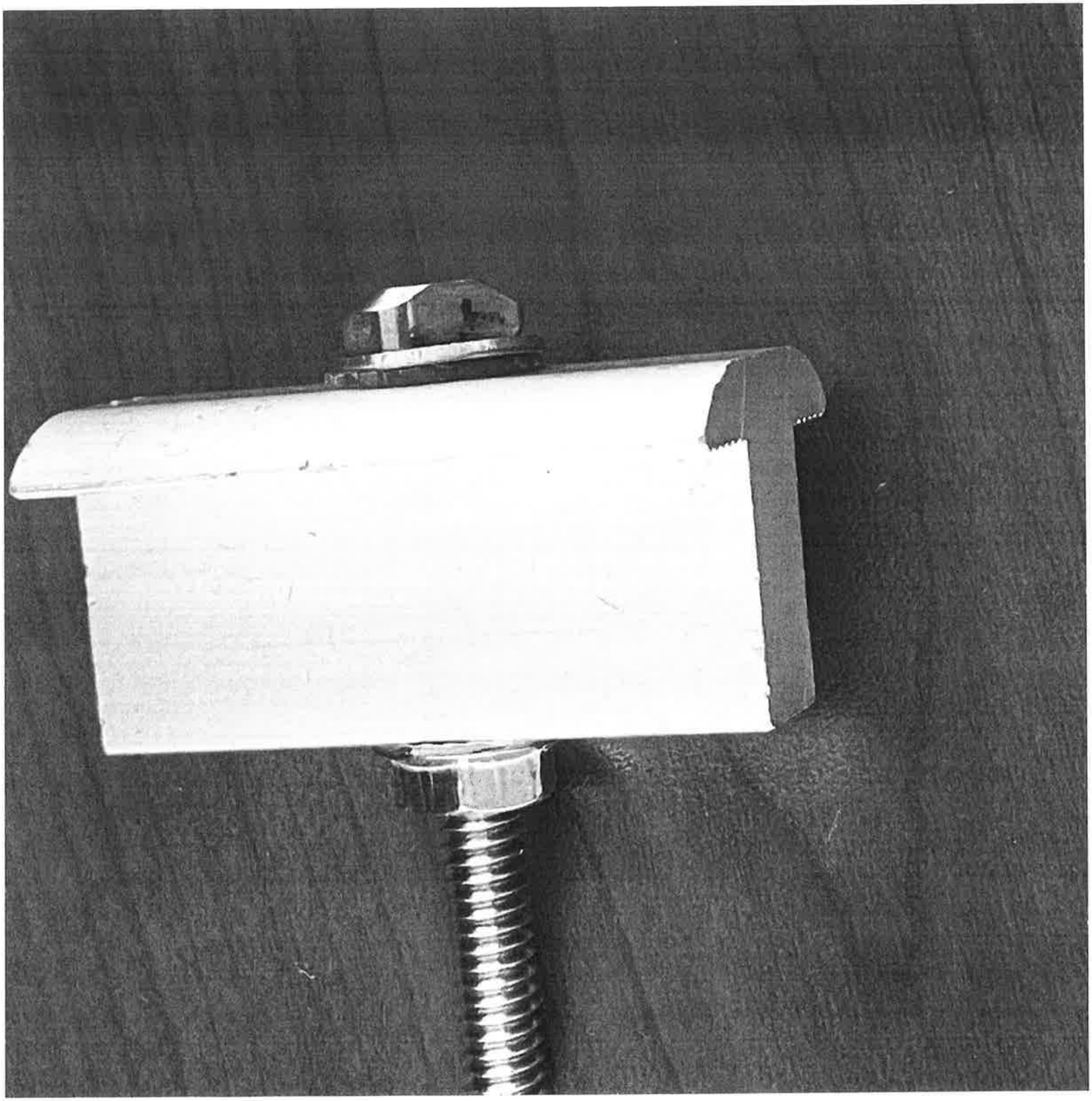
For Public Inputs 2411, 2412, 2413, 2414, 2415, 2492, and 2493.



Attachment #2

Hardware with an environmentally sealed washer.

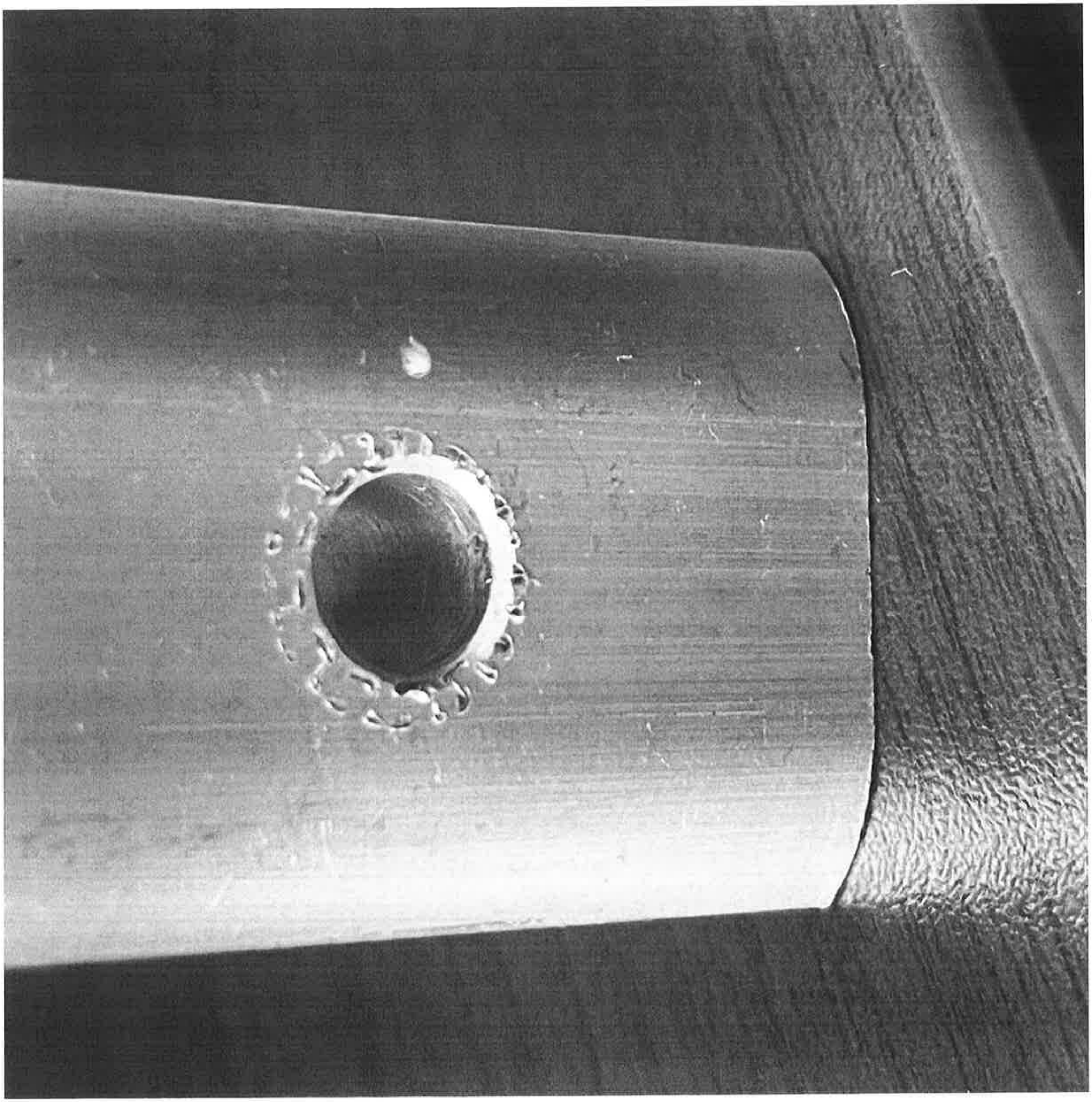
For Public Inputs 2411, 2412, 2413, 2414, 2415, 2492, and 2493.



Attachment #3

Aluminum surface showing contact by environmentally sealed washer.

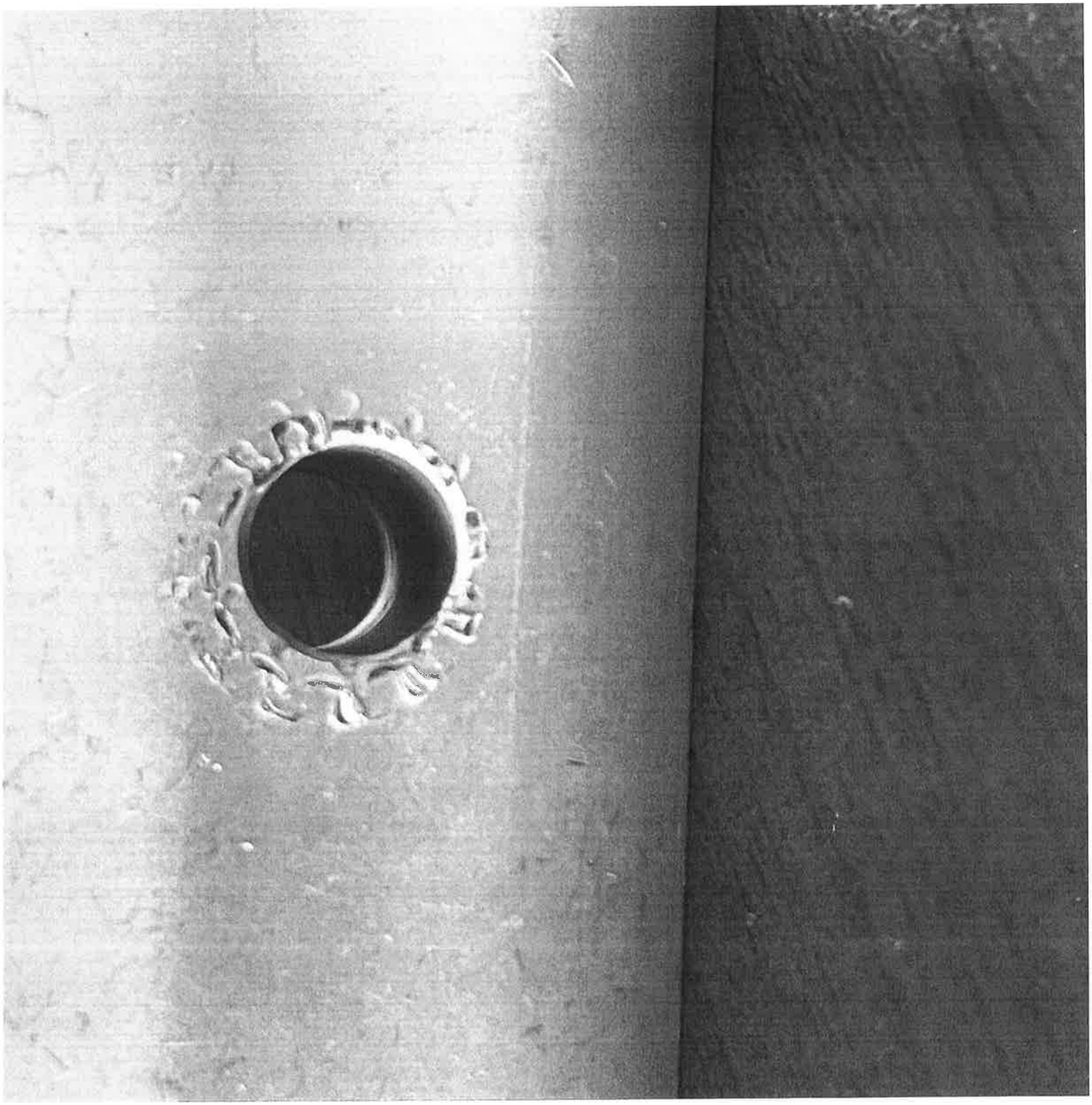
For Public Inputs 2411, 2412, 2413, 2414, 2415, 2492, and 2493.



Attachment #4

Aluminum surface showing contact by environmentally sealed washer.

For Public Inputs 2411, 2412, 2413, 2414, 2415, 2492, and 2493.



Public Input No. 1097-NFPA 70-2023 [New Section after 250.10]

TITLE OF NEW CONTENT

Reversible Connection to Grounding Electrode Accessibility

When the connection to a grounding electrode is made with a reversible method, the connection location shall remain readily accessible for inspection and testing. The connection shall be enclosed in a protective enclosure or vault so the connection location is also readily visible without the need to move equipment, vegetation, or earth.

Type your content here ...

Statement of Problem and Substantiation for Public Input

The grounding system shall dissipate fault current into the earth as quickly as possible to protect people and property, specifically sensitive electrical loads such as the internal workings of arc fault, ground fault, and combination arc fault/ground fault circuit breakers.. The performance of now-required Surge Protection Devices (SPDs) depends upon a low impedance path to earth. Therefore, when a non-reversible connection is made at the grounding electrode, that connection has to be readlily accessible for inspection and testing.

When I install SPDs on existing services I locate the connection to the grounding electrode and measure the resistance across the connection. If not an Ufer system and when buried in the earth, typically, the connection measures over one megohm. So, I reverse the connection, burnish the grounding electrode conductor and grounding electrode, treat the connection to mitigate corrosion, re-install the connection method (usually a tear drop or acorn clamp listed and labeled for direct bury, and re-test the connection to ensure an impedance of less than several ohms. When the connection location is less than twelve inches below grade I install a six inch diameter, covered vault so the connection remains accessible for re-inspection, re-test, and maintenance. This latter step is not always possible when the area has been graded post service initial installaton and is deeper than twelve inches. The connection will agan become severely ohmic over time, thus unreliable, thus, perhaps, making the utility neutral the fault current path.

I recently installed two vaults on a service replacement project and was praised by my local inspector and the electrical cooperative. The vaults I use are used for irrigation control valve access and have green lids. They're about $6.00 each. They're strong and the green lids are easily removed. My connection is immediately below the lid and, therefore, easily accessed for inspection, test, and, if needed, maintenance.

I'll leave it to the CMP's discretion as to whether a new section is needed and to where this proposed requirement should be placed in Article 250. It is my suggestion to place it close to the beginning of Article 250 so that it's interpreted as a requirement for all pertinent grounding systems.

Submitter Information Verification

Submitter Full Name:	Steve Sappington
Organization:	Electrical Safety Professionals, LLC
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Jun 16 08:57:33 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: Buried or encased connections to electrodes, whether reversible or not, are not required to be accessible in accordance with 250.68(A) Exception No. 1.

Public Input No. 3766-NFPA 70-2023 [Section No. 250.21]

250.21 Alternating-Current Systems of 50 Volts to ~~1000 Volts~~ 15,000 Volts Not Required to Be Grounded.

(A) General.

The following ac systems of 50 volts to

~~1000 volts~~

15000 volts shall be permitted to be grounded but shall not be required to be grounded:

(1) Electrical systems used exclusively to supply industrial electric furnaces used for applications such as melting, refining, or tempering

(2) Separately derived systems used exclusively for rectifiers that supply only adjustable-speed industrial drives

(3) Separately derived systems supplied by transformers that have a primary voltage rating of 1000 volts or less if all the following conditions are met:

  (4) The system is used exclusively for control circuits.

  (5) The conditions of maintenance and supervision ensure that only qualified persons service the installation.

  (6) Continuity of control power is required.

(7) Other systems that are not required to be grounded in accordance with 250.20(B)

(B) Ground Detectors.

Ground detectors shall be installed in accordance with the following:

(1) Ungrounded ac systems as permitted in 250.21(A) (1) through (A)(4) operating at not less than 120 volts and at

~~1000 volts~~

(1) 15000 volts or less shall have ground detectors installed on the system.

(2) The ground detection sensing equipment shall be connected as close as practicable to where the system receives its supply.

(C) Marking.

Ungrounded systems shall be legibly marked "Caution: Ungrounded System Operating — _____ Volts Between phase Conductors" at the source or first disconnecting means of the system. The marking shall be of sufficient durability to withstand the environment involved.

Additional Proposed Changes

File Name	Description	Approved
.1693943350515	250.21(b)1 proposed change	

Statement of Problem and Substantiation for Public Input

I have been actively involved in the Mining, and quarry industry, there are many Ungrounded delta systems that exist, with no code section to cover the requirements of "grounded Phase detection" above 1000 volts. many of these systems involve large power systems, and rely on case by case situations to determine how to handle ungrounded systems. as an inspector on Mine sites, we do NOT have a clear code section, or regulation to write a citation when we come upon these systems with NO ground detection at all because of the system voltage. I have no code section to reference to the validity of this system having ground detection.

Submitter Information Verification

Submitter Full Name:	David Fannick
Organization:	David W. Fannick Electrical Sa
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Sep 05 15:45:11 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Adequate substantiation has not been provided for the proposed requirement. The requirements for grounding and bonding AC systems for over 1000 volts are in Part X of Article 250.

Public Input No. 3183-NFPA 70-2023 [New Section after 250.21(B)]

TITLE OF NEW CONTENT

Type your content here ...250.22 Ungrounded Systems

(A) Ground Detectors. (use existing 250.21 (B) language.)

(B) Marking. (use existing 250.21 (C) language.)

Statement of Problem and Substantiation for Public Input

250.21 states what systems may or may not be grounded. Looking for requirements for ungrounded systems in a section that addresses potentially grounded systems is not an obvious place for a new or casual code user to look. Creating a new section, 250.22, for the requirements for ungrounded systems will make it easier to identify what needs to be done when a system is not grounded.

Submitter Information Verification

Submitter Full Name:	Beau Burton
Organization:	Metropolitan Detroit Electrical Industry Training Center
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 30 09:11:32 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed requirement is redundant with 250.21 and not in compliance with the NEC Style Manual Section 4.1.1.

Public Input No. 3190-NFPA 70-2023 [Section No. 250.21(C)]

(C) Marking.

Ungrounded systems shall be legibly marked “Caution: Ungrounded System Operating — ______Volts Between Conductors” at the source or first disconnecting means of the system. ~~The marking shall be of sufficient durability to withstand the environment involved.~~

Statement of Problem and Substantiation for Public Input

The deleted language is already required by 110.21 (B) (3), it is unnecessary.

Submitter Information Verification

Submitter Full Name:	Beau Burton
Organization:	Metropolitan Detroit Electrical Industry Training Center
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 30 10:08:58 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8264-NFPA 70-2024

Statement: The redundant language is removed in accordance with the NEC Style Manual Section 4.1.1 as the marking requirements for an ungrounded system are required to comply with 110.21(B)(1).

Public Input No. 423-NFPA 70-2023 [Section No. 250.24(A)(1)]

(1) General.

The grounding electrode conductor connection shall be made at any accessible point from the load end of the overhead service conductors, ~~service drop~~ utility drop , underground service conductors, or ~~service lateral~~ utility lateral to the terminal or bus to which the grounded service conductor is connected at the service disconnecting means.

> Informational Note: See Article 100 for definitions of *Service Conductors, Overhead; Service Conductors, Underground;* ~~*Service Drop*~~ *utility Drop* ; and ~~*Service Lateral*~~ utility *Lateral* .

Statement of Problem and Substantiation for Public Input

This PI is associated with several other PIs to recommend a global change from “service drop” to “utility drop” and from “service lateral” to “utility lateral.” “Service drop” appears 23 times in the Code and “service lateral” appears 15 times. There are 11 definitions that begin with the word ‘service.’ Of these, 9 are customer owned and only “service drop” and “service lateral” are utility owned and, therefore, outside the scope of the Code. “service drops” and “service laterals” are not service conductors as they do not fit the definition. Confining the word “service” to only those items that are customer owned would clear up much confusion on this topic. Appendix A shows UL 523 as having the title “telephone service drop wire” and the UL standard does, in fact, have that title. However, the text of UL 523 defines this wire as customer owned and Article 805 refers to this wire as a “drop wire.”

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 411-NFPA 70-2023 [Section No. 90.2(D)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 412-NFPA 70-2023 [Definition: Service Drop.]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 413-NFPA 70-2023 [Definition: Service-Entrance Conductors.]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 414-NFPA 70-2023 [Definition: Distribution Point (Center Yard Pole) (Meter Po...]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 415-NFPA 70-2023 [Definition: Service Lateral.]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 416-NFPA 70-2023 [Section No. 800.44(A)(4)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 417-NFPA 70-2023 [Section No. 700.12(F)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 418-NFPA 70-2023 [Section No. 701.12(F)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 419-NFPA 70-2023 [Section No. 770.44(A)(4)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 420-NFPA 70-2023 [Section No. 770.44(B)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 421-NFPA 70-2023 [Section No. 230.24(A)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'

Public Input No. 422-NFPA 70-2023 [Section No. 230.40]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 424-NFPA 70-2023 [Section No. 250.24(F)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 425-NFPA 70-2023 [Section No. 250.64(D)(1)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 426-NFPA 70-2023 [Section No. 250.66 [Excluding any Sub-Sections]]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 411-NFPA 70-2023 [Section No. 90.2(D)]	
Public Input No. 412-NFPA 70-2023 [Definition: Service Drop.]	
Public Input No. 413-NFPA 70-2023 [Definition: Service-Entrance Conductors.]	
Public Input No. 414-NFPA 70-2023 [Definition: Distribution Point (Center Yard Pole) (Meter Po...]	
Public Input No. 415-NFPA 70-2023 [Definition: Service Lateral.]	
Public Input No. 416-NFPA 70-2023 [Section No. 800.44(A)(4)]	
Public Input No. 417-NFPA 70-2023 [Section No. 700.12(F)]	
Public Input No. 418-NFPA 70-2023 [Section No. 701.12(F)]	
Public Input No. 419-NFPA 70-2023 [Section No. 770.44(A)(4)]	
Public Input No. 420-NFPA 70-2023 [Section No. 770.44(B)]	
Public Input No. 421-NFPA 70-2023 [Section No. 230.24(A)]	
Public Input No. 422-NFPA 70-2023 [Section No. 230.40]	
Public Input No. 424-NFPA 70-2023 [Section No. 250.24(F)]	
Public Input No. 425-NFPA 70-2023 [Section No. 250.64(D)(1)]	
Public Input No. 426-NFPA 70-2023 [Section No. 250.66 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:
City:
State:
Zip:
Submittal Date: Sat Mar 04 17:01:01 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: The defined terms service drop and service lateral are under the purview of Code Making Panel 10 and cannot be altered by this panel.

Public Input No. 4530-NFPA 70-2023 [Section No. 250.24(A)(1)]

(1) General.

The grounding electrode conductor connection shall be made at any accessible point from the load end of the overhead service conductors, service drop, underground service conductors, or service lateral to the terminal or bus to which the grounded service conductor is connected at the service disconnecting means.

For meter socket enclosures located ahead of the main disconnect, all grounding electrode conductors routed through the meter socket enclosure shall be insulated.

Informational Note: See Article 100 for definitions of *Service Conductors, Overhead; Service Conductors, Underground; Service Drop;* and *Service Lateral*.

Statement of Problem and Substantiation for Public Input

This proposed text will improve safety for electrical worker by decreasing chances of accidental contact between a bare ground conductor and energized conductors during activities such as: utility worker removing/installing cut across bars to bypass meter when meter blocks are damaged, during repair of meter enclosure, or other servicing of meter enclosure by utility worker.

Submitter Information Verification

Submitter Full Name: Jorge Arocha
Organization: Florida Power & Light
Street Address:
City:
State:
Zip:
Submittal Date: Fri Sep 08 08:53:31 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Sufficient information has not been provided for the panel to conclude that this proposed revision is needed to provide for a safer installation. Safety practices and policies need to be followed when working on energized equipment as addressed in NFPA 70E.

Public Input No. 3963-NFPA 70-2023 [Section No. 250.24(D)(2)]

(2) Conductors Connected in Parallel in Two or More Raceways or Cables.

If the ungrounded service-entrance conductors are connected in parallel in two or more raceways or cables, the grounded conductors shall also be installed in each raceway or cable and shall be connected in parallel. The size of each grounded conductor(s) in each raceway or cable shall not be smaller than 1/0 AWG and shall be sized in accordance with 250.24(D)(2)(a) or (D)(2)(b) in accordance with 250.24(D)(1).

(a) Shall be based on the largest ungrounded conductor in each raceway or cable.

(b) Shall be based on the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable.

Informational Note No. 1 : See 310.10(G) for grounded conductors connected in parallel.

Informational Note No. 2: See Informative Annex D, example No. D14.

Statement of Problem and Substantiation for Public Input

Correlated PI for addition of an example in Informative Annex D

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3955-NFPA 70-2023 [New Definition after Definition: Example D13 Cable Tray Cal...]	

Submitter Information Verification

Submitter Full Name: Steven Worsley
Organization: NECA IBEW Electrical JATC
Street Address:
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Submittal Date: Wed Sep 06 11:25:24 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8265-NFPA 70-2024

Statement: The informational note is added to assist the Code user with locating the new example in Annex D, No. D14 for sizing grounded conductors.

Public Input No. 424-NFPA 70-2023 [Section No. 250.24(F)]

(F) Ungrounded System Grounding Connections.

A premises wiring system that is supplied by an ac service that is ungrounded shall have, at each service, a grounding electrode conductor connected to the grounding electrode(s) required by Part III of this article. The grounding electrode conductor shall be connected to a metal enclosure of the service conductors at any accessible point from the load end of the overhead service conductors, ~~service drop~~ utility drop , underground service conductors, or ~~service lateral~~ utility lateral to the service disconnecting means.

Statement of Problem and Substantiation for Public Input

This PI is associated with several other PIs to recommend a global change from “service drop” to “utility drop” and from “service lateral” to “utility lateral.” “Service drop” appears 23 times in the Code and “service lateral” appears 15 times. There are 11 definitions that begin with the word ‘service.’ Of these, 9 are customer owned and only “service drop” and “service lateral” are utility owned and, therefore, outside the scope of the Code. “service drops” and “service laterals” are not service conductors as they do not fit the definition. Confining the word “service” to only those items that are customer owned would clear up much confusion on this topic. Appendix A shows UL 523 as having the title “telephone service drop wire” and the UL standard does, in fact, have that title. However, the text of UL 523 defines this wire as customer owned and Article 805 refers to this wire as a “drop wire.”

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 411-NFPA 70-2023 [Section No. 90.2(D)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 412-NFPA 70-2023 [Definition: Service Drop.]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 413-NFPA 70-2023 [Definition: Service-Entrance Conductors.]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 414-NFPA 70-2023 [Definition: Distribution Point (Center Yard Pole) (Meter Po...]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 415-NFPA 70-2023 [Definition: Service Lateral.]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 416-NFPA 70-2023 [Section No. 800.44(A)(4)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 417-NFPA 70-2023 [Section No. 700.12(F)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 418-NFPA 70-2023 [Section No. 701.12(F)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 419-NFPA 70-2023 [Section No. 770.44(A)(4)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 420-NFPA 70-2023 [Section No. 770.44(B)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 421-NFPA 70-2023 [Section No. 230.24(A)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 422-NFPA 70-2023 [Section No.	Global change from 'service drop' to 'utility

230.40]	drop' and 'service lateral' to 'utility lateral'
Public Input No. 423-NFPA 70-2023 [Section No. 250.24(A)(1)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 425-NFPA 70-2023 [Section No. 250.64(D)(1)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 426-NFPA 70-2023 [Section No. 250.66 [Excluding any Sub-Sections]]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 411-NFPA 70-2023 [Section No. 90.2(D)]	
Public Input No. 412-NFPA 70-2023 [Definition: Service Drop.]	
Public Input No. 413-NFPA 70-2023 [Definition: Service-Entrance Conductors.]	
Public Input No. 414-NFPA 70-2023 [Definition: Distribution Point (Center Yard Pole) (Meter Po...]	
Public Input No. 415-NFPA 70-2023 [Definition: Service Lateral.]	
Public Input No. 416-NFPA 70-2023 [Section No. 800.44(A)(4)]	
Public Input No. 417-NFPA 70-2023 [Section No. 700.12(F)]	
Public Input No. 418-NFPA 70-2023 [Section No. 701.12(F)]	
Public Input No. 419-NFPA 70-2023 [Section No. 770.44(A)(4)]	
Public Input No. 420-NFPA 70-2023 [Section No. 770.44(B)]	
Public Input No. 421-NFPA 70-2023 [Section No. 230.24(A)]	
Public Input No. 422-NFPA 70-2023 [Section No. 230.40]	
Public Input No. 423-NFPA 70-2023 [Section No. 250.24(A)(1)]	
Public Input No. 425-NFPA 70-2023 [Section No. 250.64(D)(1)]	
Public Input No. 426-NFPA 70-2023 [Section No. 250.66 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: Eric Stromberg
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Submittal Date: Sat Mar 04 17:03:49 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: The defined terms service drop and service lateral are under the purview of Code Making Panel 10 and cannot be altered by this panel.

Public Input No. 3680-NFPA 70-2023 [Section No. 250.25(A)]

(A) Grounded System.

If the utility supply system is grounded, the grounding of systems permitted to be connected on the supply side of the service disconnect and are installed in one or more separate enclosures from the service equipment enclosure shall comply with the requirements of 250.24(A) through (~~D~~ E).

Statement of Problem and Substantiation for Public Input

I believe this was an oversight that resulted from a renumbering of Section 250.24 in the 2023 NEC.

In 2020, load-side grounding connections was Section 250.24(A)(5); it was renumbered to 250.24(B) in 2023, with no other changes to the text. 2020 FR 8232 states in the substantiation “Subsection 250.24(A)(5) is relocated to 250.24(B) as it is not a permitted connection of the grounded conductor and should not be included in the list of 250.24(A).”

This resulted in 2023 Section 250.24 having parts (A) through (F), whereas in 2020 it only had parts (A) through (E). There appear to be no other major changes that would indicate that complying with 2023 Section 250.24(E) is no longer required for a grounded system.

2020 Section 250.25(A) required compliance with 250.24(A) - (D), with part (D) providing much needed clarity on the requirement for installing a grounding electrode conductor. This question - is a grounding electrode required? - regularly comes up in regards to PV systems connected on the supply-side of the service disconnect.

2023 Section 250.25(A) remained the same, still referring to 250.24(A) - (D). However, due to the renumbering of 250.24 the requirement for the grounding electrode conductor, now in the renumbered 250.24(E) in 2023, was no longer referred to.

Submitter Information Verification

Submitter Full Name: Brian Mehalic
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Affiliation: Solar Energy International
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City:
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Submittal Date: Tue Sep 05 13:46:02 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8272-NFPA 70-2024

Statement: The charging text is updated to 250.24(A) through (E) due to the change from 250.24(A)(5) to 250.24(B) during the 2023 NEC cycle.

Public Input No. 893-NFPA 70-2023 [Section No. 250.25(A)]

(A) Grounded System.

If the utility supply system is grounded, the grounding of systems permitted to be connected on the supply side of the service disconnect and are installed in one or more separate enclosures from the service equipment enclosure shall comply with the requirements of 250.24(A) through (~~D~~ E).

Statement of Problem and Substantiation for Public Input

Relocation of load-side grounding connections from 250.24(A)(5) to (B), also consequently moved previous sub-division (D) to (F). Without the proposed change to the text, the industry is left with no guidance in regards to the GEC connections in separate enclosures for those systems permitted on the supply side of the service disconnect.

Submitter Information Verification

Submitter Full Name:	Chris Papp
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Zip:	
Submittal Date:	Thu May 25 13:11:58 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution:	FR-8272-NFPA 70-2024
Statement:	The charging text is updated to 250.24(A) through (E) due to the change from 250.24(A)(5) to 250.24(B) during the 2023 NEC cycle.

Public Input No. 3102-NFPA 70-2023 [Section No. 250.28(B)]

(B) Construction.

If a main bonding jumper or a system bonding jumper is a screw only, the screw shall be identified with a green finish that shall be visible with the screw installed. If the main bonding jumper or system bonding jumper is of the wire-type, it shall be identified in accordance with 250.119.

Statement of Problem and Substantiation for Public Input

Adding the reference to 250.119 will require the system and main bonding jumpers of the wire-type to have green insulation, green covering, or be bare. This will add clarity to Code users to identify the system and main bonding jumper of the wire type just like an equipment grounding conductor. All these conductors are part of the effective ground-fault current path and should have consistency with the methods of identification.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
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City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 11:52:13 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: There is no field evidence that this change is necessary and it is not currently prohibited. They are readily identifiable by their use in the field.

Public Input No. 154-NFPA 70-2023 [Section No. 250.30(A)(5)]

(5) Grounding Electrode Conductor, Single Separately Derived System.

A grounding electrode conductor for a single separately derived system shall be sized in accordance with 250.66 for the derived ungrounded conductors. It shall be used to connect the grounded conductor of the derived system to the grounding electrode in accordance with 250.30(A)(4), or as permitted in 250.68(C)(1) and (C)(2). This connection shall be made at the same point on the separately derived system where the system bonding jumper is connected.

(a) Singe Separately Derived System installed in the same building or structure as service equipment

Where a transformer type separately derived system is installed in the same building or structure as the service equipment for that building, the transformer feeder equipment grounding conductor shall be permitted to be used as the grounding electrode conductor for the separately derived system in accordance with all of the following:

(1) The feeder overcurrent protective device is installed in or adjacent to the service equipment enclosure.

(2) The feeder voltage system is the highest voltage system in the building or structure

(3) The feeder is installed completely within the building or structure

(4) The feeder equipment grounding conductor is of the wire type and installed in accordance with 250.122.

(5) The conductor that is serving as both the grounding electrode conductor and the equipment grounding conductor for the separately derived system shall not be required to be sized in accordance with 250.66 and shall not be required to be installed in accordance with 250.64.

(6) The provisions of 250.118(B)(1) exception shall not apply.

Informational Note: See 250.104(D) for bonding requirements.

Exception No. 1: If the system bonding jumper specified in 250.30(A)(1) is a wire or busbar, it shall be permitted to connect the grounding electrode conductor to the equipment grounding terminal, bar, or bus if the equipment grounding terminal, bar, or bus is of sufficient size for the separately derived system.

Exception No. 2: If the source of a separately derived system is located within equipment listed and identified as suitable for use as service equipment, the grounding electrode conductor from the service or feeder equipment to the grounding electrode shall be permitted as the grounding electrode conductor for the separately derived system, if the grounding electrode conductor is of sufficient size for the separately derived system. If the equipment grounding bus internal to the equipment is not smaller than the required grounding electrode conductor for the separately derived system, the grounding electrode connection for the separately derived system shall be permitted to be made to the bus.

Exception No. 3: A grounding electrode conductor shall not be required for a system that supplies a Class 1, Class 2, or Class 3 circuit and is derived from a transformer rated not more than 1000 volt-amperes, provided the grounded conductor is bonded to the transformer frame or enclosure by a jumper sized in accordance with 250.30(A)(1), Exception No. 3, and the transformer frame or enclosure is grounded by one of the means specified in 250.134.

Statement of Problem and Substantiation for Public Input

Under the conditions described in this Public Input, there is no technical reason to require a grounding electrode conductor for the SDS.

250.4 tells us why we ground systems and the feeder EGC is suitable to accomplish everything that is required in that section.
1) there is no need to provide lighting protection within the building itself. All of the conductors and equipment are in the same building under this PI.
2) the only possible contact with higher voltage systems is the voltage system that supplies the transformer as this PI says the feeder voltage must be the highest voltage in the building or structure. The feeder EGC is sized to clear such faults on the primary side of the SDS.
3)Stabilization of the voltage of the SDS does not result in any appreciable current flow one the conductor that provides the voltage stabilization. The EGC sizing required by 250.122 is more that adequate to stabilize the voltage of the transformer secondary as measured to earth and conductive objects that are connected to earth.
4) there is no technical reason that a grounding electrode conductor must be unspliced or connected using irreversible connections. The EGC is much more important for electrical safety than the GEC and it is permitted to be spliced.

There is just no technical reason to install a separate grounding electrode conductor for a transformer under the limited conditions of this PI. There will be no reduction of safety if this PI is accepted.

Submitter Information Verification

Submitter Full Name:	Don Ganiere
Organization:	self
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City:	
State:	
Zip:	
Submittal Date:	Thu Jan 12 19:59:16 EST 2023
Committee:	NEC-P05

Committee Statement

Resolution: This is redundant with 250.118(B)(1) Exception, which is not in compliance with the NEC Style Manual Section 4.1.1.

Public Input No. 2386-NFPA 70-2023 [Section No. 250.30(A)(5)]

(5) Grounding Electrode Conductor, Single Separately Derived System.

A grounding electrode conductor for a single separately derived system shall be sized in accordance with 250.66 for the derived ungrounded conductors. It shall be used to connect the grounded conductor of the derived system to the grounding electrode in accordance with 250.30(A)(4), or as permitted in 250.68(C)(1) and (C)(2). This connection shall be made at the same point on the separately derived system where the system bonding jumper is connected.

Exception No. 1: If the system bonding jumper specified in 250.30(A)(1) is a wire or busbar, it shall be permitted to connect the grounding electrode conductor to the equipment grounding terminal, bar, or bus if the equipment grounding terminal, bar, or bus is of sufficient size for the separately derived system.

Exception No. 2: If the source of a separately derived system is located within equipment listed and identified as suitable for use as service equipment, the grounding electrode conductor from the service or feeder equipment to the grounding electrode shall be permitted as the grounding electrode conductor for the separately derived system, if the grounding electrode conductor is of sufficient size for the separately derived system. If the equipment grounding bus internal to the equipment is not smaller than the required grounding electrode conductor for the separately derived system, the grounding electrode connection for the separately derived system shall be permitted to be made to the bus.

Exception No. 3: A grounding electrode conductor shall not be required for a system that supplies a Class 1, Class 2, or Class 3 circuit and is derived from a transformer rated not more than 1000 volt-amperes, provided the grounded conductor is bonded to the transformer frame or enclosure by a jumper sized in accordance with 250.30(A)(1), Exception No. 3, and the transformer frame or enclosure is grounded by one of the means specified in 250.134.

Exception No. 4: The wire-type equipment grounding conductor shall be permitted to serve as both the equipment grounding conductors and grounding electrode conductor in accordance with 250.118(B)(1) Exception.

Statement of Problem and Substantiation for Public Input

When the separately derived systems are in a building that is supplied with a service, The system bonding jumper grounds the secondary winding of the system to the equipment grounding conductor, which is connected to the grounding electrode system at the service.

Submitter Information Verification

Submitter Full Name:	Mike Holt
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City:	
State:	
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Submittal Date:	Wed Aug 16 15:48:56 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: This is redundant with 250.118(B)(1) Exception, which is not in compliance with the NEC Style Manual Section 4.1.1.

Public Input No. 1117-NFPA 70-2023 [Section No. 250.30(A)(6)]

(6) Grounding Electrode Conductor, Multiple Separately Derived Systems.

A common grounding electrode conductor for multiple separately derived systems shall be permitted. If installed, the common grounding electrode conductor shall be used to connect the grounded conductor of each separately derived system to the grounding electrode as specified in 250.30(A)(4). A grounding electrode conductor tap shall then be installed from each separately derived system to the common grounding electrode conductor. Each tap conductor shall connect the grounded conductor of the separately derived system to the common grounding electrode conductor. This connection shall be made at the same point on the separately derived system where the system bonding jumper is connected.

Exception No. 1: If the system bonding jumper specified in 250.30(A)(1) is a wire or busbar, it shall be permitted to connect the grounding electrode conductor tap to the equipment grounding terminal, bar, or bus, provided the equipment grounding terminal, bar, or bus is of sufficient size for the separately derived system.

Exception No. 2: A grounding electrode conductor shall not be required for a system that supplies a Class 1, Class 2, or Class 3 circuit and is derived from a transformer rated not more than 1000 volt-amperes, provided the system grounded conductor is bonded to the transformer frame or enclosure by a jumper sized in accordance with 250.30(A)(1), Exception No. 3, and the transformer frame or enclosure is grounded by one of the means specified in 250.134.

Exception No. 3: If the source of a separately derived system is located within equipment listed and identified as suitable for use as service equipment, the grounding electrode conductor from the service or feeder equipment to the grounding electrode shall be permitted as the grounding electrode conductor for the separately derived system, if the grounding electrode conductor is of sufficient size for the separately derived system. If the equipment grounding bus internal to the equipment is not smaller than the required grounding electrode conductor for the separately derived system, the grounding electrode connection for the separately derived system shall be permitted to be made to the bus.

(a) *Common Grounding Electrode Conductor.* The common grounding electrode conductor shall be permitted to be one of the following:

(2) A conductor of the wire type not smaller than 3/0 AWG copper -clad steel or copper or 250 kcmil aluminum or copper-clad aluminum

(3) A metal water pipe in accordance with 250.68(C)(1)

(4) The metal structural frame of the building or structure in accordance with 250.68(C)(2) or is connected to the grounding electrode system by a conductor not smaller than 3/0 AWG copper -clad steel or copper or 250 kcmil aluminum or copper-clad aluminum

(e) *Tap Conductor Size.* Each tap conductor shall be sized in accordance with 250.66 based on the derived ungrounded conductors of the separately derived system it serves.

Exception to (a)(1) and (b): If the only electrodes that are present are of the types in 250.66(A), (B), or (C), the size of the common grounding electrode conductor shall not be required to be larger than the largest conductor required by 250.66(A), (B), or (C) for the type of electrode that is present.

(f) *Connections.* All tap connections to the common grounding electrode conductor shall be made at an accessible location by one of the following methods:

(7) A connector listed as grounding and bonding equipment.

(8) Listed connections to aluminum or copper busbars not smaller than 6 mm thick × 50 mm wide (1/4 in. thick × 2 in. wide) and of a length to accommodate the number of terminations necessary for the installation. If aluminum busbars are used, the installation shall also be in accordance with 250.64(A) .

(9) The exothermic welding process.

Tap conductors shall be connected to the common grounding electrode conductor in such a manner that the common grounding electrode conductor remains without a splice or joint.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name: Peter Graser
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Affiliation: American Bimetallic Association
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Submittal Date: Sat Jun 17 09:21:38 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 2387-NFPA 70-2023 [Section No. 250.30(A)(6)]

(6) Grounding Electrode Conductor, Multiple Separately Derived Systems.

A common grounding electrode conductor for multiple separately derived systems shall be permitted. If installed, the common grounding electrode conductor shall be used to connect the grounded conductor of each separately derived system to the grounding electrode as specified in 250.30(A)(4). A grounding electrode conductor tap shall then be installed from each separately derived system to the common grounding electrode conductor. Each tap conductor shall connect the grounded conductor of the separately derived system to the common grounding electrode conductor. This connection shall be made at the same point on the separately derived system where the system bonding jumper is connected.

Exception No. 1: If the system bonding jumper specified in 250.30(A)(1) is a wire or busbar, it shall be permitted to connect the grounding electrode conductor tap to the equipment grounding terminal, bar, or bus, provided the equipment grounding terminal, bar, or bus is of sufficient size for the separately derived system.

Exception No. 2: A grounding electrode conductor shall not be required for a system that supplies a Class 1, Class 2, or Class 3 circuit and is derived from a transformer rated not more than 1000 volt-amperes, provided the system grounded conductor is bonded to the transformer frame or enclosure by a jumper sized in accordance with 250.30(A)(1), Exception No. 3, and the transformer frame or enclosure is grounded by one of the means specified in 250.134.

Exception No. 3: If the source of a separately derived system is located within equipment listed and identified as suitable for use as service equipment, the grounding electrode conductor from the service or feeder equipment to the grounding electrode shall be permitted as the grounding electrode conductor for the separately derived system, if the grounding electrode conductor is of sufficient size for the separately derived system. If the equipment grounding bus internal to the equipment is not smaller than the required grounding electrode conductor for the separately derived system, the grounding electrode connection for the separately derived system shall be permitted to be made to the bus.

Exception No. 4: The wire-type equipment grounding conductor shall be permitted to serve as both the equipment grounding conductors and grounding electrode conductor in accordance with 250.118(B)(1) Exception.

(a) *Common Grounding Electrode Conductor.* The common grounding electrode conductor shall be permitted to be one of the following:

(2) A conductor of the wire type not smaller than 3/0 AWG copper or 250 kcmil aluminum

(3) A metal water pipe in accordance with 250.68(C)(1)

(4) The metal structural frame of the building or structure in accordance with 250.68(C)(2) or is connected to the grounding electrode system by a conductor not smaller than 3/0 AWG copper or 250 kcmil aluminum

(e) *Tap Conductor Size.* Each tap conductor shall be sized in accordance with 250.66 based on the derived ungrounded conductors of the separately derived system it serves.

Exception to (a)(1) and (b): If the only electrodes that are present are of the types in 250.66(A), (B), or (C), the size of the common grounding electrode conductor shall not be required to be larger than the largest conductor required by 250.66(A), (B), or (C) for the type of electrode that is present.

(f) *Connections.* All tap connections to the common grounding electrode conductor shall be made at an accessible location by one of the following methods:

(7) A connector listed as grounding and bonding equipment.

(8) Listed connections to aluminum or copper busbars not smaller than 6 mm thick × 50 mm wide (1⁄4 in. thick × 2 in. wide) and of a length to accommodate the number of terminations necessary for the installation. If aluminum busbars are used, the installation shall also be in accordance with 250.64(A) .

(9) The exothermic welding process.

Tap conductors shall be connected to the common grounding electrode conductor in such a manner that the common grounding electrode conductor remains without a splice or joint.

Statement of Problem and Substantiation for Public Input

When the separately derived systems are in a building that is supplied with a service, The system bonding jumper grounds the secondary winding of the system to the equipment grounding conductor, which is connected to the grounding electrode system at the service.

Submitter Information Verification

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Submittal Date: Wed Aug 16 15:50:41 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: This is redundant with 250.118(B)(1) Exception, which is not in compliance with the NEC Style Manual Section 4.1.1.

Public Input No. 2649-NFPA 70-2023 [Section No. 250.32(A)]

(A) Grounding Electrode System and Grounding Electrode Conductor.

A building(s) or structure(s) supplied by a feeder(s) or branch circuit(s) shall have a grounding electrode system and grounding electrode conductor installed in accordance with ~~Part III of~~ Article 250 , Part III .

Exception: A grounding electrode system and grounding electrode conductor shall not be required if only a single branch circuit, including a multiwire branch circuit, supplies the building or structure and the branch circuit includes an equipment grounding conductor for grounding the normally non-current-carrying metal parts of equipment.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name:	David Williams
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Submittal Date:	Wed Aug 23 21:47:27 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution:	FR-8653-NFPA 70-2024
Statement:	The panel has revised the text to comply with the NEC Style Manual, 2023 Section 4.1.4 when referencing specific parts of an article.

Public Input No. 1556-NFPA 70-2023 [Section No. 250.32(B)(1)]

(1) Supplied by a Feeder or Branch Circuit.

An equipment grounding conductor, as described in 250.118, shall be run with the supply conductors and be connected to the building or structure disconnecting means and to the grounding electrode(s). The equipment grounding conductor shall be used for grounding or bonding of equipment, structures, or frames required to be grounded or bonded. The equipment grounding conductor shall be sized in accordance with 250.122. Any installed grounded conductor shall not be connected to the equipment grounding conductor or to the grounding electrode(s).

Exception No. 1: For installations made in compliance with previous editions of this Code that permitted such connection, the grounded conductor run with the supply to the building or structure shall be permitted to serve as the ground-fault return path

~~if~~

, by use of a required main bonding jumper located in the building or structure's main disconnecting means enclosure, if all of the following requirements continue to be met:

(1) An equipment grounding conductor is not run with the supply to the building or structure.

(2) There are no continuous metallic paths bonded to the grounding system in each building or structure involved.

(3) Ground-fault protection of equipment has not been installed on the supply side of the feeder(s).

If the grounded conductor is used for grounding in accordance with the provision of this exception, the size of the grounded conductor shall not be smaller than the larger of either of the following:

(1) The calculated neutral load in accordance with 220.61

(2) The minimum equipment grounding conductor sized in accordance with 250.122

Exception No. 2: If system bonding jumpers are installed in accordance with 250.30(A)(1), Exception No. 2, the feeder grounded circuit conductor at the building or structure served shall be connected to the equipment grounding conductors, grounding electrode conductor, and the enclosure for the first disconnecting means.

Statement of Problem and Substantiation for Public Input

It’s critical the main bonding jumper gets installed at the fed end of an existing feeder that is minus the equipment grounding conductor. Without it, the only path for a ground fault current to travel is through the grounding electrode systems at each end of the feeder and the high impedance earth between the source end and the fed building or structure, making it delayed or impossible for an overcurrent protective device to open.

250.32B1 Exception No.1 does state that the grounded conductor shall be permitted to serve as the ground-fault return path and I believe it’s correct as currently written, being in the exception, but I was looking to make it clear that this main bonding jumper is not optional. This public input is an attempt to make it clear that the main bonding jumper at the fed end is mandatory.

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Affiliation:	self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Jul 25 14:06:10 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed language does not appear to be a technical change and does not add further clarity to the requirement.

Public Input No. 227-NFPA 70-2023 [Section No. 250.32(B)(1)]

(1) Supplied by a Feeder or Branch Circuit.

An equipment grounding conductor, as described in 250.118, shall be run with the supply conductors and be connected to the building or structure disconnecting means and to the grounding electrode ~~(s)~~ conductor . The equipment grounding conductor shall be used for grounding or bonding of equipment, structures, or frames required to be grounded or bonded. The equipment grounding conductor shall be sized in accordance with 250.122. Any installed grounded conductor shall not be connected to the equipment grounding conductor or to the grounding electrode(s).

Exception No. 1: For installations made in compliance with previous editions of this Code that permitted such connection, the grounded conductor run with the supply to the building or structure shall be permitted to serve as the ground-fault return path if all of the following requirements continue to be met:

1. *An equipment grounding conductor is not run with the supply to the building or structure.*
2. *There are no continuous metallic paths bonded to the grounding system in each building or structure involved.*
3. *Ground-fault protection of equipment has not been installed on the supply side of the feeder(s).*

If the grounded conductor is used for grounding in accordance with the provision of this exception, the size of the grounded conductor shall not be smaller than the larger of either of the following:

1. *The calculated neutral load in accordance with 220.61*
2. *The minimum equipment grounding conductor sized in accordance with 250.122*

Exception No. 2: If system bonding jumpers are installed in accordance with 250.30(A)(1), Exception No. 2, the feeder grounded circuit conductor at the building or structure served shall be connected to the equipment grounding conductors, grounding electrode conductor, and the enclosure for the first disconnecting means.

Statement of Problem and Substantiation for Public Input

This public input is one of three companion public inputs seeking to clarify the connection to the grounding electrode(s) at a building or structure supplied by a feeder or branch circuits. Although the traditional field practice is to connect the equipment grounding conductor (EGC) to the grounding electrode conductor (GEC), the literal wording of this section requires the EGC to be connected to the grounding electrode(s). Connecting the EGC to the grounding electrode would also conflict with 250.32(E) which requires the GEC to be sized in accordance with 250.66 whereas the EGC would be sized in accordance with 250.122. As an electrical inspector, I have seen cases where the current text has caused confusion resulting in noncompliant installations.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 228-NFPA 70-2023 [Section No. 250.32(C)(1)]	
Public Input No. 228-NFPA 70-2023 [Section No. 250.32(C)(1)]	
Public Input No. 229-NFPA 70-2023 [Section No. 250.32(D)]	

Submitter Information Verification

Submitter Full Name:	Mark Hilbert
Organization:	MR Hilbert Inspections & Training
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Jan 25 13:33:02 EST 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8285-NFPA 70-2024

Statement: The requirement is modified to clarify that the equipment grounding conductor terminates to the grounding electrode conductor.

The reference to 250.118 was corrected to refer to permitted equipment grounding conductors.

Public Input No. 4533-NFPA 70-2023 [Section No. 250.32(B)(1)]

(1) Supplied by a Feeder or Branch Circuit.

An equipment grounding conductor, as described in 250.118, shall be run with the supply conductors and be connected to the building or structure disconnecting means and to the grounding electrode(s). ~~The~~ Connection to the grounding electrode(s) shall be through bonding to the grounding electrode conductor. The equipment grounding conductor shall be used for grounding or bonding of equipment, structures, or frames required to be grounded or bonded. The equipment grounding conductor shall be sized in accordance with 250.122. Any installed grounded conductor shall not be connected to the equipment grounding conductor or to the grounding electrode(s).

Exception No. 1: For installations made in compliance with previous editions of this Code that permitted such connection, the grounded conductor run with the supply to the building or structure shall be permitted to serve as the ground-fault return path if all of the following requirements continue to be met:

(1) An equipment grounding conductor is not run with the supply to the building or structure.

(2) There are no continuous metallic paths bonded to the grounding system in each building or structure involved.

(3) Ground-fault protection of equipment has not been installed on the supply side of the feeder(s).

If the grounded conductor is used for grounding in accordance with the provision of this exception, the size of the grounded conductor shall not be smaller than the larger of either of the following:

(1) The calculated neutral load in accordance with 220.61

(2) The minimum equipment grounding conductor sized in accordance with 250.122

Exception No. 2: If system bonding jumpers are installed in accordance with 250.30(A)(1), Exception No. 2, the feeder grounded circuit conductor at the building or structure served shall be connected to the equipment grounding conductors, grounding electrode conductor, and the enclosure for the first disconnecting means.

Statement of Problem and Substantiation for Public Input

As written, the argument could be made that the equipment grounding conductor is to be connected directly to the grounding electrode, in apparent conflict with section 250.32(E), which describes how to size the grounding electrode conductor.

Submitter Information Verification

Submitter Full Name: Peter Noval Jr
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Fri Sep 08 09:13:12 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8285-NFPA 70-2024

Statement: The requirement is modified to clarify that the equipment grounding conductor terminates to the grounding electrode conductor.

The reference to 250.118 was corrected to refer to permitted equipment grounding conductors.

Public Input No. 228-NFPA 70-2023 [Section No. 250.32(C)(1)]

(1) Supplied by a Feeder or Branch Circuit.

An equipment grounding conductor, as described in 250.118, shall be installed with the supply conductors and be connected to the building or structure disconnecting means and to the grounding electrode ~~(s)~~ conductor . The grounding electrode(s) shall also be connected to the building or structure disconnecting means.

Statement of Problem and Substantiation for Public Input

This public input is one of three companion public inputs seeking to clarify the connection to the grounding electrode(s) at a building or structure supplied by a feeder or branch circuit. Although the traditional field practice is to connect the equipment grounding conductor (EGC) to the grounding electrode conductor (GEC), the literal wording of this section requires the EGC to be connected to the grounding electrode(s). Connecting the EGC to the grounding electrode would also conflict with 250.32(E) which requires the GEC to be sized in accordance with 250.66 whereas the EGC would be sized in accordance with 250.122.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 227-NFPA 70-2023 [Section No. 250.32(B)(1)]	
Public Input No. 227-NFPA 70-2023 [Section No. 250.32(B)(1)]	

Submitter Information Verification

Submitter Full Name:	Mark Hilbert
Organization:	MR Hilbert Inspections and Training
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Jan 25 16:04:32 EST 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8286-NFPA 70-2024

Statement: The requirement is modified to clarify that the equipment grounding conductor terminates to the grounding electrode conductor.

The reference to 250.118 was corrected to refer to permitted equipment grounding conductors.

Public Input No. 2069-NFPA 70-2023 [Section No. 250.32(D)]

(D) Disconnecting Means Located in Separate Building or Structure on the Same Premises.

If one or more disconnecting means supply one or more additional buildings or structures under single management, and where these disconnecting means are located remote from those buildings or structures in accordance with 225.31(B), Exception No. 1 and No. 2, 700.12(D)(4), 701.12(D)(3), or 702.12, all of the following conditions shall be met:

(1) The connection of the grounded conductor to the grounding electrode, to normally non-current-carrying metal parts of equipment, or to the equipment grounding conductor at a separate building or structure shall not be made.

(2) An equipment grounding conductor for grounding and bonding any normally non-current-carrying metal parts of equipment, interior metal piping systems, and building or structural metal frames is run with the circuit conductors to a separate building or structure and connected to existing grounding electrode(s) required in Part III of this article, or, if there are no existing electrodes, the grounding electrode(s) required in Part III of this article shall be installed if a separate building or structure is supplied by more than one branch circuit.

(3) The connection between the equipment grounding conductor and the grounding electrode at a separate building or structure shall be made in a junction box, enclosed panelboard, or similar enclosure located immediately inside or outside the separate building or structure.

Statement of Problem and Substantiation for Public Input

The term ‘panelboard’ and ‘enclosed panelboard’ are defined terms. Adding the word ‘enclosed panelboard’ makes the text technically correct. Note: The term ‘Enclosed Panelboard’ was added to NEC Article 100 during the 2023 Code cycle.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Aug 11 15:00:28 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8298-NFPA 70-2024

Statement: The requirement is revised to clarify that the connection of the equipment grounding conductor and the grounding electrode conductor is made inside of the panelboard enclosure.

Public Input No. 229-NFPA 70-2023 [Section No. 250.32(D)]

(D) Disconnecting Means Located in Separate Building or Structure on the Same Premises.

If one or more disconnecting means supply one or more additional buildings or structures under single management, and where these disconnecting means are located remote from those buildings or structures in accordance with 225.31(B), Exception No. 1 and No. 2, 700.12(D)(4), 701.12(D)(3), or 702.12, all of the following conditions shall be met:

(1) The connection of the grounded conductor to the grounding electrode, to normally non-current-carrying metal parts of equipment, or to the equipment grounding conductor at a separate building or structure shall not be made.

(2) An equipment grounding conductor for grounding and bonding any normally non-current-carrying metal parts of equipment, interior metal piping systems, and building or structural metal frames is run with the circuit conductors to a separate building or structure and connected to ~~existing grounding electrode(s) required in Part III of this article, or, if there are no existing electrodes, the grounding electrode(s) required in Part III of this article shall be installed if a separate building or structure is supplied by more than one branch circuit~~ the grounding electrode conductor .

(3) The connection between the equipment grounding conductor and the grounding electrode conductor at a separate building or structure shall be made in a junction box, panelboard, or similar enclosure located immediately inside or outside the separate building or structure.

Statement of Problem and Substantiation for Public Input

This public input is one of three companion public inputs seeking to clarify the connection to the grounding electrode(s) at a building or structure supplied by a feeder or branch circuits. Although the traditional field practice is to connect the equipment grounding conductor (EGC) to the grounding electrode conductor (GEC), the literal wording of this section requires the EGC to be connected to the grounding electrode(s). Connecting the EGC to the grounding electrode would also conflict with 250.32(E) which requires the GEC to be sized in accordance with 250.66 whereas the EGC would be sized in accordance with 250.122.

The text regarding the grounding electrode system in 250.32(D)(2) is being removed to correlate with actions taken by CMP 5 in the 2023 cycle regarding removing the text related to existing electrodes. Additionally, the text being removed is redundant as the requirement for the building or structure to have a grounding electrode system is already covered in 250.32(A).

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 227-NFPA 70-2023 [Section No. 250.32(B)(1)]	

Submitter Information Verification

Submitter Full Name: Mark Hilbert
Organization: MR Hilbert Inspections & Training
Affiliation: Self
Street Address:
City:

State:

Zip:

Submittal Date: Wed Jan 25 16:14:38 EST 2023

Committee: NEC-P05

Committee Statement

Resolution: FR-8300-NFPA 70-2024

Statement: The requirement is modified to clarify that the equipment grounding conductor terminates to the grounding electrode conductor.

Public Input No. 241-NFPA 70-2023 [Section No. 250.32(D)]

(D) Disconnecting Means Located in Separate Building or Structure on the Same Premises.

If one or more disconnecting means supply one or more additional buildings or structures under single management, and where these disconnecting means are located remote from those buildings or structures in accordance with 225.31(B), Exception No. 1 and No. 2, 700.12(D)(4), 701.12(D)(3), or 702.12, all of the following conditions shall be met:

(1) The connection of the grounded conductor to the grounding electrode, to normally non-current-carrying metal parts of equipment, or to the equipment grounding conductor at a separate building or structure shall not be made.

(2) An equipment grounding conductor for grounding and bonding any normally non-current-carrying metal parts of equipment, interior metal piping systems, and building or structural metal frames is run with the circuit conductors to a separate building or structure and connected to existing grounding electrode(s) required in Part III of this article, or, if there are no existing electrodes, the grounding electrode(s) required in Part III of this article shall be installed if a separate building or structure is supplied by more than one branch circuit.

(3) The connection between the equipment grounding conductor and the grounding electrode at a separate building or structure shall be made in a junction box, panelboard enclosure , or similar enclosure located immediately inside or outside the separate building or structure.

Statement of Problem and Substantiation for Public Input

The term "enclosure" is needed to clarify the difference between the panelboard (busbars) itself and the panelboard ENCLOSURE.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 240-NFPA 70-2023 [Section No. 552.43(B)]	panelboard busbars vs panelboard enclosure
Public Input No. 239-NFPA 70-2023 [Section No. 550.10(B)]	panelboard busbars vs panelboard enclosure
Public Input No. 238-NFPA 70-2023 [Section No. 408.5]	panelboard busbars vs panelboard enclosure
Public Input No. 237-NFPA 70-2023 [Section No. 408.3(F)]	panelboard busbars vs panelboard enclosure
Public Input No. 235-NFPA 70-2023 [Section No. 424.47]	panelboard busbars vs panelboard enclosure

Submitter Information Verification

Submitter Full Name: Russ Leblanc
Organization: Leblanc Consulting Services
Street Address:
City:
State:

Zip:
Submittal Date: Sat Jan 28 11:34:26 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8298-NFPA 70-2024

Statement: The requirement is revised to clarify that the connection of the equipment grounding conductor and the grounding electrode conductor is made inside of the panelboard enclosure.

Public Input No. 3482-NFPA 70-2023 [Section No. 250.32(D)]

(D) Disconnecting Means Located in Separate Building or Structure on the Same Premises.

If one or more disconnecting means supply one or more additional buildings or structures under single management, and where these disconnecting means are located remote from those buildings or structures in accordance with 225.31(B), Exception No. 1 and No. 2, 700.12(D)(4), 701.12(D)(3), or 702.12, all of the following conditions shall be met:

(1) The connection of the grounded conductor to the grounding electrode, to normally non-current-carrying metal parts of equipment, or to the equipment grounding conductor at a separate building or structure shall not be made.

(2) An equipment grounding conductor for grounding and bonding any normally non-current-carrying metal parts of equipment, interior metal piping ~~systems~~ , and building or structural metal frames is run with the circuit conductors to a separate building or structure and connected to existing grounding electrode(s) required in Part III of this article, or, if there are no existing electrodes, the grounding electrode(s) required in Part III of this article shall be installed if a separate building or structure is supplied by more than one branch circuit.

(3) The connection between the equipment grounding conductor and the grounding electrode at a separate building or structure shall be made in a junction box, panelboard, or similar enclosure located immediately inside or outside the separate building or structure.

Statement of Problem and Substantiation for Public Input

The conductor is there to bond metal piping. Through the 1965 code, Article 250 didn’t need to use the adjective “metallic” or “metal” in referring to piping systems. Nowadays, piping often mixes metallic and nonmetallic tubing, and if there’s a substantial metallic portion, we want to bond it, without debating or even knowing whether it is a complete system. Adding the term "system" does not add clarity; no one is likely to read this as requiring the bonding of a metal faucet stem if the term "system" is removed. It is not a defined NEC term, and there are disagreements on how to apply the dictionary definition.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3480-NFPA 70-2023 [New Definition after Definition: Switching Device(as applie...]	
Public Input No. 3481-NFPA 70-2023 [Section No. 110.26(E)(2)]	
Public Input No. 3483-NFPA 70-2023 [Section No. 250.52(A)(8)]	
Public Input No. 3484-NFPA 70-2023 [Section No. 250.68(B)]	
Public Input No. 3485-NFPA 70-2023 [Section No. 250.104]	
Public Input No. 3483-NFPA 70-2023 [Section No. 250.52(A)(8)]	
Public Input No. 3485-NFPA 70-2023 [Section No. 250.104]	

Submitter Information Verification

Submitter Full Name: David Shapiro
Organization: Safety First Electrical
Street Address:

City:	
State:	
Zip:	
Submittal Date:	Sun Sep 03 23:11:13 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Removing the word “system” will not add clarity. The word “piping” by itself is too vague.

Public Input No. 788-NFPA 70-2023 [Section No. 250.32(D)]

(D) Disconnecting Means Located in Separate Building or Structure on the Same Premises.

If one or more disconnecting means supply one or more additional buildings or structures under single management, and where these disconnecting means are located remote from those buildings or structures in accordance with 225.31(B), Exception No. 1 and No. 2, 700.12(D)(4), 701.12(D)(3), or 702.12, all of the following conditions shall be met:

(1) The connection of the grounded conductor to the grounding electrode, to normally non-current-carrying metal parts of equipment, or to the equipment grounding conductor at a separate building or structure shall not be made.

(2) An equipment grounding conductor for grounding and bonding any normally non-current-carrying metal parts of equipment, interior metal piping systems, and building or structural metal frames is run with the circuit conductors to a separate building or structure and connected to existing grounding electrode(s) required in Part III of this article, or, if there are no existing electrodes, the grounding electrode(s) required in Part III of this article shall be installed if a separate building or structure is supplied by more than one branch circuit.

(3) The connection between the equipment grounding conductor and the grounding electrode at a separate building or structure shall be made in a junction box, enclosed panelboard, or similar enclosure located immediately inside or outside the separate building or structure.

Statement of Problem and Substantiation for Public Input

"Enclosed" is added to make the requirement correlate with the definition of "enclosed panelboard." Note that the requirement states "in" and "similar enclosure" implying that the panelboard is enclosed.

Submitter Information Verification

Submitter Full Name:	Palmer Hickman
Organization:	Electrical Training Alliance
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue May 09 17:14:09 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8298-NFPA 70-2024

Statement: The requirement is revised to clarify that the connection of the equipment grounding conductor and the grounding electrode conductor is made inside of the panelboard enclosure.

Public Input No. 3621-NFPA 70-2023 [Section No. 250.35(B)]

(B) Nonseparately Derived System.

If the generator is installed as a nonseparately derived system, and overcurrent protection is not integral with the generator assembly, a supply-side bonding jumper shall be installed between the generator equipment grounding terminal and the equipment grounding terminal, bar, or bus of the disconnecting mean(s). ~~It shall be~~ The supply-side bonding jumper shall be permitted to be of the nonflexible metal raceway type or of the wire-type sized in accordance with 250.102(C) based on the size of the conductors supplied by the generator.

Statement of Problem and Substantiation for Public Input

The SSBJ is permitted to be a metal raceway for separately derived systems, [250.30(A)(2)], and we should also allow this method for 250.35. This proposed revision will enhance usability and add clarity for Code users.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 05 10:02:54 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8563-NFPA 70-2024

Statement: The requirement is modified to be consistent with allowances for a nonflexible metal raceway or bus to be used as a supply-side bonding jumper for separately derived systems as allowed in 250.30(A)(2). It is changed to a list format for usability.

Public Input No. 2125-NFPA 70-2023 [Section No. 250.36(C)]

(C) System ~~Grounding Connection~~ Neutral Point Connection .

The system shall not be connected to ground except through the grounding impedance device.

> Informational Note: The impedance is normally selected to limit the ground-fault current to a value slightly greater than or equal to the capacitive charging current of the system. This value of impedance will also limit transient overvoltages to safe values. For guidance, refer to criteria for limiting transient overvoltages in IEEE 3003.1-2019, *Recommended Practice for System Grounding of Industrial and Commercial Power Systems*.

Statement of Problem and Substantiation for Public Input

There is an effort to bring 250.187 into alignment with 250.36. 250.187(C) is titled System Neutral Point connection. The author of this PI thinks that the title in 250.187 is clearer and more descriptive.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	Bring the title of (C) into alignment with 250.187(C)
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Aug 12 15:35:02 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8673-NFPA 70-2024

Statement: This revision clarifies that the connection is between the neutral point and the grounding electrode. This change makes the language consistent with 250.187. The informational note is revised to meet NEC Style Manual criteria. The phrase in the informational note “to safe values” is removed since safe is an arbitrary value without a technical threshold.

Public Input No. 3591-NFPA 70-2023 [Section No. 250.36(E)]

(E) Impedance Bonding Jumper.

(1) Routing. The impedance bonding jumper (the connection between the equipment grounding conductors and the grounding impedance device) shall be an unspliced conductor run from the first system disconnecting means or overcurrent device to the grounded side of the grounding impedance device.

(2) Size. The impedance bonding jumper shall be sized the same as the impedance grounding conductor in 250.36(B)

Statement of Problem and Substantiation for Public Input

Currently, both 250.36(E) and 250.36(G) are requirements for the Impedance Bonding Jumper. As such, this PI recommends combining the two sections into one. This is a companion PI to a PI recommending the deletion of 250.36(G).

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3592-NFPA 70-2023 [Section No. 250.36(G)]	

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Sep 04 22:47:12 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8397-NFPA 70-2024

Statement: This revision consolidates subdivisions 250.36(E) and 250.36(G) for clarity and conciseness. The text is placed into list format for usability. As part of this revision 250.36(G) is deleted in a related action and a new definition for Impedance Bonding Jumper is established allowing the removal of the definition from the existing text. The term grounded is changed to grounding electrode to match the language in the new definition. The impedance bonding jumper carries the same current as the impedance grounding conductor and can be sized in the same method.

Public Input No. 2130-NFPA 70-2023 [Section No. 250.36(G)]

(G) Impedance Bonding Jumper Size.

The impedance bonding jumper shall be sized ~~in accordance with either of~~ the ~~following:~~

- ~~If the grounding electrode conductor connection is made at the grounding impedance device, the equipment bonding jumper shall be sized in accordance with 250.66 , based on the size of the service entrance conductors for a service or the derived phase conductors for a separately derived system.~~

~~If the grounding electrode conductor is connected at the first system disconnecting means or overcurrent device, the impedance bonding jumper shall be sized the~~ same as the impedance grounding conductor in 250.36(B) ~~.~~

Statement of Problem and Substantiation for Public Input

Currently, the Impedance Bonding Jumper is sized differently depending on where the Grounding Electrode Conductor is connected to the system. Upon analysis of single fault scenarios and double fault scenarios, the GEC is not in the path of fault current and the Impedance Bonding Jumper sees the same fault current regardless of where the GEC is connected. There is a companion PI to add this section, (G), to 250.187.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	comparable section in 250.187
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	
Public Input No. 3592-NFPA 70-2023 [Section No. 250.36(G)]	

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Sat Aug 12 16:19:15 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: FR-8404-NFPA 70-2024

Statement: This revision consolidates subdivisions 250.36(E) and 250.36(G) for clarity and conciseness since both refer to the same conductor. As part of this revision 250.36(G) is deleted and a new definition for Impedance Bonding Jumper is established.

Public Input No. 3592-NFPA 70-2023 [Section No. 250.36(G)]

~~**(G)** Impedance Bonding Jumper Size.~~

~~The impedance bonding jumper shall be sized in accordance with either of the following:~~

(1) ~~If the grounding electrode conductor connection is made at the grounding impedance device, the equipment bonding jumper shall be sized in accordance with 250.66 , based on the size of the service entrance conductors for a service or the derived phase conductors for a separately derived system.~~

(2) ~~If the grounding electrode conductor is connected at the first system disconnecting means or overcurrent device, the impedance bonding jumper shall be sized the same as the impedance grounding conductor in 250.36(B) .~~

Statement of Problem and Substantiation for Public Input

This is a companion PI to PI number 3591. 3591 recommends moving the text of (G) to (E), as both sections deal with the Impedance Bonding Jumper. There is also a companion PI, PI number 2130, recommending rewriting the requirements for sizing of the Impedance Bonding Jumper. The current (G) has two different sizes, depending on where the GEC is connected. The location of the connection of the GEC, however, does not effect the size of the Impedance Bonding Jumper.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3591-NFPA 70-2023 [Section No. 250.36(E)]	Combine (G) into section (E)
Public Input No. 2130-NFPA 70-2023 [Section No. 250.36(G)]	Remove different sizing requirements for the impedance bonding jumper

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Sep 04 22:54:00 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8404-NFPA 70-2024

Statement: This revision consolidates subdivisions 250.36(E) and 250.36(G) for clarity and conciseness since both refer to the same conductor. As part of this revision 250.36(G) is deleted and a new definition for Impedance Bonding Jumper is established.

Public Input No. 3241-NFPA 70-2023 [Section No. 250.36 [Excluding any Sub-Sections]]

Impedance grounded systems in which a grounding impedance device, typically a resistor, limits the ground-fault current shall be permitted for 3-phase ac systems of 480 volts to 1000 volts if all the following conditions are met:

(1) The conditions of maintenance and supervision ensure that only qualified persons service the installation.

(2) Ground detectors are installed on the system.

(3) Line-to-neutral loads are not served.

(4) The integrity of the impedance grounding system shall be monitored and the system shall have an audible or visual alarm when one of the following conditions is detected:

  (5) A loss of continuity of the impedance grounding circuit

  (6) A ground-fault in the impedance grounding circuit

Impedance grounded systems shall comply with 250.36(A) through (G).

> Informational Note: See NFPA *70E*-2021, *Standard for Electrical Safety in the Workplace*, Annex O, for information on impedance grounding to reduce arc-flash hazards.

Statement of Problem and Substantiation for Public Input

This public input is submitted along with two other companion public inputs in sections 250.187 (PI 3243) and 250.188 (PI 3244) to improve safety of impedance grounded systems by ensuring the integrity of the impedance grounding system at all times.

The intention is to monitor the impedance grounding system for its two modes of failure:

1. Loss of continuity (i.e., the impedance grounding device is open):

If the impedance grounding device fails open, the intentional connection of the power system neutral to ground is lost. Therefore, the power system will operate as an ungrounded system. According to the literature (a few examples are listed in the references), during a line-to-ground fault on any of the 3-phases (ungrounded conductors), the system voltage-to-ground will elevate to the phase-to-phase voltage (for example, from 277 V to 480 V on a 480 V system). Accordingly, steady-state and transient overvoltages will appear on the unfaulted phases, posing a serious safety hazard to personnel and equipment. Additionally, when an impedance grounded system is running as an ungrounded system (due to an open impedance grounding device), it violates the requirement of Section 250.21(B) that mandates the installation of ground detectors on ungrounded systems

2. Ground-fault (i.e., the impedance grounding device is shorted):

If the impedance grounding device is shorted, the power system will operate as a solidly grounded system. According to the literature (a few examples are listed in the references), the magnitude of line-to-ground fault current can approach the levels of three-phase fault current levels (1,000–20,000 A). This could result in devastating burn-downs of particular equipment, creating hazards to personnel. Additionally, when an impedance grounded system is running as a solidly-grounded system (due to a shorted impedance grounding device), it violates the requirement of Section 230.95 that mandates the installation of ground-fault protection of equipment on solidly-grounded systems

To avoid the interruption of a continuous industrial process and allow time for scheduled maintenance, the requirement is to alarm (not trip), if one of the aforementioned failure modes is detected.

Applications for Monitoring Impedance grounding devices:

Monitoring of the impedance grounding devices has been a code requirement or a standard practice in various applications in the US, Canada, and other countries including but not limited to Australia and New Zealand. These applications and the applicable code or standard are shown in the table below.

Application	Country	Code/Standard
Mining	US	30 CFR MSHA: Metal/Non-Metal Mining Regulations Parts 40-199
	Canada	CSA M421: Use of Electricity in Mines
	Australia & New Zealand	AS/NZS 2081: Electrical Protection Devices for Mines and Quarries
Most Installations	Canada	CSA C22.1: Canadian Electrical Code
Shore-to-ship (Cold Ironing)	International	IEC/IEEE 80005-1: Utility connections in port - Part 1: High voltage shore connection (HVSC) systems -- General requirements

Finally, the submitter understands that the current NEC language does not prevent the installation of impedance grounding system monitors. However, in practice, many users do not appreciate the hazards associated with the failure of an impedance grounding device and therefore do not monitor the integrity of their impedance grounding device. Thus, the submitter urges CMP-5 to consider adding this new requirement to the conditions that a low voltage (480 V to 1000 V) impedance grounded system must meet.

References:

[1] AIEE Committee Report, “Application guide on methods of neutral grounding of transmission systems,” Trans. Am. Inst. Electrical Engineers. Part III: Power Apparatus Syst., vol. 72, no. 4, pp. 663–668, Aug. 1953
[2] IEEE Recommended Practices for Grounding of Industrial and Commercial Power Systems, IEEE Standard 142–2007, 2007
[3] J. R. Dunki-Jacobs, F. J. Shields, and C. S. Pierre, Industrial Power System Grounding Design Handbook. Dexter, MI: Thomson-Shore, 2007
[4] N. El-Sherif and S. Kennedy, “A design guide to neutral-grounding of industrial power systems,” IEEE Ind. Appl. Mag., vol. 25, no. 1, pp. 25–36, 2019
[5] N. El-Sherif and S. Kennedy, “A Design Guide to Neutral-grounding of Industrial Power Systems – Part II: Supplementary Topics,” IEEE Industry Applications Magazine, vol. 26, no. 5, pp. 52-63, Sept/Oct 2020

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3243-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	
Public Input No. 3244-NFPA 70-2023 [Section No. 250.188]	
Public Input No. 3243-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	
Public Input No. 3244-NFPA 70-2023 [Section No. 250.188]	

Submitter Information Verification

Submitter Full Name: Nehad El-Sherif
Organization: MNKYBR Technologies Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 30 16:47:38 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Insufficient technical substantiation is provided to justify mandating additional monitoring of the integrity of the impedance grounding device. Examples provided are not unique to an impedance grounding system. Monitoring the integrity of components of any grounding system is not prohibited.

Public Input No. 3418-NFPA 70-2023 [Section No. 250.50]

250.50 Grounding Electrode System.

All grounding electrodes as described in 250.52(A)(1) through (A)(7) that are present at each building or structure served shall be bonded together to form the grounding electrode system. If none of these grounding electrodes exist, one or more of the grounding electrodes specified in 250.52(A)(4) through (A)(8) shall be installed and used. <u>If service equipment is replaced, all the requirements of Part III. of this article shall apply.</u>

Exception: Concrete-encased electrodes of existing buildings or structures shall not be required to be part of the grounding electrode system if the rebar is not accessible for use without disturbing the concrete.

Statement of Problem and Substantiation for Public Input

This public input adds a new sentence to the section that requires all the grounding electrode system requirements in Part III of Article 250 are applicable if service equipment is replaced. This ensures that replaced services are properly grounded and bonded to an effective grounding electrode system to maintain life and property safety of the premises wiring system. There are many existing homes and buildings that are 75 years or older. Most of those buildings have only one electrode, which probably has never been evaluated or reinspected. It is imperative for safety concerns to have the grounding electrode system at existing homes and buildings be brought up to current codes, especially with the capacity and ampere rating of the service increases. While Figure 230.1 implies that all services are required to comply with the grounding and bonding requirements in Article 250, it is not clear the grounding electrode system requirements apply where services are replaced.

The rapid electrification of buildings and the growth of the electric vehicle industry is resulting in homes and buildings needing service replacements to increase capacity and ampere rating to supply appliances and electric vehicle power transfer system equipment. It is essential that the grounding electrode system also be evaluated for compliance with Part III of Article 250 as the existing system may no longer be sufficient or adequate for the new service rating. This new sentence ensures the replaced service has a proper and effective grounding electrode system.

This public input has a correlating input for section 250.92(C).

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3417-NFPA 70-2023 [New Section after 250.92(B)]	
Public Input No. 3417-NFPA 70-2023 [New Section after 250.92(B)]	

Submitter Information Verification

Submitter Full Name: Megan Hayes
Organization: NEMA
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City:
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Zip:
Submittal Date: Sat Sep 02 18:22:25 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: The requirement already exists in 250.50 for installations without a grounding electrode system. The definition of Service Equipment would make this addition too broad in scope.

Public Input No. 2360-NFPA 70-2023 [Section No. 250.52(A)]

(A) Electrodes Permitted for Grounding.

~~**(2)** Metal~~

(1) Metal ~~Underground Water Pipe.~~

~~A metal underground water pipe in direct contact with the earth for 3.0 m (10 ft) or more (including any metal well casing bonded to the pipe) and electrically continuous (or made electrically continuous by bonding around insulating joints or insulating pipe) to the points of connection of the grounding electrode conductor and the bonding conductor(s) or jumper(s), if installed.~~

In-ground Support Structure(s).

One or more metal in-ground support structure(s) in direct contact with the earth vertically for 3.0 m (10 ft) or more, with or without concrete encasement. If multiple metal in-ground support structures are present at a building or a structure, it shall be permissible to bond only one into the grounding electrode system.

> Informational Note: Metal in-ground support structures include, but are not limited to, pilings, casings, and other structural metal.

(~~3~~ 2) Concrete-Encased Electrode.

A concrete-encased electrode shall consist of at least 6.0 m (20 ft) of either of the following:

(1) One or more bare or zinc galvanized or other electrically conductive coated rebar of not less than 13 mm (½ in.) in diameter, installed in one continuous 6.0 m (20 ft) length, or if in multiple pieces, the rebar shall be connected together by steel tie wires, exothermic welding, welding, or other effective means to create a 6.0 m (20 ft) or greater length

(2) Bare copper conductor not smaller than 4 AWG

Metal components shall be encased by at least 50 mm (2 in.) of concrete and shall be located horizontally within that portion of a concrete foundation or footing that is in direct contact with the earth or within vertical foundations or structural components or members that are in direct contact with the earth. If multiple concrete-encased electrodes are present at a building or structure, it shall be permissible to bond only one into the grounding electrode system.

> Informational Note: Concrete installed with insulation, vapor barriers, films, or similar items separating the concrete from the earth is not considered to be in “direct contact” with the earth.

(~~4~~ 3) Ground Ring.

A ground ring encircling the building or structure, in direct contact with the earth, consisting of at least 6.0 m (20 ft) of bare copper conductor not smaller than 2 AWG.

(~~5~~ 4) Rod and Pipe Electrodes.

Rod and pipe electrodes shall not be less than 2.44 m (8 ft) in length and consist of the following materials.

(1) Grounding electrodes of pipe or conduit shall not be smaller than metric designator 21 (trade size ¾) and, where of steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

(2) Rod-type grounding electrodes of stainless steel and copper or zinc-coated steel shall be at least 15.87 mm (⅝ in.) in diameter, unless listed.

(~~6~~ 5) Other Listed Electrodes.

Other listed grounding electrodes shall be permitted.

(~~7~~ 6) Plate Electrodes.

Each plate electrode shall expose not less than 0.186 m^2 (2 ft^2) of surface to exterior soil. Electrodes of bare or electrically conductive coated iron or steel plates shall be at least 6.4 mm (¼ in.) in thickness. Solid, uncoated electrodes of nonferrous metal shall be at least 1.5 mm (0.06 in.) in thickness.

(~~8~~ 7) Other Local Metal Underground Systems or Structures.

Other local metal underground systems or structures such as piping systems, underground tanks, and underground metal well casings that are not bonded to a metal water pipe.

Statement of Problem and Substantiation for Public Input

The metal underground water pipe is the only electrode that must be supplemented by another electrode as required in 250.52(D)(2). The reason is that if the water utilities decide to change the water pipe to nonmetallic then the building is left without a grounding electrode. If the metal water pipe grounding electrode is not sufficient to qualify as an electrode, then why is it permitted for grounding? In accordance with AWWA (American Water Works Association) milliamps of current can cause corrosion to metal water pipes and deteriorate water quality to customers as shown in their studies. In addition, if you lose the service neutral and it’s connected to the metal water pipe at there can be dangerous voltage present to cause a shock hazard to water workers if they open the underground water pipe. Keep in mind the interior metal water pipe is still required to be bonded in accordance 250.104. See below links supporting these statements:

https://portal.ct.gov/-/media/Departments-and-Agencies/DPH/dph/environmental_health/private_wells/37ElectricalGroundsAControversialNecessitypdf.pdf
https://www.awwa.org/Policy-Advocacy/AWWA-Policy-Statements/Grounding-of-Electrical-Circuits-on-Water-Pipe

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
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Submittal Date: Wed Aug 16 14:21:42 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Metal underground water piping has decades of safe history performing as grounding electrodes.

Public Input No. 3180-NFPA 70-2023 [New Section after 250.52(A)(3)]

TITLE OF NEW CONTENT

Informational Note: #2: Concrete in contact with dirt, stone dust, processed or crushed stone or any other naturally made material is considered to be in "direct contact" with the earth.

Statement of Problem and Substantiation for Public Input

Clarity is needed as to what "direct contact with the earth" is. Concrete is quite often installed on crushed stone, sand, or processed stone and is not directly placed on the "dirt". Processed stone, sand, and/or rocks are part of the earth and therefor should be considered to be "in direct contact with the earth" when used however without an informational note that states what that is some may feel that the concrete has to be installed in direct contact with the soil and do not permit concrete that is placed on other material that is in direct contact with the soil. As written the current language is not clear and leads to confusion with both enforcers and installers as far as what "in direct contact with the earth" may be.

Submitter Information Verification

Submitter Full Name:	Timothy Mikloiche
Organization:	Town of West Hartford
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State:	
Zip:	
Submittal Date:	Wed Aug 30 07:21:06 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed wording does not capture all the materials that could be considered "earth".

Public Input No. 1047-NFPA 70-2023 [Section No. 250.52(A)(3)]

(3) Concrete-Encased Electrode.

A concrete-encased electrode shall consist of at least 6.0 m (20 ft) of either of the following:

(1) One or more bare or zinc galvanized or other electrically conductive coated rebar of not less than 13 mm (½ in.) in diameter, installed in one continuous 6.0 m (20 ft) length, or if in multiple pieces, the rebar shall be connected together by steel tie wires, exothermic welding, welding, or other effective means to create a 6.0 m (20 ft) or greater length

(2) Bare copper conductor not smaller than 4 AWG

Metal components shall be encased by at least 50 mm (2 in.) of concrete and shall be located horizontally within that portion of a concrete foundation or footing that is in direct contact with the earth or within vertical foundations or structural components or members that are in direct contact with the earth. If multiple concrete-encased electrodes are present at a building or structure, it shall be permissible to bond only one into the grounding electrode system. <u>The concrete encased electrode exiting the concrete shall be protected per 300.6</u>

> Informational Note: Concrete installed with insulation, vapor barriers, films, or similar items separating the concrete from the earth is not considered to be in “direct contact” with the earth.

Additional Proposed Changes

File Name	Description	Approved
.1686602964743		

Statement of Problem and Substantiation for Public Input

Concrete encase electrode needs to be protected from corrosion with paint, or other methods

Submitter Information Verification

Submitter Full Name: John Plourde
Organization: Portsmouth Nh City Of
Affiliation: Performance Electrical Training LLC.
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City:
State:
Zip:
Submittal Date: Mon Jun 12 16:45:19 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Not all rebar extensions are exposed to corrosion. The proposed wording is unclear regarding the extent of the rebar that needs to be coated. Not all of 300.6 is applicable.

Public Input No. 1118-NFPA 70-2023 [Section No. 250.52(A)(3)]

(3) Concrete-Encased Electrode.

A concrete-encased electrode shall consist of at least 6.0 m (20 ft) of either of the following:

(1) One or more bare or zinc galvanized or other electrically conductive coated rebar of not less than 13 mm (½ in.) in diameter, installed in one continuous 6.0 m (20 ft) length, or if in multiple pieces, the rebar shall be connected together by steel tie wires, exothermic welding, welding, or other effective means to create a 6.0 m (20 ft) or greater length

(2) Bare copper-clad steel or copper conductor not smaller than 4 AWG

Metal components shall be encased by at least 50 mm (2 in.) of concrete and shall be located horizontally within that portion of a concrete foundation or footing that is in direct contact with the earth or within vertical foundations or structural components or members that are in direct contact with the earth. If multiple concrete-encased electrodes are present at a building or structure, it shall be permissible to bond only one into the grounding electrode system.

> Informational Note: Concrete installed with insulation, vapor barriers, films, or similar items separating the concrete from the earth is not considered to be in “direct contact” with the earth.

Additional Proposed Changes

File Name	Description	Approved
.1692552338573		

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name:	Peter Graser
Organization:	Copperweld
Affiliation:	American Bimetallic Association
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Jun 17 09:25:23 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 1653-NFPA 70-2023 [Section No. 250.52(A)(3)]

(3) Concrete-Encased Electrode.

A concrete-encased electrode shall consist of at least 6.0 m (20 ft) of either of the following:

(1) One or more bare or zinc galvanized or other electrically conductive coated rebar of not less than 13 mm (½ in.) in diameter, installed in one continuous 6.0 m (20 ft) length, or if in multiple pieces, the rebar shall be connected together by steel tie wires, exothermic welding, welding, or other effective means to create a 6.0 m (20 ft) or greater length. Where multiple pieces of rebar are connected together by steel tie wires to obtain the 6.0 m (20 ft) continuous minimum length, the separate rebar lengths shall overlap each other at least 30 x the rebar's diameter and be tie wire connected to each other at east every 75 mm (3").

(2) Bare copper conductor not smaller than 4 AWG

Metal components shall be encased by at least 50 mm (2 in.) of concrete and shall be located horizontally within that portion of a concrete foundation or footing that is in direct contact with the earth or within vertical foundations or structural components or members that are in direct contact with the earth. If multiple concrete-encased electrodes are present at a building or structure, it shall be permissible to bond only one into the grounding electrode system.

> Informational Note: Concrete installed with insulation, vapor barriers, films, or similar items separating the concrete from the earth is not considered to be in “direct contact” with the earth.

Statement of Problem and Substantiation for Public Input

Example: # 6 rebar has a ¾” diameter. .75” x 30 = 22 ½” overlap minimum

At present, it’s left up to the inspector to determine if multiple rebar pieces are effectively tie wired together when assessing a created a concrete encased electrode. A written minimum requirement at 250.52A3 would help NEC users.

The 30 x diameter is practiced at Colorado gas and oil sites. Regrettably, no technical information is being offered to the CMP on this public input regarding on how effective or ineffective this new minimum tie wire requirement is. The 30 x diameter may be written elsewhere but the reference for it is unknown to me. Perhaps the CMP has reference to it or another effective guideline.

Submitter Information Verification

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Affiliation:	self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Jul 27 16:31:02 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Rebar overlap lengths and tie wire details are covered by other standards and are approved by building officials or others responsible for that. No evidence of a problem has been provided.

Public Input No. 1779-NFPA 70-2023 [Section No. 250.52(A)(3)]

(3) Concrete-Encased Electrode.

A concrete-encased electrode shall consist of at least 6.0 m (20 ft) of either of the following:

(1) One or more bare or zinc galvanized or other electrically conductive coated rebar of not less than 13 mm (½ in.) in diameter, installed in one continuous 6.0 m (20 ft) length, or if in multiple pieces, the rebar shall be connected together by overlapping 20 diameters of rebar and steel tie wires, exothermic welding, welding, or other effective means to create a 6.0 m (20 ft) or greater length

(2) Bare copper conductor not smaller than 4 AWG

Metal components shall be encased by at least 50 mm (2 in.) of concrete and shall be located horizontally within that portion of a concrete foundation or footing that is in direct contact with the earth or within vertical foundations or structural components or members that are in direct contact with the earth. If multiple concrete-encased electrodes are present at a building or structure, it shall be permissible to bond only one into the grounding electrode system.

> Informational Note No. 1 : Concrete installed with insulation, vapor barriers, films, or similar items separating the concrete from the earth is not considered to be in “direct contact” with the earth.
>
> Informational Note No. 2: See NFPA 780-2022, Standard for the Installation of Lightning Protection Systems, 4.12.3.2

Statement of Problem and Substantiation for Public Input

The omission of wording "the usual steel tie wires" demonstrates the need to define an effective means to provide a low resistance path for fault current through embedded rebar.
NFPA 780, 4.12.3.2 addresses this with the 20 diameters of 1/2" rebar
Additional notation should be given in this section stating that rebar intersecting at right angles shall not be permitted unless welded or other approved means are used.
Rebar touching at right angles barely touch and the limited contact surface increases resistance especially over time and with corrosion. Rebar at right angles connected with only tie wire can't feasibly provide an effective fault pathway for high current. Perhaps phrasing like "Rebar sections connected with tie wire SHALL RUN PARALLEL and OVERLAP 20 diameters".

Submitter Information Verification

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Submittal Date: Tue Aug 01 20:11:12 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Rebar overlap lengths are covered by other standards and are approved by building officials or others responsible for that. No evidence of a problem has been provided.

Public Input No. 1024-NFPA 70-2023 [Section No. 250.52(A)(4)]

(4) Ground Ring.

A ground ring encircling the building or structure, in direct contact with the earth, consisting of at least 6.0 m (20 ft) of bare copper or 40% copper-clad steel conductor not smaller than 2 AWG.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name: Peter Graser
Organization: Copperweld
Affiliation: American Bimetallic Association
Street Address:
City:
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Submittal Date: Sun Jun 11 16:32:41 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 2522-NFPA 70-2023 [Section No. 250.52(A)(5)]

(5) Rod and Driven Pipe Electrodes.

Rod and driven pipe electrodes shall not be less than 2.44 m (8 ft) in length and consist of the following materials.

(1) Grounding electrodes of pipe or conduit shall not be smaller than metric designator 21 (trade size ¾) and, where of steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

(2) Rod-type grounding electrodes of stainless steel and copper or zinc-coated steel shall be at least 15.87 mm (⅝ in.) in diameter, unless listed.

Statement of Problem and Substantiation for Public Input

There continues to be some confusion in the field as to the difference between a "pipe electrode" and a "metal underground water pipe electrode". There should not be but there is, and changing "pipe electrode" to "driven pipe electrode" should clear any confusion up. Part of this may because, at least in my area, the use of a pipe electrode is very rare.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2523-NFPA 70-2023 [Section No. 250.53(A)]	correlating PI
Public Input No. 2524-NFPA 70-2023 [Section No. 250.66(A)]	correlating PI
Public Input No. 2523-NFPA 70-2023 [Section No. 250.53(A)]	
Public Input No. 2524-NFPA 70-2023 [Section No. 250.66(A)]	

Submitter Information Verification

Submitter Full Name:	Don Ganiere
Organization:	none
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Aug 19 14:50:13 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Not all electrodes are driven they can be buried under certain conditions.

Public Input No. 1985-NFPA 70-2023 [Section No. 250.52(A)(7)]

(7) Plate Electrodes.

Each plate electrode shall expose not less than 0.186 m^2 (2 ft^2) of surface to exterior soil. Electrodes of bare or electrically conductive coated iron or steel plates shall be at least 6.4 mm (¼ in.) in thickness. Solid, uncoated electrodes of nonferrous metal shall be at least 1.5 mm (0.06 in.) in thickness. ------ Provide clarity regarding how to determine the requirement for a minimum of two square feet of exposure to exterior soil. Clarify for example if both sides of a one square foot ground plate can be counted thus allowing a one foot by one foot ground plate to meet the two square foot requirement.

Statement of Problem and Substantiation for Public Input

250.52 (A) (7) Provide clarity regarding how to determine the requirement for a minimum of two square feet of exposure to exterior soil. Clarify for example if both sides of a one square foot ground plate can be counted thus allowing a one foot by one foot ground plate to meet the two square foot requirement.

The NEC works best when subjective language is changed to clear unambiguous language that can be consistently applied and fairly enforced.

Submitter Information Verification

Submitter Full Name: Gary Hein
Organization: [Not Specified]
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City:
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Zip:
Submittal Date: Wed Aug 09 12:49:49 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The existing wording is clear. A one ft sq plate with two conductive sides (surfaces) would comply with the rule.

Public Input No. 3483-NFPA 70-2023 [Section No. 250.52(A)(8)]

(8) Other Local Metal Underground Systems or Structures.

Other local metal underground systems or structures such as piping- ~~systems~~ , underground tanks, and underground metal well casings that are not bonded to a metal water pipe.

Statement of Problem and Substantiation for Public Input

The requirement is to bond metal piping. Through the 1965 code, Article 250 didn't need to use the adjective "metallic" or "metal" in referring to piping There are disagreements in interpreting the term "systems," and removing it does not lose the meaning of the requirement. No one's going to say there's a need to bond a stray broken pipe nipple. The fact that well casings are included where not bonded to a water "pipe," not "piping system," underscores the point.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3480-NFPA 70-2023 [New Definition after Definition: Switching Device(as applie...]	
Public Input No. 3481-NFPA 70-2023 [Section No. 110.26(E)(2)]	
Public Input No. 3482-NFPA 70-2023 [Section No. 250.32(D)]	
Public Input No. 3484-NFPA 70-2023 [Section No. 250.68(B)]	
Public Input No. 3485-NFPA 70-2023 [Section No. 250.104]	
Public Input No. 3486-NFPA 70-2023 [Section No. 250.104(A)(2)]	
Public Input No. 3482-NFPA 70-2023 [Section No. 250.32(D)]	
Public Input No. 3485-NFPA 70-2023 [Section No. 250.104]	

Submitter Information Verification

Submitter Full Name:	David Shapiro
Organization:	Safety First Electrical
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sun Sep 03 23:19:38 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Removing the word "systems" will not add clarity. The word "piping" by itself is too vague.

Public Input No. 2361-NFPA 70-2023 [Section No. 250.52(B)]

(B) Not Permitted for Use as Grounding Electrodes.

The following systems and materials shall not be used as grounding electrodes:

(1) Metal underground gas piping systems

(2) Aluminum

(3) The structures and structural rebar described in 680.26(B)(1) and (B)(2)

(4) Metal underground water piping systems

Informational Note: See 250.104(B) for bonding requirements of gas piping.

Statement of Problem and Substantiation for Public Input

The metal underground water pipe is the only electrode that must be supplemented by another electrode as required in 250.52(D)(2). The reason is that if the water utilities decide to change the water pipe to nonmetallic then the building is left without a grounding electrode. If the metal water pipe grounding electrode is not sufficient to qualify as an electrode, then why is it permitted for grounding? In accordance with AWWA (American Water Works Association) milliamps of current can cause corrosion to metal water pipes and deteriorate water quality to customers as shown in their studies. In addition, if you lose the service neutral and it's connected to the metal water pipe at there can be dangerous voltage present to cause a shock hazard to water workers if they open the underground water pipe. Keep in mind the interior metal water pipe is still required to be bonded in accordance 250.104. See below links supporting these statements:

https://portal.ct.gov/-/media/Departments-and-Agencies/DPH/dph/environmental_health/private_wells/37ElectricalGroundsAControversialNecessitypdf.pdf
https://www.awwa.org/Policy-Advocacy/AWWA-Policy-Statements/Grounding-of-Electrical-Circuits-on-Water-Pipe

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 16 14:24:16 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Metal underground water piping has decades of safe history performing as grounding electrodes.

Public Input No. 2435-NFPA 70-2023 [Section No. 250.52(B)]

(B) Not Permitted for Use as Grounding Electrodes.

The following systems and materials shall not be used as grounding electrodes:

(1) Metal underground gas piping systems

(2) Aluminum

(3) The structures and structural rebar described in 680.26(B)(1) and (B)(2)

(4) Underground metallic water piping for fire service mains

Informational Note No 1 : See 250.104(B) for bonding requirements of gas piping.

Informational Note No 2: See NFPA 24 10.5.1 concerning underground metallic water piping for fire service mains.

Statement of Problem and Substantiation for Public Input

Per NFPA 24 10.5.1 underground fire mains are not permissible as a grounding electrode.

Submitter Information Verification

Submitter Full Name: Albin Kneggs
Organization: City of Dallas
Street Address:
City:
State:
Zip:
Submittal Date: Thu Aug 17 10:06:59 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Metal underground water piping has decades of safe history performing as grounding electrodes.

Public Input No. 2320-NFPA 70-2023 [Section No. 250.53]

250.53 Grounding Electrode System Installation.

(A) Metal Underground Water Pipe.

If used as a grounding electrode, metal underground water pipe shall meet the requirements of 250.53(D)(1) and (D)(2).

(1) Continuity.

Continuity of the grounding path or the bonding connection to interior piping shall not rely on water meters or filtering devices and similar equipment.

(2) Supplemental Electrode Required.

A metal underground water pipe shall be supplemented by an additional electrode of a type specified in 250.52(A)(2) through (A)(8). If the supplemental electrode is of the rod, pipe, or plate type, it shall comply with 250.53(A) . The supplemental electrode shall be bonded to one of the following:

(1) Grounding electrode conductor

(2) Grounded service-entrance conductor

(3) Nonflexible grounded service raceway

(4) Any grounded service enclosure

(5) As provided by 250.32(B)

Exception: The supplemental electrode shall be permitted to be bonded to the interior metal water piping as specified in 250.68(C) (1).

(B) Ground Ring.

The ground ring shall be installed not less than 750 mm (30 in.) below the surface of the earth.

(C) Rod, Pipe, and Plate Electrodes.

Rod, pipe, and plate electrodes shall be free from nonconductive coatings such as paint or enamel. Rod, pipe, and plate electrodes shall meet the requirements of 250.53(A)(1) through (A)(3).

(1) Below Permanent Moisture Level.

If practicable, rod, pipe, and plate electrodes shall be embedded below permanent moisture level.

(2) Supplemental Electrode Required.

A single rod, pipe, or plate electrode shall be supplemented by an additional electrode of a type specified in 250.52(A)(2) through (A)(8). The supplemental electrode shall be permitted to be bonded to one of the following:

(1) Rod, pipe, or plate electrode

(2) Grounding electrode conductor

(3) Grounded service-entrance conductor

(4) Nonflexible grounded service raceway

(5) Any grounded service enclosure

Exception: If a single rod, pipe, or plate grounding electrode has a resistance to earth of 25 ohms or less, the supplemental electrode shall not be required.

(3) Supplemental Electrode.

If multiple rod, pipe, or plate electrodes are installed to meet the requirements of this section, they shall not be less than 1.8 m (6 ft) apart.

> Informational Note: The paralleling efficiency of rods is increased by spacing them twice the length of the longest rod.

(4) Rod and Pipe Electrodes.

The electrode shall be installed such that at least 2.44 m (8 ft) of length is in contact with the soil. It shall be driven to a depth of not less than 2.44 m (8 ft) except that, where rock bottom is encountered, the electrode shall be driven at an oblique angle not to exceed 45 degrees from the vertical or, where rock bottom is encountered at an angle up to 45 degrees, the electrode shall be permitted to be buried in a trench that is at least 750 mm (30 in.) deep. The upper end of the electrode shall be flush with or below ground level unless the aboveground end and the grounding electrode conductor attachment are protected against physical damage as specified in 250.10.

(5) Plate Electrode.

Plate electrodes shall be installed not less than 750 mm (30 in.) below the surface of the earth.

(~~B~~ D) Electrode Spacing.

If more than one of the electrodes of the type specified in 250.52(A)(5) or (A)(7) are used, each electrode of one grounding system (including that used for strike termination devices) shall not be less than 1.83 m (6 ft) from any other electrode of another grounding system.

(~~C~~ E) Bonding Jumper.

The bonding jumper(s) used to connect the grounding electrodes together to form the grounding electrode system shall be installed in accordance with 250.64(A), (B), and (E), shall be sized in accordance with 250.66, and shall be connected in the manner specified in 250.70. Rebar shall not be used as a conductor to interconnect the electrodes of grounding electrode systems.

~~**(E)** Supplemental Grounding~~

~~**(D)** Metal Underground Water Pipe.~~

~~If used as a grounding electrode, metal underground water pipe shall meet the requirements of 250.53(D)(1) and (D)(2).~~

~~**(1)** Continuity.~~

~~Continuity of the grounding path or the bonding connection to interior piping shall not rely on water meters or filtering devices and similar equipment.~~

~~**(2)** Supplemental Electrode Required.~~

~~A metal underground water pipe shall be supplemented by an additional electrode of a type specified in 250.52(A)(2) through (A)(8). If the supplemental electrode is of the rod, pipe, or plate type, it shall comply with 250.53(A) . The supplemental electrode shall be bonded to one of the following:~~

(1) ~~Grounding electrode conductor~~

(2) ~~Grounded service-entrance conductor~~

(3) ~~Nonflexible grounded service raceway~~

(4) ~~Any grounded service enclosure~~

(5) ~~As provided by 250.32(B)~~

~~*Exception: The supplemental electrode shall be permitted to be bonded to the interior metal water piping as specified in 250.68(C) (1).*~~

F) Supplemental Grounding Electrode Bonding Jumper Size.

If the supplemental electrode is a rod, pipe, or plate electrode, that portion of the bonding jumper that is the sole connection to the supplemental grounding electrode shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum or copper-clad aluminum wire.

~~**(F)** Ground Ring.~~

~~The ground ring shall be installed not less than 750 mm (30 in.) below the surface of the earth.~~

Statement of Problem and Substantiation for Public Input

Changing the order of this section to match the order of 250.52 for consistency and make life easier for Code users.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:	
State:	
Zip:	
Submittal Date:	Wed Aug 16 12:17:21 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed revision does not add clarity.

Public Input No. 2523-NFPA 70-2023 [Section No. 250.53(A)]

(A) Rod, Driven Pipe, and Plate Electrodes.

Rod, driven pipe, and plate electrodes shall be free from nonconductive coatings such as paint or enamel. Rod, pipe, and plate electrodes shall meet the requirements of 250.53(A)(1) through (A)(3).

(1) Below Permanent Moisture Level.

If practicable, rod, driven pipe, and plate electrodes shall be embedded below permanent moisture level.

(2) Supplemental Electrode Required.

A single rod, driven pipe, or plate electrode shall be supplemented by an additional electrode of a type specified in 250.52(A)(2) through (A)(8). The supplemental electrode shall be permitted to be bonded to one of the following:

(1) Rod, driven pipe, or plate electrode

(2) Grounding electrode conductor

(3) Grounded service-entrance conductor

(4) Nonflexible grounded service raceway

(5) Any grounded service enclosure

Exception: If a single rod, driven pipe, or plate grounding electrode has a resistance to earth of 25 ohms or less, the supplemental electrode shall not be required.

(3) Supplemental Electrode.

If multiple rod, driven pipe, or plate electrodes are installed to meet the requirements of this section, they shall not be less than 1.8 m (6 ft) apart.

> Informational Note: The paralleling efficiency of rods is increased by spacing them twice the length of the longest rod.

(4) Rod and Driven Pipe Electrodes.

The electrode shall be installed such that at least 2.44 m (8 ft) of length is in contact with the soil. It shall be driven to a depth of not less than 2.44 m (8 ft) except that, where rock bottom is encountered, the electrode shall be driven at an oblique angle not to exceed 45 degrees from the vertical or, where rock bottom is encountered at an angle up to 45 degrees, the electrode shall be permitted to be buried in a trench that is at least 750 mm (30 in.) deep. The upper end of the electrode shall be flush with or below ground level unless the aboveground end and the grounding electrode conductor attachment are protected against physical damage as specified in 250.10.

(5) Plate Electrode.

Plate electrodes shall be installed not less than 750 mm (30 in.) below the surface of the earth.

Statement of Problem and Substantiation for Public Input

This is to correlate with my proposed change in 250.52(A)(5) that will change "pipe" to "driven pipe"

Related Public Inputs for This Document

Related Input	Relationship

Public Input No. 2522-NFPA 70-2023 [Section No. 250.52(A)(5)]	correlating PI
Public Input No. 2524-NFPA 70-2023 [Section No. 250.66(A)]	correlatiing PI
Public Input No. 2522-NFPA 70-2023 [Section No. 250.52(A)(5)]	
Public Input No. 2524-NFPA 70-2023 [Section No. 250.66(A)]	

Submitter Information Verification

Submitter Full Name:	Don Ganiere
Organization:	none
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Aug 19 14:56:16 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Not all electrodes are driven, they can be buried under certain conditions.

Public Input No. 2027-NFPA 70-2023 [Section No. 250.53(A)(2)]

(2) Supplemental Electrode Required.

A single rod, pipe, or plate electrode shall be supplemented by an additional electrode of a type specified in 250.52(A)(2) through (A)(8). The supplemental electrode shall be permitted to be bonded to one of the following:

(1) Rod, pipe, or plate electrode

(2) Grounding electrode conductor

(3) Grounded service-entrance conductor

(4) Nonflexible grounded service raceway

(5) Any grounded service enclosure

Exception: If a single rod, pipe, or plate grounding electrode has a resistance to earth of 25 ohms or less, the supplemental electrode shall not be required. A measuring device that is listed to determine the resistance to earth shall be used in accordance with the manufacturer's specifications. Documentation of the reading shall be made available to the AHJ.

Statement of Problem and Substantiation for Public Input

This public input is being submitted on behalf of the Minnesota Department of Labor and Industry. Currently, the Department's inspection staff includes 14-office/field staff, 12-state field inspectors, 2-virtual inspectors and 50 plus contract electrical inspectors that complete over 170,000 electrical inspections annually.

This exception does not address how to determine that a single rod, pipe, or plate grounding electrode has a resistance to earth of 25 ohms or less. Adding this language would help to ensure that only measuring devices that have been listed for the use are used to take this reading. This "listing" language would be consistent with requirements for the leakage current measurement device in 555.35 (D).

Submitter Information Verification

Submitter Full Name:	Dean Hunter
Organization:	Minnesota Department of Labor
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Aug 11 10:10:10 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Determining if a single rod, pipe or plate complies with the 25 ohm resistance value can be done locally. There are other methods to measure resistance to earth, other than measuring devices listed for such. Testing for leakage current is a much different concept than testing ground resistance.

Public Input No. 3784-NFPA 70-2023 [Section No. 250.53(A)(4)]

(4) Rod and Pipe Electrodes.

The electrode shall be installed such that at least 2.44 m (8 ft) of length is in contact with the soil. If necessary, when rock bottom is encountered it shall comply with the following:

(A) It shall be driven to a depth of not less than 2.44 m (8 ft) except that, where rock bottom is encountered, the electrode shall be driven at an oblique angle not to exceed 45 degrees from the vertical ~~or, where~~ .

(B) Where rock bottom is encountered at an angle up to 45 degrees and if additional electrode is required to meet 250.53(A)(2) of resistance requirement , then the additional electrode shall be driven in

opposite direction of the other one with spacing 6 foot apart to meet the requirements of 250.53(B).

Informational Note: If driven at the same angle as the other one at (6 ft) apart, the additional electrode would be able to hit rock bottom into the other electrode and not having (6 ft) seperation of the full

length of electrode.

The electrode shall be permitted to be buried in a trench that is at least ~~750 mm~~ 750 mm (~~30 in~~ 30 in .) deep. The upper end of the electrode shall be flush with or below ground level unless the aboveground end and ~~the~~

grounding electrode ~~conductor~~ attachment are protected against physical damage as specified in 250.10 .

Statement of Problem and Substantiation for Public Input

By making this revise text in section 250.53 (A)(4) helps to understand when encountering rock bottom situations to make sure that the installer that needs additional electrode to meet the requirement of 250.53(2) of resistance requirements that the electrode is driven at opposite direction of the first one. This is to insure the 25 ohms or less are met per section 250.53(A)(2).

Submitter Information Verification

Submitter Full Name:	Rudy Garza
Organization:	IAEI
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Sep 05 16:12:18 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The six foot spacing requirement is already addressed in 250.53(B).

Public Input No. 3813-NFPA 70-2023 [Section No. 250.53(A)(4)]

(4) Rod and Pipe Electrodes.

(a) Contact with Soil. The electrode shall be installed such that at least 2.44 m (8 ft) of length is in contact with the soil.

(b) Driven or Buried. It shall be driven to a depth of not less than 2.44 m (8 ft) except that, where rock bottom is encountered, the electrode shall be driven at an oblique angle not to exceed 45 degrees from the vertical or, where rock bottom is encountered at an angle up to 45 degrees, the electrode shall be permitted to be buried in a trench that is at least 750 mm (30 in.) deep.

(c) Protected Against Physical Damage. The upper end of the electrode shall be flush with or below ground level unless the aboveground end and the grounding electrode conductor attachment are protected against physical damage as specified in 250.10.

Statement of Problem and Substantiation for Public Input

Breaking up 250.53(A)(4) into a list item format to facilitate understanding for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Sep 05 17:39:39 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8372-NFPA 70-2024

Statement: The wording was revised into a list format for usability.

Public Input No. 2397-NFPA 70-2023 [Section No. 250.53(A) [Excluding any Sub-Sections]]

Rod, pipe, and plate electrodes shall be free from nonconductive coatings such as paint or enamel <u>before the connection is made</u> . Rod, pipe, and plate electrodes shall meet the requirements of 250.53(A)(1) through (A)(3).

Statement of Problem and Substantiation for Public Input

Adding ‘before the connection is made’ because if a homeowner decides to the paint a ground rod after all connections have been properly made this shouldn’t be a Code violation.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 16 16:36:27 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Painting electrodes, before or after connections are made, can affect their contact with the soil.

Public Input No. 2317-NFPA 70-2023 [Section No. 250.53(C)]

(C)~~–~~ **Grounding Electrode** Bonding Jumper.

The bonding jumper(s) used to connect the grounding electrodes together to form the grounding electrode system shall be installed in accordance with 250.64(A), (B), and (E), shall be sized in accordance with 250.66, and shall be connected in the manner specified in 250.70. Rebar shall not be used as a conductor to interconnect the electrodes of grounding electrode systems.

Statement of Problem and Substantiation for Public Input

This requirement deals with grounding electrode bonding jumper specifically; therefore, the title should match. There is a difference between the requirements for grounding electrode conductors and bonding jumpers. Note: this term is used in 250.53(E) and 250.64(B)(4).

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 16 11:06:15 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8375-NFPA 70-2024

Statement: The words “grounding electrode” were added to be consistent with the terms used in 250.53(E) and 250.64(B)(4).

Public Input No. 2388-NFPA 70-2023 [Section No. 250.53(C)]

(C) Bonding Jumper.

The bonding jumper(s) used to connect the grounding electrodes together to form the grounding electrode system shall be installed in accordance with 250.64(A), (B), and (E), shall be sized in accordance with 250.66, and shall be connected in the manner specified in 250.70. ~~Rebar shall not be used as a conductor to interconnect the electrodes of grounding electrode systems.~~ Bonding jumpers used to extend the connection to an electrode shall comply with 250.68(C).

Statement of Problem and Substantiation for Public Input

Instead of saying that rebar can't be used to interconnect the electrodes of a grounding electrode system, revise the text to refer them to 250.68(C) that indicates when metal water piping, metal structural frame, or rebar can be used to extend the connection to an electrode. 250.68(C)(3)(c) already states rebar cannot be used as a conductor to interconnect electrodes of the grounding electrode system. Revising this text to first level subdivision 250.53(C) will be helpful to Code users.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 16 15:52:24 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Section 250.53(C) has requirements for bonding jumper installations and 250.68 (C)(3) has requirements for connections. A connection to rebar, used as part of a grounding electrode is necessary, but the rebar itself cannot be used as a conductor to establish a connection to other electrode types. The existing wording is not in conflict and is consistent.

Public Input No. 849-NFPA 70-2023 [Section No. 250.53(C)]

(C) Bonding Jumper.

The bonding jumper(s) used to connect the grounding electrodes together to form the grounding electrode system shall be installed in accordance with 250.64(A), (B), and (E), shall be sized in accordance with 250.66, and shall be connected in the manner specified in 250.70. ~~Rebar shall~~

The additional rebar section extended from its location in accordance with 250.68 (C) (3) shall be permitted for connection of grounding electrode conductors and bonding jumpers.

The horizontally run rebar network in the concrete shall not be used as a conductor to interconnect the electrodes of grounding electrode systems.

Statement of Problem and Substantiation for Public Input

Aligning 250.53 (C) with proposed 250.68 (C) (3). Eliminating the contradiction that currently exists in 250.68 (C) (3) that permits the additional rebar section for connection of grounding electrodes but then states in 250.68 (C) (3)(c) that rebar shall not be used as a conductor to interconnect the electrodes of grounding electrode systems.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 848-NFPA 70-2023 [Section No. 250.68(C)]	

Submitter Information Verification

Submitter Full Name:	Gabe Kaprelian
Organization:	Gabe Kaprelian Electrical Contractor
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu May 18 00:05:54 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Section 250.53(C) has requirements for bonding jumper installations and 250.68 (C) (3) has requirements for connections. A connection to rebar, used as part of a grounding electrode is necessary, but the rebar itself cannot be used as a conductor to establish a connection to other electrode types. The existing wording is not in conflict and is consistent.

Public Input No. 1646-NFPA 70-2023 [New Section after 250.53(D)(2)]

TITLE OF NEW CONTENT

250.53E Concrete-Encased Electrode

If used as a grounding electrode, a concrete-encased electrode shall meet the following:

A concrete encased electrode with less than 58 square m (625 square feet) shall be supplemented by an additional electrode of a type specified at 250.52A1, A2, A4, A5, A6 A7, or A8. All horizontal and vertical faces of concrete in contact with soil count towards the concrete-encased electrode's area. If the supplemental electrode is of a rod, pipe, or plate type, it shall comply with 250.53A. The supplemental electrode shall be bonded to one of the following:

(1) ***Grounding electrode conductor***

(2) ***Grounded service-entrance conductor***

(3) ***Non flexible grounded service raceway***

(4) ***Any grounded service enclosure***

(5) ***As provided by 250.32B***

Statement of Problem and Substantiation for Public Input

Greater surface area of a concrete-encased electrode will make a greater electrode. At what point does the effectiveness of a small square footage concrete-encased electrode diminish to where it can no longer stand on its own (provided 250.50 is met) without being supplemented? Richness of the soil heavily factors in as well but this is the NATIONAL Electric Code and a providing a minimum size value, such as 625 square', for the footprint area would be a compromise rather than conducting soil studies prior, for each job site, to determine the effectiveness of a future building's concrete-encased electrode. We'd be at the mercy of how wet the recent weather was too with those studies. Also, the soil under the building won't be in the permanent moisture barrier once it is built.

Smaller area concrete-encased electrodes may mean less available fault current due to smaller gauge and ampacity services and feeder conductors but this cannot be relied on therefore does not factor into this proposal.

With this code change at 250.53E, NEC 2023's 250.53E becomes 250.53F Supplemental Grounding Electrode Conductor Bonding Jumper Size, and NEC 2023's 250.53F becomes 250.53G Ground Ring.

The format of this added requirement for a supplemental grounding electrode for a concrete-encased electrode mirrors and adheres to the the current 250.53D for Metal Underground Water Pipe.

Submitter Information Verification

Submitter Full Name: Norman Feck
Organization: State of Colorado
Affiliation: self
Street Address:
City:
State:

Zip:
Submittal Date: Thu Jul 27 16:14:37 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: No substantiation was provided to require a concrete encased electrode having a minimum surface area to be supplemented.

Public Input No. 1101-NFPA 70-2023 [Section No. 250.53(E)]

(E) Supplemental Grounding Electrode Bonding Jumper Size.

If the supplemental electrode is a rod, pipe, or plate electrode, that portion of the bonding jumper that is the sole connection to the supplemental grounding electrode shall not be required to be larger than 6 AWG copper or 40% copper-clad steel wire or 4 AWG aluminum or copper-clad aluminum wire.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name:	Peter Graser
Organization:	Copperweld
Affiliation:	American Bimetallic Association
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Jun 17 08:24:45 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.102(C)(1)? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.102(C)(1) through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.102(C)(1) when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.102(C)(1). All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 1974-NFPA 70-2023 [Section No. 250.54]

~~**250.54** Auxiliary Grounding Electrodes.~~

~~One or more grounding electrodes shall be permitted to be connected to the equipment grounding conductors specified in 250.118 and shall not be required to comply with the electrode bonding requirements of 250.50 or 250.53(C) or the resistance requirements of 250.53(A)(2) Exception, but the earth shall not be used as an effective ground-fault current path as specified in 250.4(A)(5) and (B)(4).~~

Statement of Problem and Substantiation for Public Input

Section 250.54 should be deleted. This section, 250.54, has existed since the reorganization of Article 250 in the 1999 NEC. It's origin is unknown, but it seems to depend on the existing definitions of that time. Today, the definitions are very clear. In keeping with the definitions as they exist in Article 100, there needs to be a separation of the equipment grounding conductors and the grounding electrode conductors and grounding electrodes. 250.54 is allowing a mix of line side service connections and load side service connections. The reason for this allowance is not clearly stated. Section 250.54 does, however, close with the statement from 250.4(A)(5) and (B)(4) that the earth shall not be used as an effective ground-fault current path. To continue to allow or permit the connection of the grounding electrode(s) to the equipment grounding conductors only adds to the confusion of the purpose of grounding and the establishment of an effective ground-fault current path.

Submitter Information Verification

Submitter Full Name:	Roger Zieg
Organization:	NTT
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 09 06:47:12 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Section 250.50 requires a grounding electrode system for buildings and structures. Section 250.54 allows other electrodes to be connected to equipment grounding conductors, which can be done for other purposes.

Public Input No. 2461-NFPA 70-2023 [Section No. 250.54]

250.54 Auxiliary Grounding Electrodes.

One or more grounding electrodes shall be permitted to be connected to <u>noncurrent carrying metal parts of electrical equipment,</u> the equipment grounding conductors specified in 250.118<u>,</u> and <u>other metal parts of electrical equipment</u> shall not be required to comply with the electrode bonding requirements of 250.50 or 250.53(C) or the resistance requirements of 250.53(A)(2) Exception, but the earth shall not be used as an effective ground-fault current path as specified in 250.4(A)(5) and (B)(4).

Statement of Problem and Substantiation for Public Input

Adding language to permit auxiliary grounding electrodes to be connect directly to metal parts of electrical equipment or other metal parts in addition to the equipment grounding conductor. This will allow Code users to void the requirements in 250.50, 250.53(C), or 250.53(A)(2) Exception even if they don’t connect to the equipment grounding conductor. In most electrical installations the auxiliary grounding electrodes will be connected to a metal pole or metal frame of equipment and not directly to the equipment grounding conductor.

Submitter Information Verification

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City:	
State:	
Zip:	
Submittal Date:	Thu Aug 17 13:42:50 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Adding the additional wording does not improve clarity. A connection made to an equipment grounding conductor usually will also be connected to other metal parts.

Public Input No. 2630-NFPA 70-2023 [Section No. 250.54]

250.54 Auxiliary Grounding Electrodes.

One or more grounding electrodes shall be permitted to be connected to the equipment grounding conductors specified in 250.118 ~~and~~ , or the enclosures specified in 250.109, and shall not be required to comply with the electrode bonding requirements of 250.50 or 250.53(C) or the resistance requirements of 250.53(A)(2) Exception, but the earth shall not be used as an effective ground-fault current path as specified in 250.4(A)(5) and (B)(4).

Statement of Problem and Substantiation for Public Input

An auxiliary electrode should be able to be connected to any part of the effective ground-fault current path, not to just the equipment grounding conductors. Instead of "or the enclosures specified in 250.109, the Code Panel might consider, "or any part of the effective ground-fault current path." This would also include equipment housings. Adding the words "effective ground-fault current path" would also help to clarify that this auxiliary electrode must be connected to a path back to the neutral point. Of course, this is already covered by the last statement that the earth shall not be used as part of the effective ground-fault current path.

Submitter Information Verification

Submitter Full Name: Eric Stromberg
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Affiliation: self
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State:
Zip:
Submittal Date: Wed Aug 23 21:22:30 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Adding the additional wording does not improve clarity. A connection made to an equipment grounding conductor usually will also be connected to the enclosures in 250.109.

Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]

250.62 Grounding Electrode Conductor Material.

The grounding electrode conductor shall be of copper, copper-clad steel, aluminum, copper-clad aluminum, or the items as permitted in 250.68(C). The material selected shall be resistant to any corrosive condition existing at the installation or shall be protected against corrosion. Conductors of the wire type shall be solid or stranded, insulated, covered, or bare. Copper-clad steel shall adhere to the following:

1. Shall be a bimetal where the copper cladding and the steel core maintain a metallurgical bond

2. Shall be grade 40% copper-clad steel

3. Shall be listed per Section 110.3(C)

Additional Proposed Changes

File Name	Description	Approved
Copperweld_CCS_Biomechanical_Report_Copy.pdf	Exponent Scientific Test Report: Bending 40% CCS Human Factor Strain	
CCS40vsElectoPlate.pdf	Manufacturing Processes: Copper Cladding vs Electro-Plating	
CEL_-_13_Grounding_Conductor_Current_Test.pdf	Test Report: 40% CCS Low Impedance Material Testing	
Copperweld_CCS_Mechanical_Testing_Report.pdf	Exponent Scientific Test Report: Mechanical for 40% CCS	
Electrical_Analysis_and_Testing_Report_2023-09-07.pdf	Exponent Scientific Test Report: Electrical Testing 40% CCS	
PI.1102.250.62Final.docx	Clear Version of Public Input 1102	

Statement of Problem and Substantiation for Public Input

In the utility world for over a century Copper-Clad Steel (CCS) has been used as a Grounding Electrode (GE), bonding conductor, and the outdoor (and direct buried) version of a Grounding Electrode Conductor (GEC). CCS is a metallurgically bonded bimetal of copper and annealed steel. There is no shortage of knowledge about this material available to industry and its application as a primary material for grounding mats under substations, windfarms, transmission towers, industrial buildings, and solar farms. It also connects utility equipment and structures to GEs. It grounds transformers, utility fences, buildings, and affiliated equipment. Not just in the U.S., CCS is employed world-wide and is especially utilized in nations where extreme theft of grounding conductors occurs. The low scrap value and high shear strength of CCS disincentivize its theft. 40% CCS is the grade of CCS that contains the most copper by mass, and thus maintains the highest conductivity and corrosion resistance of the class of material. 40% CCS is not an electro-plated steel product (EPS). Ground rod GEs use CPS methods for depositing copper to steel through a chemical electrolytic process. In most cases, EPS ground rods contain +/- 10% copper by mass for corrosion resistance. CCS 40% is manufactured differently. Copper cladding is accomplished purely through mechanical means.

In answering panel concerns from last cycle, please note:

1. A “New and Innovative” listing program is currently being developed by UL Solutions for 40% CCS wire and cable for use as a grounding electrode (GE) and grounding electrode conductor (GEC). The program will be in place by 2024 before the 2026 NEC edition is published. This will ensure that only 40% CCS is used by the industry for GECs and GE rings, safeguarding that only the highest quality of CCS is used. To better accommodate 40% CCS, proposals to amend UL 467 will also be created. UL 467 is the listing standard for equipment used for grounding and bonding, and although the standard does not have purview over GEC’s or conductors, a degree of adjustment is in order.

2. Delamination was a question last cycle. Delamination is not uncommon with EPS products because no metallurgical bond is present between the two metals. Delamination is not typical (nor permitted) of copper clad steel products, however. Cladding is not an electrolytic process like EPS, but rather one where two single-state metals are mechanically sintered together by a rolling mill using high pressure and controlled heating. To meet ASTM B227 for Hard Drawn Copper-Clad Steel Wire, testing to ensure adhesion and cohesion of the metallurgical bond is a requirement. When a bond is present, delamination is not possible. Please see the presentation “CCS40vsElectroPlate” included as substantiation for this Public Input.

3. The apparent “too stiff to bend” claim describing 40% CCS raised last cycle is unfounded. Scientific research by a human factors research team determined that to bend 4 AWG solid 40% CCS to a 90° angle requires 6.21 Ft-Lb of force. This requires equivalent wrist strength to “open a jam jar lid.” Further, bending 4 AWG solid 40% CCS to an angle of 90° is 2X less taxing to the human wrist than terminating a small circuit conductor to a common receptacle requiring a minimum of 12 Ft-lbs. of torquing force be applied to the wire-binding screw. Terminating receptacles is a task accomplished by electricians dozens of times per day. Please see the ExPonent report “Copperweld CCS Biomechanical Report” included as substantiation for this Public Input.

4. Regarding the damaging of panelboard components by 40% CCS GECs, a study executed by a team of PhD scientists reveals that 4 AWG solid 40% CCS puts practically no strain on the lugs and plastic pieces of typical load center panels for 200, 125 and 70 ampere services. Aging experiments with strain gauges determined that installing the aluminum service conductor by far administered the most stress on panelboards. The same study reports that 40% CCS GECs do not exhibit elastic memory, and thus will not “spring back” to dislodge lugs once terminated inside a panelboard. Please see the ExPonent report “Copperweld CCS Mechanical Testing Report” included as substantiation with this Public Input.

5. Regarding questions about a GEC’s required level of electrical conductivity, Table 5 of UL 467 should not be used as a guide for determining the size of GECs. Namely UL 467 wasn’t designed to test GECs but rather (at least as part of its scope) their connectors. Table 5 aims to create extreme heat through high amperage for its test subjects – connectors and equipment. Table 5 does not employ GECs for this job. Rather, it calls for EGCs and bonding conductors for that role. In short, Table 5 is geared to evaluate the cracking and fusing potential of connectors and equipment in a laboratory setting. This testing does not reflect the duration or level of amperage a GEC is likely to experience in the field. The GEC’s role is to provide a secure connection to earth for the installation, something that requires physical strength and some degree of low impedance.

6. The sizing of GECs in Table 250.66 of the NEC does not directly translate to a required level of conductivity for each GEC size. Rather, because both copper and aluminum are soft metals, the table is geared towards ensuring the mechanical strength of a GEC through oversizing. To illustrate, GECs and their extensions are permitted to be made of materials with drastically different conductivities – some with high conductivities and some with extremely low conductivities (rebar). Second, if a GE of an installation does not extend to any other GE, and is made of a code compliant rod, pipe or plate, its GEC is only required to be 6 AWG copper (or 4 AWG Aluminum or CCA) regardless of the size of the service. These two points contradict the conventional wisdom behind Table 250.66 as being a sizing table based upon GEC conductivity. To contradict conventional wisdom further, in the case of a service where a ground ring is used as the GE, and the ground ring does not extend to any other GE, an 8 AWG copper may be used as the GEC regardless of the size of the service. In short, the GEC is not required to surpass any defined level of conductivity per se. Section 250.66 effectively decouples the GEC from the notion that its conductivity is directly related to the size of service, or that a certain level of conductivity per size is required. Rather, GECs must be mechanically robust enough to assure an electrical installation’s long-term connection to earth. Oversizing GECs for the job of carrying little-to-

no current seems illogical until viewed through the lens of mechanical strength. Oversizing gives greater mechanical strength to the GEC than it would otherwise not have, better assuring the continuity of the earth connection. Where the GEC is small with a low shear strength (a small size like 8 AWG copper for example) or when it is located where it might incur physical damage, Code requires it to be protected with steel, hard plastic or cable armor. In other words, for a GEC it is less about how conductive it is on the IACS scale, and more about how mechanically able it is to maintain connection over the life of the installation. For more information on the connection resistance of 40% CCS in current cycling tests, please see the ExPonent report “Electrical Analysis and Testing of 40% Copper Clad Steel (CCS) Conductors For Use as Grounding Electrode Conductors (GECs)” included as substantiation with this Public Input.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1024-NFPA 70-2023 [Section No. 250.52(A)(4)]	
Public Input No. 1101-NFPA 70-2023 [Section No. 250.53(E)]	
Public Input No. 1103-NFPA 70-2023 [Section No. 250.64(B)(1)]	
Public Input No. 1104-NFPA 70-2023 [Section No. 250.64(B)(2)]	
Public Input No. 1105-NFPA 70-2023 [Section No. 250.66 [Excluding any Sub-Sections]]	
Public Input No. 1106-NFPA 70-2023 [Section No. 250.66(A)]	
Public Input No. 1107-NFPA 70-2023 [Section No. 250.66(B)]	
Public Input No. 1108-NFPA 70-2023 [Section No. 250.102(A)]	
Public Input No. 1109-NFPA 70-2023 [Section No. 250.102(C)(2)]	
Public Input No. 1110-NFPA 70-2023 [Section No. 250.166 [Excluding any Sub-Sections]]	
Public Input No. 1111-NFPA 70-2023 [Section No. 250.166(A)]	
Public Input No. 1112-NFPA 70-2023 [Section No. 250.166(B)]	
Public Input No. 1113-NFPA 70-2023 [Section No. 250.166(C)]	
Public Input No. 1114-NFPA 70-2023 [Section No. 250.166(D)]	
Public Input No. 1115-NFPA 70-2023 [Section No. 250.178]	
Public Input No. 1116-NFPA 70-2023 [Section No. 250.190(B)]	
Public Input No. 1117-NFPA 70-2023 [Section No. 250.30(A)(6)]	
Public Input No. 1118-NFPA 70-2023 [Section No. 250.52(A)(3)]	

Submitter Information Verification

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Submittal Date:	Sat Jun 17 08:36:35 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Adult Human Wrist Strength Compared to the Torque Required to Bend 40% Copper Clad Steel (CCS) Wires

Prepared For:

Peter Graser
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Brentwood, TN 37027
For Use and Publication in the NFPA Standards Setting Process

Prepared By:

Hattie Cutcliffe, Ph.D., P.E.

Exponent, Inc.
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September 1, 2023

Introduction

Exponent performed laboratory testing to measure the required torque to bend 40% copper-clad steel (CCS) wires[1] to an approximately 90° angle with a calibrated torque wrench. This data was then used to draw comparisons with comparable and similar scenarios involving bending/torquing that a layperson might accomplish. This testing was performed on three different gauges of solid 40% CCS wires (8-AWG, 6-AWG, and 4-AWG) and was performed in triplicate (i.e., three tests per wire gauge, or nine tests in total).

Testing Setup and Results

The torque/bending tests were performed on a custom testing platform designed to consistently bend/torque the wires to an approximately 90° angle with an approximately 1/2” bend radius (similar to other wire/rod benders that are commercially available). Annotated photographs of the testing setup are presented below in Figure 1.

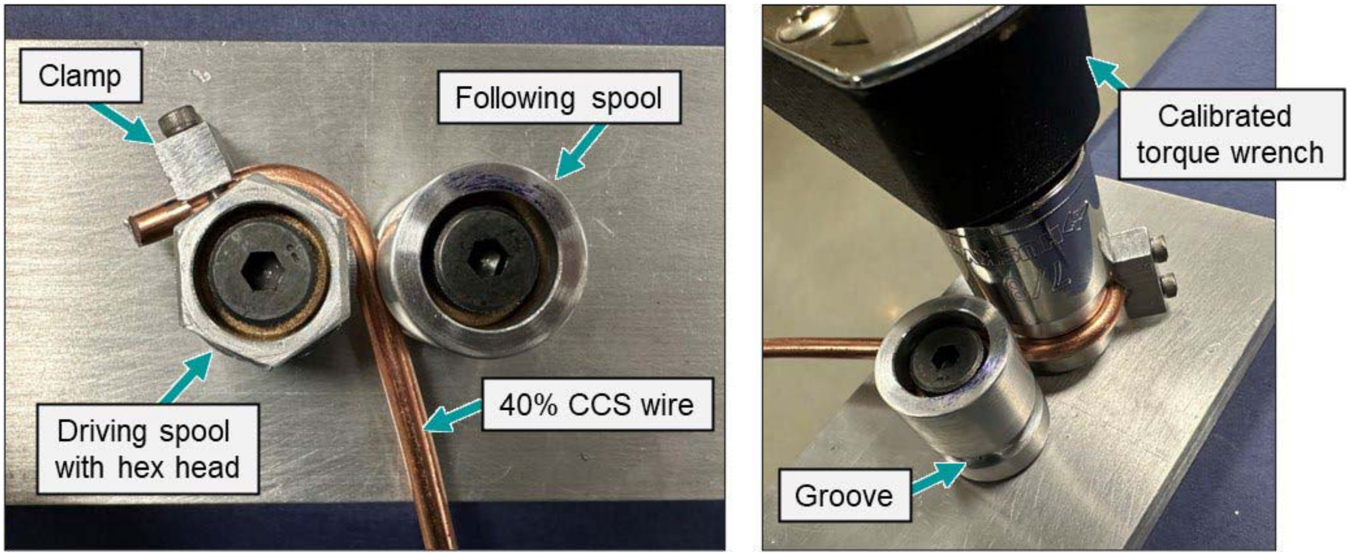

Figure 1. Overview of the testing setup used to determine the torque required to bend 40% CCS wire.

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[1] 40% CCS refers to CCS wires where the nominal wire mass is 40% Cu and 60% is steel.

As shown, two spools with a groove matching the diameter of the wire to be tested were mounted side-by-side on a platform, with enough clearance for the wire to pass in between.[2] Three sets of spools were made, with the grooves matching the diameter of each gauge of the 40% CCS wires tested. The top of the driving spool was shaped as a 7/8” hex bolt and could be driven with a socket wrench;[3] the other extremity of the wire remained free. A calibrated torque wrench was used to rotate the driving spool until the wire was bent to an approximately 90° angle. For each test, the maximum value of the torque was recorded, and the wire angle was measured afterwards via a protractor. The results of the testing are presented below in Table 1.

Table 1. Torque wrench test data.

Sample	Torque (ft-lb [N-m])	Wire Angle (degrees)
4-AWG	6.21 ± 0.07 [8.42 ± 0.10]	91.33 ± 1.25
6-AWG	2.94 ± 0.11 [3.98 ± 0.15]	89.00 ± 0.82
8-AWG	1.50 ± 0.03 [2.04 ± 0.04]	90.67 ± 1.70

As shown, the above-mentioned testing indicated that torque values between approximately 1.5 and 6.2 foot-pounds (ft-lb) were required to bend the 40% CCS wires to an approximately 90° angle, depending on the wire gauge (Table 1). As expected, CCS wires with lower gauges (i.e., larger wire diameters) required more applied torque to achieve the 90° angle when compared to CCS wires with higher gauges.

Literature Review

As part of their job responsibilities, electricians and other technical performers may be required to bend electrical wire, such as during installation or repair. This task is typically accomplished manually using the hands or via pliers held in the hands, and involves the application of torque to the wire generated primarily by forearm musculature executing wrist movement such as pronation-supination or radial-ulnar deviation (Figure 2). Examples of these types of wrist

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[2] The spools were mounted with oil-embedded flanged sleeve bearings to allow for free rotation of the spools.

[3] The driving spool includes a clamping mechanism to secure the extremity of a CCS wire sample.

movement include rotating a screwdriver to drive a screw (wrist pronation-supination) and left-right movement of a mouse across a trackpad (wrist radial-ulnar deviation).

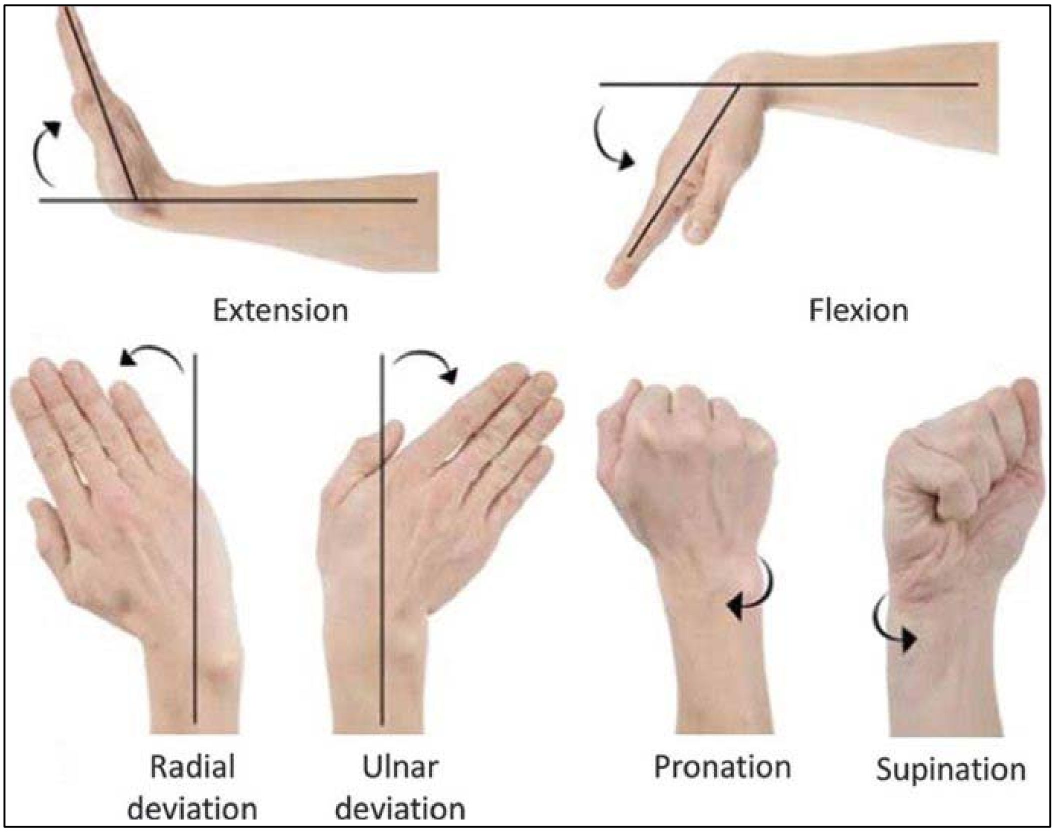

Figure 2. Categories of wrist movement.[4]

According to the peer-reviewed biomechanical and scientific literature, several authors have investigated nominally healthy, adult human wrist strength (i.e., force and torque production capability) across a variety of common tasks without the use of tools.

For example, Norris et al. 2000 quantified the torque required to open the lid of 1.5 liter carbonated drink bottles.[5] These authors reported an average maximum torque of approximately 1.9 to 2.3 ft-lb (2.6 to 3.1 N-m) was produced by males and females aged 20 to 59 years when accomplishing this task.

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[4] Pillemer R. Anatomy and Function of the Wrist. In: Handbook of Upper Extremity Examination. 2022. Springer, Cham. https://doi.org/10.1007/978-3-030-86095-0_5.

[5] Norris B, Hopkinson N, Cobb R, Wilson JR. Investigating a potential hazard of carbonated drinks bottles. Injury Control and Safety Promotion 2000; 7(4):245-259.

Daams 1994 investigated the torque required to open a jam jar lid, and reported approximately 5.9 to 6.9 ft-lb (8.0 to 9.3 N-m) was produced by adult male and female volunteers when performing this task.[6]

Putto 1988, referenced in Peebles 1998, quantified the torque generated while unscrewing light bulbs of various types and at various heights.[7,8] These authors found that the male and female volunteers, aged 23 to 29 years, generated approximately 3.2 to 10.7 ft-lb (4.3 to 14.5 N-m) of torque when accomplishing this task, depending on the light bulb type and vertical location with respect to the volunteer.

Swain et al. 1970 investigated the maximum torque male volunteers aged 22 to 40 years and in the military or electrical/mechanical engineering professions could produce when twisting doorknobs of various diameters with a single hand.[9] Notably, in this experiment the doorknobs were attached to a custom experimental apparatus designed to allow application of the maximal torque the volunteers could produce, which is not the same as the typical torque required to twist a doorknob to open a door. These authors reported that the volunteers maximally produced approximately 38.9 to 84.4 ft-lb (52.8 to 114.4 N-m) during this experiment.

In summary, according to this data, it is expected that the strength required to bend 4-AWG, 6-AWG, and 8-AWG 40% CCS wire using only the hands is similar to, and no more than, that required to complete common tasks, such as unscrewing a jam jar lid or a light bulb.

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[6] Daams BJ. Human force exertion in user-product interaction. 1994. Physical Ergonomics Series, Delftse Universitaire Pers, Delft.

[7] Putto R. Hanteren en kracht. 1988. Thesis, Faculty of Industrial Design Engineering, Delft University.

[8] Peebles L, Norris B. Adultdata: the handbook of adult anthropometric and strength measurements: data for design safety. Department of Trade and Industry, 1998.

[9] Swain AD, Shelton GC, Rigby LV. Maximum torque for small knobs operated with and without gloves. Ergonomics 1970; 13(2):201-208.

Select References

Daams BJ. Human force exertion in user-product interaction. 1994. Physical Ergonomics Series, Delftse Universitaire Pers, Delft.

Eschweiler J, Li J, Quack V, Rath B, Baroncini A, Hildebrand F, Migliorini F. Anatomy, biomechanics, and loads of the wrist joint. *Life* 2022; 12:188. DOI: https://doi.org/10.3390/life 12020188.

Norris BJ, Hopkinson N, Cobb RC, Wilson JR. Potential hazards from carbonated drinks bottles. 1994. Report DB/93/7, Product Safety and Testing Group, Department of Manufacturing Engineering and Operations Management, University Park, Nottingham, UK.

Norris B, Hopkinson N, Cobb R, Wilson JR. Investigating a potential hazard of carbonated drinks bottles. *Injury Control and Safety Promotion* 2000; 7(4):245-259.

Peebles L, Norris B. Adultdata: the handbook of adult anthropometric and strength measurements: data for design safety. Department of Trade and Industry, 1998.

Pillemer R. Anatomy and Function of the Wrist. In: Handbook of Upper Extremity Examination. 2022. Springer, Cham. https://doi.org/10.1007/978-3-030-86095-0_5.

Putto R. Hanteren en kracht. 1988. Thesis, Faculty of Industrial Design Engineering, Delft University.

Swain AD, Shelton GC, Rigby LV. Maximum torque for small knobs operated with and without gloves. *Ergonomics* 1970; 13(2):201-208.

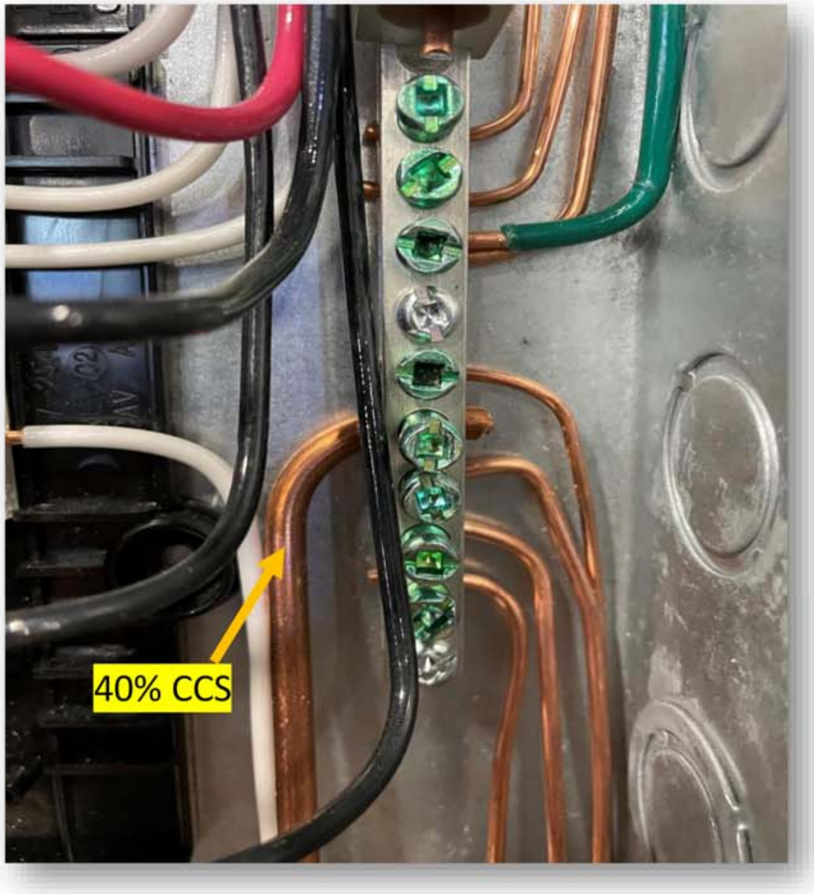
Limitations

This report includes results of work conducted at the request of Copperweld Bimetallics LLC.

The material contained herein is presented to a reasonable degree of scientific and engineering certainty, and may not adequately address the needs of any or all users of this presentation. Any re-use of this presentation, or any of its contents, is made at the sole risk of the user. No guarantee or warranty as to future relevance is expressed or implied. Exponent reserves the right to supplement this presentation and to expand or modify its contents based on review of additional material as it becomes available and/or through any additional work or review of additional work performed by others.

In the presentation, we have relied on materials and information provided by Copperweld Bimetallics LLC. We cannot verify the correctness of this input and rely on Copperweld Bimetallics LLC for accuracy.

Although Exponent has exercised usual and customary care in preparing this summary presentation, the responsibility for the design, manufacture, and quality of their products remains fully with Copperweld Bimetallics LLC.



40% Copper-Clad Steel As a GEC and GE:

As Technically Sound as Copper Plated Steel Traditionally Used in the Grounding Systems of Buildings

Copper Cladding and Copper Electro-Plating Are Different Processes

A Ground Rod is Electro-Plated whereas 40% Copper-Clad Steel is Made by Pressure Welding Copper and Steel by a Specialized Mill

Making Copper Coated Ground Rods

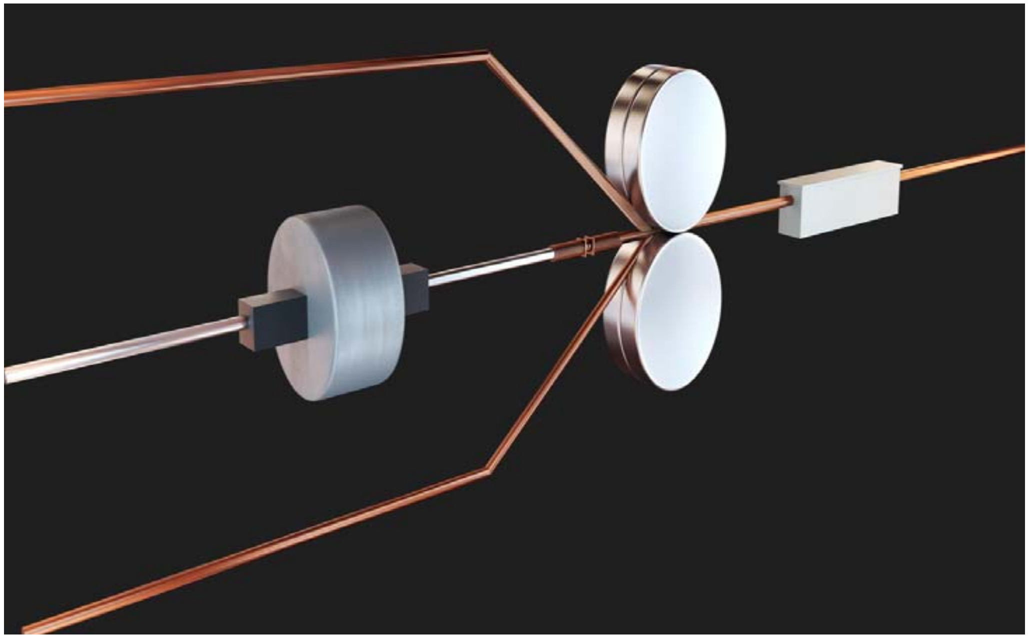
Ground Rods are Electro-Plated in Submersion Tanks as seen below

The Copper Electro-Plating of Steel

Using Electrolysis to Chemically Deposit Copper to Steel

Making Copper-Cladded Steel Wire Rod

40% CCS is made in line by a specialized rod mill



The Copper Cladding of Steel

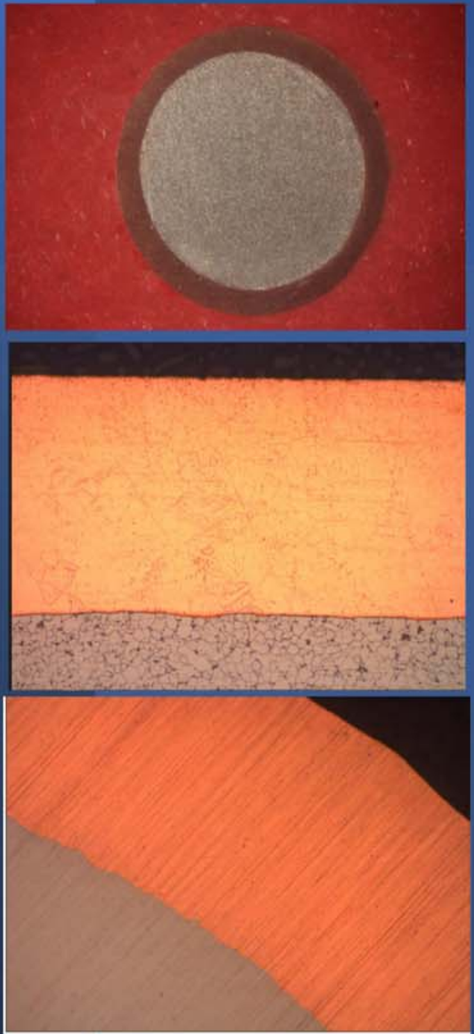
Using Heat and Pressure to Physically Unite Two Single-State Metals

Listed Copper Electro-Plated Ground Rod (GE)

- No Metallurgical Bond
- Coating Volume: 8.59%
- Coating Weight: 9.61%

40% Copper-Clad Steel GEC and GE (UL listing program underway)

- True Metallurgical Bond
- Coating Volume: 40%
- Coating Weight: 38%



Copperweld Bimetallics
Electrical Test Laboratory

Data Sheet Packet

Customer:	Copperweld Building Wire	Engineer:	Bill Lewey	Date:	8/25/2020
Sample ID:	EL-13	Tested By:	Bill Lewey, Mike Rozar	Date:	8/25/2020
Product:	Grade 40 Copper Clad Steel Wire Solid Bare #4 and #6 vs Equivalent Solid Copper: Grounding Electrode Conductor Equivalency Test	Sample Condition:	New		
Standard:	ASTM B910/910M Annealed Copper Clad Steel Wire				
Insulation: N/A - Bare		Jacket: N/A - Bare			

Table of Contents

Test Report Summary

Page	Test Performed	Date Completed	Pass/Fail
1	Grounding Electrode Conductor Test for Copper Clad Steel Grade 40	8/25/2020	**Pass**

Requirement:
#4 AWG Grade 40 Copper Clad Steel and #6 AWG Copper Clad Steel when compared to #4 solid copper and #6 solid copper for use as a grounding electrode conductor shall have equal ability to carry amperage to ground during a ground fault condition.

Conclusion:
The ability of bare #4 AWG Copper Clad Steel Grade 40 and bare #6 AWG Copper Clad Steel Grade 40 performed equally to #4 AWG bare solid copper and #6 AWG bare solid copper when used as a grounding electrode conductor under a ground fault condition. The current measured proved equivalency.

Test Equipment Used

Item	Equipment Type	Equipment #	Cal. Due Date
1	Fluke 374FC Clamp Meter	AM-1	Nov 2020
2	Acme Electric 15KVA Transformer	T2535173S	N/A
3	Square D 60A / 600V Safety Interrupter	N/A	N/A
4	Eaton Service Panel	N/A	N/A
5	Eaton Type CH 20 Amp Breaker	N/A	N/A
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

VBU – Verify Before Use

N/A – Not Applicable

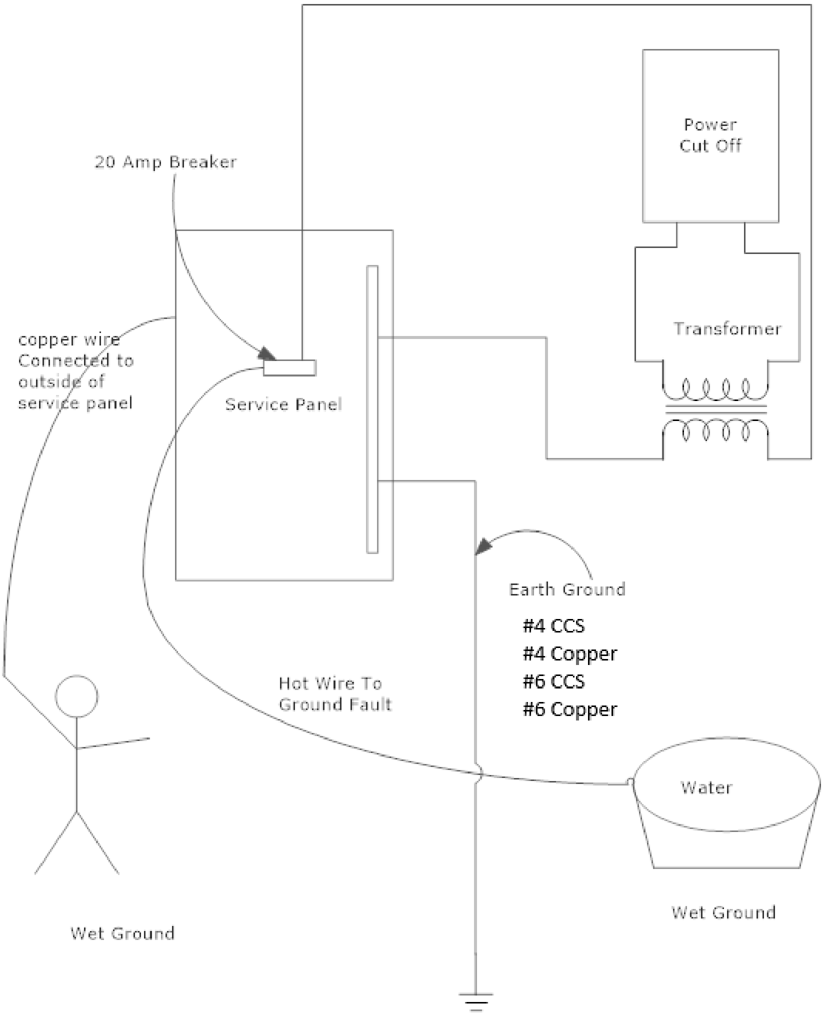
Sample Identification

Item	Description	Length/No. Rec'd
A	#4 AWG Grade 40 Copper Clad Steel Bare	35 Ft
B	#4 AWG Solid Copper Bare	35 Ft
C	#6 AWG Grade 40 Copper Clad Steel Bare	35 Ft
D	#6 AWG Solid Copper Bare	35 Ft
E		
F		

Grounding Electrode Conductor Test

Test Parameters:	
Conditioning:	No preconditioning.
Test Conductors:	1 each of #4 AWG/Grade 40 CCS Solid Bare grounding electrode conductor 1 each of #6 AWG/Grade 40 CCS Solid Bare grounding electrode conductor 1 each of #4 AWG Solid Bare copper grounding electrode conductor 1 each of #6 AWG Solid Bare copper grounding electrode conductor
Test Conductor Length:	Each conductor shall be 35 ft.
Test Circuit Configuration:	See schematic shown in Figure 1
Test Current:	Test current from 120 V / 20 A Residential Circuit
Method:	Testing was completed by creating a standard residential test circuit at 120V with 20A breaker wired to an intentional ground fault as shown in figure 1. The ground fault was created by connecting a hot wire from the breaker to a galvanized steel pan full of water and placing the pan on the wet ground. A conductor was also connected to the outside of the electrical panel and a Copper Plated Grounding Electrode (Copperweld Ground Rod) driven 6 inches into the wet ground to determine amount of current going through a grounded person touching the electrical panel during the ground fault condition. The ground fault and the grounded "man" were positioned 20 feet either side of the ground rod. The entire test area was soaked with water overnight using a sprinkler system When the ground fault was electrified, current measurements were taken from the ground fault conductor, the grounding electrode conductor and the grounded "man" conductor. For the four grounding electrode conductors tested, there was one test sequence for each. The current was measured for each. The objective: Compare the amperage measurements of the copper clad steel grounding electrode conductors to those of copper.

Figure 1



Results:			
Ground Conductor	Fault Conductor Current	Current of the Grounding Electrode Conductor	Grounded Man Conductor Current
#4 Copper	2.1 A	1.8 A	0.3 A
#4 40% CCS	2.1 A	1.8A	0.3 A
#6 Copper	1.7 A	1.6 A	0.1 A
#6 40% CCS	1.5 A	1.4 A	0.1 A

Requirement:

For equivalent sizes of Grade 40 Copper Clad steel vs. solid copper grounding conductors, the ability to carry amperage to ground during a ground fault condition is equal.

Comments:

____X__ (Pass) The product complies with all applicable requirements of this test.

________ (Fail) The product does not comply with the requirements of this test.

Test Date: 8/25/2020 **Tested By: Bill Lewey**

Environmental Conditions during Testing:

Humidity: % rh __74%________ Ambient: °C___28_______

Test setup for the electrical service panel

Ground Rod with Grounding Conductor Attached

Ground Fault

Grounded “man”

Mechanical Testing of 40% Copper Clad Steel (CCS) Wires

Mechanical Testing of 40% Copper Clad Steel (CCS) Wires

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Acronyms

A	ampere or amps
Al	aluminum
AWG	American Wire Gauge
CCS	copper clad steel
40% CCS	copper clad steel where copper constitutes 40% of the mass of the material
Cu	copper
DIC	digital image correlation
GEC	grounding electrode conductor
Hz	hertz
in	inch
mm	millimeters
NEC	National Electric Code, or NFPA 70
NFPA	National Fire Protection Association
NI	National Instruments
px	pixel
UL	Underwriters Laboratories
V	volt or volts
μm	micrometer or micron
με	microstrain

1.0 Introduction

1.1 Overview

1. The National Electric Code (NEC) is a set of standards and guidelines for electrical installations in the United States; more specifically, it provides requirements for the installation of electrical wiring, equipment, and systems in residential, commercial, and industrial buildings. Currently, copper plated steel is permitted by Article 250 of the NEC for use as a grounding electrode in the form of copper coated grounding rods,[1] whereas copper clad steel (CCS) is not. Furthermore, CCS wires are not specified as a material of use as a grounding electrode conductor (GEC).[2] A GEC is defined by the NEC as "[a] *conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system*."[3]

2. During the submission cycle for the 2023 edition of the NEC, 40% CCS was proposed as a material of use for GECs,[4] but was not accepted, in part, because "*no technical substantiation was provided to ensure that under expected conditions of use* … [CCS] *can be bent and installed without stressing terminations within equipment*."[5]

3. At the request of Copperweld Bimetallics LLC, Exponent designed and performed mechanical testing of 40% CCS wires to determine if, when terminated onto a neutral busbar, the 40% CCS wires cause levels of stress/strain that could result in damage and/or fracture of the terminations and adjacent components inside conventional panelboards.

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[1] NEC 2023, §250.

[2] Copper clad steel is a composite material featuring a metallurgical bond between a central steel core and an outer layer of copper.

[3] NEC 2023, §100.

[4] In the context of this testing, 40% CCS refers to CCS wires where the nominal wire mass is 40% Cu and 60% is steel (or approximately 36% of the cross-sectional area is Cu, and approximately 64% of the cross-sectional area is steel).

[5] NEC 2023 First Draft Technical Committee FINAL Ballot Results (A22); Code-Making Panel 5 (NEC-P05). Accessed July 12, 2023. https://www.nfpa.org/assets/files/AboutTheCodes/70/70_A2022_NEC_P05_FD_ballotfinal.pdf, PDF pp. 3, 92, 161, 178.

1.2 Test Objective

4. The objective of this testing protocol is to determine the stresses/strains imposed on terminations and adjacent components (e.g., the neutral busbar and connected metal and/or plastic components) on conventional panelboards due to the installation of 40% CCS wires.

2.0 Executive Summary

5. The results from this study indicate that free-standing 40% CCS wires, that were bent, do not retain any residual stresses that would cause the wires to return to their original position (i.e., spring back).

6. The results from this study indicate that terminated 40% CCS wires will not impose additional strains on the terminations and adjacent components (e.g., the busbar and connected metal and/or plastic components) that could result in damage that would render the panelboard unusable.

    6.a. Additional external strains imposed on the 40% CCS wires after termination, intended to induce a relatively high amount of strain in the respective panelboard after termination of the 40% CCS wire (such as if an electrician roughly bent/pulled the wires after termination), are not sufficient to permanently damage and/or break the termination and adjacent components.

    6.b. Moreover, subjecting the terminations to sufficient additional external strain to induce permanent damage to the plastic backing components resulted in strains that were significantly higher than the average recorded values after termination/clamping of the 40% CCS wires.

7. In general, the results from this study indicate that the greatest amount of strain on each panelboard was observed during tightening of the lug to terminate the neutral service conductor that was installed into the panelboard before the 40% CCS conductors. This strain returned close to its pre-termination state after the service neutral had been terminated to its specified tightening torque.

3.0 Testing Overview

8. Exponent conducted mechanical testing of 40% CCS wires to be used as GECs to determine the extent of stress/strain on the terminations. This was done through a combination of strain gauges (instrumented on the panelboards), video camera monitoring of the panelboards, and digital image correlation (DIC) described below. Testing was performed for a period of between four and five weeks; additional descriptions of the test setups are in Section 4.0 below.

3.1 Test Materials

9. Three gauges of 40% CCS wire, 8-AWG, 6-AWG, and 4-AWG were tested in 70A, 125A, and 200A panelboards, respectively.

    9.a. The panelboards selected for testing are used in residential applications. Specifically, the following panelboards were used:

        9.a.i. Square D Homeline 70 Amp Breaker (i.e., 70A Panelboard),[6]

        9.a.ii. GE PowerMark Gold 125 Amp Breaker (i.e., 125A Panelboard),[7] and

        9.a.iii. Siemens PN Series 200 Amp Breaker (i.e., 200A Panelboard).[8]

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[6] "Square D Homeline 70 Amp 2-Space 4-Circuit Indoor Surface Mount Main Lug Load Center with Cover HOM24L70SCP." n.d. The Home Depot. Accessed July 18, 2023. https://www.homedepot.com/p/Square-D-Homeline-70-Amp-2-Space-4-Circuit-Indoor-Surface-Mount-Main-Lug-Load-Center-with-Cover-HOM24L70SCP/100202333.

[7] "GE PowerMark Gold 125 Amp 24-Space 24-Circuit Indoor Main Lug/ Main Lug Kit Value Kit Includes Select Circuit Breaker TLM2412CCUG1K." n.d. The Home Depot. Accessed July 18, 2023. https://www.homedepot.com/p/GE-PowerMark-Gold-125-Amp-24-Space-24-Circuit-Indoor-Main-Lug-Main-Lug-Kit-Value-Kit-Includes-Select-Circuit-Breaker-TLM2412CCUG1K/100135380.

[8] "Siemens PN Series 200 Amp 40-Space 40-Circuit Main Breaker Plug-on Neutral Load Center Indoor with Copper Bus PN4040B1200C." n.d. The Home Depot. Accessed July 14, 2023. https://www.homedepot.com/p/Siemens-PN-Series-200-Amp-40-Space-40-Circuit-Main-Breaker-Plug-On-Neutral-Load-Center-Indoor-with-Copper-Bus-PN4040B1200C/312138643.

9.b. The 40% CCS GEC sizes were compliant with UL 67 (13th Edition) "*UL Standard for Safety Panelboards*" Table 18.1 based upon the panelboards selected for testing.[9]

9.c. Neutral service conductors selected were compliant with Table 250.66 in the 2023 edition of the NEC ("*Grounding Electrode Conductor for Alternating Current Systems*").[10]

10. A summary of the rated panelboards, GECs, and service neutrals used for the mechanical testing described herein is provided in Table 1.

Table 1 – Summary of Panelboards and GEC/Neutral Service Tested

Panelboard Rating	GEC Size / Material	Service Neutral Size / Material
70A	8-AWG Solid CCS	2-AWG Stranded Al
125A	6-AWG Solid CCS	2/0-AWG Stranded Al
200A	4-AWG Solid CCS	4/0-AWG Stranded Al

11. In addition to the panelboard setups described above, the 40% CCS wires were also bent to approximately 90° and monitored through video camera / DIC. This test was done to observe any change in geometry (such as moving from a 90° angle back to its original straight form) over time when unconstrained (or "free wire test").

3.2 Test Setup

12. The testing setup comprised a combination of strain gauges, video monitoring, and DIC:

12.a. The panelboards used were instrumented with strain gauges at regions of interest adjacent to the busbar where the 40% CCS GEC was terminated to measure the

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[9] UL 67, 13th Edition, UL Standard for Safety Panelboards, Table 18.1 "*Size of grounding electrode conductor and main bonding jumper*." 2018.
The 70A panelboard ampere rating was not listed; thus, the smallest GEC was selected (8-AWG for a 90A panelboard).
The GEC sizes were selected assuming that equally sized CCS wire can be used in place of copper wire (e.g., 4-AWG Cu for 4-AWG CCS).

[10] NEC 2023, Table 250.66.
The neutral service conductors were made of stranded aluminum (Al) wire.

amount of deformation (strain) experienced by the panelboard when subjected to the load induced through the termination.[11]

12.a.i. All strain gauges that were applied to the plastic components of each panelboard are 120 ohm, 2 mm x 3 mm, prewired linear strain gauges.[12] The strain gauges used on busbars are 350 ohm, 0.1 in. x 0.235 in., prewired linear strain gauges.[13]

12.a.ii. The strains on the 200A panelboard were measure in half-bridge mode. All other strains were measured in quarter-bridge mode with an additional strain gauge for temperature compensation.[14] The measurements were performed with a National Instruments (NI) cDAQ-9174 USB CompactDAQ Chassis and two calibrated NI-9237 cDAQ Strain/Bridge Input Module with a 2.5 V excitation voltage.

12.a.iii. All data were recorded with National Instruments FlexLogger software.

12.b. Additionally, all of the panelboards and free wires were monitored with video cameras (with images taken approximately every 30 minutes) to provide visual documentation of the entire testing process, allowing the entire systems to be analyzed for deformation over time.

12.c. Finally, several components (such as the free wires and the plastic backing for the 200A panelboard) were also analyzed through DIC, which is a non-contact optical technique used in materials testing and engineering to measure and analyze the deformation and strain of objects or surfaces. It involves applying a "speckle" pattern,[15] capturing a series of images of a specimen both before and after

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[11] Strain gauges are commonly employed in engineering and materials testing to monitor and analyze the behavior of structures, components, and materials under various conditions.

[12] Omega Engineering pre-wired strain gauge, model KFH-6-120-C1-11L3M3R.

[13] Micro-Measurements pre-wired strain gauge, product number MMF403739.

[14] In a half-bridge setup, two strain gauges are positioned at right angles to each other to increase sensitivity and counteract Poisson's effect. If space is limited, a quarter-bridge setup with one passive strain gauge was used to address temperature changes during testing.

[15] A speckle pattern in DIC refers to a random and contrast-rich arrangement of small, distinct dots (speckles) applied on the surface of an object or specimen. These speckles serve as unique identifiers for tracking displacement and deformation for DIC analysis.

deformation using a camera, and then comparing these images, tracking the movement of the speckle pattern, and determining the difference. All DIC analysis were performed with GOM Correlate software (Carl Zeiss GOM Metrology GmbH).

13. Following the installation of strain gauges and video monitoring equipment, for each panelboard, one neutral service conductor was terminated onto the neutral busbar, and subsequently one 40% CCS wire was bent and terminated onto the same neutral busbar.[16] These wires were terminated to the appropriate tightening torque (by using a calibrated torque wrench), as defined in either the panelboard manual, or the NEC Table I.1.[17] The tightening torques used for the mechanical testing are summarized below in Table 2.

Table 2 – Summary of Tightening Torques used for Terminations

Panelboard Rating	GEC (lbf-in)	Service Neutral (lbf-in)
70A	25	50
125A	45	50
200A	35	250

14. After termination of both the service neutral and the 40% CCS GEC, the samples were then manipulated to induce additional strain on the system without plastically deforming the 40% CCS wire compared to the original termination (similar to an electrician pulling/bending the wire after termination). After the high strain point was determined, the 40% CCS wire was then clamped in that position to ensure that the termination equipment would remain in this higher strain state.

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[16] The CCS wires used for testing were bent to an approximately 3/8” bend radius.

[17] NEC 2023, Table I.1.

15. The strain data were recorded with a 1 Hz frequency. The strain data (reported in microstrain or με) vs. time plots for each panelboard are reported in the relevant sections of this report.

    15.a. For clarity, the overall strain data are reported as an hourly average of the measured data as no transient spike in strain was observed <u>after</u> termination and clamping.

    15.b. However, the strain data measured during termination of the neutral service conductor, termination of the 40% CCS wire, and clamping of the 40% CCS wire for each panelboard (where significant strain variation occurred) are also reported at 1 Hz (i.e., without averaging).

16. The specific details of each testing setup are described in further detail below.

4.0 Testing Setup and Results

4.1 Free Wire Test

17. Two sets of 40% CCS wire, with each set comprising three different gauges of 40% CCS (8-AWG, 6-AWG, and 4-AWG), were bent to approximately 90° and monitored through a video camera over time (see Figure 1 below).

17.a. One set of wires was painted with a speckle pattern (left set of wires, see the white dots of paint on top of the black-painted wire) to enable the strain to be calculated through DIC.

17.b. The other set of 40% CCS wires (right) was simply bent and monitored, with no painting applied.

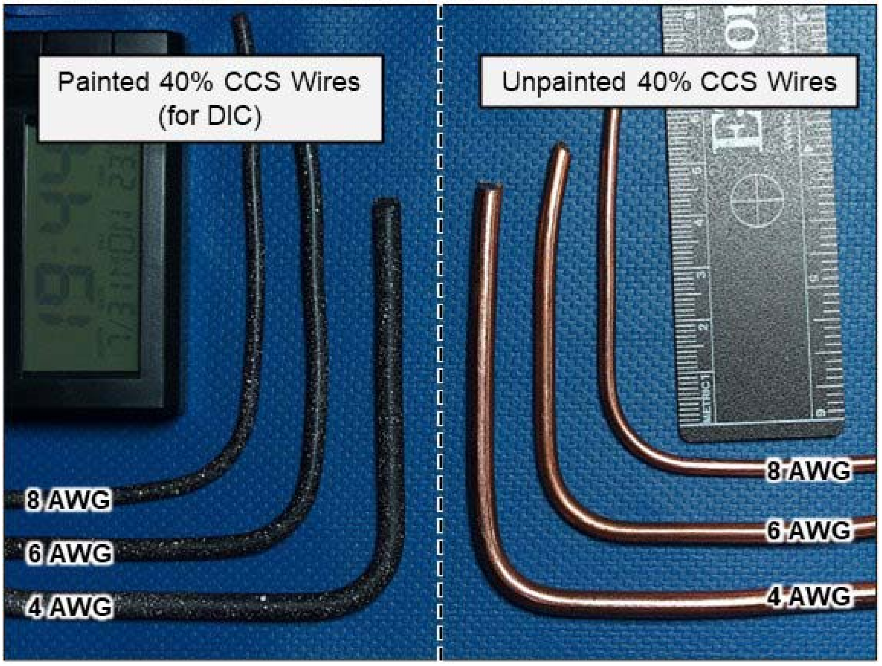

Figure 1. Setup of the free wire testing at the start of testing. As shown, two sets of CCS wire were bent to approximately 90° angles and monitored.

18. Photographs from the video monitoring system were taken approximately every 30 minutes. The difference between the photos from the start and end of testing (approximately four weeks) were compared qualitatively from an examination of the

photographs, and quantitatively through DIC (on the painted/patterned set of wires). The first and last images used for analysis is shown in Figure 2 below.

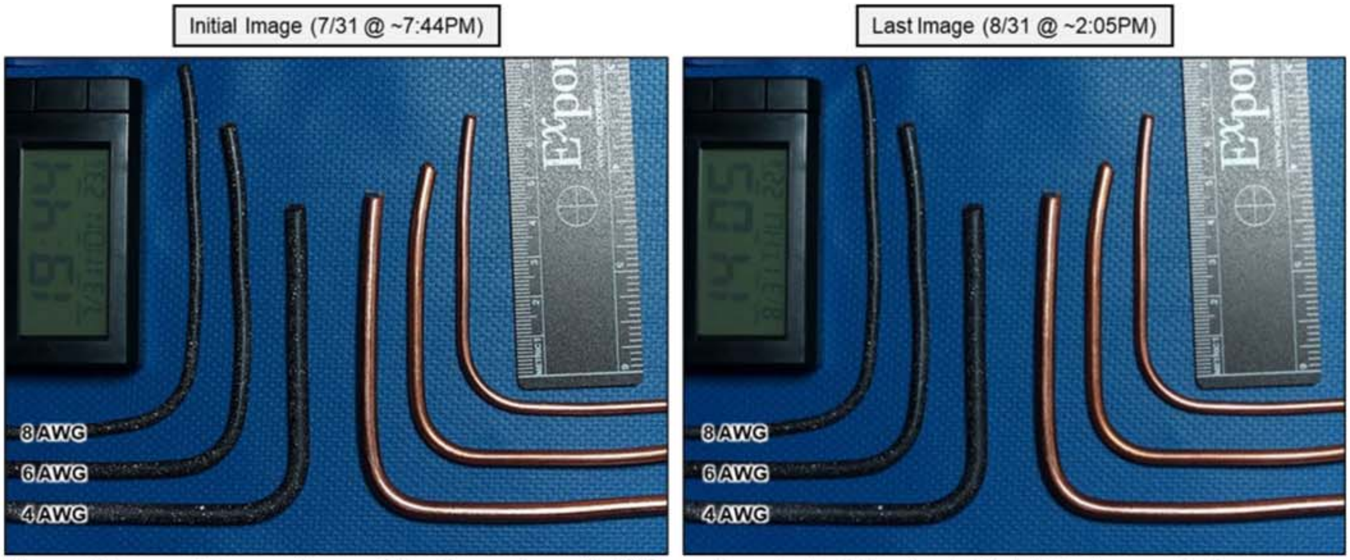

Figure 2. Comparison of the free wires (left) from the start of the test; (right) to the end of the test. The difference in time between photographs constitutes approximately four weeks.

19. The maximum displacement on each wire gauge was computed between the first and last image (for the set painted for DIC) and displayed on the last image as shown in Figure 3 below.

    19.a. As shown, the maximum displacement, and the displacement along the X- and Y-directions, for each of the three wires is reported for several representative points.

    19.b. In this case, all the displacement measurements are at or below the noise floor (i.e., lower limit of discernible signal quality),[18] indicating that no motion of the free wires was detectable during the length of the test.

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[18] Noise level in images is due to the quality of the speckle pattern, noise in the image acquisition system, variability in lighting, and various external factors including the presence of vibrations or variations in temperature.
While the software used to calculate DIC can detect sub-pixel displacements on the order of magnitude of 0.01 px, the noise threshold in images is typically of the order of 0.1 px (or, 4.2 μm in this case).
Reu, Phillip L. 2016. "A Realistic Error Budget for Two Dimension Digital Image Correlation." *Conference Proceedings of the Society for Experimental Mechanics*, January, 189–93. https://doi.org/10.1007/978-3-319-22446-6_24.
A practical guide to DIC. Accessed August 30, 2023. https://digitalimagecorrelation.org/.

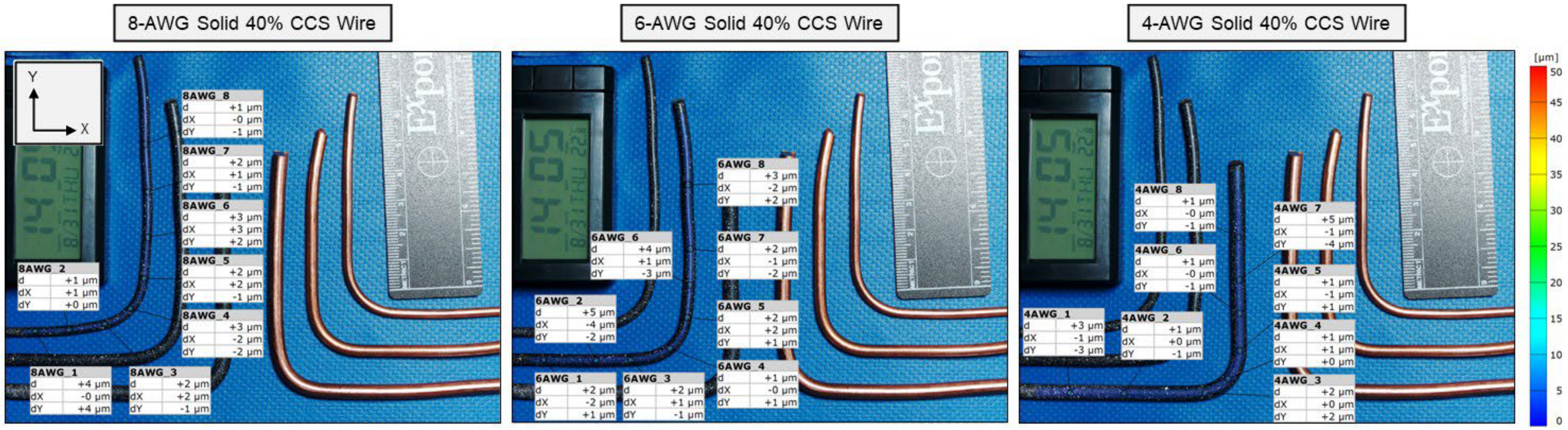

Figure 3. DIC data on the painted free wires approximately 4 weeks after bending to a 90° angle.

4.2 70A Panelboard Test

20. As described in Section 3.1, an 8-AWG solid 40% CCS wire was used in the 70A panelboard used for the mechanical testing. An overview of this panelboard, along with the locations of the strain gauges, is shown in Figure 4 below.

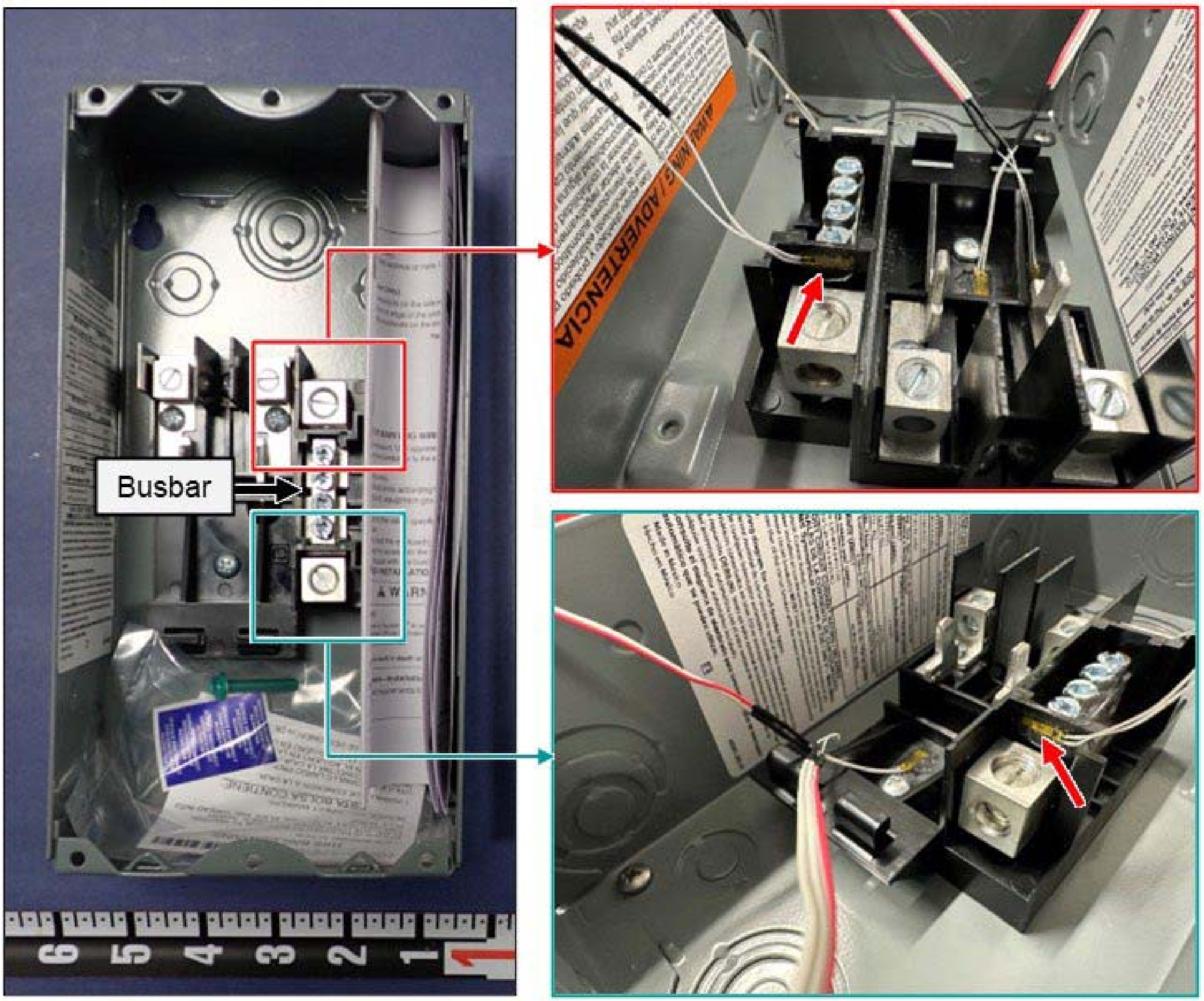

Figure 4. (Left) Overview photograph of the 70A panelboard used for mechanical testing. (Right) The location of the strain gauges used to measure deformation of the termination equipment in this panelboard are noted with the red arrows. Additional strain gauges (not noted) were used as reference gauges to account for variations in temperature.

21. As shown, the 70A panelboard contains a single busbar (with four terminations) connected to mechanical lugs. The busbar is located atop and in between layers of black

plastic backing. Strain gauges were placed on either side of the plastic backing because that is the portion of the termination equipment that constrains the busbar (which is free to move around) and therefore is expected to experience the highest strain.

22. After the strain gauges were installed, the service neutral conductor was terminated, and subsequently the 40% CCS wires was bent and terminated onto the busbar at the specified tightening torques.[19] The 40% CCS wire was then manipulated to induce a relatively high strain on the termination equipment, and then clamped at that location. The final configuration for the start of the mechanical test is shown below in Figure 5.

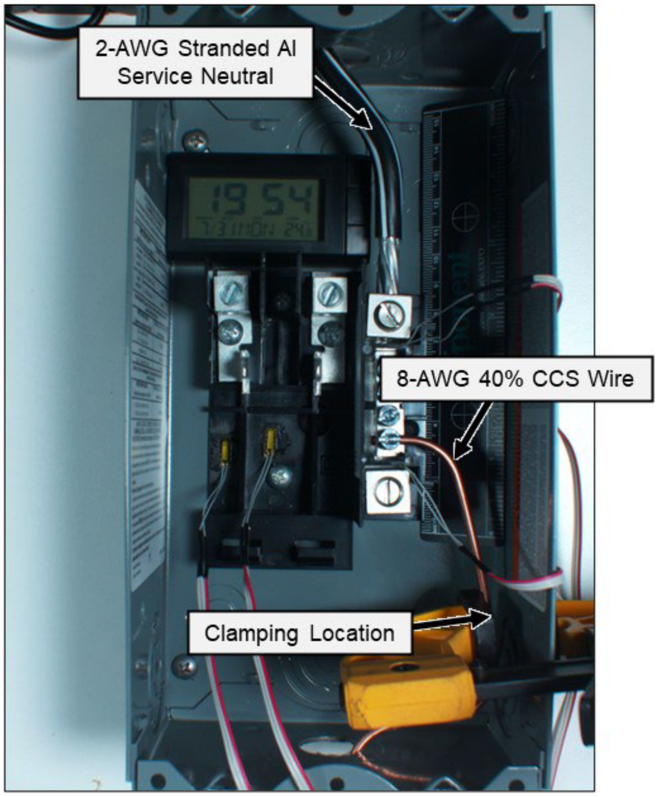

Figure 5. Configuration of the 70A panelboard for mechanical testing, with the service neutral, 40% CCS wire, and clamping location annotated.

23. The sample was then left for monitoring for a period of approximately five weeks. The strain values recorded from the strain gauges over this time period are shown below in Figure 6.

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[19] Refer to Table 2 for the tightening torques used for each panelboard.

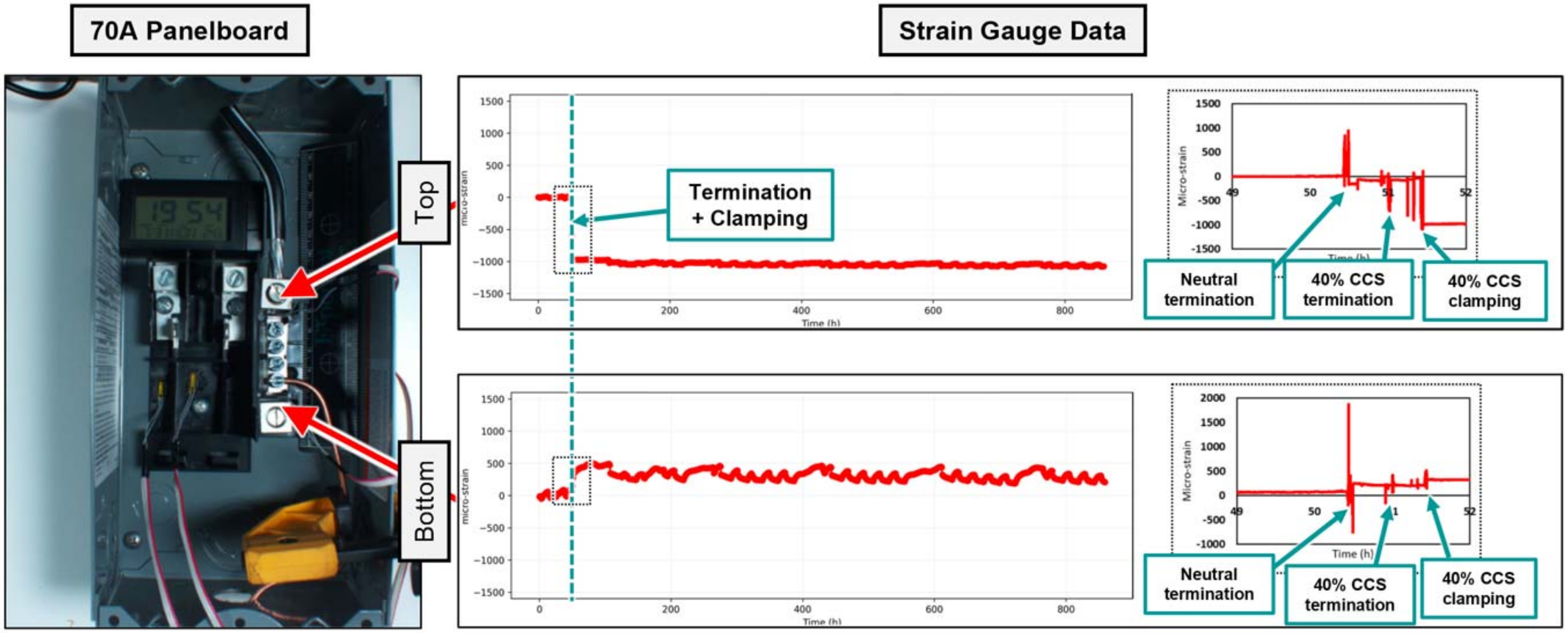

Figure 6. (Left) Photograph of the 70A panelboard. (Right) The strain gauge data from the top and bottom gauges (noted with the red arrows). The data on the main plot is reported as an hourly average of the strain data; zoomed in plots (noted with the boxes with dashed lines) of the strain during termination and clamping are shown in the rightmost plots, with the specific strains after termination of the neutral service conductor, termination of the 40% CCS wire, and clamping of the 40% CCS wire annotated.

24. As shown, the overall strain values recorded from the strain gauges were highest during neutral service conductor termination. The strain values recorded from the strain gauges jumped immediately after terminating / clamping the 40% CCS wire but remained relatively steady throughout the testing period.

   24.a. The neutral conductor installation led to the highest absolute values in both strain gauges. Strain peaked at +942 με and +1869 με at the top and bottom strain gauges, respectively. After the neutral conductor was terminated, the strain values stabilized to around -80 με and +210 με for the top and bottom strain gauge, respectively.

   24.b. The 40% CCS wire was then terminated at the lowest terminal (farthest from the service neutral) as shown in Figure 5. This is reflected through the top strain gauge reading at approximately -702 με, and the bottom strain gauge reading approximately +420 με.[20]

   24.c. Next, additional strain was induced into the system by clamping the 40% CCS wire, adding a bending moment on the system. Immediately after installation, peak strains of -1086 με and +513 με were recorded at the top and bottom strain gauges, respectively.

   24.d. The strain rapidly stabilized and remained constant during the remainder of the test with the top and bottom strain gauges reading at approximately -1033 με and +335 με, respectively.

25. This relative consistency of the strain gauge data over the testing period indicates that no additional strains (and therefore stresses) are being induced into the system after 40% CCS wire termination. Moreover, as stated in ¶24.a above, the highest overall strain introduced into the system was during termination of the neutral service conductor.

26. Furthermore, comparing photographs before and after testing show no discernible change in the 70A panelboard termination system, as shown below in Figure 7.

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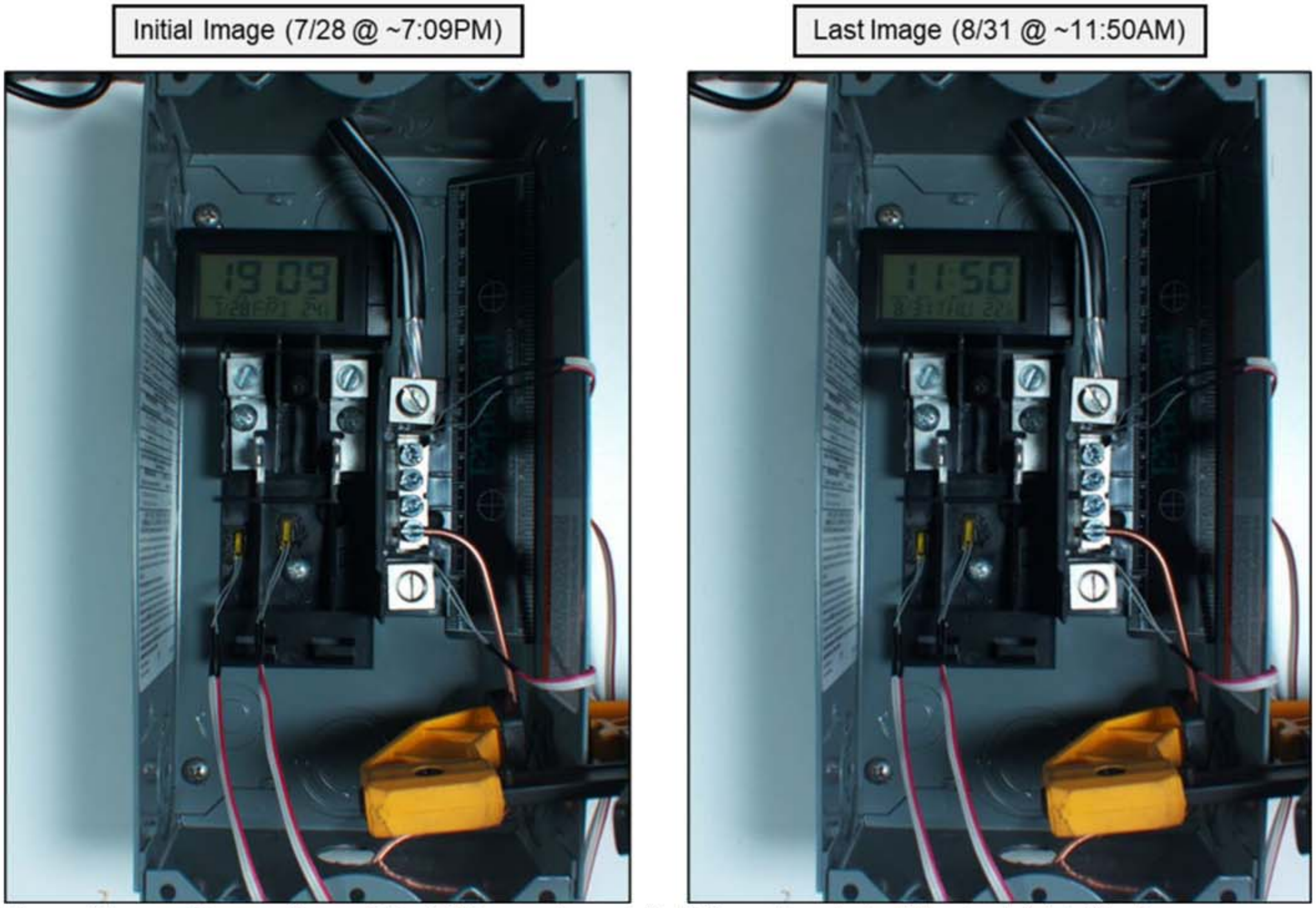
[20] The bottom strain gauge has more variation likely due to drift associated with that specific strain gauge, which can also be seen in the pre-terminated data.



Initial Image (7/28 @ ~7:09PM)

Last Image (8/31 @ ~11:50AM)

Figure 7. Comparison of the 70A panelboard (left) from the start of the test; (right) to the end of the test. The difference in time between photographs constitutes approximately five weeks.

27. At the end of the test, additional mechanical load was manually applied to the busbar to quantify the strain required to induce permanent damage to the plastic backing of the panel. As shown below in Figure 8, a clamp was applied between the neutral conductor and the right side of the panel. The maximum strain recorded was -5675 με for the top strain gauge and +5215 με for the bottom strain gauge, which corresponds to around 6 to 16 times higher than the average absolute values recorded after 40% CCS wire installation.

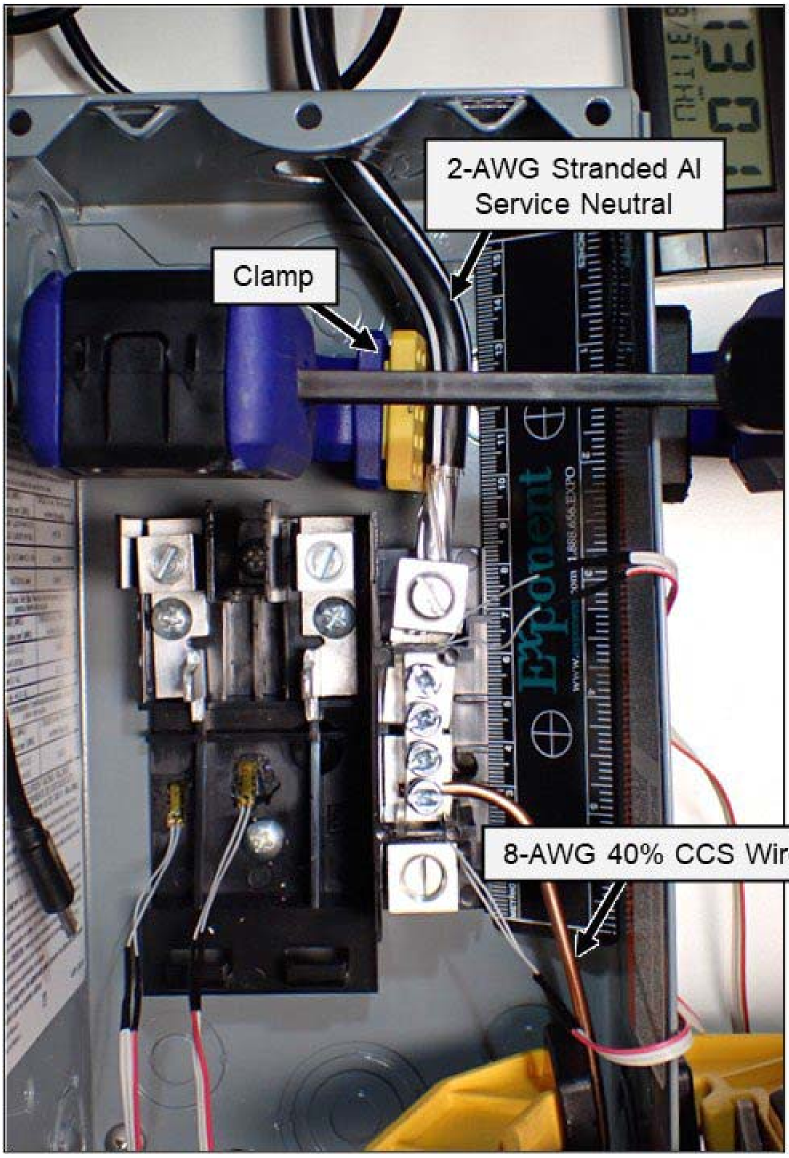


Figure 8. Photograph showing the additional clamp / mechanical load induced onto the 70A panelboard intended to result in permanent damage to the plastic components.

4.3 125A Panelboard Test

28. As described in Section 3.1, a 6-AWG solid 40% CCS wire was used in the 125A panelboard used for the mechanical testing. An overview of this panelboard, along with the locations of the strain gauges, is shown in Figure 9 below.

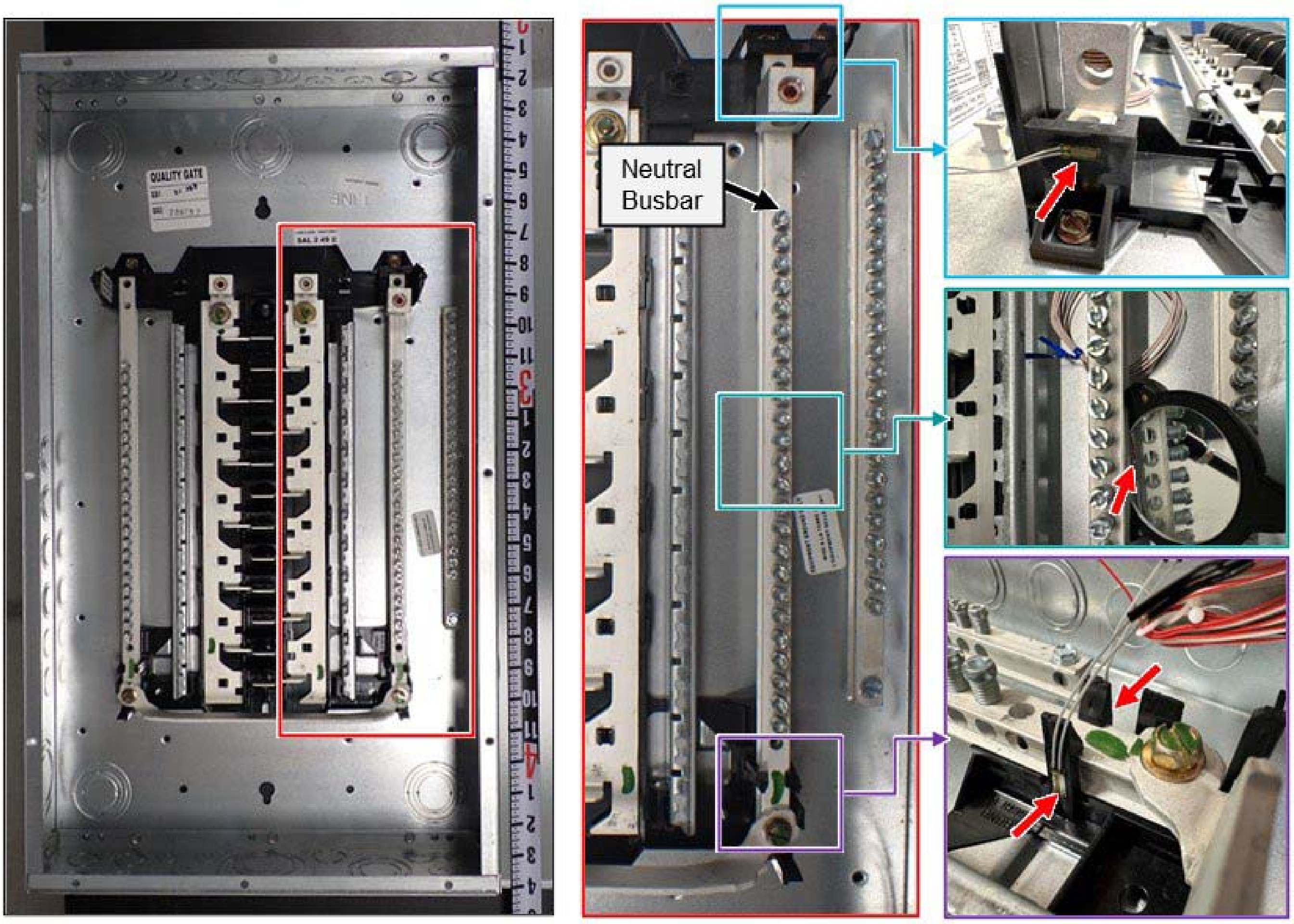


Figure 9. (Left) Overview photograph of the 125A panelboard used for mechanical testing. (Middle) Close-up of the neutral busbar where the 40% CCS wire is set to be terminated. (Right) Locations of the strain gauges (indicated by the red arrows) on the neutral busbar and plastic backing, which is mechanically connected to the busbar.

29. As shown, the neutral busbar is mechanically connected to the busbar through the plastic backing by being fastened into two plastic clips at the bottom of the panelboard (purple box) and then sliding into a pocket on the top of the panelboard (blue box). Strain gauges were placed at these locations to measure the busbar deformation if it slid along its axis. A strain gauge was also placed on the underside of the neutral busbar (teal box, located around the middle of the busbar) as it was the most compliant portion of the busbar (similar to a beam constrained at its ends) where deformation would readily occur.

30. After the strain gauges were installed, the service neutral and 40% CCS wires were terminated onto the busbar at the specified tightening torques.[21] The 40% CCS wire was terminated at the center of the busbar (above the strain gauge) as this location would induce the highest bending moment on the system. The 40% CCS wire was then manipulated to induce a relatively high strain on the termination equipment, and then clamped at that location. The final configuration for the start of the mechanical test is shown below in Figure 10.

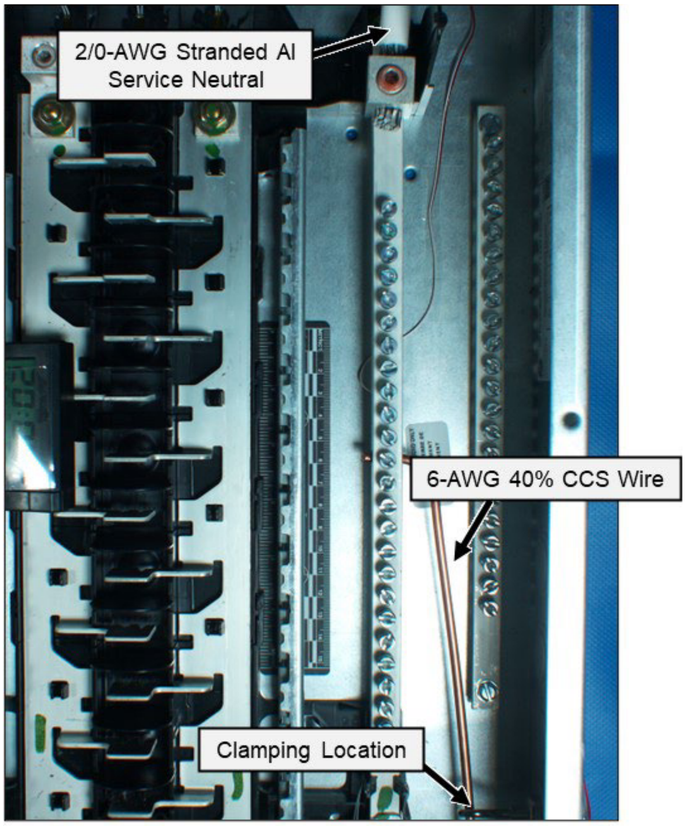


Figure 10. Configuration of the 125A panelboard for mechanical testing, with the service neutral, 40% CCS wire, and clamping location annotated.

31. The sample was then left for monitoring for a period of approximately five weeks. The strain values recorded from the strain gauges on the plastic backing (at the top and bottom of the of the neutral busbar) and the neutral busbar over this time period is shown below in Figure 11.

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[21] Refer to Table 2 for the tightening torques used for each panelboard.

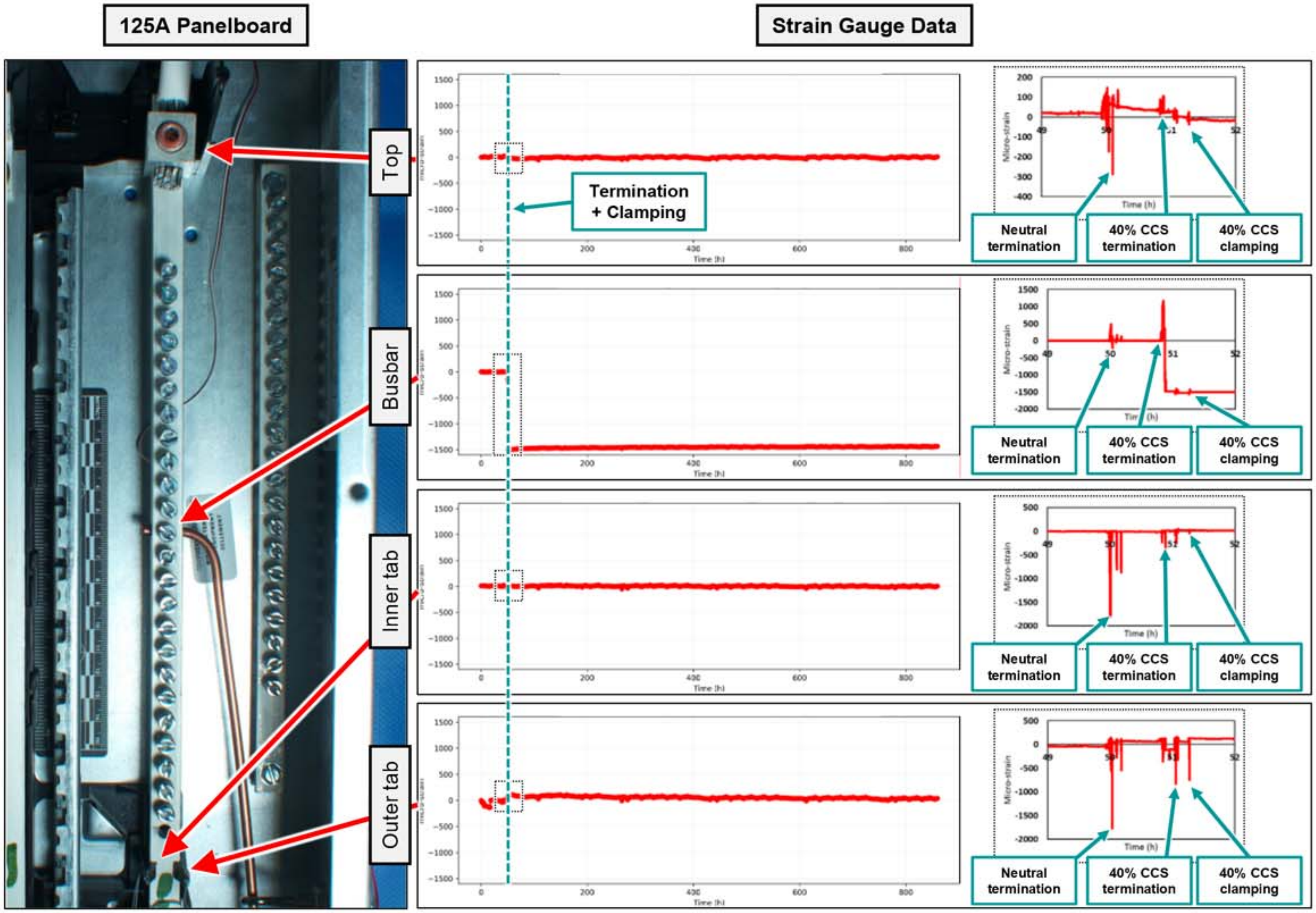


Figure 11. (Left) Photograph of the 125A panelboard. (Right) The strain gauge data from the different gauges (noted with the red arrows). The data on the main plot is reported as an hourly average of the strain data; zoomed in plots (noted with the boxes with dashed lines) of the strain during termination and clamping are shown in the rightmost plots, with the specific strains after termination of the neutral service conductor, termination of the 40% CCS wire, and clamping of the 40% CCS wire annotated.

32. The strain values recorded from the strain gauges were generally at their highest during neutral service termination. Further, the strain values jumped immediately after terminating / clamping the 40% CCS wire but remained relatively steady throughout the testing period.

  32.a. The neutral conductor installation led to the highest absolute values applied to the three strain gauges on the plastic backing during the entire duration of the test. Strain reached -283 με at the top of the panel, and -1794 με and -1754 με at the bottom inner and outer plastic tabs, respectively. The strain on the busbar was also significant with a maximum recorded value of +489 με. After the neutral conductor was terminated, the strain returned to values below +75 με for all strain gauges.

  32.b. The termination of the 40% CCS wire increased the strain in the plastic panel. Strain reached +104 με at the top of the panel and -393 με and -828 με at bottom inner and outer plastic tabs, respectively. The strain on the busbar reached +1173 με during 40% CCS wire installation.

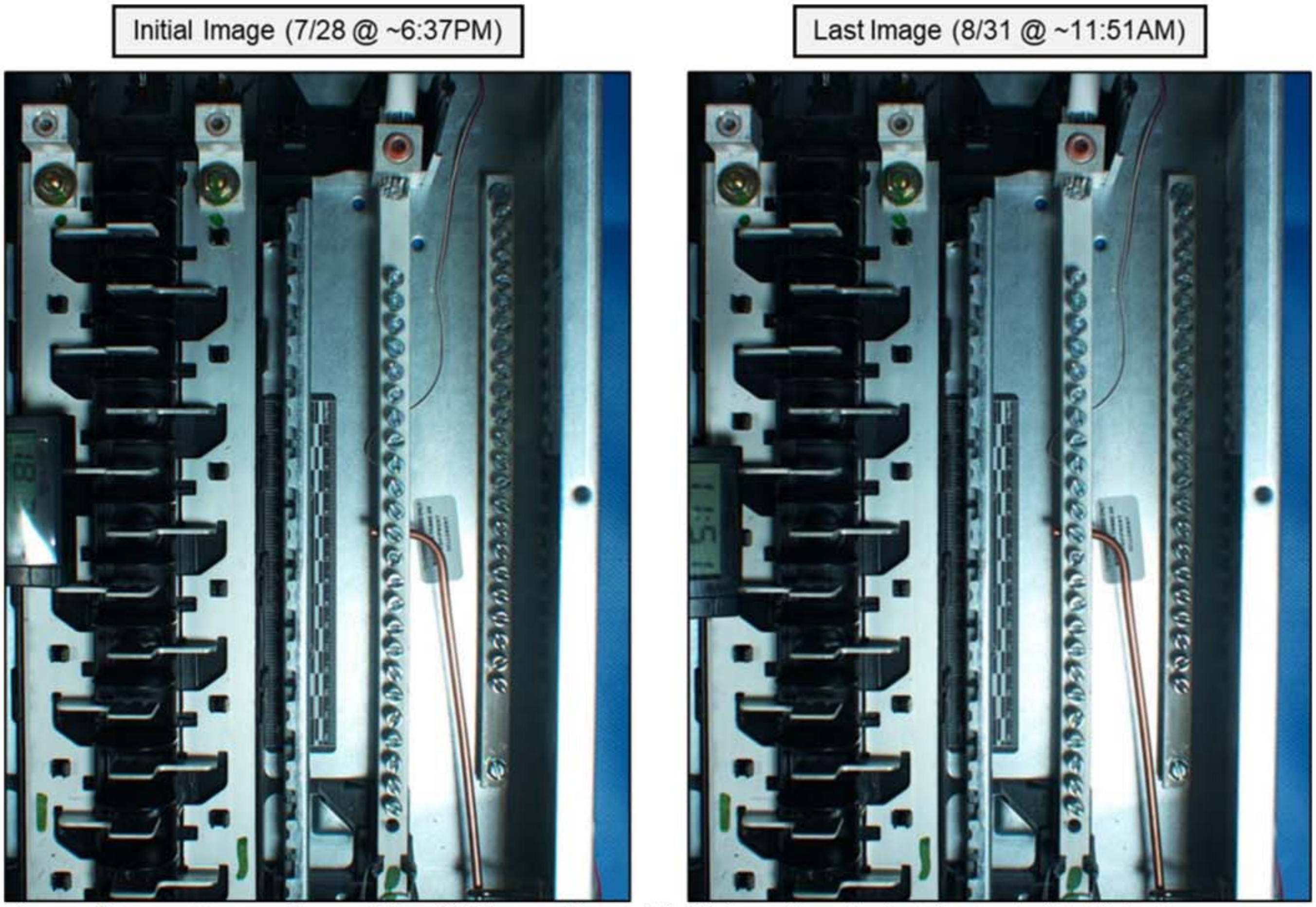
  32.c. Additional strain was induced by clamping the wire, adding a bending moment on the system. A notable strain increase was recorded on the bottom outer tab and on the busbar, with maximum values of -750 and -1564 με respectively. However, this -750 με on the bottom outer tab was not sustained after this clamping procedure, stabilizing to below 50 με (similar to the relatively low strains on the other plastic components). The strain in measured at the top and inner tab strain gauge were, on average, -4 and 7 με respectively during the whole testing period.

  32.d. The strain rapidly stabilized and remained relatively constant through the duration of testing. On average, the top strain gauge read approximately -5 με, the bottom inner and outer tab strain gauge read approximately +7 and +65 με respectively, and the busbar strain gauge read approximately -1460 με.

33. This relative consistency of the strain gauge data over the testing period indicates that no additional strains (and therefore stresses) are being induced into the system after 40% CCS wire termination. Moreover, as described in ¶32.a above, in general the highest

strain introduced into the system overall was during termination of the neutral service conductor (only the strain in the busbar was lower during neutral service termination than what it experienced after terminating/clamping the 40% CCS wire).

34. Furthermore, comparing photographs before and after testing show no discernible change in the 125A panelboard termination system, as shown below in Figure 12.



Initial Image (7/28 @ ~6:37PM)

Last Image (8/31 @ ~11:51AM)

Figure 12. Comparison of the 125A panelboard (left) from the start of the test; (right) to the end of the test. The difference in time between photographs constitutes approximately five weeks.

35. At the end of the test, additional mechanical load was manually applied to the busbar to quantify the strain required to induce permanent damage to the plastic components of the panel. As shown below in Figure 13, a clamp was applied between the middle of the busbar and the right side of the panel. The maximum strain recorded was -1110 με for the top strain gauge, -966 με and -3353 με for inner and outer tabs strain gauges

respectively, and -3256 με for the strain gauge on the busbar. The represent absolute strains that were 267, 147, 52 and 2.2 times higher than the average values recorded after 40% CCS wire installation for strain gauges at the top, inner tab, outer tab, and busbar, respectively.

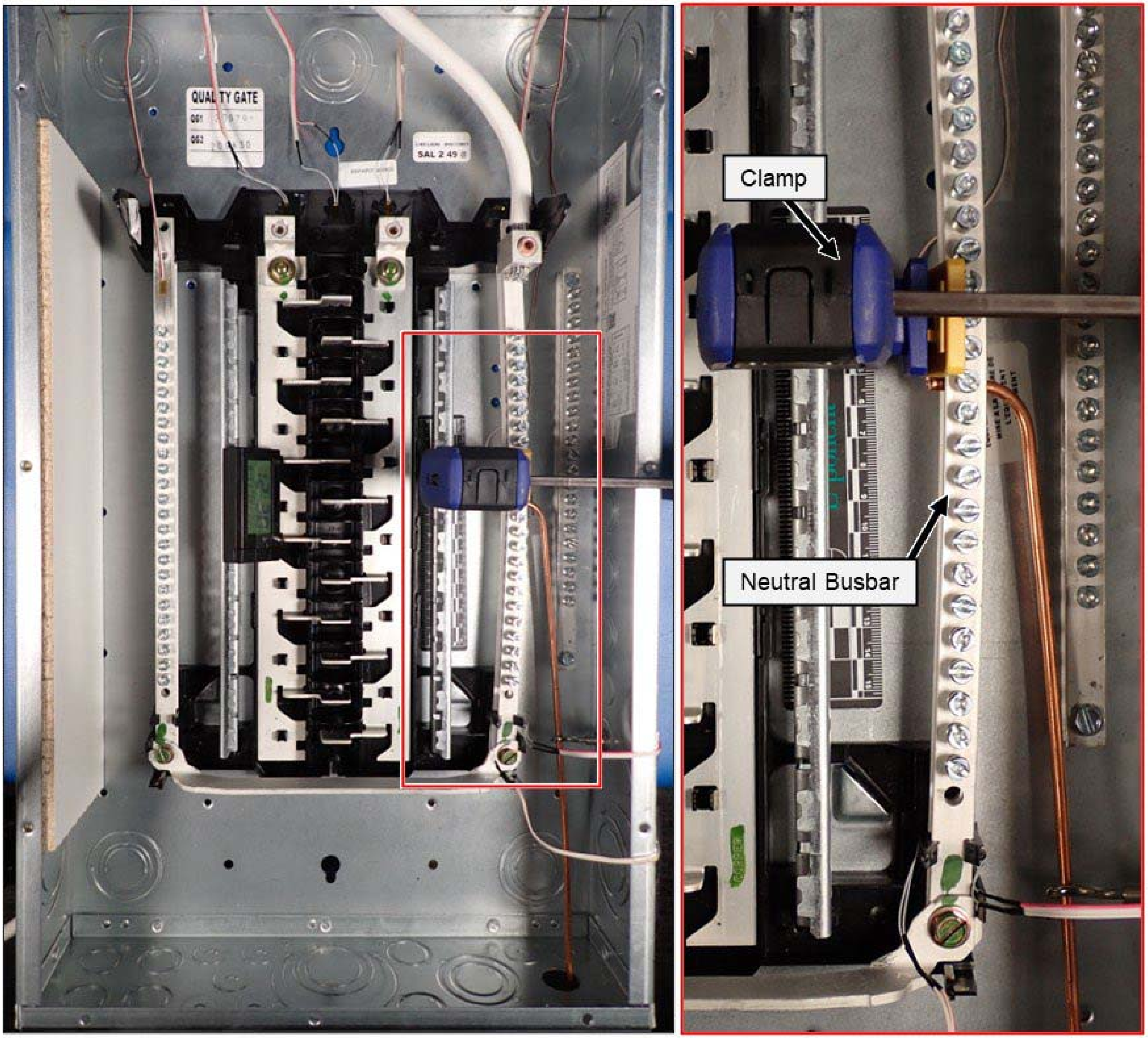


Figure 13. (Left) Overview photograph of the 125A panelboard with the clamp intended to create permanent damage. (Right) Close-up image of the left photograph showing the severe bend in the neutral busbar indicating a significant force being applied to the system.

4.4 200A Panelboard Test

36. As described in Section 3.1, a 4-AWG solid 40% CCS wire was used in the 200A panelboard used for the mechanical testing. An overview of this panelboard, along with the locations of the strain gauges, is shown in Figure 14.

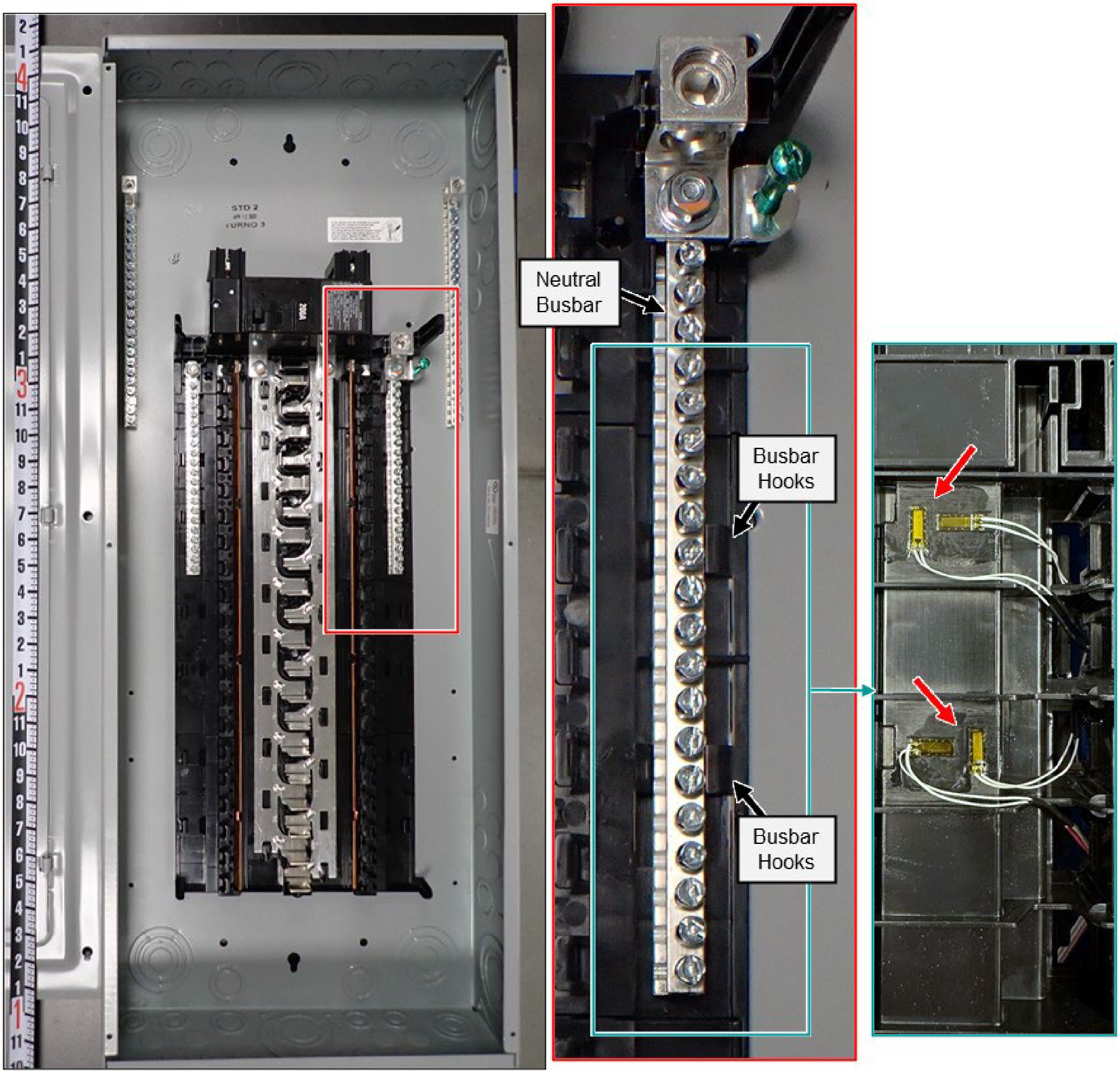


Figure 14. (Left) Overview photograph of the 200A panelboard used for mechanical testing. (Middle) Close-up of the neutral busbar where the 40% CCS wire is set to be terminated, along with the “busbar hooks” which connect the busbar and the plastic backing. (Right) Location of the strain gauges (indicated by the red arrows) on the underside of the black plastic backing where the busbar hooks are located.

37. As shown, the neutral busbar is mechanically connected to the plastic backing through the "busbar hooks":

    37.a. The neutral busbar has an hourglass cross-section, and the plastic busbar hooks prevent the busbar from being raised out of the panelboard.

    37.b. This is the location where deformation would likely occur, as termination of the 40% CCS wire would induce some load that would be transmitted to the hooks.

    37.c. Thus, the strain gauges were installed on the underside of the plastic backing directly under the hooks (the teal box in Figure 14). The top strain gauge was oriented to measure strain in the top-bottom direction (X-direction) while the bottom strain gauge was oriented to measure the strain in the left-right direction (Y-direction).

    37.d. Additionally, a speckle pattern was applied to the plastic backing to measure any deformation.

38. After the strain gauges were installed and the speckle pattern was applied, the service neutral and 40% CCS wires were terminated onto the busbar at the specified tightening torques.[22] The 40% CCS wire was installed at the termination farthest from the mechanical lug (where the service neutral was terminated) to induce the highest bending moment on the system. The wire was then manipulated to induce a relatively high strain on the termination equipment, and then clamped at that location. The final configuration for the start of the mechanical test is shown below in Figure 15.

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[22] Refer to Table 2 for the tightening torques used for each panelboard.

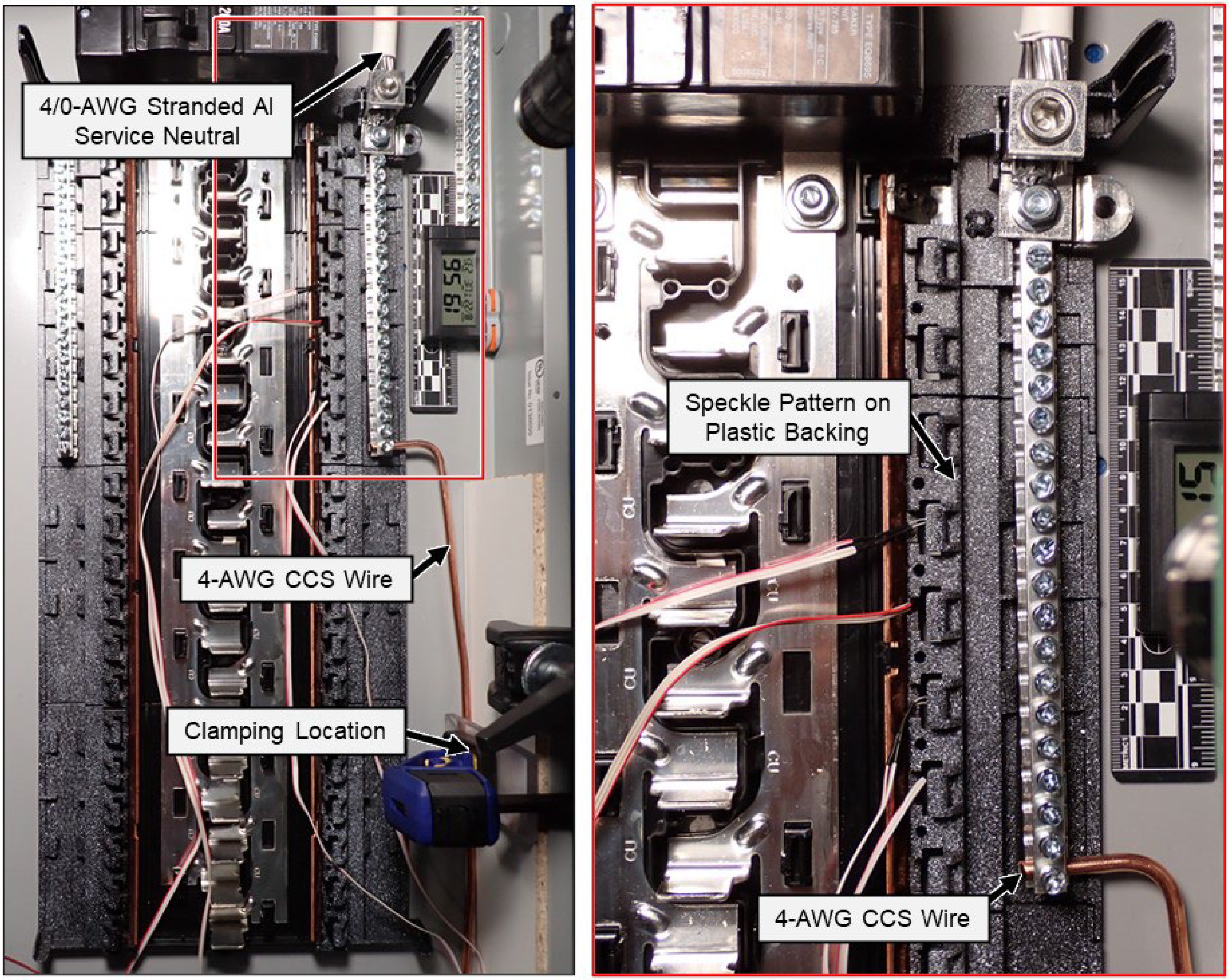

Figure 15. Configuration of the 200A panelboard for mechanical testing. (Left) Overview of the panelboard with the service neutral, 40% CCS wire, and clamping location annotated. (Right) Close-up photograph of the neutral busbar, showing the speckle pattern applied to the plastic backing.

39. The sample was then monitored for a period of approximately five weeks. The strain values recorded from the strain gauges over this time period is shown below in Figure 16.

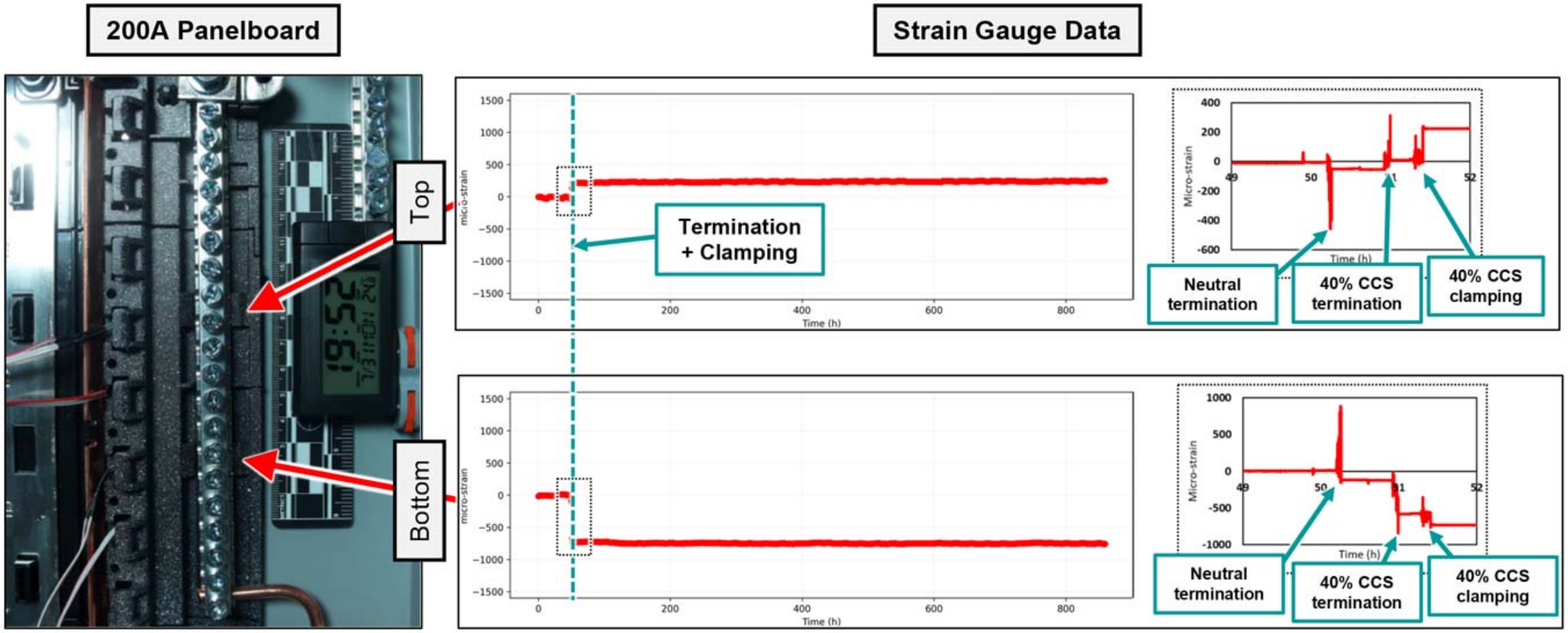

Figure 16. (Left) Photograph of the 200A panelboard. (Right) The strain gauge data from the top and bottom gauges (noted with the red arrows). The data on the main plot is reported as an hourly average of the strain data; zoomed in plots (noted with the boxes with dashed lines) of the strain during termination and clamping are shown in the rightmost plots, with the specific strains after termination of the neutral service conductor, termination of the 40% CCS wire, and clamping of the 40% CCS wire annotated.

40. The strain values recorded from the strain gauges were highest during service neutral termination. Further, the strain values jumped immediately after terminating / clamping the 40% CCS wire but remained relatively steady throughout the testing period.

40.a. The neutral conductor installation led to the highest absolute values applied to both strain gauges during the entire duration of the test. Strain reached -455 με and +885 με at the top and bottom strain gauges, respectively. After the neutral conductor was terminated, the strain values stabilized to around -50 με and -120 με for the top and bottom strain gauge, respectively.

40.b. The 40% CCS wire was terminated at the lowest terminal (farthest from the service neutral) as shown in the photograph. The termination of the 40% CCS wire led to strain reaching +312 με and -840 με at the top and bottom strain gauge, respectively. After termination, the strains returned to +10 με and -580 με for the top and bottom strain gauges, respectively.

40.c. Additional strain was induced by clamping adding a bending moment on the system. Immediately after installation, peak strains strain of +241 με and -772 με was recorded at the top and bottom strain gauge, respectively.

40.d. The strain rapidly stabilized and remained constant during the remainder of the test with the reading at approximately +230 με and -750 με at the top and bottom strain gauges, respectively.

41. This relative consistency of the strain gauge data over the testing period indicates that no additional strains (and therefore stresses) are being induced into the system after 40% CCS wire termination. Moreover, as stated in the ¶40.a above, the highest overall strain introduced into the system was during termination of the neutral service conductor.

42. Furthermore, comparing photographs before and after testing shows no discernible change in the 200A panelboard termination system, as shown below in Figure 17.

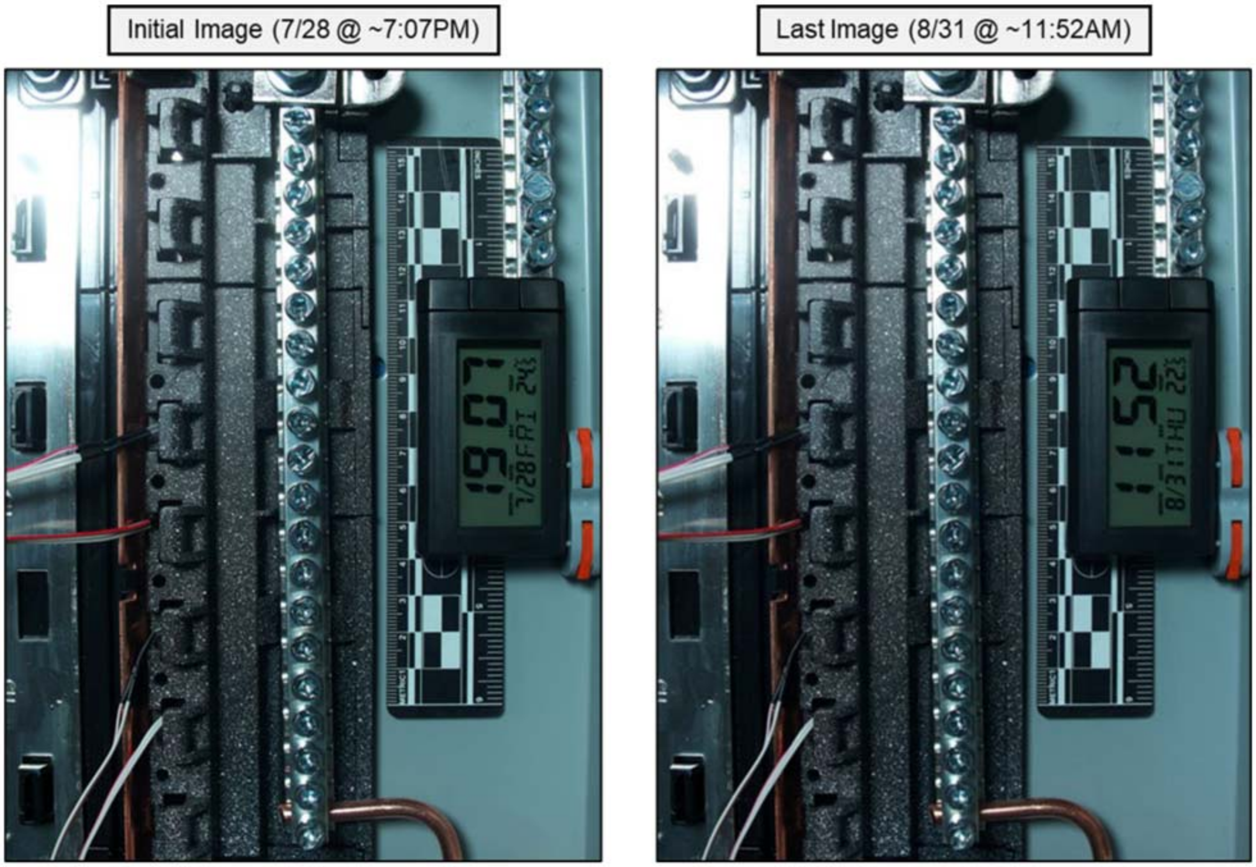

Figure 17. Comparison of the 200A panelboard (left) from the start of the test; (right) to the end of the test. The difference in time between photographs constitutes approximately five weeks.

43. Additionally, the DIC data comparing the termination system pre-termination to post-termination / clamping show that the highest strain is at the lower plastic hook., consistent with a bending stress being applied to the neutral busbar (see Figure 18). This is the type of stress state imposed onto the termination system from the termination/clamping (as described above) and is therefore expected.

43.a. As shown, the maximum displacement, and the strain along the X- and Y-directions, for each of the three wires is reported for several representative points. Point 5 is near the location of the bottom strain gauge while Point 6 is near the location of the top strain gauges. The values are consistent with a relatively large compressive strain along the Y direction at the bottom strain gauge (-7258 με at

Point 5 vs -750 με at the bottom strain gauge) and a significant tensile strain along the X-direction (+1110 με at Point 6 vs +230 με at the top strain gauge).[23]

43.b. It should be noted that the DIC strain values are taken from the top of the plastic backing while the strain gauges are underneath; thus, the strain values can differ between the two measurement methods.

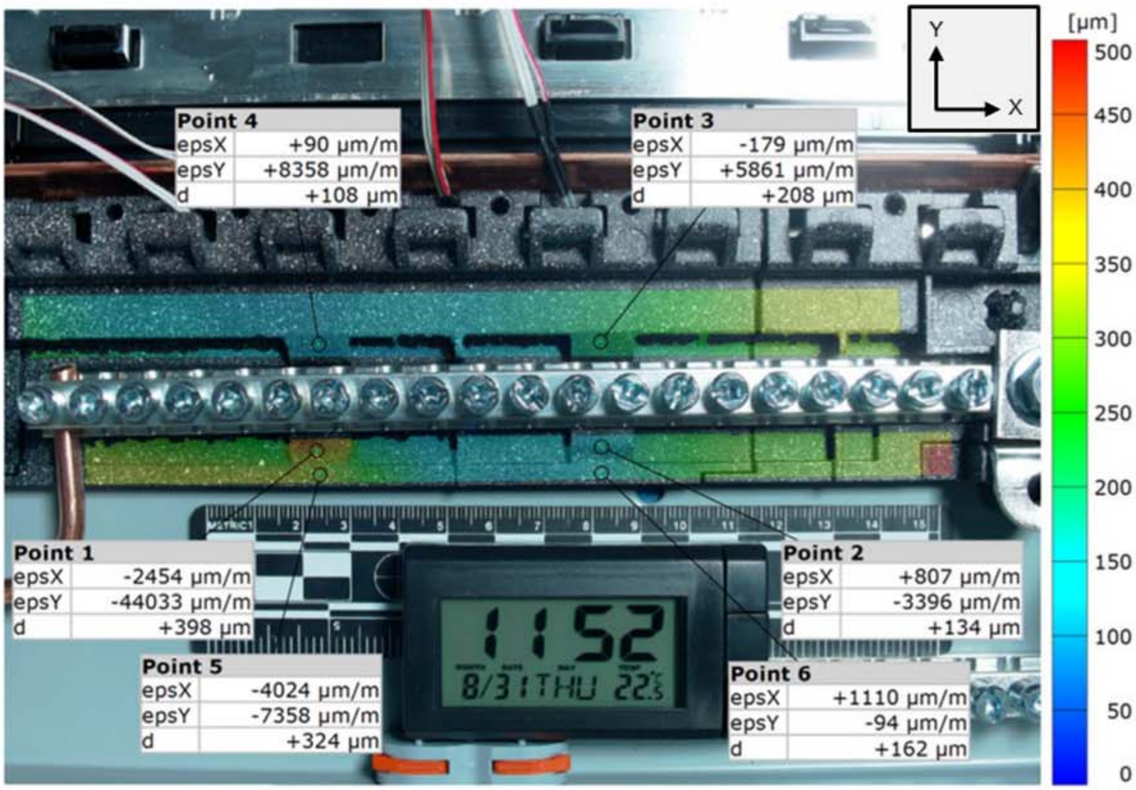

Figure 18. Results from DIC analysis of the 200A panelboard with reference state is taken before the installation of both the neutral and 40% CCS wire. The color-scale represents the local maximum displacement of the plastic backing between the reference state and the end of the test.

44. Finally, the DIC data (from the initial post-termination / clamping to the end of the test) show that the strain on the plastic backing is relatively consistent (see Figure 19).

44.a. As shown, the maximum displacement, and the strain along the X- and Y-directions, is reported for several representative points.

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[23] While DIC is a robust method for computing displacement and strains, it presents a few limitations. In particular, the out-of-plane motion of the specimen can affect the results. Here, however, the test sample is mostly planar, and no major out-of-plane deformation was observed during testing.

44.b. The magnitude of all the displacements in the backing panel after termination are small (<50 µm, or <1 px) and significantly lower than the displacement induced by the termination of the neutral and 40% CCS wires.[24]

44.c. Thus, DIC analysis indicates that the strain/displacement of the plastic backing after termination/clamping is minimal at best, but is likely relatively constant.

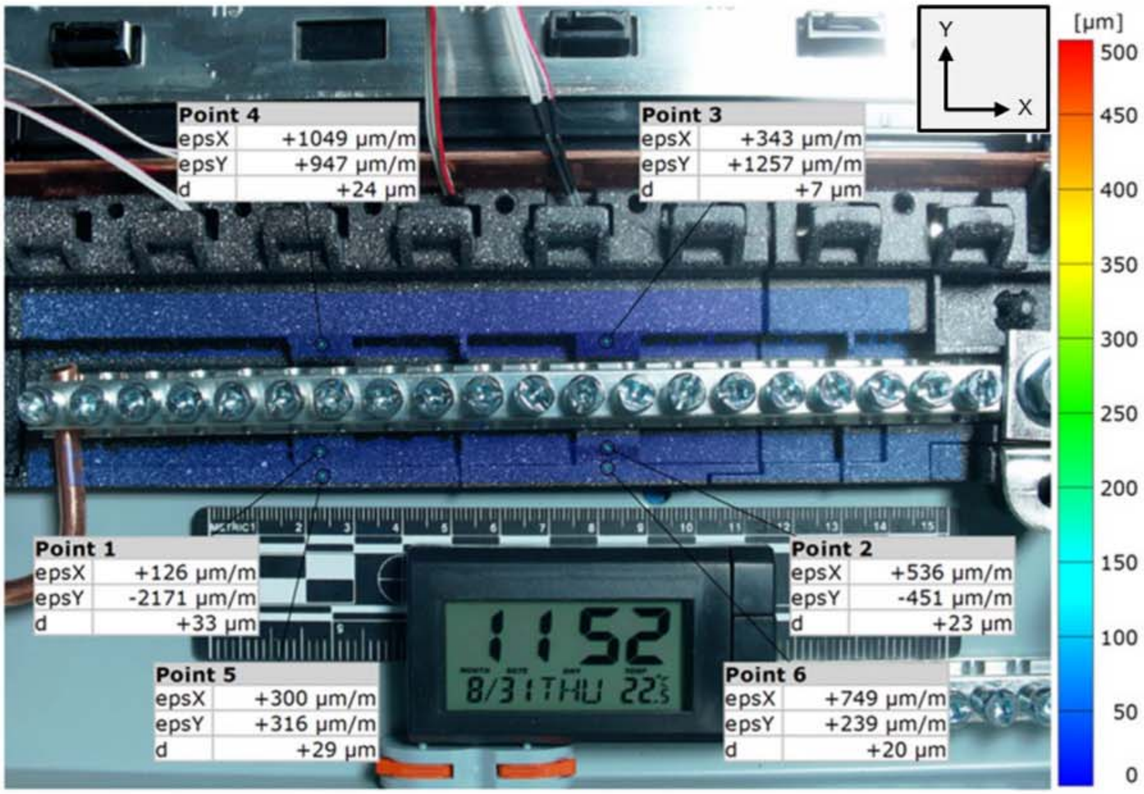

Figure 19. Results from DIC analysis of the 200A panelboard, with the reference (initial) state taken <u>after</u> the installation of both the neutral and 40% CCS wire. The color-scale represents the local maximum displacement of the plastic backing between the reference state and the end of the test.

45. At the end of the test, additional mechanical load was manually applied to the busbar to quantify the strain required to induce permanent damage to the plastic backing of the panel. As shown below in Figure 20, a clamp was applied between the busbar and the right side of the panel. The maximum strain recorded was +2778 µε for the top strain

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[24] The accuracy of DIC strain measurements tends to be lower at small displacement/strain. Typical accuracy is around 10% below 0.3% strain (3,000 µε), with higher accuracies near 1% above 3% strain (30,000 µε).

gauge and -2993 με for the bottom strain gauge,[25] which corresponds to 12.1 and 4.0 times higher than the average values recorded after 40% CCS wire installation.

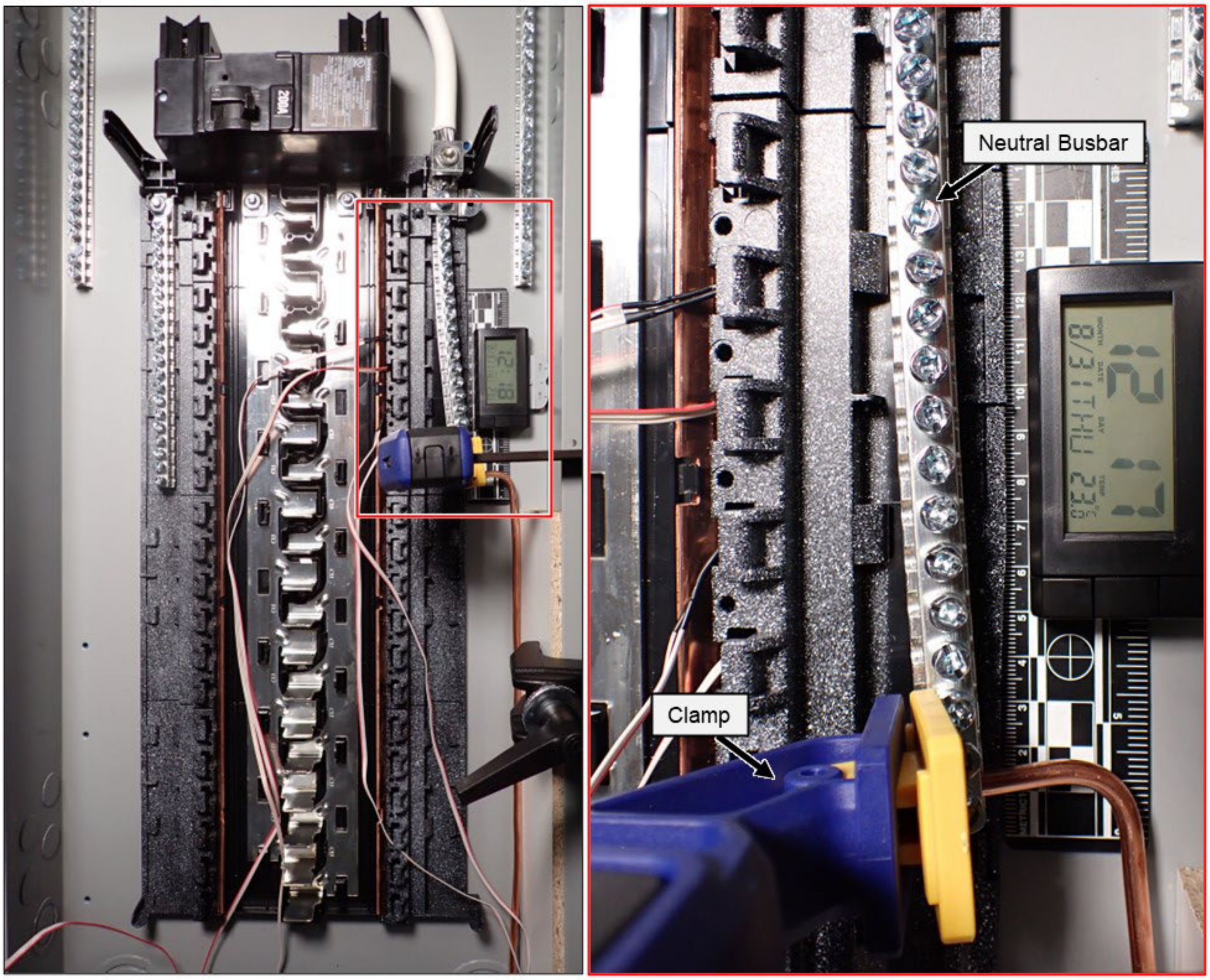

Figure 20. (Left) Overview photograph of the 200A panelboard with the clamp intended to create permanent damage. (Right) Close-up image of the left photograph showing the severe bend in the neutral busbar indicating a significant force being applied to the system.

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[25] These reported strain values are from the strain gauges underneath the plastic backing / busbar hooks; as noted in ¶43.b, the DIC strain values (taken from the top of the plastic backing) can differ from the reported strain gauge values.

5.0 Limitations

46. This report includes results of work conducted at the request of Copperweld Bimetallics LLC.

47. The material contained herein is presented to a reasonable degree of scientific and engineering certainty, and may not adequately address the needs of any or all users of this presentation. Any re-use of this presentation, or any of its contents, is made at the sole risk of the user. No guarantee or warranty as to future relevance is expressed or implied. Exponent reserves the right to supplement this presentation and to expand or modify its contents based on review of additional material as it becomes available and/or through any additional work or review of additional work performed by others.

48. In the presentation, we have relied on materials and information provided by Copperweld Bimetallics LLC. We cannot verify the correctness of this input and rely on Copperweld Bimetallics LLC for accuracy.

49. Although Exponent has exercised usual and customary care in preparing this summary presentation, the responsibility for the design, manufacture, and quality of their products remains fully with Copperweld Bimetallics LLC.

Electrical Analysis and Testing of 40% Copper Clad Steel (CCS) Conductors For Use as Grounding Electrode Conductors (GECs)

Electrical Analysis and Testing of 40% Copper Clad Steel (40% CCS) Conductors For Use as Grounding Electrode Conductors (GECs)

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Acronyms

A	ampere or amps
AC	alternating current
Al	aluminum
AWG	American Wire Gauge
CCA	copper clad aluminum
CCS	copper clad steel
Cu	copper
CPS	copper plated steel manufactured by a chemical electrolytic process
40% CCS	copper clad steel where copper constitutes 40% of the mass of the material
DC	direct current
EGC	equipment grounding conductor
GE	grounding electrode
GEC	grounding electrode conductor
Hz	hertz
IEEE	Institute of Electrical and Electronics Engineers
kHz	kilohertz
NEC	National Electrical Code (NFPA 70)
NFPA	National Fire Protection Association
UL	Underwriters Laboratories
µs	microseconds
µΩ	microohms
V	voltage or volts

1.0 Introduction

1. The National Electrical Code (NEC) is a standard for electrical installations in the United States. Currently, copper plated steel (CPS) is permitted by article 250 of the NEC for use as a Grounding Electrode (GE) in the form of copper coated ground rods, whereas copper clad steel (CCS) is not.[1] Furthermore, CCS conductors are not specified as a material of use as a grounding electrode conductor (GEC).[2]

2. During the submission cycle for the 2023 edition of the NEC, 40% CCS[3] was proposed as a material of use for GECs but was not accepted, due to concerns brought up by panel members. These concerns included technical support for the use of 40% CCS in GEC applications and more specifically regarding a particular test report submitted in support of the proposal that "*the current values used in the short time current test are less than those required in UL 467.*"[4]

3. At the request of Copperweld Bimetallics LLC (Copperweld), Exponent, Inc. (Exponent) was retained to evaluate the use of 40% CCS in GEC applications and address concerns previously raised by the panel members.

4. In doing so, Exponent reviewed relevant literature and standards regarding grounding electrode systems including GECs, performed analysis regarding the application of 40% CCS as GECs, and commenced a current cycling testing program on commonly used panelboard neutral bus bars where the neutral bus bars are interfaced with 40% CCS.

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[1] Copper-clad steel is a composite material consisting of a steel core coated with a layer of copper where a strong metallurgical bond exists between the two metals.

[2] NEC 2023, §250.62 states that GECs shall be of copper, aluminum or copper-clad aluminum (CCA), while NEC 2023, §250.62 provides options for extending GEC connections to electrodes via building materials including metal water pipes, structural components, and rebar.

[3] Copperweld 40% copper clad steel (CCS) conductors are bimetal conductors where the core of each conductor is made of annealed steel bonded to a copper cladding outer layer. Forty percent of the conductor material mass is copper and the conductor has a nominal conductance 40% that of an equivalently sized copper conductor.

[4] NEC 2023 First Draft Technical Committee FINAL Ballot Results (A22); Code-Making Panel 5 (NEC-P05). Accessed July 12, 2023. https://www.nfpa.org/assets/files/AboutTheCodes/70/70_A2022_NEC_P05_FD_ballotfinal.pdf, PDF pp. 3, 92, 161, 178.

5. This report details Exponent’s investigation findings and interpretations regarding the use of 40% CCS as GECs, and provides an update and initial interpretations from the neutral bus bar / 40% CCS GEC termination current cycling testing program.

2.0 Considerations on 40% Copper Clad Steel for Use as Grounding Electrode Conductors

2.1 Executive Summary

6. At the request of Copperweld Bimetallics LLC (Copperweld), Exponent performed an investigation into the use of 40% CCS in GEC applications.

7. For this investigation, Exponent reviewed relevant literature and standards regarding grounding electrode systems including GECs and performed analysis regarding the bimetallic construction of 40% CCS and its electrical performance related to surge currents that may be imparted on GECs due to lightning or utility switching events.

   7.a. To perform this analysis, Exponent considered 40% CCS conductor sizes 2 AWG to 8 AWG and analyzed the frequency content of standard surge waveforms used for evaluating electrical system components,[5] the 8×20μs current waveform, and the 0.5μs-100kHz underdamped ringing waveform.

   7.b. Exponent found that the thickness of the copper layer in the 40% CCS conductors are large compared to the aggregate skin effect of the 0.5μs-100kHz ring waveform and thus 40% CCS will likely exhibit similar performance with equivalently-sized copper conductors. This is true for all sizes of conductors considered (2 AWG – 8 AWG) but is most pronounced with the larger gauge 40% CCS.

   7.c. Exponent also found that while there is a difference in the effective conductance of the 8×20μs surge waveform for 40% CCS compared with copper GECs, the difference is less than the DC resistance values for the two conductor materials would indicate; this difference decreases substantially for larger gauge 40% CCS.

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[5] IEEE 62.45-2002 IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.

8. Exponent considered the applicability of UL 467 in evaluating 40% CCS performance as a GEC in response to concerns raised by panel members that test reports submitted during the previous submission cycle for the 2023 edition of the NEC did not show evaluation of 40% CCS at current levels specified for use when testing connectors with copper conductors.

    8.a. The reliance on UL 467 short-time current test requirements to evaluate 40% CCA has limitations because:

        8.a.i. UL 467's scope covers the evaluation of grounding and bonding equipment and not necessarily the conductors connected to the equipment.

        8.a.ii. Test language in the standard provides provisions for altering testing conditions if the conductors fail before the evaluation of the equipment is complete.

        8.a.iii. The standard does not distinguish between grounding applications, e.g. the difference in performance requirements between equipment grounding conductors (EGCs) and GECs.

2.2 Grounding Electrode Systems

9. A grounding electrode system is a network of one or more grounding electrodes bonded together and electrically connected to the electrical system (for grounded systems) and/or the electrical equipment (both ungrounded and grounded systems) via grounding electrode conductors (GECs).[6] This grounding electrode system,

    9.a. Electrically connects the electrical system to earth (grounded systems),

    9.b. Electrically connects electrical equipment to earth (both ungrounded and grounded systems), and

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[6] Soares Grounding & Bonding, 14th edition, International Association of Electrical Inspectors. 2020.

9.c. Provides an electrically conductive path to dissipate over-voltages and surge currents to earth.

10. By creating this network, the grounding electrode system stabilizes the electrical system voltage to an earth reference, reducing the risk of electric shock to people and limiting voltages imposed by lightning or other surges which could lead to equipment failure or other property damage.

2.2.1 Grounding Electrode Conductors (GECs)

11. The NEC defines a GEC as "[a] *conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system*."[7]

12. Currently, the NEC allows three materials to be used in grounding electrode conductors, copper, aluminum, and copper clad aluminum (CCA).[8]

12.a. The NEC does allow exceptions to this material limitation where conductive building components, including water pipes, metal structural building frames, and concrete-encased rebar, may be used to "extend" connections to electrodes.[9]

13. The NEC also currently requires that the size of GECs be based on the size of the largest ungrounded supply conductor in accordance with Table 250.66, reproduced in this report as Table 1.[10]

13.a. Here, the NEC also affords exceptions that limit the maximum required conductor size based on the grounding electrode to which the GEC connects. For example, where a GEC connects with one or more ground rod, pipe, or plate electrode (but crucially no other electrode types), the GEC is not required to be larger than 6 AWG copper or 4 AWG aluminum or CCA, regardless the size of the electrical supply conductors.

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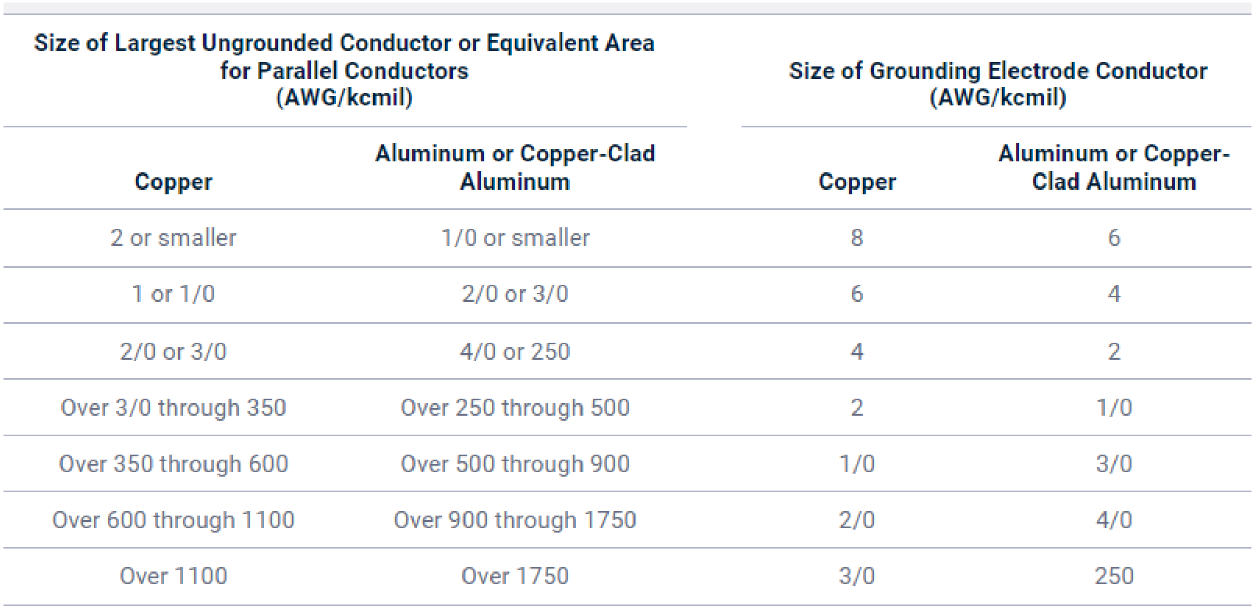
[7] NEC 2023, §100.

[8] NEC 2023, §250.62.

[9] NEC 2023, §250.68(C).

[10] NEC 2023, §250.66.

Table 1 – Reproduction of NEC 2023 Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems.



Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

2.2.2 40% Copper Clad Steel (CCS) Conductors

14. Copperweld 40% copper clad steel (CCS) conductors are bimetal conductors where the core of each conductor is made of annealed steel, which is bonded to a copper cladding outer layer.[11] Forty percent of the conductor material mass is copper. This corresponds to an outer radial copper layer with a thickness of 10% of the overall conductor diameter (20% of the radius) and a cross-sectional area of 36%.[12]

15. Table 2 below provides nominal DC resistances and dimensional measures for CCS solid conductors size 8 AWG to 2 AWG, including overall conductor diameters and cross-sectional areas as well the thicknesses and cross-sectional areas of the copper cladding outer layers.

---

[11] Copperweld CCS conductor conforms to ASTM B 227 Standard Specification for Hard-Drawn Copper-Clad Steel Wire and B910 Standard Specification for Annealed Copper-Clad Steel Wire specifications.

[12] https://www.copperweld.com/buildingwire/products/ccs-40-percent

Table 2 – Summary of Nominal 40% CCS Dimensions and Per Unit Resistance.[13]

Conductor Size (AWG)	Conductor Diameter (in / mm)	Conductor Cross-Sectional Area (kcmil / mm^2)	Copper Cladding Thickness (in / mm)	Copper Cross-Sectional Area (kcmil / mm^2)	Nominal DC Resistance (20°C) (Ω/kft / Ω/km)
2	**0.2576 / 6.54**	**66.4 / 33.62**	**0.0258 / 0.654**	**23.9 / 12.10**	**0.391 / 1.2819**
4	**0.2043 / 5.19**	**41.7 / 21.15**	**0.0204 / 0.519**	**15.0 / 7.614**	**0.621 / 2.0380**
6	**0.1620 / 4.11**	**26.3 / 13.30**	**0.0162 / 0.411**	**9.45 / 4.788**	**0.988 / 3.2413**
8	**0.1285 / 3.26**	**16.5 / 8.37**	**0.0129 / 0.326**	**5.95 / 3.013**	**1.570 / 5.1516**

2.3 40% CCS as GECs

16. Based on the reported per-unit resistances listed in Table 2, 40% CCS GECs, when connected to sufficient and properly installed grounding electrodes, provide a good electrical connection to earth for the electrical system and/or electrical equipment under normal operating conditions. In most applications, the current on a GEC is limited by the impedance of the earth and not by the impedance of the GEC conductor.[14]

17. However, occasionally GECs may be subjected to elevated voltages and current surges due to events such as lightning strikes or switching operations by utilities, and it is important that GECs are able to carry the current from these events and effectively dissipate the energy to ground.

2.3.1 Considerations of CCS GECs Subject to Surge Conditions

18. One of the main purposes of the grounding electrode system is to provide an electrically conductive path to earth to allow over-voltages and surge currents to dissipate.[15] Such electrical surges originate from two major sources, lightning and switching.[16]

---

[13] Conductor diameters, cross-sectional areas, and nominal DC resistances are reproduced from Copperweld specification sheets. The copper cladding thicknesses and cross-sectional areas are calculated assuming 36% of the conductor cross-sectional area is copper.

[14] Soares Grounding & Bonding, 14th edition, International Association of Electrical Inspectors. 2020.

[15] Soares Grounding & Bonding, 14th edition, International Association of Electrical Inspectors. 2020.

[16] IEEE Std. C62.41.1-2002 IEEE Guide to the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits. 2002.

19. IEEE Standard C62.41.2 defines two recommended standard surge waveforms useful for characterizing the surge environment and evaluating the response to surges by the electrical system components. These two waveforms are:[17]

    19.a. The combination waveform, which consists of a 1.2×50µs voltage wave across an open circuit and an 8×20µs current wave into a short circuit, and

    19.b. A 0.5µs-100kHz underdamped ringing waveform.

20. Because the focus of this investigation is the application of 40% CCS conductors as GECs, Exponent concentrated on the 8×20µs current waveform portion of the combined waveform.

21. Figure 1 provides a time-domain plot of the 8×20µs waveform and Figure 2 provides that of the 0.5µs-100kHz ring waveform.[18]

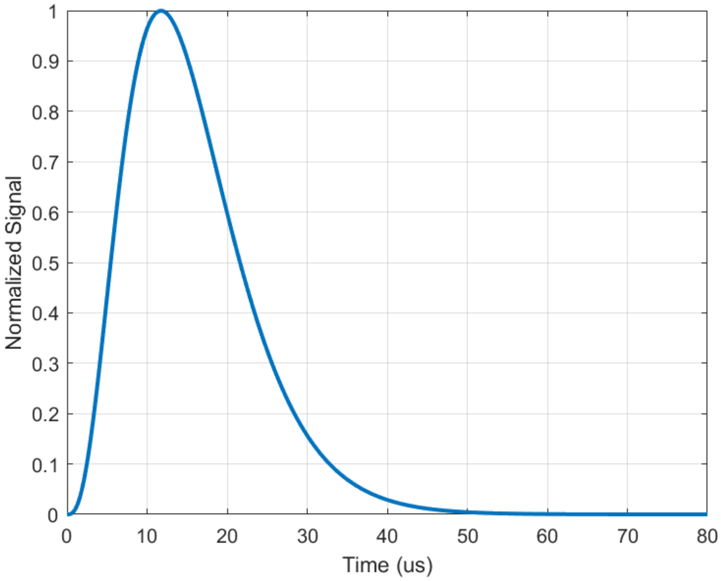


Figure 1. The normalized 8×20µs surge waveform.

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[17] IEEE Std. C62.41.2-2002 IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits. 2002.

[18] IEEE 62.45-2002 IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits – Table 5 provides equations for these two waveforms.

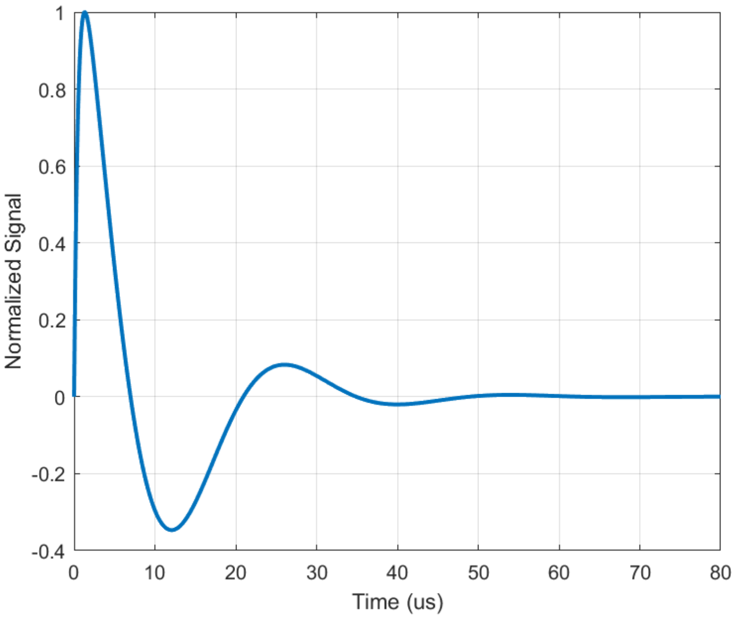

Figure 2. The normalized 0.5μs-100kHz underdamped, ringing surge waveform.

22. Surge waveforms like these deliver a "pulse" of energy in a short period of time. In the frequency domain, these surge waveforms contain a large amount of high-frequency content. This high-frequency content, when conducted through a conductor, is subject to a "skin effect" where the high-frequency current tends to travel near the outer surface of the conductor. For single metal conductors such as copper or aluminum, this results in a lower effective cross-sectional area for current flow in the conductor and a corresponding increase in ohmic resistance.

23. A metric used to define the extent of this skin effect is the skin depth, which can be simplified to $\delta = \sqrt{\frac{2\rho}{2\pi f \mu}}$, where ρ is the resistivity of the conductor, μ is the permeability of the conductor, and f is the frequency of the current. Notably, the skin depth is inversely proportional to the square root of the frequency.

24. Forty percent CCS intrinsically forces current to concentrate at the outer portion of the conductor regardless the current frequency as the outer copper layer is more conductive than the inner steel core. Fundamentally, at DC and low frequencies, 40% CCS conductors are less conductive than equivalently sized copper conductors.

25. However, at higher frequencies, where the corresponding skin depth decreases to the thickness of the 40% CCS copper layer or lower, an equivalently-sized copper conductor no longer exhibits lower resistivity and higher conductivity than the 40% CCS conductor as the effective cross-sectional area of the copper and 40% CCS conductors become similar.

26. Figure 3 and Figure 4 provide the frequency-domain representations of the 8×20μs surge waveform and the 0.5μs-100kHz ring surge waveform, respectively. The blue traces in these figures indicate the magnitude of the current (y-axis) for a given frequency (x-axis).

27. In both of these figures, the four colored vertical lines indicate the frequency values, f_d, required for a copper conductor to exhibit a skin depth equal to the thickness of the outer copper layer in an equivalently sized 40% CCS conductor (Table 2 provides the copper layer thicknesses). For frequencies above these (to the right of these lines in the figures), the skin effect is such that a copper conductor will exhibit similar conductivity to 40% CCS.

28. Thus, what these figures provide is a graphical indication of how 40% CCS conductors compare to equivalently sized copper conductors when conducting these pulse waveforms. The more the frequency content of the pulse waveform (blue traces) exists to the right of the vertical lines, the more equivalent 40% CCS is to the same sized copper conductor in terms of overall conductivity. With this context, these figures indicate that:

    28.a. There is little difference in the effective conductivity of the 0.5μs-100kHz ring waveform between copper GECs and 40% CCS GECs because the thickness of the copper layer in the 40% CCS conductors is large compared to the overall skin effect of the 0.5μs-100kHz ring waveform. This is true for all sizes of conductors considered (2 AWG – 8 AWG).

    28.b. While there is a difference in the effective conductance of the 8×20μs surge waveform for 40% CCS compared with copper GECs, the difference is less than the DC resistance values for the two conductor materials would indicate. Further, this difference decreases substantially as the gauge of the conductors increase.

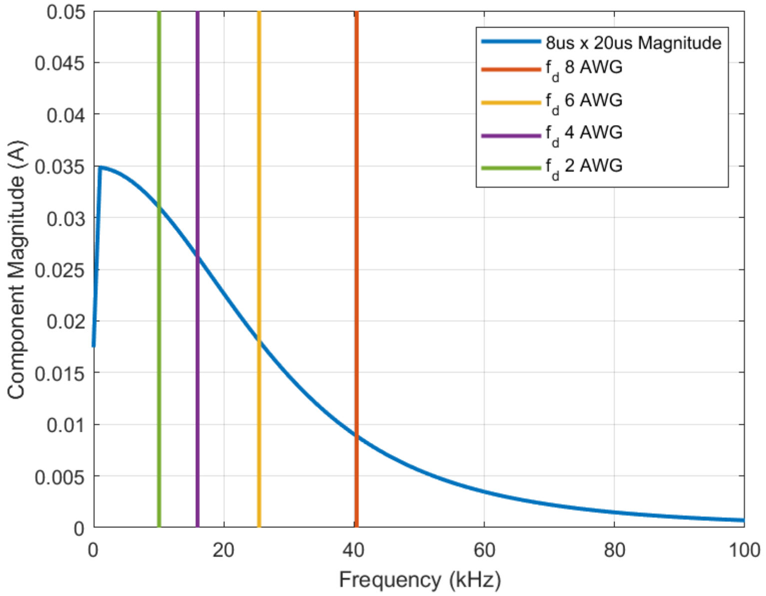

Figure 3. Frequency content of the 8×20µs surge waveform (blue trace). Each of the colored lines correspond to the frequencies of excitation required to impart a skin depth in a copper conductor equal to the radial thickness of the copper layer in a CCS conductor.

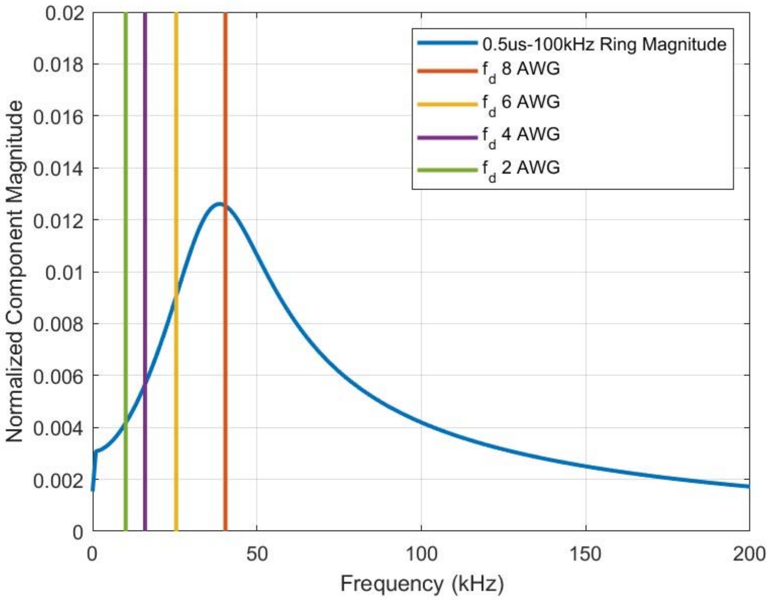

Figure 4. Frequency content of the 0.5µs-100kHz Ring Waveform (blue trace). Each of the colored lines correspond to the frequencies of excitation required to impart a skin depth in a copper conductor equal to the radial thickness of the copper layer in a CCS conductor.

2.4 Applicability of UL 467 in Evaluating CCS Performance

29. During the submission cycle for the 2023 edition of the NEC, 40% CCS was proposed as a material of use for GECs, but was not accepted, in part, because "*the current values used in the short time current test are less than those required in UL 467.*"[19]

30. The panel's feedback regarding UL 467 current levels is interpreted to correspond to a test report provided to the panel by Copperweld as part of their previous submission. In that report, the manufacturer provided the results of a test program undertaken with the purpose to determine if the , "*…Connectors can meet the*[…]*UL467 Short time current requirements when installed on* [40% CCS] *conductors*."[20]

    30.a. In this test report, the manufacturer tested equipment installed with CCS at current levels appropriate for 40% CCS (as opposed to copper) based on the CCS material properties and the testing requirements.[21] According to the report, the connectors tested passed the testing requirements.

    30.b. It is Exponent's interpretation that the panel's feedback was that the test currents did not meet the levels specified for use when testing connectors with copper conductors, and because of that, the testing did not provide sufficient technical substantiation for the use of 40% CCS in GEC applications.

31. However, the reliance on the UL 467 short-time current test requirements for evaluating equipment interfaced with copper conductors has limitations.

    31.a. First, UL 467's scope covers the evaluation of grounding and bonding equipment and not the conductors themselves. Second, UL 467 does not distinguish for grounding application, e.g., use in grounding electrode conductor systems vs equipment grounding conductor systems, which could impact the level, duration,

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[19] NEC 2023 First Draft Technical Committee FINAL Ballot Results (A22); Code-Making Panel 5 (NEC-P05). Accessed July 12, 2023. https://www.nfpa.org/assets/files/AboutTheCodes/70/70_A2022_NEC_P05_FD_ballotfinal.pdf, PDF pp. 3, 92, 161, 178.

[20] Burndy Test Report. "UL 467 Short Circuit & UL 486A-486B Mechanical Sequence Tests." 2015.

[21] The UL 467 Short time current testing provides a formula in Table 5 for calculating the ampacity of conductors derived from IEEE 837 Standard for Qualifying Permanent Connections Used in Substation Grounding.

and type of fault currents reasonably expected to be experienced by the equipment and associated conductors. Collectively, these points mean that the short-time current requirements may be more useful for stressing and evaluating the equipment being tested than for stressing and evaluating the conductors in a realistic real-world fashion.

31.a.i. In fact, the standard allows for wide variations in the applied test current and time-length of application if the conductor used in testing cannot maintain sufficient levels.[22] The standard also allows changing the conductor type if the conductor in use for testing fails to carry the required current for the specified length of time.[23]

31.a.ii. Regarding applications, UL 467 Table 5, which lists the time length and amplitude of current required for testing equipment based on conductor size, specifically lists these conductors as "equipment grounding and bonding conductor[s]."[24] These conductors and associated connectors and equipment, particularly in grounded electrical systems, are required to form low impedance return paths to conduct sufficient fault current to allow over-current protection devices to trip. In contrast, fault currents in GECs are typically limited by the impedance of the earth.[25]

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[22] For some test cases, UL 467 §9.5.8 allows currents to be reduced provided the test time is increased in accordance the formula listed in UL 467 Table 5.

[23] UL 467 §9.5.9.

[24] UL 467 Table 5 column header.

[25] Exceptions to this may occur due to lightning strikes or accidental energization by high-voltage sources (e.g. downed utility conductors).

3.0 Cyclic Current Testing of Neutral Bus Bars with 40% Copper Clad Steel Grounding Electrode Conductors

3.1 Executive Summary

32. Exponent is presently conducting current cycling testing of neutral bus bars interfaced with 40% copper clad steel (40% CCS) conductors terminated in the bus bars as grounding electrode conductors (GECs).

    32.a. In this testing program, neutral bus bars are subjected to cyclic loading profiles consisting of 500 cycles of one hour at rated current and one hour at no current loading.

    32.b. Subjecting the neutral bus bar to rated current loading represents a "worst-case" loading scenario as under normal operation, loads served by panelboards are typically balanced between phases and only a portion of the total load returns on the neutral.

    32.c. The 40% CCS GECs do not carry the load current, however their terminations in the neutral bus bar are potentially subjected to electrical and thermal stresses due to the neutral bus bar conducting current.

33. At the date of this reporting (September 7, 2023), the neutral bus bars under testing have been subjected to approximately 250 cycles.

    33.a. Even under rated current loads, which represent worst-case loading for the neutral bus bars, the bus bar material only modestly increases in temperature and thus likely does not significantly stress the 40% CCS GEC terminations.

    33.b. The resistance measurements achieved to date are both small (tens of μΩ) and generally stable throughout testing, further suggesting that these terminations are not significantly affected by current cycling on the neutral bus bars.

3.2 Testing Overview

34. Exponent is conducting current cycling testing of neutral bus bars interfaced with 40% copper clad steel (40% CCS) conductors terminated in the bus bars as grounding electrode conductors (GECs). The purpose of this testing program is to expose the 40% CCS GEC / neutral bus bar terminations to electrical and thermal stresses caused by the cyclic current conducting through the neutral bus bars, and to characterize any effects these stresses have on the efficacy of the terminations.

35. In this testing program, neutral bus bars installed in commonly used electrical panelboards are being subjected to cyclic loading profiles consisting of 500 cycles of one hour at rated current and one hour at no current loading.

    35.a. Figure 5 provides a diagram of the testing setup. Current is supplied to these bus bars from power supplies via aluminum service conductors and stranded copper neutral conductors.

    35.b. In this testing, the 40% CCS GECs do not carry the load current,[26] however their terminations in the neutral bus bar could be subjected to electrical and thermal stresses due to the neutral bus bar conducting current.

    35.c. Subjecting the neutral bus bar to rated current loading represents a "worst-case" loading scenario. Under normal operation, current loads on neutral bus bars are less than rated levels; loads served by panelboards are typically balanced between phases and only the difference in the aggregate current demand of those loads returns on the neutral.

36. During this testing, the bus bar and ambient lab space temperatures are being monitored and recorded during all cycles to track the bus bar temperature cycles.

37. Periodically during the portions of cycles when current is not being applied (off-periods), the resistances through the neutral bus bars and 40% CCS GEC terminations are being

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[26] In real-world installations, GECs serve to provide a low impedance path to ground. The ground impedance limits the load current flow through the GEC as it is higher than the impedance of the service neutral conductor. Thus, while some current can flow on the GEC as a parallel return path to the service neutral, this current is typically small compared to the current flowing in the neutral conductor.

measured, recorded, and tracked to determine if the current cycling is affecting the efficacy of these terminations. These resistance measurements are made using four-terminal probe equipment, and they are taken at locations as near to the terminal contacts as possible to minimize the bulk material resistance contributions and maximize the surface contact resistance contributions.[27]

37.a. The off-period resistances are being measured at the following cycles, approximately: 25th, 50th, 75th, 100th, 125th, 175th, 225th, 275th, 350th, 425th, and 500th cycle. The actual cycle of measurement may differ if the nominal current cycle listed above occurs during off-work hours or otherwise at a time when physical measurements cannot be achieved. [28]

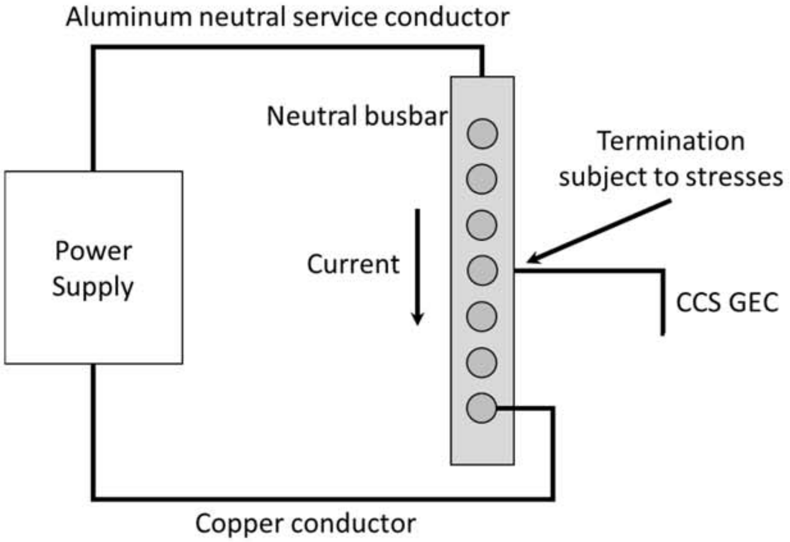

Figure 5. Diagram of the testing setup. Current is supplied from a power supply to the neutral bus bar. The CCS GEC termination is subjected to electrical and thermal stresses from this conduction.

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[27] Terminal resistance measurements are performed in accordance with ASTM B539-20 Standard Test Methods for Measuring Resistance of Electrical Connections (Static Contacts).

[28] As described later in this report, this testing program is primarily based on UL 486E Current Cycling and UL67 Temperature Test programs. UL 486E Current Cycling dictates reporting terminal temperature measurements at approximately these cycles. Thus, resistance measurement reporting was elected to follow a similar reporting requirement.

3.2.1 Testing Design Considerations

38. Testing is designed based on methods described in UL 486E Current Cycling[29] and UL 67 Temperature Test[30].

39. UL 486E Current Cycling testing is applicable to equipment wiring terminals including bus bars. This testing requires elevated current loads be cyclically conducted through conductor-bus bar termination points. During testing, the termination temperatures are measured and periodically reported.

    39.a. This method of testing is intended to emulate the stress effects of variable current loads on neutral conductor / bus bar terminations. Neutral conductors carry the return current from loads to the bus bar and thus are subjected to load current and subsequent thermal stresses.

    39.b. This method of testing does not emulate the stress effects on GEC / neutral bus bar termination points because GECs nominally do not carry significant load currents during normal installations.

40. UL 67's Temperature Test is applicable to panelboard equipment including those containing neutral bus bars where GECs may be terminated. In this test, neutral bus bars are subjected to current loads not less than their rated currents and the temperature of the neutral bus bar assemblies are monitored and reported. The measured temperature rise on the neutral bus bar is required to not exceed a set amount depending on how the test is performed.

    40.a. This test is not required to be applied cyclically and thus it is not intended to impart cyclic stresses to terminations.

    40.b. However, this required current does represent a worst-case scenario for loading of the bus bars as noted above.

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[29] UL 486E, 5th Edition, Sections 7.2, 8.2, and 9.2 collectively describe the current cycling testing procedures and performance requirements.

[30] UL 67, 13th Edition, Section 21.4.2 Neutral "black box" test (Method A).

41. For this investigation, Exponent combined elements of the UL 486E Current Cycling test and UL 67 Temperature Test to cyclically load neutral bus bars, and via contact, electrically and thermally stress GEC / neutral bus bar termination points. Under this testing plan:

    41.a. Forty percent CCS conductors are terminated in neutral bus bars in a manner consistent with their field installation for use as GECs.

    41.b. These neutral bus bar assemblies are subjected to rated current loads and the temperature of the bus bars are monitored as required in UL 67 Temperature Test.

    41.c. These rated current loads are applied cyclically as described in UL 486E Cyclic Current testing.

    41.d. Periodically throughout testing, the contact resistance of the neutral bus bar / 40% CCS GEC termination is measured. These measurements are performed on a schedule consistent with the reporting requirements of termination temperatures described in UL 486E Current Cycling testing.

3.2.2 Test Materials

42. Three gauges of 40% CCS conductors (8 AWG, 6 AWG, and 4 AWG) are being tested as GECs installed in neutral bus bars of various current ratings (70A, 125A, 200A, respectively).

43. The neutral bus bar assemblies selected for testing are obtained from commonly used panelboards:

    43.a. Square D Homeline 70 Amp Breaker,[31]

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[31] "Square D Homeline 70 Amp 2-Space 4-Circuit Indoor Surface Mount Main Lug Load Center with Cover HOM24L70SCP." n.d. The Home Depot. Accessed July 18, 2023. https://www.homedepot.com/p/Square-D-Homeline-70-Amp-2-Space-4-Circuit-Indoor-Surface-Mount-Main-Lug-Load-Center-with-Cover-HOM24L70SCP/100202333.

43.b. GE PowerMark Gold 125 Amp Breaker,[32] and

43.c. Siemens PN Series 200 Amp Breaker.[33]

44. Aluminum conductors from conductor service bundles are being used to provide service to each neutral bus bar being tested. The size of these aluminum conductors are:

44.a. 2 AWG Al for the 70A bus bar,

44.b. 2/0 AWG Al for the 125A bus bar, and

44.c. 4/0 AWG Al for the 200A bus bar.

45. Stranded copper conductors are used as return conductors for each neutral bus bar being tested. The number and size of these conductors are:

45.a. 1× 4 AWG Cu for the 70A bus bar,

45.b. 3× 4 AWG Cu for the 125A bus bar, and

45.c. 4× 4 AWG Cu for the 200A bus bar.

46. Current is supplied to the neutral bus bars under test from the following power supplies:

46.a. Keysight N5764A (70A testing)

46.b. Keysight N7970A (125A testing)

46.c. Keysight RP7932A (200A testing)

47. Bus bar and ambient air temperatures are measured using 24 AWG K-type thermocouples interfaced with a Graphtec GL240 datalogger.

48. Periodic contact resistance measurements between the neutral bus bars and the 40% CCS GEC conductors are collected using a Hioki RM3584 Resistance Meter.

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[32] "GE PowerMark Gold 125 Amp 24-Space 24-Circuit Indoor Main Lug/ Main Lug Kit Value Kit Includes Select Circuit Breaker TLM2412CCUG1K." n.d. The Home Depot. Accessed July 18, 2023. https://www.homedepot.com/p/GE-PowerMark-Gold-125-Amp-24-Space-24-Circuit-Indoor-Main-Lug-Main-Lug-Kit-Value-Kit-Includes-Select-Circuit-Breaker-TLM2412CCUG1K/100135380.

[33] "Siemens PN Series 200 Amp 40-Space 40-Circuit Main Breaker Plug-on Neutral Load Center Indoor with Copper Bus PN4040B1200C." n.d. The Home Depot. Accessed July 14, 2023. https://www.homedepot.com/p/Siemens-PN-Series-200-Amp-40-Space-40-Circuit-Main-Breaker-Plug-On-Neutral-Load-Center-Indoor-with-Copper-Bus-PN4040B1200C/312138643.

3.2.3 Test Setup

49. Figure 6 through Figure 8 provide images of the 40% CCS GEC test samples terminated in the neutral bus bar assemblies used for testing.

50. Each neutral bus bar along with the plastic housing required for bus bar mounting were removed from their original panelboard enclosures and reinstalled in steel enclosures painted black and sized to provide the required spacing around the neutral bus bar assemblies.[34]

51. These enclosures were mounted vertically on ¾-inch plywood and holes were drilled or knocked out of the enclosure top and bottom to allow conductor access to the neutral bus bar terminals.

52. The aluminum conductor bundles with aluminum neutral conductor were installed into the enclosure through the top hole. The neutral conductor was then terminated into the neutral bar assemblies after scoring with a steel brush and applying an antioxidant compound.

53. The 4 AWG stranded copper return conductors, along with the 40% CCS GEC conductor samples, were installed into the enclosure through the bottom hole. The stranded copper conductors were terminated into locations on the bus bar at the opposite end from where the service neutral terminated to ensure that current conducts through the full length of the bus bar.

    53.a. As shown in Figure 8, the 200A bus bar assembly consists of two bus bars bonded together via a jumper bar embedded into the plastic housing (not observable in image). To emulate a worst-case scenario where all load neutrals are installed on only one of these bus bars, the stranded copper return conductors were installed on only the right bus bar.

54. As shown in Figure 7 and Figure 8, two 40% CCS GEC samples were installed in the 125A and 200A bus bars, one at locations between two 4 AWG copper return conductors and one at midpoint locations in the bus bars and away from load carrying conductors.

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[34] UL 67, 13th Edition, Section 21.4.2 Neutral "black box" test (Method A).

54.a. The purpose of testing at two locations is to ensure one 40% CCS GEC sample is installed in a location where the bus bar is conducting the full load (midpoint locations) and the other 40% CCS GEC sample is installed near load carrying conductors where adjacent terminal heating may further affect the 40% CCS GEC termination (lower locations).

54.b. Due to limitations in the number of termination points available in the 70A bus bar, only one 40% CCS GEC sample was included for testing (Figure 6).

55. Following installation of the GECs, 24 AWG K-type thermocouples were wrapped in Kapton tape and installed via the lower enclosure hole and terminated in bus bar terminal locations near each of the 40% CCS GEC samples. Figure 9 and Figure 10 provide images of the thermocouples installed in 125A neutral bus bar.

55.a. Additional thermocouples were installed in each enclosure to monitor the internal air temperature and an additional thermocouple was installed in the testing space to record ambient lab air temperature.

56. As required in UL 67 Temperature Test, surgical cotton was installed around the conductors in each of the top and bottom holes prior to commencing testing. Figure 11 provides example images of this for the 125A bus bar test setup.

57. All conductors were terminated to the appropriate tightening torque (by using a calibrated torque wrench), as defined in either the panelboard manual, or the NEC Table I.1.[35] The tightening torques used for the testing are summarized below in Table 3.

Table 3 – Summary of Tightening Torques used for Terminations

Neutral Bus Bar Rating	Service Neutral (lbf-in)	GEC (lbf-in)	4 AWG Stranded Cu (lbf-in)
70A	50	25	25
125A	50	45	45
200A	250	35	35

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[35] NEC 2023, Table I.1 Tightening Torque for Screws

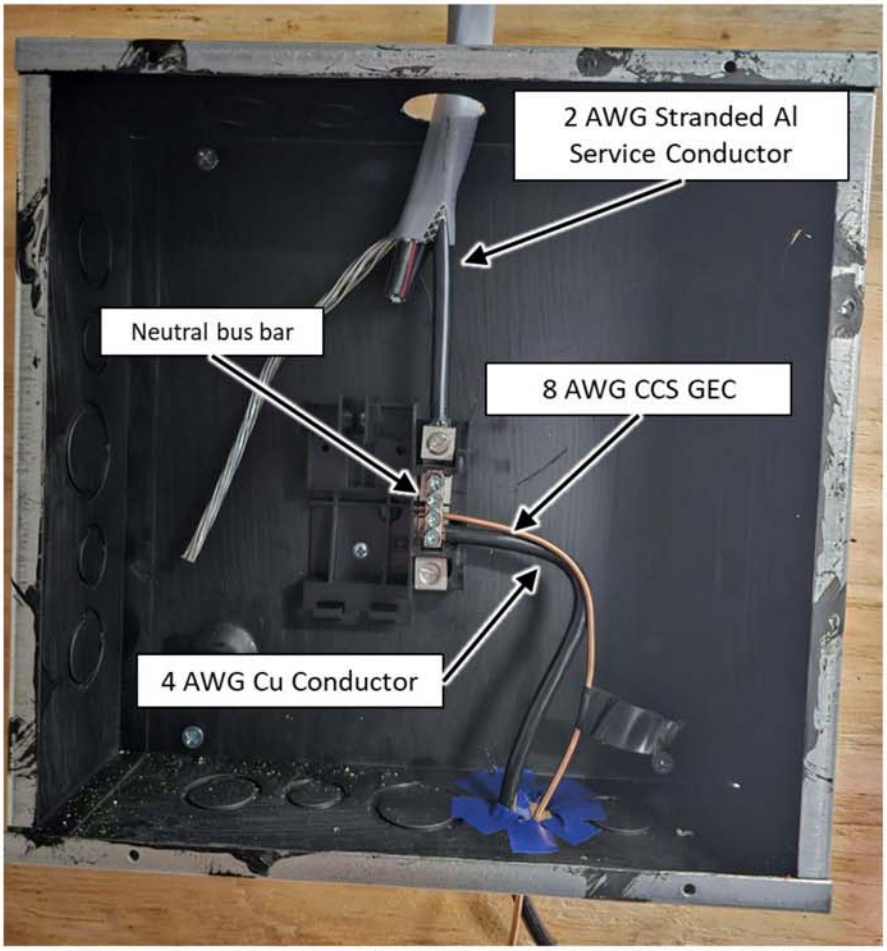

Figure 6. The 70A neutral bus bar and enclosure. Note, this photo was taken prior to the installation of the thermocouples and the surgical cotton in the openings around the conductors entering the enclosure.

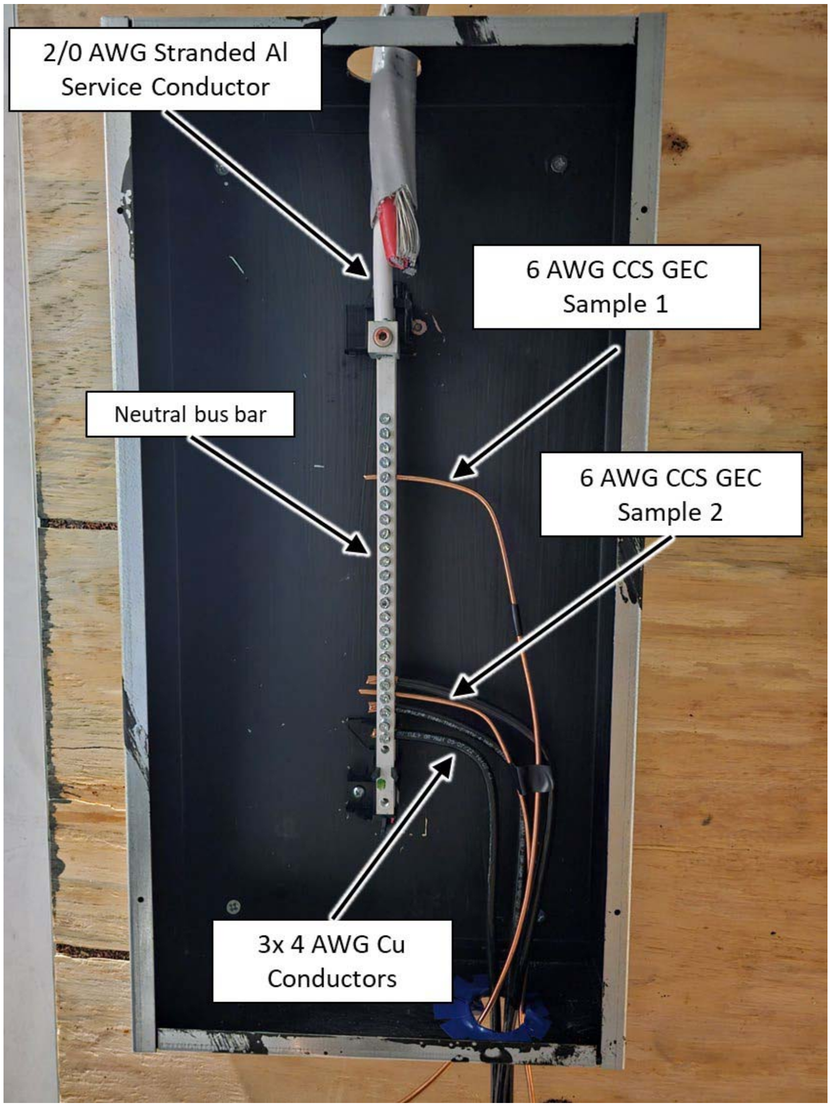

Figure 7. The 125A neutral bus bar and enclosure. Note, this photo was taken prior to the installation of the thermocouples and the surgical cotton in the openings around the conductors entering the enclosure.

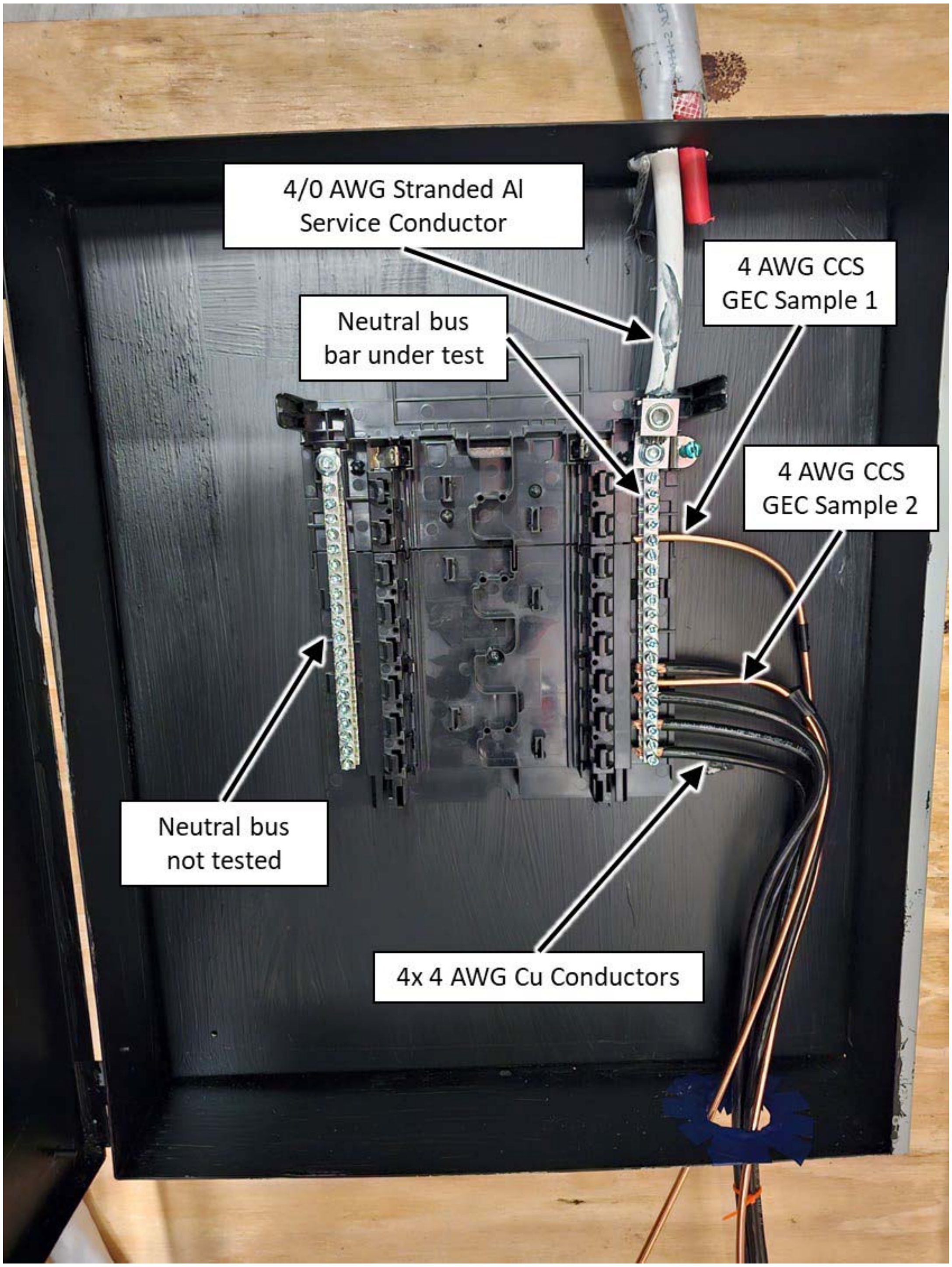

Figure 8. The 200A neutral bus bar assembly and enclosure. Only the right bus bar was incorporated into testing.Note, this photo was taken prior to the installation of the thermocouples and the surgical cotton in the openings around the conductors entering the enclosure.

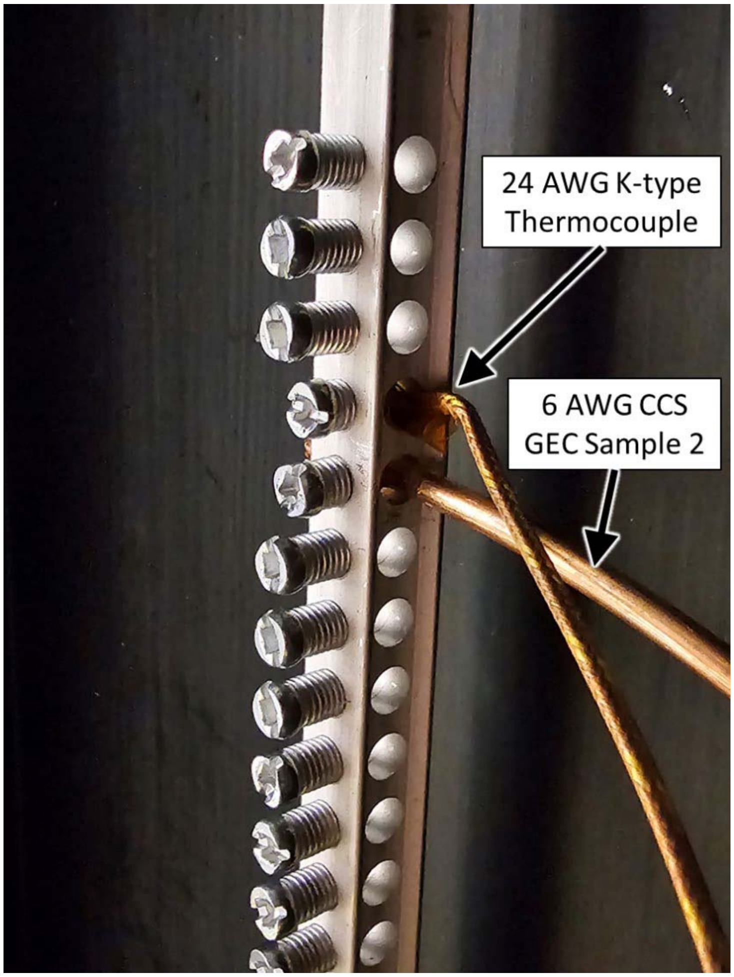

Figure 9. Image of the thermocouple installed adjacent to the top 40% CCS GEC termination on the 125A neutral bus bar. This image is representative of the thermocouples installed in the 200A and 70A neutral bus bars as well.

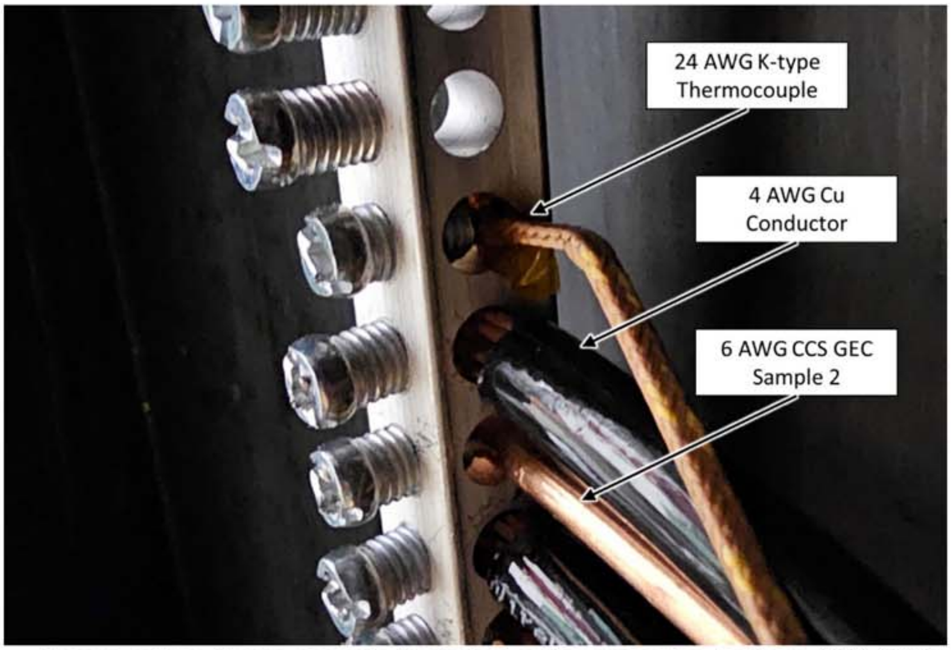

Figure 10. Image of the thermocouple installed adjacent to the bottom 40% CCS GEC termination on the 125A neutral bus bar. This image is representative of the thermocouples installed in the 200A and 70A neutral bus bars as well.

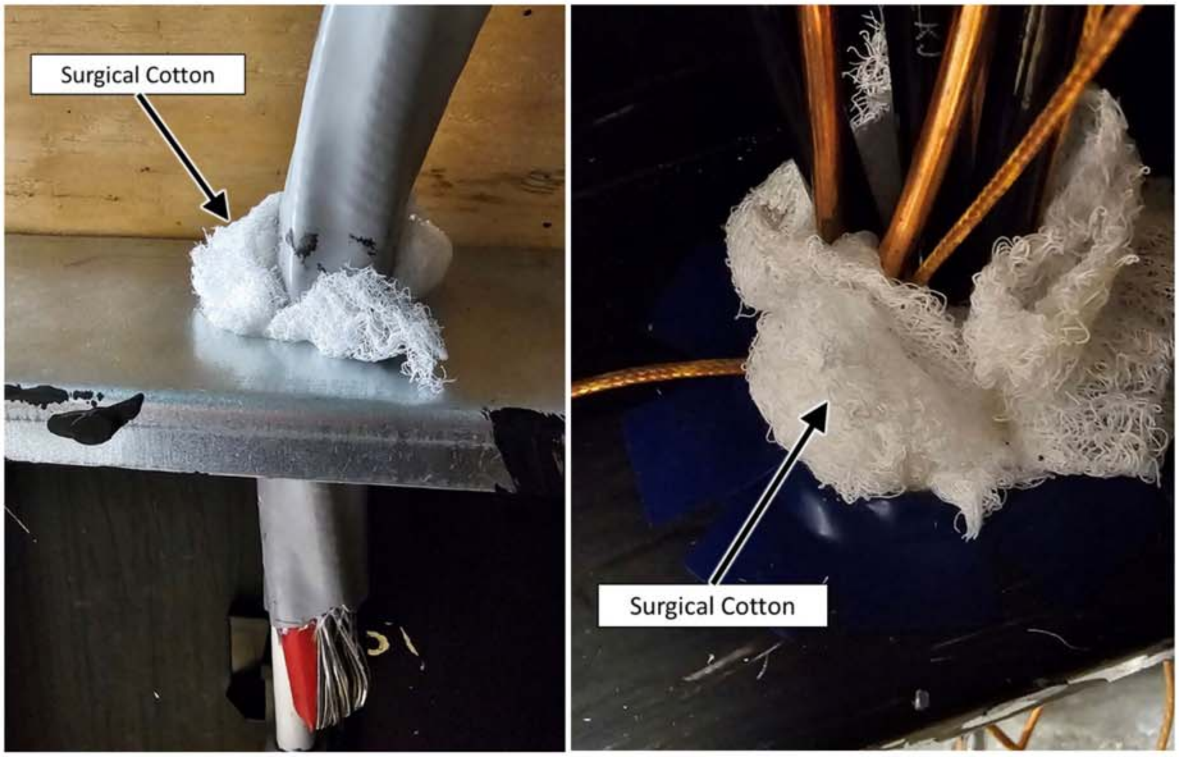

Figure 11. Surgical cotton installed around the conductors entering the 125A bus bar enclosure. These photos are also representative of the installations for the 70A and 200A bus bars.

3.3 Testing Procedure and Results

3.3.1 Testing and Measurement Procedure

58. Each bus bar assembly is being subjected to a series of 500 current cycles with each cycle consisting of one hour under load at the bus bar rated current and one hour under no load.

    58.a. Observations of data collected during the first 25 cycles indicated that these lengths time lengths were sufficient for driving measured temperatures to stable values (< 2 ºC temperature change across a 30-minute measurement period) in accordance with UL 486E Current Cycling testing procedures.

59. Prior to the first cycle, the Hioki RM3584 was used to measure the contact resistance between each 40% CCS GEC sample and its corresponding bus bar.

    59.a. Figure 12 shows the method used to measure the contact resistance. One of the Kelvin clip probes from the Hioki RM3584 is clipped to the portion of the 40% CCS GEC just outside the bus bar termination. The other Kelvin clip is clipped to the bus bar or otherwise held in place at a location on the bus bar adjacent to the 40% CCS GEC termination.

60. Following this initial measurement, the covers for the bus bar enclosures were installed and the current cycling commenced.

61. Throughout testing, thermocouple readings are being recorded every two minutes.[36]

62. Additional resistance measurements are being obtained during the off portions of cycles at approximately the target cycle locations for reporting.

63. Table 4 provides the resistance measurements achieved at the time of this report's publication. This table also includes the actual cycle number when the measurements were achieved and the maximum recorded temperature rise above ambient at the bus bar measurement locations adjacent the 40% CCS GEC termination.

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[36] This frequency of recording is faster than UL 486E Current Cycling requirements but was elected for use as it provides better insight into temperature trends.

3.3.2 Results to Date[37]

64. The temperature values and resistance measurements reported to date in Table 4 suggest the following points.[38]

64.a. Even under rated current loads, which represent worst-case loading for the neutral bus bars, the bus bar material only modestly increases in temperature and thus likely does not significantly stress the 40% CCS GEC terminations.

64.b. The resistance measurements achieved are both small (tens of μΩ) and generally stable throughout testing further suggesting that these terminations are not significantly affected by the current cycling program.

64.b.i. In the 143rd cycle data points, the measured resistance values are slightly lower (3-6 μΩ) than the measured resistances from the previous cycle measurements on the 70A and 200A bus bars. This is most likely due to differences in placement of the Hioki probes on the bus bar for these measurements. Starting with the 179th cycle, the locations for probe placement were better standardized and the measured resistance values can be observed to normalize to previous values.

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[37] Exponent reserves the ability to update or otherwise modify these initial interpretations as further test data and results are achieved.

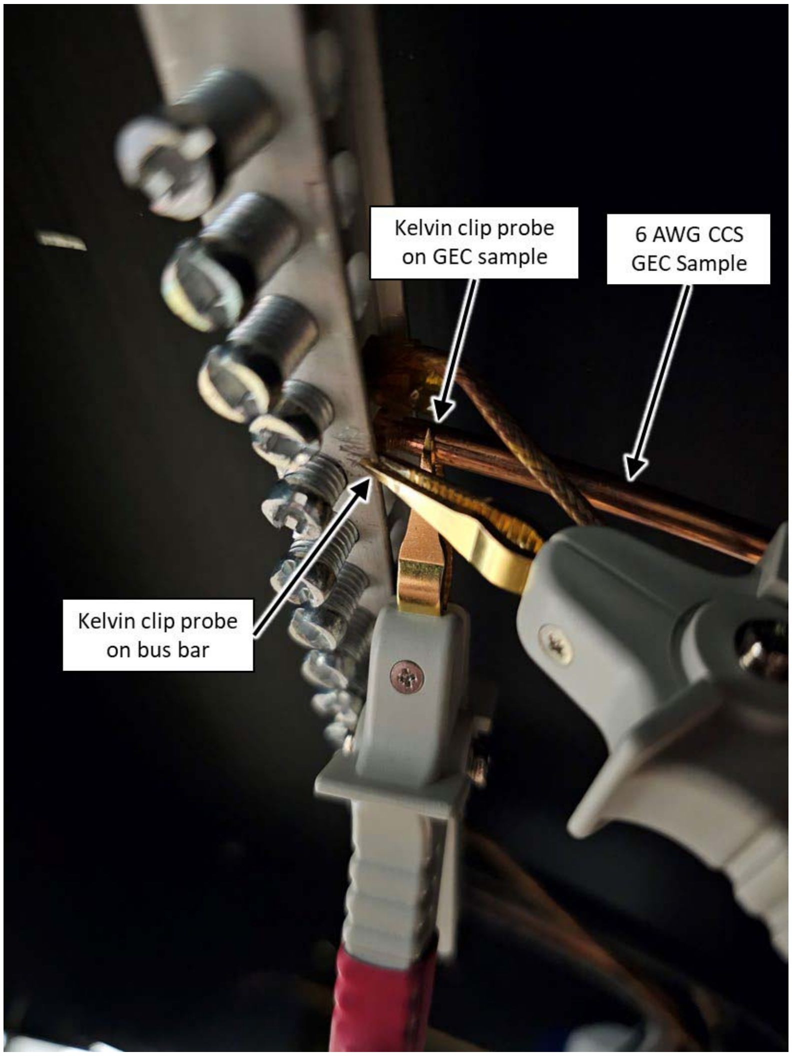

Figure 12. Method and Kelvin clip probe location for one of the GEC samples tested with the 125A neutral bus bar.

Table 4 – Results to date of the current cycling testing program.

Nominal Cycle Number	**0**	**25**	**50**	**75**	**100**	**125**	**175**	**225**	**275**	**350**	**425**	**500**
Measured Cycle Number	**0**	**25**	**50**	**75**	**107**	**143**	**179**	**229**				
70A bus bar 40% CCS GEC testing												
Max Temp. Rise (ºC)	N/A	8.1	8.0	8.4	8.5	8.3	8.5	8.6				
Measured Resistance (μΩ)	47	46	46	44	43	38	42	45				
125A bus bar 40% CCS GEC testing												
Max Temp. Rise (ºC)	N/A	14	13	14	14	14	15	14				
Measured Resistance (μΩ)	30	31	28	30	30	30	31	33				
Max Temp. Rise (ºC)	N/A	9.6	9.4	9.7	9.9	9.5	10	10				
Measured Resistance (μΩ)	32	30	31	30	33	30	31	33				
200A bus bar 40% CCS GEC testing												
Max Temp. Rise (ºC)	N/A	20	20	20	20	20	21	20				
Measured Resistance (μΩ)	23	24	23	24	22	18	21	24				
Max Temp. Rise (ºC)	N/A	14	13	13	13	13	14	13				
Measured Resistance (μΩ)	21	22	23	21	21	18	22	24				

4.0 Limitations

65. This presentation includes results of ongoing work being conducted at the request of Copperweld Bimetallics LLC.

66. The material contained herein is presented to a reasonable degree of scientific and engineering certainty and may not adequately address the needs of any or all users of this presentation. Any re-use of this presentation, or any of its contents, is made at the sole risk of the user. No guarantee or warranty as to future relevance is expressed or implied. Exponent reserves the right to supplement this presentation and to expand or modify its contents based on review of additional material as it becomes available and/or through any additional work or review of additional work performed by others.

67. In this report, we have relied on materials and information provided by Copperweld Bimetallics LLC. We cannot verify the correctness of this input and rely on Copperweld Bimetallics LLC for accuracy.

68. Although Exponent has exercised usual and customary care in preparing this summary presentation, the responsibility for the design, manufacture, and quality of their products remains fully with Copperweld Bimetallics LLC.

Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]

250.62 Grounding Electrode Conductor Material.

The grounding electrode conductor shall be of copper, copper-clad steel, aluminum, copper-clad aluminum, or the items as permitted in 250.68(C). The material selected shall be resistant to any corrosive condition existing at the installation or shall be protected against corrosion. Conductors of the wire type shall be solid or stranded, insulated, covered, or bare. Copper-clad steel shall adhere to the following:

1. Shall be a bimetal where the copper cladding and the steel core maintain a metallurgical bond

2. Shall be grade 40% copper-clad steel

3. Shall be listed per Section 110.3(C)

Additional Proposed Changes

File Name	Description	Approved
Copperweld_CCS_Biomechanical_Report_Copy.pdf	Exponent Scientific Test Report: Bending 40% CCS Human Factor Strain	✓
CCS40vsElectoPlate.pdf	Manufacturing Processes: Copper Cladding vs Electro-Plating	✓
CEL_-_13_Grounding_Conductor_Current_Test.pdf	Test Report: 40% CCS Low Impedance Material Testing	✓
Copperweld_CCS_Mechanical_Testing_Report.pdf	Exponent Scientific Test Report: Mechanical for 40% CCS	✓
Electrical_Analysis_and_Testing_Report_2023-09-07.pdf	Exponent Scientific Test Report: Electrical Testing 40% CCS	✓

Statement of Problem and Substantiation for Public Input

In the utility world for over a century Copper-Clad Steel (CCS) has been used as a Grounding Electrode (GE), bonding conductor, and the outdoor (and direct buried) version of a Grounding Electrode Conductor (GEC). CCS is a metallurgically bonded bimetal of copper and annealed steel. There is no shortage of knowledge about this material available to industry and its application as a primary material for grounding mats under substations, windfarms, transmission towers, industrial buildings, and solar farms. It also connects utility equipment and structures to GEs. It grounds transformers, utility fences, buildings, and affiliated equipment. Not just in the U.S., CCS is employed world-wide and is especially utilized in nations where extreme theft of grounding conductors occurs. The low scrap value and high shear strength of CCS disincentivize its theft. 40% CCS is the grade of CCS that contains the most copper by mass, and thus maintains the highest conductivity and corrosion resistance of the class of material. 40% CCS is not an electro-plated steel product (EPS). Ground rod GEs use CPS methods for depositing copper to steel through a chemical electrolytic process. In most cases, EPS ground rods contain +/- 10% copper by mass for corrosion resistance. CCS 40% is manufactured differently. Copper cladding is accomplished purely through mechanical means. In answering panel concerns from last cycle, please note:

1. A “New and Innovative” listing program is currently being developed by UL Solutions for 40% CCS wire and cable for use as a grounding electrode (GE) and grounding electrode conductor (GEC). The program will be in place by 2024 before the 2026 NEC edition is published. This will ensure that only 40% CCS is used by the industry for GECs and GE rings, safeguarding that only the highest quality of CCS is used. To better accommodate 40% CCS, proposals to amend UL 467 will also be created. UL 467 is the listing standard for equipment used for grounding and bonding, and although the standard does not have purview over GEC’s or conductors, a degree of adjustment is in order.

2. Delamination was a question last cycle. Delamination is not uncommon with EPS products because no metallurgical bond is present between the two metals. Delamination is not typical (nor permitted) of copper clad steel products, however. Cladding is not an electrolytic process like EPS, but rather one where two single-state metals are mechanically sintered together by a rolling mill using high pressure and controlled heating. To meet ASTM B227 for Hard Drawn Copper-Clad Steel Wire, testing to ensure adhesion and cohesion of the metallurgical bond is a requirement. When a bond is present, delamination is not possible. Please see the presentation “CCS40vsElectroPlate” included as substantiation for this Public Input.

3. The apparent “too stiff to bend” claim describing 40% CCS raised last cycle is unfounded. Scientific research by a human factors research team determined that to bend 4 AWG solid 40% CCS to a 90° angle requires 6.21 Ft-Lb of force. This requires equivalent wrist strength to “open a jam jar lid.” Further, bending 4 AWG solid 40% CCS to an angle of 90° is 2X less taxing to the human wrist than terminating a small circuit conductor to a common receptacle requiring a minimum of 12 Ft-lbs. of torquing force be applied to the wire-binding screw. Terminating receptacles is a task accomplished by electricians dozens of times per day. Please see the ExPonent report “Copperweld CCS Biomechanical Report” included as substantiation for this Public Input.

4. Regarding the damaging of panelboard components by 40% CCS GECs, a study executed by a team of PhD scientists reveals that 4 AWG solid 40% CCS puts practically no strain on the lugs and plastic pieces of typical load center panels for 200, 125 and 70 ampere services. Aging experiments with strain gauges determined that installing the aluminum service conductor by far administered the most stress on panelboards. The same study reports that 40% CCS GECs do not exhibit elastic memory, and thus will not “spring back” to dislodge lugs once terminated inside a panelboard. Please see the ExPonent report “Copperweld CCS Mechanical Testing Report” included as substantiation with this Public Input.

5. Regarding questions about a GEC’s required level of electrical conductivity, Table 5 of UL 467 should not be used as a guide for determining the size of GECs. Namely UL 467 wasn’t designed to test GECs but rather (at least as part of its scope) their connectors. Table 5 aims to create extreme heat through high amperage for its test subjects – connectors and equipment. Table 5 does not employ GECs for this job. Rather, it calls for EGCs and bonding conductors for that role. In short, Table 5 is geared to evaluate the cracking and fusing potential of connectors and equipment in a laboratory setting. This testing does not reflect the duration or level of amperage a GEC is likely to experience in the field. The GEC’s role is to provide a secure connection to earth for the installation, something that requires physical strength and some degree of low impedance.

6. The sizing of GECs in Table 250.66 of the NEC does not directly translate to a required level of conductivity for each GEC size. Rather, because both copper and aluminum are soft metals, the table is geared towards ensuring the mechanical strength of a GEC through oversizing. To illustrate, GECs and their extensions are permitted to be made of materials with drastically different conductivities – some with high conductivities and some with extremely low conductivities (rebar). Second, if a GE of an installation does not extend to any other GE, and is made of a code compliant rod, pipe or plate, its GEC is only required to be 6 AWG copper (or 4 AWG Aluminum or CCA) regardless of the size of the service. These two points contradict the

conventional wisdom behind Table 250.66 as being a sizing table based upon GEC conductivity. To contradict conventional wisdom further, in the case of a service where a ground ring is used as the GE, and the ground ring does not extend to any other GE, an 8 AWG copper may be used as the GEC regardless of the size of the service. In short, the GEC is not required to surpass any defined level of conductivity per se. Section 250.66 effectively decouples the GEC from the notion that its conductivity is directly related to the size of service, or that a certain level of conductivity per size is required. Rather, GECs must be mechanically robust enough to assure an electrical installation’s long-term connection to earth. Oversizing GECs for the job of carrying little-to-no current seems illogical until viewed through the lens of mechanical strength. Oversizing gives greater mechanical strength to the GEC than it would otherwise not have, better assuring the continuity of the earth connection. Where the GEC is small with a low shear strength (a small size like 8 AWG copper for example) or when it is located where it might incur physical damage, Code requires it to be protected with steel, hard plastic or cable armor. In other words, for a GEC it is less about how conductive it is on the IACS scale, and more about how mechanically able it is to maintain connection over the life of the installation. For more information on the connection resistance of 40% CCS in current cycling tests, please see the ExPonent report “Electrical Analysis and Testing of 40% Copper Clad Steel (CCS) Conductors For Use as Grounding Electrode Conductors (GECs)” included as substantiation with this Public Input.

Submitter Information Verification

Submitter Full Name: Peter Graser
Organization: Copperweld
Affiliation: American Bimetallic Association
Street Address:
City:
State:
Zip:
Submittal Date: Sat Jun 17 08:36:35 EDT 2023
Committee: NEC-AAC

Copyright Assignment
I, Peter Graser, hereby irrevocably grant and assign to the National Fire Protection Association (NFPA) all and full rights in copyright in this Public Input (including both the Proposed Change and the Statement of Problem and Substantiation). I understand and intend that I acquire no rights, including rights as a joint author, in any publication of the NFPA in which this Public Input in this or another similar or derivative form is used. I hereby warrant that I am the author of this Public Input and that I have full power and authority to enter into this copyright assignment.

By checking this box I affirm that I am Peter Graser, and I agree to be legally bound by the above Copyright Assignment and the terms and conditions contained therein. I understand and intend that, by checking this box, I am creating an electronic signature that will, upon my submission of this form, have the same legal force and effect as a handwritten signature

Public Input No. 975-NFPA 70-2023 [Section No. 250.62]

250.62 Grounding Electrode Conductor Material.

The grounding electrode conductor shall be ~~of copper, aluminum, copper-clad aluminum, or~~ the items ~~as~~ permitted in 250. 118(A) or 250. 68(C). The material selected shall be resistant to any corrosive condition existing at the installation or shall be protected against corrosion. Conductors of the wire type shall be solid or stranded, insulated, covered, or bare.

Statement of Problem and Substantiation for Public Input

The electrical requirements for grounding electrode conductors are less stringent than those for equipment grounding conductors, so all equipment grounding conductor types shall be permitted for use as grounding electrode conductors as long as they comply with 250.66 and are resistant against corrosion in the environment that they are installed in. Especially raceways and equipment enclosures made of corrosion resistant metals such as galvanized steel shall be allowed for use as grounding electrode conductors.

Submitter Information Verification

Submitter Full Name: Conrad Ko
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 07 16:53:44 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: No substantiation was provided to allow the other types of materials to be used as grounding electrode conductors.

Public Input No. 1986-NFPA 70-2023 [Section No. 250.64(A)]

(A) Aluminum or Copper-Clad Aluminum Conductors.

Grounding electrode conductors of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following:

(1) Bare or covered conductors without an extruded polymeric covering shall not be installed where subject to corrosive conditions or be installed in direct contact with concrete.

(2) Terminations made within outdoor enclosures that are listed and identified for the environment shall be permitted within 450 mm (18 in.) of the bottom of the enclosure.

(3) Aluminum or copper-clad aluminum conductors external to buildings or equipment enclosures shall not be terminated within 450 mm (18 in.) of the earth.

(4) Uninsulated aluminum conductors shall be a minimum of 18 inches above the earth.

Statement of Problem and Substantiation for Public Input

To lessen the possibility of insulated aluminum conductors from coming into contact with the earth.

Submitter Information Verification

Submitter Full Name: Gary Hein
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 09 12:51:53 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The proposed requirement is already addressed in the requirements of the section. The proposed language does not add any further clarity and is not needed. Adequate substantiation was not provided to require the enclosure to be installed on a solid surface. The device described for termination within 18” of the earth is for a splice and not a device that would be able to make a termination connection of an aluminum or copper-clad aluminum grounding electrode conductor to an electrode.

Public Input No. 1994-NFPA 70-2023 [Section No. 250.64(A)]

(A) Aluminum or Copper-Clad Aluminum Conductors.

Grounding electrode conductors of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following:

(1) Bare or covered conductors without an extruded polymeric covering shall not be installed where subject to corrosive conditions or be installed in direct contact with concrete, masonry or the earth .

(2) Terminations made within outdoor enclosures that are listed and identified for the environment shall be permitted within 450 mm (18 in.) of the bottom of the enclosure.

(3) Aluminum or copper-clad aluminum conductors external to buildings or equipment enclosures shall not be terminated within 450 mm (18 in.) of the earth.

Statement of Problem and Substantiation for Public Input

Clearly state that bare or covered aluminum conductors cannot be installed in direct contact with the earth or masonry.

- Consider using similar language from 250.120 (B) (1)
- Many of the same concerns that would affect bare or covered aluminum equipment grounding conductors can be expected to be similar for bare or covered aluminum grounding electrode conductors.

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Aug 10 12:29:31 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: The proposed requirement is already addressed in the requirements of the section. The proposed language does not add any further clarity and is not needed. Adequate substantiation was not provided to require the enclosure to be installed on a solid surface. The device described for termination within 18” of the earth is for a splice and not a device that would be able to make a termination connection of an aluminum or copper-clad aluminum grounding electrode conductor to an electrode.

Public Input No. 43-NFPA 70-2023 [Section No. 250.64(A)]

(A) Aluminum or Copper-Clad Aluminum Conductors.

Grounding electrode conductors of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following:

(1) Bare or covered conductors without an extruded polymeric covering shall not be installed where subject to corrosive conditions or be installed in direct contact with concrete.

(2) Terminations made within outdoor enclosures that are listed and identified for the environment and installed on solid surfaces shall be permitted within 450 mm (18 in.) of the bottom of the enclosure.

(3) Aluminum or copper-clad aluminum conductors external to buildings or equipment enclosures shall not be terminated within 450 mm (18 in.) of the earth.

(4) Wet location rated insulated conductors shall be permitted to be terminated within 18" of earth using waterproof connectors.

Statement of Problem and Substantiation for Public Input

NEC has made some changes in recent cycles to address circumstances with outdoor installations where aluminum EGC or GEC conductors may not be used simply because a designer is not certain they will not end up terminating in an enclosure that happens to be less than 18" from grade. However, 2 changes are proposed to address 2 remaining potential issues.

Change to (2): There is no consideration for the common "boxout" often used at pad-mounted outdoor equipment such as transformers and switchboards. These boxouts introduce significant amounts of moisture which could corrode aluminum conductors. Installers can not always be required to fill these boxouts with grout. Thus, it would seem that if there is an opening to earth, that aluminum ground conductors should be restricted. This change would ensure that the NEC would restrict the use of aluminum ground conductors in this scenario.

Addition of (4): GEC/EGC conductors may be spliced in padmount equipment with boxouts and some other open bottom outdoor pad mounted enclosures. The text as written may not allow this, even if a waterproof termination means is used. The change would allow aluminum ground conductors to be installed within 18" of earth in these enclosures, provided corrosion protection in the form of a waterproof splice (such as the one referenced below) is used.
https://hubbellcdn.com/specsheet/BURNDY_BIBS5006DB_Specsheet.pdf

Submitter Information Verification

Submitter Full Name: Josh Weaver
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 04 17:00:57 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: The proposed requirement is already addressed in the requirements of the section. The proposed language does not add any further clarity and is not needed. Adequate substantiation was not provided to require the enclosure to be installed on a solid surface. The device described for termination within 18” of the earth is for a splice and not a device that would be able to make a termination connection of an aluminum or copper-clad aluminum grounding electrode conductor to an electrode.

Public Input No. 3103-NFPA 70-2023 [Section No. 250.64(B)]

(B) Securing and Protection Against Physical Damage.

If exposed, a grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried and shall be mechanically secured to the enclosure(s) it enters . Grounding electrode conductors shall be permitted to be installed on or through framing members.

Exception: A grounding electrode conductor is not required to be secured to an enclosure that provides the 1/4 in. entry for the grounding electrode conductor.

(1) Not Exposed to Physical Damage.

A 6 AWG or larger copper, copper-clad aluminum, or aluminum grounding electrode conductor not exposed to physical damage shall be permitted to be run along the surface of the building construction without metal covering or protection.

(2) Exposed to Physical Damage.

A 6 AWG or larger copper, copper-clad aluminum, or aluminum grounding electrode conductor exposed to physical damage shall be protected in rigid metal conduit (RMC), intermediate metal conduit (IMC), Schedule 80 rigid polyvinyl chloride conduit (PVC), reinforced thermosetting resin conduit Type XW (RTRC-XW), electrical metallic tubing (EMT), or cable armor.

(3) Smaller Than 6 AWG.

Grounding electrode conductors smaller than 6 AWG shall be protected in RMC, IMC, Schedule 80 PVC, RTRC-XW, EMT, or cable armor.

(4) In Contact with the Earth.

Grounding electrode conductors and grounding electrode bonding jumpers in contact with the earth shall not be required to comply with 300.5 or 305.15, but shall be buried or otherwise protected if subject to physical damage.

Statement of Problem and Substantiation for Public Input

The added text is intended to require the grounding electrode conductor to be mechanically secured to any enclosure through which it passes. Added an exception for grounding electrode conductors that enter the enclosure via ¼ in. knockout entry. Section 312.5 already requires openings through which conductors enter to be closed in an approved manner, this requirement includes the grounding electrode conductor. Adding the proposed language to Article 250 will bring clarity to Code users that the grounding electrode conductor is required to be secured to the enclosure it enters just like any other conductor.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 11:56:25 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Sufficient information or substantiation has not been provided to conclude that this proposed revision is needed or will provide for a safer installation. It has been a common practice to route grounding electrode conductors into enclosures without securing them.

Public Input No. 1103-NFPA 70-2023 [Section No. 250.64(B)(1)]

(1) Not Exposed to Physical Damage.

A 6 AWG or larger copper, copper-clad steel, copper-clad aluminum, or aluminum grounding electrode conductor not exposed to physical damage shall be permitted to be run along the surface of the building construction without metal covering or protection.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name:	Peter Graser
Organization:	Copperweld
Affiliation:	American Bimetallic Association
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Jun 17 08:41:39 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 1104-NFPA 70-2023 [Section No. 250.64(B)(2)]

(2) Exposed to Physical Damage.

A 6 AWG or larger copper, copper-clad steel, copper-clad aluminum, or aluminum grounding electrode conductor exposed to physical damage shall be protected in rigid metal conduit (RMC), intermediate metal conduit (IMC), Schedule 80 rigid polyvinyl chloride conduit (PVC), reinforced thermosetting resin conduit Type XW (RTRC-XW), electrical metallic tubing (EMT), or cable armor.

Statement of Problem and Substantiation for Public Input

See technical substantiation of Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name: Peter Graser
Organization: Copperweld
Affiliation: American Bimetallic Association
Street Address:
City:
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Zip:
Submittal Date: Sat Jun 17 08:42:54 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 2381-NFPA 70-2023 [Section No. 250.64(B) [Excluding any Sub-Sections]]

Grounding electrode conductor(s) shall be secured to the enclosure it enters in an approved manner. If exposed, a grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried. Grounding electrode conductors shall be permitted to be installed on or through framing members.

Statement of Problem and Substantiation for Public Input

It’s not 100% clear whether or not grounding electrode conductors are required to be secured to the enclosures in a manner that is approved by the AHJ. All other conductors, cables, and raceways are required to be secured to the enclosure they enter, why is the GEC any different? Adding this language to first level subdivision will make it clear to Code users that the GEC must be secured to the enclosure it enters.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 16 15:24:29 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Sufficient information or substantiation has not been provided to conclude that this proposed revision is needed or will provide for a safer installation. It has been a common practice to route grounding electrode conductors into enclosures without securing them.

Public Input No. 1090-NFPA 70-2023 [Section No. 250.64(C)]

(C) Continuous.

Except as provided in 250.30(A)(5) and (A)(6), 250.30(B)(1), and 250.68(C), grounding electrode conductor(s) shall be installed in one continuous length without a splice or joint. If necessary, splices or connections shall be made as permitted in the following:

(1) Splicing of the wire-type grounding electrode conductor shall be permitted only by irreversible compression-type connectors listed as grounding and bonding equipment or by the exothermic welding process.

(2) Sections of busbars <u>within a single enclosure</u> shall be permitted to be connected together to form a grounding electrode conductor.

(3) Bolted, riveted, or welded connections of structural metal frames of buildings or structures.

(4) Threaded, welded, brazed, soldered or bolted-flange connections of metal water piping.

Statement of Problem and Substantiation for Public Input

It strikes me as bizarre, but a colleague contacted me about approximately this discovery:
A GEC was brought to a subpanel's neutral busbar. From there a grounded feeder conductor went to the service panel's neutral busbar, to which the incoming neutral was attached, along with the (screw-type) main bonding jumper. The argument, presumably, was that this "connected together" the two neutral busbars, per the present language of 250.64(C)(2).
Adding these few words will eliminate the possibility of this interpretation. I've read this simply as intending that when a service panel has a neutral busbar in each side wiring channel, bonded together, so long as you don't remove that (normally factory-installed) bond you can bring the GEC to one and the incoming neutral to the other and it makes no difference. You're not using the cabinet to establish GEC continuity with the utility neutral, and you're not interposing the possible voltage drop of feeder connections. Section 250.64(D)(1) makes the restriction more explicit by specifying how GECs may be tapped, but (C) is the more general section and likely to be looked at more often.

Submitter Information Verification

Submitter Full Name: David Shapiro
Organization: Safety First Electrical
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 14 18:15:03 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The proposed language does not add further clarity to the requirement.

Public Input No. 1825-NFPA 70-2023 [Section No. 250.64(C)]

(C) ~~Continuous.~~

~~Except as provided in 250.30(A)(5) and (A)(6), 250.30(B)(1) , and 250.68(C) , grounding electrode conductor(s) shall be installed in one continuous length without a splice or joint. If necessary, splices or connections shall be made as permitted in the following:~~

- ~~Splicing of the wire-type grounding electrode conductor shall be permitted only by irreversible compression-type connectors listed as grounding and bonding equipment or by the exothermic welding process.~~
- ~~Sections of busbars shall be permitted to be connected together to form a grounding electrode conductor.~~
- ~~Bolted, riveted, or welded connections of structural metal frames of buildings or structures.~~

~~Threaded, welded, brazed, soldered or bolted-flange connections of metal water piping~~

Installation

The Grounding Electrode Conductor shall be installed in accordance with the applicable provisions in this *Code* using fittings for joints and terminations approved for use with the type of raceway or conductor used. All connections, joints, and fittings shall be made tight using suitable tools .

Statement of Problem and Substantiation for Public Input

Irreversibility of the GEC was important in the early 1900's when the metallic water pipe system was used as the effective ground-fault current path. NFPA 70 now requires an effective ground-fault current path that is a component part of the electrical system. The effective ground-fault current path can be made up from many different components: raceways, fittings, enclosures, jumpers, screws, and such. The proposed language in this PI is a copy of the language in 250.20 for the means of connection of equipment grounding conductors. Since irreversibility is not required in the effective ground-fault path, why should it be required in the Grounding Electrode Conductor path? The GEC is already allowed to be connected to/through building steel, busbars, and copper plates without reversibility.

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Aug 05 15:05:47 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The input includes unenforceable language in accordance with 3.2.1 from the NEC Style Manual and references to the entire code are not permitted by 4.1.4 of NEC Style

Manual.

Public Input No. 2321-NFPA 70-2023 [Section No. 250.64(C)]

(C) Continuous.

Except as provided in 250.30(A)(5) and (A)(6), 250.30(B)(1), and 250.68(C), grounding electrode conductor(s) shall be installed in one continuous length without a splice or joint. If necessary, splices or connections shall be made as permitted in the following:

(1) Splicing of the wire-type grounding electrode conductor shall be permitted only by ~~irreversible compression-type~~ connectors listed as grounding and bonding equipment or by the exothermic welding process.

(2) Sections of busbars shall be permitted to be connected together to form a grounding electrode conductor.

(3) Bolted, riveted, or welded connections of structural metal frames of buildings or structures.

(4) Threaded, welded, brazed, soldered or bolted-flange connections of metal water piping.

Statement of Problem and Substantiation for Public Input

The term irreversible means the connection cannot be undone. Equipment grounding conductors and bonding jumpers that are part of the effective ground-fault current path only need to comply with 250.8 for their connection requirement. Why do grounding electrode conductors have this special requirement? It seems that a conductor part of the effective ground-fault current path would have stricter requirement than a conductor used to ground equipment. This proposed change would allow mechanical connectors to be used on the grounding electrode conductor just like there are used on equipment grounding conductors.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 16 12:22:49 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Adequate substantiation was not provided to support splices in GEC in non-accessible locations using reversible means.

Public Input No. 3104-NFPA 70-2023 [Section No. 250.64(C)]

(C) Continuous.

Except as provided in 250.30(A)(5) and (A)(6), 250.30(B)(1), and 250.68(C), grounding electrode conductor(s) shall be installed in one continuous length without a splice or joint. If necessary, splices or connections shall be made as permitted in the following:

(1) Splicing of the wire-type grounding electrode conductor shall be permitted only by irreversible compression-type connectors listed as grounding and bonding equipment ~~or~~ , pressure connectors listed as grounding and bonding, or by the exothermic welding process.

(2) Sections of busbars shall be permitted to be connected together to form a grounding electrode conductor.

(3) Bolted, riveted, or welded connections of structural metal frames of buildings or structures.

(4) Threaded, welded, brazed, soldered or bolted-flange connections of metal water piping.

Statement of Problem and Substantiation for Public Input

Section 250.64(D)(1)(2) permits grounding electrode taps to be spliced with a fitting listed as grounding and bonding equipment. There is not a technical reason to prohibit the grounding electrode conductor to be ‘terminated’ (spliced) to a fitting listed as grounding and bonding equipment. This proposed revision will give Code users another option to terminate the grounding electrode conductor.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
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City:
State:
Zip:
Submittal Date: Tue Aug 29 12:00:15 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Adequate technical substantiation was not provided to allow the splice of a grounding electrode conductor to be made by a pressure connector listed as grounding and bonding.

Public Input No. 3139-NFPA 70-2023 [Section No. 250.64(C)]

~~**(C)** Continuous.~~

~~Except as provided in 250.30(A)(5) and (A)(6), 250.30(B)(1) , and 250.68(C) , grounding electrode conductor(s) shall be installed in one continuous length without a splice or joint. If necessary, splices or connections shall be made as permitted in the following:~~

(1) ~~Splicing of the wire-type grounding electrode conductor shall be permitted only by irreversible compression-type connectors listed as grounding and bonding equipment or by the exothermic welding process.~~

(2) ~~Sections of busbars shall be permitted to be connected together to form a grounding electrode conductor.~~

(3) ~~Bolted, riveted, or welded connections of structural metal frames of buildings or structures.~~

(4) ~~Threaded, welded, brazed, soldered or bolted-flange connections of metal water piping.~~

Statement of Problem and Substantiation for Public Input

There is no reason to prohibit a splice in a grounding electrode conductor. An equipment grounding conductor is allowed to be spliced, and its role is infinitley more important than that of the grounding electrode conductor. Not only is the EGC more important as it relates to electrical safety, it will also carry current in far greater amounts than the GEC, yet has no splicing limitations. Recent revisions in the NEC allow an EGC to act as the required GEC if both wires meet the requirements for both purposes, but the deal breaker is usually the splicing limitation.

Submitter Information Verification

Submitter Full Name:	Ryan Jackson
Organization:	Self-employed
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 15:57:20 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Adequate substantiation was not provided to support splices in GEC in non-accessible locations using reversible means.

Public Input No. 3252-NFPA 70-2023 [Section No. 250.64(C)]

(C) Continuous.

~~Except as provided in 250.30(A)(5) and (A)(6), 250.30(B)(1) , and 250.68(C) , grounding electrode conductor(s) shall be installed in one continuous length without a splice or joint.~~ If necessary, splices or connections shall be made as permitted in the following:

(1) Splicing of the wire-type grounding electrode conductor shall be permitted only by irreversible compression-type connectors listed as grounding and bonding equipment or by the exothermic welding process.

(2) Sections of busbars shall be permitted to be connected together to form a grounding electrode conductor.

(3) Bolted, riveted, or welded connections of structural metal frames of buildings or structures.

(4) Threaded, welded, brazed, soldered or bolted-flange connections of metal water piping.

Statement of Problem and Substantiation for Public Input

The current text is clear that splices and terminations in 250.30(A)(5) and (A)(5, 250.30(B)(1) and 250.68(C), as well as the rules in 250.64(C) permit the grounding electrode conductor to be spliced or terminated. The text about the grounding electrode conductor to be in one continuous length without splice or joint service no value other than to confuse the reader. Some have read this rule to require that the grounding electrode conductor to multiple grounding electrodes to be run without splice. Those of us that know the grounding electrode conductor end at the first electrode. Removing this unnecessary language will simply make the use of the NEC a little easier without any loss in NEC requirements.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 30 17:39:53 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Adequate substantiation was not provided to support splices in GEC in non-accessible locations using reversible means.

Public Input No. 3821-NFPA 70-2023 [Section No. 250.64(D)(1)]

(1) Common Grounding Electrode Conductor and Taps.

~~A common grounding electrode conductor and grounding electrode conductor taps shall be installed~~ (a) Common Grounding Electrode Conductor . The common grounding electrode conductor shall be sized in accordance with 250.66, based on the sum of the circular mil area of the largest ungrounded conductor(s) of each set of conductors that supplies the disconnecting means. If the service-entrance conductors connect directly to the overhead service conductors, service drop, underground service conductors, or service lateral, the common grounding electrode conductor shall be sized in accordance with Table 250.66, note 1.

(b) Grounding Electrode Conductor Tap. A grounding electrode conductor tap shall extend to the inside of each disconnecting means enclosure. The grounding electrode conductor taps shall be sized in accordance with 250.66 for the largest service-entrance or feeder conductor serving the individual enclosure. The tap conductors shall be connected to the common grounding electrode conductor by one of the following methods in such a manner that the common grounding electrode conductor remains without a splice or joint:

(1) Exothermic welding.

(2) Connectors listed as grounding and bonding equipment.

(3) Connections to an aluminum or copper busbar not less than 6 mm thick × 50 mm wide (¼ in. thick × 2 in. wide) and of a length to accommodate the number of terminations necessary for the installation. The busbar shall be securely fastened and shall be installed in an accessible location. Connections shall be made by a listed connector or by the exothermic welding process. If aluminum busbars are used, the installation shall comply with 250.64(A).

Statement of Problem and Substantiation for Public Input

Breaking up 250.64(D)(1) into a list item format to facilitate understanding for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 05 17:47:36 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8318-NFPA 70-2024

Statement: The section is revised to multiple subdivisions for compliance with NEC Style Manual 3.5.2.

Public Input No. 425-NFPA 70-2023 [Section No. 250.64(D)(1)]

(1) Common Grounding Electrode Conductor and Taps.

A common grounding electrode conductor and grounding electrode conductor taps shall be installed. The common grounding electrode conductor shall be sized in accordance with 250.66, based on the sum of the circular mil area of the largest ungrounded conductor(s) of each set of conductors that supplies the disconnecting means. If the service-entrance conductors connect directly to the overhead service conductors, ~~service drop~~ utility drop , underground service conductors, or ~~service lateral~~ utility lateral , the common grounding electrode conductor shall be sized in accordance with Table 250.66, note 1.

A grounding electrode conductor tap shall extend to the inside of each disconnecting means enclosure. The grounding electrode conductor taps shall be sized in accordance with 250.66 for the largest service-entrance or feeder conductor serving the individual enclosure. The tap conductors shall be connected to the common grounding electrode conductor by one of the following methods in such a manner that the common grounding electrode conductor remains without a splice or joint:

(1) Exothermic welding.

(2) Connectors listed as grounding and bonding equipment.

(3) Connections to an aluminum or copper busbar not less than 6 mm thick × 50 mm wide (¼ in. thick × 2 in. wide) and of a length to accommodate the number of terminations necessary for the installation. The busbar shall be securely fastened and shall be installed in an accessible location. Connections shall be made by a listed connector or by the exothermic welding process. If aluminum busbars are used, the installation shall comply with 250.64(A).

Statement of Problem and Substantiation for Public Input

This PI is associated with several other PIs to recommend a global change from “service drop” to “utility drop” and from “service lateral” to “utility lateral.” “Service drop” appears 23 times in the Code and “service lateral” appears 15 times. There are 11 definitions that begin with the word ‘service.’ Of these, 9 are customer owned and only “service drop” and “service lateral” are utility owned and, therefore, outside the scope of the Code. “service drops” and “service laterals” are not service conductors as they do not fit the definition. Confining the word “service” to only those items that are customer owned would clear up much confusion on this topic. Appendix A shows UL 523 as having the title “telephone service drop wire” and the UL standard does, in fact, have that title. However, the text of UL 523 defines this wire as customer owned and Article 805 refers to this wire as a “drop wire.”

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 411-NFPA 70-2023 [Section No. 90.2(D)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 412-NFPA 70-2023 [Definition: Service Drop.]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 413-NFPA 70-2023 [Definition: Service-Entrance Conductors.]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 414-NFPA 70-2023 [Definition: Distribution Point (Center Yard Pole) (Meter Po...]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'

Public Input No. 415-NFPA 70-2023 [Definition: Service Lateral.]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 416-NFPA 70-2023 [Section No. 800.44(A)(4)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 417-NFPA 70-2023 [Section No. 700.12(F)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 418-NFPA 70-2023 [Section No. 701.12(F)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 419-NFPA 70-2023 [Section No. 770.44(A)(4)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 420-NFPA 70-2023 [Section No. 770.44(B)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 421-NFPA 70-2023 [Section No. 230.24(A)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 422-NFPA 70-2023 [Section No. 230.40]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 423-NFPA 70-2023 [Section No. 250.24(A)(1)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 424-NFPA 70-2023 [Section No. 250.24(F)]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 426-NFPA 70-2023 [Section No. 250.66 [Excluding any Sub-Sections]]	Global change from 'service drop' to 'utility drop' and 'service lateral' to 'utility lateral'
Public Input No. 411-NFPA 70-2023 [Section No. 90.2(D)]	
Public Input No. 412-NFPA 70-2023 [Definition: Service Drop.]	
Public Input No. 413-NFPA 70-2023 [Definition: Service-Entrance Conductors.]	
Public Input No. 414-NFPA 70-2023 [Definition: Distribution Point (Center Yard Pole) (Meter Po...]	
Public Input No. 415-NFPA 70-2023 [Definition: Service Lateral.]	
Public Input No. 416-NFPA 70-2023 [Section No. 800.44(A)(4)]	
Public Input No. 417-NFPA 70-2023 [Section No. 700.12(F)]	
Public Input No. 418-NFPA 70-2023 [Section No. 701.12(F)]	
Public Input No. 419-NFPA 70-2023 [Section No. 770.44(A)(4)]	
Public Input No. 420-NFPA 70-2023 [Section No. 770.44(B)]	
Public Input No. 421-NFPA 70-2023 [Section No. 230.24(A)]	
Public Input No. 422-NFPA 70-2023 [Section No. 230.40]	
Public Input No. 423-NFPA 70-2023 [Section No. 250.24(A)(1)]	
Public Input No. 424-NFPA 70-2023 [Section No. 250.24(F)]	
Public Input No. 426-NFPA 70-2023 [Section No. 250.66 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:
City:
State:
Zip:
Submittal Date: Sat Mar 04 17:06:13 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: The defined terms service drop, and service lateral are under the purview of Code Making Panel 10 and cannot be altered by this panel.

Public Input No. 2007-NFPA 70-2023 [Section No. 250.64(D) [Excluding any Sub-Sections]]

If a building or structure is supplied by a service or feeder with two or more disconnecting means in separate enclosures, the grounding electrode connections shall be made in accordance with 250.64(D)(1), (D)(2), or (D)(3). Any mechanical connection shall be accessible.

Statement of Problem and Substantiation for Public Input

Connections made by mechanical means should remain accessible for maintenance and inspection.

Submitter Information Verification

Submitter Full Name:	Peter Diamond
Organization:	Diamond Seminars
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Aug 11 05:33:40 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed requirement is not needed as the requirement for accessible connections for grounding electrodes are already covered by 250.68(A).

Public Input No. 102-NFPA 70-2023 [Section No. 250.64(E)(1)]

(1) General.

Ferrous metal raceways, enclosures, and cable armor for grounding electrode conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode and shall be securely fastened to the ground clamp or fitting. Ferrous metal raceways, enclosures, and cable armor shall be bonded at each end of the raceway ~~or enclosure to~~ , enclosure, or cable armor to the grounding electrode or grounding electrode conductor to create an electrically parallel path. Nonferrous metal raceways, enclosures, and cable armor shall not be required to be electrically continuous.

Statement of Problem and Substantiation for Public Input

Presently cable armor does not have the same bonding requirement as raceways and enclosures. To provide consistency, “cable armor” should be added here too.

Submitter Information Verification

Submitter Full Name: Russ Leblanc
Organization: Leblanc Consulting Services
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 11 13:14:05 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8320-NFPA 70-2024

Statement: The term cable armor is added to clarify that the bonding requirement for ferrous cable armor applies to both ends of the cable armor.

Public Input No. 4532-NFPA 70-2023 [Section No. 250.64(E)(3)]

(3) Size.

The bonding jumper for a grounding electrode conductor(s), raceway(s), enclosure(s), or cable armor shall be the same size as, or larger than, the largest enclosed grounding electrode conductor. A single common continuous enclosure or cable armor bonding jumper shall be permitted to connect two or more raceways if the bonding jumper is the same size, or larger than, the largest enclosed grounding electrode conductor.

Statement of Problem and Substantiation for Public Input

This proposed added text provides clarification on the sizing of a single bonding jumper, where utilized, for bonding multiple conduits, enclosures, and cable armor containing grounding electrode conductors. This code section, as presently written, could lead to a requirement for the size of such a single bonding conductor to be equal to, or greater than, the total equivalent circular mils(cross-sectional area)of all enclosed grounding electrode conductors, potentially resulting in an unnecessarily large bonding jumper. This proposed added text will help to eliminate any confusion and benefit designers, installers and inspectors alike.

Submitter Information Verification

Submitter Full Name:	Peter Noval Jr
Organization:	[Not Specified]
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Sep 08 09:10:22 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed revision does not add clarity to the current Code language.

Public Input No. 1084-NFPA 70-2023 [Section No. 250.64(G)]

(G) Enclosures with ~~Ventilation Openings~~ Openings intended for Ventilation, Mounting, or Drainage .

Grounding electrode conductors shall not be installed through a ventilation opening of an enclosure.
Their installation through other openings such as drain holes and mounting holes shall be permitted where this use will not interfere with an opening's intended purpose.

Statement of Problem and Substantiation for Public Input

The addition of these words will correct a misunderstanding.

Once an enclosure is fixed in place, its mounting holes are up for grabs. For the best part of a century, electricians used them for GECs, at least the small ones such as 6AWG, when installed bare. I know of no problems resulting from this use. I am sure some people have used wrong-size holes, and earned a red-tag from the inspector. I imagine that someone somewhere has failed to staple or strap the GEC, and someone else has yanked on that very conductor, challenging the termination. If so, over all these decades that's happened rarely enough that it hasn't ended the respected practice. Meanwhile, armored GECs and GECs in raceways entered through knockouts, using connectors.

Relatively recently, in part to solve a different problem–like installers nut-and-bolting a grounding wire through ventilation openings–inventors have given us connectors to secure and bond bare GECs to knockouts. The ones I've installed are good, and I've used them on some jobs. Still, their availability has caused some to presume that they are not just a nice job but required even in a service panel with other openings that have long been acknowledged as suitable. This looks like the way the availability of anti-short bushings has led some to presume that those are required for installation of MC-I cable.

This is an unfortunate but understandable misunderstanding, and would be easy to eliminate by adding these words.

Submitter Information Verification

Submitter Full Name: David Shapiro
Organization: Safety First Electrical
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 14 16:10:40 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8323-NFPA 70-2024

Statement: The requirement is revised to clarify that grounding electrode conductors are not to be installed through mounting and drainage openings as those are not intended for the installation of a grounding electrode conductor but for mounting and drainage purposes.

Public Input No. 1748-NFPA 70-2023 [Section No. 250.66]

250.66 Size of Alternating-Current Grounding Electrode Conductor.

The size of the grounding electrode conductor and bonding jumper(s) for connection of grounding electrodes shall not be smaller than given in Table 250.66, except as permitted in 250.66(A) through (C).

Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		-	**Size of Grounding Electrode Conductor (AWG/kcmil)**	
Copper	**Aluminum or Copper-Clad Aluminum**	-	**Copper**	**Aluminum or Copper-Clad Aluminum**
2 or smaller	1/0 or smaller	-	8	6
1 or 1/0	2/0 or 3/0	-	6	4
2/0 or 3/0	4/0 or 250	-	4	2
Over 3/0 through 350	Over 250 through 500	-	2	1/0
Over 350 through 600	Over 500 through 900	-	1/0	3/0
Over 600 through 1100	Over 900 through 1750	-	2/0	4/0
Over 1100	Over 1750	-	3/0	250

Notes:

1. If multiple sets of service-entrance conductors connect directly to a service drop, set of overhead service conductors, set of underground service conductors, or service lateral, the equivalent size of the largest service-entrance conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.

2. If there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

3. See installation restrictions in 250.64.

(A) Connections to a Rod, Pipe, or Plate Electrode(s).

If the grounding electrode conductor or bonding jumper connected to a single or multiple rod, pipe, or plate electrode(s), or any combination thereof, as described in 250.52(A)(5) or (A)(7), does not extend on to other types of electrodes that require a larger size conductor, the grounding electrode conductor shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum or copper-clad aluminum wire.

(B) Connections to Concrete-Encased Electrodes.

If the grounding electrode conductor or bonding jumper connected to a single or multiple concrete-encased electrode(s), as described in 250.52(A)(3), does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than 4 AWG copper wire.

(C) Connections to Ground Rings.

If the grounding electrode conductor or bonding jumper connected to a ground ring, as described in 250.52(A)(4), does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than the conductor used for the ground ring.

Delete the following wording in 250.66... , except as permitted in 250.66(A) through (C) and deleted 250.66(A) thru (C).

Additional Proposed Changes

File Name	Description	Approved
Table_250.66.png		

Statement of Problem and Substantiation for Public Input

There has been discussion on the social media sites that Table 250.66 can be used to size the grounding electrode conductor for a ground rod, pipe, or plate electrode(s), concrete-encased electrodes, and ground rings. I personally do not agree with these interpretations, the wording "shall not be required to be larger than" replaced with the wording "shall be" would help clarify the intent of this section, or a substantiation on the intent from the Code Making Panel would help.

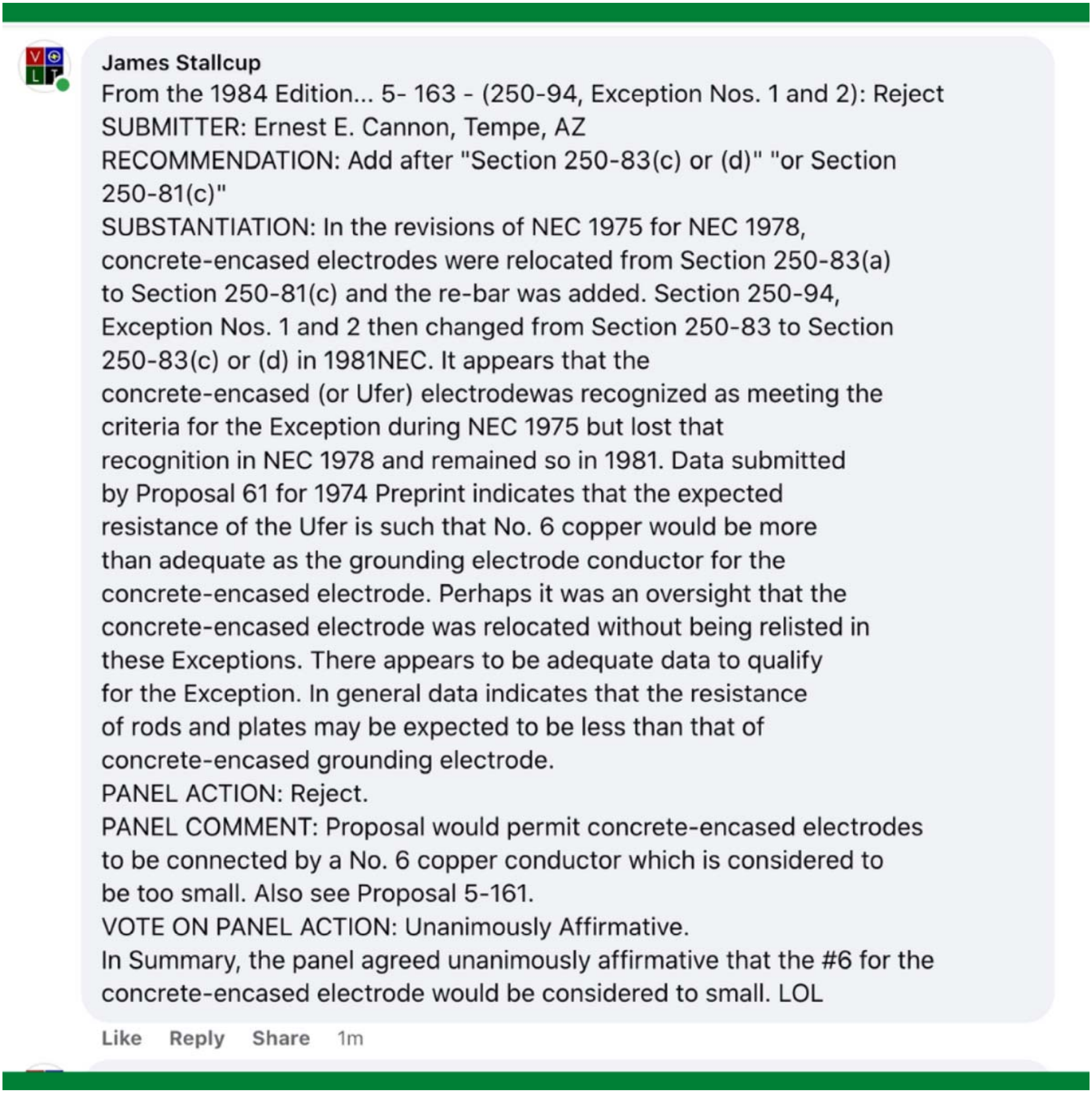
The intent from previous Code Making Panels was the size shall not be smaller than listed in 250.66(A) thru (C), I have enclosed one of those statements. Notice the Code Making Panel even stated that a #6 was considered too small, if this is the case, I don't see how Table 250.66 could be used.

Submitter Information Verification

Submitter Full Name: James Stallcup
Organization: Volt Online Academy
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 31 15:53:34 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Table 250.66 can be used to size grounding electrode conductors for rod, pipe and plate type grounding electrodes. If the conditions in 250.66 (A), (B), or (C) are met then smaller sizes are allowed. Removing the wording as suggested does not improve clarity.



James Stallcup

From the 1984 Edition... 5- 163 - (250-94, Exception Nos. 1 and 2): Reject

SUBMITTER: Ernest E. Cannon, Tempe, AZ

RECOMMENDATION: Add after "Section 250-83(c) or (d)" "or Section 250-81(c)"

SUBSTANTIATION: In the revisions of NEC 1975 for NEC 1978, concrete-encased electrodes were relocated from Section 250-83(a) to Section 250-81(c) and the re-bar was added. Section 250-94, Exception Nos. 1 and 2 then changed from Section 250-83 to Section 250-83(c) or (d) in 1981NEC. It appears that the concrete-encased (or Ufer) electrodewas recognized as meeting the criteria for the Exception during NEC 1975 but lost that recognition in NEC 1978 and remained so in 1981. Data submitted by Proposal 61 for 1974 Preprint indicates that the expected resistance of the Ufer is such that No. 6 copper would be more than adequate as the grounding electrode conductor for the concrete-encased electrode. Perhaps it was an oversight that the concrete-encased electrode was relocated without being relisted in these Exceptions. There appears to be adequate data to qualify for the Exception. In general data indicates that the resistance of rods and plates may be expected to be less than that of concrete-encased grounding electrode.

PANEL ACTION: Reject.

PANEL COMMENT: Proposal would permit concrete-encased electrodes to be connected by a No. 6 copper conductor which is considered to be too small. Also see Proposal 5-161.

VOTE ON PANEL ACTION: Unanimously Affirmative.

In Summary, the panel agreed unanimously affirmative that the #6 for the concrete-encased electrode would be considered to small. LOL

Public Input No. 2323-NFPA 70-2023 [Section No. 250.66]

250.66 Size of Alternating-Current Grounding Electrode Conductor.

The size of the grounding electrode conductor and bonding jumper(s) for connection of grounding electrodes shall not be smaller than given in ~~Table~~ 250.66~~, except as~~ (A) through (D).

(A) Connections to a Rod, Pipe, or Plate Electrode(s).

If the grounding electrode conductor or bonding jumper connected to a single or multiple rod, pipe, or plate electrode(s), or any combination thereof, as described in 250.52(A)(5) or (A)(7), does not extend on to other types of electrodes that require a larger size conductor, the grounding electrode conductor shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum or copper-clad aluminum wire.

(B) Connections to Concrete-Encased Electrodes.

If the grounding electrode conductor or bonding jumper connected to a single or multiple concrete-encased electrode(s), as described in 250.52(A)(3) , does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than 4 AWG copper wire.

(C) Connections to Ground Rings.

If the grounding electrode conductor or bonding jumper connected to a ground ring, as described in 250.52(A)(4) , does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than the conductor used for the ground ring.

(D) All other Electrodes

Except as permitted in 250.66(A) through (C)

.

~~Table 250.66 Grounding~~

the size of the grounding electrode conductor and bonding jumper(s) for the connection of grounding electrodes shall not be smaller than given in Table 250.66(D).

Table 250.66(D) Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)			
-			
	Size of Grounding Electrode Conductor (AWG/kcmil)		
Copper	**Aluminum or Copper-Clad Aluminum**		
-			
	Copper	**Aluminum or Copper-Clad Aluminum**	
2 or smaller	1/0 or smaller		
-			
		8	6
1 or 1/0		2/0 or 3/0	
-			
		6	4
2/0 or 3/0		4/0 or 250	
-			
		4	2
Over 3/0 through 350		Over 250 through 500	
-			
		2	1/0
Over 350 through 600		Over 500 through 900	
-			
		1/0	3/0
Over 600 through 1100		Over 900 through 1750	

-			
		2/0	4/0
Over 1100	Over 1750		
-			
3/0	250		

Notes:

1. If multiple sets of service-entrance conductors connect directly to a service drop, set of overhead service conductors, set of underground service conductors, or service lateral, the equivalent size of the largest service-entrance conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.

2. If there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

3. See installation restrictions in 250.64.

~~**(A)** Connections to a Rod, Pipe, or Plate Electrode(s).~~

~~If the grounding electrode conductor or bonding jumper connected to a single or multiple rod, pipe, or plate electrode(s), or any combination thereof, as described in 250.52(A)(5) or (A)(7), does not extend on to other types of electrodes that require a larger size conductor, the grounding electrode conductor shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum or copper-clad aluminum wire.~~

~~**(B)** Connections to Concrete-Encased Electrodes.~~

~~If the grounding electrode conductor or bonding jumper connected to a single or multiple concrete-encased electrode(s), as described in 250.52(A)(3) , does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than 4 AWG copper wire.~~

~~**(C)** Connections to Ground Rings.~~

~~If the grounding electrode conductor or bonding jumper connected to a ground ring, as described in 250.52(A)(4) , does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than the conductor used for the ground ring.~~

Statement of Problem and Substantiation for Public Input

Relocating Table 250.66 to new first level subdivision 250.66(D) and relocating Table 250.66 to Table 250.66(D). The proposed revisions would make this requirement a lot easier to understand for Code users.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 16 12:26:13 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The proposed revision does not improve clarity. Table 250.66 is the general rule and placing the conditional options first, could create confusion.

Public Input No. 1106-NFPA 70-2023 [Section No. 250.66(A)]

(A) Connections to a Rod, Pipe, or Plate Electrode(s).

If the grounding electrode conductor or bonding jumper connected to a single or multiple rod, pipe, or plate electrode(s), or any combination thereof, as described in 250.52(A)(5) or (A)(7), does not extend on to other types of electrodes that require a larger size conductor, the grounding electrode conductor shall not be required to be larger than 6 AWG copper-clad steel or copper wire or 4 AWG aluminum or copper-clad aluminum wire.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name: Peter Graser
Organization: Copperweld
Affiliation: American Bimetallic Association
Street Address:
City:
State:
Zip:
Submittal Date: Sat Jun 17 08:51:56 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 2524-NFPA 70-2023 [Section No. 250.66(A)]

(A) Connections to a Rod, Driven Pipe, or Plate Electrode(s).

If the grounding electrode conductor or bonding jumper connected to a single or multiple rod, driven pipe, or plate electrode(s), or any combination thereof, as described in 250.52(A)(5) or (A)(7), does not extend on to other types of electrodes that require a larger size conductor, the grounding electrode conductor shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum or copper-clad aluminum wire.

Statement of Problem and Substantiation for Public Input

This correlates with my PI to change "pipe electrode" to "driven pipe electrode" in 250.52(A)(5)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2522-NFPA 70-2023 [Section No. 250.52(A)(5)]	correlating PI
Public Input No. 2523-NFPA 70-2023 [Section No. 250.53(A)]	correlating PI
Public Input No. 2522-NFPA 70-2023 [Section No. 250.52(A)(5)]	
Public Input No. 2523-NFPA 70-2023 [Section No. 250.53(A)]	

Submitter Information Verification

Submitter Full Name:	Don Ganiere
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Submittal Date:	Sat Aug 19 14:59:51 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Not all electrodes are driven they can be buried under certain conditions.

Public Input No. 1107-NFPA 70-2023 [Section No. 250.66(B)]

(B) Connections to Concrete-Encased Electrodes.

If the grounding electrode conductor or bonding jumper connected to a single or multiple concrete-encased electrode(s), as described in 250.52(A)(3), does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than 4 AWG copper-clad steel or copper wire.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name: Peter Graser
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Street Address:
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Zip:
Submittal Date: Sat Jun 17 08:53:46 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 1105-NFPA 70-2023 [Section No. 250.66 [Excluding any Sub-Sections]]

The size of the grounding electrode conductor and bonding jumper(s) for connection of grounding electrodes shall not be smaller than given in Table 250.66, except as permitted in 250.66(A) through (C).

Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		-	Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	**Aluminum or Copper-Clad Aluminum**	-	**Copper or Copper-Clad Steel**	**Aluminum or Copper-Clad Aluminum**
2 or smaller	1/0 or smaller	-	8	6
1 or 1/0	2/0 or 3/0	-	6	4
2/0 or 3/0	4/0 or 250	-	4	2
Over 3/0 through 350	Over 250 through 500	-	2	1/0
Over 350 through 600	Over 500 through 900	-	1/0	3/0
Over 600 through 1100	Over 900 through 1750	-	2/0	4/0
Over 1100	Over 1750	-	3/0	250

Notes:

1. If multiple sets of service-entrance conductors connect directly to a service drop, set of overhead service conductors, set of underground service conductors, or service lateral, the equivalent size of the largest service-entrance conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.

2. If there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

3. See installation restrictions in 250.64.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name:	Peter Graser
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Submittal Date:	Sat Jun 17 08:49:32 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 426-NFPA 70-2023 [Section No. 250.66 [Excluding any Sub-Sections]]

The size of the grounding electrode conductor and bonding jumper(s) for connection of grounding electrodes shall not be smaller than given in Table 250.66, except as permitted in 250.66(A) through (C).

Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		-	Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	**Aluminum or Copper-Clad Aluminum**	-	**Copper**	**Aluminum or Copper-Clad Aluminum**
2 or smaller	1/0 or smaller	-	8	6
1 or 1/0	2/0 or 3/0	-	6	4
2/0 or 3/0	4/0 or 250	-	4	2
Over 3/0 through 350	Over 250 through 500	-	2	1/0
Over 350 through 600	Over 500 through 900	-	1/0	3/0
Over 600 through 1100	Over 900 through 1750	-	2/0	4/0
Over 1100	Over 1750	-	3/0	250

Notes:

1. If multiple sets of service-entrance conductors connect directly to a ~~service drop~~ utility drop , set of overhead service conductors, set of underground service conductors, or ~~service lateral~~ utility lateral , the equivalent size of the largest service-entrance conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.

2. If there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

3. See installation restrictions in 250.64.

Statement of Problem and Substantiation for Public Input

This PI is associated with several other PIs to recommend a global change from “service drop” to “utility drop” and from “service lateral” to “utility lateral.” “Service drop” appears 23 times in the Code and “service lateral” appears 15 times. There are 11 definitions that begin with the word ‘service.’ Of these, 9 are customer owned and only “service drop” and “service lateral” are utility owned and, therefore, outside the scope of the Code. “service drops” and “service laterals” are not service conductors as they do not fit the definition. Confining the word “service” to only those items that are customer owned would clear up much confusion on this topic. Appendix A shows UL 523 as having the title “telephone service drop wire” and the UL standard does, in fact, have that title. However, the text of UL 523 defines this wire as customer owned and Article 805 refers to this wire as a “drop wire.”

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 411-NFPA 70-2023 [Section No. 90.2(D)]	Global change
Public Input No. 412-NFPA 70-2023 [Definition: Service Drop.]	Global change
Public Input No. 413-NFPA 70-2023 [Definition: Service-Entrance Conductors.]	Global change
Public Input No. 414-NFPA 70-2023 [Definition: Distribution Point (Center Yard Pole) (Meter Po...]	Global change
Public Input No. 415-NFPA 70-2023 [Definition: Service Lateral.]	Global change
Public Input No. 416-NFPA 70-2023 [Section No. 800.44(A)(4)]	Global change
Public Input No. 417-NFPA 70-2023 [Section No. 700.12(F)]	Global change
Public Input No. 418-NFPA 70-2023 [Section No. 701.12(F)]	Global change
Public Input No. 419-NFPA 70-2023 [Section No. 770.44(A)(4)]	Global change
Public Input No. 420-NFPA 70-2023 [Section No. 770.44(B)]	Global change
Public Input No. 421-NFPA 70-2023 [Section No. 230.24(A)]	Global change
Public Input No. 422-NFPA 70-2023 [Section No. 230.40]	Global change
Public Input No. 423-NFPA 70-2023 [Section No. 250.24(A)(1)]	Global change
Public Input No. 424-NFPA 70-2023 [Section No. 250.24(F)]	Global change
Public Input No. 425-NFPA 70-2023 [Section No. 250.64(D)(1)]	Global change

Public Input No. 411-NFPA 70-2023 [Section No. 90.2(D)]
Public Input No. 412-NFPA 70-2023 [Definition: Service Drop.]
Public Input No. 413-NFPA 70-2023 [Definition: Service-Entrance Conductors.]
Public Input No. 414-NFPA 70-2023 [Definition: Distribution Point (Center Yard Pole) (Meter Po...]
Public Input No. 415-NFPA 70-2023 [Definition: Service Lateral.]
Public Input No. 416-NFPA 70-2023 [Section No. 800.44(A)(4)]
Public Input No. 417-NFPA 70-2023 [Section No. 700.12(F)]
Public Input No. 418-NFPA 70-2023 [Section No. 701.12(F)]
Public Input No. 419-NFPA 70-2023 [Section No. 770.44(A)(4)]
Public Input No. 420-NFPA 70-2023 [Section No. 770.44(B)]
Public Input No. 421-NFPA 70-2023 [Section No. 230.24(A)]
Public Input No. 422-NFPA 70-2023 [Section No. 230.40]
Public Input No. 423-NFPA 70-2023 [Section No. 250.24(A)(1)]
Public Input No. 424-NFPA 70-2023 [Section No. 250.24(F)]
Public Input No. 425-NFPA 70-2023 [Section No. 250.64(D)(1)]

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
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Affiliation:	Self
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State:	
Zip:	
Submittal Date:	Sat Mar 04 17:08:49 EST 2023
Committee:	NEC-P05

Committee Statement

Resolution: The defined terms service drop, and service lateral are under the purview of Code Making Panel 10 and cannot be altered by this panel.

Public Input No. 3484-NFPA 70-2023 [Section No. 250.68(B)]

(B) Effective Grounding Path.

The connection of a grounding electrode conductor or bonding jumper to a grounding electrode shall be made in a manner that will ensure an effective grounding path. Where necessary to ensure the grounding path for ~~a~~ metal piping ~~system~~ used as a grounding electrode, bonding shall be provided around insulated joints and around any equipment likely to be disconnected for repairs or replacement. Bonding jumpers shall be of sufficient length to permit removal of such equipment while retaining the integrity of the grounding path.

Statement of Problem and Substantiation for Public Input

There are specific rules for metal water piping that is to serve as a grounding electrode. The term "system" does not add, and as "piping system" is not defined in the NEC, it is best to remove it where possible.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3482-NFPA 70-2023 [Section No. 250.32(D)]	
Public Input No. 3483-NFPA 70-2023 [Section No. 250.52(A)(8)]	
Public Input No. 3485-NFPA 70-2023 [Section No. 250.104]	

Submitter Information Verification

Submitter Full Name: David Shapiro
Organization: Safety First Electrical
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Zip:
Submittal Date: Sun Sep 03 23:27:22 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Removing the word “systems” will not add clarity. The word “piping” by itself is too vague.

Public Input No. 2475-NFPA 70-2023 [Section No. 250.68(C)]

(C) Grounding Electrode Conductor Connections.

Grounding electrode conductors and bonding jumpers shall be permitted to be connected at the following locations and used to extend the connection to an electrode(s):

(1) - ~~Interior~~ Grounding electrode conductors and bonding jumpers shall be connected to interior metal water piping that is electrically continuous with a metal underground water pipe electrode ~~and is located~~ not more than 1.52 m (5 ft) from the point of entrance to the building, as measured along the water piping~~, shall~~ . This portion of interior metal water piping shall be permitted to extend the connection to ~~an electrode(s)~~ one or more electrodes of the grounding electrode system . Interior metal water piping located more than 1.52 m (5 ft) from the point of entrance to the building, as measured along the water piping, shall not be used as a conductor to interconnect electrodes of the grounding electrode system.

Exception: In industrial, commercial, and institutional buildings or structures, if conditions of maintenance and supervision ensure that only qualified persons service the installation, interior metal water piping located more than 1.52 m (5 ft) from the point of entrance to the building, as measured along the water piping, shall be permitted as a bonding conductor to interconnect electrodes that are part of the grounding electrode system, or as a grounding electrode conductor, if the entire length, other than short sections passing perpendicularly through walls, floors, or ceilings, of the interior metal water pipe that is being used for the conductor is exposed.

(2) The metal structural frame of a building shall be permitted to be used as a conductor to interconnect electrodes that are part of the grounding electrode system, or as a grounding electrode conductor. Hold-down bolts securing the structural steel column that are connected to a concrete-encased electrode complying with 250.52(A)(3) and located in the support footing or foundation shall be permitted to connect the metal structural frame of a building or structure to the concrete-encased grounding electrode. The hold-down bolts shall be connected to the concrete-encased electrode by welding, exothermic welding, steel tie wires, or other approved means.

(3) A rebar-type concrete-encased electrode installed in accordance with 250.52(A)(3) with an additional rebar section extended from its location within the concrete foundation or footing to an accessible location that is not subject to corrosion shall be permitted for connection of grounding electrode conductors and bonding jumpers in accordance with the following:

    (4) The additional rebar section shall be continuous with the grounding electrode rebar or shall be connected to the grounding electrode rebar and connected together by steel tie wires, exothermic welding, welding, or other effective means.

    (5) The rebar extension shall not be exposed to contact with the earth without corrosion protection.

    (6) Rebar shall not be used as a conductor to interconnect the electrodes of grounding electrode systems.

Statement of Problem and Substantiation for Public Input

As the code is written for 250.68(C)(1), it does not explicitly state that the connection of a grounding electrode conductor or bonding jumper to interior water piping shall be made within five feet, measured along the pipe, of where it enters the building. While it has been understood and interpreted that this is the intent of this section of the code, this change would help to clarify that intent.

Submitter Information Verification

Submitter Full Name:	Steven Worsley
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Street Address:	
City:	
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Zip:	
Submittal Date:	Thu Aug 17 20:49:59 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The title and initial wording in 250.68(C) uses the word “connections”. The proposed revision does not improve clarity.

Public Input No. 848-NFPA 70-2023 [Section No. 250.68(C)]

(C) Grounding Electrode Conductor Connections.

Grounding electrode conductors and bonding jumpers shall be permitted to be connected at the following locations and used to extend the connection to an electrode(s):

(1) Interior metal water piping that is electrically continuous with a metal underground water pipe electrode and is located not more than 1.52 m (5 ft) from the point of entrance to the building, as measured along the water piping, shall be permitted to extend the connection to an electrode(s). Interior metal water piping located more than 1.52 m (5 ft) from the point of entrance to the building, as measured along the water piping, shall not be used as a conductor to interconnect electrodes of the grounding electrode system.

Exception: In industrial, commercial, and institutional buildings or structures, if conditions of maintenance and supervision ensure that only qualified persons service the installation, interior metal water piping located more than 1.52 m (5 ft) from the point of entrance to the building, as measured along the water piping, shall be permitted as a bonding conductor to interconnect electrodes that are part of the grounding electrode system, or as a grounding electrode conductor, if the entire length, other than short sections passing perpendicularly through walls, floors, or ceilings, of the interior metal water pipe that is being used for the conductor is exposed.

(2) The metal structural frame of a building shall be permitted to be used as a conductor to interconnect electrodes that are part of the grounding electrode system, or as a grounding electrode conductor. Hold-down bolts securing the structural steel column that are connected to a concrete-encased electrode complying with 250.52(A)(3) and located in the support footing or foundation shall be permitted to connect the metal structural frame of a building or structure to the concrete-encased grounding electrode. The hold-down bolts shall be connected to the concrete-encased electrode by welding, exothermic welding, steel tie wires, or other approved means.

(3) A rebar-type concrete-encased electrode installed in accordance with 250.52(A)(3) with an additional rebar section extended from its location within the concrete foundation or footing to an accessible location that is not subject to corrosion shall be permitted for connection of grounding electrode conductors and bonding jumpers in accordance with the following:

(4) The additional rebar section shall be continuous with the grounding electrode rebar or shall be connected to the grounding electrode rebar and connected together by steel tie wires, exothermic welding, welding, or other effective means.

(5) The additional rebar extension shall not be exposed to contact with the earth without corrosion protection.

(6) The additional rebar extension shall be permitted for connection of grounding electrode conductor(s) and bonding jumper(s).

(7) Rebar that runs horizontally through the concrete foundation shall not be used as a conductor to interconnect the electrodes of grounding electrode systems.

Statement of Problem and Substantiation for Public Input

250.68(C) (3) states that the additional rebar section extended from its location.......shall be permitted for connection of grounding electrode conductors (s implies multiple) and bonding jumpers (s implies multiple). Then 250.68 (C) (3) (c) contradicts the above and says Rebar shall not be used as a conductor to interconnect the electrodes of grounding electrode systems. This contradiction is confusing and needs to be clarified. The NEC Handbook commentary following 250.68 (C) (3) (c)

tries to clarify that the "rebar network in the concrete is not permitted as a means to bond different types of electrodes together to form the grounding electrode system". Making the proposed change clarifies that the additional rebar section is permitted for multiple connections but that the horizontal rebar within the concrete shall not be used as a conductor to interconnect the electrodes of grounding electrode systems.
250.64 (F) (1) states that the grounding electrode conductor shall be permitted to be run to any convenient grounding electrode available in the grounding electrode system where the other electrode(s) if any, is connected by bonding jumpers that are installed in accordance with 250.53 (C). 250.53 (C) also needs to be changed to allow the additional rebar section ...to be permitted for connection of grounding electrode conductors and bonding jumpers.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 849-NFPA 70-2023 [Section No. 250.53(C)]	

Submitter Information Verification

Submitter Full Name:	Gabe Kaprelian
Organization:	[Gabe Kaprelian Electrical Contractor
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed May 17 23:28:18 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Rebar is not permitted to be used as a conductor to connect other grounding electrodes in any orientation.

Public Input No. 4448-NFPA 70-2023 [Section No. 250.70]

250.70 Methods of Grounding and Bonding Conductor Connection to Electrodes.

(A) General.

The grounding or bonding conductor shall be connected to the grounding electrode by exothermic welding, listed lugs, listed pressure connectors, listed clamps, or other listed means. Connections depending on solder shall not be used. Ground clamps shall be listed for the materials of the grounding electrode and the grounding electrode conductor and, if used on pipe, rod, or other buried electrodes, shall also be listed for direct soil burial or concrete encasement. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting unless the clamp or fitting is listed for multiple conductors.

Informational Note: Listed ground clamps that are identified for direct burial are also suitable for concrete encasement.

(B) Indoor Communications Systems.

For indoor communications purposes only, a listed sheet metal strap-type ground clamp having a rigid metal base that seats on the electrode and having a strap of such material and dimensions that it is not likely to stretch during or after installation shall be permitted.

~~Informational Note: Listed ground clamps that are identified for direct burial are also suitable for concrete encasement.~~

Statement of Problem and Substantiation for Public Input

The content of the informational note refers to ground clamps mentioned in 250.70(A), so it should follow 250.70(A) instead of 250.70(B).

Submitter Information Verification

Submitter Full Name:	Nick Starks
Organization:	Denver Joint Electrical Apprenticeship and Training Committee
Affiliation:	IBEW Local 68
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City:	
State:	
Zip:	
Submittal Date:	Thu Sep 07 15:32:23 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8384-NFPA 70-2024

Statement: The wording was separated into a list format and titles were added to improve usability.

The informational Note was relocated after 250.70(A) because it applies to that subdivision.

Public Input No. 3825-NFPA 70-2023 [Section No. 250.70(A)]

(A) General.

(1) Connections. The grounding or bonding conductor shall be connected to the grounding electrode by exothermic welding, listed lugs, listed pressure connectors, listed clamps, or other listed means. Connections depending on solder shall not be used.

(2) Direct Burial or Concrete Encasement. Ground clamps shall be listed for the materials of the grounding electrode and the grounding electrode conductor and, if used on pipe, rod, or other buried electrodes, shall also be listed for direct soil burial or concrete encasement.

(3) One Conductor. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting unless the clamp or fitting is listed for multiple conductors.

Statement of Problem and Substantiation for Public Input

Breaking up 250.70(A) into a list item format to facilitate understanding for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 05 17:51:56 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8384-NFPA 70-2024

Statement: The wording was separated into a list format and titles were added to improve usability.

The informational Note was relocated after 250.70(A) because it applies to that subdivision.

Public Input No. 1851-NFPA 70-2023 [Section No. 250.86]

250.86 Other than Service Conductor Enclosures and Raceways.

Except as permitted by 250.112(I), metal enclosures and raceways for other than service conductors shall be connected to the equipment grounding conductor.

Exception No. 1: Metal enclosures and raceways for conductors added to existing installations of open wire, knob-and-tube wiring, and nonmetallic-sheathed cable shall not be required to be connected to the equipment grounding conductor if these enclosures or wiring methods comply with all the following:

(1) Do not provide an equipment ground

(2) Are in runs of less than 7.5 m (25 ft)

(3) Are free from probable contact with ground, grounded metal, metal lath, or other conductive material

(4) Are guarded against contact by persons

Exception No. 2: Short sections of metal enclosures or raceways used to provide support or protection of cable assemblies from physical damage shall not be required to be connected to the equipment grounding conductor.

Exception No. 3: Metal components shall not be required to be connected to the equipment grounding conductor or supply-side bonding jumper if either of the following conditions exist:

(1) The metal components are installed in a run of nonmetallic raceway(s) and isolated from possible contact by a minimum cover of 450 mm (18 in.) to any part of the metal components.

(2) The metal components are part of an installation of nonmetallic raceway(s) and are isolated from possible contact to any part of the metal components by being encased in not less than 50 mm (2 in.) of concrete.

Statement of Problem and Substantiation for Public Input

Title edited for clarity and to match up with the requirements of the section.

Submitter Information Verification

Submitter Full Name: Don Ganiere
Organization: none
Street Address:
City:
State:
Zip:
Submittal Date: Sun Aug 06 15:27:10 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The application of this article is clearly covered in the body of this section for other than service conductors.

Public Input No. 3105-NFPA 70-2023 [Section No. 250.92(A)]

(A) Bonding of Equipment for Services.

The normally non-current-carrying metal parts of equipment indicated in the following shall be bonded together and to the grounded conductor in accordance with 250.92(B) :

(1) All raceways, cable trays, cablebus framework, auxiliary gutters, or service cable armor or sheath that enclose, contain, or support service conductors, except as permitted in 250.80

(2) All enclosures containing service conductors, including meter fittings, boxes, or the like, interposed in the service raceway or armor

Statement of Problem and Substantiation for Public Input

Revising text to meet the intent of the requirement, which is to bond these conductive parts together and to the grounded service conductor, not just to bond the conductive parts together. For example, if we had a metal nipple between the meter enclosure and service disconnect, we only need to bond one end of the nipple, not both ends. This added language will bring clarity to Code users.

Submitter Information Verification

Submitter Full Name:	Mike Holt
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Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 12:05:04 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Not all systems have a grounded conductor. This requirement is covered in 250.4(A) and 250.24(A).

Public Input No. 3417-NFPA 70-2023 [New Section after 250.92(B)]

250.92(C) Replacement.

If service equipment is replaced, all the requirements of Part V. of this article shall apply.

Statement of Problem and Substantiation for Public Input

This public input adds a new part (C) to section 250.92 that requires all the bonding requirements in Part V of Article 250 are applicable if service equipment is replaced. This ensures that replaced services are properly bonded and include an intersystem bonding (IBT) device to maintain life and property safety of the premises wiring system. There are many existing homes and buildings that are 75 years or older. Most of those buildings have never been evaluated or reinspected and likely do not have proper bonding or an IBT installed. It is imperative for safety concerns to have the service bonding and IBT at existing homes and buildings be brought up to current codes, especially with the capacity and ampere rating of the service increases. While Figure 230.1 implies that all services are required to comply with the grounding and bonding requirements in Article 250, it is not clear the grounding electrode system or IBT requirements apply where services are replaced.

The rapid electrification of buildings and the growth of the electric vehicle industry is resulting in homes and buildings needing service replacements to increase capacity and ampere rating to supply appliances and electric vehicle power transfer system equipment. It is essential that the bonding requirements also be evaluated for compliance with Part V of Article 250 as the existing system may no longer be sufficient or adequate for the new service rating. This new sentence ensures the replaced service has proper and effective bonding.

This public input has a correlating input for section 250.50.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3418-NFPA 70-2023 [Section No. 250.50]	
Public Input No. 3418-NFPA 70-2023 [Section No. 250.50]	

Submitter Information Verification

Submitter Full Name: Megan Hayes
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Submittal Date: Sat Sep 02 18:17:15 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The addition of Service Equipment as defined in Article 100 would make this addition too broad in scope.

Public Input No. 2457-NFPA 70-2023 [Section No. 250.92(B)]

(B) Method of Bonding at the Service.

Bonding jumpers meeting the requirements of this article shall be used around impaired connections, such as reducing washers or oversized, concentric, or eccentric knockouts. Standard locknuts or bushings shall not be the only means for the bonding required by this section but shall be permitted to be installed to make a mechanical connection of the raceway(s).

Electrical continuity at service equipment, service raceways, and service conductor enclosures shall be ensured by one or more of the following methods:

(1) Bonding equipment to the grounded service conductor by an applicable method in 250.8(A)

(2) Connections made up wrenchtight using threaded couplings, threaded entries, or listed threaded hubs on enclosures

(3) Threadless couplings and connectors if made up tight for metal raceways and metal-clad cables

(4) Other listed devices, such as bonding-type locknuts, bushings, or bushings with bonding jumpers sized in accordance with 250.102(C)

Statement of Problem and Substantiation for Public Input

Adding the reference to 250.102(C)(4) will inform Code users on how to properly size the supply side bonding jumper. This proposed revision will provide guidance on where to go in the NEC for sizing supply-side bonding jumpers at the service.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Thu Aug 17 13:14:05 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Sizing of bonding jumpers is addressed in other parts of Article 250.

Public Input No. 876-NFPA 70-2023 [Section No. 250.92(B)]

(B) Method of Bonding at the Service.

Bonding jumpers meeting the requirements of this article shall be used around impaired connections, such as reducing washers or oversized, concentric, or eccentric knockouts. Standard locknuts or bushings shall not be the only means for the bonding required by this section but shall be permitted to be installed to make a mechanical connection of the raceway(s).

Electrical continuity at service equipment, service raceways, and service conductor enclosures shall be ensured by one or more of the following methods:

(1) Bonding equipment to the grounded service conductor by an applicable method in 250.8(A)

(2) Connections made up wrenchtight using threaded couplings, threaded entries, or listed threaded hubs on enclosures

(3) Threadless couplings and connectors if made up tight for metal raceways and metal-clad cables

(4) Other listed devices, such as bonding-type locknuts, bushings, or bushings with bonding jumpers

I'm not sure I have anything to change in the section, but what I am looking at is the "enhanced content" for this section. Where it says, " For concentric, eccentric, or oversized knockouts, electrical continuity must be ensured through a supply-side bonding jumper that connects the raceway to the enclosure through an approved grounding fitting." I have concerns about this. Also, the picture directly below this section shows a "Supply-side equipment bonding jumper" and it's referencing 250.92(B)(1). Here are my concerns:

1) I believe this section 250.92(B) and 250.80 need to reference a supply-side bonding jumper and reference the sizing in accordance with 250.102(C)(1). The NEC is not clear on supply-side bonding jumpers at a service, both in the utility transformer and in the service equipment. For a separately derived system, it's called the system bonding jumper but for inside the utility transformer it's called a supply-side bonding jumper. You can have the supply side bonding jumper in the utility transformer (not shown in NEC that I can find...however, i attached a screen shot from soares grounding and bonding that shows this for parallel conductors at a service entrance) and in the service equipment, like the picture shows in the enhanced content where there is a supply side bonding jumper from the conduit bushing to the enclosure. And then since it's a service, you have a main bonding jumper (for separately derived system only would it be called a supply-side bonding jumper). (408.3(C) does mention a supply-side bonding jumper for switchboards, switchgear, and panelboards used as service equipment...but i still think it needs mentioned in article 250 for services)

2) The picture brings up another concern I have. Let's say the metal raceway that contains the grounded service conductor and the ungrounded service conductors is bonded to the grounded service conductor in that panel (by the supply-side equipment bonding jumper) as that picture shows. Or even if just through the couplings and connectors. If that metal raceway goes all the way back to the transformer and is bonded to the transformer enclosure and then the neutral point or grounded point in the transformer, won't that be a parallel path for neutral current? That seems like a safety issue to me. This may call for a need to revise this section to account for this scenario. (upon further study, perhaps the neutral conductor is technically in parallel but because the neutral has much lower impedance, the current flow through the conduit is negligible or would not pose a shock hazard or anything...can you verify if this is correct?)

It appears this issue is somewhat recognized for a separately derived system when you reference 250.30(A)(2) and the exception. Within the exception, it references 250.30(A)(1), exception no. 2. So, that is saying a supply-side bonding jumper is not required when a building or structure is supplied by a feeder from an outdoor separately derived system, where a system bonding jumper at both the source and the disconnecting means shall be permitted if doing so does not establish a parallel path for the grounded conductor. (by removing the supply-side bonding jumper, you alleviate the parallel path). The last sentence says for the purposes of this exception, connection through the earth shall not be considered as providing a parallel path. But again, if you had metal conduit and it was bonded on both ends in this situation you would still have the parallel path issue. (as mentioned above, upon further study, perhaps the neutral conductor is technically in parallel but because the neutral has much lower impedance, the current flow through the conduit is negligible or would not pose a shock hazard or anything...can you verify if this is correct?)

Additional Proposed Changes

File Name	Description	Approved
250.92_enhanced_content_picture.png	enhanced content picture	
supply-side_bonding_jumper_on_line_side_of_service.png	soares grounding & bonding	

Statement of Problem and Substantiation for Public Input

I don't really have a proposed change but more of a proposed issue. If you see the same issue as me, there should be some exception about using metal conduit for a service that is bonded on both ends.

-Brad Brack, Electrical Engineer, US Army Corps of Engineers, PE

Submitter Information Verification

Submitter Full Name: Brad Brack
Organization: US Army Corps of Engineers
Street Address:
City:
State:
Zip:
Submittal Date: Tue May 23 08:08:13 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The public input is not in compliance with Section 4.3.4 of the Regulations Governing the Development of NFPA Standards. There is no proposed text to be added, modified, or deleted. The submitter appears to be referencing publications other than NFPA 70.

Public Input No. 1852-NFPA 70-2023 [Section No. 250.94(A)]

(A) The Intersystem Bonding Termination Device.

An intersystem bonding termination (IBT) for connecting intersystem bonding conductors shall be provided external to enclosures at the service equipment or metering equipment enclosure and at the disconnecting means for any buildings or structures that are supplied by a feeder or branch circuit. If an IBT is used, it shall comply with the following:

(1) Be accessible for connection and inspection

(2) Consist of a set of terminals with the capacity for connection of not less than three intersystem bonding conductors

(3) Not interfere with opening the enclosure for a service, building or structure disconnecting means, or metering equipment

(4) Be securely mounted as follows:

  (5) At the service equipment, to a metal enclosure for the service equipment, to a metal meter enclosure, or to an exposed nonflexible metal service raceway, or be connected to the metal enclosure for the grounding electrode conductor with a minimum 6 AWG copper conductor

  (6) At the disconnecting means for a building or structure that is supplied by a feeder or branch circuit, be electrically connected to the metal enclosure for the building or structure disconnecting means, or be connected to the metal enclosure for the grounding electrode conductor with a minimum 6 AWG copper conductor

(7) Be listed as communications grounding and bonding equipment

Exception: In existing buildings or structures, if any of the intersystem bonding and grounding electrode conductors required by 770.100(B)(2), 800.100(B)(2), 810.21(F)(2), and 820.100 exist, installation of an IBT shall not be required. An accessible means external to enclosures for connecting intersystem bonding and grounding electrode conductors shall be permitted at the service equipment and at the disconnecting means for any buildings or structures that are supplied by a feeder or branch circuit by at least one of the following means:

(1) Exposed nonflexible metal raceways

(2) An exposed grounding electrode conductor

(3) Approved means for the external connection of a copper or other corrosion-resistant bonding or grounding electrode conductor to the grounded raceway or equipment

Informational Note: See 770.100, 800.100, 810.21, and 820.100 for intersystem bonding and grounding requirements for conductive optical fiber cables, communications circuits, radio and television equipment, CATV circuits, and network-powered broadband communications systems, respectively.

Statement of Problem and Substantiation for Public Input

These devices are covered by the UL Guide Information for Grounding and Bonding Equipment, Communications (KDSH) and not the UL Guide for Grounding and Bonding Equipment (KDER).
The Guide for Grounding and Bonding Equipment, Communications says:
"This category covers grounding devices intended for use in telecommunication applications, such as telephone, radio, CATV and the like, in accordance with Articles 770, 800, 810, 820, 830 and Section 250.94 of NFPA 70, "National Electrical Code" (NEC)."

This will also help clarify that the intersystem bonding device cannot be used for any purpose other than the connection of the communications system bonding conductor.

Note, even though terraview shows otherwise the only change is to add the word "communications" in list item 5.

Submitter Information Verification

Submitter Full Name: Don Ganiere
Organization: none
Street Address:
City:
State:
Zip:
Submittal Date: Sun Aug 06 15:29:41 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Existing devices listed in accordance with UL 467 and under category KDER (Grounding and Bonding) are also permitted to be used as an intersystem bonding termination.

Public Input No. 2339-NFPA 70-2023 [Section No. 250.94(A)]

(A) The Intersystem Bonding Termination Device.

An intersystem bonding termination (IBT) for connecting intersystem bonding conductors shall be provided external to enclosures at the service equipment or metering equipment enclosure and at the disconnecting means for any buildings or structures that are supplied by a feeder or branch circuit. If an IBT is used, it shall comply with the following:

(1) Be accessible for connection and inspection

(2) Consist of a set of terminals with the capacity for connection of not less than three intersystem bonding conductors

(3) Not interfere with opening the enclosure for a service, building or structure disconnecting means, or metering equipment

(4) Be securely mounted as follows:

  (5) At the service equipment, to a metal enclosure for the service equipment, to a metal meter enclosure, or to an exposed nonflexible metal service raceway, or be connected to the metal enclosure for the grounding electrode conductor , or be connected to the grounding electrode conductor with a minimum 6 AWG copper conductor

  (6) At the disconnecting means for a building or structure that is supplied by a feeder or branch circuit, be electrically connected to the metal enclosure for the building or structure disconnecting means, or be connected to the metal enclosure for the grounding electrode conductor , or be connected to the grounding electrode conductor with a minimum 6 AWG copper conductor

(7) Be listed as grounding and bonding equipment

Exception: In existing buildings or structures, if any of the intersystem bonding and grounding electrode conductors required by 770.100(B)(2), 800.100(B)(2), 810.21(F)(2), and 820.100 exist, installation of an IBT shall not be required. An accessible means external to enclosures for connecting intersystem bonding and grounding electrode conductors shall be permitted at the service equipment and at the disconnecting means for any buildings or structures that are supplied by a feeder or branch circuit by at least one of the following means:

(1) Exposed nonflexible metal raceways

(2) An exposed grounding electrode conductor

(3) Approved means for the external connection of a copper or other corrosion-resistant bonding or grounding electrode conductor to the grounded raceway or equipment

Informational Note: See 770.100, 800.100, 810.21, and 820.100 for intersystem bonding and grounding requirements for conductive optical fiber cables, communications circuits, radio and television equipment, CATV circuits, and network-powered broadband communications systems, respectively.

Statement of Problem and Substantiation for Public Input

Adding text to clarify that the intersystem bonding termination can be connected to service disconnect enclosure or raceway, or remote building metal enclosure or raceway, and additionally also be able to connect directly to the grounding electrode conductor itself.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 16 13:34:35 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8767-NFPA 70-2024

Statement: The additional language is added to permit the commonly used Intersystem Bonding Termination device mounted directly to a building or structure. Text is arranged in list format to comply with the style manual and for clarity.

Public Input No. 3867-NFPA 70-2023 [Section No. 250.96(B)]

(B) Isolated Grounding Circuits.

~~If installed for the reduction of electromagnetic interference on the grounding circuit, an~~ An equipment enclosure supplied by a branch circuit shall be permitted to be isolated from a raceway containing circuits supplying only that equipment by one or more listed nonmetallic raceway fittings located at the point of attachment of the raceway to the equipment enclosure. The metal raceway shall comply with this article and shall be supplemented by an internal insulated equipment grounding conductor installed in accordance with 250.146(D) to ground the equipment enclosure.

Informational Note: Use of an isolated equipment grounding conductor does not relieve the requirement for ~~grounding the raceway system~~ an effective ground-fault current path .

Statement of Problem and Substantiation for Public Input

The requirements of 250.96(B) are only in force if the isolated ground is installed specifically to reduce electromagnetic interference. If the isolated ground is installed for any other reason, e.g. to reduce objectionable current, the requirements of 250.96(B) are not in force. It doesn't matter why the isolated ground system was installed. There shouldn't be any conditions. The requirements should apply if the isolated ground system was installed for any reason whatsoever.

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 05 21:25:54 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8467-NFPA 70-2024

Statement: An effective ground fault current path is required regardless of the reason for isolation of equipment.

The informational note is modified to better reflect its purpose.

Public Input No. 3267-NFPA 70-2023 [Section No. 250.97]

250.97 Bonding for Over 250 Volts to Ground.

(A) General. For circuits of over 250 volts to ground, the electrical continuity of metal raceways and cables with metal sheaths that itself qualify as an equipment grounding conductor that contain any conductor other than service conductors shall be ensured by ~~one or more of the methods specified for services in 250.92~~ a bonding jumper in accordance with 250.97 (B)~~, except for~~ .

(B) Method of Bonding.

(1) Supply-Side Bonding Jumper. Supply-side bonding jumper(s) shall be selected from 250.102(C).

~~Exception: If oversized, concentric, or eccentric knockouts are not encountered, or~~

(2) Load-Side Bonding Jumper. The equipment bonding jumper on the load side of an overcurrent device shall be sized in accordance with 250.122.

Exception: Bonding jumpers shall not be required if a box or enclosure with concentric or eccentric knockouts is listed to provide a reliable bonding connection

~~, the following methods shall be permitted:~~

(1) ~~Threadless couplings and connectors for cables with metal sheaths~~

(2) ~~Two locknuts, on rigid metal conduit or intermediate metal conduit, one inside and one outside of boxes and cabinets~~

(3) ~~Fittings with shoulders that seat tightly against the box or cabinet, such as electrical metallic tubing connectors, flexible metal conduit connectors, and cable connectors, with one locknut on the inside of boxes and cabinets~~

(4) ~~Listed fittings~~

.

Statement of Problem and Substantiation for Public Input

Revised text makes it clear that there is no reason to bond the connector of Type MC cable, FMC, and LFMC if the wiring method does not qualify as an equipment grounding conductor. Additional text references 250.102 and 122 adds value to the user of the NEC. Revise the text to reflect that the basic rule requires a bonding jumper and the exception is clear when a bonding jumper is not required.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 30 20:43:11 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Metal raceways and fittings must always be bonded, whether they are an equipment grounding conductor or not to provide protection against shock and fire hazard. See 250.86. Sizing of bonding jumpers is covered in other sections of the Code.

Public Input No. 1108-NFPA 70-2023 [Section No. 250.102(A)]

(A) Material.

Bonding jumpers shall be of copper, copper-clad steel, aluminum, copper-clad aluminum, or other corrosion-resistant material. A bonding jumper shall be a wire, bus, screw, or similar suitable conductor. Bonding jumpers of copper-clad steel shall be 40% conductivity.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name:	Peter Graser
Organization:	Copperweld
Affiliation:	American Bimetallic Association
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Jun 17 08:55:32 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.102(C)(1)? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.102(C)(1) through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.102(C)(1) when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.102(C)(1). All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 3487-NFPA 70-2023 [Section No. 250.102(A)]

(A) Material.

Bonding jumpers shall be of copper, aluminum, copper-clad aluminum, or other corrosion-resistant material. A bonding jumper shall be a wire, bus, screw, non-flexible metal raceway or fittings, or similar suitable conductor.

Statement of Problem and Substantiation for Public Input

Currently, the allowance for a non-metal raceway as a suitable Supply Side Bonding Jumper is in 250.30(A)(2). Adding this allowance to 250.102 achieves two initiatives. 1, it puts the rules for a Supply Side Bonding Jumper in 250.102, the same location as the other rules. 2, It extends the allowance to Services as well as Separately Derived Systems. An example of where this might come in to play with Services is with CT cabinets. Oftentimes, CT cabinets do not have a provision for bonding the neutral conductor to the enclosure.

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
Organization:	Los Alamos National Laboratory
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Sep 04 00:16:17 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8469-NFPA 70-2024

Statement: Non-flexible metal raceway and fittings is added to coordinate with 250.30(A)(2).

Public Input No. 3216-NFPA 70-2023 [Section No. 250.102(C)]

(C) Size — Supply-Side Bonding Jumper.

(1) Size for Supply Conductors in a Single Raceway or Cable.

The supply-side bonding jumper shall not be smaller than specified in Table 250.102(C)(1).

(2) Size for Parallel Conductor Installations in Two or More Raceways or Cables.

If the ungrounded supply conductors are connected in parallel in two or more raceways or cables, the supply-side bonding jumper shall be sized in accordance with either of the following:

(1) An individual bonding jumper for each raceway or cable shall be selected from Table 250.102(C)(1) based on the size of the largest ungrounded supply conductor in each raceway or cable.

(2) A single bonding jumper installed for bonding two or more raceways or cables shall be sized in accordance with Table 250.102(C)(1) based on the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable. The size of the grounded conductor(s) in each raceway or cable shall be based on the largest ungrounded conductor in each raceway or cable, or the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable.

Informational Note No. 1: The term *supply conductors* includes ungrounded conductors that do not have overcurrent protection on their supply side and terminate at service equipment or the first disconnecting means of a separately derived system.

Informational Note No. 2: See Chapter 9, Table 8, for the circular mil area of conductors 18 AWG through 4/0 AWG.

Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		-	**Size of Grounded Conductor or Bonding Jumper (AWG/kcmil)**	
Copper	**Aluminum or Copper-Clad Aluminum**	-	**Copper**	**Aluminum or Copper-Clad Aluminum**
2 or smaller	1/0 or smaller	-	8	6
1 or 1/0	2/0 or 3/0	-	6	4
2/0 or 3/0	4/0 or 250	-	4	2
Over 3/0 through 350	Over 250 through 500	-	2	1/0
Over 350 through 600	Over 500 through 900	-	1/0	3/0
Over 600 through 1100	Over 900 through 1750	-	2/0	4/0
Over 1100	Over 1750	-	See Notes 1 and 2.	

Notes:

1. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum, the grounded conductor or bonding jumper shall have an area not less than 12½ percent of the area of the largest ungrounded supply conductor or equivalent area for parallel supply conductors.

2. The grounded conductor or bonding jumper shall not be required to be larger than the largest ungrounded conductor or set of ungrounded conductors.

~~2~~ 3 . If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum and if the ungrounded supply conductors and the bonding jumper are of different materials (copper, aluminum, or copper-clad aluminum), the minimum size of the grounded conductor or bonding jumper shall be based on the assumed use of ungrounded supply conductors of the same material as the grounded conductor or bonding jumper that has an ampacity equivalent to that of the installed ungrounded supply conductors.

~~3~~ 4 . If there are no service-entrance conductors, the supply conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

Statement of Problem and Substantiation for Public Input

Table 250.102(C) Note 1 has multiple requirements that should be broken into another list item. In accordance with NFPA Style Manual multiple requirements can be broken into independent requirements. This will improve usability and add clarity for Code users.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 30 11:46:07 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution:	FR-8471-NFPA 70-2024
Statement:	Editorial change to separate out distinct parts to comply with the NEC Style Manual 3.5.1.2

Public Input No. 3626-NFPA 70-2023 [Section No. 250.102(C)]

(C) Size — Supply-Side Bonding Jumper.

The supply-side bonding jumper shall be permitted to be of the nonflexible metal raceway type or of the wire type sized as follows:

(1) Size for Supply Conductors in a Single Raceway or Cable.

The supply-side bonding jumper shall not be smaller than specified in Table 250.102(C)(1).

(2) Size for Parallel Conductor Installations in Two or More Raceways or Cables.

If the ungrounded supply conductors are connected in parallel in two or more raceways or cables, the supply-side bonding jumper shall be sized in accordance with either of the following:

(1) An individual bonding jumper for each raceway or cable shall be selected from Table 250.102(C)(1) based on the size of the largest ungrounded supply conductor in each raceway or cable.

(2) A single bonding jumper installed for bonding two or more raceways or cables shall be sized in accordance with Table 250.102(C)(1) based on the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable. The size of the grounded conductor(s) in each raceway or cable shall be based on the largest ungrounded conductor in each raceway or cable, or the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable.

Informational Note No. 1: The term *supply conductors* includes ungrounded conductors that do not have overcurrent protection on their supply side and terminate at service equipment or the first disconnecting means of a separately derived system.

Informational Note No. 2: See Chapter 9, Table 8, for the circular mil area of conductors 18 AWG through 4/0 AWG.

Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		-	**Size of Grounded Conductor or Bonding Jumper (AWG/kcmil)**	
Copper	**Aluminum or Copper-Clad Aluminum**	-	**Copper**	**Aluminum or Copper-Clad Aluminum**
2 or smaller	1/0 or smaller	-	8	6
1 or 1/0	2/0 or 3/0	-	6	4
2/0 or 3/0	4/0 or 250	-	4	2
Over 3/0 through 350	Over 250 through 500	-	2	1/0
Over 350 through 600	Over 500 through 900	-	1/0	3/0
Over 600 through 1100	Over 900 through 1750	-	2/0	4/0
Over 1100	Over 1750	-	See Notes 1 and 2.	

Notes:

1. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum, the grounded conductor or bonding jumper shall have an area not less than 12½ percent of the area of the largest ungrounded supply conductor or equivalent area for parallel supply conductors. The grounded conductor or bonding jumper shall not be required to be larger than the largest ungrounded conductor or set of ungrounded conductors.

2. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum and if the ungrounded supply conductors and the bonding jumper are of different materials (copper, aluminum, or copper-clad aluminum), the minimum size of the grounded conductor or bonding jumper shall be based on the assumed use of ungrounded supply conductors of the same material as the grounded conductor or bonding jumper that has an ampacity equivalent to that of the installed ungrounded supply conductors.

3. If there are no service-entrance conductors, the supply conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

Statement of Problem and Substantiation for Public Input

The SSBJ is permitted to be a metal raceway for separately derived systems, [250.30(A)(2)], and we should also allow this method for 250.102. Adding this language will enhance usability and clarity for Code users.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 05 10:15:40 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: FR-8469-NFPA 70-2024

Statement: Non-flexible metal raceway and fittings is added to coordinate with 250.30(A)(2).

Public Input No. 1495-NFPA 70-2023 [New Section after 250.102(C)(2)]

TITLE OF NEW CONTENT

250.102C3 Continuity

Supply-side bonding jumpers shall connect to each enclosure in which they route.

Statement of Problem and Substantiation for Public Input

This NEC addition for a supply side bonding jumper installation reflects that of 250.148 for equipment grounding conductors.

As an example of the problem; the supply-side bonding jumper terminates in a meter disconnect enclosure, passes through the meter enclosure without terminating, and then terminates in a service disconnect enclosure. Possibly, the meter enclosure was bonded as required by appropriate raceway fittings or 250.142A. It’s a rookie installation where this not landing the supply-side bonding jumper occurs but at present, it is not an NEC violation provided all required bonding is met.

Submitter Information Verification

Submitter Full Name:	Norman Feck
Organization:	State of Colorado
Affiliation:	self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Jul 21 17:34:29 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: This public input would require non-metallic enclosures to be bonded. Meter disconnect enclosures are generally bonded from the factory. There are several different code compliant methods to meet the requirements of bonding enclosures.

Public Input No. 1109-NFPA 70-2023 [Section No. 250.102(C)(2)]

(2) Size for Parallel Conductor Installations in Two or More Raceways or Cables.

If the ungrounded supply conductors are connected in parallel in two or more raceways or cables, the supply-side bonding jumper shall be sized in accordance with either of the following:

(1) An individual bonding jumper for each raceway or cable shall be selected from Table 250.102(C)(1) based on the size of the largest ungrounded supply conductor in each raceway or cable.

(2) A single bonding jumper installed for bonding two or more raceways or cables shall be sized in accordance with Table 250.102(C)(1) based on the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable. The size of the grounded conductor(s) in each raceway or cable shall be based on the largest ungrounded conductor in each raceway or cable, or the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable.

Informational Note No. 1: The term *supply conductors* includes ungrounded conductors that do not have overcurrent protection on their supply side and terminate at service equipment or the first disconnecting means of a separately derived system.

Informational Note No. 2: See Chapter 9, Table 8, for the circular mil area of conductors 18 AWG through 4/0 AWG.

Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		-	**Size of Grounded Conductor or Bonding Jumper (AWG/kcmil)**	
Copper	**Aluminum or Copper-Clad Aluminum**	-	**Copper-Clad Steel or Copper**	**Aluminum or Copper-Clad Aluminum**
2 or smaller	1/0 or smaller	-	8	6
1 or 1/0	2/0 or 3/0	-	6	4
2/0 or 3/0	4/0 or 250	-	4	2
Over 3/0 through 350	Over 250 through 500	-	2	1/0
Over 350 through 600	Over 500 through 900	-	1/0	3/0
Over 600 through 1100	Over 900 through 1750	-	2/0	4/0
Over 1100	Over 1750	-	See Notes 1 and 2.	

Notes:

1. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum, the grounded conductor or bonding jumper shall have an area not less than 12½ percent of the area of the largest ungrounded supply conductor or equivalent area for parallel supply conductors. The grounded conductor or bonding jumper shall not be required to be larger than the largest ungrounded conductor or set of ungrounded conductors.

2. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum and if the ungrounded supply conductors and the bonding jumper are of different materials (copper, aluminum, or copper-clad aluminum), the minimum size of the grounded conductor or bonding jumper shall be based on the assumed use of ungrounded supply conductors of the same material as the grounded conductor or bonding jumper that has an ampacity equivalent to that of the installed ungrounded supply conductors.

3. If there are no service-entrance conductors, the supply conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name: Peter Graser
Organization: Copperweld
Affiliation: American Bimetallic Association
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Submittal Date: Sat Jun 17 09:04:11 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.102(C)(1)? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.102(C)(1) through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.102(C)(1) when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.102(C)(1). All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 839-NFPA 70-2023 [Section No. 250.102(C)(2)]

(2) Size for Parallel Conductor Installations in Two or More Raceways or Cables.

If the ungrounded supply conductors are connected in parallel in two or more raceways or cables, the supply-side bonding jumper shall be sized in accordance with either of the following:

(1) An individual bonding jumper for each raceway or cable shall be selected from Table 250.102(C)(1) based on the size of the largest ungrounded supply conductor in each raceway or cable.

(2) A single bonding jumper installed for bonding two or more raceways or cables shall be sized in accordance with Table 250.102(C)(1) based on the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable. ~~The size of the grounded conductor(s) in each raceway or cable shall be based on the largest ungrounded conductor in each raceway or cable, or the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable.~~

Informational Note No. 1: The term *supply conductors* includes ungrounded conductors that do not have overcurrent protection on their supply side and terminate at service equipment or the first disconnecting means of a separately derived system.

Informational Note No. 2: See Chapter 9, Table 8, for the circular mil area of conductors 18 AWG through 4/0 AWG.

Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		-	**Size of Grounded Conductor or Bonding Jumper (AWG/kcmil)**	
Copper	**Aluminum or Copper-Clad Aluminum**	-	**Copper**	**Aluminum or Copper-Clad Aluminum**
2 or smaller	1/0 or smaller	-	8	6
1 or 1/0	2/0 or 3/0	-	6	4
2/0 or 3/0	4/0 or 250	-	4	2
Over 3/0 through 350	Over 250 through 500	-	2	1/0
Over 350 through 600	Over 500 through 900	-	1/0	3/0
Over 600 through 1100	Over 900 through 1750	-	2/0	4/0
Over 1100	Over 1750	-	See Notes 1 and 2.	

Notes:

1. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum, the grounded conductor or bonding jumper shall have an area not less than 12½ percent of the area of the largest ungrounded supply conductor or equivalent area for parallel supply conductors. The grounded conductor or bonding jumper shall not be required to be larger than the largest ungrounded conductor or set of ungrounded conductors.

2. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum and if the ungrounded supply conductors and the bonding jumper are of different materials (copper, aluminum, or copper-clad aluminum), the minimum size of the grounded conductor or bonding jumper shall be based on the assumed use of ungrounded supply conductors of the same material as the grounded conductor or bonding jumper that has an ampacity equivalent to that of the installed ungrounded supply conductors.

3. If there are no service-entrance conductors, the supply conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

Statement of Problem and Substantiation for Public Input

Delete the last sentence in this paragraph. This sentence is about sizing for the grounded conductor, which is covered in 250.24(D) for services and 250.30(A)(3) for separately derived systems. Also the title of 250.102 (C) is "Size - Supply-Side Bonding Jumper" which should be exclusive to bonding jumpers, and should not have language/requirements for sizing the grounded conductor(s) which are a system or circuit conductor per the definition in Article 100.

Submitter Information Verification

Submitter Full Name:	Darryl Hill
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Zip:	
Submittal Date:	Wed May 17 12:23:00 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Table 250.102(C)(1) is used to size grounded conductors.

Public Input No. 3485-NFPA 70-2023 [Section No. 250.104]

250.104 Bonding of Piping ~~Systems~~ and Exposed Structural Metal.

(A) Metal Water Piping.

The metal water piping ~~system~~ shall be bonded as required in 250.104(A)(1), (A)(2), or (A)(3).

(1) General.

Metal water piping ~~system(s)~~ installed in or attached to a building or structure shall be bonded to any of the following:

(1) Service equipment enclosure

(2) Grounded conductor at the service

(3) Grounding electrode conductor, if of sufficient size

(4) One or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is of sufficient size

The bonding jumper(s) shall be installed in accordance with 250.64(A), (B), and (E). The points of attachment of the bonding jumper(s) shall be accessible. The bonding jumper(s) shall be sized in accordance with Table 250.102(C)(1) except that it shall not be required to be larger than 3/0 copper or 250 kcmil aluminum or copper-clad aluminum and except as permitted in 250.104(A)(2) and (A)(3).

(2) Buildings of Multiple Occupancy.

In buildings of multiple occupancy where the metal water piping ~~system(s)~~ installed in or attached to a building or structure for the individual occupancies is metallically isolated from all other occupancies by use of nonmetallic water piping, the metal water piping ~~system(s)~~ for each occupancy shall be permitted to be bonded to the equipment grounding terminal of the switchgear, switchboard, or panelboard enclosure (other than service equipment) supplying that occupancy. The bonding jumper shall be sized in accordance with 250.102(D).

(3) Buildings or Structures Supplied by a Feeder(s) or Branch Circuit(s).

The metal water ~~piping system(s)~~ piping_ installed in or attached to a building or structure shall be bonded to any of the following:

(1) Building or structure disconnecting means enclosure where located at the building or structure

(2) Equipment grounding conductor run with the supply conductors

(3) One or more grounding electrodes used

The bonding jumper(s) shall be sized in accordance with 250.102(D). The bonding jumper shall not be required to be larger than the largest ungrounded feeder or branch-circuit conductor supplying the building or structure.

(B) Other Metal Piping.

If installed in or attached to a building or structure, ~~a~~ metal piping ~~system(s)~~ , including gas piping, that is likely to become energized shall be bonded to any of the following:

(1) Equipment grounding conductor for the circuit that is likely to energize the piping ~~system~~

(2) Service equipment enclosure

(3) Grounded conductor at the service

(4) Grounding electrode conductor, if of sufficient size

(5) One or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is of sufficient size

The bonding conductor(s) or jumper(s) shall be sized in accordance with Table 250.122, and equipment grounding conductors shall be sized in accordance with Table 250.122 using the rating of the circuit that is likely to energize the piping ~~system(s)~~ . The points of attachment of the bonding jumper(s) shall be accessible.

> Informational Note No. 1: Bonding all piping and metal air ducts within the premises will provide additional safety.
>
> Informational Note No. 2: See NFPA 54, *National Fuel Gas Code*, and NFPA 780, *Standard for the Installation of Lightning Protection Systems*, for information on gas piping systems.

(C) Structural Metal.

Exposed structural metal that is interconnected to form a metal building frame, is not intentionally grounded or bonded, and is likely to become energized shall be bonded to any of the following:

(1) Service equipment enclosure

(2) Grounded conductor at the service

(3) Disconnecting means for buildings or structures supplied by a feeder or branch circuit

(4) Grounding electrode conductor, if not smaller than a conductor sized in accordance with Table 250.102(C)(1)

(5) One or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is not smaller than a conductor sized in accordance with Table 250.102(C)(1)

The bonding conductor(s) or jumper(s) shall be sized in accordance with Table 250.102(C)(1), except that it shall not be required to be larger than 3/0 AWG copper or 250 kcmil aluminum or copper-clad aluminum, and installed in accordance with 250.64(A), (B), and (E). The points of attachment of the bonding jumper(s) shall be accessible unless installed in compliance with 250.68(A), Exception No. 2.

(D) Separately Derived Systems.

Metal water piping ~~systems~~ and structural metal that is interconnected to form a building frame shall be bonded to separately derived systems in accordance with 250.104(D)(1) through (D)(3).

(1) Metal Water Piping ~~System(s)~~ .

The grounded conductor of each separately derived system shall be bonded to the nearest accessible point of the metal water ~~piping system(s)~~ piping in the area served by each separately derived system. This connection shall be made at the same point on the separately derived system where the grounding electrode conductor is connected. Each bonding jumper shall be sized in accordance with Table 250.102(C)(1) based on the largest ungrounded conductor of the separately derived system except that it shall not be required to be larger than 3/0 AWG copper or 250 kcmil aluminum or copper-clad aluminum.

Exception No. 1: A separate bonding jumper to the metal water piping ~~system~~ shall not be required if the metal water piping ~~system~~ is used as the grounding electrode or grounding electrode conductor for the separately derived system and the connection to the water piping ~~system~~ is in the area served by the separately derived system.

Exception No. 2: A separate bonding jumper to the metal water piping ~~system~~ shall not be required if the metal in-ground support structure is used as a grounding electrode or the metal frame of a building or structure is used as the grounding electrode conductor for a separately derived system and is bonded to the metal water piping system in the area served by the separately derived system.

(2) Structural Metal.

If exposed structural metal that is interconnected to form the building frame exists in the area served by the separately derived system, it shall be bonded to the grounded conductor of each separately derived system. This connection shall be made at the same point on the separately derived system where the grounding electrode conductor is connected. Each bonding jumper shall be sized in accordance with Table 250.102(C)(1) based on the largest ungrounded conductor of the separately derived system except that it shall not be required to be larger than 3/0 AWG copper or 250 kcmil aluminum or copper-clad aluminum.

Exception No. 1: A separate bonding jumper to the building structural metal shall not be required if the metal in-ground support structure is used as a grounding electrode or the metal frame of a building or structure is used as the grounding electrode conductor for the separately derived system.

Exception No. 2: A separate bonding jumper to the building structural metal shall not be required if the water piping ~~system~~ of a building or structure is used as the grounding electrode or grounding electrode conductor for a separately derived system and is bonded to the building structural metal in the area served by the separately derived system.

(3) Common Grounding Electrode Conductor.

If a common grounding electrode conductor is installed for multiple separately derived systems as permitted by 250.30(A)(6), and exposed structural metal that is interconnected to form the building frame or interior metal water piping exists in the area served by the separately derived system, the metal water piping and the structural metal member shall be bonded to the common grounding electrode conductor in the area served by the separately derived system.

Exception: A separate bonding jumper from each derived system to metal water piping and to structural metal members shall not be required if the metal water piping and the structural metal members in the area served by the separately derived system are bonded to the common grounding electrode conductor.

Statement of Problem and Substantiation for Public Input

The idea is to bond metal piping. Through the 1965 code, Article 250 didn’t need to use the adjective “metallic” or “metal” in referring to piping systems. Nowadays, piping often mixes metallic and nonmetallic tubing, and if there’s a substantial metallic portion, we want to bond it, without debating or even knowing whether it is a complete system. Adding the term "system" does not add clarity. It is not a defined NEC term, and there are disagreements on how to apply the dictionary definition.

Related Public Inputs for This Document

Related Input	**Relationship**

Public Input No. 3481-NFPA 70-2023 [Section No. 110.26(E)(2)]
Public Input No. 3482-NFPA 70-2023 [Section No. 250.32(D)]
Public Input No. 3483-NFPA 70-2023 [Section No. 250.52(A)(8)]
Public Input No. 3484-NFPA 70-2023 [Section No. 250.68(B)]
Public Input No. 3482-NFPA 70-2023 [Section No. 250.32(D)]
Public Input No. 3483-NFPA 70-2023 [Section No. 250.52(A)(8)]

Submitter Information Verification

Submitter Full Name:	David Shapiro
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City:	
State:	
Zip:	
Submittal Date:	Sun Sep 03 23:34:43 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Removing the word “systems” will not add clarity. The word “piping” by itself is too vague.

Public Input No. 3486-NFPA 70-2023 [Section No. 250.104(A)(2)]

(2) Buildings of Multiple Occupancy.

In buildings of multiple occupancy where the metal water piping system(s) installed in or attached to a building or structure for the individual occupancies is metallically isolated from all other occupancies by use of nonmetallic water piping or dielectric fittings , the metal water piping system(s) for each occupancy shall be permitted to be bonded to the equipment grounding terminal of the switchgear, switchboard, or panelboard enclosure (other than service equipment) supplying that occupancy. The bonding jumper shall be sized in accordance with 250.102(D).

Statement of Problem and Substantiation for Public Input

It is easily to identify a discontinuity that needs to be bonded around where nonmetallic pipe interrupts copper tubing. It is less obvious when a push-in fitting, for example, is used on copper tubing. Some brands of these are electrically continuous, others not; this makes the need to bond around them important to highlight here.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3483-NFPA 70-2023 [Section No. 250.52(A)(8)]	

Submitter Information Verification

Submitter Full Name: David Shapiro
Organization: Safety First Electrical
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Submittal Date: Mon Sep 04 00:08:57 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8473-NFPA 70-2024

Statement: There are non-electrical metal water piping fittings that may not provide the bonding required by the NEC and have not been evaluated for grounding continuity.

Public Input No. 2340-NFPA 70-2023 [Section No. 250.104(B)]

(B) Other Metal Piping.

(1) Metal Piping Systems. If installed in or attached to a building or structure, a metal piping system(s), including gas piping, that is likely to become energized shall be bonded to any of the following:

(1) Equipment grounding conductor for the circuit that is likely to energize the piping system

(2) Service equipment enclosure

(3) Grounded conductor at the service

(4) Grounding electrode conductor, if of sufficient size

(5) One or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is of sufficient size

The bonding conductor(s) or jumper(s) shall be sized in accordance with Table 250.122, and equipment grounding conductors shall be sized in accordance with Table 250.122 using the rating of the circuit that is likely to energize the piping system(s). The points of attachment of the bonding jumper(s) shall be accessible.

(2) Metal Gas Piping.

(a) Other than CSST. Each aboveground portion of a gas piping system, other than CSST, that is likely to become energized shall be electrically continuous and bonded to an effective ground-fault current path. Gas piping, other than CSST, shall be considered to be bonded when it is connected to the equipment grounding conductor of the circuit supplying that appliance. [**54**: 7.12.1]

(b) CSST Piping. CSST gas piping systems shall be bonded to the electrical service grounding electrode system or, where provided, lightning protection grounding electrode system. The bonding jumper shall connect to a metallic pipe, pipe fitting, or CSST fitting and shall not be smaller than 6 AWG copper wire or equivalent. The length of the jumper between the connection to the gas piping system and the grounding electrode system shall not exceed 22 m (75 ft). [**54:** 7.12.2]

(c) Arc-Resistant CSST. Arc-resistant jacketed CSST shall be considered to be bonded when it is connected to equipment grounding conductor of the circuit supplying that appliance. [**54:** 7.12.3]

Informational Note No. 1: Bonding all piping and metal air ducts within the premises will provide additional safety.

Informational Note No. 2: See NFPA 54, *National Fuel Gas Code*, and NFPA 780, *Standard for the Installation of Lightning Protection Systems*, for information on gas piping systems.

Statement of Problem and Substantiation for Public Input

The NEC is the electrical safety standard and Article 250 covers grounding and bonding, yet an electrical professional is forced to search NFPA 54 section 7.12 for the bonding requirements of metal gas piping systems. Adding extracted material in accordance with NEC Style Manual 2.1.12 to inform Code users on how to bond metal gas piping systems. This new second level subdivision will bridge the gap between both NFPA documents.

Submitter Information Verification

Submitter Full Name: Mike Holt

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City:	
State:	
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Submittal Date:	Wed Aug 16 13:36:32 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Bonding of metal pipe is covered in 250.104(B) and Lightning Protection is covered in NFPA 780. The bonding of gas piping is adequately covered as to shock hazard and ground fault current path. Bonding of CSST as a lightning protection system is not within the scope of NFPA 70.

Public Input No. 1768-NFPA 70-2023 [Section No. 250.109]

250.109 Metal and Nonmetal Enclosures.

Metal enclosures shall be permitted as part of the effective ground fault current path in accordance with 250.109(A). Nonmetallic enclosures installed with metallic wiring methods shall be installed in accordance with 250.109(B).

(A) Metal Enclosures

Metal enclosures shall be permitted to be used to connect bonding jumpers or equipment grounding conductors, or both, together to become a part of an effective ground-fault current path. If installed, metal covers, plaster rings, extension rings, and metal fittings shall be attached to these metal enclosures to ensure an effective ground-fault current path or shall be connected with bonding jumpers or equipment grounding conductors, or both.

Informational Note: See 250.97 for bonding requirements for over 250 volts to ground.

(B) Nonmetallic Boxes and Enclosures Installed with Metallic Wiring Methods

Nonmetallic boxes and enclosures installed with metal raceways or metal armored cable shall comply with 250.109(B)(1) and 250.109(B)(2).

(1) Nonmetallic boxes and enclosures installed with metallic wiring methods shall have bonding means and equipment bonding jumpers installed for each metal raceway or metal armored cable entry to ensure continuity of the metal wiring method and effective ground fault current path.

(2) Metal covers installed on nonmetallic enclosures shall have an equipment bonding jumper or other bonding means installed from the metal cover to the bonding means provided for the metal raceway or cable armor.

\Exception No.1. A listed nonmetallic box or enclosure with integral bonding means to interconnect all metallic raceway or cable armor entries and provide bonding for any metal cover installed shall not be required to have additional bonding means or equipment bonding jumpers installed.

Exception No 2. A nonmetallic box or enclosure that is supplied by a single metal raceway or single metal armored cable shall not be required to have bonding where all the following conditions are met:

1. There are no other metal raceways, or armored type cables entering the box or enclosure.

2. The supply end of the metal raceway or metal armored cable is bonded meeting the requirements of 250.86.

3, There is a wire type equipment grounding conductor sized in accordance with 250.122 installed in the metal raceway or armored cable connected to the equipment or device to complete the effective ground fault current path.

4. The conductors installed in the metal raceway or armored cable are not service conductors, grounding electrode conductors, or bonding jumpers interconnecting grounding electrodes.

Statement of Problem and Substantiation for Public Input

The use of non-metal enclosures for electrical equipment and electrical installations is becoming more prevalent. In the rapidly growing area of alternate energy installations, most of the enclosures used for the inverters, dc/ac combiners of photovoltaic systems, and energy storage systems are non-metallic. In addition, these installations are using non-metallic junction boxes. However, the raceway and cable

systems
used to connect the enclosures are usually metal. See attached photos from such installations as typical
examples.

While “boxes” may be covered by 314.3, the equipment enclosures, such as the examples above, are outside the scope of Article 314 and therefore these installations become difficult for AHJs to ensure a safe
installation with equipment grounding continuity.

The recent addition of 250.109 currently addresses the effective ground-fault current path for metal enclosures only. The need for requirements for proper bonding of metal raceways or cables when used with
non-metallic boxes or enclosures is not specifically addressed in Article 250. The proposed requirements are
necessary for correct bonding of connected metal raceways/cables and to ensure an effective path for ground-fault current. The proposed revision of 250.109 to address metal raceway/cable systems used with
non-metal enclosures is essential for proper application by AHJ’s. The exceptions bring into general application for non-metallic enclosures the provision from 314.3 that would be limited to boxes. Article 250 is
the proper place to address all these types of installations as a general requirement.

Other applications of non-metallic boxes where there is only one metal raceway of cable armor entry is not
considered in the present code. The provisions in 314.3 are there for multiple metal raceways or armored
cables enter the box to ensure continuity but does not consider a single raceway or metal armored cable.
An additional exception allows for non-metallic boxes where a single metal raceway or metal armored cable
enters with specific provisions. Under this exception if a fault were to occur in the raceway or cable, the fault
current will flow toward the source, not away from it and the required bonding at the supply end provides the
necessary fault current path. The required wire type equipment grounding conductor provides the necessary
effective ground fault current path the same as provided with nonmetallic the non-metallic wiring methods
identified in 314.3. This exception specifically prohibits use where the contained conductors are for service,
grounding electrode conductors or grounding electrode bonding conductors where bonding at both ends of
ferrous metal raceways is necessary for proper performance.

A companion public input, attached for reference, has been submitted to 314.3 to correlate with this proposed change and to correctly place all these grounding and bonding considerations into Article 250 for
better usability of the code.

Note: There are words that appear in the PI not underlined in the new parent text and also underlined in existing
text under (A) Metal Enclosures that is not intentional by the submitter. The Informational Note beneath text for
(A) Metal Enclosures is existing text from 2023 cycle and should not appear as new underlined text. Seems to
be a Terra View issue.

Submitter Information Verification

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Submittal Date:	Tue Aug 01 14:18:57 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8534-NFPA 70-2024

Statement: Separated distinct parts out to comply with the NEC Style Manual 3.5.1.2

This FR will provide additional guidance for installation of metal raceways systems into non-metallic boxes or enclosures which is now commonly being seen in the field.

Public Input No. 2192-NFPA 70-2023 [Section No. 250.109]

250.109 Metal Enclosures.

(A) Metal Equipment and Enclosures. Metal equipment and enclosures shall be permitted to be used to connect bonding jumpers or equipment grounding conductors, or both, together to become a part of an effective ground-fault current path.

(B) Metal Covers, Plaster Rings, Extension Rings, and Fittings. If installed, metal covers, plaster rings, extension rings, and metal fittings shall be attached to these metal enclosures to ensure an effective ground-fault current path or shall be connected with bonding jumpers or equipment grounding conductors, or both.

(C) Metal Raceways and Cable Armor. Metal raceways and cable armor shall be metallically joined together into a continuous electrical conductor and shall be connected to all boxes, fittings, and cabinets to provide an effective ground-fault current path in accordance with 250.4(A)(5).

Informational Note: See 250.97 for bonding requirements for over 250 volts to ground.

Statement of Problem and Substantiation for Public Input

Formatted this rule into two first level subdivisions to make it clear for Code users that this single paragraph contains multiple requirements. Added ‘’equipment’’ to both section title and text to recognize that metal equipment serves as part of the effective ground-fault current path. In accordance with NEC Style Manual section 3.5.1.2 multiple requirements within a single subdivision shall be avoided. Additional subdivisions or lists shall be used to express independent requirements. There should be a rule in Article 250 addressing that metal raceways and metal armor is required to maintain an effective ground-fault current path in accordance with 250.4(A)(5).

Submitter Information Verification

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Submittal Date: Mon Aug 14 13:43:19 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The title of this section is Metal Enclosures; therefore, raceways and cable armor bonding are outside the scope of this section.

Public Input No. 3470-NFPA 70-2023 [Section No. 250.109]

250.109 Metal and Non-metal Enclosures.

Metal enclosures shall be permitted as part of the effective ground fault current path in accordance with 250.109(A). Nonmetallic boxes and enclosures installed with metallic wiring methods shall be installed in accordance with 250.109(B).

(A) Metal Enclosures. Metal enclosures shall be permitted to be used to connect bonding jumpers or equipment grounding conductors, or both, together to become a part of an effective ground-fault current path. If installed, metal covers, plaster rings, extension rings, and metal fittings shall be attached to these metal enclosures to ensure an effective ground-fault current path or shall be connected with bonding jumpers or equipment grounding conductors, or both.

Informational Note: See 250.97 for bonding requirements for over 250 volts to ground.

(B) Non-metallic Boxes and Enclosures Installed with Metal Wiring Methods

Nonmetallic boxes and enclosures installed with metal raceways or metal armored cable shall comply with 250.109(B)(1) and 250.109(B)(2).

(1) Nonmetallic boxes and enclosures installed with metallic wiring methods shall have bonding means and equipment bonding jumpers installed for each metal raceway or metal armored cable entry to ensure continuity of the metal wiring method and effective ground fault current path.

(2) Metal covers installed on nonmetallic enclosures shall have an equipment bonding jumper or other bonding means installed from the metal cover to the bonding means provided for the metal raceway or cable armor.

Exception No.1. A listed nonmetallic box or enclosure with integral bonding means to interconnect all metallic raceway or cable armor entries and provide bonding for any metal cover installed shall not be required to have additional bonding means or equipment bonding jumpers installed.

Exception No 2. A nonmetallic box or enclosure that is supplied by a single metal raceway or single metal armored cable shall not be required to have bonding where all the following conditions are met:

1. No other metal raceways, or metal armored type cables enter the box or enclosure.
2. The supply end of the metal raceway or metal armored cable is bonded meeting the requirements of 250.86.
3, A wire type equipment grounding conductor sized in accordance with 250.122 is installed in the metal raceway or armored cable connected to the equipment or device to complete the effective ground fault current path.
4. The conductors installed in the metal raceway or armored cable are not service conductors, grounding electrode conductors, or bonding jumpers interconnecting grounding electrodes.

Additional Proposed Changes

File Name	Description	Approved
250.109_Proposed_Text_Submittal.docx	Clean copy of proposed text with legislative markings due to Terra issues	

PI_250.109_Photos.pdf	Example photos of non-metallic enclosures and boxes with metal wiring methods

Statement of Problem and Substantiation for Public Input

The use of non-metal enclosures for electrical equipment and electrical installations is becoming more prevalent. In the rapidly growing area of renewable energy installations, most of the enclosures used for the inverters, dc/ac combiners of photovoltaic systems, and energy storage systems are non-metallic. In addition, these installations are using non-metallic junction boxes. However, the raceway and cable systems used to connect the enclosures are usually metal. See attached photos from such installations as typical examples.

While “boxes” may be covered by 314.3, the equipment enclosures, such as the examples above, are outside the scope of Article 314 and therefore these installations become difficult for AHJs to ensure a safe installation with equipment grounding continuity.

The recent addition of 250.109 currently addresses the effective ground-fault current path for metal enclosures only. The need for requirements for proper bonding of metal raceways or cables when used with non-metallic boxes or enclosures is not specifically addressed in Article 250. The proposed requirements are necessary to ensure correct bonding of connected metal raceways/cables and ensuring the effective ground fault current path is provided. The proposed revision of 250.109 to address metal raceway/cable systems used with non-metal enclosures is essential for proper application by AHJ’s. The exceptions bring into general application for non-metallic enclosures the provision from 314.3 that would be limited to boxes. Article 250 is the proper place to address all these types of installations as a general requirement.

Other applications of non-metallic boxes where there is only one metal raceway of cable armor entry is not considered in the present code. The provisions in 314.3 are there for multiple metal raceways or armored cables enter the box to ensure continuity but does not consider a single raceway or metal armored cable.

An additional exception allows for non-metallic boxes where a single metal raceway or metal armored cable enters with specific provisions. Under this exception if a fault were to occur in the raceway or cable, the fault current will flow toward the source, not away from it and the required bonding at the supply end provides the necessary fault current path. The required wire type equipment grounding conductor provides the necessary effective ground fault current path the same as provided with nonmetallic the non-metallic wiring methods identified in 314.3. This exception specifically prohibits use where the contained conductors are for service, grounding electrode conductors or grounding electrode bonding conductors where bonding at both ends of ferrous metal raceways is necessary for proper performance.

A companion public input, attached for reference, has been submitted to 314.3 to correlate with this proposed change and to correctly place all these grounding and bonding considerations into Article 250 for better usability of the code.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3639-NFPA 70-2023 [Section No. 314.3]	
Public Input No. 3639-NFPA 70-2023 [Section No. 314.3]	

Submitter Information Verification

Submitter Full Name:	Charles Mello
Organization:	Cdcmello Consulting Llc
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sun Sep 03 16:36:29 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: FR-8534-NFPA 70-2024

Statement: Separated distinct parts out to comply with the NEC Style Manual 3.5.1.2

This FR will provide additional guidance for installation of metal raceways systems into non-metallic boxes or enclosures which is now commonly being seen in the field.

250.109 Proposed revised text

250.109 Metal and Nonmetal Enclosures.

Metal enclosures shall be permitted as part of the effective ground fault current path in accordance with 250.109(A). Nonmetallic boxes and enclosures installed with metallic wiring methods shall be installed in accordance with 250.109(B).

(A) Metal Enclosures

Metal enclosures shall be permitted to be used to connect bonding jumpers or equipment grounding conductors, or both, together to become a part of an effective ground-fault current path. If installed, metal covers, plaster rings, extension rings, and metal fittings shall be attached to these metal enclosures to ensure an effective ground-fault current path or shall be connected with bonding jumpers or equipment grounding conductors, or both.

> Informational Note: See 250.97 for bonding requirements for over 250 volts to ground.

(B) Nonmetallic Boxes and Enclosures Installed with Metallic Wiring Methods

Nonmetallic boxes and enclosures installed with metal raceways or metal armored cable shall comply with 250.109(B)(1) and 250.109(B)(2).

(1) Nonmetallic boxes and enclosures installed with metallic wiring methods shall have bonding means and equipment bonding jumpers installed for each metal raceway or metal armored cable entry to ensure continuity of the metal wiring method and effective ground fault current path.

(2) Metal covers installed on nonmetallic enclosures shall have an equipment bonding jumper or other bonding means installed from the metal cover to the bonding means provided for the metal raceway or cable armor.

Exception No.1. A listed nonmetallic box or enclosure with integral bonding means to interconnect all metallic raceway or cable armor entries and provide bonding for any metal cover installed shall not be required to have additional bonding means or equipment bonding jumpers installed.

Exception No 2. A nonmetallic box or enclosure that is supplied by a single metal raceway or single metal armored cable shall not be required to have bonding where all the following conditions are met:

1. No other metal raceways, or metal armored type cables enter the box or enclosure.
2. The supply end of the metal raceway or metal armored cable is bonded meeting the requirements of 250.86.
3, A wire type equipment grounding conductor sized in accordance with 250.122 is installed in the metal raceway or armored cable connected to the equipment or device to complete the effective ground fault current path.
4. The conductors installed in the metal raceway or armored cable are not service conductors, grounding electrode conductors, or bonding jumpers interconnecting grounding electrodes.

Photo 1 – Common Alternate Energy Installation

Photo 2 – Proper Bonding Completed but Not Clearly Required

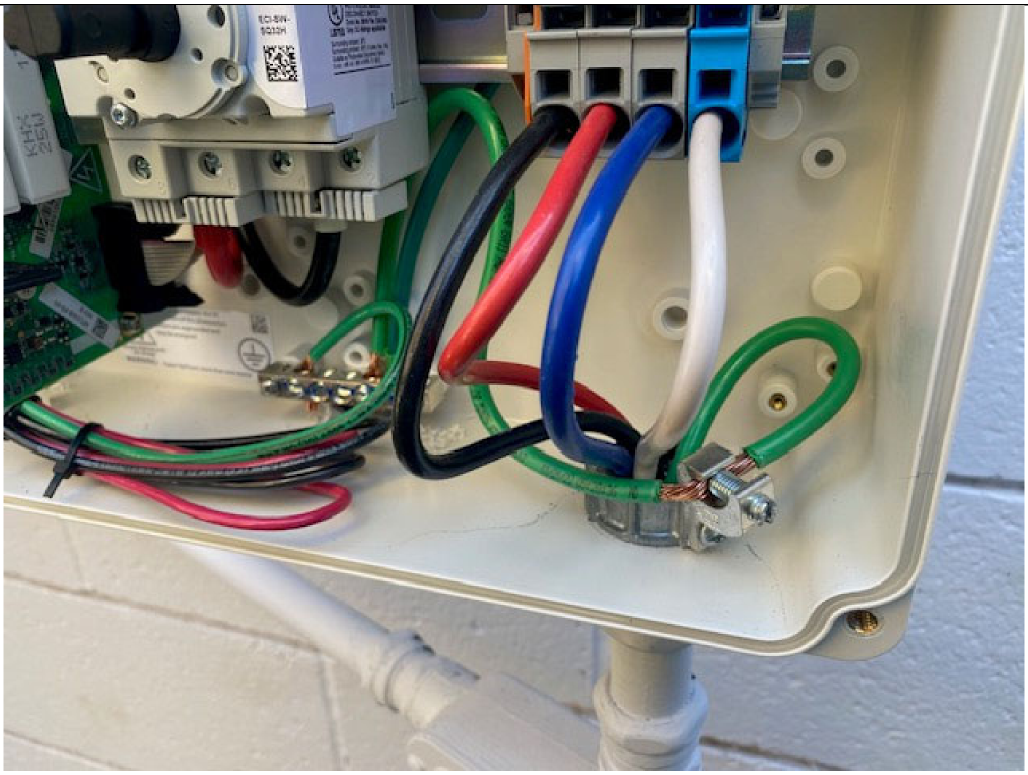


Photo 3 – EMT Into Non-metallic Enclosure

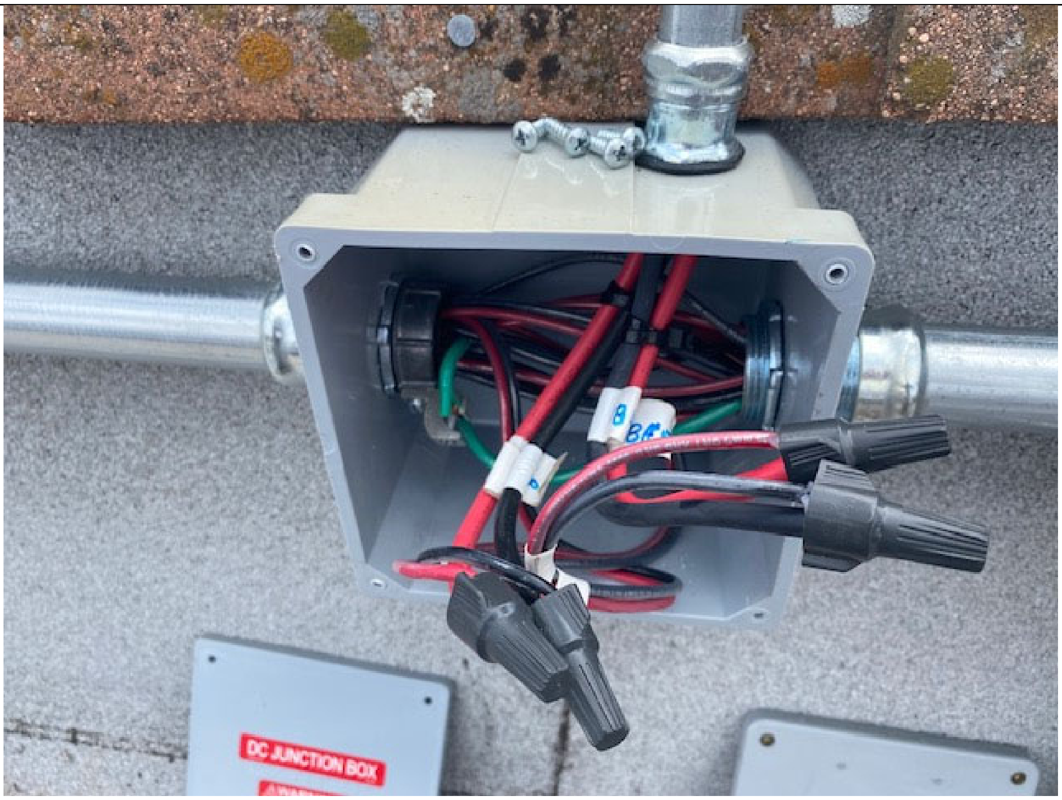


Photo 4 – Non-metallic DC Junction Box with EMT Raceways

Photo 5 – Non-metallic Junction Box with EMT Raceway

Public Input No. 1-NFPA 70-2023 [New Section after 250.110]

TITLE OF NEW CONTENT

Equipment Ground Current Detection System

Feeders or branch circuits feeding pool equipment shall be provided with a current detection system that provides an alarm if there is current detected on the equipment ground.

Statement of Problem and Substantiation for Public Input

The NESC requires grounding of the utility systems at 4 point over each mile of the utility distribution system. The NESC also requires that the primary and secondary neutral conductors be be bonded together and grounded. When pools are installed there is a parallel path for current through the utility feeder conductor to the premises and through the earth. The current through the earth will vary depending on the the resistivity of the earth. The pools is also required to have an equipotential bonding conductor or wire mesh installed around the perimeter of the pool. The equipotential bonding conductor or wire mesh also ends up being electrically connected to the equipment grounding system for the pool equipment and is also connected to the grounding electrode system for the service. The parallel path through the earth then becomes a much shorter path to the utility supply creating a difference of potential around the pool area.

Submitter Information Verification

Submitter Full Name: Dennis Querry
Organization: Trinity River Authority
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 03 17:24:25 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: This is outside the scope of Article 250.

Public Input No. 840-NFPA 70-2023 [Section No. 250.112(I)]

(I) Remote-Control, Signaling, and Fire Alarm Circuits.- ~~Equipment supplied by Class 1 circuits shall be grounded unless operating at less than 50 volts. Equipment supplied by Class 1~~

power-limited circuits, by Class 2 and Class 3 remote-control and signaling circuits, and by fire alarm circuits shall be grounded if system grounding is required by Part II or Part VIII of this article.

Statement of Problem and Substantiation for Public Input

Class 1 nonpower-limited circuits were removed during the 2023 NEC revision process.

Submitter Information Verification

Submitter Full Name:	Ryan Jackson
Organization:	Self-employed
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed May 17 14:28:55 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Proposed wording does not address nonpowered-limited. The proposed new wording is not a complete sentence.

Public Input No. 2650-NFPA 70-2023 [Section No. 250.112(J)]

(J) Luminaires.

Luminaires as provided in Article 410, Part V- ~~of Article 410~~ .

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name:	David Williams
Organization:	Delta Charter Township
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 23 21:48:38 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution:	FR-8686-NFPA 70-2024
Statement:	The panel has revised the text to comply with 4.1.4 of the NEC Style Manual, 2023 when referencing specific parts of an article.

Public Input No. 1585-NFPA 70-2023 [Section No. 250.114]

250.114 Equipment Connected by Cord and Plug.

Exposed, normally non-current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor under any of the following conditions:

Exception: Listed tools, listed appliances, and listed equipment covered in 250.114, list items 2 through 4, shall not be required to be connected to an equipment grounding conductor if protected by a system of double insulation or its equivalent. Double-insulated equipment shall be distinctively marked.

(1) In hazardous (classified) locations

(2) If operated at over 150 volts to ground

Exception No. 1 to (2): Motors, if guarded, shall not be required to be connected to an equipment grounding conductor.

Exception No. 2 to (2): Metal frames of electrically heated appliances, exempted by special permission, shall not be required to be connected to an equipment grounding conductor, in which case the frames shall be permanently and effectively insulated from ground.

(3) In residential occupancies:

a. Refrigerators, freezers, icemakers, and air conditioners

b. Clothes-washing, clothes-drying, and dish-washing machines; ranges; kitchen waste disposers; information technology equipment; sump pumps; and electrical aquarium equipment

c. Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools

d. Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers

e. Portable handlamps

(4) In other than residential occupancies:

a. Refrigerators, freezers, icemakers, and air conditioners

b. Clothes-washing, clothes-drying, and dish-washing machines; information technology equipment; sump pumps; and electrical aquarium equipment

c. Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools

d. Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers

e. Portable handlamps

f. Cord-and-plug-connected appliances used in damp or wet locations or by persons standing on the ground, standing on metal floors, or working inside of metal tanks or boilers

g. Tools likely to be used in wet or conductive locations

Exception: Tools and portable handlamps and portable luminaires likely to be used in wet or conductive locations shall not be required to be connected to an equipment grounding conductor if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts.

Additional Proposed Changes

File Name	Description	Approved
TIA_1608_70_23_1.pdf	NEC TIA 23-1 Log 1608	

TIA_1608_70_20_16.pdf NEC TIA 20-16 TIA 1608

Statement of Problem and Substantiation for Public Input

NOTE: This public input originates from Tentative Interim Amendment No. 23-1 and 20-16 (Log 1608) issued by the Standards Council on December 8, 2021 and per the NFPA Regs., needs to be reconsidered by the Code-Making Panel for the next edition of the Document.

Substantiation: The phrase “and portable luminaires” was added during the 2020 cycle (FR 8040, based on PI 1200) to both 250.114(3)(e) and (4)(e). The FR substantiation (carried forward from the PI) states:

“Portable handlamps were originally covered by UL 298, titled "Portable Electric Hand Lamps". UL 298 was withdrawn in 2004, and has been superceded by UL 153, titled "Portable Electric Luminaires". Devices that were once called "Portable Handlamp" on their label are now being labeled as "Portable Luminaire", but are the same product. Therefore, 3(e) and 4(e) should include "portable luminaires" to continue to cover the grounding need for these products.”

The substantiation conflated the certification organization label designation (“Portable Luminaire”) with the requirements in the standard that apply to the specific product type (a portable hand light). UL 153 (clause 138.6.1) explicitly requires portable hand lights, which are typically used in garages and similar environments, to use a grounding type attachment plug when they have accessible metal that may become energized. UL 153 applies a similar grounding plug requirement on other types of portable luminaires, such as those for wet locations. But there are many indoor use (residential and commercial) portable luminaire types that have always been permitted, by UL 153 and NEC 410.82, to use a polarized, 2-wire supply plug. Polarized portable luminaires compliant with UL 153 have a well-established acceptable field record of adequately managing the associated risks. The substantiation for FR 8040 did not claim otherwise but appears to have inadvertently removed this longstanding design option.

During the 2020 cycle, NEC 410.42 was revised (PI 2473, FR 8426) to reinforce the longstanding permission (in 410.82) for portable luminaires to use a polarized plug.

The result is that NEC 250.114(3) and (4), which now require all portable luminaires with accessible metal (and without double insulation) to be grounded, is in conflict with 410.82 which permits a polarized plug and 410.42 which says those with a polarized plug do not require grounding. This TIA therefore proposes that 250.114(3)(e) and (4)(e) be returned to their 2017 edition status to eliminate this conflict. The objective of PI 1200 / FR 8040, to maintain the grounding requirement for portable hand lights (despite their requirements shifting from UL 298 to UL 153) was never in jeopardy so the PI / FR was never needed.

Emergency Nature: The NFPA Standard contains a conflict within the NFPA Standard or within another NFPA Standard.

Portable luminaires listed in accordance with UL 153 and with a polarized plug should not be rejected due to non-compliance with 250.114. The conflict between this section and 410.42 was found too late in the 2023 cycle for a public input, and it should not be left to linger until the 2026 revision cycle opens.

Submitter Information Verification

Submitter Full Name:	CMP ON NEC-P05
Organization:	NFPA
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Jul 26 13:04:38 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: The panel reaffirms the action of the standards council for TIA’s 23-1 and 20-16 (Log 1608) to delete “and portable luminaries” from 250.114(8). The concerns in PI-4077 are addressed by TIA 23-1, no additional actions are needed.

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 250.114(3)e and 250.114(4)e
TIA 23-1
(SC 21-12-13 / TIA Log #1608)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. Revise 250.114(3)e and (4)e to read as follows:

250.114 Equipment Connected by Cord and Plug. Exposed, normally non-current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor under any of the following conditions:

…

(3) In residential occupancies:

…

e. Portable handlamps ~~and portable luminaires~~

(4) In other than residential occupancies:

…

e. Portable handlamps ~~and portable luminaires~~

…

Issue Date: December 8, 2021

Effective Date: December 28, 2021

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**

Tentative Interim Amendment

NFPA$^{®}$ 70®

National Electrical Code®

2020 Edition

Reference: 250.114(3)e and 250.114(4)e
TIA 20-16
(SC 21-12-13 / TIA Log #1608)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2020 edition. The TIA was processed by the Code-Making Panel 5, and the NEC Correlating Committee, and was issued by the Standards Council on December 8, 2021, with an effective date of December 28, 2021.

1. Revise 250.114(3)e and (4)e to read as follows:

> **250.114 Equipment Connected by Cord and Plug.** Exposed, normally non-current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor under any of the following conditions:
> …
> (3) In residential occupancies:
> …
> e. Portable handlamps ~~and portable luminaires~~
> (4) In other than residential occupancies:
> …
> e. Portable handlamps ~~and portable luminaires~~
> …

Issue Date: December 8, 2021

Effective Date: December 28, 2021

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo)

Public Input No. 2004-NFPA 70-2023 [Section No. 250.114]

250.114 Equipment Connected by Cord and Plug.

Exposed, normally non-current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor under any of the following conditions:

Exception: Listed tools, listed appliances, and listed equipment covered in 250.114, list items 2 through 4, shall not be required to be connected to an equipment grounding conductor if protected by a system of double insulation or its equivalent. Double-insulated equipment shall be distinctively marked.

(1) In hazardous (classified) locations

(2) If operated at over 150 volts to ground

Exception No. 1 to (2): Motors, if guarded, shall not be required to be connected to an equipment grounding conductor.

Exception No. 2 to (2): Metal frames of electrically heated appliances, exempted by special permission, shall not be required to be connected to an equipment grounding conductor, in which case the frames shall be permanently and effectively insulated from ground.

(3) In residential occupancies:

(4) _ Refrigerators, freezers, icemakers, and air conditioners

(5) _ Clothes-washing, clothes-drying, and dish-washing machines; ranges; kitchen waste disposers; information technology equipment; sump pumps; and electrical aquarium equipment . ____ *Exception to (b): Electric ranges, wall-mounted ovens, counter-mounted cooking units, and clothes dryers installed in accordance with 250.140(B) .*

(6) _ Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools

(7) _ Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers

(8) _ Portable handlamps

(9) In other than residential occupancies:

(10) _ Refrigerators, freezers, icemakers, and air conditioners

(11) _ Clothes-washing, clothes-drying, and dish-washing machines; information technology equipment; sump pumps; and electrical aquarium equipment

(12) _ Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools

(13) _ Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers

(14) _ Portable handlamps

(15) _ Cord-and-plug-connected appliances used in damp or wet locations or by persons standing on the ground, standing on metal floors, or working inside of metal tanks or boilers

(16) _ Tools likely to be used in wet or conductive locations

Exception: Tools and portable handlamps and portable luminaires likely to be used in wet or conductive locations shall not be required to be connected to an equipment grounding conductor if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts.

Additional Proposed Changes

File Name	Description	Approved
250.114_screenshot.pdf	250.114 screenshot	

Statement of Problem and Substantiation for Public Input

This exception to 250.114(3)(b) is needed to correlate with existing circuits installed in compliance with 250.140(B) which allows the use of the grounded conductor for grounding/bonding of the appliance frame.The product standard for electric ranges, ovens , and cooktops (UL 858) and electric clothes dryers (UL 2158) still permits appliance grounding through the neutral-grounding link.

As usual, TerraView was acting wonky and would seemingly not allow me the correct numbering/lettering for the final layout. I provided a screenshot showing correct layout for proposed revision.

Related Public Inputs for This Document

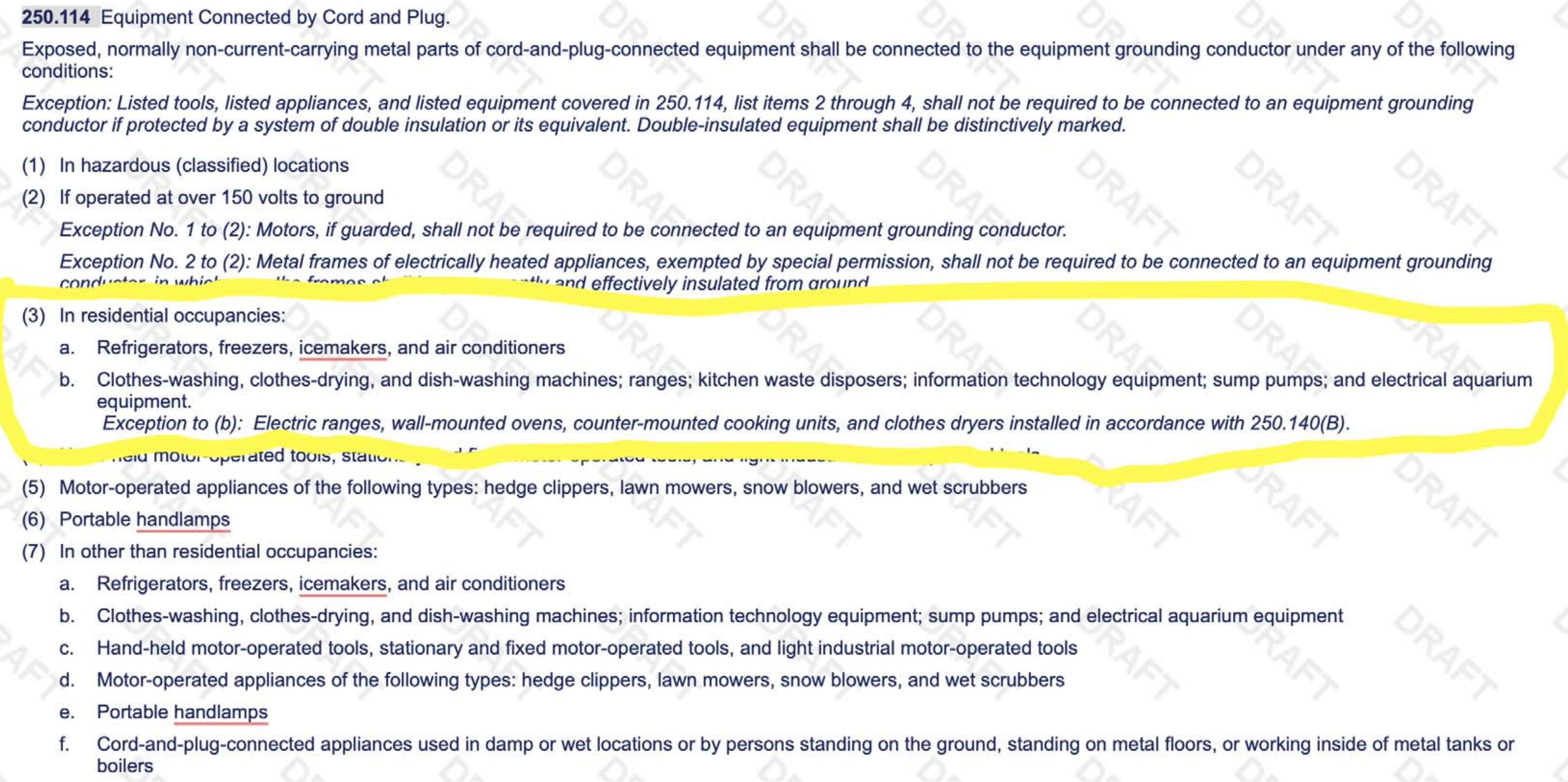
Related Input	Relationship
Public Input No. 1885-NFPA 70-2023 [Section No. 406.4(D)(3)]	

Submitter Information Verification

Submitter Full Name: Russ Leblanc
Organization: Leblanc Consulting Services
Street Address:
City:
State:
Zip:
Submittal Date: Thu Aug 10 17:56:51 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The exception is unnecessary because existing branch circuit installation is covered in 250.140(B).



250.114 Equipment Connected by Cord and Plug.

Exposed, normally non-current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor under any of the following conditions:

Exception: Listed tools, listed appliances, and listed equipment covered in 250.114, list items 2 through 4, shall not be required to be connected to an equipment grounding conductor if protected by a system of double insulation or its equivalent. Double-insulated equipment shall be distinctively marked.

(1) In hazardous (classified) locations

(2) If operated at over 150 volts to ground

Exception No. 1 to (2): Motors, if guarded, shall not be required to be connected to an equipment grounding conductor.

Exception No. 2 to (2): Metal frames of electrically heated appliances, exempted by special permission, shall not be required to be connected to an equipment grounding conductor, in which the frames shall be permanently and effectively insulated from ground.

(3) In residential occupancies:

a. Refrigerators, freezers, icemakers, and air conditioners

b. Clothes-washing, clothes-drying, and dish-washing machines; ranges; kitchen waste disposers; information technology equipment; sump pumps; and electrical aquarium equipment.

Exception to (b): Electric ranges, wall-mounted ovens, counter-mounted cooking units, and clothes dryers installed in accordance with 250.140(B).

(4) Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools

(5) Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers

(6) Portable handlamps

(7) In other than residential occupancies:

a. Refrigerators, freezers, icemakers, and air conditioners

b. Clothes-washing, clothes-drying, and dish-washing machines; information technology equipment; sump pumps; and electrical aquarium equipment

c. Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools

d. Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers

e. Portable handlamps

f. Cord-and-plug-connected appliances used in damp or wet locations or by persons standing on the ground, standing on metal floors, or working inside of metal tanks or boilers

Public Input No. 4077-NFPA 70-2023 [Section No. 250.114]

250.114 Equipment Connected by Cord and Plug.

Exposed, normally non-current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor under any of the following conditions:

Exception: Listed tools, listed appliances, and listed equipment covered in 250.114, list items 2 through 4, shall not be required to be connected to an equipment grounding conductor if protected by a system of double insulation or its equivalent. Double-insulated equipment shall be distinctively marked.

(1) In hazardous (classified) locations

(2) If operated at over 150 volts to ground

Exception No. 1 to (2): Motors, if guarded, shall not be required to be connected to an equipment grounding conductor.

Exception No. 2 to (2): Metal frames of electrically heated appliances, exempted by special permission, shall not be required to be connected to an equipment grounding conductor, in which case the frames shall be permanently and effectively insulated from ground.

(3) In residential occupancies:

  a. Refrigerators, freezers, icemakers, and air conditioners
  b. Clothes-washing, clothes-drying, and dish-washing machines; ranges; kitchen waste disposers; information technology equipment; sump pumps; and electrical aquarium equipment
  c. Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools
  d. Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers
  e. Portable handlamps

(4) In other than residential occupancies:

  a. Refrigerators, freezers, icemakers, and air conditioners
  b. Clothes-washing, clothes-drying, and dish-washing machines; information technology equipment; sump pumps; and electrical aquarium equipment
  c. Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools
  d. Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers
  e. Portable handlamps
  f. Cord-and-plug-connected appliances used in damp or wet locations or by persons standing on the ground, standing on metal floors, or working inside of metal tanks or boilers
  g. Tools likely to be used in wet or conductive locations

Exception: Tools and portable handlamps and portable luminaires likely to be used in wet or conductive locations shall not be required to be connected to an equipment grounding conductor if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts.

Additional Proposed Changes

File Name	Description	Approved
PC_1433_CMP_5.pdf	NEC_PC1433	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as “Reject but Hold” in Public Comment No. 1433 of the (A2022) Second Draft Report for NFPA 70 and per the Regs. at 4.4.8.3.1.

The phrase “and portable luminaires” was added during the 2020 cycle (FR 8040, based on PI 1200) to
both 250.114(3)(e) and (4)(e). The FR substantiation (carried forward from the PI) states:
“Portable handlamps were originally covered by UL 298, titled "Portable Electric Hand Lamps". UL 298 was withdrawn in 2004, and has been superseded by UL 153, titled "Portable Electric Luminaires". Devices that were once called "Portable Handlamp" on their label are now being labeled as "Portable Luminaire” but are the same product. Therefore, 3(e) and 4(e) should include "portable luminaires" to continue to cover the grounding need for these products.”
The substantiation conflated the certification organization label designation (“Portable Luminaire”) with the
requirements in the standard that apply to the specific product type (a portable hand light). UL 153 (clause 138.6.1) explicitly requires portable hand lights, which are typically used in garages and similar environments, to use a grounding type attachment plug when they have accessible metal that may become energized. UL 153 applies a similar grounding plug requirement on other types of portable luminaires, such as those for wet locations. But there are many indoor use (residential and commercial)
portable luminaire types that have always been permitted, by UL 153 and NEC 410.82, to use a polarized,
2-wire supply plug. Polarized portable luminaires compliant with UL 153 have a well-established acceptable field record of adequately managing the associated risks. The substantiation for FR 8040 did
not claim otherwise but appears to have inadvertently removed this longstanding design option.
During the 2020 cycle, NEC 410.42 was revised (PI 2473, FR 8426) to reinforce the longstanding permission (in 410.82) for portable luminaires to use a polarized plug.
The result is that NEC 250.114(3) and (4), which now require all portable luminaires with accessible metal
(and without double insulation) to be grounded, is in conflict with 410.82 which permits a polarized plug and 410.42 which says those with a polarized plug do not require grounding. This public comment therefore proposes that 250.114(3)(e) and (4)(e) be returned to their 2017 edition status to eliminate this
conflict. The objective of PI 1200 / FR 8040, to maintain the grounding requirement for portable hand lights (despite their requirements shifting from UL 298 to UL 153) was never in jeopardy so the PI / FR was never needed.

Submitter Information Verification

Submitter Full Name:	CMP ON NEC-P05
Organization:	Code-Making Panel 5
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Sep 06 15:56:51 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The panel reaffirms the action of the standards council for TIA’s 23-1 and 20-16 (Log 1608) to delete “and portable luminaries” from 250.114(8). The concerns in PI-4077 are addressed by TIA 23-1, no additional actions are needed.

Public Comment No. 1433-NFPA 70-2021 [Section No. 250.114]

250.114 Equipment Connected by Cord and Plug.

Exposed, normally non-current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor under any of the following conditions:

Exception: Listed tools, listed appliances, and listed equipment covered in 250.114, list items 2 through 4, shall not be required to be connected to an equipment grounding conductor if protected by a system of double insulation or its equivalent. Double-insulated equipment shall be distinctively marked.

(1) In hazardous (classified) locations

(2) If operated at over 150 volts to ground

Exception No. 1 to (2): Motors, if guarded, shall not be required to be connected to an equipment grounding conductor.

Exception No. 2 to (2): Metal frames of electrically heated appliances, exempted by special permission, shall not be required to be connected to an equipment grounding conductor, in which case the frames shall be permanently and effectively insulated from ground.

(3) In residential occupancies:

- (4) _ Refrigerators, freezers, icemakers, and air conditioners
- (5) _ Clothes-washing, clothes-drying, and dish-washing machines; ranges; kitchen waste disposers; information technology equipment; sump pumps; and electrical aquarium equipment
- (6) _ Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools
- (7) _ Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers
- (8) Portable

~~handlamps and portable luminaires~~

a. handlamps

(9) In other than residential occupancies:

- (10) _ Refrigerators, freezers, icemakers, and air conditioners
- (11) _ Clothes-washing, clothes-drying, and dish-washing machines; information technology equipment; sump pumps; and electrical aquarium equipment
- (12) _ Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools
- (13) _ Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers
- (14) Portable

~~handlamps and portable luminaires~~

a. handlamps

b. _ Cord-and-plug-connected appliances used in damp or wet locations or by persons standing on the ground, standing on metal floors, or working inside of metal tanks or boilers

c. _ Tools likely to be used in wet or conductive locations

Exception: Tools and portable handlamps

~~and portable luminaires likely~~

a.

likely to be used in wet or conductive locations shall not be required to be connected to an equipment grounding conductor if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts.

Statement of Problem and Substantiation for Public Comment

The phrase “and portable luminaires” was added during the 2020 cycle (FR 8040, based on PI 1200) to both 250.114(3)(e) and (4)(e). The FR substantiation (carried forward from the PI) states:
“Portable handlamps were originally covered by UL 298, titled "Portable Electric Hand Lamps". UL 298 was withdrawn in 2004, and has been superseded by UL 153, titled "Portable Electric Luminaires". Devices that were once called "Portable Handlamp" on their label are now being labeled as "Portable Luminaire” but are the same product. Therefore, 3(e) and 4(e) should include "portable luminaires" to continue to cover the grounding need for these products.”
The substantiation conflated the certification organization label designation (“Portable Luminaire”) with the requirements in the standard that apply to the specific product type (a portable hand light). UL 153 (clause 138.6.1) explicitly requires portable hand lights, which are typically used in garages and similar environments, to use a grounding type attachment plug when they have accessible metal that may become energized. UL 153 applies a similar grounding plug requirement on other types of portable luminaires, such as those for wet locations. But there are many indoor use (residential and commercial) portable luminaire types that have always been permitted, by UL 153 and NEC 410.82, to use a polarized, 2-wire supply plug. Polarized portable luminaires compliant with UL 153 have a well-established acceptable field record of adequately managing the associated risks. The substantiation for FR 8040 did not claim otherwise but appears to have inadvertently removed this longstanding design option.
During the 2020 cycle, NEC 410.42 was revised (PI 2473, FR 8426) to reinforce the longstanding permission (in 410.82) for portable luminaires to use a polarized plug.
The result is that NEC 250.114(3) and (4), which now require all portable luminaires with accessible metal (and without double insulation) to be grounded, is in conflict with 410.82 which permits a polarized plug and 410.42 which says those with a polarized plug do not require grounding. This public comment therefore proposes that 250.114(3)(e) and (4)(e) be returned to their 2017 edition status to eliminate this conflict. The objective of PI 1200 / FR 8040, to maintain the grounding requirement for portable hand lights (despite their requirements shifting from UL 298 to UL 153) was never in jeopardy so the PI / FR was never needed.

Related Item

- This Public Comment is related to FR No. 8179

Submitter Information Verification

Submitter Full Name:	Christopher Jensen
Organization:	UL LLC
Affiliation:	UL LLC
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Aug 13 11:20:11 EDT 2021
Committee:	NEC-P05

Committee Statement

Committee Action:	Rejected but held

Resolution: No action is taken as this public comment is considered new material per 4.4.8.3 of the NFPA regulations.

Copyright Assignment

I, Christopher Jensen, hereby irrevocably grant and assign to the National Fire Protection Association (NFPA) all and full rights in copyright in this Public Comment (including both the Proposed Change and the Statement of Problem and Substantiation). I understand and intend that I acquire no rights, including rights as a joint author, in any publication of the NFPA in which this Public Comment in this or another similar or derivative form is used. I hereby warrant that I am the author of this Public Comment and that I have full power and authority to enter into this copyright assignment.

☑ By checking this box I affirm that I am Christopher Jensen, and I agree to be legally bound by the above Copyright Assignment and the terms and conditions contained therein. I understand and intend that, by checking this box, I am creating an electronic signature that will, upon my submission of this form, have the same legal force and effect as a handwritten signature

Public Input No. 2311-NFPA 70-2023 [Section No. 250.118(A)]

(A) Permitted.

Each equipment grounding conductor run with or enclosing the circuit conductors shall be one or more or a combination of the following:

(1) A copper, aluminum, or copper-clad aluminum conductor. This conductor shall be solid or stranded; insulated, covered, or bare; and in the form of a wire or a busbar of any shape.

(2) Rigid metal conduit.

(3) Intermediate metal conduit.

(4) ~~Electrical metallic tubing.~~

(5) Listed flexible metal conduit meeting all the following conditions:

(6) The conduit is terminated in listed fittings.

(7) The circuit conductors contained in the conduit are protected by overcurrent devices rated at 20 amperes or less.

(8) The size of the conduit does not exceed metric designator 35 (trade size 1 1⁄4).

(9) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 1.8 m (6 ft).

(10) If flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, a wire-type equipment grounding conductor or a bonding jumper in accordance with 250.102(E)(2) shall be installed.

(11) If flexible metal conduit is constructed of stainless steel, a wire-type equipment grounding conductor or bonding jumper in accordance with 250.102(E)(2) shall be installed.

(12) Listed liquidtight flexible metal conduit meeting all the following conditions:

(13) The conduit is terminated in listed fittings.

(14) For metric designators 12 through 16 (trade sizes 3⁄8 through 1⁄2), the circuit conductors contained in the conduit are protected by overcurrent devices rated at 20 amperes or less.

(15) For metric designators 21 through 35 (trade sizes 3⁄4 through 1 1⁄4), the circuit conductors contained in the conduit are protected by overcurrent devices rated not more than 60 amperes and there is no flexible metal conduit, flexible metallic tubing, or liquidtight flexible metal conduit in metric designators 12 through 16 (trade sizes 3⁄8 through 1⁄2) in the effective ground-fault current path.

(16) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 1.8 m (6 ft).

(17) If flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, a wire-type equipment grounding conductor or a bonding jumper in accordance with 250.102(E)(2) shall be installed.

(18) If liquidtight flexible metal conduit contains a stainless steel core, a wire-type equipment grounding conductor or a bonding jumper in accordance with 250.102(E)(2) shall be installed.

(19) Flexible metallic tubing if the tubing is terminated in listed fittings and meeting the following conditions:

(20) The circuit conductors contained in the tubing are protected by overcurrent devices rated at 20 amperes or less.

  (21) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 1.8 m (6 ft).

(22) Armor of Type AC cable as provided in 320.108.

(23) The copper sheath of mineral-insulated, metal-sheathed cable Type MI.

(24) Type MC cable that provides an effective ground-fault current path in accordance with one or more of the following:

  (25) It contains an insulated or uninsulated equipment grounding conductor in compliance with 250.118 (1).

  (26) The combined metallic sheath and uninsulated equipment grounding/bonding conductor of interlocked metal tape–type MC cable that is listed and identified as an equipment grounding conductor

  (27) The metallic sheath or the combined metallic sheath and equipment grounding conductors of the smooth or corrugated tube-type MC cable that is listed and identified as an equipment grounding conductor

(28) Cable trays as permitted in 392.10 and 392.60.

(29) Cablebus framework as permitted in 370.60(1).

(30) Other listed electrically continuous metal raceways and listed auxiliary gutters.

(31) Surface metal raceways listed for grounding.

Informational Note: See Article 100 for a definition of *effective ground-fault current path*.

Statement of Problem and Substantiation for Public Input

EMT is not an adequate ground path in real life. I have personally witnessed three electrical fires that were a direct result of a lost ground path that prevented a fault from clearing. The only way EMT is a good ground path is when ALL connections are tight and properly connected. The reality is that time pulls the connections apart most of the time and poor installation is rampant. Using EMT for your equipment ground has such a high risk of being lost that just shouldn't be used as an equipment ground. I personally never use the EMT for a ground but it always makes me nervous working around old EMT, I've also seen guys get shocked off these when they get between the loose parts and there is a fault. I understand old installs but new installations should not allow this.

Submitter Information Verification

Submitter Full Name: Elissa Hoefs
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 15 19:34:34 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: EMT has been proven to provide an effective ground fault current path.

Public Input No. 74-NFPA 70-2023 [Section No. 250.118(A)]

(A) Permitted.

Each equipment grounding conductor run with or enclosing the circuit conductors shall be one or more or a combination of the following:

(1) A copper, aluminum, or copper-clad aluminum conductor. This conductor shall be solid or stranded; insulated, covered, or bare; and in the form of a wire or a busbar of any shape.

(2) Rigid metal conduit, except where installed in areas of heavy vibration .

(3) Intermediate metal conduit, except where installed in areas of heavy vibration .

(4) Electrical metallic tubing, except where installed in areas of heavy vibration .

(5) Listed flexible metal conduit meeting all the following conditions:

  (6) The conduit is terminated in listed fittings.

  (7) The circuit conductors contained in the conduit are protected by overcurrent devices rated at 20 amperes or less.

  (8) The size of the conduit does not exceed metric designator 35 (trade size 1 $\frac{1}{4}$).

  (9) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 1.8 m (6 ft).

  (10) If flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, a wire-type equipment grounding conductor or a bonding jumper in accordance with 250.102(E)(2) shall be installed.

  (11) If flexible metal conduit is constructed of stainless steel, a wire-type equipment grounding conductor or bonding jumper in accordance with 250.102(E)(2) shall be installed.

(12) Listed liquidtight flexible metal conduit meeting all the following conditions:

  (13) The conduit is terminated in listed fittings.

  (14) For metric designators 12 through 16 (trade sizes $\frac{3}{8}$ through $\frac{1}{2}$), the circuit conductors contained in the conduit are protected by overcurrent devices rated at 20 amperes or less.

  (15) For metric designators 21 through 35 (trade sizes $\frac{3}{4}$ through 1 $\frac{1}{4}$), the circuit conductors contained in the conduit are protected by overcurrent devices rated not more than 60 amperes and there is no flexible metal conduit, flexible metallic tubing, or liquidtight flexible metal conduit in metric designators 12 through 16 (trade sizes $\frac{3}{8}$ through $\frac{1}{2}$) in the effective ground-fault current path.

  (16) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 1.8 m (6 ft).

  (17) If flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, a wire-type equipment grounding conductor or a bonding jumper in accordance with 250.102(E)(2) shall be installed.

  (18) If liquidtight flexible metal conduit contains a stainless steel core, a wire-type equipment grounding conductor or a bonding jumper in accordance with 250.102(E)(2) shall be installed.

(19) Flexible metallic tubing if the tubing is terminated in listed fittings and meeting the following conditions:

  (20) The circuit conductors contained in the tubing are protected by overcurrent devices rated at 20 amperes or less.

(21) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 1.8 m (6 ft).

(22) Armor of Type AC cable as provided in 320.108.

(23) The copper sheath of mineral-insulated, metal-sheathed cable Type MI.

(24) Type MC cable that provides an effective ground-fault current path in accordance with one or more of the following:

(25) It contains an insulated or uninsulated equipment grounding conductor in compliance with 250.118 (1).

(26) The combined metallic sheath and uninsulated equipment grounding/bonding conductor of interlocked metal tape–type MC cable that is listed and identified as an equipment grounding conductor

(27) The metallic sheath or the combined metallic sheath and equipment grounding conductors of the smooth or corrugated tube-type MC cable that is listed and identified as an equipment grounding conductor

(28) Cable trays as permitted in 392.10 and 392.60.

(29) Cablebus framework as permitted in 370.60(1).

(30) Other listed electrically continuous metal raceways and listed auxiliary gutters.

(31) Surface metal raceways listed for grounding.

Informational Note: See Article 100 for a definition of *effective ground-fault current path*.

Statement of Problem and Substantiation for Public Input

When raceways are installed in areas of heavy vibration, they're subject immense amounts of metal fatigue. These rigid raceways end up either breaking or having their couplings come loose. As soon as the electrical continuity of the raceway is broken, you lose your purposefully installed equipment grounding path. This is obviously a severe safety issue, which is why I believe that in these areas of heavy vibration (such as but not limited to an industrial facility) that they shall not be permitted to serve as the equipment grounding conductor by themselves.

Submitter Information Verification

Submitter Full Name: Jesse Duvuvei
Organization: Middle Department Inspection Agency
Street Address:
City:
State:
Zip:
Submittal Date: Sat Jan 07 18:54:29 EST 2023
Committee: NEC-P05

Committee Statement

Resolution: The phrase “areas of heavy vibration” is undefined, subjective, and unenforceable. Wiring methods should be selected for the expected environment including mechanical items such as vibration.

Public Input No. 1614-NFPA 70-2023 [Section No. 250.118(B)]

(B) Not Permitted.

The following shall not be used as equipment grounding conductors.

(1) Grounding electrode conductors

Exception: A wire-type equipment grounding conductor installed in compliance with 250.6(A) and the applicable requirements for both the equipment grounding conductor and the grounding electrode conductor in Parts II, III, and VI of this article shall be permitted to serve as both an equipment grounding conductor and a grounding electrode conductor.

(2) Structural metal frame of a building or structure

(3) <u>Mineral insulated, Type MI Cable with metallic sheathing, other than copper, unless the cable and associated fittings are listed for equipment grounding.</u>

Statement of Problem and Substantiation for Public Input

Stainless Steel and other Types of MI cable that are not copper sheathed. The UL Solutions Guide Info for MI Cable does not recognize other metallic sheathing of Type MI Cable for Equipment Grounding. One of the conductors must be used for Equipment Grounding.

See UL Category PPKV:
The copper sheath is suitable as an equipment grounding conductor. For cable with alloy steel outer sheath, one of the conductors is to be used for equipment grounding.

Submitter Information Verification

Submitter Full Name:	Kyle Krueger
Organization:	NECA
Affiliation:	NECA
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Jul 27 13:12:07 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed change would be redundant as 250.118(A)(9) allows only copper sheathed MI cable to be used as an equipment grounding conductor.

Public Input No. 740-NFPA 70-2023 [Section No. 250.118(B)]

(B) Not Permitted.

The following shall not be used as equipment grounding conductors unless meeting 250 .118(A).

(1) Grounding electrode conductors

Exception: A wire-type equipment grounding conductor installed in compliance with 250.6(A) and the applicable requirements for both the equipment grounding conductor and the grounding electrode conductor in Parts II, III, and VI of this article shall be permitted to serve as both an equipment grounding conductor and a grounding electrode conductor.

(2) Structural metal frame of a building or structure

Statement of Problem and Substantiation for Public Input

Under the old wording, it blanket prohibited grounding electrode conductors and structural frames from being used as equipment grounding conductors. However, there may exist grounding electrode conductors and structural frames (such as box beams that also happen to both be listed electrically continuous raceways and meet 250.68(C)(2)) that meet 250.118(A). So, this revision probably portrays exactly what the intent of the Code meant.

Submitter Information Verification

Submitter Full Name: Conrad Ko
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Apr 26 02:45:23 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The additional wording is unnecessary as this is already addressed in 250.118(A).

Public Input No. 3001-NFPA 70-2023 [Section No. 250.119]

250.119 Identification of Wire-Type Equipment Grounding Conductors and Bonding Jumpers .

(A) General.

Unless required elsewhere in this *Code,* equipment grounding conductors shall be permitted to be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors of the wire type shall have a continuous outer finish that is either green or green with one or more yellow stripes except as permitted in this section. Conductors with insulation or individual covering that is green, green with one or more yellow stripes, or otherwise identified as permitted by this section shall not be used for ungrounded or grounded circuit conductors.

Exception No. 1: Power-limited Class 2 or Class 3 cables, power-limited fire alarm cables, or communications cables containing only circuits operating at less than 50 volts ac or 60 volts dc if connected to equipment not required to be grounded shall be permitted to use a conductor with green insulation or green with one or more yellow stripes for other than equipment grounding purposes.

Exception No. 2: Flexible cords having an integral insulation and jacket without an equipment grounding conductor shall be permitted to have a continuous outer finish that is green.

Informational Note: An example of a flexible cord with integral-type insulation is Type SPT-2, 2 conductor.

Exception No. 3: Conductors with green insulation shall be permitted to be used as ungrounded signal conductors where installed between the output terminations of traffic signal control and traffic signal indicating heads. Signaling circuits installed in accordance with this exception shall include an equipment grounding conductor in accordance with 250.118. Wire-type equipment grounding conductors shall be bare or have insulation or covering that is green with one or more yellow stripes.

(B) Conductors 4 AWG and Larger.

Equipment grounding conductors 4 AWG and larger shall comply with the following:

(1) At the time of installation, if the insulation does not comply with 250.119(A), it shall be permanently identified as an equipment grounding conductor at each end and at every point where the conductor is accessible.

Exception: Conductors 4 AWG and larger shall not be required to be marked in conduit bodies that contain no splices or unused hubs.

(2) Identification shall encircle the conductor and shall be accomplished by one of the following:

  (3) Stripping the insulation or covering from the entire exposed length

  (4) Coloring the insulation or covering green at the termination

  (5) Marking the insulation or covering with green tape or green adhesive labels at the termination

(C) Multiconductor Cable.

One or more insulated conductors in a multiconductor cable, at the time of installation, shall be permitted to be permanently identified as equipment grounding conductors at each end and at every point where the conductors are accessible by one of the following means:

(1) Stripping the insulation from the entire exposed length.

(2) Coloring the exposed insulation green.

(3) Marking the exposed insulation with green tape or green adhesive labels. Identification shall encircle the conductor.

(D) Flexible Cord.

Equipment grounding conductors in flexible cords shall be insulated and shall have a continuous outer finish that is either green or green with one or more yellow stripes.

Statement of Problem and Substantiation for Public Input

Changing the section title of 250.119 to apply for bonding jumpers as well as equipment grounding conductors. Identifying main bonding jumpers, system bonding jumpers, and supply-side bonding jumpers using the methods specified in 250.119 will increase electrical safety for the electrical workers. These conductors are all part of the effective ground-fault current path and should all be identified the exact same way. The proposed revisions will bring clarity for Code users.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Aug 28 15:37:10 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: There is no field evidence that this change is necessary. They are readily identifiable by their use in the field. Identifying bonding jumpers using the color green is not currently prohibited.

Public Input No. 2327-NFPA 70-2023 [Section No. 250.119(A)]

(A) ~~General~~ Conductors 6 AWG and Smaller .

Unless required elsewhere in this *Code,* equipment grounding conductors 6 AWG and smaller shall be permitted to be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors of the wire type shall have a continuous outer finish that is either green or green with one or more yellow stripes except as permitted in this section. Conductors with insulation or individual covering that is green, green with one or more yellow stripes, or otherwise identified as permitted by this section shall not be used for ungrounded or grounded circuit conductors.

Exception No. 1: Power-limited Class 2 or Class 3 cables, power-limited fire alarm cables, or communications cables containing only circuits operating at less than 50 volts ac or 60 volts dc if connected to equipment not required to be grounded shall be permitted to use a conductor with green insulation or green with one or more yellow stripes for other than equipment grounding purposes.

Exception No. 2: Flexible cords having an integral insulation and jacket without an equipment grounding conductor shall be permitted to have a continuous outer finish that is green.

Informational Note: An example of a flexible cord with integral-type insulation is Type SPT-2, 2 conductor.

Exception No. 3: Conductors with green insulation shall be permitted to be used as ungrounded signal conductors where installed between the output terminations of traffic signal control and traffic signal indicating heads. Signaling circuits installed in accordance with this exception shall include an equipment grounding conductor in accordance with 250.118. Wire-type equipment grounding conductors shall be bare or have insulation or covering that is green with one or more yellow stripes.

Statement of Problem and Substantiation for Public Input

Changing the title of first level subdivision (A) to clarify what size conductors this requirement is for. This format matches 200.6(A) for grounded conductors 6 AWG smaller and 200.6(B) for grounded conductors 4 AWG and larger. 250.119(B) is titled ‘4 AWG and larger’ therefore 250.119(A) should be titled 6 AWG and smaller so these rules stay consistent in structure and makes life easier for Code users.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 16 12:33:34 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The proposed revision does not add clarity and is addressed in 250.119(B). This would restrict the general requirements in 250.119(A) and would limit to 6 AWG and smaller some of the general requirements now recognized for larger conductors.

Public Input No. 2915-NFPA 70-2023 [Section No. 250.119(A)]

(A) General.

Unless required elsewhere in this *Code,* equipment grounding conductors shall be permitted to be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors of the wire type shall have a continuous outer finish that is either green ~~or~~ , green with one or more yellow stripes, or yellow with one or more green stripes except as permitted in this section. Conductors with insulation or individual covering that is green, green with one or more yellow stripes, yellow with one or more green stripes, or otherwise identified as permitted by this section shall not be used for ungrounded or grounded circuit conductors.

Exception No. 1: Power-limited Class 2 or Class 3 cables, power-limited fire alarm cables, or communications cables containing only circuits operating at less than 50 volts ac or 60 volts dc if connected to equipment not required to be grounded shall be permitted to use a conductor with green insulation or green with one or more yellow stripes for other than equipment grounding purposes.

Exception No. 2: Flexible cords having an integral insulation and jacket without an equipment grounding conductor shall be permitted to have a continuous outer finish that is green.

Informational Note: An example of a flexible cord with integral-type insulation is Type SPT-2, 2 conductor.

Exception No. 3: Conductors with green insulation shall be permitted to be used as ungrounded signal conductors where installed between the output terminations of traffic signal control and traffic signal indicating heads. Signaling circuits installed in accordance with this exception shall include an equipment grounding conductor in accordance with 250.118. Wire-type equipment grounding conductors shall be bare or have insulation or covering that is green with one or more yellow stripes.

Additional Proposed Changes

File Name	Description	Approved
yg.png	example of yellow with green stripe	

Statement of Problem and Substantiation for Public Input

Manufacturers are using a yellow with green stripe as an equipment grounding conductor. This proposal would prohibit the use of yellow with a green stripe as a ungrounded conductor.

Submitter Information Verification

Submitter Full Name:	Stephen Schmiechen
Organization:	[Not Specified]
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sun Aug 27 15:49:23 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8521-NFPA 70-2024

Statement: The additional wording clarifies that the use of a yellow conductor with one or more green stripes is prohibited from being used as an ungrounded or grounded circuit conductor. A yellow conductor with one or more green stripes is recognized in manufacturing standards for internal equipment wiring but is not allowed as a field installed equipment grounding conductor.

Public Input No. 3000-NFPA 70-2023 [Section No. 250.119(A)]

(A) General.

Unless required elsewhere in this *Code,* equipment grounding conductors, bonding jumpers, equipment bonding jumpers, main bonding jumpers, system bonding jumpers, and supply-side bonding jumpers shall be permitted to be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors, bonding jumpers, equipment bonding jumpers, main bonding jumpers, system bonding jumpers, and supply-side bonding jumpers of the wire type shall have a continuous outer finish that is either green or green with one or more yellow stripes except as permitted in this section. Conductors with insulation or individual covering that is green, green with one or more yellow stripes, or otherwise identified as permitted by this section shall not be used for ungrounded or grounded circuit conductors.

Exception No. 1: Power-limited Class 2 or Class 3 cables, power-limited fire alarm cables, or communications cables containing only circuits operating at less than 50 volts ac or 60 volts dc if connected to equipment not required to be grounded shall be permitted to use a conductor with green insulation or green with one or more yellow stripes for other than equipment grounding purposes.

Exception No. 2: Flexible cords having an integral insulation and jacket without an equipment grounding conductor shall be permitted to have a continuous outer finish that is green.

Informational Note: An example of a flexible cord with integral-type insulation is Type SPT-2, 2 conductor.

Exception No. 3: Conductors with green insulation shall be permitted to be used as ungrounded signal conductors where installed between the output terminations of traffic signal control and traffic signal indicating heads. Signaling circuits installed in accordance with this exception shall include an equipment grounding conductor in accordance with 250.118. Wire-type equipment grounding conductors shall be bare or have insulation or covering that is green with one or more yellow stripes.

Statement of Problem and Substantiation for Public Input

Adding text to first level subdivision 250.119(A) to apply for bonding jumpers as well as equipment grounding conductors 6 AWG and smaller. Identifying main bonding jumpers, system bonding jumpers, and supply-side bonding jumpers using the methods specified in 250.119 will increase electrical safety for the electrical workers. These conductors are all part of the effective ground-fault current path and should all be identified the exact same way.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Mon Aug 28 15:35:53 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: There is no field evidence that this change is necessary. They are readily identifiable by their use in the field. Identifying bonding jumpers using the color green is not currently prohibited.

Public Input No. 3884-NFPA 70-2023 [Section No. 250.119(A)]

(A) General.

Unless required elsewhere in this *Code,* equipment grounding conductors shall be permitted to be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors of the wire type shall have a continuous outer finish that is either green or green with one or more yellow stripes except as permitted in this section. Conductors with insulation or individual covering that is green, green with one or more yellow stripes, or otherwise identified as permitted by this section shall not be used for ungrounded or grounded circuit conductors.

Exception No. 1: Power-limited Class 2 or Class 3 cables, Fault Managed Power Class 4 cables, power-limited fire alarm cables, or communications cables containing only circuits operating at less than 50 volts ac or 60 volts dc if connected to equipment not required to be grounded shall be permitted to use a conductor with green insulation or green with one or more yellow stripes for other than equipment grounding purposes.

Exception No. 2: Flexible cords having an integral insulation and jacket without an equipment grounding conductor shall be permitted to have a continuous outer finish that is green.

Informational Note: An example of a flexible cord with integral-type insulation is Type SPT-2, 2 conductor.

Exception No. 3: Conductors with green insulation shall be permitted to be used as ungrounded signal conductors where installed between the output terminations of traffic signal control and traffic signal indicating heads. Signaling circuits installed in accordance with this exception shall include an equipment grounding conductor in accordance with 250.118. Wire-type equipment grounding conductors shall be bare or have insulation or covering that is green with one or more yellow stripes.

Statement of Problem and Substantiation for Public Input

Class 4 cables may have multiple pairs of conductors and will need color coding to identify the various pairs. As such, green insulation is bound to be needed and these conductors will not be equipment ground. Therefore, this exception is also needed for Class 4 cables.
I will point out that there is a bit of vagueness in the text. "Power-limited Class 2 or Class 3 cables, Fault Managed Power Class 4 cables, power-limited fire alarm cables, or communications cables containing only circuits operating at less than 50 volts ac or 60 volts dc" can be read two ways. Either the 50/60V restriction applies to only the communications cables or it applies to the whole list and I understand it is only to apply to communications cables. This cold be fixed by making that item first in the parenthetical list: "Communications cables containing only circuits operating at less than 50 volts ac or 60 volts dc, Power-limited Class 2 or Class 3 cables, Fault Managed Power Class 4 cables, or power-limited fire alarm cables..."

Submitter Information Verification

Submitter Full Name:	Chad Jones
Organization:	Cisco Systems
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Sep 06 09:04:26 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: FR-8519-NFPA 70-2024

Statement: The revision provides consistency with grouping of Fault Managed Power Class 4 cables as found elsewhere in the code such as Article 722.

Public Input No. 816-NFPA 70-2023 [Section No. 250.119(A)]

(A) General.

Unless required elsewhere in this *Code,* equipment grounding conductors shall be permitted to be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors of the wire type shall have a continuous outer finish that is either green or green with one or more yellow stripes except as permitted in this section. Conductors with insulation or individual covering that is green, green with one or more yellow stripes, or otherwise identified as permitted by this section shall not be used for ungrounded or grounded circuit conductors.

Exception No.

~~*1: Power-limited Class 2 or Class 3 cables, power-limited fire alarm cables, or communications cables containing only circuits operating at less than 50 volts ac or 60 volts dc if connected to equipment not required to be grounded shall be permitted to use a conductor with green insulation or green with one or more yellow stripes for other than equipment grounding purposes. Exception No. 2:*~~

1: Flexible cords having an integral insulation and jacket without an equipment grounding conductor shall be permitted to have a continuous outer finish that is green.

Informational Note: An example of a flexible cord with integral-type insulation is Type SPT-2, 2 conductor.

Exception No.

~~*3*~~

2 : Conductors with green insulation shall be permitted to be used as ungrounded signal conductors where installed between the output terminations of traffic signal control and traffic signal indicating heads. Signaling circuits installed in accordance with this exception shall include an equipment grounding conductor in accordance with 250.118 . Wire-type equipment grounding conductors shall be bare or have insulation or covering that is green with one or more yellow stripes.

Statement of Problem and Substantiation for Public Input

Deleting Exception No. 1 will improve the usability of the Code. It's extremely confusing to have permission to use green wires for other than grounding in Exception No. 1 and also in multiple places in Chapter 7. See Article 722, Cables for Power-Limited Circuits and Fault-Managed Power Circuits; Article 728 Fire-Resistive Cable Systems; and Article 760 Fire Alarm Systems.

Section 90.3 Code Arrangement permits Chapter 7 to "supplement or modify the requirements in Chapters 1 through 7".

"722.3(N) Identification of Equipment Grounding Conductors. Equipment grounding conductors shall be identified in accordance with 250.119.
Exception: Cables that do not contain an equipment grounding conductor shall be permitted to use a conductor with green insulation, or green insulation with one or more yellow stripes, for other than equipment grounding purposes."

"728.60 Equipment Grounding Conductor. Fire-resistive cables installed in a raceway requiring an equipment grounding conductor shall use the same fire-resistive cable described in the system unless alternative equipment grounding conductors are listed with the system. Any alternative equipment grounding conductors shall be marked with the system number. The system shall specify a permissible equipment grounding conductor. If not specified, the equipment grounding conductor shall be the same as the fire-resistive cable described in the system."

"760.3(N) Identification of Equipment Grounding Conductors. Equipment grounding conductors shall be identified in accordance with 250.119.
Exception: Conductors with green insulation shall be permitted to be used as ungrounded signal conductors for Types FPLP, FPLR, FPL, and substitute cables installed in accordance with 760.154(A)."

It's even more confusing to include communications cables in Exception No. 1. Section 90.3 states: Chapter 8 covers communications systems and is not subject to the requirements of Chapters 1 through 7 except where the requirements are specifically referenced in Chapter 8.
There is no reference to the requirement to use green wires in a cable for grounding in Chapter 8 because green wires have been used in telephone cables ever since plastic insulation was introduced after World War II.

Submitter Information Verification

Submitter Full Name: David Kiddoo
Organization: CCCA
Affiliation: Communications Cable & Connectivity Association
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 12 23:58:11 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The deletion of Exception 1 and restructuring of 250.119(A) may have unintended consequences of creating a disconnect between Chapter 7 and Article 250.

Public Input No. 3002-NFPA 70-2023 [Section No. 250.119(B)]

(B) Conductors 4 AWG and Larger.

Equipment grounding conductors, bonding jumpers, equipment bonding jumpers, main bonding jumpers, system bonding jumpers, and supply-side bonding jumpers 4 AWG and larger shall comply with the following:

(1) At the time of installation, if the insulation does not comply with 250.119(A), it shall be permanently identified as an equipment grounding conductor, bonding jumpers, equipment bonding jumpers, main bonding jumpers, system bonding jumpers, and supply-side bonding jumpers at each end and at every point where the conductor is accessible.

Exception: Conductors 4 AWG and larger shall not be required to be marked in conduit bodies that contain no splices or unused hubs.

(2) Identification shall encircle the conductor and shall be accomplished by one of the following:

(3) Stripping the insulation or covering from the entire exposed length

(4) Coloring the insulation or covering green at the termination

(5) Marking the insulation or covering with green tape or green adhesive labels at the termination

Statement of Problem and Substantiation for Public Input

Adding text to first level subdivision 250.119(B) to apply for bonding jumpers as well as equipment grounding conductors 4 AWG and larger. Identifying main bonding jumpers, system bonding jumpers, and supply-side bonding jumpers using the methods specified in 250.119 will increase electrical safety for the electrical workers. These conductors are all part of the effective ground-fault current path and should all be identified the exact same way.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Mon Aug 28 15:39:09 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: There is no field evidence that this change is necessary. They are readily identifiable by their use in the field. Identifying bonding jumpers using the color green is not currently prohibited.

Public Input No. 1996-NFPA 70-2023 [Section No. 250.120(B)]

(B) Aluminum and Copper-Clad Aluminum Conductors.

Equipment grounding conductors of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following:

(1) Unless part of an applicable cable wiring method, bare or covered conductors shall not be installed if subject to corrosive conditions or be installed in direct contact with concrete, masonry, or the earth.

(2) Terminations made within outdoor enclosures that are listed and identified for the environment shall be permitted within 450 mm (18 in.) of the bottom of the enclosure.

(3) Aluminum or copper-clad aluminum conductors external to buildings or enclosures shall not be terminated within 450 mm (18 in.) of the earth, unless terminated within a listed wire connector system.

(4) Insulated aluminum or copper-clad aluminum equipment grounding conductors may be installed in any applicable cable wiring method or any suitable Chapter 3 raceway and may be installed in direct contact with concrete, masonry, _ or the earth.

Statement of Problem and Substantiation for Public Input

250.120 (B) states “Equipment grounding conductors of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following: 250.120(B) (1) “Unless part of an applicable cable wiring method, bare, covered, or covered conductors shall not be installed if subject to to corrosive conditions or be installed in direct contact with concrete, masonry, or the earth.”.

- 250.120 (B) (1) provides requirements for bare or covered conductors but is silent on insulated aluminum conductors even though it is specifically identified in 250.122 (B) text. Add language as to how or insulated aluminum or copper-clad aluminum conductors are to be installed to ensure compliance with 250.120 (B).

Submitter Information Verification

Submitter Full Name:	Gary Hein
Organization:	[Not Specified]
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Aug 10 12:37:54 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: The language is too general and conflicts with 250.120(B)(1) and (3) and does not add clarity. The installation is already covered in this Section.

Public Input No. 3222-NFPA 70-2023 [Section No. 250.122]

250.122 Size of Equipment Grounding Conductors.

(A) General.

Copper, aluminum, or copper-clad aluminum equipment grounding conductors of the wire type shall not be smaller than shown in Table 250.122. The equipment grounding conductor shall not be required to be larger than the circuit conductors supplying the equipment. If a cable tray, a raceway, or a cable armor or sheath is used as the equipment grounding conductor, as provided in 250.118 and 250.134(1), it shall comply with 250.4(A)(5) or (B)(4).

Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with.Table 250.122.

(B) Increased in Size.

If ungrounded conductors are increased in size for any reason other than as required in 310.15(B) or 310.15(C), wire-type equipment grounding conductors, if installed, shall be increased in size proportionately to the increase in circular mil area of the ungrounded conductors.

Exception: Equipment grounding conductors shall be permitted to be sized by a qualified person to provide an effective ground fault current path in accordance with 250.4(A)(5) or (B)(4)

(C) Multiple Circuits.

A single equipment grounding conductor shall be permitted to be installed for multiple circuits that are installed in the same raceway, cable, trench, or cable tray. It shall be sized from Table 250.122 for the largest overcurrent device protecting circuit conductors in the raceway, cable, trench, or cable tray. Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c).

(D) Motor Circuits.

Equipment grounding conductors for motor circuits shall be sized in accordance with 250.122(D)(1) or (D)(2).

(1) General.

The equipment grounding conductor size shall not be smaller than determined by 250.122(A) based on the rating of the branch-circuit short-circuit and ground-fault protective device.

(2) Instantaneous-Trip Circuit Breaker and Motor Short-Circuit Protector.

If the overcurrent device is an instantaneous-trip circuit breaker or a motor short-circuit protector, the equipment grounding conductor shall be sized not smaller than that given by 250.122(A) using the maximum permitted rating of a dual element time-delay fuse selected for branch-circuit short-circuit and ground-fault protection in accordance with 430.52(C)(1), Exception No. 1.

(E) Flexible Cord and Fixture Wire.

The equipment grounding conductor in a flexible cord with the largest circuit conductor 10 AWG or smaller, and the equipment grounding conductor used with fixture wires of any size in accordance with 240.5, shall not be smaller than 18 AWG copper and shall not be smaller than the circuit conductors. The equipment grounding conductor in a flexible cord with a circuit conductor larger than 10 AWG shall be sized in accordance with Table 250.122.

(F) Conductors in Parallel.

For circuits of parallel conductors as permitted in 310.10(G), the equipment grounding conductor shall be installed in accordance with 250.122(F)(1) or (F)(2).

(1) Conductor Installations in Raceways, Auxiliary Gutters, or Cable Trays.

(a) *Single Raceway or Cable Tray, Auxiliary Gutter*, *or Cable Tray*. If circuit conductors are connected in parallel in the same raceway, auxiliary gutter, or cable tray, a single wire-type conductor shall be permitted as the equipment grounding conductor. The wire-type equipment grounding conductor shall be sized in accordance with 250.122 based on the overcurrent protective device for the feeder or branch circuit.

(b) *Multiple Raceways*. If conductors are installed in multiple raceways and are connected in parallel, a wire-type equipment grounding conductor, if used, shall be installed in each raceway and shall be connected in parallel. The equipment grounding conductor installed in each raceway shall be sized in accordance with 250.122 based on the rating of the overcurrent protective device for the feeder or branch circuit.

(c) *Wire-Type Equipment Grounding Conductors in Cable Trays.* Wire-type equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c).

(d) *Metal Raceways, Auxiliary Gutters, or Cable Trays.* Metal raceways or auxiliary gutters in accordance with 250.118 or cable trays complying with 392.60(B) shall be permitted as the equipment grounding conductor.

(2) Multiconductor Cables.

(a) Except as provided in 250.122(F)(2)(c) for raceway or cable tray installations, the equipment grounding conductor in each multiconductor cable shall be sized in accordance with 250.122 based on the overcurrent protective device for the feeder or branch circuit.

(b) If circuit conductors of multiconductor cables are connected in parallel, the equipment grounding conductor(s) in each cable shall be connected in parallel.

(c) If multiconductor cables are paralleled in the same raceway, auxiliary gutter, or cable tray, a single equipment grounding conductor that is sized in accordance with 250.122 shall be permitted in combination with the equipment grounding conductors provided within the multiconductor cables and shall all be connected together.

(d) Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c). Cable trays complying with 392.60(B), metal raceways in accordance with 250.118, or auxiliary gutters shall be permitted as the equipment grounding conductor.

(G) Feeder Taps.

Equipment grounding conductors installed with feeder taps shall not be smaller than shown in Table 250.122 based on the rating of the overcurrent device ahead of the feeder on the supply side ahead of the tap but shall not be required to be larger than the tap conductors.

Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	**Size (AWG or kcmil)**	
	Copper	**Aluminum or Copper-Clad Aluminum***
15	14	12
20	12	10
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	750
5000	700	1250
6000	800	1250

Note 1 : Where necessary to comply with 250.4(A)(5) or (B)(4), the equipment grounding conductor shall be sized larger than given in this table.

Note 2: The equipment grounding conductor or equipment bonding jumepr shall not be required to be larger than the largest ungrounded conductor or set of ungrounded conductors.

*See installation restrictions in 250.120.

Statement of Problem and Substantiation for Public Input

Relocated text from 250.122(A) to Table 250.122 note 2 with revisions to match the text contained in Note 1 of Table 250.102(C).
For example, a 4000A circuit supplied with 12 sets of 600 kcmil aluminum ungrounded conductors connected in parallel would require:
Grounded Conductor [250.24(D) = 12 sets x 600,000 x 12.5% = 900 kcmil, but Table 250.102(C) Note 1 only requires the conductor to not be larger than the ungrounded conductor = 600 kcmil aluminum.
Equipment Grounding Conductor =- 750 kcmil, Table 250.122

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
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Zip:
Submittal Date: Wed Aug 30 12:07:56 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8446-NFPA 70-2024

Statement: The revision to 250.122(F)(1)(b) is necessary to be consistent with requirements elsewhere in the NEC that size wire-type conductors intended to carry fault current. For example, 215.2(B), 250.24(D)(2), and 250.102(C)(2) have for many years limited the size of ground-fault-carrying conductors in parallel to no more than the size of the largest ungrounded conductor in each raceway with no reports of failure. As the number of paralleled raceways increases and the size of the paralleled circuit conductors decreases, it is unnecessary to have a paralleled EGC to be larger than the fault current supplying conductor.

Adding the trench location in 250.122(F)(2) aligns with 250.122(C).

Public Input No. 2573-NFPA 70-2023 [Section No. 250.122(A)]

(A) General.

Copper, aluminum, or copper-clad aluminum equipment grounding conductors of the wire type shall not be smaller than shown in Table 250.122. The equipment grounding conductor shall not be required to be larger than the circuit conductors supplying the equipment. If a cable tray, a raceway, or a cable armor or sheath is used as the equipment grounding conductor, as provided in 250.118 and 250.134(1), it shall comply with 250.4(A)(5) or (B)(4).

Where circuit conductors supplying equipment are installed in parallel (electrically joined at both ends), the sum of the conductors composing one paralleled set shall be considered circuit conductors when applying this section.

Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with.Table 250.122.

Statement of Problem and Substantiation for Public Input

Greetings CMP Members,
In the 2023 development stage we had this written into the language of 250.122(A) and sadly it got thrown out due to a disagreement over an informational note. It is common knowledge that an EGC may indeed be larger than the circuit conductors in a given raceway or cable if the installation is a parallel installation. Since we are not permitted to reduce the size of the EGC via like we can when we parallel ungronded and grounded conductors, it does present a situation where the EGC will indeed be larger than the circuit conductors in each raceway. When you parallel conductors to obtain more ampacity the OCPD also increases. Since the OCPD dictates the size of the EGC it standards reason we should explain to users what happens when you may have a EGC larger, due to paralleling, than the circuit conductors in a given raceway.

Now, if the CMP believes that the EGC never needs to be larger than the circuit conductors inside a set of (10) raceways then I would like the CMP to be on the record with a response please.

Fact is, if you parallel (10) sets of 250 kcmil CU you have now 2,500,000 circular mils of "circuit conductor" and the EGC is never requried to be larger than the "circuit conductor". However, if the (10) sets of 250 kcmil was being used on a 2,500A feeder then based on Table 250.122 the EGC would need to be 350 kcmil and indeed larger than the 250 kcmil in each individual nonmetallic raceway.

So, does this panel mean that the 350 kcmil is required in each raceway or is the 250 kcmil conductor in each raceway the circuit conductor in question and the EGC doesn't have to exceed the 250 kcmil.

If the 350 kcmil is what is necessary to clear the OCPD per Table 250.122 and the EGC is required to be full sized in each raceway or cable then the above langage proposed will add clarity to the language. If I am wrong then the rejection and code panel substiation will clear the air over an issue that has been debated since the "informational note" debate in 2020 caused everything to go out with the baby in the bath water.

Submitter Information Verification

Submitter Full Name: Paul Abernathy
Organization: Electrical Code Academy, Inc.
Affiliation: Electrical Code Academy, Inc.
Street Address:
City:

State:
Zip:
Submittal Date: Tue Aug 22 13:56:16 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8446-NFPA 70-2024

Statement: The revision to 250.122(F)(1)(b) is necessary to be consistent with requirements elsewhere in the NEC that size wire-type conductors intended to carry fault current. For example, 215.2(B), 250.24(D)(2), and 250.102(C)(2) have for many years limited the size of ground-fault-carrying conductors in parallel to no more than the size of the largest ungrounded conductor in each raceway with no reports of failure. As the number of paralleled raceways increases and the size of the paralleled circuit conductors decreases, it is unnecessary to have a paralleled EGC to be larger than the fault current supplying conductor.

Adding the trench location in 250.122(F)(2) aligns with 250.122(C).

Public Input No. 3150-NFPA 70-2023 [Section No. 250.122(A)]

(A) General.

If required by 250.122, Copper, aluminum, or copper-clad aluminum equipment grounding conductors of the wire type shall not be smaller than shown in Table 250.122. The equipment grounding conductor shall not be required to be larger than the circuit conductors supplying the equipment. If a cable tray, a raceway, or a cable armor or sheath is used as the equipment grounding conductor, as provided in 250.118 and 250.134(1), it shall comply with 250.4(A)(5) or (B)(4).

Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with.Table 250.122.

Statement of Problem and Substantiation for Public Input

There are many wiring methods to accomplish grounding and bonding of electrical systems identified in 250.118. If a wire-type equipment grounding conductor is not utilized, one of the other EGC's must be installed and fully complies with the requirements. If a wire-type equipment grounding conductor is also installed in parallel with the other method, the language requires that wire be no smaller than as specified in Table 250.122. Since the wire-type in this instance is not required at all, it seems inconsistent with the intent of 90.2 to provide practical safeguarding of persons and property. There are numerous reports of wire-type EGC's being installed in parallel with another compliant EGC that are not "full sized" per Table 250.122. It empirically makes sense to allow that conductor to remain rather than allow it to be removed completely in order to comply with the letter of the code, which will obviously result in a less substantial installation.

Submitter Information Verification

Submitter Full Name:	Joseph Andre
Organization:	Self
Affiliation:	Self
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 17:09:46 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Wire-type equipment grounding conductors are not required by 250.122.

Public Input No. 3221-NFPA 70-2023 [Section No. 250.122(A)]

(A) General.

(1) Sizing. Copper, aluminum, or copper-clad aluminum equipment grounding conductors of the wire type shall not be smaller than shown in Table 250.122.

(2) Not Larger. The equipment grounding conductor shall not be required to be larger than the circuit conductors supplying the equipment.

(3) Cable Tray, Raceway, or Cable Armor. If a cable tray, a raceway, or a cable armor or sheath is used as the equipment grounding conductor, as provided in 250.118 and 250.134(1), it shall comply with 250.4(A)(5) or (B)(4).

(4) Sectioned. Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with.Table 250.122.

Statement of Problem and Substantiation for Public Input

Broke up 250.122(A) into a list item format to make the requirement simpler for Code users. In accordance with NEC Style Manual section 3.5.1.2 multiple requirements within a single subdivision shall be avoided. Additional subdivisions or lists shall be used to express independent requirements.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 30 12:04:16 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution:	FR-8425-NFPA 70-2024
Statement:	This subdivision is formatted into multiple subdivisions to comply with NEC Style Manual 3.5.1.2.

Public Input No. 1796-NFPA 70-2023 [Section No. 250.122(B)]

(B) Increased in Size.

If ungrounded conductors are increased in size for any reason other than as required in 310.15(B) or 310.15(C), wire-type equipment grounding conductors, if installed, shall be increased in size proportionately to the increase in circular mil area of the ungrounded conductors.

Exception: Equipment grounding conductors shall be permitted to be sized by a qualified person to provide an effective ground fault current path in accordance with 250.4(A)(5) or (B)(4).

Statement of Problem and Substantiation for Public Input

The exception was missing punctuation.

Submitter Information Verification

Submitter Full Name:	jonathan shields
Organization:	CNS Y12
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Aug 03 12:25:34 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution:	FR-8427-NFPA 70-2024
Statement:	This action corrects an editorial omission of a period at the end of the exception.

Public Input No. 2454-NFPA 70-2023 [Section No. 250.122(B)]

(B) Increased in Size.

If ungrounded conductors are increased in size for any reason other than as required in 310.15(B) or 310.15(C), such as for voltage drop considerations, wire-type equipment grounding conductors, if installed, shall be increased in size proportionately to the increase in circular mil area of the ungrounded conductors.

Exception: Equipment grounding conductors shall be permitted to be sized by a qualified person to provide an effective ground fault current path in accordance with 250.4(A)(5) or (B)(4)

Statement of Problem and Substantiation for Public Input

Adding text to help Code users understand this requirement better. This requirement is primarily about increasing the ungrounded conductors due to voltage drop considerations and therefore adding 'such as voltage drop considerations' will be positive text reinforcing the intent of 250.122(B).

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Aug 17 13:05:15 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Specifying an example inside the requirement does not add clarity and could result in misapplication. The exception provides the necessary allowance to determine applicability.

Public Input No. 280-NFPA 70-2023 [Section No. 250.122(B)]

~~**(B)** Increased in Size.~~

~~If ungrounded conductors are increased in size for any reason other than as required in 310.15(B) or 310.15(C) , wire-type equipment grounding conductors, if installed, shall be increased in size proportionately to the increase in circular mil area of the ungrounded conductors.~~

~~*Exception: Equipment grounding conductors shall be permitted to be sized by a qualified person to provide an effective ground fault current path in accordance with 250.4(A)(5) or (B)(4)*~~

Statement of Problem and Substantiation for Public Input

This rule needs to be removed. Increasing the size of the circuit conductors already lowers the overall impedance of the ground-fault current path. Increasing the size of the EGC too is simply not needed and should not be required. There is no real-world safety concern here. It makes no sense.

Some examples...

A 50-amp breaker with 750 ft. long 8 AWG circuit wires and a 10 AWG equipment grounding wire is perfectly code compliant……

But the same 750 ft. foot long 8 AWG circuit wires and 10 AWG equipment grounding conductor on a 15-amp breaker is a violation if circuit wires were increased in size from 14 AWG to 8 AWG for voltage drop or some other design! How can a 10 AWG EGC on a 15-amp circuit possibly be considered unsafe when a 10 AWG EGC on a 50-amp circuit is perfectly code compliant? The circuit wires in both scenarios have the exact same impedance, why is the 15-amp circuit considered a violation? This makes absolutely no sense.

Next example:
A 100-amp breaker with 600 ft. long 3 AWG circuit wires and 8 AWG equipment grounding conductor is perfectly code compliant…..

But the same 600 ft. long 3 AWG circuit wires and 8 AWG equipment grounding conductor on a 60-amp breaker is a violation if circuit wires were increased from in size from 6 AWG to 3 AWG by design! How can a 3 AWG EGC be a violation on a 60-amp circuit but be considered Code-compliant on a 100-amp circuit? This makes absolutely no practical sense! Is the 60-amp circuit more dangerous than the 100-amp circuit? I don't see how that is possible when the wires are exactly the same in each scenario.

Here's another one…
A 125A circuit wired with a 6 AWG Equipment Grounding Conductor and 1 AWG circuit conductors is perfectly Code-compliant. But that same 6 AWG EGC with 1 AWG circuit conductors could be a violation on a 110A circuit!!! Is the 110A circuit breaker somehow more dangerous than the 125A breaker? I don't think so, but that same 6 AWG EGC on a lower-rated circuit breaker is literally a violation if those 1 AWG circuit conductors were increased from 2 AWG. And yet, according to Table 250.122, a 6 AWG EGC would be perfectly fine on a 200A circuit too. I'm having a difficult time reconciling this in my brain. Let's review for a moment. A 6 AWG EGC is perfectly fine for a 200A circuit, but it could be a violation on a 175A, 150A, 125A, or 110A circuit!!! But it's not always a violation on a 175A, 150A, 125A, or 110A circuit. ?????????

And this...
How should 250.122(B) be applied when one equipment grounding conductor is run in a raceway as the EGC for several circuits as permitted by 250.122(C)?

For this example; a 100-amp, an 80-amp, a 70-amp circuit and a 15-amp circuit are all installed in the same raceway with an 8AWG equipment grounding conductor sized for the 100-amp circuit as required by 250.122(C). If only the 70-amp circuit had the ungrounded conductors increased from 6 AWG to 4 AWG to reduce voltage drop, would the 8 AWG equipment grounding conductor still need to be increased by that same ratio? Yes it would! The literal wording in 250.122(B) requires it even though that 8 AWG is perfectly fine for the 100A circuit it would be violation for the 70A circuit if not increased in size by the same ratio! And what if 2 sets of the circuit conductors in that raceway are increased in size by different ratios? What ratio do we use for sizing the EGC? The largest? The smallest? Combined? ???? Or what if only the 15-amp circuit wires were increased in size? would the 8 AWG EGC need to be increased in size too? Apparently, yes it would.

I can’t see how not increasing the size of EGC in this case would be of any safety concern since the overall impedance of the ground-fault current path was lowered once the circuit conductors were increased in size. I cannot think of a real world safety concern with leaving that 8 AWG EGC as an 8 AWG EGC!

I could give a thousand more examples of why this requirement makes no sense, and should be removed, but I'm hoping I've made made it clear how superfluous and impractical this rule is.

Submitter Information Verification

Submitter Full Name:	Russ Leblanc
Organization:	Leblanc Consulting Services
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Feb 03 13:28:48 EST 2023
Committee:	NEC-P05

Committee Statement

Resolution: The exception to 250.122(B) provides the allowance necessary to apply the proper size of the equipment grounding conductor for unusual installations. There are various applications to which this situation applies that were not addressed in the substantiation.

Public Input No. 3107-NFPA 70-2023 [Section No. 250.122(D)]

(D) Motor and Air-Conditioning Circuits.

Equipment grounding conductors for motor and air-conditioning circuits shall be sized in accordance with 250.122(D)(1) or (D)(2).

(1) General.

The equipment grounding conductor size shall not be smaller than determined by 250.122(A) based on the rating of the branch-circuit short-circuit and ground-fault protective device.

(2) Instantaneous-Trip Circuit Breaker and Motor Short-Circuit Protector.

If the overcurrent device is an instantaneous-trip circuit breaker or a motor short-circuit protector, the equipment grounding conductor shall be sized not smaller than that given by 250.122(A) using the maximum permitted rating of a dual element time-delay fuse selected for branch-circuit short-circuit and ground-fault protection in accordance with 430.52(C)(1), Exception No. 1.

Statement of Problem and Substantiation for Public Input

The intent of the added text is for the requirements contained in 250.122(D) to apply also to air-conditioning equipment, for the same reasons they apply to motors. The reason 250.122(D) is in the NEC is because protection for the motor is based on ground-fault and short-circuit conditions, not overload. This same concept is true for air-conditioning equipment and the added text will bring clarity to Code users.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 12:08:32 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Subdivision 250.122(D) is specific to motor circuits. Overcurrent protection for air-conditioning equipment could apply to other circuits within the equipment.

Public Input No. 1959-NFPA 70-2023 [Section No. 250.122(D)(2)]

(2) Instantaneous-Trip Circuit Breaker and Motor Short-Circuit Protector.

If the overcurrent device is an instantaneous-trip circuit breaker or a motor short-circuit protector, the equipment grounding conductor shall be sized not smaller than that given by 250.122(A) using the maximum permitted rating of a dual element time-delay fuse selected for branch-circuit short-circuit and ground-fault protection in accordance with 430.52(C)(1)~~, Exception No. 1.~~ (a) .

Statement of Problem and Substantiation for Public Input

Revised the referenced Code section to 430.52(C)(1)(a) to make this requirement technically correct. 430.52(C)(1) Exception 1 no longer exists in the Code and the allowance for the next size up OCPD is now in 430.52(C)(1)(a).

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 08 15:59:59 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: This was corrected by Errata 70-23-6.

Public Input No. 768-NFPA 70-2023 [Section No. 250.122(D)(2)]

(2) Instantaneous-Trip Circuit Breaker and Motor Short-Circuit Protector.

~~If the overcurrent device is an instantaneous~~ Where an instantaneous -trip circuit breaker or a motor short-circuit protector is the motor branch-circuit , short-circuit, ground-fault protective device, the equipment grounding conductor shall be sized not smaller ~~than that given by~~ than 250.122(A) using the maximum permitted rating of a dual element time-delay fuse selected for branch-circuit short-circuit and ground-fault protection in accordance with 430.52(C)(1)~~, Exception No. 1.~~ (a).

Statement of Problem and Substantiation for Public Input

Making the language in 250.122(D) align with the terminology in Art. 430 adds clarity for users. Also, the exception referred to in 430.52 no longer exists and was apparently not caught in the 2023 edition before publication. The added section reference corrects this error.

Submitter Information Verification

Submitter Full Name: Paul Guidry
Organization: Fluor Enterprises, Inc.
Affiliation: Associated Builders and Contractors
Street Address:
City:
State:
Zip:
Submittal Date: Wed May 03 17:51:16 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8430-NFPA 70-2024
Statement: The revised language is consistent with 430.52(A) and improves clarity for users.

Public Input No. 846-NFPA 70-2023 [Section No. 250.122(D)(2)]

(2) Instantaneous-Trip Circuit Breaker and Motor Short-Circuit Protector.

If the overcurrent device is an instantaneous-trip circuit breaker or a motor short-circuit protector, the equipment grounding conductor shall be sized not smaller than that given by 250.122(A) using the maximum permitted rating of a dual element time-delay fuse selected for branch-circuit short-circuit and ground-fault protection in accordance with 430.52(C)(1)~~, Exception No. 1.~~ (a).

Statement of Problem and Substantiation for Public Input

Updating the reference.

Submitter Information Verification

Submitter Full Name: Ryan Jackson
Organization: Self-employed
Street Address:
City:
State:
Zip:
Submittal Date: Wed May 17 16:13:50 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: This was corrected by Errata 70-23-6.

Public Input No. 935-NFPA 70-2023 [Section No. 250.122(D)(2)]

(2) Instantaneous-Trip Circuit Breaker and Motor Short-Circuit Protector.

If the overcurrent device is an instantaneous-trip circuit breaker or a motor short-circuit protector, the equipment grounding conductor shall be sized not smaller than that given by 250.122(A) using the maximum permitted rating of a dual element time-delay fuse selected for branch-circuit short-circuit and ground-fault protection in accordance with 430.52(C)(1)~~,~~ ~~Exception No. 1.~~ (a) .

Statement of Problem and Substantiation for Public Input

The 2023 NEC edition revised this section and moved the exceptions into positive text. This reference is no longer valid. The change here as part of this public input corrects the reference error.

Submitter Information Verification

Submitter Full Name: Thomas Domitrovich
Organization: Eaton Corporation
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 05 07:57:27 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: This was corrected by Errata 70-23-6.

Public Input No. 2571-NFPA 70-2023 [Section No. 250.122(F)(2)]

(2) Multiconductor Cables.

(a) Except as provided in 250.122(F)(2)(c) for raceway, trench, or cable tray installations, the equipment grounding conductor in each multiconductor cable shall be sized in accordance with 250.122 based on the overcurrent protective device for the feeder or branch circuit.

(b) If circuit conductors of multiconductor cables are connected in parallel, the equipment grounding conductor(s) in each cable shall be connected in parallel.

(c) If multiconductor cables are paralleled in the same raceway, auxiliary gutter, trench, or cable tray, a single equipment grounding conductor that is sized in accordance with 250.122 shall be permitted in combination with the equipment grounding conductors provided within the multiconductor cables and shall all be connected together.

(d) Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c). Cable trays complying with 392.60(B), metal raceways in accordance with 250.118, or auxiliary gutters shall be permitted as the equipment grounding conductor.

Statement of Problem and Substantiation for Public Input

Greetings CMP Members,

It stands to reason that in 250.122(C) Multiple Circuits, the installer is permitted to install a single, properly sized EGC in a trench based on the largest OCPD in for the multiple circuits installed in the trench. However, when it comes to parallel sets of conductors in 250.122(F)(2) the installers are only permitted to utilize the additional, properly sized, single EGC for multiconductor cables with the cables existing EGC's when installed in raceways, auxiliary gutters, and cable trays.

If we are not concerned about the single EGC in the trench with multiple circuits that are relying on that EGC, how come in a trench with multiconductor cables, which already do have an EGC, we are not permitted to install a properly sized EGC to be installed in parallel with the multiconductor cables existing EGC just like the rule already permits in raceways, auxiliary gutters, and cable trays.

It seems to me the EGC will be fine and no less adequate than what is permitted in 250.122(C), which includes the allowance for "trench" applications.

Submitter Information Verification

Submitter Full Name: Paul Abernathy
Organization: Electrical Code Academy, Inc.
Affiliation: Electrical Code Academy, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 22 13:43:44 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8446-NFPA 70-2024

Statement: The revision to 250.122(F)(1)(b) is necessary to be consistent with requirements elsewhere in the NEC that size wire-type conductors intended to carry fault current. For example, 215.2(B), 250.24(D)(2), and 250.102(C)(2) have for many years limited the size of ground-fault-carrying conductors in parallel to no more than the size of the largest ungrounded conductor in each raceway with no reports of failure. As the number of paralleled raceways increases and the size of the paralleled circuit conductors decreases, it is unnecessary to have a paralleled EGC to be larger than the fault current supplying conductor.

Adding the trench location in 250.122(F)(2) aligns with 250.122(C).

Public Input No. 1480-NFPA 70-2023 [Section No. 250.130(C)]

(C) Replacement of Nongrounding Receptacle or Snap Switch and Branch Circuit Extensions.

The equipment grounding conductor that is connected to a grounding-type receptacle, a snap switch with an equipment grounding terminal, or a branch-circuit extension shall be permitted to be connected to any of the following:

(1) ~~Any accessible point on the grounding electrode system as described in 250.50~~

(2) ~~Any accessible point on the grounding electrode conductor~~

(3) The equipment grounding terminal bar within the enclosure where the branch circuit for the receptacle or branch circuit originates

(4) An equipment grounding conductor that is part of another branch circuit that originates from the enclosure where the branch circuit for the receptacle, snap switch, or branch circuit originates

(5) For grounded systems, the grounded service conductor within the service equipment enclosure

(6) For ungrounded systems, the grounding terminal bar within the service equipment enclosure

Informational Note No. 1: See 406.4(D) for the use of a ground-fault circuit-interrupting type of receptacle.

Informational Note No. 2: See 404.9(B) for requirements regarding grounding of snap switches.

Statement of Problem and Substantiation for Public Input

Deleting (1) and (2) makes this section conform with the general requirements found in 250.4(A)(5) and 250.4(B)(4) where it is stated that the earth shall not be considered an effective fault-current path. Connecting to the grounding electrode or the grounding electrode conductor makes it seem that the earth can be used. Deleting (1) and (2) helps to make this clear.

Submitter Information Verification

Submitter Full Name:	Roger Zieg
Organization:	NTT
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Jul 20 18:20:41 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Deleting option one and two does not make this clearer. These list items permit the connection to be at an accessible point for replacing a non-grounding receptacle or snap switch. The items in the list are connected to the neutral point and provide an effective ground fault current path.

Public Input No. 3108-NFPA 70-2023 [Section No. 250.134]

250.134 Equipment Fastened in Place or Connected by Permanent Wiring Methods (Fixed).

Unless connected to the grounded circuit conductor as permitted by 250.32, 250.140, and 250.142, non-current-carrying metal parts of equipment, raceways, and other enclosures, ~~if grounded,~~ shall be connected to an equipment grounding conductor by one of the following methods:

(1) By connecting to any of the equipment grounding conductors permitted by 250.118(2) through (14)

(2) By connecting to an equipment grounding conductor of the wire type that is contained within the same raceway, contained within the same cable, or otherwise run with the circuit conductors

Exception No. 1: As provided in 250.130(C), the equipment grounding conductor shall be permitted to be run separately from the circuit conductors.

Exception No. 2: For dc circuits, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors

Informational Note No. 1: See 250.102 and 250.168 for equipment bonding jumper requirements.

Informational Note No. 2: See 400.10 for use of flexible cords and flexible cables for fixed equipment.

Statement of Problem and Substantiation for Public Input

Deleting text “if grounded” because the metal parts of all equipment are required to be grounded, whether the system is a grounded or ungrounded in accordance with 250.4(A)(1) for grounded systems and 250.4(B)(1) for ungrounded systems. This deleted text removes the question as to when the metal parts might not need to be grounded and brings clarity to Code users.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 12:11:04 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Deleting the phrase “if grounded” could create a conflict for Class II double insulated equipment and limited energy systems.

Public Input No. 2651-NFPA 70-2023 [Section No. 250.142(B)]

(B) Load-Side Equipment.

Except as permitted in 250.30(A)(1), 250.32(B)(1), Exception No. 1, and ~~Part X of~~ Article 250 , Part X, a grounded circuit conductor shall not be connected to non–current-carrying metal parts of equipment on the load side of the service disconnecting means or on the load side of a separately derived system disconnecting means or the overcurrent devices for a separately derived system not having a main disconnecting means.

Exception No. 1: The frames of ranges, wall-mounted ovens, counter-mounted cooking units, and clothes dryers under the conditions permitted for existing installations by 250.140 shall be permitted to be connected to the grounded circuit conductor.

Exception No. 2: It shall be permissible to connect meter enclosures to the grounded circuit conductor on the load side of the service disconnect if all of the following conditions apply:

(1) Ground-fault protection of equipment is not installed.

(2) All meter enclosures are located immediately adjacent to the service disconnecting means.

(3) The size of the grounded circuit conductor is not smaller than the size specified in Table 250.122 for equipment grounding conductors.

Exception No. 3: Electrode-type boilers operating at over 1000 volts shall be grounded as required in 495.72(E)(1) and 495.74.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name:	David Williams
Organization:	Delta Charter Township
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 23 21:49:43 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8694-NFPA 70-2024

Statement: This reference is for over 1000 volt installations, this section covers less than 1000 volt installations, so Article 250, Part X would not apply, therefore, the reference is deleted.

Public Input No. 3250-NFPA 70-2023 [Section No. 250.142(B)]

(B) Load-Side Equipment.

Except as permitted in 250.30(A)(1), 250.32(B)(1), Exception No. 1, and Part X of Article 250, a grounded circuit conductor shall not be connected to non–current-carrying metal parts of equipment on the load side of the service disconnecting means or on the load side of a separately derived system disconnecting means or the overcurrent devices for a separately derived system not having a main disconnecting means.

Exception No. 1: The frames of ranges, wall-mounted ovens, counter-mounted cooking units, and clothes dryers under the conditions permitted for existing installations by 250.140 shall be permitted to be connected to the grounded circuit conductor.

Exception No. 2: It shall be permissible to connect meter enclosures to the grounded circuit conductor on the load side of the service disconnect if all of the following conditions apply:

(1) Ground-fault protection of equipment is not installed.

(2) All meter enclosures are located immediately adjacent to the service disconnecting means.

(3) The size of the grounded circuit conductor is not smaller than the size specified in Table 250.122 for equipment grounding conductors.

Exception No. 3: Electrode-type boilers operating at over 1000 volts shall be grounded as required in 495.72(E)(1) and 495.74.

Exception No. 4: The noncurrent carrying metal parts of a cabinet is permitted to be connected to the grounded circuit conductor where an emergency disconnect required by 230.85 is installed to an existing one- or two-family dwelling.

Statement of Problem and Substantiation for Public Input

Since 2020, the NEC has required an emergency disconnect to be located outside of one- and two-family dwellings for the protection of fire fighters and other first responders. Section 250.85(B)(3) permits the emergency disconnect to be located ahead of the service disconnect. Informational Note 1 states that “Conductors between the emergency disconnect and the service disconnect in 230.85(2) and 230.85(3) are service conductors.” The proposed new Exception No 4 to 250.142(B) makes it clear that when an emergency disconnect in accordance with 250.85 is installed, the existing wiring to the current service equipment is not required to be replaced.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Aug 30 17:33:33 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Emergency disconnects are not allowed on the load side of the service. See 230.85(B).

Public Input No. 3109-NFPA 70-2023 [Section No. 250.144]

250.144 Multiple Circuit Connections.

If equipment is ~~required to be grounded and is~~ supplied by more than one circuit containing an equipment grounding conductor, a means to terminate each equipment grounding conductor meeting the requirements of 250.8 shall be provided as specified in 250.134 and 250.138.

Statement of Problem and Substantiation for Public Input

Deleting text “if required to be grounded” because the metal parts of all equipment are required to be grounded, whether the system is a grounded or ungrounded in accordance with 250.4(A)(1) for grounded systems and 250.4(B)(1) for ungrounded systems. This deleted text removes the question as to when the metal parts might not need to be grounded and brings clarity to Code users.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 12:12:39 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: Deleting the phrase “required to be grounded” is inappropriate because only equipment required to be grounded requires provisions for terminating equipment grounding conductors.

Public Input No. 2462-NFPA 70-2023 [Section No. 250.146(A)]

(A) Surface-Mounted Box.

(1) Direct Metal-to-Metal Contact. If a metal box is mounted on the surface, the direct metal-to-metal contact between the device yoke or strap to the box shall be permitted to provide the required effective ground-fault current path. At least one of the insulating washers shall be removed from receptacles that do not have a contact yoke or device to ensure direct metal-to-metal contact. Direct metal-to-metal contact for providing continuity applies to cover-mounted receptacles if the box and cover combination are listed as providing continuity between the box and the receptacle.

(2) Exposed Work Cover. A listed exposed work cover shall be permitted to be the grounding and bonding means under both of the following conditions:

(a) The device is attached to the cover with at least two fasteners that are permanent (such as a rivet) or have a thread-locking or screw- or nut-locking means.

(b) The cover mounting holes are located on a flat nonraised portion of the cover.

Statement of Problem and Substantiation for Public Input

Formatted this rule into two second level subdivisions to make it clear for Code users that this single paragraph contains multiple requirements. In accordance with NEC Style Manual section 3.5.1.2 multiple requirements within a single subdivision shall be avoided. Additional subdivisions or lists shall be used to express independent requirements.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Thu Aug 17 13:47:16 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8546-NFPA 70-2024
Statement: Editorial revision to reformat the section into distinct parts per NEC Style Manual 3.5.1.2

Public Input No. 3830-NFPA 70-2023 [Section No. 250.146(A)]

(A) Surface-Mounted Box.

(1) Metal Box. If a metal box is mounted on the surface, the direct metal-to-metal contact between the device yoke or strap to the box shall be permitted to provide the required effective ground-fault current path. At least one of the insulating washers shall be removed from receptacles that do not have a contact yoke or device to ensure direct metal-to-metal contact. Direct metal-to-metal contact for providing continuity applies to cover-mounted receptacles if the box and cover combination are listed as providing continuity between the box and the receptacle.

(2) Metal Exposed Work Cover. A listed exposed work cover shall be permitted to be the grounding and bonding means under both of the following conditions:

(a) The device is attached to the cover with at least two fasteners that are permanent (such as a rivet) or have a thread-locking or screw- or nut-locking means.

(b) The cover mounting holes are located on a flat nonraised portion of the cover.

Statement of Problem and Substantiation for Public Input

Breaking up 250.146(A) into a list item format to facilitate understanding for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Sep 05 18:06:38 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8546-NFPA 70-2024

Statement: Editorial revision to reformat the section into distinct parts per NEC Style Manual 3.5.1.2

Public Input No. 2070-NFPA 70-2023 [Section No. 250.146(D)]

(D) Isolated Ground Receptacles.

If installed for the reduction of electromagnetic interference on the equipment grounding conductor, a receptacle in which the grounding terminal is purposely insulated from the receptacle mounting means shall be permitted. The receptacle grounding terminal shall be connected to an insulated equipment grounding conductor run with the circuit conductors. This equipment grounding conductor shall be permitted to pass through one or more enclosed panelboards without a connection to the enclosed panelboard grounding terminal bar as permitted in 408.40, Exception, so as to terminate within the same building or structure directly at an equipment grounding conductor terminal of the applicable derived system or service. If installed in accordance with this section, this equipment grounding conductor shall also be permitted to pass through boxes, wireways, or other enclosures without being connected to such enclosures.

Informational Note: Use of an isolated equipment grounding conductor does not relieve the requirement for connecting the raceway system and outlet box to an equipment grounding conductor.

Statement of Problem and Substantiation for Public Input

The term ‘panelboard’ and ‘enclosed panelboard’ are defined terms. Adding the word ‘enclosed panelboard’ makes the text technically correct. Note: The term ‘Enclosed Panelboard’ was added to NEC Article 100 during the 2023 Code cycle. The proposed revision will enhance usability throughout the NEC.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Fri Aug 11 15:04:14 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8550-NFPA 70-2024

Statement: The section is reformatted into distinct parts per 3.5.1.2 of the NEC Style Manual.

The change to the first line in 250.146(D)(1) is because there can be an isolated ground receptable for reasons other than electromagnetic interference.

Adding the term “panelboard enclosures” where the conductors pass through makes the text technically correct. The second instance of the term “panelboard” was deleted as grounding terminal bars are attached to the enclosure not the panelboard.

Public Input No. 3833-NFPA 70-2023 [Section No. 250.146(D)]

(D) Isolated Ground Receptacles.

(1) Insulated Equipment Grounding Conductor. If installed for the reduction of electromagnetic interference on the equipment grounding conductor, a receptacle in which the grounding terminal is purposely insulated from the receptacle mounting means shall be permitted. The receptacle grounding terminal shall be connected to an insulated equipment grounding conductor run with the circuit conductors.

(2) Connection to Grounding Terminal. This equipment grounding conductor shall be permitted to pass through one or more panelboards without a connection to the panelboard grounding terminal bar as permitted in 408.40, Exception, so as to terminate within the same building or structure directly at an equipment grounding conductor terminal of the applicable derived system or service. If installed in accordance with this section, this equipment grounding conductor shall also be permitted to pass through boxes, wireways, or other enclosures without being connected to such enclosures.

> Informational Note: Use of an isolated equipment grounding conductor does not relieve the requirement for connecting the raceway system and outlet box to an equipment grounding conductor.

Statement of Problem and Substantiation for Public Input

Breaking up 250.146 into a list item format to facilitate understanding for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Sep 05 18:09:48 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8550-NFPA 70-2024

Statement: The section is reformatted into distinct parts per 3.5.1.2 of the NEC Style Manual.

The change to the first line in 250.146(D)(1) is because there can be an isolated ground receptable for reasons other than electromagnetic interference.

Adding the term “panelboard enclosures” where the conductors pass through makes the text technically correct. The second instance of the term “panelboard” was deleted as grounding terminal bars are attached to the enclosure not the panelboard.

Public Input No. 1998-NFPA 70-2023 [Section No. 250.148]

250.148 Continuity of Equipment Grounding Conductors and Attachment in Boxes.

If circuit conductors are spliced within a box, a metallic or nonmetallic gutter or wireway or terminated on equipment within or supported by a box, the installation shall comply with 250.148(A) through (D).

Exception: The equipment grounding conductor permitted in 250.146(D) shall not be required to be connected to the other equipment grounding conductors or to the box.

(A) Connections and Splices.

All equipment grounding conductors that are spliced or terminated within the box, a metallic or nonmetallic gutter or wireway shall be connected together. Connections and splices shall be made in accordance with 110.14(B) and 250.8 except that insulation shall not be required.

(B) Equipment Grounding Conductor Continuity.

The arrangement of grounding connections shall be such that the disconnection or the removal of a luminaire, receptacle, or other device fed from the box does not interrupt the electrical continuity of the equipment grounding conductor(s) providing an effective ground-fault current path.

(C) Metal Boxes.

A connection used for no other purpose shall be made between the metal box and the equipment grounding conductor(s). The equipment bonding jumper or equipment grounding conductor shall be sized from Table 250.122 based on the largest overcurrent device protecting circuit conductors in the box.

(D) Nonmetallic Boxes.

One or more equipment grounding conductors brought into a nonmetallic outlet box shall be arranged to provide a connection to any fitting or device in that box requiring connection to an equipment grounding conductor.

Statement of Problem and Substantiation for Public Input

The continuity of spliced equipment grounding conductors needs to be ensured in more than installations involving boxes.

Submitter Information Verification

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Submittal Date: Thu Aug 10 12:43:07 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The title of this section is limited to boxes.

Public Input No. 2652-NFPA 70-2023 [Section No. 250.160]

250.160 General.

Direct-current systems shall comply with Article 250, Part VIII and other ~~sections of Article 250 not~~ sections not specifically intended for ac systems.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

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Committee:	NEC-P05

Committee Statement

Resolution:	FR-8696-NFPA 70-2024
Statement:	The panel as revised the text to comply with the NEC Style Manual, 2023 Section 4.1.4 when referencing specific parts of an article.

Public Input No. 1111-NFPA 70-2023 [Section No. 250.166(A)]

(A) Not Smaller Than the Neutral Conductor.

If the dc system consists of a 3-wire balancer set or a balancer winding with overcurrent protection as provided in 445.12(D), the grounding electrode conductor shall not be smaller than the neutral conductor and not smaller than 8 AWG copper-clad steel or copper or 6 AWG aluminum or copper-clad aluminum.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name:	Peter Graser
Organization:	Copperweld
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Submittal Date:	Sat Jun 17 09:09:38 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 1112-NFPA 70-2023 [Section No. 250.166(B)]

(B) Not Smaller Than the Largest Conductor.

If the dc system is other than as in 250.166(A), the grounding electrode conductor shall not be smaller than the largest conductor supplied by the system and not smaller than 8 AWG copper-clad steel or copper or 6 AWG aluminum or copper-clad aluminum.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name: Peter Graser
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Submittal Date: Sat Jun 17 09:10:55 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 1113-NFPA 70-2023 [Section No. 250.166(C)]

(C) Connected to Rod, Pipe, or Plate Electrodes.

If connected to rod, pipe, or plate electrodes as in 250.52(A)(5) or (A)(7), that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than 6 AWG copper-clad steel or copper wire or 4 AWG aluminum or copper-clad aluminum wire.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

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Submittal Date:	Sat Jun 17 09:12:49 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 1114-NFPA 70-2023 [Section No. 250.166(D)]

(D) Connected to a Concrete-Encased Electrode.

If connected to a concrete-encased electrode as in 250.52(A)(3), that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than 4 AWG copper- ~~wire~~ -clad steel or copper wire .

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name: Peter Graser
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Submittal Date: Sat Jun 17 09:13:54 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 1110-NFPA 70-2023 [Section No. 250.166 [Excluding any Sub-Sections]]

> The size of the grounding electrode conductor for a dc system shall be as specified in 250.166(A) and (B), except as permitted by 250.166(C) through (E). The grounding electrode conductor for a dc system shall meet the sizing requirements in this section but shall not be required to be larger than 3/0 copper-clad steel or copper or 250 kcmil aluminum or copper-clad aluminum.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

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Committee:	NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 4309-NFPA 70-2023 [Section No. 250.170]

250.170 Instrument Transformer Circuits.

Secondary circuits of current and potential instrument transformers shall be grounded if the primary windings are connected to circuits of 300 volts or more to ground and, if installed on or in switchgear and on switchboards, shall be grounded irrespective of voltage.

Exception No. 1: Circuits where the primary windings are connected to circuits of 1000 volts or less with no live parts or wiring exposed or accessible to other than qualified persons.

Exception No. 2: Current transformer secondaries connected in a three-phase delta configuration shall not be required to be grounded.

Informational Note 1: See IEEE 3004.1 Recommended Practice for the Application of Instrument Transformers in Industrial and Commercial Power Systems for more information.

Statement of Problem and Substantiation for Public Input

This is another slice of updated content from the legacy "Red Book" IEEE 141 and "Gray Book: IEEE 241 into the new IEEE 3000 Standards Collection. From the project prospectus:

"The selection and application of instrument transformers used in industrial and commercial power systems are covered in this recommended practice."

https://standards.ieee.org/standard/3004_1-2013.html

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Committee: NEC-P05

Committee Statement

Resolution: The reference to the standard provides no additional clarity for installers for grounding secondary circuits of instrument transformers.

Public Input No. 1115-NFPA 70-2023 [Section No. 250.178]

250.178 Instrument Equipment Grounding Conductor.

The equipment grounding conductor for secondary circuits of instrument transformers and for instrument cases shall not be smaller than 12 AWG copper-clad steel or copper or 10 AWG aluminum or copper-clad aluminum. Cases of instrument transformers, instruments, meters, and relays that are mounted directly on grounded metal surfaces of enclosures or grounded metal of switchgear or switchboard panels shall not be required to be connected to an additional equipment grounding conductor.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name: Peter Graser
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Submittal Date: Sat Jun 17 09:15:07 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.122? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.122 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.122 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.122. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 3496-NFPA 70-2023 [Section No. 250.180]

~~**250.180** General.~~

~~If systems over 1000 volts are grounded, they shall comply with all applicable requirements of 250.1 through 250.178 and with 250.182 through 250.194 , which supplement and modify the preceding sections.~~

Statement of Problem and Substantiation for Public Input

New Article 350 covers installations for over 1000 VAC and over 1500 VDC. As such Part X from Article 250 can be deleted.

Submitter Information Verification

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Submittal Date: Mon Sep 04 16:57:00 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8825-NFPA 70-2024

Statement: This new article is being created based on direction from the NEC Correlating Committee to provide separate articles for systems over 1000 volts ac and 1500 volts dc, nominal, as part of an overall revision to the NEC. It is noted that there will be a lot of duplicated material from Article 250.

Tables 350.122(A) and 350.122(B) for Equipment grounding conductors are based on UL 1072, UL Standard for Safety Medium-Voltage Power Cables, Tables 23-1 and 23-2 respectively. This consensus standard has been used successfully in the industry for sizing equipment grounding conductors in MV-90 and MV-105 cables since it was first published in 1986. Table ranges are 2001 – 35,000 volts, to align with tables in Article 315. Voltages above this are often bare overhead lines (with cables being the exception).

Note: The new article was proposed as a new 350 but was renumbered to 252.

Public Input No. 3498-NFPA 70-2023 [Section No. 250.182]

~~**250.182** Derived Neutral Systems.~~

~~A system neutral point derived from a grounding transformer shall be permitted to be used for grounding systems over 1 kV.~~

Statement of Problem and Substantiation for Public Input

New Article 350 covers installations for over 1000 VAC and over 1500 VDC. As such Part X from Article 250 can be deleted.

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Committee:	NEC-P05

Committee Statement

Resolution: FR-8825-NFPA 70-2024

Statement: This new article is being created based on direction from the NEC Correlating Committee to provide separate articles for systems over 1000 volts ac and 1500 volts dc, nominal, as part of an overall revision to the NEC. It is noted that there will be a lot of duplicated material from Article 250.

Tables 350.122(A) and 350.122(B) for Equipment grounding conductors are based on UL 1072, UL Standard for Safety Medium-Voltage Power Cables, Tables 23-1 and 23-2 respectively. This consensus standard has been used successfully in the industry for sizing equipment grounding conductors in MV-90 and MV-105 cables since it was first published in 1986. Table ranges are 2001 – 35,000 volts, to align with tables in Article 315. Voltages above this are often bare overhead lines (with cables being the exception).

Note: The new article was proposed as a new 350 but was renumbered to 252.

Public Input No. 3499-NFPA 70-2023 [Section No. 250.184]

~~**250.184** Solidly Grounded Neutral Systems.~~

~~Solidly grounded neutral systems shall be permitted to be either single point grounded or multigrounded neutral.~~

~~**(A)** Neutral Conductor.~~

~~**(1)** Insulation Level.~~

~~The minimum insulation level for neutral conductors of solidly grounded systems shall be 600 volts.~~

~~Exception No. 1: For multigrounded neutral systems as permitted in 250.184(C) , bare copper conductors shall be permitted to be used for the neutral conductor of the following:~~

(1) ~~Service-entrance conductors~~

(2) ~~Service laterals or underground service conductors~~

(3) ~~Direct-buried portions of feeders~~

~~Exception No. 2: Bare conductors shall be permitted for the neutral conductor of overhead portions installed outdoors.~~

~~Exception No. 3: The grounded neutral conductor shall be permitted to be a bare conductor if isolated from phase conductors and protected from physical damage.~~

> ~~Informational Note: See 225.4 for conductor covering where within 3.0 m (10 ft) of any building or other structure.~~

~~**(2)** Ampacity.~~

~~The neutral conductor shall have an ampacity that is not less than the load imposed and be not less than 33 $^{1}/_{3}$ percent of the ampacity of the phase conductors.~~

~~Exception: In industrial and commercial premises under engineering supervision, it shall be permissible to size the ampacity of the neutral conductor to not less than 20 percent of the ampacity of the phase conductor.~~

~~**(B)** Single-Point Grounded Neutral System.~~

~~If a single-point grounded neutral system is used, the following shall apply:~~

(1) ~~A single-point grounded neutral system shall be permitted to be supplied from one of the following:~~

    (2) ~~A separately derived system~~
    (3) ~~A multigrounded neutral system with an equipment grounding conductor connected to the multigrounded neutral conductor at the source of the single-point grounded neutral system~~

(4) ~~A grounding electrode shall be provided for the system.~~

(5) ~~A grounding electrode conductor shall connect the grounding electrode to the system neutral conductor.~~

(6) ~~A bonding jumper shall connect the equipment grounding conductor to the grounding electrode conductor.~~

(7) ~~An equipment grounding conductor shall be provided to each building, structure, and equipment enclosure.~~

(8) ~~A neutral conductor shall only be required if phase-to-neutral loads are supplied.~~

(9) ~~The neutral conductor, if provided, shall be insulated and isolated from earth except at one location.~~

(10) ~~An equipment grounding conductor shall be run with the phase conductors and shall comply with all of the following:~~

    (11) ~~Shall not carry continuous load~~
    (12) ~~Shall be bare, covered, or insulated~~
    (13) ~~Shall have ampacity for fault current duty~~

~~(C) Multigrounded Neutral Systems.~~

~~If a multigrounded neutral system is used, the following shall apply:~~

(1) ~~The neutral conductor of a solidly grounded neutral system shall be permitted to be grounded at more than one point. Grounding shall be permitted at one or more of the following locations:~~

  (2) ~~Transformers supplying conductors to a building or other structure~~

  (3) ~~Underground circuits if the neutral conductor is exposed~~

  (4) ~~Overhead circuits installed outdoors~~

(5) ~~The multigrounded neutral conductor shall be grounded at each transformer and at other additional locations by connection to a grounding electrode.~~

(6) ~~At least one grounding electrode shall be installed and connected to the multigrounded neutral conductor every 400 m (1300 ft).~~

(7) ~~The maximum distance between any two adjacent electrodes shall not be more than 400 m (1300 ft).~~

(8) ~~In a multigrounded shielded cable system, the shielding shall be grounded at each cable joint that is exposed to personnel contact.~~

~~*Exception: In a multipoint grounded system, a grounding electrode shall not be required to bond the neutral conductor in an uninterrupted conductor exceeding 400 m (1300 ft) if the only purpose for removing the cable jacket is for bonding the neutral conductor to a grounding electrode.*~~

Statement of Problem and Substantiation for Public Input

New Article 350 covers installations for over 1000 VAC and over 1500 VDC. As such Part X from Article 250 can be deleted.

Submitter Information Verification

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Submittal Date: Mon Sep 04 16:59:48 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8825-NFPA 70-2024

Statement: This new article is being created based on direction from the NEC Correlating Committee to provide separate articles for systems over 1000 volts ac and 1500 volts dc, nominal, as part of an overall revision to the NEC. It is noted that there will be a lot of duplicated material from Article 250.

Tables 350.122(A) and 350.122(B) for Equipment grounding conductors are based on UL 1072, UL Standard for Safety Medium-Voltage Power Cables, Tables 23-1 and 23-2 respectively. This consensus standard has been used successfully in the industry for sizing equipment grounding conductors in MV-90 and MV-105 cables since it was first published in 1986. Table ranges are 2001 – 35,000 volts, to align with tables in Article 315. Voltages above this are often bare overhead lines (with cables being the exception).

Note: The new article was proposed as a new 350 but was renumbered to 252.

Public Input No. 3500-NFPA 70-2023 [Section No. 250.186]

~~**250.186** Grounding Service-Supplied Alternating-Current Systems.~~

~~**(A)** Systems with a Grounded Conductor at the Service Point.~~

~~If an ac system is grounded at any point and is provided with a grounded conductor at the service point, a grounded conductor(s) shall be installed and routed with the ungrounded conductors to each service disconnecting means and shall be connected to each disconnecting means grounded conductor(s) terminal or bus. A main bonding jumper shall connect the grounded conductor(s) to each service disconnecting means enclosure. The grounded conductor(s) shall be installed in accordance with 250.186(A)(1) through (A)(4). The size of the solidly grounded circuit conductor(s) shall be the larger of that determined by 250.184 or 250.186(A)(1) or (A)(2).~~

~~*Exception: If two or more service disconnecting means are located in a single assembly listed for use as service equipment, it shall be permitted to connect the grounded conductor(s) to the assembly common grounded conductor(s) terminal or bus. The assembly shall include a main bonding jumper for connecting the grounded conductor(s) to the assembly enclosure.*~~

~~**(1)** Sizing for a Single Raceway or Overhead Conductor.~~

~~The grounded conductor shall not be smaller than the required grounding electrode conductor specified in Table 250.102(C)(1) but shall not be required to be larger than the largest ungrounded service-entrance conductor(s).~~

~~**(2)** Parallel Conductors in Two or More Raceways or Overhead Conductors.~~

~~If the ungrounded service-entrance conductors are installed in parallel in two or more raceways or as overhead parallel conductors, the grounded conductors shall also be installed in parallel. The size of the grounded conductor in each raceway or overhead shall be based on the total circular mil area of the parallel ungrounded conductors in the raceway or overhead, as indicated in 250.186(A)(1) , but not smaller than 1/0 AWG.~~

~~Informational Note: See 310.10(G) for grounded conductors connected in parallel.~~

~~**(3)** Delta-Connected Service.~~

~~The grounded conductor of a 3-phase, 3-wire delta service shall have an ampacity not less than that of the ungrounded conductors.~~

~~**(4)** Impedance Grounded Systems.~~

~~Impedance grounded systems shall be installed in accordance with 250.187 .~~

~~**(B)** Systems Without a Grounded Conductor at the Service Point.~~

~~If an ac system is grounded at any point and is not provided with a grounded conductor at the service point, a supply-side bonding jumper shall be installed and routed with the ungrounded conductors to each service disconnecting means and shall be connected to each disconnecting means equipment grounding conductor terminal or bus. The supply-side bonding jumper shall be installed in accordance with 250.186(B)(1) through (B)(3).~~

~~*Exception: If two or more service disconnecting means are located in a single assembly listed for use as service equipment, it shall be permitted to connect the supply-side bonding jumper to the assembly common equipment grounding terminal or bus.*~~

~~**(1)** Sizing for a Single Raceway or Overhead Conductor.~~

~~The supply-side bonding jumper shall not be smaller than the required grounding electrode conductor specified in Table 250.102(C)(1) but shall not be required to be larger than the largest ungrounded service-entrance conductor(s).~~

~~(2) Parallel Conductors in Two or More Raceways or Overhead Conductors.~~

~~If the ungrounded service-entrance conductors are installed in parallel in two or more raceways or overhead conductors, the supply-side bonding jumper shall also be installed in parallel. The size of the supply-side bonding jumper in each raceway or overhead shall be based on the total circular mil area of the parallel ungrounded conductors in the raceway or overhead, as indicated in 250.186(A)(1) , but not smaller than 1/0 AWG.~~

~~(3) Impedance Grounded Systems.~~

~~Impedance grounded systems shall be installed in accordance with 250.187 .~~

Statement of Problem and Substantiation for Public Input

New Article 350 covers installations for over 1000 VAC and over 1500 VDC. As such Part X from Article 250 can be deleted.

Submitter Information Verification

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Submittal Date: Mon Sep 04 17:01:09 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8825-NFPA 70-2024

Statement: This new article is being created based on direction from the NEC Correlating Committee to provide separate articles for systems over 1000 volts ac and 1500 volts dc, nominal, as part of an overall revision to the NEC. It is noted that there will be a lot of duplicated material from Article 250.

Tables 350.122(A) and 350.122(B) for Equipment grounding conductors are based on UL 1072, UL Standard for Safety Medium-Voltage Power Cables, Tables 23-1 and 23-2 respectively. This consensus standard has been used successfully in the industry for sizing equipment grounding conductors in MV-90 and MV-105 cables since it was first published in 1986. Table ranges are 2001 – 35,000 volts, to align with tables in Article 315. Voltages above this are often bare overhead lines (with cables being the exception).

Note: The new article was proposed as a new 350 but was renumbered to 252.

Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]

(A) Location.

The grounding impedance device shall be installed between the grounding electrode conductor and the impedance grounding conductor connected to the system neutral point. If a neutral point is not available, the grounding impedance shall be installed between the grounding electrode conductor and the impedance grounding conductor connected to the neutral point derived from a grounding transformer.

Statement of Problem and Substantiation for Public Input

This is a companion PI to a group of PIs whose intent is to bring 250.187 in alignment with the text of 250.36. The added text to this section is directly from 250.36.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	Group of PIs to edit 250.187 to match 250.36
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2125-NFPA 70-2023 [Section No. 250.36(C)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2130-NFPA 70-2023 [Section No. 250.36(G)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	

Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]

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Submittal Date:	Sat Aug 12 14:09:25 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution:	FR-8405-NFPA 70-2024
Statement:	This revision provides consistency between the rules in 250.36 and 250.187. This language has been in 250.36 for several cycles and applies to impedance grounded systems in a medium voltage application.

Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]

(B) ~~– Insulated.~~

~~The impedance grounding conductor shall be insulated for the maximum neutral voltage.~~

Impedance Grounding Conductor Insulation and Ampacity

The Impedance Grounding Conductor, from the neutral point of the transformer or generator to its connection point to the grounding impedance, shall be insulated for the phase to ground voltage of the system.

The Impedance Grounding Conductor shall have an ampacity of not less than the phase to neutral voltage of the system, divided by the value of the grounding impedance. In no case shall the Impedance Grounding Conductor be smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum.

Exception: A bare impedance grounding conductor shall be permitted if the bare portion of the grounding impedance device and conductor are not in a readily accessible location and securely separated from the ungrounded conductors.

Informational Note: The maximum ~~neutral voltage~~ phase to neutral voltage in a 3-phase wye system is 57.7 percent of the phase-to-phase voltage.

Statement of Problem and Substantiation for Public Input

This is a companion PI to a group of PIs whose intent is to bring 250.187 in alignment with the text of 250.36. The text in 250.36 states that this conductor shall be no smaller than the current rating of the grounding impedance. For 250.187, i'm recommending the conductor to be no less than the actual current of the system (voltage divided by impedance). The current text of 250.187 also states "neutral voltage." This PI is recommending a change to "phase to neutral voltage." The informational note explains this.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	Part of a group of PIs to bring 250.187 into alignment with 250.36
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	Part of a group of PIs to bring 250.187 into alignment with 250.36
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2125-NFPA 70-2023 [Section No. 250.36(C)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2130-NFPA 70-2023 [Section No. 250.36(G)]	companion PI to bring 250.187 into alignment with 250.36

Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]

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Submittal Date: Sat Aug 12 14:19:56 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: The proposed revision does not add clarity or usability. This proposed revision does not apply to 250.187, it applies better to 250.36.

Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]

(C) System Neutral Point Connection.

The system neutral point shall not be connected to ground, except through the grounding impedance device.

Informational Note: The impedance is normally selected to limit the ground-fault current to a value slightly greater than or equal to the capacitive charging current of the system. This value of impedance will also limit transient overvoltages to safe values. For guidance, refer to criteria for limiting transient overvoltages in IEEE 3003.1-2019, Recommended Practice for System Grounding of Industrial and Commercial Power Systems.

Statement of Problem and Substantiation for Public Input

This is a companion PI to a group of PIs whose intent is to bring 250.187 in alignment with the text of 250.36. The proposed change here is the addition of the informational note. 250.187(C) is titled "System Neutral Point Connection," whereas 250.36(C) title is "System Grounding Connection." Between the two, i think the title of 250.187 is clearer. There is a companion PI to change the title of 250.36(C) to match 250.187(C)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	PI to bring 250.187 into alignment with 250.36
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	PI to bring 250.187 into alignment with 250.36
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	PI to bring 250.187 into alignment with 250.36
Public Input No. 2125-NFPA 70-2023 [Section No. 250.36(C)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2130-NFPA 70-2023 [Section No. 250.36(G)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	
Public Input No. 2125-NFPA 70-2023 [Section No. 250.36(C)]	

Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]

Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]

Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]

Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]

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Committee:	NEC-P05

Committee Statement

Resolution:	FR-8417-NFPA 70-2024
Statement:	The informational note is added to be consistent with 250.36 since the information also applies to 250.187 systems.

Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]

(E) Impedance Bonding Jumper

The impedance bonding jumper (the connection between the equipment grounding conductors and the grounding impedance device) shall be an unspliced conductor run from the first system disconnecting means or overcurrent device to the grounded side of the grounding impedance device .

Statement of Problem and Substantiation for Public Input

This is a companion PI to a group of PIs whose intent is to bring 250.187 in alignment with the text of 250.36. (E) is a new section. The highlights in the proposed text are because this text was a direct copy and paste from 250.36 and the highlighted words were different for 2023.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2130-NFPA 70-2023 [Section No. 250.36(G)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	

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Committee: NEC-P05

Committee Statement

Resolution: FR-8618-NFPA 70-2024

Statement: This new subdivision recognizes the new definition of impedance bonding jumper and better describes the purpose of the conductor that bonds the grounding electrode conductor to the system equipment grounding conductors. This conductor carries ground fault current to the impedance and is a path for imposed voltages from sources identified in 250.4(A)(1).

This new subdivision provides methods to size the impedance bonding jumper. It accounts for the multiple purposes of the bonding jumper, including providing a path for impulses caused by lightning.

Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]

(F) Grounding Electrode Conductor Connection Location

For services or separately derived systems, the grounding electrode conductor shall be connected at any point from the grounded side of the grounding impedance device to the equipment grounding connection at the service equipment or the first system disconnecting means of a separately derived system.

Statement of Problem and Substantiation for Public Input

This is a companion PI to a group of PIs whose intent is to bring 250.187 in alignment with the text of 250.36. (F) is a new section that is copied from 250.36(F).

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2130-NFPA 70-2023 [Section No. 250.36(G)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	

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Committee:	NEC-P05

Committee Statement

Resolution: FR-8621-NFPA 70-2024

Statement: This new subdivision provides consistency between 250.36 and 250.187. The language is taken from 250.36(F).

Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]

(G) Impedance Bonding Jumper Size

The Impedance Bonding Jumper shall be sized the same as the impedance grounding conductor in 250.187(B)

Statement of Problem and Substantiation for Public Input

This is a companion PI to a group of PIs whose intent is to bring 250.187 in alignment with the text of 250.36. The author of this PI has submitted a different (G) section than the one in 250.36. 250.36(G) has different requirements based on the location of the GEC. After discussions with members of CMP-5 and further analysis of the potential types of faults (single vs. double), it is the opinion of the author that the location of the connection of the GEC makes no difference in the sizing of this conductor.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2130-NFPA 70-2023 [Section No. 250.36(G)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	

Public Input No. 2130-NFPA 70-2023 [Section No. 250.36(G)]

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Committee Statement

Resolution: FR-8618-NFPA 70-2024

Statement: This new subdivision recognizes the new definition of impedance bonding jumper and better describes the purpose of the conductor that bonds the grounding electrode conductor to the system equipment grounding conductors. This conductor carries ground fault current to the impedance and is a path for imposed voltages from sources identified in 250.4(A)(1).

This new subdivision provides methods to size the impedance bonding jumper. It accounts for the multiple purposes of the bonding jumper, including providing a path for impulses caused by lightning.

Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]

(D) ~~Equipment Grounding Conductors.~~

~~Equipment grounding conductors~~

Impedance Grounding Conductor Routing

The Impedance Grounding Conductor shall be permitted to be ~~bare and shall be electrically connected to the ground bus and grounding electrode conductor.~~ installed in a separate raceway from the ungrounded conductors. It shall not be required to run this conductor with the phase conductors to the first system disconnecting means or overcurrent device.

Statement of Problem and Substantiation for Public Input

This is a companion PI to a group of PIs whose intent is to bring 250.187 in alignment with the text of 250.36. The text in (D) was deleted and replaced with the text from 250.36(D). The previous 250.187(D) concerned equipment grounding conductors in the system and gave permission for these to be bare. If CMP-5 feels that this text is important, it could be added as (H) and the charging text in 250.187 could be changed from A to G to A to H.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2125-NFPA 70-2023 [Section No. 250.36(C)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2130-NFPA 70-2023 [Section No. 250.36(G)]	companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	

Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]

Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]

Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]

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Submittal Date: Sat Aug 12 15:40:57 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8418-NFPA 70-2024

Statement: The revisions incorporate proper terminology and reconciles the language with 250.36(D). The allowance for the impedance grounding conductor to be bare is removed since it is redundant with the exception to 250.187(B).

Public Input No. 2121-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]

Impedance grounded systems in which a grounding impedance device, typically a resistor, limits the ground-fault current shall be permitted if all of the following conditions are met:

(1) The conditions of maintenance and supervision ensure that only qualified persons service the installation.

(2) Ground detectors are installed on the system.

(3) Line-to-neutral loads are not served.

Impedance grounded systems shall comply with 250.187(A) through (~~D~~ G).

Additional Proposed Changes

File Name	Description	Approved
250_187_2020_version.docx	These are all the changes i'm proposing for 250.187. The intention is to make 250.187 more parallel with 250.36.	

Statement of Problem and Substantiation for Public Input

250.187 is not parallel with 250.36. For example, there are no requirements or direction in 250.187 for the sizing of the grounding impedance conductor. This PI was birthed out of the Medium Voltage task group to create an Article 350 for grounding and bonding above 1000 vac and 1500 vdc.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2125-NFPA 70-2023 [Section No. 250.36(C)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]	Companion PI to bring 250.187 into alignment with 250.36
Public Input No. 2122-NFPA 70-2023 [Section No. 250.187(A)]	
Public Input No. 2123-NFPA 70-2023 [Section No. 250.187(B)]	

Public Input No. 2124-NFPA 70-2023 [Section No. 250.187(C)]

Public Input No. 2126-NFPA 70-2023 [Section No. 250.187(D)]

Public Input No. 2127-NFPA 70-2023 [New Section after 250.187(D)]

Public Input No. 2128-NFPA 70-2023 [New Section after 250.187(D)]

Public Input No. 2129-NFPA 70-2023 [New Section after 250.187(D)]

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Committee:	NEC-P05

Committee Statement

Resolution:	FR-8422-NFPA 70-2024
Statement:	This action recognizes new subsections added to 250.187.

250.187 Impedance Grounded Systems.

Impedance grounded systems in which a grounding impedance device, typically a resistor, limits the ground-fault current shall be permitted if all of the following conditions are met:

- (1) The conditions of maintenance and supervision ensure that only qualified persons service the installation.
- (2) Ground detectors are installed on the system.
- (3) Line-to-neutral loads are not served.

Impedance grounded systems shall comply with **250.187(A)** through (G~~D~~).

(A) Location.

The grounding impedance device shall be installed between the grounding electrode conductor and the impedance grounding conductor connected to the system neutral point. If a neutral point is not available, the grounding impedance shall be installed between the grounding electrode conductor and the impedance grounding conductor connected to the neutral point derived from a grounding transformer.

(B) Impedance Grounding Conductor Insulation and Ampacity~~Insulated.~~

The impedance grounding conductor from the neutral point of the transformer or generator to its connection point to the grounding impedance shall be insulated for the ~~maximum~~ phase to ground voltage of the system. ~~neutral voltage.~~

The Impedance Grounding Conductor shall have an ampacity of not less than the phase to neutral voltage of the system, divided by the value of the grounding impedance. In no case shall the impedance grounding conductor be smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum.

Exception: A bare impedance grounding conductor shall be permitted if the bare portion of the grounding impedance device and conductor are not in a readily accessible location and securely separated from the ungrounded conductors.

Informational Note: The maximum phase to ground~~neutral~~ voltage in a 3-phase wye system is 57.7 percent of the phase-to-phase voltage.

(C) System Grounding~~Neutral Point~~ Connection.
The system neutral point shall not be connected to ground, except through the grounding impedance device.

Information note: The impedance is normally selected to limit the ground-fault current to a value slightly greater than or equal to the capacitive charging current of the system. This value of impedance will also limit transient overvoltages to safe values. For guidance, refer to criteria for limiting transient overvoltages in IEEE 3003.1-2019, *Recommended Practice for System Grounding of Industrial and Commercial Power Systems*.

(D) Impedance Grounding Conductor Routing.~~Equipment Grounding Conductors.~~
The impedance grounding conductor shall be permitted to be installed in a separate raceway from the ungrounded conductors. It shall not be required to run this conductor with the phase conductors to the first system disconnecting means or overcurrent device.

(E) Impedance Bonding Jumper.
The impedance bonding jumper (the connection between the equipment grounding conductors and the grounding impedance device) shall be an unspliced conductor run

from the first system disconnecting means or overcurrent device to the grounded side of the grounding impedance device.

(F) Grounding Electrode Conductor Connection Location.
For services or separately derived systems, the grounding electrode conductor shall be connected at any point from the grounded side of the grounding impedance device to the equipment grounding connection at the service equipment or the first system disconnecting means of a separately derived system.

(G) Impedance Bonding Jumper Size
The Impedance Bonding Jumper shall be sized the same as the impedance grounding conductor in 250.187(B)

~~Equipment grounding conductors shall be permitted to be bare and shall be electrically connected to the ground bus and grounding electrode conductor.~~

Public Input No. 3243-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]

Impedance grounded systems in which a grounding impedance device, typically a resistor, limits the ground-fault current shall be permitted if all of the following conditions are met:

(1) The conditions of maintenance and supervision ensure that only qualified persons service the installation.

(2) Ground detectors are installed on the system.

(3) Line-to-neutral loads are not served.

(4) The integrity of the impedance grounding system shall be monitored and the system shall have an audible or visual alarm when one of the following conditions is detected:

  (5) A loss of continuity of the impedance grounding circuit

  (6) A ground-fault in the impedance grounding circuit

Impedance grounded systems shall comply with 250.187(A) through (D).

Statement of Problem and Substantiation for Public Input

This public input is submitted along with two other companion public inputs in sections 250.36 (PI 3241) and 250.188 (PI 3244) to improve safety of impedance grounded systems by ensuring the integrity of the impedance grounding system at all times.

The intention is to monitor the impedance grounding system for its two modes of failure:

1. Loss of continuity (i.e., the impedance grounding device is open):

If the impedance grounding device fails open, the intentional connection of the power system neutral to ground is lost. Therefore, the power system will operate as an ungrounded system. According to the literature (a few examples are listed in the references), during a line-to-ground fault on any of the 3-phases (ungrounded conductors), the system voltage to ground will elevate to phase to ground voltage (for example, from 2400 V to 4160 V on a 4160 V system). Accordingly, steady-steate and transient overvoltages will appear on the unfaulted phases, posing a serious safety hazard due to personnel and equipment.

2. Ground-fault (i.e., the impedance grounding device is shorted):

If the impedance grounding device is shorted, the power system will operate as a solidly grounded system. According to the literature (a few examples are listed in the references), the magnitude of line-to-ground fault current can approach the levels of three-phase fault current levels (1,000–20,000 A). This could result in devastating burn-downs of particular equipment, creating hazards to personnel.

To avoid the interruption of a continuous industrial process and allow time for scheduled maintenance, the requirement is to alarm (not trip), if one of the aforementioned failure modes is detected.

Applications for Monitoring Impedance grounding devices:

Monitoring of the impedance grounding devices has been a code requirement or a standard practice in various applications in the US, Canada, and other countries including but not limited to Australia and New Zealand. These applications and the applicable code or standard are shown in the table below.

Application	Country	Code/Standard
Mining	US	30 CFR MSHA: Metal/Non-Metal Mining Regulations Parts 40-199
	Canada	CSA M421: Use of Electricity in Mines
	Australia & New Zealand	AS/NZS 2081: Electrical Protection Devices for Mines and Quarries
Most Installations	Canada	CSA C22.1: Canadian Electrical Code
Shore-to-ship (Cold Ironing)	International	IEC/IEEE 80005-1: Utility connections in port - Part 1: High voltage shore connection (HVSC) systems -- General requirements

Finally, the submitter understands that the current NEC language does not prevent the installation of impedance grounding system monitors. However, in practice, many users do not appreciate the hazards associated with the failure of an impedance grounding device and therefore do not monitor the integrity of their impedance grounding device. Thus, the submitter urges CMP-5 to consider adding this new requirement to the conditions that a medium voltage (over 1000 V) impedance grounded system must meet.

References:

[1] AIEE Committee Report, “Application guide on methods of neutral grounding of transmission systems,” Trans. Am. Inst. Electrical Engineers. Part III: Power Apparatus Syst., vol. 72, no. 4, pp. 663–668, Aug. 1953
[2] IEEE Recommended Practices for Grounding of Industrial and Commercial Power Systems, IEEE Standard 142–2007, 2007
[3] J. R. Dunki-Jacobs, F. J. Shields, and C. S. Pierre, Industrial Power System Grounding Design Handbook. Dexter, MI: Thomson-Shore, 2007
[4] N. El-Sherif and S. Kennedy, “A design guide to neutral-grounding of industrial power systems,” IEEE Ind. Appl. Mag., vol. 25, no. 1, pp. 25–36, 2019
[5] N. El-Sherif and S. Kennedy, “A Design Guide to Neutral-grounding of Industrial Power Systems – Part II: Supplementary Topics,” IEEE Industry Applications Magazine, vol. 26, no. 5, pp. 52-63, Sept/Oct 2020

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3241-NFPA 70-2023 [Section No. 250.36 [Excluding any Sub-Sections]]	
Public Input No. 3244-NFPA 70-2023 [Section No. 250.188]	
Public Input No. 3241-NFPA 70-2023 [Section No. 250.36 [Excluding any Sub-Sections]]	
Public Input No. 3244-NFPA 70-2023 [Section No. 250.188]	

Submitter Information Verification

Submitter Full Name: Nehad El-Sherif
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Street Address:
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Submittal Date: Wed Aug 30 17:05:53 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Insufficient technical justification is provided to support mandating additional monitoring of the integrity of the impedance grounding device. Examples provided are not unique to an impedance grounding system and additional monitoring is not prohibited.

Public Input No. 3244-NFPA 70-2023 [Section No. 250.188]

250.188 Grounding of Systems Supplying Portable or Mobile Equipment.

Systems supplying portable or mobile equipment over 1000 volts, other than substations installed on a temporary basis, shall comply with 250.188(A) through (~~F~~ G).

(A) Portable or Mobile Equipment.

Portable or mobile equipment over 1000 volts shall be supplied from a system having its neutral conductor grounded through an impedance. If a delta-connected system over 1000 volts is used to supply portable or mobile equipment, a system neutral point and associated neutral conductor shall be derived.

(B) Exposed Non-Current-Carrying Metal Parts.

Exposed non-current-carrying metal parts of portable or mobile equipment shall be connected by an equipment grounding conductor to the point at which the system neutral impedance is grounded.

(C) Ground-Fault Current.

The voltage developed between the portable or mobile equipment frame and ground by the flow of maximum ground-fault current shall not exceed 100 volts.

(D) Ground-Fault Detection and Relaying.

Ground-fault detection and relaying shall be provided to automatically de-energize any component of a system over 1000 volts that has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to automatically de-energize the circuit of the system over 1000 volts to the portable or mobile equipment upon loss of continuity of the equipment grounding conductor.

(E) Impedance Grounded System Monitoring.

The integrity of the impedance grounding system shall be monitored and the system shall be automatically de-energized when one of the following conditions is detected:

(1) A loss of continuity of the impedance grounding circuit

(2) A ground-fault in the impedance grounding circuit

(F) Isolation.

The grounding electrode to which the portable or mobile equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 6.0 m (20 ft) from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe and fence, and so forth.

(~~F~~ G) Trailing Cable and Couplers.

Trailing cable and couplers of systems over 1000 volts for interconnection of portable or mobile equipment shall meet the requirements of Part III of Article 400 for cables and 495.65 for couplers.

Statement of Problem and Substantiation for Public Input

This public input is submitted along with two other companion public inputs in sections 250.36 (PI 3241) and 250.187 (PI 3243) to improve safety of impedance grounded systems by ensuring the integrity of the impedance grounding system at all times.

The intention is to monitor the impedance grounding system for its two modes of failure:

1. Loss of continuity (i.e., the impedance grounding device is open):

If the impedance grounding device fails open, the intentional connection of the power system neutral to ground is lost. Therefore, the power system will operate as an ungrounded system. According to the literature (a few examples are listed in the references), during a line-to-ground fault on any of the 3-phases (ungrounded conductors), the system voltage-to-ground will elevate to phase-to-phase voltage (for example, from 277 V to 480 V on a 480 V system). Accordingly, steady-state and transient overvoltages appear on the unfaulted phases, posing a serious safety hazard due to personnel and equipment.

2. Ground-fault (i.e., the impedance grounding device is shorted):

If the impedance grounding device is shorted, the power system will operate as a solidly grounded system. According to the literature (a few examples are listed in the references), the magnitude of line-to-ground fault current can approach the levels of three-phase fault current levels (1,000–20,000 A). This could result in devastating burn-downs of particular equipment, creating hazards to personnel.

Because of the hazards associated with portable equipment, the requirement is to automatically de-energize the system if one of the aforementioned failure modes is detected.

Finally, the submitter understands that the current NEC language does not prevent the installation of impedance grounding system monitors. However, in practice, many users do not appreciate the hazards associated with the failure of an impedance grounding device and therefore do not monitor the integrity of their impedance grounding device. Thus, the submitter urges CMP-5 to consider adding this new requirement to the conditions that an impedance grounded system supplying portable or mobile equipment must meet.

References:

[1] AIEE Committee Report, “Application guide on methods of neutral grounding of transmission systems,” Trans. Am. Inst. Electrical Engineers. Part III: Power Apparatus Syst., vol. 72, no. 4, pp. 663–668, Aug. 1953
[2] IEEE Recommended Practices for Grounding of Industrial and Commercial Power Systems, IEEE Standard 142–2007, 2007
[3] J. R. Dunki-Jacobs, F. J. Shields, and C. S. Pierre, Industrial Power System Grounding Design Handbook. Dexter, MI: Thomson-Shore, 2007
[4] N. El-Sherif and S. Kennedy, “A design guide to neutral-grounding of industrial power systems,” IEEE Ind. Appl. Mag., vol. 25, no. 1, pp. 25–36, 2019
[5] N. El-Sherif and S. Kennedy, “A Design Guide to Neutral-grounding of Industrial Power Systems – Part II: Supplementary Topics,” IEEE Industry Applications Magazine, vol. 26, no. 5, pp. 52-63, Sept/Oct 2020

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3241-NFPA 70-2023 [Section No. 250.36 [Excluding any Sub-Sections]]	
Public Input No. 3243-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	
Public Input No. 3241-NFPA 70-2023 [Section No. 250.36 [Excluding any Sub-Sections]]	
Public Input No. 3243-NFPA 70-2023 [Section No. 250.187 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: Nehad El-Sherif

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Submittal Date: Wed Aug 30 17:14:20 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: Insufficient technical substantiation is provided to justify mandating additional monitoring of the integrity of the impedance grounding device. Examples provided are not unique to an impedance grounding system and additional monitoring is not prohibited currently. 250.188(D) addresses the concern of the submitter.

Public Input No. 3503-NFPA 70-2023 [Section No. 250.188]

~~**250.188** Grounding of Systems Supplying Portable or Mobile Equipment.~~

~~Systems supplying portable or mobile equipment over 1000 volts, other than substations installed on a temporary basis, shall comply with 250.188(A) through (F).~~

~~**(A)** Portable or Mobile Equipment.~~

~~Portable or mobile equipment over 1000 volts shall be supplied from a system having its neutral conductor grounded through an impedance. If a delta-connected system over 1000 volts is used to supply portable or mobile equipment, a system neutral point and associated neutral conductor shall be derived.~~

~~**(B)** Exposed Non-Current-Carrying Metal Parts.~~

~~Exposed non-current-carrying metal parts of portable or mobile equipment shall be connected by an equipment grounding conductor to the point at which the system neutral impedance is grounded.~~

~~**(C)** Ground-Fault Current.~~

~~The voltage developed between the portable or mobile equipment frame and ground by the flow of maximum ground-fault current shall not exceed 100 volts.~~

~~**(D)** Ground-Fault Detection and Relaying.~~

~~Ground-fault detection and relaying shall be provided to automatically de-energize any component of a system over 1000 volts that has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to automatically de-energize the circuit of the system over 1000 volts to the portable or mobile equipment upon loss of continuity of the equipment grounding conductor.~~

~~**(E)** Isolation.~~

~~The grounding electrode to which the portable or mobile equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 6.0 m (20 ft) from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe and fence, and so forth.~~

~~**(F)** Trailing Cable and Couplers.~~

~~Trailing cable and couplers of systems over 1000 volts for interconnection of portable or mobile equipment shall meet the requirements of Part III of Article 400 for cables and 495.65 for couplers.~~

Statement of Problem and Substantiation for Public Input

New Article 350 covers installations for over 1000 VAC and over 1500 VDC. As such Part X from Article 250 can be deleted.

Submitter Information Verification

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Submittal Date:	Mon Sep 04 17:10:48 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution: FR-8825-NFPA 70-2024

Statement: This new article is being created based on direction from the NEC Correlating Committee to provide separate articles for systems over 1000 volts ac and 1500 volts dc, nominal, as part of an overall revision to the NEC. It is noted that there will be a lot of duplicated material from Article 250.

Tables 350.122(A) and 350.122(B) for Equipment grounding conductors are based on UL 1072, UL Standard for Safety Medium-Voltage Power Cables, Tables 23-1 and 23-2 respectively. This consensus standard has been used successfully in the industry for sizing equipment grounding conductors in MV-90 and MV-105 cables since it was first published in 1986. Table ranges are 2001 – 35,000 volts, to align with tables in Article 315. Voltages above this are often bare overhead lines (with cables being the exception).

Note: The new article was proposed as a new 350 but was renumbered to 252.

Public Input No. 2653-NFPA 70-2023 [Section No. 250.188(F)]

(F) Trailing Cable and Couplers.

Trailing cable and couplers of systems over 1000 volts for interconnection of portable or mobile equipment shall meet the requirements of ~~Part III of~~ Article 400 - ~~for~~ , Part III for cables and 495.65 for couplers.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

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Submittal Date:	Wed Aug 23 21:52:49 EDT 2023
Committee:	NEC-P05

Committee Statement

Resolution:	FR-8698-NFPA 70-2024
Statement:	The panel has revised the text to comply with the NEC Style Manual, 2023 Section 4.1.4 when referencing specific parts of an article.

Public Input No. 3504-NFPA 70-2023 [Section No. 250.190]

~~**250.190** Grounding of Equipment.~~

~~**(A)** Equipment Grounding.~~

~~All non-current-carrying metal parts of fixed, portable, and mobile equipment and associated fences, housings, enclosures, and supporting structures shall be grounded.~~

~~*Exception: If isolated from ground and located such that any person in contact with ground cannot contact such metal parts when the equipment is energized, the metal parts shall not be required to be grounded.*~~

> ~~Informational Note: See 250.110 , Exception No. 2, for pole-mounted distribution apparatus.~~

~~**(B)** Grounding Electrode Conductor.~~

~~If a grounding electrode conductor connects non-current-carrying metal parts to ground, the grounding electrode conductor shall be sized in accordance with Table 250.66 , based on the size of the largest ungrounded service, feeder, or branch-circuit conductors supplying the equipment. The grounding electrode conductor shall not be smaller than 6 AWG copper or 4 AWG aluminum or copper-clad aluminum.~~

~~**(C)** Equipment Grounding Conductor.~~

~~Equipment grounding conductors shall comply with 250.190(C)(1) through (C)(3).~~

~~**(1)** General.~~

~~Equipment grounding conductors that are not an integral part of a cable assembly shall not be smaller than 6 AWG copper or 4 AWG aluminum or copper-clad aluminum.~~

~~**(2)** Shielded Cables.~~

~~The metallic insulation shield encircling the current-carrying conductors shall be permitted to be used as an equipment grounding conductor, if it is rated for clearing time of ground-fault current protective device operation without damaging the metallic shield. The metallic tape insulation shield and drain wire insulation shield shall not be used as an equipment grounding conductor for solidly grounded systems.~~

~~**(3)** Sizing.~~

~~Equipment grounding conductors shall be sized in accordance with Table 250.122 based on the current rating of the fuse or the overcurrent setting of the protective relay.~~

> ~~Informational Note: The overcurrent rating for a circuit breaker is the combination of the current transformer ratio and the current pickup setting of the protective relay.~~

Statement of Problem and Substantiation for Public Input

New Article 350 covers installations for over 1000 VAC and over 1500 VDC. As such Part X from Article 250 can be deleted.

Submitter Information Verification

Submitter Full Name: Eric Stromberg
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Submittal Date: Mon Sep 04 17:12:12 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8825-NFPA 70-2024

Statement: This new article is being created based on direction from the NEC Correlating Committee to provide separate articles for systems over 1000 volts ac and 1500 volts dc, nominal, as part of an overall revision to the NEC. It is noted that there will be a lot of duplicated material from Article 250.

Tables 350.122(A) and 350.122(B) for Equipment grounding conductors are based on UL 1072, UL Standard for Safety Medium-Voltage Power Cables, Tables 23-1 and 23-2 respectively. This consensus standard has been used successfully in the industry for sizing equipment grounding conductors in MV-90 and MV-105 cables since it was first published in 1986. Table ranges are 2001 – 35,000 volts, to align with tables in Article 315. Voltages above this are often bare overhead lines (with cables being the exception).

Note: The new article was proposed as a new 350 but was renumbered to 252.

Public Input No. 1116-NFPA 70-2023 [Section No. 250.190(B)]

(B) Grounding Electrode Conductor.

If a grounding electrode conductor connects non-current-carrying metal parts to ground, the grounding electrode conductor shall be sized in accordance with Table 250.66, based on the size of the largest ungrounded service, feeder, or branch-circuit conductors supplying the equipment. The grounding electrode conductor shall not be smaller than 6 AWG copper-clad steel or copper or 4 AWG aluminum or copper-clad aluminum.

Statement of Problem and Substantiation for Public Input

See substantiation in Public Input 1102 for Section 250.62.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1102-NFPA 70-2023 [Section No. 250.62]	

Submitter Information Verification

Submitter Full Name: Peter Graser
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Submittal Date: Sat Jun 17 09:16:54 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: CMP 5 requests that additional information on the following be provided: 1. How does the conductivity of copper-clad steel compare to the other conductors in Table 250.66? 2. Demonstrate that copper-clad steel performs comparably to conductors in Table 250.66 through testing such as that specified in UL 467 or IEEE 837. 3. Testing that compares copper-clad steel with the current types of conductors in Table 250.66 when bent at an angle of 90 degrees with fault current stresses. 4. Technical data demonstrating that the minimum equivalent fusing current of copper-clad steel conductors operating at 60HZ are not less than the minimum equivalent fusing current of the conductors currently contained in Table 250.66. All testing and/or technical data compilation shall be performed by a recognized qualified electrical testing laboratory.

Public Input No. 3506-NFPA 70-2023 [Section No. 250.194]

~~**250.194** Grounding and Bonding of Fences and Other Metal Structures.~~

~~Metal fences enclosing, and other metal structures in or surrounding, a substation with exposed electrical conductors and equipment shall be grounded and bonded to limit step, touch, and transfer voltages.~~

~~**(A)** Metal Fences.~~

~~If metal fences are located within 5 m (16 ft) of the exposed electrical conductors or equipment, the fence shall be bonded to the grounding electrode system with wire-type bonding jumpers as follows:~~

(1) ~~Bonding jumpers shall be installed at each fence corner and at maximum 50 m (160 ft) intervals along the fence.~~

(2) ~~If bare overhead conductors cross the fence, bonding jumpers shall be installed on each side of the crossing.~~

(3) ~~Gates shall be bonded to the gate support post, and each gate support post shall be bonded to the grounding electrode system.~~

(4) ~~Any gate or other opening in the fence shall be bonded across the opening by a buried bonding jumper.~~

(5) ~~The grounding grid or grounding electrode systems shall be extended to cover the swing of all gates.~~

(6) ~~The barbed wire strands above the fence shall be bonded to the grounding electrode system.~~

~~Alternate designs performed under engineering supervision shall be permitted for grounding or bonding of metal fences.~~

> ~~Informational Note No. 1: A nonconducting fence or section may provide isolation for transfer of voltage to other areas.~~
>
> ~~Informational Note No. 2: See IEEE 80, *IEEE Guide for Safety In AC Substation Grounding,* for design and installation of fence grounding.~~

~~**(B)** Metal Structures.~~

~~All exposed conductive metal structures, including guy wires within 2.5 m (8 ft) vertically or 5 m (16 ft) horizontally of exposed conductors or equipment and subject to contact by persons, shall be bonded to the grounding electrode systems in the area.~~

Statement of Problem and Substantiation for Public Input

New Article 350 covers installations for over 1000 VAC and over 1500 VDC. As such Part X from Article 250 can be deleted.

Submitter Information Verification

Submitter Full Name: Eric Stromberg
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Submittal Date: Mon Sep 04 17:13:16 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8825-NFPA 70-2024

Statement: This new article is being created based on direction from the NEC Correlating Committee to provide separate articles for systems over 1000 volts ac and 1500 volts dc, nominal, as part of an overall revision to the NEC. It is noted that there will be a lot of duplicated material from Article 250.

Tables 350.122(A) and 350.122(B) for Equipment grounding conductors are based on UL 1072, UL Standard for Safety Medium-Voltage Power Cables, Tables 23-1 and 23-2 respectively. This consensus standard has been used successfully in the industry for sizing equipment grounding conductors in MV-90 and MV-105 cables since it was first published in 1986. Table ranges are 2001 – 35,000 volts, to align with tables in Article 315. Voltages above this are often bare overhead lines (with cables being the exception).

Note: The new article was proposed as a new 350 but was renumbered to 252.

Public Input No. 3955-NFPA 70-2023 [New Definition after Definition: Example D13 Cable Tray Cal...]

Example D14 Grounded Service Conductor

[see 250.24(D)]

A service installation with four parallel sets of 350kcmil ungrounded service entrance conductors. All conductors are copper. No additional considerations for adjustments or corrections are included.

D.14(a) Parallel Grounded Service Conductors in a Single Raceway/Wireway

250.24(D)(1) requires a single grounded conductor be installed in the raceway and shall not be smaller than specified in Table 250.102(C)(1). The size of the grounded conductor is based off the size of the equivalent area for parallel conductors.

350kcmil x 4 = 1400kcmil of equivalent area.

According to Table 250.102(C)(1), Note 1, the grounded conductor shall not be smaller than 12.5 percent of the equivalent area of the parallel ungrounded conductors.

1400kcmil x 12.5% = 175kcmil

The smallest standard size wire that meets this criteria is 4/0 AWG copper.

D.14(b) Parallel Grounded Service Conductors in Four Separate Raceways/Wireways

250.24(D) states that a grounded conductor is to be routed with the ungrounded service conductors. There will be four grounded service conductors in total, one in each raceway or wireway. 250.24(D)(2) requires that each grounded conductor be sized in accordance with Table 250.102(C)(1), based in the size of the largest ungrounded conductor in the raceway, and not smaller than 1/0 AWG. See 310.10(G) for the requirements of circuit conductors installed in parallel.

For this installation, Table 250.102(C)(1) would require the installation of a #2 conductor in each raceway. However, 250.24(D)(2) states that the grounded conductor installed shall not be smaller than 1/0 AWG.

A 1/0 AWG copper grounded service conductor shall be installed in each of the four raceways containing ungrounded service conductors.

D.14(c) Parallel Grounded Service Conductors in Two Separate Raceways/Wireways.

As noted in D.14(b), a grounded conductor shall be routed with the ungrounded service conductors. In this example, two parallel sets of the 350kcmil ungrounded service conductors will be installed in each raceway or wireway. There will be two grounded service conductors in total, one in each raceway or wireway. 250.24(D)(2) applies, as well as the rules in 310.10(G).

With two sets installed in one raceway, the size of the grounded conductor shall be sized in accordance with Table 250.102(C)(1), and based off the equivalent area of the two sets of 350kcmil ungrounded service conductors, or 700kcmil.

A 2/0 AWG grounded service conductor shall be installed in each of the two raceways containing ungrounded service conductors.

Statement of Problem and Substantiation for Public Input

A common issue I see at the level of knowledge of both apprentices and journey-level workers, is the confusion around grounded conductor sizing for alternating-current services. While the language was modified to clarify intent for Section 250.24(D) in the 2023 cycle, an example in Informative Annex D would further help in this matter.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3963-NFPA 70-2023 [Section No. 250.24(D)(2)]	

Submitter Information Verification

Submitter Full Name: Steven Worsley
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Submittal Date: Wed Sep 06 11:16:41 EDT 2023
Committee: NEC-P05

Committee Statement

Resolution: FR-8241-NFPA 70-2024

Statement: The example is added in Annex D14 to provide examples for sizing grounded service conductors in accordance with 250.24(D) to assist users of the NEC.

Public Input No. 3584-NFPA 70-2023 [New Part after X.]

Article 350. Grounding and Bonding for systems over 1000 volts AC and 1500 volts DC
[see attached file]

Additional Proposed Changes

File Name	Description	Approved
Article_350_MV_grounding_and_bonding_for_review_Aug_2023_final_draft.docx	New Article 350	

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Medium Voltage Grounding and Bonding Task Group that was established to create a Grounding and Bonding Article above 1000 volts AC and 1500 volts DC.

The task group members were Paul Dobrowsky, Bobby Gray, Juan Lahera, Daleep Mohla, Darrell Sumbera. Ken Crawford and Eric Stromberg were co-chairs.

This new article is being created based on a request from the NEC Correlating Committee to provide separate articles for systems over 1000 volts ac and 1500 volts dc, nominal, as part of an overall revision to the NEC. It is noted that there will be a lot of duplicated material from Article 250.

Text in Article 250 not applicable to voltages about 1000 volts AC and 1500 volts DC was changed or deleted as necessary by the task group.

Table 250.122 was not copied into 350.122 due to systems above 1000 VAC and 1500 VDC not using the overcurrent protection to determine the equipment grounding conductor size.

Tables 350.122 (A) and 350.122 (B) for Equipment grounding conductors are based on UL 1072, -“ UL Standard for Safety Medium-Voltage Power Cables”, Tables 23-1 and 23-2 respectively. This consensus standard has been used successfully in the industry for sizing equipment grounding conductors in MV-90 and MV-105 cables since it was first published in 1986. Table ranges are 2001 - 35,000 volts, to align with tables in Article 315.
Voltages above this are often bare overhead lines with cables being the exception. This is another reason for the proposed added statement to 350.122(A) that the sizing of the equipment grounding conductor may be accomplished under engineering supervision.

Submitter Information Verification

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Submittal Date:	Mon Sep 04 20:55:20 EDT 2023

Committee: NEC-P05

Committee Statement

Resolution: FR-8825-NFPA 70-2024

Statement: This new article is being created based on direction from the NEC Correlating Committee to provide separate articles for systems over 1000 volts ac and 1500 volts dc, nominal, as part of an overall revision to the NEC. It is noted that there will be a lot of duplicated material from Article 250.

Tables 350.122(A) and 350.122(B) for Equipment grounding conductors are based on UL 1072, UL Standard for Safety Medium-Voltage Power Cables, Tables 23-1 and 23-2 respectively. This consensus standard has been used successfully in the industry for sizing equipment grounding conductors in MV-90 and MV-105 cables since it was first published in 1986. Table ranges are 2001 – 35,000 volts, to align with tables in Article 315. Voltages above this are often bare overhead lines (with cables being the exception).

Note: The new article was proposed as a new 350 but was renumbered to 252.

Article 350 Grounding and Bonding of Systems over 1000 Volts ac, 1500 Volts dc, Nominal

Part I. General

350.1 Scope.

This article covers general requirements for grounding and bonding of electrical installations over 1000 volts ac, 1500 volts dc, nominal and the following specific requirements:

(1) Systems, circuits, and equipment required, or permitted to be grounded

(2) Circuit conductor to be grounded on grounded systems

(3) Location of grounding connections

(4) Types and sizes of grounding and bonding conductors and electrodes

(5) Methods of grounding and bonding

(6) Conditions under which isolation, insulation, or guards are permitted to be substituted for grounding

Informational Note: See Informational Note Figure 350.1 for information on the organization of this article covering grounding and bonding requirements.?

Figure Informational Note Figure 350.1 Grounding and Bonding.

350.4 General Requirements for Grounding and Bonding.

The following general requirements identify what grounding and bonding of electrical systems are required to accomplish. The prescriptive methods contained in this article shall be followed to comply with the performance requirements of this section.

(A) Grounded Systems.

(1) Electrical System Grounding.

Electrical systems that are grounded shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation.

Informational Note No. 1: An important consideration for limiting the imposed voltage is the routing of bonding and grounding electrode conductors so that they are not any longer than necessary to complete the connection without disturbing the permanent parts of the installation and so that unnecessary bends and loops are avoided.

Informational Note No. 2: See NFPA 780-2020, *Standard for the Installation of Lightning Protection Systems*, for information on installation of grounding and bonding for lightning protection systems.

(2) Grounding of Electrical Equipment.

Normally non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected to earth so as to limit the voltage to ground on these materials.

(3) Bonding of Electrical Equipment.

Normally non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path.

(4) Bonding of Electrically Conductive Materials and Other Equipment.

Normally non-current-carrying electrically conductive materials that are likely to become energized shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path.

(5) Effective Ground-Fault Current Path.

Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault occurs to the electrical supply source. The earth shall not be considered as an effective ground-fault current path.

(B) Ungrounded Systems.

(1) Grounding Electrical Equipment.

Non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected to earth in a manner that will limit the voltage imposed by lightning or unintentional contact with higher-voltage lines and limit the voltage to ground on these materials.

Informational Note: See NFPA 780-2020, *Standard for the Installation of Lightning Protection Systems*, for information on installation of grounding and bonding for lightning protection systems.

(2) Bonding of Electrical Equipment.

Non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected together and to the supply system grounded equipment in a manner that creates a low-impedance path for ground-fault current that is capable of carrying the maximum fault current likely to be imposed on it.

(3) Bonding of Electrically Conductive Materials and Other Equipment.

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Deleted sections are 250.116,250.126,250.140 (250.140 was modified instead) ,250.146

Sections receiving 4 out of 7 delete votes
250.21,250.36,250.114,250.130,250.132,250.138,250.142

Sections receiving 3 out of 7 delete votes
250.24,250.25,250.58,250.122

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Electrically conductive materials that are likely to become energized shall be connected together and to the supply system grounded equipment in a manner that creates a low-impedance path for ground-fault current that is capable of carrying the maximum fault current likely to be imposed on it.

(4) Path for Fault Current.

Electrical equipment, wiring, and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit from any point on the wiring system to the electrical supply source to facilitate the operation of overcurrent devices should a second ground fault from a different phase occur on the wiring system. The earth shall not be considered as an effective fault-current path.

350.6 Objectionable Current.

(A) Arrangement to Prevent Objectionable Current.

The grounding and bonding of electrical systems, circuit conductors, surge arresters, surge-protective devices, and conductive normally non-current-carrying metal parts of equipment shall be installed and arranged in a manner that will prevent objectionable current.

(B) Alterations to Stop Objectionable Current.

If the use of multiple grounding or bonding connections results in objectionable current and the requirements of 350.4(A)(5) or (B)(4) are met, one or more of the following alterations shall be permitted:

(1) Discontinue one or more but not all of such grounding or bonding connections.

(2) Change the locations of the grounding or bonding connections.

(3) Interrupt the continuity of the conductor or conductive path causing the objectionable current.

(4) Take other remedial and approved action.

(C) Currents Not Classified as Objectionable Currents.

Currents resulting from abnormal conditions such as ground faults, and from currents resulting from required grounding and bonding connections shall not be classified as objectionable current for the purposes specified in 350.6(A) and (B).

(D) Limitations to Permissible Alterations.

This section shall not be considered as permitting electronic equipment to be operated on ac systems or branch circuits that are not connected to an equipment grounding conductor as required by this article. Currents that introduce electromagnetic interference or data errors in electronic equipment shall not be considered the objectionable currents addressed in this section.

(E) Isolation of Objectionable Direct-Current from Cathodic Protection Systems.

If isolation of objectionable direct currents from a cathodic protection system is required, a listed isolator device shall be permitted in the equipment grounding conductor path to provide an effective return path for ac ground-fault current while blocking the flow of direct currents.

350.8 Connection of Grounding and Bonding Equipment.

(A) Permitted Methods.

Equipment grounding conductors, grounding electrode conductors, and bonding jumpers shall be connected by one or more of the following means:

(1) Listed pressure connectors

(2) Terminal bars

(3) Pressure connectors listed as grounding and bonding equipment

(4) Exothermic welding process

(5) Machine screw-type fasteners that engage not less than two threads or are secured with a nut

(6) Thread-forming machine screws that engage not less than two threads in the enclosure

(7) Connections that are part of a listed assembly

(8) Other listed means

(B) Methods Not Permitted.

Connection devices or fittings that depend solely on solder shall not be used.

350.10 Protection of Ground Clamps and Fittings.

Ground clamps or other fittings exposed to physical damage shall be enclosed in metal, wood, or equivalent protective covering.

350.12 Clean Surfaces.

Nonconductive coatings (such as paint, lacquer, and enamel) on equipment to be grounded or bonded shall be removed from threads and other contact surfaces to ensure electrical continuity or shall be connected by means of fittings designed to make such removal unnecessary.

Part II. System Grounding

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350.20 Alternating-Current Systems to Be Grounded.

Alternating-current systems shall be grounded in accordance with 350.20(A)~~, (B), (C),~~ or (B~~D~~), unless prohibited elsewhere in this *Code*. Other systems shall be permitted to be grounded. If such systems are grounded, they shall comply with the applicable provisions of this article.

Informational Note No. 1: An example of a system permitted to be grounded is a corner-grounded delta transformer connection.

~~Informational Note No. 2: See 503.155, 517.61, 517.160, 668.10, and 680.23(A)(2) for examples of circuits prohibited to be grounded.~~

~~(A) Alternating-Current Systems of Less Than 50 Volts.~~

~~Alternating-current systems of less than 50 volts shall be grounded under any of the following conditions:~~

- ~~(1) If supplied by transformers, if the transformer supply system exceeds 150 volts to ground~~
- ~~(2) If supplied by transformers, if the transformer supply system is ungrounded~~
- ~~(3) If installed outside as overhead conductors~~

~~(B) Alternating-Current Systems of 50 Volts to 1000 Volts.~~

~~Alternating-current systems of 50 volts to 1000 volts that supply premises wiring and premises wiring systems shall be grounded under any of the following conditions:~~

- ~~(1) If the system can be grounded so that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts~~
- ~~(2) If the system is 3-phase, 4-wire, wye connected in which the neutral conductor is used as a circuit conductor~~
- ~~(3) If the system is 3-phase, 4-wire, delta connected in which the midpoint of one phase winding is used as a circuit conductor~~

~~Informational Note: See NFPA *70E*-2021, *Standard for Electrical Safety in the Workplace*, Annex O, for information on impedance grounding to reduce arc-flash hazards.~~

(A~~C~~) Alternating-Current Systems~~ of over 1000 Volts~~.

Alternating-current systems supplying mobile or portable equipment shall be grounded in accordance with 350.188. If supplying other than mobile or portable equipment, such systems shall be permitted to be grounded.

(B~~D~~) Impedance Grounded Systems.

Impedance grounded systems shall be grounded in accordance with ~~350.36 or~~ 350.187~~, as applicable~~.

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350.21 Alternating-Current Systems ~~of 50 Volts to 1000 Volts~~ Not Required to Be Grounded.

(A) General.

The following ac systems ~~of 50 volts to 1000 volts~~ shall be permitted to be grounded but shall not be required to be grounded:

(1) Electrical systems used exclusively to supply~~ industrial~~ electric furnaces used for applications such as melting, refining, or tempering

(2) Separately derived systems used exclusively for rectifiers that supply only adjustable-speed~~ industrial~~ drives

(3) Equipment used exclusively for harmonic mitigation

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~~(3) Separately derived systems supplied by transformers that have a primary voltage rating of 1000 volts or less if all the following conditions are met:~~

~~a. The system is used exclusively for control circuits.~~

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~~b. The conditions of maintenance and supervision ensure that only qualified persons service the installation.~~

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~~c. Continuity of control power is required.~~

~~(4) Other systems that are not required to be grounded in accordance with 350.20(B)~~

(B) Ground Detectors.

Ground detectors shall be installed in accordance with the following:

(1) Ungrounded ac systems as permitted in 350.21(A)(1) through (A)(2~~4~~) ~~operating at not less than 120 volts and at 1000 volts or less~~ shall have ground detectors installed on the system.

(2) The ground detection sensing equipment shall be connected as close as practicable to where the system receives its supply.

(C) Marking.

Ungrounded systems shall be legibly marked "Caution: Ungrounded System Operating — _____Volts Between Conductors" at the source or first disconnecting means of the system. The marking shall be of sufficient durability to withstand the environment involved.

350.24 Grounding of Service-Supplied Alternating-Current Systems.

(A) System Grounding Connections.

A premises wiring system supplied by a grounded ac service shall have a grounding electrode conductor connected to the grounded service conductor, at each service, in accordance with 350.24(A)(1) through (A)(4).

(1) General.

The grounding electrode conductor connection shall be made at any accessible point from the load end of the overhead service conductors, service drop, underground service conductors, or service lateral to the terminal or bus to which the grounded service conductor is connected at the service disconnecting means.

Informational Note: See Article 100 for definitions of *Service Conductors, Overhead; Service Conductors, Underground; Service Drop;* and *Service Lateral*.

(2) Outdoor Transformer.

If the transformer supplying the service is located outside the building, at least one additional grounding connection shall be made from the grounded service conductor to a grounding electrode, either at the transformer or elsewhere outside the building.

Exception: The additional grounding electrode conductor connection shall not be made on impedance grounded systems. Impedance grounded systems shall meet the requirements of~~ 350.36 or~~ 350.187.~~, as applicable.~~

(3) Dual-Fed Services.

For services that are dual fed (double ended) in a common enclosure or grouped together in separate enclosures and employing a secondary tie, a single grounding electrode conductor connection to the tie point of the grounded conductor(s) from each power source shall be permitted.

(4) Main Bonding Jumper as Wire or Busbar.

If the main bonding jumper specified in 350.28 is a wire or busbar and is installed from the grounded conductor terminal bar or bus to the equipment grounding terminal bar or bus in the service equipment, the grounding electrode conductor shall be permitted to be connected to the equipment grounding terminal, bar, or bus to which the main bonding jumper is connected.

(B) Load-Side Grounding Connections.

A grounded conductor shall not be connected to normally non-current-carrying metal parts of equipment, to equipment grounding conductor(s), or be reconnected to ground on the load side of the service disconnecting means except as otherwise permitted in this article.

Informational Note: See 350.30 for separately derived systems, 350.32 for connections at separate buildings or structures, and 350.142 for use of the grounded circuit conductor for grounding equipment.

(C) Main Bonding Jumper.

For a grounded system, an unspliced main bonding jumper shall be used to connect the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor within the enclosure for each service disconnect in accordance with 350.28.

Exception No. 1: If more than one service disconnecting means is located in an assembly listed for use as service equipment, an unspliced main bonding jumper shall bond the grounded conductor(s) to the assembly enclosure.

Exception No. 2: Impedance grounded systems shall be permitted to be connected in accordance with ~~350.36 and~~ 350.187.

(D) Grounded Conductor Brought to Service Equipment.

If an ac system ~~operating at 1000 volts or less~~ is grounded at any point, the grounded conductor(s) shall be routed with the ungrounded conductors to each service disconnecting means and shall be connected to each disconnecting means grounded conductor(s) terminal or bus. A main bonding jumper shall connect the grounded conductor(s) to each service disconnecting means enclosure. The grounded conductor(s) shall be installed in accordance with 350.24(C)(1) and 350.24(D)(1) through (D)(4).

Exception: If two or more service disconnecting means are located in a single assembly listed for use as service equipment, it shall be permitted to connect the grounded conductor(s) to the assembly common grounded conductor(s) terminal or bus. The assembly shall include a main bonding jumper for connecting the grounded conductor(s) to the assembly enclosure.

(1) Sizing for a Single Raceway or Cable.

The grounded conductor shall not be smaller than specified in Table 350.102(C)(1).

(2) Conductors Connected in Parallel in Two or More Raceways or Cables.

If the ungrounded service-entrance conductors are connected in parallel in two or more raceways or cables, the grounded conductors shall also be installed in each raceway or cable and shall be connected in parallel. The size of each grounded conductor(s) in each raceway or cable shall not be smaller than 1/0 AWG and shall be sized in accordance with 350.24(D)(2)(a) or (D)(2)(b) in accordance with 350.24(D)(1).

(a) Shall be based on the largest ungrounded conductor in each raceway or cable.

(b) Shall be based on the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable.

Informational Note: See 310.10(G) for grounded conductors connected in parallel.

(3) Delta-Connected Service.

The grounded conductor of a 3-phase, 3-wire delta service shall have an ampacity not less than that of the ungrounded conductors.

(4) Impedance Grounded Service.

The impedance grounding conductor on an impedance grounded system shall be ~~connected~~connected and sized in accordance with ~~350.36 or~~ 350.187~~, as applicable~~.

(E) Grounding Electrode Conductor.

A grounding electrode conductor shall be used to connect the equipment grounding conductors, the service-equipment enclosures, and, if the system is grounded, the grounded service conductor to the grounding electrode(s) required by Part III of this article. This conductor shall be sized in accordance with 350.66.

Impedance grounded system connections shall be made in accordance with ~~350.36 or~~ 350.187~~, as applicable~~.

(F) Ungrounded System Grounding Connections.

A premises wiring system that is supplied by an ac service that is ungrounded shall have, at each service, a grounding electrode conductor connected to the grounding electrode(s) required by Part III of this article. The grounding electrode conductor shall be connected to a metal enclosure of the service conductors at any accessible point from the load end of the overhead service conductors, service drop, underground service conductors, or service lateral to the service disconnecting means.

350.25 Grounding of Systems Permitted to Be Connected on the Supply Side of the Service Disconnect.

The grounding of systems connected on the supply side of the service disconnect, in accordance with 230.82, that are in enclosures separate from the service equipment enclosure shall comply with 350.25(A) or (B).

(A) Grounded System.

If the utility supply system is grounded, the grounding of systems permitted to be connected on the supply side of the service disconnect and are installed in one or more separate enclosures from the service equipment enclosure shall comply with the requirements of 350.24(A) through (D).

(B) Ungrounded Systems.

If the utility supply system is ungrounded, the grounding of systems permitted to be connected on the supply side of the service disconnect and are installed in one or more separate enclosures from the service equipment enclosure shall comply with the requirements of 350.24(F).

350.26 Conductor to Be Grounded — Alternating-Current Systems.

If an ac premises wiring system is grounded, the conductor to be grounded shall be one of the following:

(1) Single-phase, 2-wire — one conductor

(2) Single-phase, 3-wire — the neutral conductor

(3) Multiphase systems having one wire common to all phases — the neutral conductor

(4) Multiphase systems if one phase is grounded — that phase conductor

~~(5) Multiphase systems in which one phase is used as in (2) — the neutral conductor~~

350.28 Main Bonding Jumper and System Bonding Jumper.

For a grounded system, main bonding jumpers and system bonding jumpers shall be installed as follows:

(A) Material.

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Main bonding jumpers and system bonding jumpers shall be of copper, aluminum, copper-clad aluminum, or other corrosion-resistant material. A main bonding jumper and a system bonding jumper shall be a wire, bus, screw, or similar suitable conductor.

(B) Construction.

If a main bonding jumper or a system bonding jumper is a screw only, the screw shall be identified with a green finish that shall be visible with the screw installed.

(C) Attachment.

Main bonding jumpers and system bonding jumpers shall be connected by one or more of the methods in 350.8 that is suitable for the material of the bonding jumper and enclosure.

(D) Size.

Main bonding jumpers and system bonding jumpers shall be sized in accordance with 350.28(D)(1) through (D)(3).

(1) General.

Main bonding jumpers and system bonding jumpers shall not be smaller than specified in Table 350.102(C)(1).

(2) Main Bonding Jumper for Service with More Than One Enclosure.

If a service consists of more than a single enclosure as permitted in 230.71(B), the main bonding jumper for each enclosure shall be sized in accordance with 350.28(D)(1) based on the largest ungrounded service conductor serving that enclosure.

(3) Separately Derived System with More Than One Enclosure.

If a separately derived system supplies more than a single enclosure, the system bonding jumper for each enclosure shall be sized in accordance with 350.28(D)(1) based on the largest ungrounded feeder conductor serving that enclosure, or a single system bonding jumper shall be installed at the source and sized in accordance with 350.28(D)(1) based on the equivalent size of the largest supply conductor determined by the largest sum of the areas of the corresponding conductors of each set.

350.30 Grounding Separately Derived Alternating-Current Systems.

In addition to complying with 350.30(A) for grounded systems, or as provided in 350.30(B) for ungrounded systems, separately derived systems shall comply with 350.20, 350.21, or 350.26, as applicable. Multiple power sources of the same type that are connected in parallel to form one system that supplies premises wiring shall be treated as a single separately derived system and shall be installed in accordance with 350.30.

Informational Note No. 1: An alternate ac power source, such as an on-site generator, is not a separately derived system if the grounded conductor is solidly interconnected to a service-supplied system grounded conductor. An example of such a situation is if the alternate source transfer equipment does not include a switching action in the grounded conductor and allows it to remain solidly connected to the service-supplied grounded conductor when the alternate source is operational and supplying the load served.

Informational Note No. 2: See 445.13 for the minimum size of conductors that carry fault current.

(A) Grounded Systems.

A separately derived ac system that is grounded shall comply with 350.30(A)(1) through (A)(8). Except as otherwise permitted in this article, a grounded conductor shall not be connected to normally non-current-carrying metal parts of equipment, be connected to equipment grounding conductors, or be reconnected to ground on the load side of the system bonding jumper.

Informational Note: See 350.32 for connections at separate buildings or structures and 350.142 for use of the grounded circuit conductor for grounding equipment.

Exception: Impedance grounded system grounding connections shall be made in accordance with ~~350.36 or~~ 350.187~~7, as applicable~~.

(1) System Bonding Jumper.

An unspliced system bonding jumper shall comply with 350.28(A) through (D). This connection shall be made at any single point on the separately derived system from the source to the first system disconnecting means or overcurrent device, or it shall be made at the source of a separately derived system that has no disconnecting means or overcurrent devices, in accordance with 350.30(A)(1)(a) or (A)(1)(b). The system bonding jumper shall remain within the enclosure where it originates. If the source is located outside the building or structure supplied, a system bonding jumper shall be installed at the grounding electrode connection in compliance with 350.30(C).

Exception No. 1: For systems installed in accordance with 450.6, a single system bonding jumper connection to the tie point of the grounded circuit conductors from each power source shall be permitted.

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Exception No. 2: If a building or structure is supplied by a feeder from an outdoor separately derived system, a system bonding jumper at both the source and the first disconnecting means shall be permitted if doing so does not establish a parallel path for the grounded conductor. If a grounded conductor is used in this manner, it shall not be smaller than the size specified for the system bonding jumper but shall not be required to be larger than the ungrounded conductor(s). For the purposes of this exception, connection through the earth shall not be considered as providing a parallel path.

~~*Exception No. 3: The size of the system bonding jumper for a system that supplies a Class 1, Class 2, or Class 3 circuit, and is derived from a transformer rated not more than 1000 volt-amperes, shall not be smaller than the derived ungrounded conductors and shall not be smaller than 14 AWG copper or 12 AWG aluminum.*~~

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(a) *Installed at the Source.* The system bonding jumper shall connect the grounded conductor to the supply-side bonding jumper and the normally non-current-carrying metal enclosure.

(b) *Installed at the First Disconnecting Means.* The system bonding jumper shall connect the grounded conductor to the supply-side bonding jumper, the disconnecting means enclosure, and the equipment grounding conductor(s).

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Exception: Separately derived systems consisting of multiple sources of the same type that are connected in parallel shall be permitted to have the system bonding jumper installed at the paralleling switchgear, switchboard, or other paralleling connection point instead of at the disconnecting means located at each separate source.

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(2) Supply-Side Bonding Jumper.

If the source of a separately derived system and the first disconnecting means are located in separate enclosures, a supply-side bonding jumper shall be installed with the circuit conductors from the source enclosure to the first disconnecting means enclosure. A supply-side bonding jumper shall not be required to be larger than the derived ungrounded conductors. The supply-side bonding jumper shall be permitted to be of nonflexible metal raceway type or of the wire or bus type as follows:

(1) A supply-side bonding jumper of the wire type shall comply with 350.102(C), based on the size of the derived ungrounded conductors.

(2) A supply-side bonding jumper of the bus type shall have a cross-sectional area not smaller than a supply-side bonding jumper of the wire type as determined in 350.102(C).

Exception: A supply-side bonding jumper shall not be required between enclosures for installations made in compliance with 350.30(A)(1), Exception No. 2.

(3) Grounded Conductor.

If a grounded conductor is installed and the system bonding jumper connection is not located at the source, 350.30(A)(3)(a) through (A)(3)(d) shall apply. The grounded conductor shall not be required to be larger than the derived ungrounded conductors.

(a) *Sizing for a Single Raceway.* The grounded conductor shall not be smaller than specified in Table 350.102(C)(1).

(b) *Conductors Connected in Parallel in Two or More Raceways or Cables.* If the ungrounded conductors are connected in parallel in two or more raceways or cables, the grounded conductors shall also be installed in each raceway or cable and shall be connected in parallel. The size of the grounded conductor(s) in each raceway or cable shall be based on the largest derived ungrounded conductor in each raceway or cable, or the sum of the circular mil areas of the largest derived ungrounded conductors from each set connected in parallel in each raceway or cable, in accordance with 350.30(A)(3)(a), but not smaller than 1/0 AWG.

Informational Note: See 310.10(G) for grounded conductors connected in parallel.

(c) *Delta-Connected System.* The grounded conductor of a 3-phase, 3-wire delta system shall have an ampacity not less than that of the ungrounded conductors.

(d) *Impedance Grounded System.* The impedance grounding conductor of an impedance grounded system shall be installed in accordance with ~~350.36 or~~ 350.187~~, as applicable~~.

(4) Grounding Electrode.

The building or structure grounding electrode system shall be used as the grounding electrode for the separately derived system. If located outdoors, the grounding electrode shall be in accordance with 350.30(C).

Exception: If a separately derived system originates in equipment that is listed and identified as suitable for use as service equipment, the grounding electrode used for the service or feeder equipment shall be permitted to be used as the grounding electrode for the separately derived system.

Informational Note No. 1: See 350.104(D) for bonding requirements for interior metal water piping in the area served by separately derived systems.

Informational Note No. 2: See 350.50 and 350.58 for requirements for bonding all electrodes together if located at the same building or structure.

(5) Grounding Electrode Conductor, Single Separately Derived System.

A grounding electrode conductor for a single separately derived system shall be sized in accordance with 350.66 for the derived ungrounded conductors. It shall be used to connect the grounded conductor of the derived system to the grounding electrode in accordance with 350.30(A)(4), or as permitted in 350.68(C)(1) and (C)(2). This connection shall be made at the same point on the separately derived system where the system bonding jumper is connected.

Exception No. 1: If the system bonding jumper specified in 350.30(A)(1) is a wire or busbar, it shall be permitted to connect the grounding electrode conductor to the equipment grounding terminal, bar, or bus if the equipment grounding terminal, bar, or bus is of sufficient size for the separately derived system.

Exception No. 2: If the source of a separately derived system is located within equipment listed and identified as suitable for use as service equipment, the grounding electrode conductor from the service or feeder equipment to the grounding electrode shall be permitted as the grounding electrode conductor for the separately derived system, if the grounding electrode conductor is of sufficient size for the separately derived system. If the equipment grounding bus internal to the equipment is not smaller than the required grounding electrode conductor for the separately derived system, the grounding electrode connection for the separately derived system shall be permitted to be made to the bus.

~~*Exception No. 3: A grounding electrode conductor shall not be required for a system that supplies a Class 1, Class 2, or Class 3 circuit and is derived from a transformer rated not more than 1000 volt-amperes, provided the grounded conductor is bonded to the transformer frame or enclosure by a jumper sized in accordance with 350.30(A)(1), Exception No. 3, and the transformer frame or enclosure is grounded by one of the means specified in 350.134.*~~

(6) Grounding Electrode Conductor, Multiple Separately Derived Systems.

A common grounding electrode conductor for multiple separately derived systems shall be permitted. If installed, the common grounding electrode conductor shall be used to connect the grounded conductor of each separately derived system to the grounding electrode as specified in 350.30(A)(4). A grounding electrode conductor tap shall then be installed from each separately derived system to the common grounding electrode conductor. Each tap conductor shall connect the grounded conductor of the separately derived system to the common grounding electrode conductor. This connection shall be made at the same point on the separately derived system where the system bonding jumper is connected.

Exception No. 1: If the system bonding jumper specified in 350.30(A)(1) is a wire or busbar, it shall be permitted to connect the grounding electrode conductor tap to the equipment grounding terminal, bar, or bus, provided the equipment grounding terminal, bar, or bus is of sufficient size for the separately derived system.

~~*Exception No. 2: A grounding electrode conductor shall not be required for a system that supplies a Class 1, Class 2, or Class 3 circuit and is derived from a transformer rated not more than 1000 volt-amperes, provided the system grounded conductor is bonded to the transformer frame or enclosure by a jumper sized in accordance with 350.30(A)(1), Exception No. 3, and the transformer frame or enclosure is grounded by one of the means specified in 350.134.*~~

Exception No. 3: If the source of a separately derived system is located within equipment listed and identified as suitable for use as service equipment, the grounding electrode conductor from the service or feeder equipment to the grounding electrode shall be permitted as the grounding electrode conductor for the separately derived system, if the grounding electrode conductor is of sufficient size for the separately derived system. If the equipment grounding bus internal to the equipment is not smaller than the required grounding electrode conductor for the separately derived system, the grounding electrode connection for the separately derived system shall be permitted to be made to the bus.

(a) *Common Grounding Electrode Conductor.* The common grounding electrode conductor shall be permitted to be one of the following:

(1) A conductor of the wire type not smaller than 3/0 AWG copper or 350 kcmil aluminum

(2) A metal water pipe in accordance with 350.68(C)(1)

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    (3) The metal structural frame of the building or structure in accordance with 350.68(C)(2) or is connected to the grounding electrode system by a conductor not smaller than 3/0 AWG copper or 350 kcmil aluminum

(b) *Tap Conductor Size.* Each tap conductor shall be sized in accordance with 350.66 based on the derived ungrounded conductors of the separately derived system it serves.

Exception to (a)(1) and (b): If the only electrodes that are present are of the types in 350.66(A), (B), or (C), the size of the common grounding electrode conductor shall not be required to be larger than the largest conductor required by 350.66(A), (B), or (C) for the type of electrode that is present.

(c) *Connections.* All tap connections to the common grounding electrode conductor shall be made at an accessible location by one of the following methods:

    (1) A connector listed as grounding and bonding equipment.

    (2) Listed connections to aluminum or copper busbars not smaller than 6 mm thick × 50 mm wide (1⁄4 in. thick × 2 in. wide) and of a length to accommodate the number of terminations necessary for the installation. If aluminum busbars are used, the installation shall also be in accordance with 350.64(A).

    (3) The exothermic welding process.

Tap conductors shall be connected to the common grounding electrode conductor in such a manner that the common grounding electrode conductor remains without a splice or joint.

(7) Installation.

The installation of all grounding electrode conductors shall comply with 350.64(A), (B), (C), and (E).

(8) Bonding.

Structural steel and metal piping shall be connected to the grounded conductor of a separately derived system in accordance with 350.104(D).

(B) Ungrounded Systems.

The equipment of an ungrounded separately derived system shall be grounded and bonded as specified in 350.30(B)(1) through (B)(3).

(1) Grounding Electrode Conductor.

A grounding electrode conductor, sized in accordance with 350.66 for the largest derived ungrounded conductor(s) or set of derived ungrounded conductors, shall be used to connect the metal enclosures of the derived system to the grounding electrode as specified in 350.30(A)(5) or (A)(6), as applicable. This connection shall be made at any point on the separately derived system from the source to the first system disconnecting means. If the source is located outside the building or structure supplied, a grounding electrode connection shall be made in compliance with 350.30(C).

(2) Grounding Electrode.

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Except as permitted by 350.34 for portable and vehicle-mounted generators, the grounding electrode shall comply with 350.30(A)(4).

(3) Bonding Path and Conductor.

A supply-side bonding jumper shall be installed from the source of a separately derived system to the first disconnecting means in compliance with 350.30(A)(2).

(C) Outdoor Source.

If the source of the separately derived system is located outside the building or structure supplied, a grounding electrode connection shall be made at the source location to one or more grounding electrodes in accordance with 350.50. In addition, the installation shall be in accordance with 350.30(A) for grounded systems or with 350.30(B) for ungrounded systems.

Exception: The grounding electrode conductor connection for impedance grounded systems shall be in accordance with ~~350.36 or~~ 350.187~~, as applicable~~.

350.32 Buildings or Structures Supplied by a Feeder(s) or Branch Circuit(s).

(A) Grounding Electrode System and Grounding Electrode Conductor.

A building(s) or structure(s) supplied by a feeder(s) or branch circuit(s) shall have a grounding electrode system and grounding electrode conductor installed in accordance with Part III of Article 350.

Exception: A grounding electrode system and grounding electrode conductor shall not be required if only a single branch circuit, including a multiwire branch circuit, supplies the building or structure and the branch circuit includes an equipment grounding conductor for grounding the normally non-current-carrying metal parts of equipment.

(B) Grounded Systems.

(1) Supplied by a Feeder or Branch Circuit.

An equipment grounding conductor, as described in 350.118, shall be run with the supply conductors and be connected to the building or structure disconnecting means and to the grounding electrode(s). The equipment grounding conductor shall be used for grounding or bonding of equipment, structures, or frames required to be grounded or bonded. The equipment grounding conductor shall be sized in accordance with 350.122. Any installed grounded conductor shall not be connected to the equipment grounding conductor or to the grounding electrode(s).

Exception No. 1: For installations made in compliance with previous editions of this Code that permitted such connection, the grounded conductor run with the supply to the building or structure shall be permitted to serve as the ground-fault return path if all of the following requirements continue to be met:

(1) An equipment grounding conductor is not run with the supply to the building or structure.

(2) There are no continuous metallic paths bonded to the grounding system in each building or structure involved.

(3) Ground-fault protection of equipment has not been installed on the supply side of the feeder(s).

If the grounded conductor is used for grounding in accordance with the provision of this exception, the size of the grounded conductor shall not be smaller than the larger of either of the following:

(1) *The calculated neutral load in accordance with 220.61*

(2) *The minimum equipment grounding conductor sized in accordance with 350.122*

Exception No. 2: If system bonding jumpers are installed in accordance with 350.30(A)(1), Exception No. 2, the feeder grounded circuit conductor at the building or structure served shall be connected to the equipment grounding conductors, grounding electrode conductor, and the enclosure for the first disconnecting means.

(2) Supplied by Separately Derived System.

(a) *With Overcurrent Protection.* If overcurrent protection is provided where the conductors originate, the installation shall comply with 350.32(B)(1).

(b) *Without Overcurrent Protection.* If overcurrent protection is not provided where the conductors originate, the installation shall comply with 350.30(A). If installed, the supply-side bonding jumper shall be connected to the building or structure disconnecting means and to the grounding electrode(s).

(C) Ungrounded Systems.

(1) Supplied by a Feeder or Branch Circuit.

An equipment grounding conductor, as described in 350.118, shall be installed with the supply conductors and be connected to the building or structure disconnecting means and to the grounding electrode(s). The grounding electrode(s) shall also be connected to the building or structure disconnecting means.

(2) Supplied by a Separately Derived System.

(a) *With Overcurrent Protection.* If overcurrent protection is provided where the conductors originate, the installation shall comply with 350.32(C)(1).

(b) *Without Overcurrent Protection.* If overcurrent protection is not provided where the conductors originate, the installation shall comply with 350.30(B). If installed, the supply-side bonding jumper shall be connected to the building or structure disconnecting means and to the grounding electrode(s).

(D) Disconnecting Means Located in Separate Building or Structure on the Same Premises.

If one or more disconnecting means supply one or more additional buildings or structures under single management, and where these disconnecting means are located remote from those buildings or structures in accordance with 225.31(B), Exception No. 1 and No. 2, 700.12(D)(4), 701.12(D)(3), or 702.12, all of the following conditions shall be met:

(1) The connection of the grounded conductor to the grounding electrode, to normally non-current-carrying metal parts of equipment, or to the equipment grounding conductor at a separate building or structure shall not be made.

(2) An equipment grounding conductor for grounding and bonding any normally non-current-carrying metal parts of equipment, interior metal piping systems, and building or structural metal frames is run with the circuit conductors to a separate building or structure and connected to existing grounding electrode(s) required in Part III of this article, or, if there are no existing electrodes, the grounding electrode(s) required in Part III of this article shall be installed if a separate building or structure is supplied by more than one branch circuit.

(3) The connection between the equipment grounding conductor and the grounding electrode at a separate building or structure shall be made in a junction box, panelboard, or similar enclosure located immediately inside or outside the separate building or structure.

(E) Grounding Electrode Conductor.

The size of the grounding electrode conductor to the grounding electrode(s) shall not be smaller than given in 350.66, based on the largest ungrounded supply conductor. The installation shall comply with Part III of this article.

350.34 Portable, Vehicle-Mounted, and Trailer-Mounted Generators.

(A) Portable Generators.

The frame of a portable generator shall not be required to be connected to a grounding electrode as defined in 350.52 for a system supplied by the generator under both of the following conditions:

(1) The generator supplies only equipment mounted on the generator, cord-and-plug-connected equipment through receptacles mounted on the generator, or both.

(2) The normally non-current-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are connected to the generator frame.

(B) Vehicle-Mounted and Trailer-Mounted Generators.

The frame of a vehicle or trailer shall not be required to be connected to a grounding electrode as defined in 350.52 for a system supplied by a generator located on this vehicle or trailer under all of the following conditions:

(1) The frame of the generator is bonded to the vehicle or trailer frame.

(2) The generator supplies only equipment located on the vehicle or trailer; cord-and-plug-connected equipment through receptacles mounted on the vehicle; or both equipment located on the vehicle or trailer and cord-and-plug-connected equipment through receptacles mounted on the vehicle, trailer, or on the generator.

(3) The normally non-current-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are connected to the generator frame.

(C) Grounded Conductor Bonding.

A conductor that is required to be grounded by 350.26 shall be connected to the generator frame if the generator is a component of a separately derived system.

Informational Note: See 350.30 for grounding portable generators supplying fixed wiring systems.

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Feeding portable equipment is handled by 350.188 and feeding systems is handled by 350.30

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350.35 Permanently Installed Generators.

A conductor that provides an effective ground-fault current path shall be installed with the supply conductors from a permanently installed generator(s) to the first disconnecting mean(s) in accordance with 350.35(A) or (B).

(A) Separately Derived System.

If the generator is installed as a separately derived system, the requirements in 350.30 shall apply.

(B) Non~~separately Derived System.~~-integral overcurrent protection.

Commented [ES15]: This section deals with non-integral overcurrent protection. The fact that it is also non-separately derived is secondary to the section.

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If the generator is installed as a nonseparately derived system, and overcurrent protection is not integral with the generator assembly, a supply-side bonding jumper shall be installed between the generator equipment grounding terminal and the equipment grounding terminal, bar, or bus of the disconnecting mean(s) where the overcurrent protective device is located. It shall be sized in accordance with 350.102(C) based on the size of the conductors supplied by the generator.

350.36 Impedance Grounded Systems — Over 1000 Volts ac or 1500 volts dc.

Impedance grounded systems in which a grounding impedance device, typically a resistor, limits the ground-fault current shall be permitted for 3-phase ac systems ~~of 480 volts to 1000 volt~~ if all the following conditions are met:

(1) The conditions of maintenance and supervision ensure that only qualified persons service the installation.

(2) Ground detectors are installed on the system.

(3) Line-to-neutral loads are not served.

Impedance grounded systems shall comply with 350.36(A) through (G).

~~Informational Note: See NFPA *70E-2021, Standard for Electrical Safety in the Workplace*, Annex O, for information on impedance grounding to reduce arc-flash hazards.~~

(A) Location.

The grounding impedance device shall be installed between the effective ground-fault current path~~grounding electrode conductor~~ and the impedance grounding conductor connected to the system neutral point. If a neutral point is not available, the grounding impedance shall be installed between the ~~grounding electrode~~effective ground-fault current path ~~conductor~~ and the impedance grounding conductor connected to the neutral point derived from a grounding transformer.

(B) Impedance Grounding Conductor Insulation and Ampacity.

The impedance grounding conductor from the neutral point of the transformer or generator to its connection point to the grounding impedance shall be fully insulated.

The impedance grounding conductor shall have an ampacity of not less than the maximum current rating of the grounding impedance but in no case shall the impedance grounding conductor be smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum.

(C) System Grounding Connection.

The system shall not be connected to ground except through the grounding impedance device.

Informational Note: The impedance is normally selected to limit the ground-fault current to a value slightly greater than or equal to the capacitive charging current of the system. This value of impedance will also limit transient overvoltages to safe values. For guidance, refer to criteria for limiting transient overvoltages in IEEE 3003.1-2019, *Recommended Practice for System Grounding of Industrial and Commercial Power Systems*.

(D) Impedance Grounding Conductor Routing.

The impedance grounding conductor shall be permitted to be installed in a separate raceway from the ungrounded conductors. It shall not be required to run this conductor with the phase conductors to the first system disconnecting means or overcurrent device.

(E) Impedance Bonding Jumper.

The impedance bonding jumper (the connection between the equipment grounding conductors and the grounding impedance device) shall be an unspliced conductor run from the first system disconnecting means or overcurrent device to the grounded side of the grounding impedance device.

(F) Grounding Electrode Conductor Connection Location.

Commented [ES16]: One thought is to move .187 to .36. That way, all the 'grounding' of the system stays in the same place.

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Commented [ES17]: This can be deleted, since it repeats the scope of the article

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Commented [ES18]: The intent here is that the bottom side of the resistor is connected to the system of enclosures and raceways. Where the GEC is connected has no effect on fault current.

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For services or separately derived systems, the grounding electrode conductor shall be connected at any point from the grounded side of the grounding impedance device to the equipment grounding connection at the service equipment or the first system disconnecting means of a separately derived system.

(G) Impedance Bonding Jumper Size.

The impedance bonding jumper shall be sized the same as the impedance grounding conductor in 350.36(B)~~in accordance with either of the following~~:

~~(1) If the grounding electrode conductor connection is made at the grounding impedance device, the equipment bonding jumper shall be sized in accordance with 350.66, based on the size of the service entrance conductors for a service or the derived phase conductors for a separately derived system.~~

~~(2) If the grounding electrode conductor is connected at the first system disconnecting means or overcurrent device, the impedance bonding jumper shall be sized the same as the impedance grounding conductor in 350.36(B).~~

Commented [ES19]: It doesn't matter where the GEC is connected. If the fault is in the transformer secondary, the resistor enclosure, or anywhere on the system, the fault is limited by the resistor.

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Commented [ES20]: I don't know why this would make a difference. My idea is to delete (1) and just make the requirement to follow 350.36(B).
It doesn't matter where the GEC is connected. If the fault is in the transformer secondary, the resistor enclosure, or anywhere on the system, the fault is limited by the resistor.

Part III. Grounding Electrode System and Grounding Electrode Conductor

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350.50 Grounding Electrode System.
All grounding electrodes as described in 350.52(A)(1) through (A)(8~~7~~) that are present at each building or structure served shall be bonded together to form the grounding electrode system. If none of these grounding electrodes exist, one or more of the grounding electrodes specified in 350.52(A)(4) through (A)(8) shall be installed and used.
Exception: Concrete-encased electrodes of existing buildings or structures shall not be required to be part of the grounding electrode system if the rebar is not accessible for use without disturbing the concrete.

350.52 Grounding Electrodes.

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(A) Electrodes Permitted for Grounding.

(1) Metal Underground Water Pipe.
A metal underground water pipe in direct contact with the earth for 3.0 m (10 ft) or more (including any metal well casing bonded to the pipe) and electrically continuous (or made electrically continuous by bonding around insulating joints or insulating pipe) to the points of connection of the grounding electrode conductor and the bonding conductor(s) or jumper(s), if installed.

(2) Metal In-ground Support Structure(s).
One or more metal in-ground support structure(s) in direct contact with the earth vertically for 3.0 m (10 ft) or more, with or without concrete encasement. If multiple metal in-ground support structures are present at a building or a structure, it shall be permissible to bond only one into the grounding electrode system.
Informational Note: Metal in-ground support structures include, but are not limited to, pilings, casings, and other structural metal.

(3) Concrete-Encased Electrode.
A concrete-encased electrode shall consist of at least 6.0 m (20 ft) of either of the following:

(1) One or more bare or zinc galvanized or other electrically conductive coated rebar of not less than 13 mm (1/2 in.) in diameter, installed in one continuous 6.0 m (20 ft) length, or if in multiple pieces, the rebar shall be connected together by steel tie wires, exothermic welding, welding, or other effective means to create a 6.0 m (20 ft) or greater length

(2) Bare copper conductor not smaller than 4 AWG

Metal components shall be encased by at least 50 mm (2 in.) of concrete and shall be located horizontally within that portion of a concrete foundation or footing that is in direct contact with the earth or within vertical foundations or structural components or members that are in direct contact with the earth. If multiple concrete-encased electrodes are present at a building or structure, it shall be permissible to bond only one into the grounding electrode system.
Informational Note: Concrete installed with insulation, vapor barriers, films, or similar items separating the concrete from the earth is not considered to be in "direct contact" with the earth.

(4) Ground Ring.
A ground ring encircling the building or structure, in direct contact with the earth, consisting of at least 6.0 m (20 ft) of bare copper conductor not smaller than 2 AWG.

~~*Exception: A ground ring shall not be required to encircle a building or structure if the service is remote from a building or structure.*~~

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(5) Rod and Pipe Electrodes.
Rod and pipe electrodes shall not be less than 2.44 m (8 ft) in length and consist of the following materials.

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(1) Grounding electrodes of pipe or conduit shall not be smaller than metric designator 21 (trade size 3/4) and, where of steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

(2) Rod-type grounding electrodes of stainless steel and copper or zinc-coated steel shall be at least 15.87 mm (5/8 in.) in diameter, unless listed.

(6) Other Listed Electrodes.
Other listed grounding electrodes shall be permitted.

(7) Plate Electrodes.
Each plate electrode shall expose not less than 0.186 m^2 (2 ft^2) of surface to exterior soil. Electrodes of bare or electrically conductive coated iron or steel plates shall be at least 6.4 mm (1/4 in.) in thickness. Solid, uncoated electrodes of nonferrous metal shall be at least 1.5 mm (0.06 in.) in thickness.

(8) Ground Grid – (Description to follow with more details)

(9~~8~~) Other Local Metal Underground Systems or Structures.
Other local metal underground systems or structures such as piping systems, underground tanks, and underground metal well casings that are not bonded to a metal water pipe.

(B) Not Permitted for Use as Grounding Electrodes.
The following systems and materials shall not be used as grounding electrodes:

(1) Metal underground gas piping systems

(2) Aluminum

(3) The structures and structural rebar described in 680.26(B)(1) and (B)(2)

Informational Note: See 350.104(B) for bonding requirements of gas piping.

350.53 Grounding Electrode System Installation.

(A) Rod, Pipe, and Plate Electrodes.
Rod, pipe, and plate electrodes shall be free from nonconductive coatings such as paint or enamel. Rod, pipe, and plate electrodes shall meet the requirements of 350.53(A)(1) through (A)(3).

(1) Below Permanent Moisture Level.
If practicable, rod, pipe, and plate electrodes shall be embedded below permanent moisture level.

(2) Supplemental Electrode Required.
A single rod, pipe, or plate electrode shall be supplemented by an additional electrode of a type specified in 350.52(A)(2) through (A)(8). The supplemental electrode shall be permitted to be bonded to one of the following:

(1) Rod, pipe, or plate electrode

(2) Grounding electrode conductor

(3) Grounded service-entrance conductor

(4) Nonflexible grounded service raceway

(5) Any grounded service enclosure

Exception: If a single rod, pipe, or plate grounding electrode has a resistance to earth of 25 ohms or less, the supplemental electrode shall not be required.

(3) Supplemental Electrode.
If multiple rod, pipe, or plate electrodes are installed to meet the requirements of this section, they shall not be less than 1.8 m (6 ft) apart.

Informational Note: The paralleling efficiency of rods is increased by spacing them twice the length of the longest rod.

(4) Rod and Pipe Electrodes.
The electrode shall be installed such that at least 2.44 m (8 ft) of length is in contact with the soil. It shall be driven to a depth of not less than 2.44 m (8 ft) except that, where rock bottom is encountered, the electrode shall be driven at an oblique angle not to exceed 45 degrees from the vertical or, where rock bottom is encountered at an angle up to 45 degrees, the electrode shall be permitted to be buried in a trench that is at least 750 mm (30 in.) deep. The upper end of the electrode shall be flush with or below ground level unless the aboveground end and the grounding electrode conductor attachment are protected against physical damage as specified in 350.10.

(5) Plate Electrode.
Plate electrodes shall be installed not less than 750 mm (30 in.) below the surface of the earth.

(B) Electrode Spacing.
If more than one of the electrodes of the type specified in 350.52(A)(5) or (A)(7) are used, each electrode of one grounding system (including that used for strike termination devices) shall not be less than 1.83 m (6 ft) from any other electrode of another grounding system.

(C) Bonding Jumper.
The bonding jumper(s) used to connect the grounding electrodes together to form the grounding electrode system shall be installed in accordance with 350.64(A), (B), and (E), shall be sized in accordance with 350.66, and shall be connected in the manner specified in 350.70. Rebar shall not be used as a conductor to interconnect the electrodes of grounding electrode systems.

(D) Metal Underground Water Pipe.
If used as a grounding electrode, metal underground water pipe shall meet the requirements of 350.53(D)(1) and (D)(2).

(1) Continuity.
Continuity of the grounding path or the bonding connection to interior piping shall not rely on water meters or filtering devices and similar equipment.

(2) Supplemental Electrode Required.
A metal underground water pipe shall be supplemented by an additional electrode of a type specified in 350.52(A)(2) through (A)(8). If the supplemental electrode is of the rod, pipe, or plate type, it shall comply with 350.53(A). The supplemental electrode shall be bonded to one of the following:

(1) Grounding electrode conductor

(2) Grounded service-entrance conductor

(3) Nonflexible grounded service raceway

(4) Any grounded service enclosure

(5) As provided by 350.32(B)

Exception: The supplemental electrode shall be permitted to be bonded to the interior metal water piping as specified in 350.68(C)(1).

(E) Supplemental Grounding Electrode Bonding Jumper Size.
If the supplemental electrode is a rod, pipe, or plate electrode, that portion of the bonding jumper that is the sole connection to the supplemental grounding electrode shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum or copper-clad aluminum wire.

(F) Ground Ring.
The ground ring shall be installed not less than 750 mm (30 in.) below the surface of the earth.

350.54 Auxiliary Grounding Electrodes.
One or more grounding electrodes shall be permitted to be connected to the equipment grounding conductors specified in 350.118 and shall not be required to comply with the electrode bonding requirements of 350.50 or 350.53(C) or the resistance requirements of 350.53(A)(2) Exception, but the earth shall not be used as an effective ground-fault current path as specified in 350.4(A)(5) and (B)(4).

350.58 Common Grounding Electrode.
If an ac system is connected to a grounding electrode in or at a building or structure, the same electrode shall be used to ground conductor enclosures and equipment in or on that building or structure. If separate services, feeders, or branch circuits supply a building and are required to be connected to a grounding electrode(s), the same grounding electrode(s) shall be used.

350.60 Use of Strike Termination Devices.
Conductors and driven pipes, rods, or plate electrodes used for grounding strike termination devices shall not be used in lieu of the grounding electrodes required by 350.50 for grounding wiring systems and equipment. This provision shall not prohibit the required bonding together of grounding electrodes of different systems.

Informational Note No. 1: See 350.106 for the bonding requirement of the lightning protection system components to the building or structure grounding electrode system.

Informational Note No. 2: Bonding together of all separate grounding electrodes will limit voltage differences between them and between their associated wiring systems.

350.62 Grounding Electrode Conductor Material.
The grounding electrode conductor shall be of copper, aluminum, copper-clad aluminum, or the items as permitted in 350.68(C). The material selected shall be resistant to any corrosive condition existing at the installation or shall be protected against corrosion. Conductors of the wire type shall be solid or stranded, insulated, covered, or bare.

350.64 Grounding Electrode Conductor Installation.
Grounding electrode conductors at the service, at each building or structure where supplied by a feeder(s) or branch circuit(s), or at a separately derived system shall be installed as specified in 350.64(A) through (G).

(A) Aluminum or Copper-Clad Aluminum Conductors.
Grounding electrode conductors of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following:

(1) Bare or covered conductors without an extruded polymeric covering shall not be installed where subject to corrosive conditions or be installed in direct contact with concrete.

(2) Terminations made within outdoor enclosures that are listed and identified for the environment shall be permitted within 450 mm (18 in.) of the bottom of the enclosure.

(3) Aluminum or copper-clad aluminum conductors external to buildings or equipment enclosures shall not be terminated within 450 mm (18 in.) of the earth.

(B) Securing and Protection Against Physical Damage.
If exposed, a grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried. Grounding electrode conductors shall be permitted to be installed on or through framing members.

(1) Not Exposed to Physical Damage.
A 6 AWG or larger copper, copper-clad aluminum, or aluminum grounding electrode conductor not exposed to physical damage shall be permitted to be run along the surface of the building construction without metal covering or protection.

(2) Exposed to Physical Damage.
A 6 AWG or larger copper, copper-clad aluminum, or aluminum grounding electrode conductor exposed to physical damage shall be protected in rigid metal conduit (RMC), intermediate metal conduit (IMC), Schedule 80 rigid polyvinyl chloride conduit (PVC), reinforced thermosetting resin conduit Type XW (RTRC-XW), electrical metallic tubing (EMT), or cable armor.

(3) Smaller Than 6 AWG.
Grounding electrode conductors smaller than 6 AWG shall be protected in RMC, IMC, Schedule 80 PVC, RTRC-XW, EMT, or cable armor.

(4) In Contact with the Earth.
Grounding electrode conductors and grounding electrode bonding jumpers in contact with the earth shall not be required to comply with 300.5 or 305.15, but shall be buried or otherwise protected if subject to physical damage.

(C) Continuous.
Except as provided in 350.30(A)(5) and (A)(6), 350.30(B)(1), and 350.68(C), grounding electrode conductor(s) shall be installed in one continuous length without a splice or joint. If necessary, splices or connections shall be made as permitted in the following:

(1) Splicing of the wire-type grounding electrode conductor shall be permitted only by irreversible compression-type connectors listed as grounding and bonding equipment or by the exothermic welding process.

(2) Sections of busbars shall be permitted to be connected together to form a grounding electrode conductor.

(3) Bolted, riveted, or welded connections of structural metal frames of buildings or structures.

(4) Threaded, welded, brazed, soldered or bolted-flange connections of metal water piping.

(D) Building or Structure with Multiple Disconnecting Means in Separate Enclosures.
If a building or structure is supplied by a service or feeder with two or more disconnecting means in separate enclosures, the grounding electrode connections shall be made in accordance with 350.64(D)(1), (D)(2), or (D)(3).

(1) Common Grounding Electrode Conductor and Taps.
A common grounding electrode conductor and grounding electrode conductor taps shall be installed. The common grounding electrode conductor shall be sized in accordance with 350.66, based on the sum of the circular mil area of the largest ungrounded conductor(s) of each set of conductors that supplies the disconnecting means. If the service-entrance conductors connect directly to the overhead service conductors, service drop, underground service conductors, or service lateral, the common grounding electrode conductor shall be sized in accordance with Table 350.66, note 1.

A grounding electrode conductor tap shall extend to the inside of each disconnecting means enclosure. The grounding electrode conductor taps shall be sized in accordance with 350.66 for the largest service-entrance or feeder conductor serving the individual enclosure. The tap conductors shall be connected to the common grounding electrode conductor by one of the following methods in such a manner that the common grounding electrode conductor remains without a splice or joint:

(1) Exothermic welding.

(2) Connectors listed as grounding and bonding equipment.

(3) Connections to an aluminum or copper busbar not less than 6 mm thick × 50 mm wide (1/4 in. thick × 2 in. wide) and of a length to accommodate the number of terminations necessary for the installation. The busbar shall be securely fastened and shall be installed in an accessible location. Connections shall be made by a listed connector or by the exothermic welding process. If aluminum busbars are used, the installation shall comply with 350.64(A).

(2) Individual Grounding Electrode Conductors.
A grounding electrode conductor shall be connected between the grounding electrode system and one or more of the following, as applicable:

(1) Grounded conductor in each service equipment disconnecting means enclosure

(2) Equipment grounding conductor installed with the feeder(s) or branch circuit(s) for other than services

(3) Supply-side bonding jumper

Each grounding electrode conductor shall be sized in accordance with 350.66 based on the service-entrance or feeder conductor(s) supplying the individual disconnecting means.

(3) Common Location.

A grounding electrode conductor shall be connected in a wireway or other accessible enclosure on the supply side of the disconnecting means to one or more of the following, as applicable:

(1) Grounded service conductor(s)

(2) Equipment grounding conductor installed with the feeder

(3) Supply-side bonding jumper

The connection shall be made with exothermic welding or a connector listed as grounding and bonding equipment. The grounding electrode conductor shall be sized in accordance with 350.66 based on the service-entrance or feeder conductor(s) at the common location where the connection is made.

(E) Raceways, Cable Armor, and Enclosures for Grounding Electrode Conductors.

(1) General.

Ferrous metal raceways, enclosures, and cable armor for grounding electrode conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode and shall be securely fastened to the ground clamp or fitting. Ferrous metal raceways, enclosures, and cable armor shall be bonded at each end of the raceway or enclosure to the grounding electrode or grounding electrode conductor to create an electrically parallel path. Nonferrous metal raceways, enclosures, and cable armor shall not be required to be electrically continuous.

(2) Methods.

Bonding shall be in compliance with 350.92(B) and ensured by one of the methods in 350.92(B)(2) through (B)(4).

(3) Size.

The bonding jumper for a grounding electrode conductor(s), raceway(s), enclosure(s), or cable armor shall be the same size as, or larger than, the largest enclosed grounding electrode conductor.

(4) Wiring Methods.

If a raceway is used as protection for a grounding electrode conductor, the installation shall comply with the requirements of the applicable raceway article.

(F) Installation to Electrode(s).

Grounding electrode conductor(s) and bonding jumpers interconnecting grounding electrodes shall be installed in accordance with one of the following. The grounding electrode conductor shall be sized for the largest grounding electrode conductor required among all the electrodes connected to it.

(1) The grounding electrode conductor shall be permitted to be run to any convenient grounding electrode available in the grounding electrode system where the other electrode(s), if any, is connected by bonding jumpers that are installed in accordance with 350.53(C).

(2) Grounding electrode conductor(s) shall be permitted to be run to one or more grounding electrode(s) individually.

(3) Bonding jumper(s) from grounding electrode(s) shall be permitted to be connected to an aluminum or copper busbar not less than 6 mm thick × 50 mm wide (1⁄4 in. thick × 2 in wide.) and of sufficient length to accommodate the number of terminations necessary for the installation. The busbar shall be securely fastened and shall be installed in an accessible location. Connections shall be made by a listed connector or by the exothermic welding process. The grounding electrode conductor shall be permitted to be run to the busbar. Where aluminum busbars are used, the installation shall comply with 350.64(A).

(G) Enclosures with Ventilation Openings.

Grounding electrode conductors shall not be installed through a ventilation opening of an enclosure.

350.66 Size of Alternating-Current Grounding Electrode Conductor.

PI-426-NFPA 70-2023 submitted by [Eric Stromberg] on Sat Mar 04 17:08:49 EST 2023 **SUBMITTED**

View	Public Input No. 426-NFPA 70-2023 Section No. 350.66 [Excluding any Sub-Sections] Committee: NEC-AAC

The size of the grounding electrode conductor and bonding jumper(s) for connection of grounding electrodes shall not be smaller than given in Table 350.66, except as permitted in 350.66(A) through (C).

Table 350.66 Grounding Electrode Conductor for Alternating-Current Systems

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Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	**Aluminum or Copper-Clad Aluminum**	**Copper**	**Aluminum or Copper-Clad Aluminum**
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 350	4	2
Over 3/0 through 350	Over 350 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	350

Notes:
1. If multiple sets of service-entrance conductors connect directly to a service drop, set of overhead service conductors, set of underground service conductors, or service lateral, the equivalent size of the largest service-entrance conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.
2. If there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.
3. See installation restrictions in 350.64.

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(A) Connections to a Rod, Pipe, or Plate Electrode(s).

If the grounding electrode conductor or bonding jumper connected to a single or multiple rod, pipe, or plate electrode(s), or any combination thereof, as described in 350.52(A)(5) or (A)(7), does not extend on to other types of electrodes that require a larger size conductor, the grounding electrode conductor shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum or copper-clad aluminum wire.

(B) Connections to Concrete-Encased Electrodes.

If the grounding electrode conductor or bonding jumper connected to a single or multiple concrete-encased electrode(s), as described in 350.52(A)(3), does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than 4 AWG copper wire.

(C) Connections to Ground Rings.

If the grounding electrode conductor or bonding jumper connected to a ground ring, as described in 350.52(A)(4), does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than the conductor used for the ground ring.

350.68 Grounding Electrode Conductor and Bonding Jumper Connection to Grounding Electrodes.

The connection of a grounding electrode conductor at the service, at each building or structure where supplied by a feeder(s) or branch circuit(s), or at a separately derived system and associated bonding jumper(s) shall be made as specified 350.68(A) through (C).

(A) Accessibility.

All mechanical elements used to terminate a grounding electrode conductor or bonding jumper to a grounding electrode shall be accessible.

Exception No. 1: An encased or buried connection to a concrete-encased, driven, or buried grounding electrode shall not be required to be accessible.

Exception No. 2: Exothermic or irreversible compression connections used at terminations, together with the mechanical means used to attach such terminations to fireproofed structural metal whether or not the mechanical means is reversible, shall not be required to be accessible.

(B) Effective Grounding Path.

The connection of a grounding electrode conductor or bonding jumper to a grounding electrode shall be made in a manner that will ensure an effective grounding path. Where necessary to ensure the grounding path for a metal piping system used as a grounding electrode, bonding shall be provided around insulated joints and around any equipment likely to be disconnected for repairs or replacement. Bonding jumpers shall be of sufficient length to permit removal of such equipment while retaining the integrity of the grounding path.

(C) Grounding Electrode Conductor Connections.

Grounding electrode conductors and bonding jumpers shall be permitted to be connected at the following locations and used to extend the connection to an electrode(s):

(1) Interior metal water piping that is electrically continuous with a metal underground water pipe electrode and is located not more than 1.52 m (5 ft) from the point of entrance to the building, as measured along the water piping, shall be permitted to extend the connection to an electrode(s). Interior metal water piping located more than 1.52 m (5 ft) from the point of entrance to the building, as measured along the water piping, shall not be used as a conductor to interconnect electrodes of the grounding electrode system.

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Exception: In industrial, commercial, and institutional buildings or structures, if conditions of maintenance and supervision ensure that only qualified persons service the installation, interior metal water piping located more than 1.52 m (5 ft) from the point of entrance to the building, as measured along the water piping, shall be permitted as a bonding conductor to interconnect electrodes that are part of the grounding electrode system, or as a grounding electrode conductor, if the entire length, other than short sections passing perpendicularly through walls, floors, or ceilings, of the interior metal water pipe that is being used for the conductor is exposed.

(2) The metal structural frame of a building shall be permitted to be used as a conductor to interconnect electrodes that are part of the grounding electrode system, or as a grounding electrode conductor. Hold-down bolts securing the structural steel column that are connected to a concrete-encased electrode complying with 350.52(A)(3) and located in the support footing or foundation shall be permitted to connect the metal structural frame of a building or structure to the concrete-encased grounding electrode. The hold-down bolts shall be connected to the concrete-encased electrode by welding, exothermic welding, steel tie wires, or other approved means.

(3) A rebar-type concrete-encased electrode installed in accordance with 350.52(A)(3) with an additional rebar section extended from its location within the concrete foundation or footing to an accessible location that is not subject to corrosion shall be permitted for connection of grounding electrode conductors and bonding jumpers in accordance with the following:

a. The additional rebar section shall be continuous with the grounding electrode rebar or shall be connected to the grounding electrode rebar and connected together by steel tie wires, exothermic welding, welding, or other effective means.

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b. The rebar extension shall not be exposed to contact with the earth without corrosion protection.

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c. Rebar shall not be used as a conductor to interconnect the electrodes of grounding electrode systems.

350.70 Methods of Grounding and Bonding Conductor Connection to Electrodes.

(A) General.

The grounding or bonding conductor shall be connected to the grounding electrode by exothermic welding, listed lugs, listed pressure connectors, listed clamps, or other listed means. Connections depending on solder shall not be used. Ground clamps shall be listed for the materials of the grounding electrode and the grounding electrode conductor and, if used on pipe, rod, or other buried electrodes, shall also be listed for direct soil burial or concrete encasement. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting unless the clamp or fitting is listed for multiple conductors.

(B) Indoor Communications Systems.

For indoor communications purposes only, a listed sheet metal strap-type ground clamp having a rigid metal base that seats on the electrode and having a strap of such material and dimensions that it is not likely to stretch during or after installation shall be permitted.

Informational Note: Listed ground clamps that are identified for direct burial are also suitable for concrete encasement.

Part IV. Enclosure, Raceway, and Service Cable Connections

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350.80 Service Raceways and Enclosures.

Metal enclosures and raceways for service conductors and equipment shall be connected to the grounded conductor if the electrical system is grounded or to the grounding electrode conductor for electrical systems that are not grounded.

Exception: Metal components that are installed in a run of underground nonmetallic raceway(s) and are isolated from possible contact by a minimum cover of 450 mm (18 in.) to all parts of the metal components shall not be required to be connected to the grounded conductor, supply-side bonding jumper, or grounding electrode conductor.

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350.84 Underground Service Cable or Raceway.

(A) Underground Service Cable.

The sheath or armor of a continuous underground metal-sheathed or armored service cable system that is connected to the grounded conductor on the supply side shall not be required to be connected to the grounded conductor at the building or structure. The sheath or armor shall be permitted to be insulated from the interior metal raceway or piping.

(B) Underground Service Raceway Containing Cable.

An underground metal service raceway that contains a metal-sheathed or armored cable connected to the grounded conductor shall not be required to be connected to the grounded conductor at the building or structure. The sheath or armor shall be permitted to be insulated from the interior metal raceway or piping.

350.86 Other Conductor Enclosures and Raceways.

~~Except as permitted by 350.112(I),~~ metal enclosures and raceways for other than service conductors shall be connected to the equipment grounding conductor.

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Exception No. 1: Metal enclosures and raceways for conductors added to existing installations of open wire, ~~knob-and-tube wiring~~, and nonmetallic-sheathed cable shall not be required to be connected to the equipment grounding conductor if these enclosures or wiring methods comply with all the following:

1. *Do not provide an equipment ground*
2. *Are in runs of less than 7.5 m (25 ft)*
3. *Are free from probable contact with ground, grounded metal, metal lath, or other conductive material*
4. *Are guarded against contact by persons*

Exception No. 2: Short sections of metal enclosures or raceways used to provide support or protection of cable assemblies from physical damage shall not be required to be connected to the equipment grounding conductor.
Exception No. 3: Metal components shall not be required to be connected to the equipment grounding conductor or supply-side bonding jumper if either of the following conditions exist:

1. *The metal components are installed in a run of nonmetallic raceway(s) and isolated from possible contact by a minimum cover of 450 mm (18 in.) to any part of the metal components.*
2. *The metal components are part of an installation of nonmetallic raceway(s) and are isolated from possible contact to any part of the metal components by being encased in not less than 50 mm (2 in.) of concrete.*

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Part V. Bonding

350.90 General.

Bonding shall be provided if necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

350.92 Services.

(A) Bonding of Equipment for Services.

The normally non-current-carrying metal parts of equipment indicated in the following shall be bonded together:

1. All raceways, cable trays, cablebus framework, auxiliary gutters, or service cable armor or sheath that enclose, contain, or support service conductors, except as permitted in 350.80
2. All enclosures containing service conductors, including meter fittings, boxes, or the like, interposed in the service raceway or armor

(B) Method of Bonding at the Service.

Bonding jumpers meeting the requirements of this article shall be used around impaired connections, such as reducing washers or oversized, concentric, or eccentric knockouts. Standard locknuts or bushings shall not be the only means for the bonding required by this section but shall be permitted to be installed to make a mechanical connection of the raceway(s).

Electrical continuity at service equipment, service raceways, and service conductor enclosures shall be ensured by one or more of the following methods:

1. Bonding equipment to the grounded service conductor by an applicable method in 350.8(A)
2. Connections made up wrenchtight using threaded couplings, threaded entries, or listed threaded hubs on enclosures
3. Threadless couplings and connectors if made up tight for metal raceways and metal-clad cables
4. Other listed devices, such as bonding-type locknuts, bushings, or bushings with bonding jumpers

350.94 Bonding for Communications Systems.

Communications system bonding conductor terminations shall be connected in accordance with 350.94(A) or (B).

(A) The Intersystem Bonding Termination Device.

An intersystem bonding termination (IBT) for connecting intersystem bonding conductors shall be provided external to enclosures at the service equipment or metering equipment enclosure and at the disconnecting means for any buildings or structures that are supplied by a feeder or branch circuit. If an IBT is used, it shall comply with the following:

1. Be accessible for connection and inspection
2. Consist of a set of terminals with the capacity for connection of not less than three intersystem bonding conductors
3. Not interfere with opening the enclosure for a service, building or structure disconnecting means, or metering equipment

(4) Be securely mounted as follows:

- a. At the service equipment, to a metal enclosure for the service equipment, to a metal meter enclosure, or to an exposed nonflexible metal service raceway, or be connected to the metal enclosure for the grounding electrode conductor with a minimum 6 AWG copper conductor

- b. At the disconnecting means for a building or structure that is supplied by a feeder or branch circuit, be electrically connected to the metal enclosure for the building or structure disconnecting means, or be connected to the metal enclosure for the grounding electrode conductor with a minimum 6 AWG copper conductor

(5) Be listed as grounding and bonding equipment

Exception: In existing buildings or structures, if any of the intersystem bonding and grounding electrode conductors required by 770.100(B)(2), 800.100(B)(2), 810.21(F)(2), and 820.100 exist, installation of an IBT shall not be required. An accessible means external to enclosures for connecting intersystem bonding and grounding electrode conductors shall be permitted at the service equipment and at the disconnecting means for any buildings or structures that are supplied by a feeder or branch circuit by at least one of the following means:

(1) Exposed nonflexible metal raceways

(2) An exposed grounding electrode conductor

(3) Approved means for the external connection of a copper or other corrosion-resistant bonding or grounding electrode conductor to the grounded raceway or equipment

Informational Note: See 770.100, 800.100, 810.21, and 820.100 for intersystem bonding and grounding requirements for conductive optical fiber cables, communications circuits, radio and television equipment, CATV circuits, and network-powered broadband communications systems, respectively.

(B) Other Means.

Connections to an aluminum or copper busbar not less than 6 mm thick × 50 mm wide (1/4 in. thick × 2 in. wide) and of a length to accommodate at least three terminations for communication systems in addition to other connections. The busbar shall be securely fastened and shall be installed in an accessible location. Connections shall be made by a listed connector. If aluminum busbars are used, the installation shall also comply with 350.64(A). The busbar shall be connected to the grounding electrode system by a conductor that is the larger of the following:

(1) The largest grounding electrode conductor that is connected to the busbar

(2) As required or permitted in 350.94(A)

Exception to (A) and (B): Means for connecting intersystem bonding conductors are not required if communications systems are not likely to be used in or on the building or structure.

Informational Note: The use of an IBT can reduce electrical noise on communication systems.

350.96 Bonding Other Enclosures.

(A) General.

Metal raceways, cable trays, cable armor, cable sheath, enclosures, frames, fittings, and other metal non-current-carrying parts that are to serve as equipment grounding conductors, with or without the use of wire-type supplementary equipment grounding conductors, shall be bonded if necessary to ensure electrical continuity and the capacity to conduct fault current likely to be imposed on them. Any nonconductive paint, enamel, or similar coating shall be removed at threads, contact points, and contact surfaces or shall be connected by means of fittings designed so as to make such removal unnecessary.

~~**(B) Isolated Grounding Circuits.**~~

~~If installed for the reduction of electromagnetic interference on the grounding circuit, an equipment enclosure supplied by a branch circuit shall be permitted to be isolated from a raceway containing circuits supplying only that equipment by one or more listed nonmetallic raceway fittings located at the point of attachment of the raceway to the equipment enclosure. The metal raceway shall comply with this article and shall be supplemented by an internal insulated equipment grounding conductor installed in accordance with 350.146(D) to ground the equipment enclosure.~~

~~Informational Note: Use of an isolated equipment grounding conductor does not relieve the requirement for grounding the raceway system.~~

350.97 Bonding for Over ~~3~~2~~50 Volts to Ground.~~ 1000 Volts ac, 1500 Volts dc

For circuits of over ~~2~~3~~50 volts to ground~~ 1000 Volts ac, 1500 Volts dc, the electrical continuity of metal raceways and cables with metal sheaths that contain any conductor other than service conductors shall be ensured by one or more of the methods specified for services in 350.92(B), except for (B)(1).

Exception: If oversized, concentric, or eccentric knockouts are not encountered, or if a box or enclosure with concentric or eccentric knockouts is listed to provide a reliable bonding connection, the following methods shall be permitted:

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(1) *Threadless couplings and connectors for cables with metal sheaths*

(2) *Two locknuts, on rigid metal conduit or intermediate metal conduit, one inside and one outside of boxes and cabinets*

(3) *Fittings with shoulders that seat tightly against the box or cabinet, such as electrical metallic tubing connectors, flexible metal conduit connectors, and cable connectors, with one locknut on the inside of boxes and cabinets*

(4) *Listed fittings*

350.98 Bonding Loosely Jointed Metal Raceways.

Expansion, expansion-deflection, or deflection fittings and telescoping sections of metal raceways shall be made electrically continuous by equipment bonding jumpers or other means.

350.100 Bonding in Hazardous (Classified) Locations.

Regardless of the voltage of the electrical system, the electrical continuity of normally non-current-carrying metal parts of electrical equipment, raceways, metal-clad cable, and metal enclosures containing electrical equipment in any hazardous (classified) location, as defined in 500.5, 505.5, and 506.5, shall be ensured by any of the bonding methods specified in 350.92(B)(2) through (B)(4). One or more of these bonding methods shall be used whether or not equipment grounding conductors of the wire type are installed in the raceway or in a multiconductor cable assembly.

Informational Note: See 501.30, 502.30, 503.30, 505.30, or 506.30 for specific bonding requirements.

350.102 Grounded Conductor, Bonding Conductors, and Jumpers.

(A) Material.

Bonding jumpers shall be of copper, aluminum, copper-clad aluminum, or other corrosion-resistant material. A bonding jumper shall be a wire, bus, screw, or similar suitable conductor.

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(B) Attachment.

Bonding jumpers shall be attached in the manner specified in 350.8 for circuits and equipment and in 350.70 for grounding electrodes.

(C) Size — Supply-Side Bonding Jumper.

(1) Size for Supply Conductors in a Single Raceway or Cable.

The supply-side bonding jumper shall not be smaller than specified in Table 350.102(C)(1).

(2) Size for Parallel Conductor Installations in Two or More Raceways or Cables.

If the ungrounded supply conductors are connected in parallel in two or more raceways or cables, the supply-side bonding jumper shall be sized in accordance with either of the following:

(1) An individual bonding jumper for each raceway or cable shall be selected from Table 350.102(C)(1) based on the size of the largest ungrounded supply conductor in each raceway or cable.

(2) A single bonding jumper installed for bonding two or more raceways or cables shall be sized in accordance with Table 350.102(C)(1) based on the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable. The size of the grounded conductor(s) in each raceway or cable shall be based on the largest ungrounded conductor in each raceway or cable, or the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable.

Informational Note No. 1: The term *supply conductors* includes ungrounded conductors that do not have overcurrent protection on their supply side and terminate at service equipment or the first disconnecting means of a separately derived system.

Informational Note No. 2: See Chapter 9, Table 8, for the circular mil area of conductors 18 AWG through 4/0 AWG.

Table 350.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounded Conductor or Bonding Jumper (AWG/kcmil)	
Copper	**Aluminum or Copper-Clad Aluminum**	**Copper**	**Aluminum or Copper-Clad Aluminum**
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 350	4	2
Over 3/0 through 350	Over 350 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0

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Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		**Size of Grounded Conductor or Bonding Jumper (AWG/kcmil)**	
Copper	**Aluminum or Copper-Clad Aluminum**	**Copper**	**Aluminum or Copper-Clad Aluminum**
Over 1100	Over 1750	See Notes 1 and 2.	

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Notes:
1. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum, the grounded conductor or bonding jumper shall have an area not less than 12½ percent of the area of the largest ungrounded supply conductor or equivalent area for parallel supply conductors. The grounded conductor or bonding jumper shall not be required to be larger than the largest ungrounded conductor or set of ungrounded conductors.
2. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum and if the ungrounded supply conductors and the bonding jumper are of different materials (copper, aluminum, or copper-clad aluminum), the minimum size of the grounded conductor or bonding jumper shall be based on the assumed use of ungrounded supply conductors of the same material as the grounded conductor or bonding jumper that has an ampacity equivalent to that of the installed ungrounded supply conductors.
3. If there are no service-entrance conductors, the supply conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

(D) Size — Equipment Bonding Jumper on Load Side of an Overcurrent Device.

The equipment bonding jumper on the load side of an overcurrent device(s) shall be sized in accordance with 350.122.

A single common continuous equipment bonding jumper shall be permitted to connect two or more raceways or cables if the bonding jumper is sized in accordance with 350.122 for the largest overcurrent device supplying circuits therein.

(E) Installation.

Bonding jumpers or conductors and equipment bonding jumpers shall be permitted to be installed inside or outside of a raceway or an enclosure.

(1) Inside a Raceway or an Enclosure.

If installed inside a raceway, equipment bonding jumpers and bonding jumpers or conductors shall comply with the requirements of 350.119 and 350.148.

(2) Outside a Raceway or an Enclosure.

If installed on the outside, the length of the bonding jumper or conductor or equipment bonding jumper shall not exceed 1.8 m (6 ft) and shall be routed with the raceway or enclosure.

Exception: An equipment bonding jumper or supply-side bonding jumper longer than 1.8 m (6 ft) shall be permitted at outside pole locations for the purpose of bonding or grounding isolated sections of metal raceways or elbows installed in exposed risers of metal conduit or other metal raceway, and for bonding grounding electrodes, and shall not be required to be routed with a raceway or enclosure.

(3) Protection.

Bonding jumpers or conductors and equipment bonding jumpers shall be installed in accordance with 350.64(A) and (B).

350.104 Bonding of Piping Systems and Exposed Structural Metal.

(A) Metal Water Piping.

The metal water piping system shall be bonded as required in 350.104(A)(1), (A)(2), or (A)(3).

(1) General.

Metal water piping system(s) installed in or attached to a building or structure shall be bonded to any of the following:

(1) Service equipment enclosure

(2) Grounded conductor at the service

(3) Grounding electrode conductor, if of sufficient size

(4) One or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is of sufficient size

The bonding jumper(s) shall be installed in accordance with 350.64(A), (B), and (E). The points of attachment of the bonding jumper(s) shall be accessible. The bonding jumper(s) shall be sized in accordance with Table 350.102(C)(1) except that it shall not be required to be larger than 3/0 copper or 350 kcmil aluminum or copper-clad aluminum and except as permitted in 350.104(A)(2) and (A)(3).

(2) Buildings of Multiple Occupancy.

In buildings of multiple occupancy where the metal water piping system(s) installed in or attached to a building or structure for the individual occupancies is metallically isolated from all other occupancies by use of nonmetallic water piping, the metal water piping system(s) for each occupancy shall be permitted to be bonded to the equipment grounding terminal of the switchgear, switchboard, or panelboard enclosure (other than service equipment) supplying that occupancy. The bonding jumper shall be sized in accordance with 350.102(D).

(3) Buildings or Structures Supplied by a Feeder(s) or Branch Circuit(s).

The metal water piping system(s) installed in or attached to a building or structure shall be bonded to any of the following:

(1) Building or structure disconnecting means enclosure where located at the building or structure

(2) Equipment grounding conductor run with the supply conductors

(3) One or more grounding electrodes used

The bonding jumper(s) shall be sized in accordance with 350.102(D). The bonding jumper shall not be required to be larger than the largest ungrounded feeder or branch-circuit conductor supplying the building or structure.

(B) Other Metal Piping.

If installed in or attached to a building or structure, a metal piping system(s), including gas piping, that is likely to become energized shall be bonded to any of the following:

(1) Equipment grounding conductor for the circuit that is likely to energize the piping system

(2) Service equipment enclosure

(3) Grounded conductor at the service

(4) Grounding electrode conductor, if of sufficient size

(5) One or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is of sufficient size

The bonding conductor(s) or jumper(s) shall be sized in accordance with Table 350.122, and equipment grounding conductors shall be sized in accordance with Table 350.122 using the rating of the circuit that is likely to energize the piping system(s). The points of attachment of the bonding jumper(s) shall be accessible.

Informational Note No. 1: Bonding all piping and metal air ducts within the premises will provide additional safety.

Informational Note No. 2: See NFPA 54, *National Fuel Gas Code*, and NFPA 780, *Standard for the Installation of Lightning Protection Systems*, for information on gas piping systems.

(C) Structural Metal.

Exposed structural metal that is interconnected to form a metal building frame, is not intentionally grounded or bonded, and is likely to become energized shall be bonded to any of the following:

(1) Service equipment enclosure

(2) Grounded conductor at the service

(3) Disconnecting means for buildings or structures supplied by a feeder or branch circuit

(4) Grounding electrode conductor, if not smaller than a conductor sized in accordance with Table 350.102(C)(1)

(5) One or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is not smaller than a conductor sized in accordance with Table 350.102(C)(1)

The bonding conductor(s) or jumper(s) shall be sized in accordance with Table 350.102(C)(1), except that it shall not be required to be larger than 3/0 AWG copper or 350 kcmil aluminum or copper-clad aluminum, and installed in accordance with 350.64(A), (B), and (E). The points of attachment of the bonding jumper(s) shall be accessible unless installed in compliance with 350.68(A), Exception No. 2.

(D) Separately Derived Systems.

Metal water piping systems and structural metal that is interconnected to form a building frame shall be bonded to separately derived systems in accordance with 350.104(D)(1) through (D)(3).

(1) Metal Water Piping System(s).

The grounded conductor of each separately derived system shall be bonded to the nearest accessible point of the metal water piping system(s) in the area served by each separately derived system. This connection shall be made at the same point on the separately derived system where the grounding electrode conductor is connected. Each bonding jumper shall be sized in accordance with Table 350.102(C)(1) based on the largest ungrounded conductor of the separately derived system except that it shall not be required to be larger than 3/0 AWG copper or 350 kcmil aluminum or copper-clad aluminum.

Exception No. 1: A separate bonding jumper to the metal water piping system shall not be required if the metal water piping system is used as the grounding electrode or grounding electrode conductor for the separately derived system and the connection to the water piping system is in the area served by the separately derived system.

Exception No. 2: A separate bonding jumper to the metal water piping system shall not be required if the metal in-ground support structure is used as a grounding electrode or the metal frame of a building or structure is used as the grounding electrode conductor for a separately derived system and is bonded to the metal water piping system in the area served by the separately derived system.

(2) Structural Metal.

If exposed structural metal that is interconnected to form the building frame exists in the area served by the separately derived system, it shall be bonded to the grounded conductor of each separately derived system. This connection shall be made at the same point on the separately derived system where the grounding electrode conductor is connected. Each bonding jumper shall be sized in accordance with Table 350.102(C)(1) based on the largest ungrounded conductor of the separately derived system except that it shall not be required to be larger than 3/0 AWG copper or 350 kcmil aluminum or copper-clad aluminum.

Exception No. 1: A separate bonding jumper to the building structural metal shall not be required if the metal in-ground support structure is used as a grounding electrode or the metal frame of a building or structure is used as the grounding electrode conductor for the separately derived system.

Exception No. 2: A separate bonding jumper to the building structural metal shall not be required if the water piping system of a building or structure is used as the grounding electrode or grounding electrode conductor for a separately derived system and is bonded to the building structural metal in the area served by the separately derived system.

(3) Common Grounding Electrode Conductor.

If a common grounding electrode conductor is installed for multiple separately derived systems as permitted by 350.30(A)(6), and exposed structural metal that is interconnected to form the building frame or interior metal water piping exists in the area served by the separately derived system, the metal water piping and the structural metal member shall be bonded to the common grounding electrode conductor in the area served by the separately derived system.

Exception: A separate bonding jumper from each derived system to metal water piping and to structural metal members shall not be required if the metal water piping and the structural metal members in the area served by the separately derived system are bonded to the common grounding electrode conductor.

350.106 Lightning Protection Systems.

The lightning protection system ground terminals shall be bonded to the building or structure grounding electrode system.

Informational Note No. 1: See 350.60 for use of strike termination devices.

Informational Note No. 2: See NFPA 780, *Standard for the Installation of Lightning Protection Systems*, which contains detailed information on grounding, bonding, and sideflash distance from lightning protection systems.

Part VI. Equipment Grounding and Equipment Grounding Conductors

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~~250~~350.109 Metal Enclosures.

Metal enclosures shall be permitted to be used to connect bonding jumpers or equipment grounding conductors, or both, together to become a part of an effective ground-fault current path. If installed, metal covers, plaster rings, extension rings, and metal fittings shall be attached to these metal enclosures to ensure an effective ground-fault current path or shall be connected with bonding jumpers or equipment grounding conductors, or both.

Informational Note: See ~~250~~350.97 for bonding requirements for over ~~250~~350 volts to ground.

~~250~~350.110 Equipment Fastened in Place (Fixed) or Connected by Permanent Wiring Methods.

Exposed, normally non-current-carrying metal parts of fixed equipment supplied by or enclosing conductors or components that are likely to become energized shall be connected to an equipment grounding conductor under any of the following conditions:

(1) If within 2.5 m (8 ft) vertically or 1.5 m (5 ft) horizontally of ground or grounded metal objects and subject to contact by persons

(2) If located in a wet or damp location and not isolated

(3) If in electrical contact with metal

(4) If in a hazardous (classified) location

(5) If supplied by a wiring method that provides an equipment grounding conductor, except as permitted by ~~250~~350.86, Exception No. 2, for short sections of metal enclosures

(6) If equipment operates with any terminal at over 150 volts to ground

Exception No. 1: If exempted by special permission, the metal frame of electrically heated appliances that have the frame permanently and effectively insulated from ground shall not be required to be grounded.

Exception No. 2: Distribution apparatus, such as transformer and capacitor cases, mounted on wooden poles at a height exceeding 2.5 m (8 ft) above ground or grade level shall not be required to be grounded.

Exception No. 3: Listed equipment protected by a system of double insulation, or its equivalent, shall not be required to be connected to the equipment grounding conductor. If such a system is employed, the equipment shall be distinctively marked.

~~250~~350.112 Specific Equipment Fastened in Place (Fixed) or Connected by Permanent Wiring Methods.

~~Except as permitted in 250350.112(F) and (I), E~~exposed, normally non-current-carrying metal parts of equipment described in ~~250~~350.112(A) through (G~~K~~), and normally non-current-carrying metal parts of equipment and enclosures described in ~~250~~350.112(F~~L~~) and (G~~M~~), shall be connected to an equipment grounding conductor, regardless of voltage.

(A) Switchgear and Switchboard Frames and Structures.

Switchgear or switchboard frames and structures supporting switching equipment, except frames of 2-wire dc switchgear or switchboards if effectively insulated from ground.

~~(B) Pipe Organs.~~

~~Generator and motor frames in an electrically operated pipe organ, unless effectively insulated from ground and the motor driving it.~~

(B~~C~~) Motor Frames.

Motor frames, as provided by 430.242.

(C~~D~~) Enclosures for Motor Controllers.

Enclosures for motor controllers unless attached to ungrounded portable equipment.

~~(E) Elevators and Cranes.~~

~~Electrical equipment for elevators and cranes.~~

~~(F) Garages, Theaters, and Motion Picture Studios.~~

~~Electrical equipment in commercial garages, theaters, and motion picture studios, except pendant lampholders supplied by circuits not over 150 volts to ground~~.

(D~~G~~) Electric Signs.

Electric signs, outline lighting, and associated equipment as provided in 600.7.

~~(H) Motion Picture Projection Equipment.~~

~~Motion picture projection equipment~~.

~~(I) Remote-Control, Signaling, and Fire Alarm Circuits.~~

~~Equipment supplied by Class 1 circuits shall be grounded unless operating at less than 50 volts. Equipment supplied by Class 1 power-limited circuits, by Class 2 and Class 3 remote-control and signaling circuits, and by fire alarm circuits shall be grounded if system grounding is required by Part II or Part VIII of this article.~~

~~(J) Luminaires.~~

~~Luminaires as provided in Part V of Article 410.~~

(E~~K~~) Skid-Mounted Equipment.

Permanently mounted electrical equipment and skids shall be connected to the equipment grounding conductor. Wire-type equipment grounding conductors shall be sized as required by ~~250~~350.122.

(F~~L~~) Motor-Operated Water Pumps.

Motor-operated water pumps, including the submersible type.

(G~~M~~) Metal Well Casings.

If a submersible pump is used in a metal well casing, the well casing shall be connected to the pump circuit equipment grounding conductor.

~~250350.114 Equipment Connected by Cord and Plug.~~

~~Exposed, normally non-current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor under any of the following conditions:~~

~~Exception: Listed tools, listed appliances, and listed equipment covered in 250350.114, list items 2 through 4, shall not be required to be connected to an equipment grounding conductor if protected by a system of double insulation or its equivalent. Double-insulated equipment shall be distinctively marked.~~

~~(1) In hazardous (classified) locations~~

~~(2) If operated at over 150 volts to ground~~

~~Exception No. 1 to (2): Motors, if guarded, shall not be required to be connected to an equipment grounding conductor.~~

~~Exception No. 2 to (2): Metal frames of electrically heated appliances, exempted by special permission, shall not be required to be connected to an equipment grounding conductor, in which case the frames shall be permanently and effectively insulated from ground.~~

~~(3) In residential occupancies:~~

- ~~a. Refrigerators, freezers, icemakers, and air conditioners~~
- ~~b. Clothes-washing, clothes-drying, and dish-washing machines; ranges; kitchen waste disposers; information technology equipment; sump pumps; and electrical aquarium equipment~~
- ~~c. Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools~~
- ~~d. Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers~~
- ~~e. Portable handlamps~~

~~(4) In other than residential occupancies:~~

- ~~a. Refrigerators, freezers, icemakers, and air conditioners~~
- ~~b. Clothes-washing, clothes-drying, and dish-washing machines; information technology equipment; sump pumps; and electrical aquarium equipment~~
- ~~c. Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools~~
- ~~d. Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers~~
- ~~e. Portable handlamps~~

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~~f. Cord-and-plug-connected appliances used in damp or wet locations or by persons standing on the ground, standing on metal floors, or working inside of metal tanks or boilers~~

~~g. Tools likely to be used in wet or conductive locations~~

~~*Exception: Tools and portable handlamps and portable luminaires likely to be used in wet or conductive locations shall not be required to be connected to an equipment grounding conductor if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts.*~~

~~250.116 Nonelectrical Equipment.~~

~~The metal parts of the following nonelectrical equipment described in this section shall be connected to the equipment grounding conductor:~~

~~(1) Frames and tracks of electrically operated cranes and hoists~~

~~(2) Frames of nonelectrically driven elevator cars to which electrical conductors are attached~~

~~(3) Hand-operated metal shifting ropes or cables of electric elevators~~

~~Informational Note: If extensive metal in or on buildings or structures may become energized and is subject to personal contact, adequate bonding and grounding will provide additional safety.~~

~~250~~350.118 Types of Equipment Grounding Conductors.

(A) Permitted.

Each equipment grounding conductor run with or enclosing the circuit conductors shall be one or more or a combination of the following:

(1) A copper, aluminum, or copper-clad aluminum conductor. This conductor shall be solid or stranded; insulated, covered, or bare; and in the form of a wire or a busbar of any shape.

(2) Rigid metal conduit.

(3) Intermediate metal conduit.

(4) Electrical metallic tubing.

(5) Shielded Cables

The metallic insulation shield encircling the current-carrying conductors shall be permitted to be used as an equipment grounding conductor, if it is rated for clearing time of ground-fault current protective device operation without damaging the metallic shield. The metallic tape insulation shield and drain wire insulation shield shall not be used as an equipment grounding conductor for solidly grounded systems.

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~~(5) Listed flexible metal conduit meeting all the following conditions:~~

~~a. The conduit is terminated in listed fittings.~~

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~~b. The circuit conductors contained in the conduit are protected by overcurrent devices rated at 20 amperes or less.~~

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~~c. The size of the conduit does not exceed metric designator 35 (trade size 1¼).~~

~~d. The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 1.8 m (6 ft).~~

~~e. If flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, a wire-type equipment grounding conductor or a bonding jumper in accordance with 250350.102(E)(2) shall be installed.~~

    - ~~f. If flexible metal conduit is constructed of stainless steel, a wire-type equipment grounding conductor or bonding jumper in accordance with 250~~350~~.102(E)(2) shall be installed.~~

- ~~(6) Listed liquidtight flexible metal conduit meeting all the following conditions:~~
    - ~~a. The conduit is terminated in listed fittings.~~

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    - ~~b. For metric designators 12 through 16 (trade sizes 3/8 through 1/2), the circuit conductors contained in the conduit are protected by overcurrent devices rated at 20 amperes or less.~~

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    - ~~c. For metric designators 21 through 35 (trade sizes 3/4 through 1 1/4), the circuit conductors contained in the conduit are protected by overcurrent devices rated not more than 60 amperes and there is no flexible metal conduit, flexible metallic tubing, or liquidtight flexible metal conduit in metric designators 12 through 16 (trade sizes 3/8 through 1/2) in the effective ground-fault current path.~~
    - ~~d. The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 1.8 m (6 ft).~~
    - ~~e. If flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, a wire-type equipment grounding conductor or a bonding jumper in accordance with 250~~350~~.102(E)(2) shall be installed.~~
    - ~~f. If liquidtight flexible metal conduit contains a stainless steel core, a wire-type equipment grounding conductor or a bonding jumper in accordance with 250~~350~~.102(E)(2) shall be installed.~~
- ~~(7) Flexible metallic tubing if the tubing is terminated in listed fittings and meeting the following conditions:~~
    - ~~a. The circuit conductors contained in the tubing are protected by overcurrent devices rated at 20 amperes or less.~~

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    - ~~b. The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 1.8 m (6 ft).~~

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- ~~(8) Armor of Type AC cable as provided in 320.108.~~
- ~~(9) The copper sheath of mineral-insulated, metal-sheathed cable Type MI.~~
- (10) Type MC cable that provides an effective ground-fault current path in accordance with one or more of the following:
    - a. It contains an insulated or uninsulated equipment grounding conductor in compliance with ~~250~~350.118(1).

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    - b. The combined metallic sheath and uninsulated equipment grounding/bonding conductor of interlocked metal tape–type MC cable that is listed and identified as an equipment grounding conductor

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    - c. The metallic sheath or the combined metallic sheath and equipment grounding conductors of the smooth or corrugated tube-type MC cable that is listed and identified as an equipment grounding conductor
- (11) Cable trays as permitted in 392.10 and 392.60.
- (12) Cablebus framework as permitted in 370.60(1).
- (13) Other listed electrically continuous metal raceways and listed auxiliary gutters.
- (14) Surface metal raceways listed for grounding.

Informational Note: See Article 100 for a definition of *effective ground-fault current path*.

(B) Not Permitted.

The following shall not be used as equipment grounding conductors.

- (1) Grounding electrode conductors

Exception: A wire-type equipment grounding conductor installed in compliance with ~~250~~350.6(A) and the applicable requirements for both the equipment grounding conductor and the grounding electrode conductor in Parts II, III, and VI of this article shall be permitted to serve as both an equipment grounding conductor and a grounding electrode conductor.

(2) Structural metal frame of a building or structure

~~250~~350.119 Identification of Wire-Type Equipment Grounding Conductors.

(A) General.

Unless required elsewhere in this *Code,* equipment grounding conductors shall be permitted to be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors of the wire type shall have a continuous outer finish that is either green or green with one or more yellow stripes except as permitted in this section. Conductors with insulation or individual covering that is green, green with one or more yellow stripes, or otherwise identified as permitted by this section shall not be used for ungrounded or grounded circuit conductors.

Exception No. 1: Power-limited Class 2 or Class 3 cables, power-limited fire alarm cables, or communications cables containing only circuits operating at less than 50 volts ac or 60 volts dc if connected to equipment not required to be grounded shall be permitted to use a conductor with green insulation or green with one or more yellow stripes for other than equipment grounding purposes.

Exception No. 2: Flexible cords having an integral insulation and jacket without an equipment grounding conductor shall be permitted to have a continuous outer finish that is green.

Informational Note: An example of a flexible cord with integral-type insulation is Type SPT-2, 2 conductor.

Exception No. 3: Conductors with green insulation shall be permitted to be used as ungrounded signal conductors where installed between the output terminations of traffic signal control and traffic signal indicating heads. Signaling circuits installed in accordance with this exception shall include an equipment grounding conductor in accordance with ~~250~~350.118. Wire-type equipment grounding conductors shall be bare or have insulation or covering that is green with one or more yellow stripes.

(B) Conductors 4 AWG and Larger.

Equipment grounding conductors 4 AWG and larger shall comply with the following:

(1) At the time of installation, if the insulation does not comply with ~~250~~350.119(A), it shall be permanently identified as an equipment grounding conductor at each end and at every point where the conductor is accessible.

Exception: Conductors 4 AWG and larger shall not be required to be marked in conduit bodies that contain no splices or unused hubs.

(2) Identification shall encircle the conductor and shall be accomplished by one of the following:

    a. Stripping the insulation or covering from the entire exposed length
    b. Coloring the insulation or covering green at the termination
    c. Marking the insulation or covering with green tape or green adhesive labels at the termination

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(C) Multiconductor Cable.

One or more insulated conductors in a multiconductor cable, at the time of installation, shall be permitted to be permanently identified as equipment grounding conductors at each end and at every point where the conductors are accessible by one of the following means:

(1) Stripping the insulation from the entire exposed length.

(2) Coloring the exposed insulation green.

(3) Marking the exposed insulation with green tape or green adhesive labels. Identification shall encircle the conductor.

(D) Flexible Cord.

Equipment grounding conductors in flexible cords shall be insulated and shall have a continuous outer finish that is either green or green with one or more yellow stripes.

~~250~~350.120 Equipment Grounding Conductor Installation.

An equipment grounding conductor shall be installed in accordance with ~~250~~350.120(A), (B), and (C).

(A) Raceway, Cable Trays, Cable Armor, Cablebus, or Cable Sheaths.

If it consists of a raceway, cable tray, cable armor, cablebus framework, or cable sheath or if it is a wire within a raceway or cable, it shall be installed in accordance with the applicable provisions in this *Code* using fittings for joints and terminations approved for use with the type of raceway or cable used. All connections, joints, and fittings shall be made tight using suitable tools.

Informational Note: See the UL Guide Information for Electrical Circuit Integrity Systems (FHIT) for equipment grounding conductors installed in a raceway that are part of a listed electrical circuit protective system or a listed fire-resistive cable system.

(B) Aluminum and Copper-Clad Aluminum Conductors.

Equipment grounding conductors of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following:

(1) Unless part of an applicable cable wiring method, bare or covered conductors shall not be installed if subject to corrosive conditions or be installed in direct contact with concrete, masonry, or the earth.

(2) Terminations made within outdoor enclosures that are listed and identified for the environment shall be permitted within 450 mm (18 in.) of the bottom of the enclosure.

(3) Aluminum or copper-clad aluminum conductors external to buildings or enclosures shall not be terminated within 450 mm (18 in.) of the earth, unless terminated within a listed wire connector system.

(C) Equipment Grounding Conductors Smaller Than 6 AWG.

If not routed with circuit conductors as permitted in ~~250~~350.130(C) and ~~250~~350.134, Exception No. 2, equipment grounding conductors smaller than 6 AWG shall be protected from physical damage by an identified raceway or cable armor unless installed within hollow spaces of the framing members of buildings or structures and if not subject to physical damage.

350.122 Size of Equipment Grounding Conductors.

(A) General

Unless permitted elsewhere in the Code, the equipment grounding conductor shall be one, or more, of the combination of the type provided in 350.118. Equipment grounding conductors shall comply with 350.4(A)(5) and 350.4(B)(4).

Equipnent Grounding Conductors shall be permitted to be sized under engineering supervision, based on industry standard software or industry standard practices. The calculations and/or selections, along with their bases, shall be made available to the Authority Having Jursidiction and to those who maintain and service the installation.

(B) Wire Typ~~o~~e Equipment Grounding Conductor

1. ~~Copper, aluminum, or copper-clad aluminum eEquipment~~Equipment grounding conductors of the wire type shall be sized according to (1)(2) or (3) below~~not bebe -smaller than-~~ but shall not be required to -be larger than the circuit conductors.
1, Equipment Grounding conductor for multiple conductor cable for 1001- 2000 V application shall not be smaller

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than as shown in Table 350.122 (B)(1) ~~shown in Table 350.122. The equipment grounding conductor shall not be required to be larger than the circuit conductors supplying the equipment. If a cable tray, a raceway, or a cable armor or sheath is used as the equipment grounding conductor, as provided in 350.118 and 350.134(1), it shall comply with 350.4(A)(5) or (B)(4).~~) Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with.Table 350.122(B)(1)

2, Equipment Grounding conductor for Type MV -90 multiple conductor cable for 2001- 35.000 V application shall not be smaller than as shown in Table 350.122 (B)(2)~~-~~) Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with ~~.~~Table350.122(B)2)

3 Equipment Grounding conductor for Type MV-105 ~~-~~multiple conductor cable for 2001- 35,000 V application shall not be smaller than as shown in Table 350.122 (B)(3))) Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with.Table 350.122(B)(3)

Exception to (1) ~~,~~(2) and (3) *: Equipment grounding conductors shall be permitted to be sized by a qualified person to provide an effective ground fault current path in accordance with 350.4(A)(5) or (B)(4)*

(C) Metallic insulation shield or armor of the Cables.

The metallic insulation shield, ~~-~~metallic armor, or a combination of both encircling the current-carrying conductors shall be permitted to be used as an equipment grounding conductor, if it is rated for clearing time of ground-fault current protective device operation without damaging the metallic shield. The tape metallic insulation shield and drain wire insulation shield shall not be used as an equipment grounding conductor for solidly grounded systems.

~~)~~

~~(DEquipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with.Table 350.122.~~

~~E<~~

~~**(B) Increased in Size**~~
~~:~~

~~If ungrounded conductors are increased in size for any reason other than as required in 310.15(B) or 310.15(C), wire-type equipment grounding conductors, if installed, shall be increased in size proportionately to the increase in circular mil area of the ungrounded conductors.~~

~~*Exception: Equipment grounding conductors shall be permitted to be sized by a qualified person to provide an effective ground fault current path in accordance with 350.4(A)(5) or (B)(4)*~~

(D~~C~~) Multiple Circuits.

A single equipment grounding conductor shall be permitted to be installed for multiple circuits that are installed in the same raceway, cable, trench, or cable tray. It shall be sized f according~~rom Table~~ to Table 350.122(A) for the largest ~~overcurrent device protecting~~ circuit conductors in the raceway, cable, trench, or cable tray. Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c).

~~**(D) Motor Circuits.**~~

~~Equipment grounding conductors for motor circuits shall be sized in accordance with 350.122(D)(1) or (D)(2).~~

~~**(1) General.**~~

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~~The equipment grounding conductor size shall not be smaller than determined by 350.122(A) based on the rating of the branch-circuit short-circuit and ground-fault protective device.~~

~~**(2) Instantaneous-Trip Circuit Breaker and Motor Short-Circuit Protector.**~~

~~If the overcurrent device is an instantaneous-trip circuit breaker or a motor short-circuit protector, the equipment grounding conductor shall be sized not smaller than that given by 350.122(A) using the maximum permitted rating of a dual element time-delay fuse selected for branch-circuit short-circuit and ground-fault protection in accordance with 430.52(C)(1), Exception No. 1.~~

~~**(E) Flexible Cord and Fixture Wire.**~~

~~The equipment grounding conductor in a flexible cord with the largest circuit conductor 10 AWG or smaller, and the equipment grounding conductor used with fixture wires of any size in accordance with 240.5, shall not be smaller than 18 AWG copper and shall not be smaller than the circuit conductors. The equipment grounding conductor in a flexible cord with a circuit conductor larger than 10 AWG shall be sized in accordance with Table 350.122.~~

(F) Conductors in Parallel.

For circuits of parallel conductors as permitted in 310.10(G), the equipment grounding conductor shall be installed in accordance with 350.122(F)(1) or (F)(2).

(1) Conductor Installations in Raceways, Auxiliary Gutters, or Cable Trays.

(a) *Single Raceway or Cable Tray, Auxiliary Gutter, or Cable Tray*. If circuit conductors are connected in parallel in the same raceway, auxiliary gutter, or cable tray, a single wire-type conductor shall be permitted as the equipment grounding conductor. The wire-type equipment grounding conductor shall be sized in accordance with Table 350.122(A) based on the ~~overcurrent protective device for the feeder or branch circuit.~~largest circuit conductor within the raceway or cable

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(b) *Multiple Raceways*. If conductors are installed in multiple raceways and are connected in parallel, a wire-type equipment grounding conductor, if used, shall be installed in each raceway and shall be connected in parallel. The equipment grounding conductor installed in each raceway shall be sized in accordance with Table 350.122 (A) based on the ~~rating of the overcurrent protective device for the feeder or branch circuit.~~largest circuit conductor in each raceway or cable

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(c) *Wire-Type Equipment Grounding Conductors in Cable Trays.* Wire-type equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c).

~~(d) *Metal Raceways, Auxiliary Gutters, or Cable Trays.* Metal raceways or auxiliary gutters in accordance with 350.118 or cable trays complying with 392.60(B) shall be permitted as the equipment grounding conductor.~~

(2) Multiconductor Cables.

(a) Except as provided in 350.122(F)(2)(c) for raceway or cable tray installations, the equipment grounding conductor in each multiconductor cable shall be sized in accordance with Table 350.122(A) based on the ~~overcurrent protective device for the feeder or branch circuit.~~largest circuit conductor in the cable

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(b) If circuit conductors of multiconductor cables are connected in parallel, the equipment grounding conductor(s) in each cable shall be connected in parallel.

(c) If multiconductor cables are paralleled in the same raceway, auxiliary gutter, or cable tray, a single equipment grounding conductor that is sized in accordance with Table 350.122(A) shall be permitted in combination with the equipment grounding conductors provided within the multiconductor cables and shall all be connected together.

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(d) ~~Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c). Cable trays complying with 392.60(B), metal raceways in accordance with 350.118, or auxiliary gutters shall be permitted as the equipment grounding conductor.~~

(G) Feeder Taps.

Equipment grounding conductors installed with feeder taps shall not be smaller than shown in Table ~~Table~~ 350.122(A) based on the ~~rating of the overcurrent device ahead of~~largest circuit conductor of the feeder on the supply side ahead of the tap but shall not be required to be larger than the tap conductors.

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~~250350.122 Size of Equipment Grounding Conductors.~~

~~(A) General.~~

~~Copper, aluminum, or copper-clad aluminum equipment grounding conductors of the wire type shall not be smaller than shown in Table 250350.122. The equipment grounding conductor shall not be required to be larger than the circuit conductors supplying the equipment. If a cable tray, a raceway, or a cable armor or sheath is used as the equipment grounding conductor, as provided in 250350.118 and 250350.134(1), it shall comply with 250350.4(A)(5) or (B)(4).~~

~~Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with.Table 250350.122.~~

~~(B) Increased in Size.~~

~~If ungrounded conductors are increased in size for any reason other than as required in 310.15(B) or 310.15(C), wire-type equipment grounding conductors, if installed, shall be increased in size proportionately to the increase in circular mil area of the ungrounded conductors.~~

~~*Exception: Equipment grounding conductors shall be permitted to be sized by a qualified person to provide an effective ground fault current path in accordance with 250350.4(A)(5) or (B)(4)*~~

~~(C) Multiple Circuits.~~

~~A single equipment grounding conductor shall be permitted to be installed for multiple circuits that are installed in the same raceway, cable, trench, or cable tray. It shall be sized from Table 250350.122 for the largest overcurrent device protecting circuit conductors in the raceway, cable, trench, or cable tray. Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c).~~

~~(D) Motor Circuits.~~

~~Equipment grounding conductors for motor circuits shall be sized in accordance with 250350.122(D)(1) or (D)(2).~~

~~(1) General.~~

~~The equipment grounding conductor size shall not be smaller than determined by 250350.122(A) based on the rating of the branch-circuit short-circuit and ground-fault protective device.~~

~~(2) Instantaneous-Trip Circuit Breaker and Motor Short-Circuit Protector.~~

~~If the overcurrent device is an instantaneous-trip circuit breaker or a motor short-circuit protector, the equipment grounding conductor shall be sized not smaller than that given by 250350.122(A) using the maximum permitted rating of a dual element time-delay fuse selected for branch-circuit short-circuit and ground-fault protection in accordance with 430.52(C)(1), Exception No. 1.~~

~~(E) Flexible Cord and Fixture Wire.~~

~~The equipment grounding conductor in a flexible cord with the largest circuit conductor 10 AWG or smaller, and the equipment grounding conductor used with fixture wires of any size in accordance with 240.5, shall not be smaller than 18 AWG copper and shall not be smaller than the circuit conductors. The equipment grounding conductor in a flexible cord with a circuit conductor larger than 10 AWG shall be sized in accordance with Table 250350.122.~~

~~(F) Conductors in Parallel.~~

~~For circuits of parallel conductors as permitted in 310.10(G), the equipment grounding conductor shall be installed in accordance with 250350.122(F)(1) or (F)(2).~~

~~(1) Conductor Installations in Raceways, Auxiliary Gutters, or Cable Trays.~~

~~(a) *Single Raceway or Cable Tray, Auxiliary Gutter, or Cable Tray.* If circuit conductors are connected in parallel in the same raceway, auxiliary gutter, or cable tray, a single wire-type conductor shall be~~

~~permitted as the equipment grounding conductor. The wire-type equipment grounding conductor shall be sized in accordance with 250~~350~~.122 based on the overcurrent protective device for the feeder or branch circuit.~~

~~(b) *Multiple Raceways*. If conductors are installed in multiple raceways and are connected in parallel, a wire-type equipment grounding conductor, if used, shall be installed in each raceway and shall be connected in parallel. The equipment grounding conductor installed in each raceway shall be sized in accordance with 250~~350~~.122 based on the rating of the overcurrent protective device for the feeder or branch circuit.~~

~~(c) *Wire-Type Equipment Grounding Conductors in Cable Trays.* Wire-type equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c).~~

~~(d) *Metal Raceways, Auxiliary Gutters, or Cable Trays.* Metal raceways or auxiliary gutters in accordance with 250~~350~~.118 or cable trays complying with 392.60(B) shall be permitted as the equipment grounding conductor.~~

~~(2) Multiconductor Cables.~~

~~(a) Except as provided in 250~~350~~.122(F)(2)(c) for raceway or cable tray installations, the equipment grounding conductor in each multiconductor cable shall be sized in accordance with 250~~350~~.122 based on the overcurrent protective device for the feeder or branch circuit.~~

~~(b) If circuit conductors of multiconductor cables are connected in parallel, the equipment grounding conductor(s) in each cable shall be connected in parallel.~~

~~(c) If multiconductor cables are paralleled in the same raceway, auxiliary gutter, or cable tray, a single equipment grounding conductor that is sized in accordance with 250~~350~~.122 shall be permitted in combination with the equipment grounding conductors provided within the multiconductor cables and shall all be connected together.~~

~~(d) Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c). Cable trays complying with 392.60(B), metal raceways in accordance with 250~~350~~.118, or auxiliary gutters shall be permitted as the equipment grounding conductor.~~

~~(G) Feeder Taps.~~

~~Equipment grounding conductors installed with feeder taps shall not be smaller than shown in Table 250~~350~~.122 based on the rating of the overcurrent device ahead of the feeder on the supply side ahead of the tap but shall not be required to be larger than the tap conductors.~~

~~Table 250~~350~~.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment~~

~~Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)~~	~~Size (AWG or kcmil)~~	
	~~Copper~~	~~Aluminum or Copper-Clad Aluminum*~~
~~15~~	~~14~~	~~12~~
~~20~~	~~12~~	~~10~~
~~60~~	~~10~~	~~8~~
~~100~~	~~8~~	~~6~~

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~~Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)~~	~~Size (AWG or kcmil)~~	
	~~Copper~~	~~Aluminum or Copper-Clad Aluminum*~~
~~200~~	~~6~~	~~4~~
~~300~~	~~4~~	~~2~~
~~400~~	~~3~~	~~1~~
~~500~~	~~2~~	~~1/0~~
~~600~~	~~1~~	~~2/0~~
~~800~~	~~1/0~~	~~3/0~~
~~1000~~	~~2/0~~	~~4/0~~
~~1200~~	~~3/0~~	~~250~~350
~~1600~~	~~4/0~~	~~350~~
~~2000~~	~~250~~350	~~400~~
~~250~~3500	~~350~~	~~600~~
~~3000~~	~~400~~	~~600~~
~~4000~~	~~500~~	~~750~~
~~5000~~	~~700~~	~~1250~~350
~~6000~~	~~800~~	~~1250~~350

~~Note: Where necessary to comply with 250~~350~~.4(A)(5) or (B)(4), the equipment grounding conductor shall be sized larger than given in this table.~~

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Table 350-122 (A) Smallest acceptable Equipment Grounding conductor in Multiple -conductor cables, or with two or more Type MV-90 insulated conductors 2001-35,000 Volts

Copper		Aluminum	
Size of circuit conductors AWG or kcmil	Smallest size of sectioned Grounding conductor AWG	Size of circuit conductor AWG or kcmil	Smallest size of sectioned Grounding conductor AWG
8	8	8- 6	6
6-2	6	4-1/0	4
1-2/0	4	2/0- 250	2
3/0- 250	3	300-400	1
300-400	2	450-600	1/0
450-600	1	750-900	2/0
750-1000	1/0	1000	3/0

Based on UL 1072 Table 23.1

Table 350-122 (B) Smallest acceptable Equipment Grounding conductor in Multiple -conductor cables, or with two or more Type MV-105 insulated conductors 2001-35,000 Volts

Copper		Aluminum	
Size of circuit conductors AWG or kcmil	Smallest size of sectioned Grounding conductor AWG	Size of circuit conductor AWG or Kcmil	Smallest size of sectioned Grounding conductor AWG
8	8	8- 6	6
6-2	6	4-1/0	4
1-2/0	4	2/0- 4/0	2
3/0- 4/0	3	250-350	1
250-350	2	400-500	1/0
400-500	1	550-750	2/0

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550-750	1/0	800-1000	3/0
800-1000	2/0		

Based on UL1072 Table 23.2

~~*See installation restrictions in 250350.120.~~

~~250~~350.124 Equipment Grounding Conductor Continuity.

(A) Separable Connections.

Separable connections such as those provided in drawout equipment or attachment plugs and mating connectors and receptacles shall provide for first-make, last-break of the equipment grounding conductor. First-make, last-break shall not be required if interlocked equipment, plugs, receptacles, and connectors preclude energization without grounding continuity.

(B) Switches.

No automatic cutout or switch shall be placed in the equipment grounding conductor of a premises wiring system unless the opening of the cutout or switch disconnects all sources of energy.

Part VII. Methods of Equipment Grounding Conductor Connections

350.130 Equipment Grounding Conductor Connections.

Equipment grounding conductor connections at the source of separately derived systems shall be made in accordance with 350.30(A)(1). Equipment grounding conductor connections at service equipment shall be made as indicated in 350.130(A) or (B). ~~For replacement of non-grounding-type receptacles with grounding-type receptacles, or snap switches without an equipment grounding terminal with snap switches with an equipment grounding terminal, and for branch-circuit extensions only in existing installations that do not have an equipment grounding conductor in the branch circuit, connections shall be permitted as indicated in 350.130(C).~~

(A) For Grounded Systems.

The connection shall be made by bonding the equipment grounding conductor to the grounded service conductor and the grounding electrode conductor.

(B) For Ungrounded Systems.

The connection shall be made by bonding the equipment grounding conductor to the grounding electrode conductor.

~~**(C) Replacement of Nongrounding Receptacle or Snap Switch and Branch Circuit Extensions.**~~

~~The equipment grounding conductor that is connected to a grounding-type receptacle, a snap switch with an equipment grounding terminal, or a branch-circuit extension shall be permitted to be connected to any of the following:~~

~~(1) Any accessible point on the grounding electrode system as described in 350.50~~
~~(2) Any accessible point on the grounding electrode conductor~~
~~(3) The equipment grounding terminal bar within the enclosure where the branch circuit for the receptacle or branch circuit originates~~
~~(4) An equipment grounding conductor that is part of another branch circuit that originates from the enclosure where the branch circuit for the receptacle, snap switch, or branch circuit originates~~
~~(5) For grounded systems, the grounded service conductor within the service equipment enclosure~~
~~(6) For ungrounded systems, the grounding terminal bar within the service equipment enclosure~~

~~Informational Note No. 1: See 406.4(D) for the use of a ground-fault circuit-interrupting type of receptacle.~~

~~Informational Note No. 2: See 404.9(B) for requirements regarding grounding of snap switches.~~

350.132 Short Sections of Raceway or Cable Armor.

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Isolated sections of metal raceway or cable armor, if required to be connected to an equipment grounding conductor, shall be connected in accordance with 350.134.

350.134 Equipment Fastened in Place or Connected by Permanent Wiring Methods (Fixed).

Unless connected to the grounded circuit conductor as permitted by 350.32, 350.140, and 350.142, non-current-carrying metal parts of equipment, raceways, and other enclosures, if grounded, shall be connected to an equipment grounding conductor by one of the following methods:

(1) By connecting to any of the equipment grounding conductors permitted by 350.118(2) through (14)

(2) By connecting to an equipment grounding conductor of the wire type that is contained within the same raceway, contained within the same cable, or otherwise run with the circuit conductors

~~*Exception No. 1: As provided in 350.130(C), the equipment grounding conductor shall be permitted to be run separately from the circuit conductors.*~~

Exception No. 2: For dc circuits, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors

Informational Note No. 1: See 350.102 and 350.168 for equipment bonding jumper requirements.

Informational Note No. 2: See 400.10 for use of flexible cords and flexible cables for fixed equipment.

350.136 Equipment Secured to a Metal Rack or Structure.

If a metal rack or structure is connected to an equipment grounding conductor in accordance with 350.134, it shall be permitted to serve as the equipment grounding conductor for electrical equipment secured to and in electrical contact with the metal rack or structure.

350.138 Cord-and-Plug-Connected Equipment.

Non–current-carrying metal parts of cord-and-plug-connected equipment, if required to be connected to an equipment grounding conductor, shall be connected by one of the methods in 350.138(A) or (B).

(A) By Means of an Equipment Grounding Conductor.

By means of an equipment grounding conductor run with the power supply conductors in a cable assembly or flexible cord properly terminated in a grounding-type attachment plug with one fixed grounding contact.

~~*Exception: The grounding contacting pole of grounding-type plug-in ground-fault circuit interrupters shall be permitted to be of the movable, self-restoring type on circuits operating at not over 150 volts between any two conductors or over 150 volts between any conductor and ground.*~~

(B) By Means of a Separate Flexible Wire or Strap.

By means of a separate flexible wire or strap, insulated or bare, connected to an equipment grounding conductor, and protected as well as practicable against physical damage, if part of equipment.

3~~2~~50.140 Frames of Ranges and Clothes Dryers.

Frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and outlet or junction boxes that are part of the circuit shall be connected to the equipment grounding conductor in accordance with 3~~2~~50.140(A) ~~or the grounded conductor in accordance with 250.140(B).~~

(A) Equipment Grounding Conductor Connections.

The circuit supplying the equipment ~~appliance~~ shall include an equipment grounding conductor. The frame of the equipment~~appliance~~ shall be connected to the equipment grounding conductor in the manner specified by 250.134 or 250.138.

~~**(A) Equipment Grounding Conductor Connections.**~~

~~The circuit supplying the appliance equipment shall include an equipment grounding conductor. The frame of the appliance equipment shall be connected to the equipment grounding conductor in the manner specified by 350.134 or 350.138.~~

~~**(B) Grounded Conductor Connections.**~~

~~For existing branch-circuit installations only, if an equipment grounding conductor is not present in the outlet or junction box the frame of the appliance shall be permitted to be connected to the grounded conductor if all the conditions in the following list items (1), (2), and (3) are met and the grounded conductor complies with either list item (4) or (5):~~

~~(1) The supply circuit is 120/240-volt, single-phase, 3-wire; or 208Y/120-volt derived from a 3-phase, 4-wire, wye-connected system.~~

~~(2) The grounded conductor is not smaller than 10 AWG copper or 8 AWG aluminum or copper-clad aluminum.~~

~~(3) Grounding contacts of receptacles furnished as part of the equipment are bonded to the equipment.~~

~~(4) The grounded conductor is insulated, or the grounded conductor is uninsulated and part of a Type SE service-entrance cable and the branch circuit originates at the service equipment.~~

~~(5) The grounded conductor is part of a Type SE service-entrance cable that originates in equipment other than a service. The grounded conductor shall be insulated or field covered within the supply enclosure with listed~~

~~insulating material, such as tape or sleeving to prevent contact of the uninsulated conductor with any normally non-current-carrying metal parts.~~

350.142 Use of Grounded Circuit Conductor for Grounding Equipment.

(A) Supply-Side Equipment.

A grounded circuit conductor shall be permitted to be connected to non-current-carrying metal parts of equipment, raceways, and other enclosures at any of the following locations:

(1) On the supply side or within the enclosure of the ac service disconnecting means

(2) On the supply side or within the enclosure of the main disconnecting means for separate buildings as provided in 350.32(B)(1) Exception No. 1

(3) On the supply side or within the enclosure of the main disconnecting means or overcurrent devices of a separately derived system where permitted by 350.30(A)(1)

(B) Load-Side Equipment.

Except as permitted in 350.30(A)(1), 350.32(B)(1), Exception No. 1, and Part X of Article 350, a grounded circuit conductor shall not be connected to non–current-carrying metal parts of equipment on the load side of the service disconnecting means or on the load side of a separately derived system disconnecting means or the overcurrent devices for a separately derived system not having a main disconnecting means.

~~*Exception No. 1: The frames of ranges, wall-mounted ovens, counter-mounted cooking units, and clothes dryers under the conditions permitted for existing installations by 350.140 shall be permitted to be connected to the grounded circuit conductor.*~~

Exception No. 2: It shall be permissible to connect meter enclosures to the grounded circuit conductor on the load side of the service disconnect if all of the following conditions apply:

(1) Ground-fault protection of equipment is not installed.

(2) All meter enclosures are located immediately adjacent to the service disconnecting means.

(3) The size of the grounded circuit conductor is not smaller than the size specified in Table 350.122 for equipment grounding conductors.

Exception No. 3: Electrode-type boilers operating at over 1000 volts shall be grounded as required in 495.72(E)(1) and 495.74.

350.144 Multiple Circuit Connections.

If equipment is required to be grounded and is supplied by more than one circuit containing an equipment grounding conductor, a means to terminate each equipment grounding conductor meeting the requirements of 350.8 shall be provided as specified in 350.134 and 350.138.

350.148 Continuity of Equipment Grounding Conductors and Attachment in Boxes.

If circuit conductors are spliced within a box or terminated on equipment within or supported by a box, the installation shall comply with 350.148(A) through (D).

Exception: The equipment grounding conductor permitted in 350.146(D) shall not be required to be connected to the other equipment grounding conductors or to the box.

(A) Connections and Splices.

All equipment grounding conductors that are spliced or terminated within the box shall be connected together. Connections and splices shall be made in accordance with 110.14(B) and 350.8 except that insulation shall not be required.

~~**(B) Equipment Grounding Conductor Continuity.**~~

~~The arrangement of grounding connections shall be such that the disconnection or the removal of a luminaire, receptacle, or other device fed from the box does not interrupt the electrical continuity of the equipment grounding conductor(s) providing an effective ground-fault current path.~~

(C) Metal Boxes.

A connection used for no other purpose shall be made between the metal box and the equipment grounding conductor(s). The equipment bonding jumper or equipment grounding conductor shall be sized from Table 350.122 based on the largest overcurrent device protecting circuit conductors in the box.

(D) Nonmetallic Boxes.

One or more equipment grounding conductors brought into a nonmetallic ~~outlet~~ box shall be arranged to provide a connection to any fitting or device in that box requiring connection to an equipment grounding conductor.

Part VIII. Direct-Current Systems

~~250~~350.160 General.

Direct-current systems shall comply with Part VIII and other sections of Article ~~250~~350 not specifically intended for ac systems.

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350.140 (A) The word "appliance" was changed to "equipment" in two places to be more applicable above 1000 volts.

350.148(D) The word "outlet" was deleted to be more applicable above 1000 volts. (this was agreed to)

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~~250~~350.162 Direct-Current Circuits and Systems to Be Grounded.

Direct-current circuits and systems shall be grounded as provided for in ~~250~~350.162(A) and (B).

(A) Two-Wire, Direct-Current Systems.

~~A 2-wire, dc system supplying premises wiring and operating at greater than 60 volts but not greater than 300 volts shall be grounded.~~

~~Exception No. 1:~~ A system equipped with a ground detector and supplying only industrial equipment in limited areas shall not be required to be grounded if installed immediately adjacent to, or integral with, the source of supply.

~~Exception No. 2:~~ A rectifier-derived dc system supplied from an ac system complying with ~~250~~350.20 shall not be required to be grounded.

~~Exception No. 3: Direct-current fire alarm circuits having a maximum current of 0.030 ampere as specified in Article 760, Part III, shall not be required to be grounded.~~

(B) Three-Wire, Direct-Current Systems.

The neutral conductor of all 3-wire, dc systems supplying premises wiring shall be grounded.

~~250~~350.164 Point of Connection for Direct-Current Systems.

(A) Off-Premises Source.

Direct-current systems to be grounded and supplied from an off-premises source shall have the grounding connection made at one or more supply stations. A grounding connection shall not be made at individual services or at any point on the premises wiring.

(B) On-Premises Source.

If the dc system source is located on the premises, a grounding connection shall be made at one of the following:

(1)   The source

(2)   The first system disconnection means or overcurrent device

(3)   By other means that accomplish system protection and that use equipment listed and identified for the use

~~250~~350.166 Size of the Direct-Current Grounding Electrode Conductor.

The size of the grounding electrode conductor for a dc system shall be as specified in ~~250~~350.166(A) and (B), except as permitted by ~~250~~350.166(C) through (E). The grounding electrode conductor for a dc system shall meet the sizing requirements in this section but shall not be required to be larger than 3/0 copper or ~~250~~350 kcmil aluminum or copper-clad aluminum.

(A) Not Smaller Than the Neutral Conductor.

If the dc system consists of a 3-wire balancer set or a balancer winding with overcurrent protection as provided in 445.12(D), the grounding electrode conductor shall not be smaller than the neutral conductor and not smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum.

(B) Not Smaller Than the Largest Conductor.

If the dc system is other than as in ~~250~~350.166(A), the grounding electrode conductor shall not be smaller than the largest conductor supplied by the system and not smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum.

(C) Connected to Rod, Pipe, or Plate Electrodes.

If connected to rod, pipe, or plate electrodes as in ~~250~~350.52(A)(5) or (A)(7), that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum or copper-clad aluminum wire.

(D) Connected to a Concrete-Encased Electrode.

If connected to a concrete-encased electrode as in ~~250~~350.52(A)(3), that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than 4 AWG copper wire.

(E) Connected to a Ground Ring.

If connected to a ground ring as in ~~250~~350.52(A)(4), that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than the conductor used for the ground ring.

~~250~~350.167 Direct-Current Ground-Fault Detection.

(A) Ungrounded Systems.

Ground-fault detection systems shall be required for ungrounded systems.

(B) Grounded Systems.

Ground-fault detection shall be permitted for grounded systems.

(C) Marking.

Direct-current systems shall be legibly marked to indicate the grounding type at the dc source or the first disconnecting means of the system. The marking shall be of sufficient durability to withstand the environment involved.

Informational Note: See NFPA *70E*-2018, *Standard for Electrical Safety in the Workplace*, which identifies four dc grounding types in detail.

~~250~~350.168 Direct-Current System Bonding Jumper.

For direct-current systems that are to be grounded, an unspliced bonding jumper shall be used to connect the equipment grounding conductor(s) to the grounded conductor at the source or to the first system disconnecting means where the system is grounded. The size of the bonding jumper shall not be smaller than the system grounding electrode conductor specified in ~~250~~350.166 and shall comply with ~~250~~350.28(A), (B), and (C).

~~250~~350.169 Ungrounded Direct-Current Separately Derived Systems.

Except as otherwise permitted in ~~250~~350.34 for portable and vehicle-mounted generators, an ungrounded dc separately derived system supplied from a stand-alone power source (such as an engine–generator set) shall have a grounding electrode conductor connected to an electrode that complies with Part III of this article to provide for grounding of metal enclosures, raceways, cables, and exposed non–current-carrying metal parts of equipment. The grounding electrode conductor connection shall be to the metal enclosure at any point on the separately derived system from the source to the first system disconnecting means or overcurrent device, or it shall be made at the source of a separately derived system that has no disconnecting means or overcurrent devices.

The size of the grounding electrode conductor shall be in accordance with ~~250~~350.166.

Part IX. Instruments, Meters, and Relays

350.170 Instrument Transformer Circuits.

Secondary circuits of current and potential instrument transformers shall be grounded.~~ if the primary windings are connected to circuits of 300 volts or more to ground and, if installed on or in switchgear and on switchboards, shall be grounded irrespective of voltage.~~

~~*Exception No. 1: Circuits where the primary windings are connected to circuits of 1000 volts or less with no live parts or wiring exposed or accessible to other than qualified persons.*~~

Exception No. 2: Current transformer secondaries connected in a three-phase delta configuration shall not be required to be grounded.

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350.172 Instrument Transformer Cases.

Cases or frames of instrument transformers shall be connected to the equipment grounding conductor if accessible to other than qualified persons.

~~*Exception: Cases or frames of current transformers, the primaries of which are not over 150 volts to ground and that are used exclusively to supply current to meters.*~~

~~350.174 Cases of Instruments, Meters, and Relays Operating at 1000 Volts or Less.~~

~~Instruments, meters, and relays operating with windings or working parts at 1000 volts or less shall be connected to the equipment grounding conductor as specified in 350.174(A), (B), or (C).~~

~~(A) Not on Switchgear or Switchboards.~~

~~Instruments, meters, and relays not located on switchgear or switchboards operating with windings or working parts at 300 volts or more to ground, and accessible to other than qualified persons, shall have the cases and other exposed metal parts connected to the equipment grounding conductor.~~

~~(B) On Switchgear or Dead-Front Switchboards.~~

~~Instruments, meters, and relays (whether operated from current and potential transformers or connected directly in the circuit) on switchgear or switchboards having no live parts on the front of the panels shall have the cases connected to the equipment grounding conductor.~~

~~(C) On Live-Front Switchboards.~~

~~Instruments, meters, and relays (whether operated from current and potential transformers or connected directly in the circuit) on switchboards having exposed live parts on the front of panels shall not have their cases connected to the equipment grounding conductor. Mats of insulating rubber or other approved means of floor insulation shall be provided for the operator where the voltage to ground exceeds 150 volts.~~

350.176 Cases of Instruments, Meters, and Relays — Operating at Over 1000 Volts.

If instruments, meters, and relays have current-carrying parts of over 1000 volts to ground, they shall be isolated by elevation or protected by a barrier(s), grounded metal, or insulating covers or guards. Their cases shall not be connected to the equipment grounding conductor.

Exception: Cases of electrostatic ground detectors shall be permitted to be connected to an equipment grounding conductor if the internal ground segments of the instrument are connected to the instrument case and grounded and the ground detector is isolated by elevation.

350.178 Instrument Equipment Grounding Conductor.

The equipment grounding conductor for secondary circuits of instrument transformers and for instrument cases shall not be smaller than 12 AWG copper or 10 AWG aluminum or copper-clad aluminum. Cases of instrument transformers, instruments, meters, and relays that are mounted directly on grounded metal surfaces of enclosures or grounded metal of switchgear or switchboard panels shall not be required to be connected to an additional equipment grounding conductor.

~~250~~350.180 General.

If systems over 1000 volts are grounded, they shall comply with all applicable requirements of this article. ~~250350.1 through 250350.178 and with 250350.182 through 250350.194, which supplement and modify the preceding sections.~~

~~250~~350.182 Derived Neutral Systems.

A system neutral point derived from a grounding transformer shall be permitted to be used for grounding systems. ~~over 1 kV.~~

~~250~~350.184 Solidly Grounded Neutral Systems.

Solidly grounded neutral systems shall be permitted to be either single point grounded or multigrounded neutral.

(A) Neutral Conductor.

(1) Insulation Level.

The minimum insulation level for neutral conductors of solidly grounded systems shall be 600 volts.

Exception No. 1: For multigrounded neutral systems as permitted in ~~250~~350.184(C), bare copper conductors shall be permitted to be used for the neutral conductor of the following:

(1) Service-entrance conductors

(2) Service laterals or underground service conductors

(3) Direct-buried portions of feeders

Exception No. 2: Bare conductors shall be permitted for the neutral conductor of overhead portions installed outdoors.

Exception No. 3: The grounded neutral conductor shall be permitted to be a bare conductor if isolated from phase conductors and protected from physical damage.

Informational Note: See 225.4 for conductor covering where within 3.0 m (10 ft) of any building or other structure.

(2) Ampacity.

The neutral conductor shall have an ampacity that is not less than the load imposed and be not less than 33⅓ percent of the ampacity of the phase conductors.

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Exception: In industrial and commercial premises under engineering supervision, it shall be permissible to size the ampacity of the neutral conductor to not less than 20 percent of the ampacity of the phase conductor.

(B) Single-Point Grounded Neutral System.

If a single-point grounded neutral system is used, the following shall apply:

(1) A single-point grounded neutral system shall be permitted to be supplied from one of the following:

- a. A separately derived system
- b. A multigrounded neutral system with an equipment grounding conductor connected to the multigrounded neutral conductor at the source of the single-point grounded neutral system

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(2) A grounding electrode shall be provided for the system.
(3) A grounding electrode conductor shall connect the grounding electrode to the system neutral conductor.
(4) A bonding jumper shall connect the equipment grounding conductor to the grounding electrode conductor.
(5) An equipment grounding conductor shall be provided to each building, structure, and equipment enclosure.
(6) A neutral conductor shall only be required if phase-to-neutral loads are supplied.
(7) The neutral conductor, if provided, shall be insulated and isolated from earth except at one location.
(8) An equipment grounding conductor shall be run with the phase conductors and shall comply with all of the following:

- a. Shall not carry continuous load
- b. Shall be bare, covered, or insulated
- c. Shall have ampacity for fault current duty

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(C) Multigrounded Neutral Systems.

If a multigrounded neutral system is used, the following shall apply:

(1) The neutral conductor of a solidly grounded neutral system shall be permitted to be grounded at more than one point. Grounding shall be permitted at one or more of the following locations:

- a. Transformers supplying conductors to a building or other structure
- b. Underground circuits if the neutral conductor is exposed
- c. Overhead circuits installed outdoors

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(2) The multigrounded neutral conductor shall be grounded at each transformer and at other additional locations by connection to a grounding electrode.
(3) At least one grounding electrode shall be installed and connected to the multigrounded neutral conductor every 400 m (1300 ft).
(4) The maximum distance between any two adjacent electrodes shall not be more than 400 m (1300 ft).
(5) In a multigrounded shielded cable system, the shielding shall be grounded at each cable joint that is exposed to personnel contact.

Exception: In a multipoint grounded system, a grounding electrode shall not be required to bond the neutral conductor in an uninterrupted conductor exceeding 400 m (1300 ft) if the only purpose for removing the cable jacket is for bonding the neutral conductor to a grounding electrode.

~~250~~350.186 Grounding Service-Supplied Alternating-Current Systems.

(A) Systems with a Grounded Conductor at the Service Point.

If an ac system is grounded at any point and is provided with a grounded conductor at the service point, a grounded conductor(s) shall be installed and routed with the ungrounded conductors to each service disconnecting means and shall be connected to each disconnecting means grounded conductor(s) terminal or bus. A main bonding jumper shall connect the grounded conductor(s) to each service disconnecting means enclosure. The grounded conductor(s) shall be installed in accordance with ~~250~~350.186(A)(1) through (A)(4). The size of the solidly grounded circuit conductor(s) shall be the larger of that determined by ~~250~~350.184 or ~~250~~350.186(A)(1) or (A)(2).

Exception: If two or more service disconnecting means are located in a single assembly listed for use as service equipment, it shall be permitted to connect the grounded conductor(s) to the assembly common grounded conductor(s) terminal or bus. The assembly shall include a main bonding jumper for connecting the grounded conductor(s) to the assembly enclosure.

(1) Sizing for a Single Raceway or Overhead Conductor.

The grounded conductor shall not be smaller than the required grounding electrode conductor specified in Table ~~250~~350.102(C)(1) but shall not be required to be larger than the largest ungrounded service-entrance conductor(s).

(2) Parallel Conductors in Two or More Raceways or Overhead Conductors.

If the ungrounded service-entrance conductors are installed in parallel in two or more raceways or as overhead parallel conductors, the grounded conductors shall also be installed in parallel. The size of the grounded conductor in each raceway or overhead shall be based on the total circular mil area of the parallel ungrounded conductors in the raceway or overhead, as indicated in ~~250~~350.186(A)(1), but not smaller than 1/0 AWG.

Informational Note: See 310.10(G) for grounded conductors connected in parallel.

(3) Delta-Connected Service.

The grounded conductor of a 3-phase, 3-wire delta service shall have an ampacity not less than that of the ungrounded conductors.

(4) Impedance Grounded Systems.

Impedance grounded systems shall be installed in accordance with ~~250~~350.187.

(B) Systems Without a Grounded Conductor at the Service Point.

If an ac system is grounded at any point and is not provided with a grounded conductor at the service point, a supply-side bonding jumper shall be installed and routed with the ungrounded conductors to each service disconnecting means and shall be connected to each disconnecting means equipment grounding conductor terminal or bus. The supply-side bonding jumper shall be installed in accordance with ~~250~~350.186(B)(1) through (B)(3).

Exception: If two or more service disconnecting means are located in a single assembly listed for use as service equipment, it shall be permitted to connect the supply-side bonding jumper to the assembly common equipment grounding terminal or bus.

(1) Sizing for a Single Raceway or Overhead Conductor.

The supply-side bonding jumper shall not be smaller than the required grounding electrode conductor specified in Table ~~250~~350.102(C)(1) but shall not be required to be larger than the largest ungrounded service-entrance conductor(s).

(2) Parallel Conductors in Two or More Raceways or Overhead Conductors.

If the ungrounded service-entrance conductors are installed in parallel in two or more raceways or overhead conductors, the supply-side bonding jumper shall also be installed in parallel. The size of the supply-side bonding jumper in each raceway or overhead shall be based on the total circular mil area of the parallel ungrounded conductors in the raceway or overhead, as indicated in ~~250~~350.186(A)(1), but not smaller than 1/0 AWG.

(3) Impedance Grounded Systems.

Impedance grounded systems shall be installed in accordance with ~~250~~350.187.

~~250~~350.187 Impedance Grounded Systems.

Impedance grounded systems in which a grounding impedance device, typically a resistor, limits the ground-fault current shall be permitted if all of the following conditions are met:

(1) The conditions of maintenance and supervision ensure that only qualified persons service the installation.

(2) Ground detectors are installed on the system.

(3) Line-to-neutral loads are not served.

Impedance grounded systems shall comply with ~~250~~350.187(A) through (D).

(A) Location.

The grounding impedance device shall be installed between the grounding electrode conductor and the impedance grounding conductor connected to the system neutral point.

(B) Insulated.

The impedance grounding conductor shall be insulated for the maximum neutral voltage.

Exception: A bare impedance grounding conductor shall be permitted if the bare portion of the grounding impedance device and conductor are not in a readily accessible location and securely separated from the ungrounded conductors.

Informational Note: The maximum neutral voltage in a 3-phase wye system is 57.7 percent of the phase-to-phase voltage.

(C) System Neutral Point Connection.

The system neutral point shall not be connected to ground, except through the grounding impedance device.

(D) Equipment Grounding Conductors.

Equipment grounding conductors shall be permitted to be bare and shall be electrically connected to the ground bus and grounding electrode conductor.

~~250~~350.188 Grounding of Systems Supplying Portable or Mobile Equipment.

Systems supplying portable or mobile equipment~~ over 1000 volts~~, other than substations installed on a temporary basis, shall comply with ~~250~~350.188(A) through (F).

(A) Portable or Mobile Equipment.

Portable or mobile equipment ~~over 1000 volts~~ shall be supplied from a system having its neutral conductor grounded through an impedance. If a delta-connected system ~~over 1000 volts~~ is used to supply portable or mobile equipment, a system neutral point and associated neutral conductor shall be derived.

(B) Exposed Non-Current-Carrying Metal Parts.

Exposed non-current-carrying metal parts of portable or mobile equipment shall be connected by an equipment grounding conductor to the point at which the system neutral impedance is grounded.

(C) Ground-Fault Current.

The voltage developed between the portable or mobile equipment frame and ground by the flow of maximum ground-fault current shall not exceed 100 volts.

(D) Ground-Fault Detection and Relaying.

Ground-fault detection and relaying shall be provided to automatically de-energize any component of a system ~~over 1000 volts~~ that has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to automatically de-energize the circuit of the system ~~over 1000 volts~~ to the portable or mobile equipment upon loss of continuity of the equipment grounding conductor.

(E) Isolation.

The grounding electrode to which the portable or mobile equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 6.0 m (20 ft) from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe and fence, and so forth.

(F) Trailing Cable and Couplers.

Trailing cable and couplers of systems ~~over 1000 volts~~ for interconnection of portable or mobile equipment shall meet the requirements of Part III of Article 400 for cables and 495.65 for couplers.

~~250~~350.190 Grounding of Equipment.

(A) Equipment Grounding.

All non-current-carrying metal parts of fixed, portable, and mobile equipment and associated fences, housings, enclosures, and supporting structures shall be grounded.

Exception: If isolated from ground and located such that any person in contact with ground cannot contact such metal parts when the equipment is energized, the metal parts shall not be required to be grounded.

Informational Note: See ~~250~~350.110, Exception No. 2, for pole-mounted distribution apparatus.

(B) Grounding Electrode Conductor.

If a grounding electrode conductor connects non-current-carrying metal parts to ground, the grounding electrode conductor shall be sized in accordance with Table ~~250~~350.66, based on the size of the largest ungrounded service, feeder, or branch-circuit conductors supplying the equipment. The grounding electrode conductor shall not be smaller than 6 AWG copper or 4 AWG aluminum or copper-clad aluminum.

(C) Equipment Grounding Conductor.

Equipment grounding conductors shall comply with ~~250~~350.190(C)(1) through (C)(3).

(1) General.

Equipment grounding conductors that are not an integral part of a cable assembly shall not be smaller than 6 AWG copper or 4 AWG aluminum or copper-clad aluminum.

(2) Shielded Cables.

The metallic insulation shield encircling the current-carrying conductors shall be permitted to be used as an equipment grounding conductor, if it is rated for clearing time of ground-fault current protective device operation without damaging the metallic shield. The metallic tape insulation shield and drain wire insulation shield shall not be used as an equipment grounding conductor for solidly grounded systems.

(3) Sizing.

Equipment grounding conductors shall be sized in accordance with Table ~~250~~350.122 based on the current rating of the fuse or the overcurrent setting of the protective relay.

Informational Note: The overcurrent rating for a circuit breaker is the combination of the current transformer ratio and the current pickup setting of the protective relay.

~~250~~350.191 Grounding System at Alternating-Current Substations.

For ac substations, the grounding system shall be in accordance with Part III of this article.

Informational Note: See IEEE 80, *IEEE Guide for Safety in AC Substation Grounding*, for further information on outdoor ac substation grounding.

~~250~~350.194 Grounding and Bonding of Fences and Other Metal Structures.

Metal fences enclosing, and other metal structures in or surrounding, a substation with exposed electrical conductors and equipment shall be grounded and bonded to limit step, touch, and transfer voltages.

(A) Metal Fences.

If metal fences are located within 5 m (16 ft) of the exposed electrical conductors or equipment, the fence shall be bonded to the grounding electrode system with wire-type bonding jumpers as follows:

(1) Bonding jumpers shall be installed at each fence corner and at maximum 50 m (160 ft) intervals along the fence.

(2) If bare overhead conductors cross the fence, bonding jumpers shall be installed on each side of the crossing.

(3) Gates shall be bonded to the gate support post, and each gate support post shall be bonded to the grounding electrode system.

(4) Any gate or other opening in the fence shall be bonded across the opening by a buried bonding jumper.

(5) The grounding grid or grounding electrode systems shall be extended to cover the swing of all gates.

(6) The barbed wire strands above the fence shall be bonded to the grounding electrode system.

Alternate designs performed under engineering supervision shall be permitted for grounding or bonding of metal fences.

Informational Note No. 1: A nonconducting fence or section may provide isolation for transfer of voltage to other areas.

Informational Note No. 2: See IEEE 80, *IEEE Guide for Safety In AC Substation Grounding,* for design and installation of fence grounding.

(B) Metal Structures.

All exposed conductive metal structures, including guy wires within 2.5 m (8 ft) vertically or 5 m (16 ft) horizontally of exposed conductors or equipment and subject to contact by persons, shall be bonded to the grounding electrode systems in the area.

Public Input No. 3495-NFPA 70-2023 [Part X.]

~~**Part X.** Grounding of Systems and Circuits of over 1000 Volts~~

Statement of Problem and Substantiation for Public Input

CMP-5 was tasked with creating a new Article 350 for systems above 1000 VAC and 1500 VDC. part X of 250 is for systems above 1000 volts. This PI is to delete Part X of Article 250 in its entirety.

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Committee:	NEC-P05

Committee Statement

Resolution: FR-8825-NFPA 70-2024

Statement: This new article is being created based on direction from the NEC Correlating Committee to provide separate articles for systems over 1000 volts ac and 1500 volts dc, nominal, as part of an overall revision to the NEC. It is noted that there will be a lot of duplicated material from Article 250.

Tables 350.122(A) and 350.122(B) for Equipment grounding conductors are based on UL 1072, UL Standard for Safety Medium-Voltage Power Cables, Tables 23-1 and 23-2 respectively. This consensus standard has been used successfully in the industry for sizing equipment grounding conductors in MV-90 and MV-105 cables since it was first published in 1986. Table ranges are 2001 – 35,000 volts, to align with tables in Article 315. Voltages above this are often bare overhead lines (with cables being the exception).

Note: The new article was proposed as a new 350 but was renumbered to 252.